STUDIES ON THE AGRONOMIC AND BREEDING POTENTIAL OF SOME INTERSPECIFIC HYBRIDS IN ARACHIS

M. Sc. THESIS

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STUDIES ON THE AGRONOMIC AND BREEDING POTENTIAL OF SOME INTERSPECIFIC HYBRIDS IN ARACHIS

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BY

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CERTIFICATE

This is to certify that this thesis entitled "Studies on the agronomic and breeding potential of some interspecific hybrids in Arachis" submitted for the degree of M.Sc (Agriculture) in the major subject of Genetics and Plant Breeding to the Andhra Pradesh Agricultural University, is the result of bonafide research work carried out by Mr. Kwadjo Owusu Marfo (RA/79-164) under my supervision and that the thesis has not formed in whole or in part, the basis for the award of any Degree, Diploma or other similar distinctions.

The assistance and help received during the course of the investigation have been fully acknowledged.

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INTRODUCTION:

Groundnut, otherwise known as peanut (*Arachis hypogaea L.*) is a legume used primarily as a vegetable oil crop. The haulms are used as fodder, but the most important part, the kernel which is formed underground, as well as having very high oil content, is a good source of digestible protein. The groundnut cake, which is obtained from the residue of the kernel after oil extraction, is also highly nutritious as a cattle feed. The importance of groundnut, as a food crop in world trade, moreover, has increased tremendously in recent years (McGill, 1973).

India is the world's leading producer of groundnuts followed by China, U.S.A., Senegal, Sudan and Nigeria in that order (F.A.O. Production Yearbook, 1978). Although there are large areas of land put under groundnut cultivation in some of the producing areas in the developing countries, yields generally in these areas are poorer than those in the developed countries. For instance; whilst the average yield (in kg/ha) in U.S.A. was 2,958; the yields in India, Senegal, Sudan, Nigeria and China were 861; 1053; 1048; 731 and 1174 kg/ha respectively in the year 1978 (F.A.O. Yearbook, 1978).

Plant breeders have been able to improve yields (especially in the developed countries) and to a lesser degree the quality of the crop (Stalker *et al.* 1979). They have drawn on three basic sources outlined below to utilise the genetic material in the breeding of groundnuts (Gregory, 1962). They are:

a) The hereditary differences among varieties of cultivated groundnuts.

b) The differences that may be created artificially by the use of physical or chemical mutagens; and

c) Differences which occur among the wild relatives of the cultivated species.

In most developing countries of the world, the basic source of genetic material has been only from the first category. New varieties of groundnut are developed here mainly by selection from within indigenous populations, by introduction and also by hybridization within cultivated varieties.

However, improvement of several traits, such as insect and disease resistances is difficult, because most of the cultivated genotypes show some amount of susceptibility to these diseases and pests (Stalker *et al.* 1979). Thus, the exploitation of genetic resources from germplasm of wild closely related species becomes imperative. Initially, there were a lot of problems to be overcome, especially with hybridization between wild and cultivated species. Among the host of factors to be overcome were the short period available for floral emasculation and low multiplication rate probably due to the sterile hybrid progenies that sometimes resulted. The hybrids produced were usually sterile, as the species which could be crossed were diploids, producing sterile triploids when they were crossed with *A. hypogaea*, a tetraploid.

Nevertheless, most of these barriers to interspecific hybridization are being overcome, resulting in a tremendous success in the production of hybrids to utilize disease reistance genes to improve the performance

of cultivated varieties, which but for their susceptibility to these diseases are well adapted to the existing conditions.

Success in this direction is exemplified by the investigations of Raman (1973), Gopinath Nair *et al.* (1975), Jayaramaiah *et al.* (1979) and Gibbons *et al.* (1980) among other workers in India. Elsewhere in other parts of the world, successes like those of Conagin *et al.* (1972), Sharief *et al.* (1978) and Smartt and Gregory (1967) have all been very encouraging.

A lot of material from the groundnut breeding programmes of Reading University, U.K. and North Carolina State University and Georgia Experimental Station, Tifton, both of U.S.A., have been assembled in ICRISAT since it was designated as germplasm centre for *Arachis* (Moss, 1979). These include some interspecific hybrid progenies selected for disease resistance by Moss and Spielman (1976) and other wild species from North Carolina.

In this investigation, some of those interspecific *Arachis* hybrids at or near the hexaploid or tetraploid level, and which had been selected for a range of characters, such as productivity, disease resistance, earliness or combinations of these, were tested along with some established cultivars. The disease resistances are mainly for the peanut leaf rust caused by *Puccinia arachidis* and the early and late leaf spots caused by *Cercospora arachidicola* and *Cercosporidium personatum* respectively. Thus here, attempts were made to compare the selected lines

with the cultivars to assess the range of characters present in populations derived from wild species.

LITERATURE REVIEW

USE OF WILD SPECIES IN IMPROVEMENT OF *Arachis hypogaea*:

In the past, interspecific crosses have shown little promise in *Arachis*. However, *Arachis hypogaea* has been found now to cross easily with other species in the section *Arachis*. Krapovickas and Rigoni (1951) were among the first to produce such a hybrid, with *Arachis villosa* var. *correntina*.' Many more such hybrids have been produced since then. For example, Smartt and Gregory (1967) produced hybrids with seven species in the section *Arachis*. The success of interspecific cross compatibility between the cultivated groundnut and a number of its wild relatives made Darlington in 1948 express the hope that interspecific hybridization might be used in peanut improvement.

Smartt and Gregory (1967) crossing *Arachis hypogaea* with *Arachis cardenasii* in North Carolina, U.S.A. produced hexaploids from which a number of lines with high yielding potential were subsequently derived (Stalker *et al.* 1979). Crosses of *Arachis hypogaea* with *Arachis stenosperma*, *A.cardenasii* and *A.chacoense* by Moss and Spielman (1976) and subsequent years, produced triploids, and the chromosome numbers were doubled by colchicine treatment. These hexaploids were then tested for disease resistance, vigor and productivity; and selected plants were backcrossed to the parental cultivar with the aim of producing 40 chromosome plants similar to the *A.hypogaea* parent but incorporating desirable traits from wild species.

Different interspecific hybrid progenies exhibit different potentialities in different areas as reported by Moss, (1979); Abdou *et al.* (1974) and Sharief (1972). For example Moss (1979) reported that *A. chacoense* amphiploids were more resistant to leaf spot in Malawi than in India. On the other hand, *Arachis cardenasii* amphiploids were more resistant in India than in Malawi.

Stalker *et al.* (1979) studied variation in progenies of an *Arachis hypogaea* crossed with a diploid wild species *A. cardenasii*. They realized that many of the hybrids were intermediate to the 2 parents in morphology. Individual traits like growth habit, pod and seed size, elongation of the constricted area between pods or catenate nature, nodulation and leaflet size were altered by the presence of the wild diploid species germplasm in many of the hybrid plants. Furthermore, an assessment of the resistance of the plants to *Cercospora arachidicola* and *Cercosporidium personatum* indicated that several hybrids had few lesions caused by either of the leafspot pathogens mentioned above. In addition to these, large seeded interspecific hybrid selections were compared to the cultivated variety NC 5 for yield. Five selections were superior to both parents at P = 0.01. Thus they concluded from the above, that morphology, disease resistances and yields appeared to be greatly influenced by the wild species germplasm in plants of the interspecific hybrid population.

Jayaramaiah *et al.* (1979) in their experiment with wild species *Arachis monticola, Arachis prostrata, Arachis villosa* and 30 lines of *Arachis hypogaea* tested under field conditions for susceptibility to

Puccinia arachidis found out that the wild species were free from infection and five lines of the cultivars proved moderately resistant. This is an indication of the potential use of wild species to obtain disease free desirable plants in groundnuts. This also confirms previous reports in other crops that a wide range of morphological, disease, insect and yield characters can be transferred from wild to cultivated species for utilization in crop improvement programme as reviewed by Harlan in 1976.

Seetharam and his collegues in 1974 working on interspecific hybridization in groundnuts to transfer resistance to 'tikka' leaf spot disease, crossed *Arachis hypogaea* var. HG 8 (2n = 40) as female parent with *Arachis duranensis* (2n = 20) which is resistant to *Cercospora* leafspot. The hybrid was a triploid (2n = 3x = 30) with 82.5% pollen sterility and the habit and resistance of *Arachis duranensis*. Similarly, Raman (1973) determining the genome relationships in *Arachis*, crossed *Arachis hypogaea* with 4 diploid species, *Arachis villosa*, *Arachis duranensis*, *Arachis diogoi* and *Arachis villosulicarpa*, produced triploid F_1 hybrids which had spreading habit, increased vigor, profuse flowering and resistance to leafspot.

In Samaru in Northern Nigeria, Kolawole (1976) obtained triploids when he crossed *Arachis hypogaea*, Samaru 38; F452-4 and F439-2 as females to the wild species *Arachis chacoense* (2n = 20) resistant to *Cercospora arachidicola* (*Mycosphaerella arachidis*); and to *Arachis cardenasii* (2n=20) immune to late leafspot *Cercosporidium personatum*.

Triploids were also obtained when Samaru 38 and F439-2 were crossed as male to an unnamed *Arachis* sp. Resistance occurred under field conditions in the hybrid *Arachis hypogaea* x *Arachis chacoense* and *Arachis hypogaea* x *Arachis* (unnamed species)

Sharief *et al.* (1978) estimated leafspot resistance in 3 interspecific crosses of *Arachis*. They inoculated the F_1 and F_2 hybrids with spore suspensions of *Cercospora arachidicola* and *Cercosporidium personatum*. Measurements of the degree of infection of the various forms followed by statistical analysis led to the conclusion that introgression from the 2 resistant species into *Arachis hypogaea* should increase resistance to both pathogens. Moss *et al.* (1978) and Gibbons *et al.* (1980) have been exploiting leafspot resistance characters in wild *Arachis* species; utilizing 3 sources of resistance to leafspots. It has been observed that *Arachis chacoense* is highly resistant to *Cercospora arachidicola*, *A. cardenasii* is immune to *Cercosporidium personatum* and *Arachis* species HLK 410 is resistant to both fungi (Abdou *et al.* 1974).

Sandhu and Khehra (1977) on the other hand reported that progenies of the crosses of cultivars C 501 x Ak 12-24 and C 501 x Ah 6595 showed differences in resistance to *Cercosporidium personatum*, pod yield, 100 fruit weight and oil and protein content. Subrahmanyam *et al.* (1980) and Anonymous, (1977-78) screened over 6000 germplasm collection at ICRISAT for rust resistance. A number of cultivars including 2 land races NC Ac 17090 and EC 76446 (292) showed resistance, but seven wild species and one hybrid were immune to rust.

Selection Criteria:

Sauger and Boufil (1955) reported that varieties selected for multiplication in areas where farmers lack experience in maintaining pure stocks, as prevalent in most parts of developing countries, should be those with small seeds and high reproduction rate per plant. They have shown that natural selection was beneficial to the strains producing the largest number of viable seeds per kilogram harvested, and that these types maintain their purity most easily in comparison with others. This offers a useful guide to the choice of varieties for distribution in developing regions. The total yield depends largely on the number and weight of sound pods per plant, plant population and ratio of sound kernels to pods i.e. shelling percentage (Oram, 1958). Although quality of oil was affected by spacing, time of sowing and fertilizer treatment, variety was probably the main determining factor, with special importance being attached by the confectionery trade to the shape, colour and weight of pods, and the distribution of 1,2,3 and 4 seeded pods in the sample. A high percentage of one seeded, light (pops), diseased or damaged pods profoundly affected the price obtainable for the product; and also the total weight available for exports where grading standards were operat asserted Oram. It thus becomes imperative to present results of research not only in terms of total yield, but also of yield of exportable produce. Hence, varieties which gave the highest total yield were not always the most attractive to the consumer (Oram, 1957)

He further stated that productivity was influenced by plant type, season length and agronomic practices. Sauger (1954) independently observed that strains which produced the largest number of early flowers were the most productive; whilst Shear and Miller (1955) observed that the time of peg initiation was critical for fruit development and that as the season progressed, fewer pegs developed fruits.

REPRODUCTIVE CHARACTERS OF *Arachis*:

Plant Habit:

Evaluation of sub-specific variation for pod and seed characters in groundnut were undertaken by Jaya Mohan Rao and his associates in India in 1975. Here, morphological and reproductive characters were evaluated in 260 varieties, including Virginia, Spanish and Valencia types and spreading and bunch forms. They found that varieties of the spreading form had higher pod number, pod weight and shelling percentage than the bunch types, but the Virginia bunch varieties had heavier and larger kernels. The Spanish type varieties flowered earlier and had more variability for pod characters. At the Taiwan Agricultural Research Station, between 1970 and 1974; they found that the time required for fruits of groundnut to attain full development after flowering differed among varieties (Anonymous, 1975). Varieties of Spanish and Valencia type took 60 days while those of Virginia type needed 80 days. They also found significant differences in protein and oil content among 250 varieties that were tested.

Thus in areas where literacy level of the farmers are high it was advisable to select for bolder seeds, and vice versa in low literacy areas. We should also aim at selecting for erect types since they gave higher oil content in addition to producing higher yields in some cases. However, in some places, the semispreading types perform well. Thus in deciding the plant type, we should take into consideration the performance of the plant habit in that location.

Oil Content:

Cherry J.P. (1975) in his work to determine potential sources of peanut seed proteins and oil in the genus *Arachis* observed that the percentage oil in seed meals from wild species ranged from 46.5 to 63.1%, while those of the varieties ranged from 43.6 to 55.5%.

Lin *et al.* 1969 in China observed that oil content in the Spanish and Valencia varieties gradually increased during the early stages of fruit development and abruptly decreased 60 days after flowering, but in Virginia types, oil content increased steadily until 70 days after flowering. Belovan (1970), however, observed that upright forms of *Arachis hypogaea* were earlier and had higher yields and oil content than semi procumbent and procumbent forms. Furthermore; protein content was negatively correlated with oil and positively with phosphorus content. Shanny (1977), aside confirming that plants with high protein content tended to have a low oil content and vice versa; also noticed that protein content was positively correlated with percentage of mature pods and negatively with number of pods per plant

and seed weight. Oil yield had also been observed by Varisai *et al.* (1973) to be higher in Spanish and Valencia groups. Thus, to be able to obtain higher oil contents, the genotypes should be single seeded pod yielders, which will mean lower yields. Such high oil content lines with higher yields may be obtained from wild species derivatives through interspecific crosses.

Yield Components:

Khan and Shad (1964) undertook correlation and inter-relationship studies among some important characters of *Arachis hypogaea L.* From their studies; it was evident that there were positive correlations between pod yield and pod number. Multiple correlations were also significant for pod number and number of inflorescences , flower and branches. Husk weight on the other hand, was negatively associated with the ratio of seed weight: husk weight. Similar studies by Ramanathan *et al.* (1968) indicated correlations between (1) pod weight (2) kernel weight (3) shell thickness (4) percentage of well filled kernels and (5) shelling percentage (the proportion of kernels to pod by weight) when studies were made in populations of *Arachis hypogaea* x *Arachis glabrata* (var. *hagenbeckii*) and *A.hypogaea* x F_1 (*A.hypogaea* x *A.villosa*). Shelling percentage was further found to be significantly correlated with pod weight, kernel weight and percentage of well filled kernels. In a related work to the above undertaken by Ramanathan and other co-workers in 1969 from population of interspecific crosses of:

a) F_3 of A.*hypogaea* x A.*glabrata* (var. *hagenbeckii*)

b) BC_1F_3 of a backcross involving A.*hypogaea* and

c) BC_1F_4 of A.*hypogaea* x allotriploid (A.*hypogaea* x A.*villosa*),

it became apparent that number of pods per plant; weight of 2-kernelled pods, shelling outturn, 100-pod weight and 100 kernel weight had genetic improvement in these characters over those of the parental varieties.

Coffelt and Hammons (1974) were among other scientists who did comprehensive correlation studies on *Arachis hypogaea* populations. They made reciprocal crosses between Argentine (sp. *fastigiata* var. *vulgaris*) and early runner (spp. *hypogaea* var. *hypogaea*); and the parents and F_2 were used in the study of 9 characters. They observed consistent significant positive correlations in all populations between number of pods and pod weight; number of seeds and seed weight; pod weight, no. of seeds and seed weight. Pod length, breadth, the length/breadth ratio and weight/100 seed were highly heritable. Differences were observed between the reciprocal cross populations; the population with Argentine as female parent having lower values, except for number of seeds.

Similar studies by Merchant and Munshi (1971) utilizing 15 varieties showed a significant and positive correlation between leaf length and breadth, pod length and seed length, and seed length and seed weight. There was a negative correlation between seed length and shelling percentage. Almost similar results were also obtained by the same authors in 1973. Rahman and Ali (1970) reported positive correlation

between number of flowers produced per plant and yield of nuts per acre. Another yield component which has been found to be very important is the ratio of seed weight to husk weight. This has been shown to be an index of fruit maturity in groundnuts (Pattee *et al.* 1977). This ratio might also be helpful in estimating the optimum time for harvesting peanuts to obtain maximum yields as elucidated by Pattee *et al.* (1976 and 1978). There are many evidences to show that the plant habit affects yields directly or indirectly. Chahal and Sandhu (1972) screened 58 varieties of groundnut. They realized that generally the bunch type varieties were more susceptible to early and late *Cercospora* leafspot than spreading or semispreading varieties. In Sudan, in trials involving 13 introductions and one local variety, Tsangarakis and Gerakis (1969) observed that the upright bunch types proved more adaptable to the short rainy season in Umn Higlig, than spreading bunch or runner types. Varisai Mohammad *et al.* (1973) also realised that, of 719 varieties they studied, those of the semispreading plant type generally had bigger kernels while bunch types gave higher shelling percentages. Further, larger kernels tended to be associated with low shelling percentage. The highest coefficients of variation were found in the semispreading types for kernel weight and in the spreading types for shelling percentage. Kushwaha *et al.* (1973) estimated genotypic and phenotypic variability in groundnuts. They observed that the genetic coefficient of variability was lowest for 100 pod weight and highest for pod yield per plant.

Working on genotypic and phenotypic variability in quantitative characters in groundnut, Majumdar *et al.* (1969) obtained high significant differences among 45 varieties that were grown under rainfed conditions for all the 17 characters studied. A wide range of phenotypic variation was observed in flowering, number of branches, number of nodes, number of leaves, peg bearing nodes and pod bearing nodes, days to maturity, number of mature pods, 100 pod weight, shelling percentage and pod yield. The highest genetic coefficient of variation was observed for number of branches followed by number of leaves , number of nodes, number of peg bearing nodes, number of pod bearing nodes and length of pod.

Sarma and Viziakumar (1971) presented data on 225 varieties grown for 2 years which indicated that 2 main groups of groundnut can be distinguished. The Valencia and Spanish types, with sequential branching flowered about 22 days after sowing and then produced a sudden increase in flowering, reaching a maximum in the 5th week. The alternately branching types which includedvirginia and those with spreading growth habit, flowered about 28-31 days after sowing and then showed a gradual increase until maximum flowering at about the 9th week.

Joshi and Gajipara (1971) observed that semispreading variety (narrow leaf) showed less seasonal variation (with year) in flower numbers per plant; flower duration and ratios of flowers to pegs than Punjab I and Junagadah 11, representing the spreading and bunch forms respectively.

There has been indications that the range of variation in weight of 100 pods in 331 bunch, 191 semispreading and 191 spreading varieties studied by Varisai *et al.* in 1973 was 53.0 - 187.5, 37.0 - 215.0 and 73.5 - 195.0 g . respectively. During a 26 day period; Nicholaides *et al.* (1969) observed that the number of flowers on a given day was significantly and positively correlated with the highest and average daily temperatures which had occured 3 days earlier; and with the lowest daily temperature prevailing 2 days earlier. None of the daily relative humidity values were related to subsequent flowering. They also observed individual plant fluctuations in flowering.

Scandaliaris and a group of scientists (1978) studied 4 varieties growing in the field for 3 growing seasons. Only 3-7% of the flowers according to variety and year developed into mature fruits. The start and duration of flowering period and number of flowers per day varied with the variety and the year.

Dholaria *et al.* (1975) obtained multiple regression analysis data from 20 varieties. They observed that; number of branches or pods per plant made the main contribution to variation in pod yield. Branch number was more important in selecting for improved yield in varieties with spreading habit of growth; while pod number was more important for selecting bunch types. The greatest contribution to Kernel yield, however, was made by pod weight per plant in both types.

It has been observed that pod rot, adversely affects yields in some groundnut producing areas of the world. Walker and Csinos(1980); however, observed that severe pod rot occurred on plots receiving no gypsum; but the severity decreased for all cultivars as the rate of gypsum applied was increased. Thus there is the possibility of reducing pod rot incidence by increasing pod fill.

It has been observed in Malawi that, plants with red, brown or variegated brown and white seeds derived from the variety Mani Pintar bred true for their respective seed colour (Anonymous, 1971). After one generation of mass selection from a bulk population of the cultivars Chalimbana; Thomas *et al.* (1974) observed that seed size had increased tremendously. Further, size of seed planted was positively correlated with the subsequent mean size harvested. Large seed also tended to produce an increased proportion of 2 seeded rather than 3-seeded pods.

From the above, it can be deduced that if our aim is to select for improvement in yields; then we should select for entries with higher seed numbers or total number of pods since these factors are closely associated with most yield parameters. Also the contributions that wild species have made towards yield improvement in *Arachis hypogaea* through obtaining disease free lines have been very tremendous. Selection within cultivars towards improvement in resistance to diseases such as leaf spots and rust has not been very encouraging of late; although there have been isolated reported cases of such lines.

MATERIALS AND METHODS:

Thirty-six entries (Table 1) including hexaploids and tetraploids of interspecific origin and standard local cultivars were planted during the kharif season (major rainy season) of 1980, at the ICRISAT Research Centre, Patancheru; in the alfisols. The entries of interspecific origin were classified as:

1) Consistently high yielding bulks and High yieldings-single plant selections for crosses.

2) Segregants for high yield (single and 2 plant progenies)

3) Miscellaneous i.e. early, disease resistant, or other selections

4) Consistently low yielding bulks depending on their productivity in the past season.

The design used was a 6 x 6 triple lattice. Each treatment consisted of 3 rows, 4 meters in length and spaced 75 cm. apart. The plant spacings within a row were 15 cm. Infector rows, of alternate plants of two cultivars, both susceptible to rust and leafspots were provided between each treatment (Fig. 1). The plants were irrigated when it became necessary to maintain adequate soil moisture.

Table - 1

LIST OF GENOTYPES USED

Treatment	Parental Genotype	Original Species Cross
Consistently High Yielding Bulks:		
1.	H1/1-23-3	*A. hypogaea* x *A. cardenasii*
2.	H2/5-7-4	*A. hypogaea* x *A. cardenasii*
3.	H5/CF19-8	*A. hypogaea* x *A. cardenasii*
4.	H6/CF23-4	*A. hypogaea* x *A. batizocoi*
5.	HP3/15-5-11	*A. hypogaea* x *A. batizocoi*
6.	27HP14-18/9	*A. hypogaea* x *A. batizocoi*
7.	29HP43-1A/5	*A. hypogaea* x *A. cardenasii*
8.	HP4/16-263-11	*A. hypogaea* x *A. batizocoi*
9.	H7/17-17-5	*A. hypogaea* x *A. batizocoi*
10.	28HP 41/1	*A. hypogaea* x *A. duranensis*
11.	HP6/3-11-6	*A. hypogaea* x *A. cardenasii*
12.	HP6/13-101-3	*A. hypogaea* x *A. batizocoi*
13.	30-44 x 10017/1	*A. hypogaea* x *A. cardenasii*
14.	501-181/67-2	*A. hypogaea* x *A. cardenasii*
Segregants for High Yield (1 or 2 Plant Progenies):		
15.	HP3/15-5-11	*A. hypogaea* x *A. batizocoi*
16.	27HP14-18/9	*A. hypogaea* x *A. batizocoi*
17.	HP2/8-37 N.P.N.	*A. hypogaea* x *A. batizocoi*
18.	HP14-M/13-101-6	*A. hypogaea* x *A. batizocoi*
19.	HP6/7-31-5	*A. hypogaea* x *A. cardenasii*
20.	H1/2-43-11	*A. hypogaea* x *A. cardenasii*
21.	H5/CF-19-8	*A. hypogaea* x *A. cardenasii*
Miscellaneous:		
22.	Mutant from M- 13	*A. hypogaea*
23.	*A. monticola* x M -13	*A. monticola* x *A. hypogaea*
24.	Hexaploid HIC/192/215	*A. hypogaea* x *A. chacoense*
25.	Hexaploid HIL 8/13/24	*A. hypogaea* x *A. stenosperma* (Florunner)
26.	Hexaploid HJK 8/10/22	*A. hypogaea* x *A. cardenasii* (Florispan)

Treatment	Parental Genotype	Original Species Cross
Consistantly Low Yielding Bulks:		
27.	H6/5-165-6	A.*hypogaea* x A.*batizocoi*
28.	H3/4-41-11	A.*hypogaea* x A.*cardenasii*
29.	HP6/5-57	A.*hypogaea* x A.*cardenasii*
30.	HP43-1A 262/CF41-10	A.*hypogaea* x A.*cardenasii*
31.	H1/4-11-11	A.*hypogaea* x A.*cardenasii*
Standard Cultivars (A.*hypogaea*):		
32.	TMV 2	A.*hypogaea* - Spanish Bunch
33.	Robut 33-1	A.*hypogaea* - Virginia Runner: Short duration
34.	M-13	A.*hypogaea* - Virginia Runner: Long duration
35.	Gangapuri	A.*hypogaea* - Valencia
36.	Makulu Red	A.*hypogaea* - Virginia Bunch

Fig. 1. FIELD LAYOUT FOR STUDIES ON INTERSPECIFIC HYBRIDS OF ARACHIS

Row	REPLICATION-I					
	BI	BII	BIII	BIV	BV	BVI
1	INFECTOR ROW					
2	INFECTOR ROW					
3	4	15	32	28	20	7
4	"	"	"	"	"	"
5	"	"	"	"	"	"
6	INFECTOR ROW					
7	2	16	35	25	19	12
8	"	"	"	"	"	"
9	"	"	"	"	"	"
10	INFECTOR ROW					
11	1	17	31	30	32	10
12	"	"	"	"	"	"
13	"	"	"	"	"	"
14	INFECTOR ROW					
15	3	14	36	26	24	9
16	"	"	"	"	"	"
17	"	"	"	"	"	"
18	INFECTOR ROW					
19	6	18	34	29	23	8
20	"	"	"	"	"	"
21	"	"	"	"	"	"
22	INFECTOR ROW					
23	5	13	33	27	21	11
24	"	"	"	"	"	"
25	"	"	"	"	"	"
26	INFECTOR ROW					
27	INFECTOR ROW					

	REPLICATION-II					
	BI	BII	BIII	BIV	BV	BVI
	INFECTOR ROW					
	INFECTOR ROW					
	33	32	36	34	31	35
	"	"	"	"	"	"
	"	"	"	"	"	"
	INFECTOR ROW					
	3	6	5	1	2	4
	"	"	"	"	"	"
	"	"	"	"	"	"
	INFECTOR ROW					
	15	17	18	13	14	16
	"	"	"	"	"	"
	"	"	"	"	"	"
	INFECTOR ROW					
	8	7	12	10	9	11
	"	"	"	"	"	"
	"	"	"	"	"	"
	INFECTOR ROW					
	30	29	25	27	28	26
	"	"	"	"	"	"
	"	"	"	"	"	"
	INFECTOR ROW					
	22	20	23	24	21	19
	"	"	"	"	"	"
	"	"	"	"	"	"
	INFECTOR ROW					
	INFECTOR ROW					

	REPLICATION-III					
	BI	BII	BIII	BIV	BV	BVI
	INFECTOR ROW					
	INFECTOR ROW					
	23	33	28	13	4	8
	"	"	"	"	"	"
	"	"	"	"	"	"
	INFECTOR ROW					
	7	21	31	27	16	1
	"	"	"	"	"	"
	"	"	"	"	"	"
	INFECTOR ROW					
	6	9	24	36	29	17
	"	"	"	"	"	"
	"	"	"	"	"	"
	INFECTOR ROW					
	18	2	11	19	35	26
	"	"	"	"	"	"
	"	"	"	"	"	"
	INFECTOR ROW					
	30	15	5	10	20	32
	"	"	"	"	"	"
	"	"	"	"	"	"
	INFECTOR ROW					
	34	25	14	3	12	22
	"	"	"	"	"	"
	"	"	"	"	"	"
	INFECTOR ROW					
	INFECTOR ROW					

Season: Kharif-1980
Design: 6 x 6 Triple Lattice

Soil type : Alfisol
Row Direction : East-West

Plant Spacing: 15 cm
Row Length : 4 Meters
Row Spacing : 75 cm

Data Recorded:

The following pre harvest records were taken:

1. a) Date of germination - The date when the first seedling emerged was recorded.

   b) Uniformity of germination - The number of emerged plants was recorded every other day to give an indication of the uniformity of germination

2. a) Date of flowering - First date of flowering was recorded for each entry

   b) Number of flowers produced per day - One plant was selected at random from within each row of each replicate (9 plants per treatment) and total number of flowers produced by each plant daily was recorded.

3. Plant habit (Table 25) using the following classes:
   a) Erect bunch (Spanish bunch)
   b) Semi-spreading bunch (Virginia bunch)
   c) Semi-spreading (Virginia runner)
   d) Spreading bunch (Prostrate with bunchy type of pod formation)
   e) Valencia runner (not more than 3-5 prostrate branches)
   f) Spreading runner (more than 5 branches running prostrately and very lengthy in nature).

4. Disease resistance:

   Scoring for diseases (*Cercospora* and rust) was done on a 9 point scale for lower, mid and top leaves of the 3 randomly selected plants mentioned above. The field scale used was developed by ICRISAT Groundnut Pathologists (Anonymous, 1979) as follows:-

Cercospora	Score	Rust
No disease	1	No disease
Few, small necrotic spots on older leaves	2	Few, very small pustules on some older leaves
Small spots mainly on leaves, sparse sporulation	3	Few pustules mainly on older leaves, some ruptured; poor sporulation
Many spots mostly on lower and middle leaves: disease evident	4	Pustules small or big, mostly on lower and middle leaves, disease evident
Spots easily seen on lower and middle leaves: sporulating, yellowing and defoliation of some lower leaves seen	5	Many pustules mostly on lower and middle leaves: yellowing and necrosis of some lower and middle leaves seen, moderately sporulating
Like rating 5 but spots heavily sporulating	6	Like rating 5 but spots heavily sporulating
Disease easily seen from a distance, spots present all over the plant: lower and middle leaves defoliating	7	Pustules all over the plant; lower and middle leaves withering
Like rating 7 but defoliation is heavy	8	Like rating 7 but withering is heavy
Plants severely affected: 50-100% defoliation	9	Plants severely affected: 50-100% leaves withering

The following post harvest records were taken on the tagged plants after they reached maturity.

1 a) Number of pegs produced

b) Dormancy as measured by sprouts per plant and frequency of

plants with sprouts at harvest: $\frac{\text{Number of sprouted pods}}{\text{Total Number of pods}} \times 100$

2) Maturity: After harvest; total number of both mature and immature pods was noted.

Percentage maturity was estimated based on $\frac{\text{No. of mature pods}}{\text{Total number of pods}} \times 100$

3) Yield and Yield Components:

a) Number of pods per plant

b) Number of kernels per plant

c) Percentage of rotted pods as given by $= \frac{\text{No. of rotted pods}}{\text{Total No. of pods}} \times 100$

d) The average length for five pods of each of the selected plants was determined using a Vernier screw gauge

e) The average width of the same pods was assessed also using a Vernier screw gauge.

f) Percentage single seeded pods was determined from $= \frac{\text{No. of single pods}}{\text{Total No. of mature pods}} \times 100$

g) Percentage bilobed pods was also assessed as $= \frac{\text{No. of bilobed pods}}{\text{Total No. of mature pods}} \times 100$

h) Percentage trilobed pods was determined from $= \frac{\text{No. of trilobed pods}}{\text{Total No. of mature pods}} \times 100$

i) The pod weight per plant

j) The total number of kernels per plant

k) The total weight of kernel per plant

l) The shelling percentage (Ratio of weight of kernel to pod weight per plant).

m) The kernel content, an indication of the average number of seeds contained in a pod, was determined for each plant. i.e.

$$\frac{\text{No. of kernels}}{\text{No. of mature pods}}$$

n) The weight per 100 seeds (kernels).

o) The percentage oil content for each of the entries was determined using Nuclear Magnetic Resonance (NMR) Spectrometer, from a 20 g sample.

Analysis of Results:

The results were analysed by basic plus programme using the computer at ICRISAT.

RESULTS AND DISCUSSION:

Germination (Table 2):

It was observed that germination was very poor in some of the treatments, in fact lower than 40% for treatments 18, 19 and 23 i.e. HP9/13-101-6 and HP6/7-31-5 and *A.monticola* x M-13 lines respectively. The entry number 10 (28HP41/1), a cross of *A.hypogaea* with *A.duranensis*, however, was the only interspecific progeny which showed consistently high germination performance in all the replications. Generally, germination percentages in some of the standard cultivars were higher, compared with most of the wild species derivatives. Despite the pre-treatment of the seeds with ethaphon before sowing to break the dormancy, the overall germination was both slow and poor. There were a lot of factors which might have contributed to the lower germination performance. Prominent among them was, because of our lack of basic knowledge of the wild species, there might have been the possibility that the seeds did not reach full maturity before harvest in the previous season. Also since the moisture level in the soil was quite low at the time of sowing, the delay in irrigation and possible susceptibility of the materials to the high temperatures in June might have been some of the causes of the low germination. The slower germination rates of most of the wild species derivatives however, is an advantage that can be exploited to increase the dormancy of some of the cultivars in interspecific hybridization programmes.

The analysis of variance (ANOVA) of the variable number of days to germination (Appendix 1) indicates that there were significant differences

(P=0.05) between the various treatments. Treatments 21 and 10 (Table 1) which are derivatives of *A.cardenasii* and *A.duranensis* respectively germinated early (about 11 days) whilst the only *A.chacoense* derivative in the treatments which is a hexaploid (T_{24}) germinated late as did the *A.cardenasii* hexaploid (T_{26}). The *Arachis stenosperma* derivative, also a hexaploid, germinated early.

Correlation coefficients between number of days to germination and all the variables that were studied indicate that there were no significance between them (Table 3). However, there was the tendency for early germination to be associated with high *Cercospora* and rust incidence. Similarly there were negative correlations between total number of pods produced per plant, number of matured pods produced, pod and kernel weight with number of days to germination. These show that quick germination resulted in higher yields.

Interestingly, although there was negative non significant correlation between percentage of double seeded pods produced and number of days to germination; the percentage single and 3- seeded pods produced showed non significant positive correlations. Further, the more the germination of the seeds were delayed; the more the initial flowering was also delayed.

Table 2. Ranked Adjusted Means for the Genotypes-No. of Days to Germination

S.No.	Treatment Numbers	Mean of Days to Germination
1.	21	11
2.	10	12
3	16	12
4.	36	12
5.	33	13
6.	32	13
7	9	13
8.	15	13
9.	1	13
10.	4	13
11.	25	13
12.	23	13
13.	28	14
14	5	14
15	6	14
16.	11	14
17.	27	14
18.	22	14
19	20	14
20.	31	14
21.	18	14
22.	14	15
23.	19	15
24.	2	15
25.	8	15
26.	30	15
27.	34	15
28.	13	15
29.	29	16
30.	35	17

contd/.

Table. 2 contd/...

S.No.	Treatment Numbers	Mean of Days to Germination
31.	12	17
32.	17	17
33	7	17
34.	24	18
35.	3	18
36.	26	18

Grand Mean = 14
C.V.% = 5
C.D. at 5% = 1

Table 3. Contd....

Abbrevation	Name
NDG	No. of Days to Germination
DF	Days to Flowering
NF	No. of Flowers
NP	No. of Pegs
CR	*Cercospora* Rating
RR	Rust Rating
DP	Dormancy Percentage
TNP	Total No. of Pods
NMP	No. of Matured Pods
MP	Maturity Percentage
PL	Pod Length
PW	Pod Width
SSP	Percentage of Single Seeded Pods
DSP	Percentage of Double Seeded Pods
TSP	Percentage of 3 Seeded Pods
PWT	Pod Weight
NK	No.ofKernels per Plant
RP	Percentage of Rotten Pods
WK	Weight of Kernel
OC	Oil Content
SP	Shelling Percentage
KC	Average kernel content
WPS	Weight per 100 Seeds
*	Significant at 5% level of probability
**	Significant at 1% level of probability

Table 3. Contd....

Abbrevation	Name
NDG	No. of Days to Germination
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SSP	Percentage of Single Seeded Pods
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TSP	Percentage of 3 Seeded Pods
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NK	No.ofKernels per Plant
RP	Percentage of Rotten Pods
WK	Weight of Kernel
OC	Oil Content
SP	Shelling Percentage
KC	Average kernel content
WPS	Weight per 100 Seeds
*	Significant at 5% level of probability
**	Significant at 1% level of probability

FLOWERING:

(a) No. of Days to Flowering:

There were significant differences (P=0.05) between the genotypes as to the number of days they took to reach flowering stage. Whilst the 2 cultivars Gangapuri (a valencia erect bunch) T_{35}; and TMV 2 (a Spanish bunch) T_{32} were the earliest to flower (within 33 days); Treatment 31, (H1/4-11-10) a virginia semispreading bunch and also a derivative of *Arachis cardenasii* took the longest period of over 50 days (Table 4). Sowing date was used to calculate time to germination and flowering. Germination was slow. Times from germination to flowering ranged from 16 days (Gangapuri) to 37 days (T_{31}). The observations seem to confirm earlier ones made by Sarma and Viziakumar (1971) and also at the Taiwan Agricultural Research Station (Anonymous 1975) that the Valencia and Spanish types tended to reach earlier flowering compared with the alternately branching types which include Virginia and those with spreading growth habit (Refer to Table 4).

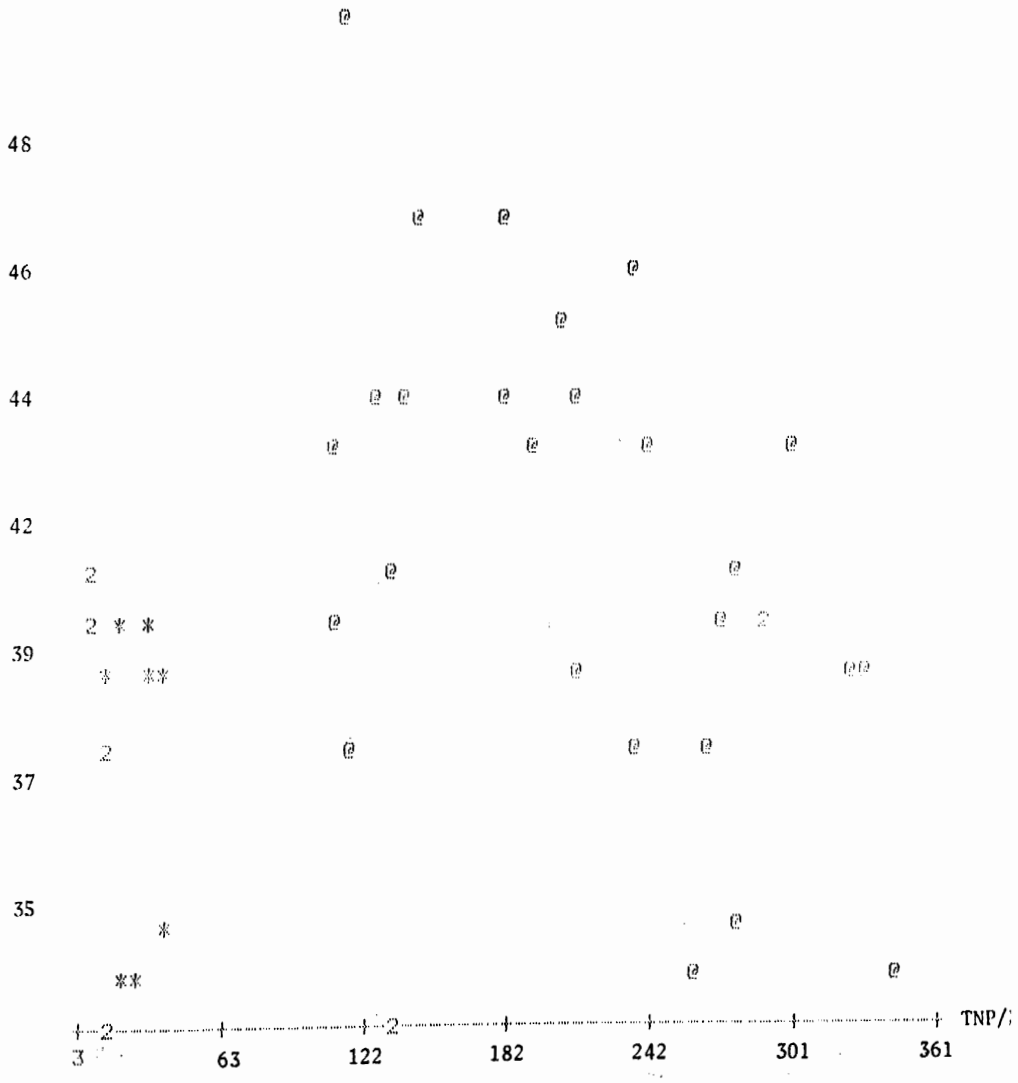
Significant negative correlations existed between number of days to first flowering and pod length, pod width, number of kernels and average kernel content. Thus genotypes which had their flowering delayed tended to be less productive in terms of yields of kernel numbers and average kernel content. However, late flowering resulted in a non significant decrease in disease incidence. There were also reductions in number of flowers produced, number of pegs, total number of pods and number of matured pods, pod weight and shelling percentage. Single seeded pods, characteristic of most wild *Arachis* tended to be associated with delay in flowering. Thus late flowering was significant and positively correlated

Table 4: Ranked Adjusted Means for Number of Days to Flowering

S.No.	Treatment No.	Means of No.of days to 1st Flowering	S.No.	Treatment No.	Means of No.of days to 1st Flowering
1	35	33	19	28	40
2	32	34	20	17	41
3	12	34	21	9	42
4	4	35	22	33	42
5	3	36	23	1	43
6	14	37	24	22	43
7	21	37	25	16	43
8	8	37	26	11	44
9	36	38	27	7	44
10	10	38	28	20	44
11	5	39	29	13	44
12	15	39	30	29	45
13	2	39	31	34	45
14	27	39	32	30	46
15	6	40	33	25	46
16	18	40	34	24	47
17	23	40	35	26	48
18	19	40	36	31	51

Grand Mean = 41 C.V..% = 6 C.D. at 5% = 4

COMPARISON OF DAYS TO FLOWERING(DF) WITH TOTAL NO. OF PODS (TNP) AND NO. OF FLOWERS (NF)



with percentage single seeded pods; whilst bilobed and trilobed pods percentages decreased with late flowering. It looks as if delay in flowering may be associated with wild characteristics since T_{24}, T_{25}, T_{26} which were all late flowering were hexaploids; which were very close to wild species in their characters.

A look at the scatter diagram (Fig. 2) of days to flowering with number of flowers produced and total number of pods produced reveal that the entries with delayed flowering produced fewer flowers or pods.

(b) Number of Flowers:

The analysis of variance table (Appendix 3) indicates that signifi cant differences exist between the number of flowers produced. The top 9 genotypes with highest productivity of flowers were all of inter-specific origin, with derivatives of *A.batizocoi* being the greater part of them (see Table 5).

Graphs of cumulative number of flowers produced per plant per day for the hexaploid (T_{24}) compared with the high and low yielding *A.cardenasii* derivatives, T_2 and T_{31} respectively, show that the intial flower production by the hexaploid was very slow (similar to the low yielding *A.duranensis* and *A.cardenasii*) but about 30 days after flowering it produced a large number of flowers per day (Fig. 4). This may also probably account for the reason why quite substantial amounts of the flowers did not result in pod formation at harvest. Thus whilst the

cultivars and other tetraploids had stopped producing flowers at harvest, there was a linear increase in flowers produced by T_{24}, a hexaploid. Fig. 4 also confirms that whilst the flower production by other entries was decreasing, that of T_{25} a hexaploid, was increasing up to the time of harvest (see Sarma and Viziakumar, 1971).

An increase in number of flowers produced by a plant resulted in highly significant increases in the number of pegs, total number of pods, number of matured pods, pod length and width, pod weight, number of kernels and weight of kernels that were produced (Table 3). Thus flower production was intimately associated with all the yield parameters. The highly floriforous lines were however, susceptible to rust and leafspots and also had less oil content.

Whilst increase in number of flowers produced by the plants resulted in non-significant increase in percentage single and bilobed pods; such an increase resulted in a decrease in the number of trilobed pods that were produced. Fig. 3 shows the diagram of the relationship between Number of flowers produced per plant with number of pegs and pod weight per plant.

Whilst Jaya Mohan *et al.* (1975) reported that the Spanish type varieties flowered earlier, this seemed to be true for only the cultivars but not the progenies of the interspecific crosses in this experiment. Here, the Virginia bunch and semispreading bunches of the derivatives of the wild species flowered earlier, which is of significance in breeding for early genotypes.

Table 5. Ranked Adjusted Means for the Number of Flowers Producted per Plant.

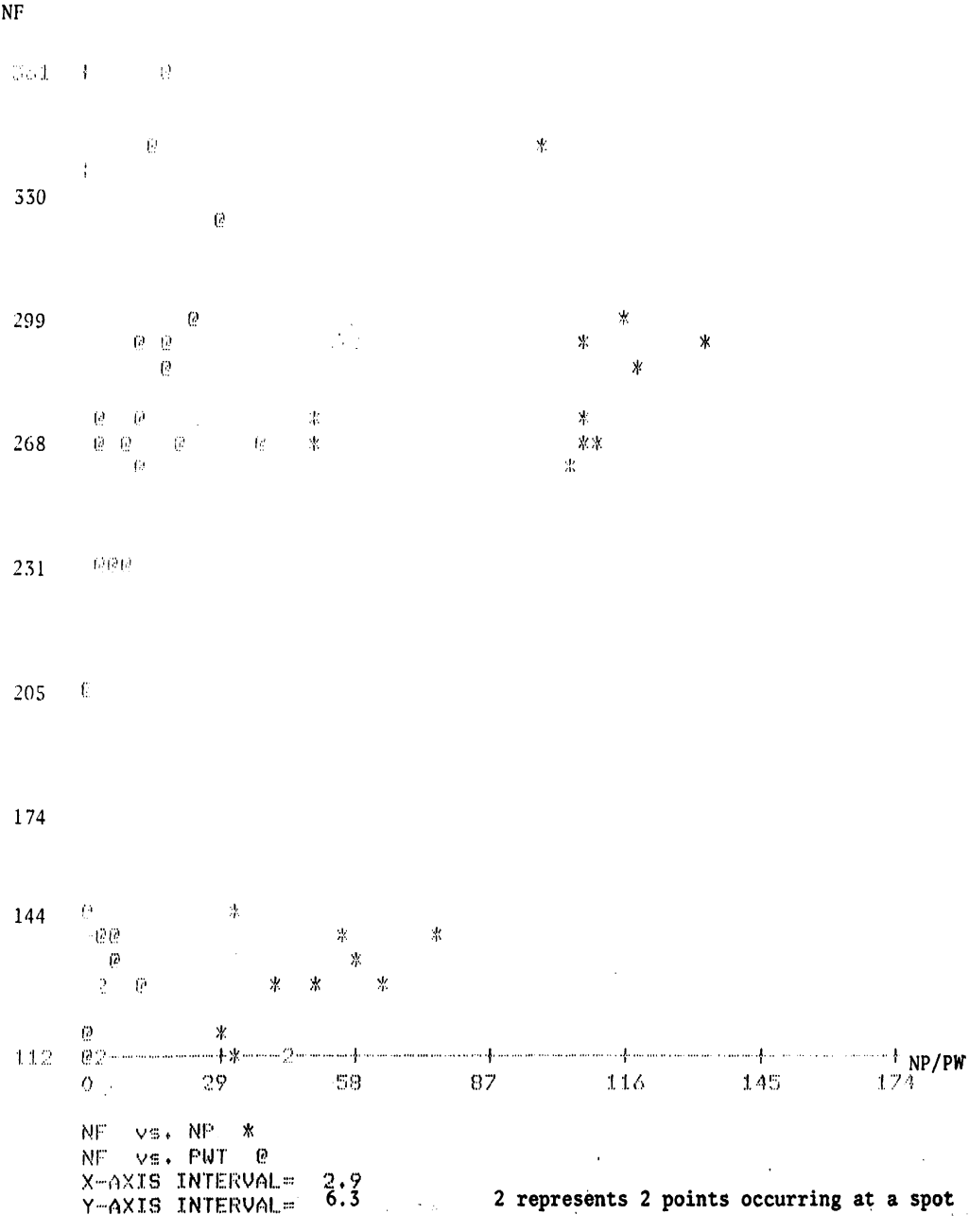
S.No.	Treatment Nos.	No. of flowers produced	S.No.	Treatment Nos.	No. of flowers produced
1.	8	363	19	20	217
2.	4	348	20.	6	211
3.	27	336	21.	30	210
4.	2	333	22.	1	195
5.	16	306	23.	13	184
6.	28	297	24.	24	175
7.	21	290	25.	14	173
8.	18	285	26.	26	156
9.	17	278	27.	36	146.
10.	34	276	28.	7	142
11.	3	276	29.	32	142
12.	23	275	30	9	139
13.	33	273	31.	35	139
14.	5	272	32.	29	136
15.	12	264	33.	31	127
16.	22	241	34.	10	118
17.	25	239	35.	11	114
18.	15	235	36.	19	111

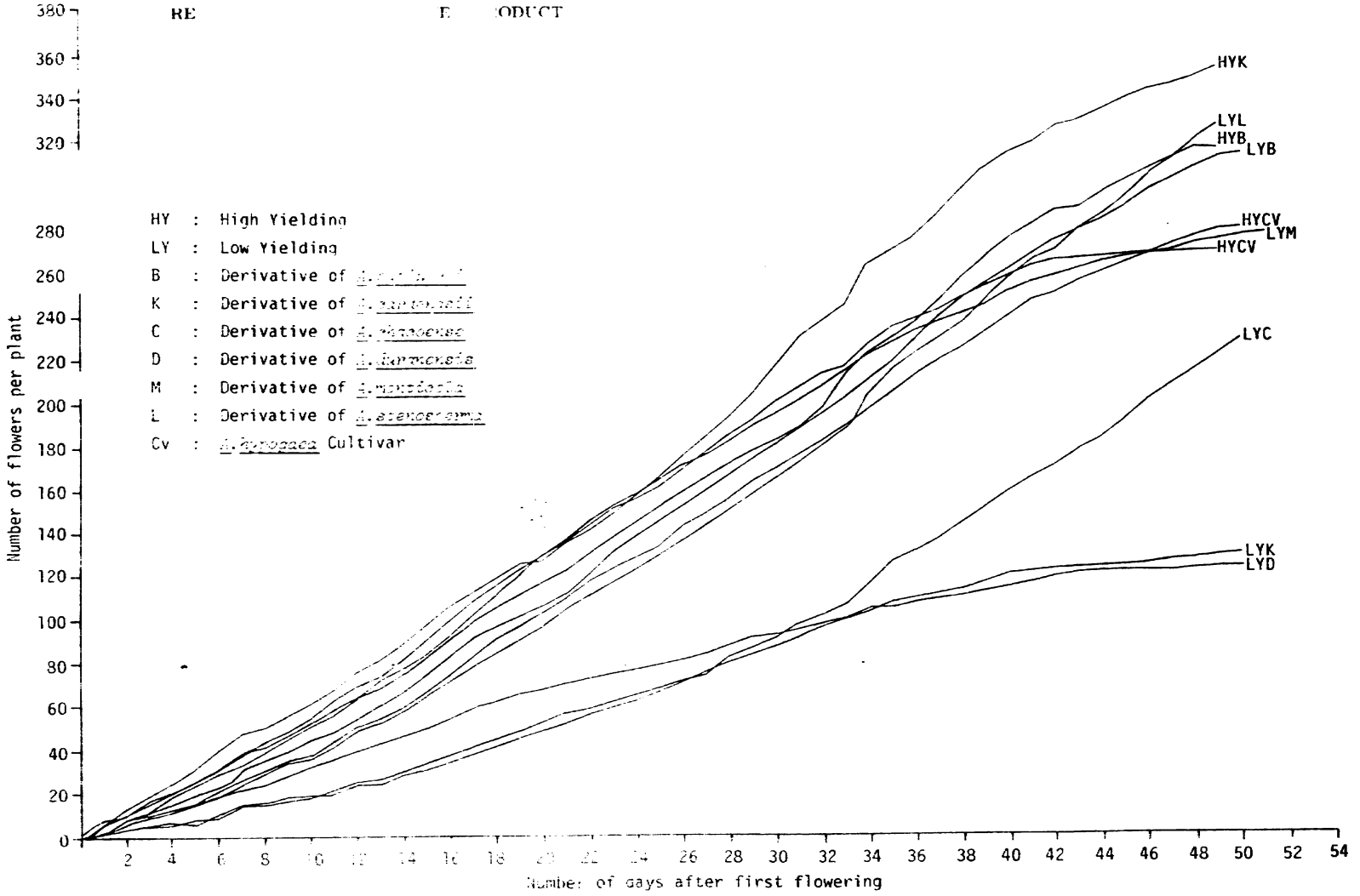
Grand Mean = 223 C.V. % = 25.24 C.D. at 5% = 92

NUMBER OF PEGS:

A critical look at the analysis of variance table (Appendix 4) for the variable - number of pegs produced - shows significant differences at 5 percent level of probability. There was the general trend of the entries that produced the largest number of flowers to show high productivity of pegs (Refer to Tables 5 and 6), and subsequently a highly significant positive correlation with the number

Fig. 3. COMPARISON OF NUMBER OF FLOWERS (NF) WITH NO. OF PEGS(NP) AND POD WEIGHT(PWT)




RE
E ODUCT
HY : High Yielding
LY : Low Yielding
B : Derivative of A.
K : Derivative of A.
C : Derivative of A.
D : Derivative of A.
M : Derivative of A.
L : Derivative of A.
Cv : A. Cultivar
HYK
LYL
HYB
LYB
HYCV
LYM
HYCV
LYC
LYK
LYD
Number of flowers per plant
Number of days after first flowering

of fruits developed. From Table 3 it is clear that high number of pegs produced resulted in high total number of pods that were subsequently produced. The number of matured pods increased as well as the length and width of pods, percentage double seeded pods, pod weight, number of kernels produced, weight of kernel and weight per 100 seeds with increase in number of pegs per plant. Whilst high number of pegs by the plants resulted in a non significant increase in incidence of leafspots and rust, it resulted in a decrease in oil content and dormancy percentages.

A further look at table 6 shows only 2 cultivars, treatments 33 and 34, were included in the 10 most productive entries in terms of number of pegs produced. Aside from treatments 19 and 31, both derivatives of *Arachis cardenasii*; the remaining of the lowest 5 entries in terms of productivity of pegs were all hexaploids. This may give an indication of the low yields of the hexaploids that were included in the studies.

The scatter diagrams of the variable number of pegs produced with number of matured pods (NMP) and number of kernels (NK) produced indicate positive correlation relationships (Fig. 5).

Cercospora Rating:

Both leafspot fungi, *Cercospora arachidicola* and *Cercosporidium personatum* were common in most of the lines that were tested. However, there were a few lines which showed resistance and or tolerance to these leafspot fungi. The much commoner of the leafspots was

Table 6. Ranked Adjusted Means for the Variable No. of Pegs Produced, for the Genotypes.

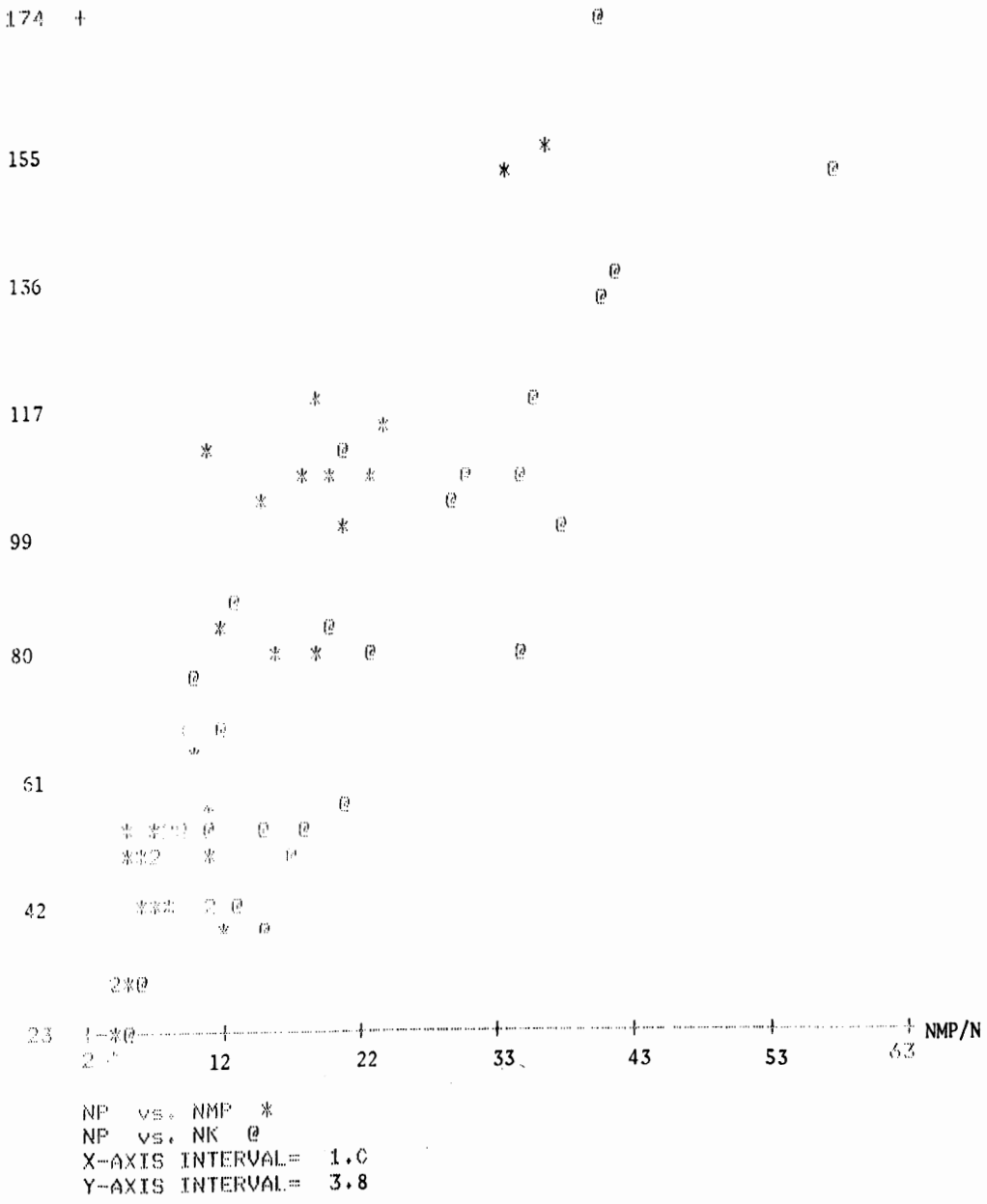
S.No.	Treatment Nos.	Mean of No. of pegs produced	S.No.	Treatment Nos.	Mean of No. of pegs produced
1.	27	177	19.	6	69
2.	33	156	20.	35	65
3.	2	155	21.	32	60
4.	8	137	22.	30	58
5.	28	136	23.	20	57
6.	16	117	24.	7	56
7.	18	117	25.	1	55
8.	5	113	26.	9	54
9.	34	111	27.	23	52
10.	3	108	28.	17	49
11.	21	108	29.	11	45
12.	12	106	30.	10	45
13.	4	101	31.	29	43
14.	22	87	32.	25	42
15.	15	86	33.	19	34
16.	13	82	34.	31	33
17.	14	78	35.	26	33
18.	36	77	36.	24	23

Grand Mean = 81

C.V.% = 33

C.D. at 5% = 44

ig. 5. COMPARISON OF NO. OF PEGS (NP) WITH NO. OF MATURE PODS (NMP) AND NO. OF KERNEL(NK)



C.personatum and was the more destructive. Table 7, shows the ranked adjusted means for *Cercospora* incidence. The most striking feature of the table is the fact that almost all the standard cultivars incorporated in the experiment were highly susceptible to leafspots. Thus it becomes increasingly important to screen for the resistant lines with high yielding ability to improve on yields generally by taking into consideration the resistant nature of most of the lines of interspecific origin. It is also clear from Table 7 that the top six most resistant lines are derivatives of *A.cardenasii* except treatment 15 which is of *A.batizocoi* origin. The hexaploids (Treatments 25, 24 and 26) were also fairly resistant ranking 8th, 9th and 11th in the order of resistance.

Table 3 shows that whilst increase in *Cercospora* incidence resulted in significant increases in the incidence of rust, and average kernel content, it resulted in significant decrease of the number of single pods that were produced. Fortunately, an increase in *Cercospora* incidence did not result in a significant decrease in yield per plant. For example a look at the scatter diagrams of *Cercospora* ratings with all the yield characters show that there were few entries which yielded well although heavily infested with *Cercospora*. Also, most of the points were concentrated at the lower yield levels and lower *Cercospora* incidence levels. These were mainly the entries of interspecific origin with lower yield characters, but resistance to the disease (Figs. 6,7,8, & 9).

Table 7: Ranked Adjusted Means of *Cercospora* Rating*

S.No.	Treatment	Mean of CR	S.No.	Treatment	Mean of CR
1	7	2.7	19	27	3.6
2	2	2.7	20	3	3.7
3	28	2.8	21	23	3.7
4	15	3.0	22	6	3.8
5	1	3.0	23	18	3.8
6	20	3.0	24	22	3.9
7	9	3.0	25	19	3.9
8	25	3.1	26	8	4.2
9	24	3.1	27	17	4.3
10	21	3.2	28	31	4.4
11	26	3.2	29	14	4.8
12	13	3.2	30	12	4.9
13	30	3.3	31	16	5.4
14	29	3.3	32	36	5.9
15	4	3.3	33	33	7.2
16	5	3.4	34	34	7.3
17	10	3.4	35	35	8.0
18	11	3.6	36	32	8.4

Grand mean = 4.1 C.D.at 5% = 1.4 C.V.% = 20.2

CR = *Cercospora* Rating

*A 9 point scale was used where

1 represents no disease

9 represents severe disease

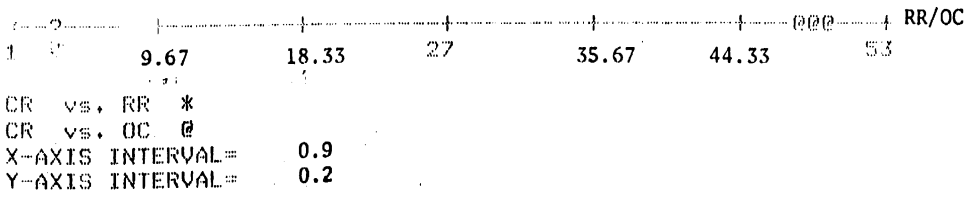
Fig. 6. COMPARISON OF CERCOSPORA RATING(CR) WITH RUST RATING(RR) AND OIL CONTENT(OC)

2 represents 2 points occurring at a spot

3 represents 3 points occurring at a spot

4 represents 4 points occurring at a spot

5 represents 5 points occurring at a spot



g. 7. COMPARISON OF CERCOSPORA RATING (CR) WITH TOTAL NUMBER OF PODS PER PLANT(TNP) AND NO. OF KERNELS PER PLANT(NK)

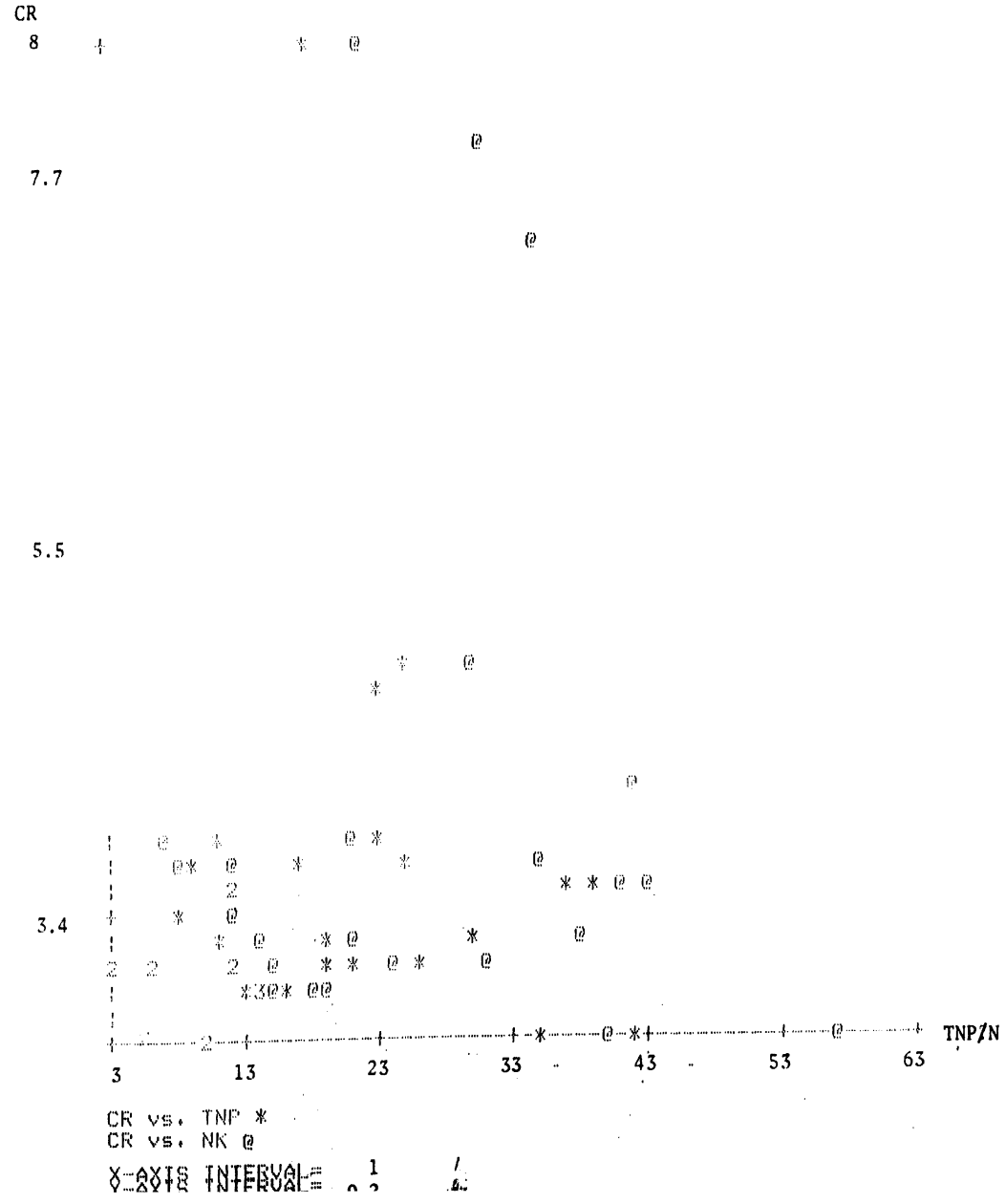


Fig. 8. COMPARISON OF CERCOSPORA RATING(CR) WITH NUMBER OF MATURE PODS(NMP) AND KERNEL WEIGHT (WK) PER PLANT.

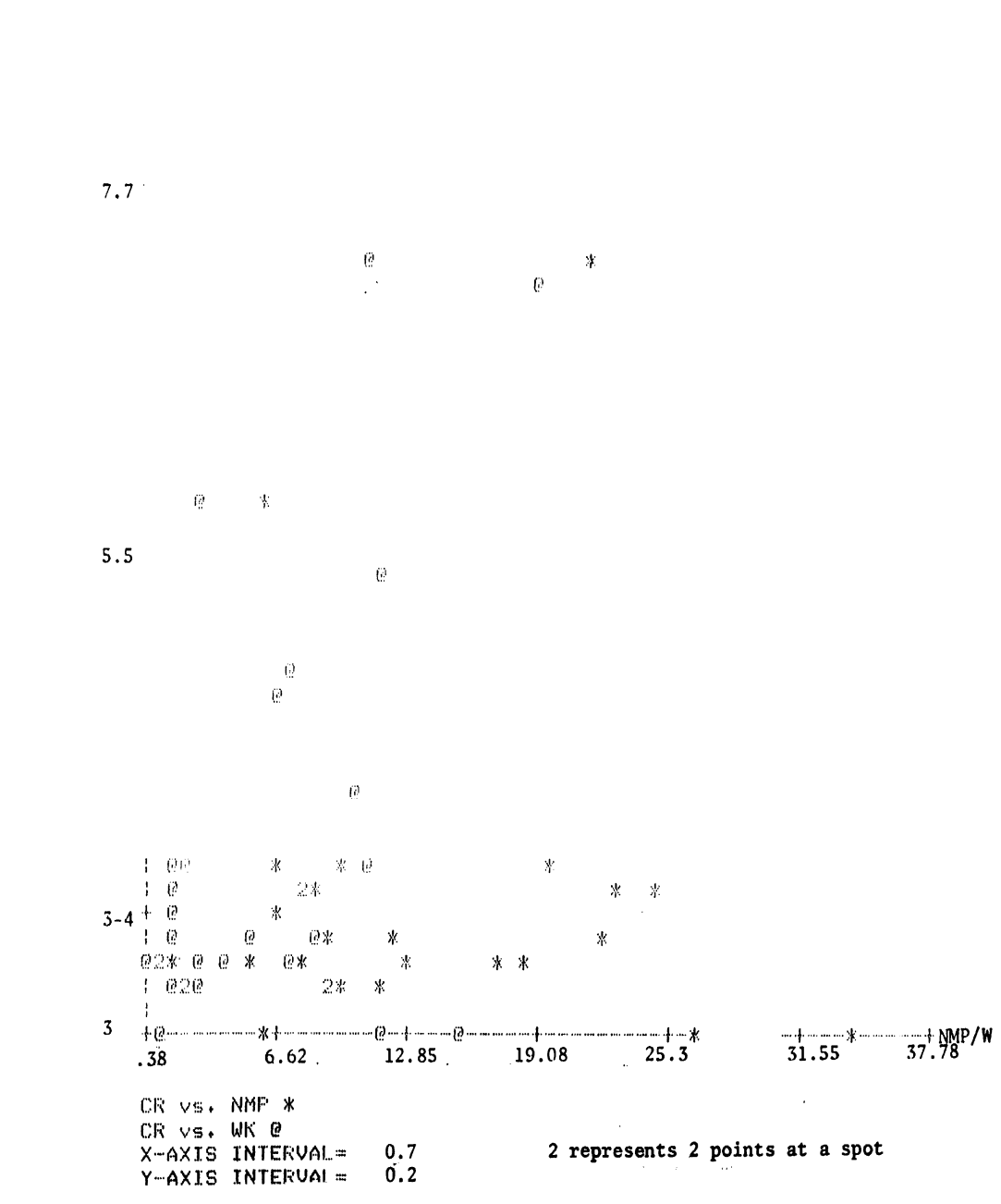
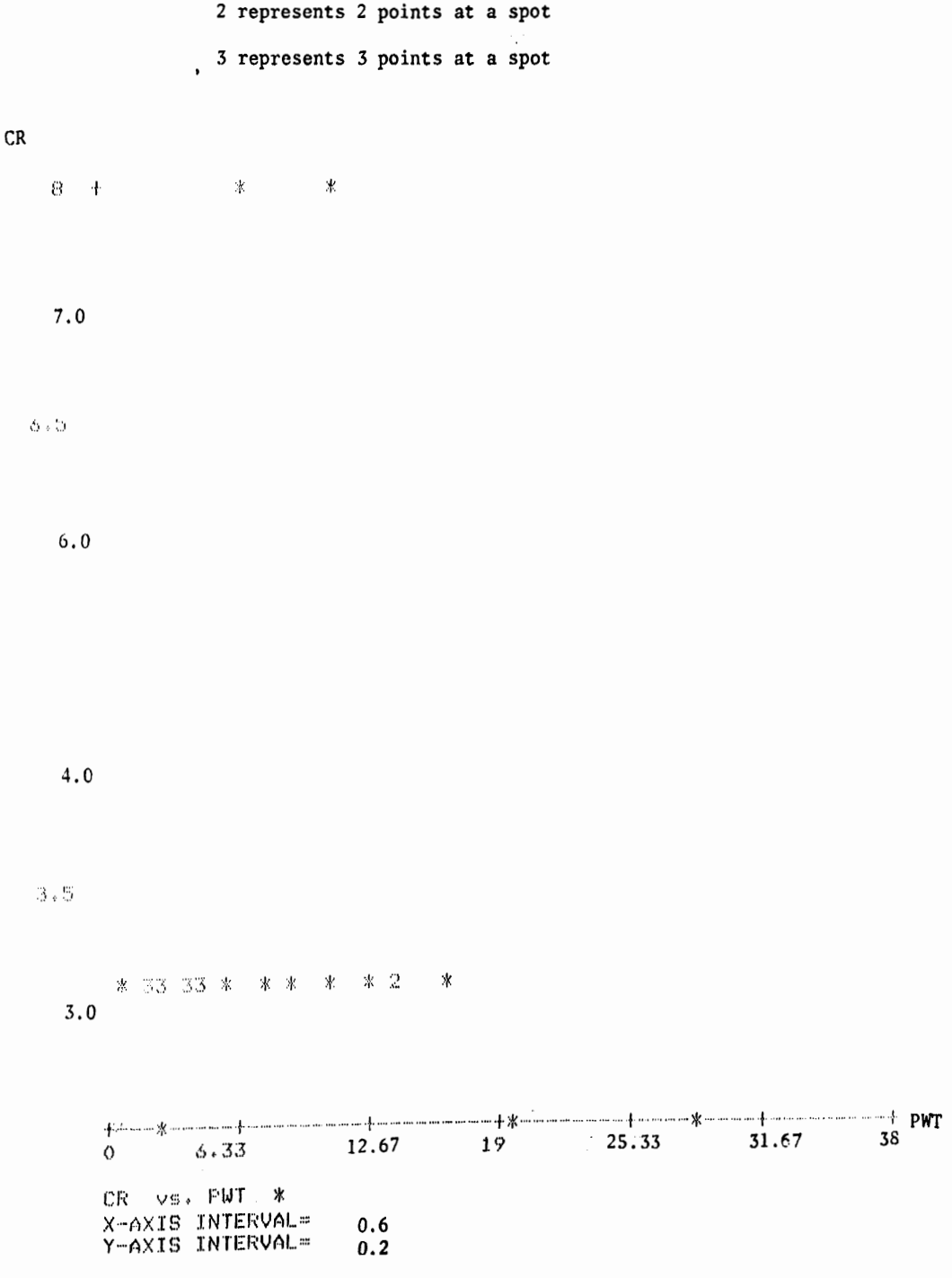


Fig. 9. COMPARISON OF CERCOSPORA RATING (CR) WITH POD WEIGHT (PWT)



Rust Incidence:

The incidence of rust, like *Cercospora* was very high in most of the lines. However, there were a few lines (mainly of interspecific origin) which showed complete resistance to the fungus *Puccinia arachidis*. There were significant differences among the entries at 5% level of probability with respect to their reaction to rust incidence. Here also, a careful look at Table 8 reveals that, almost all the standard cultivars included in the experiment were highly susceptible to rust incidence. Further, aside from T_{28} which is a derivative of *A. cardenasii* all the 5 top resistant lines were of *A. batizocoi* origin. Coincidentally, treatments 28 and 15 were resistant to both leafspots and rust fungi simultaneously.

Table 3 shows that increase in the level of rust incidence leads to a non significant decrease of single seeded pods. But most of the rust resistant lines were single seeded pods; indicating the importance of the wild species derivatives. Here also increase in the level of rust incidence resulted in a non significant increase in the level of yields obtained. For example a look at the scatter diagrams of rust incidence with the various yield parameters like pod weight, total number of pods produced, kernel weight and number of kernels produced showed that under the conditions of the trial, there were a few genotypes (mainly the cultivars) which produced reasonable yields, though the rust ratings were all greater than seven. Rust infestation like leafspot resulted in a non significant reduction in the level of oil content (refer Figs. 10, 11 & 12).

Table 8. Ranked Adjusted Means for Rust Incidence*

S.No.	Treatment Nos.	Mean of Rust Rating	S.No.	Treatment Nos.	Mean of Rust Rating
1.	15	0.9	19	7	3.9
2.	17	1.0	20	1	4.0
3.	12	1.1	21.	29	4.0
4.	5	1.1	22.	20	4.0
5.	28	1.2	23.	11.	4.2
6.	4	1.3	24.	31	4.3
7.	8	1.5	25.	22	4.5
8.	3	1.5	26.	13	4.8
9.	24	1.6	27.	2	4.9
10.	21	1.7	28.	6	5.0
11.	26	1.8	29.	14	5.1
12.	18	1.9	30.	19	5.1
13.	25	3.2	31.	16	6.3
14.	27	3.4	32.	34	7.3
15.	10	3.7	33.	36	7.5
16.	30	3.8	34.	35	7.9
17.	9	3.9	35.	32	8.5
18.	23	3.9	36.	33	8.8

Efficiency of lattice over RBD is 102.85

Grand mean = 3.8 C.V. % = 28.4 C.D.at 5% = 1.80

* 1-9 point scale was used where

1 represents no disease

9 represents severe disease

Fig. 10. COMPARISON OF RUST RATING WITH TOTAL NUMBER OF PODS (TNP) PER PLANT AND NO. OF MATURE PODS (NMP) PER PLANT.

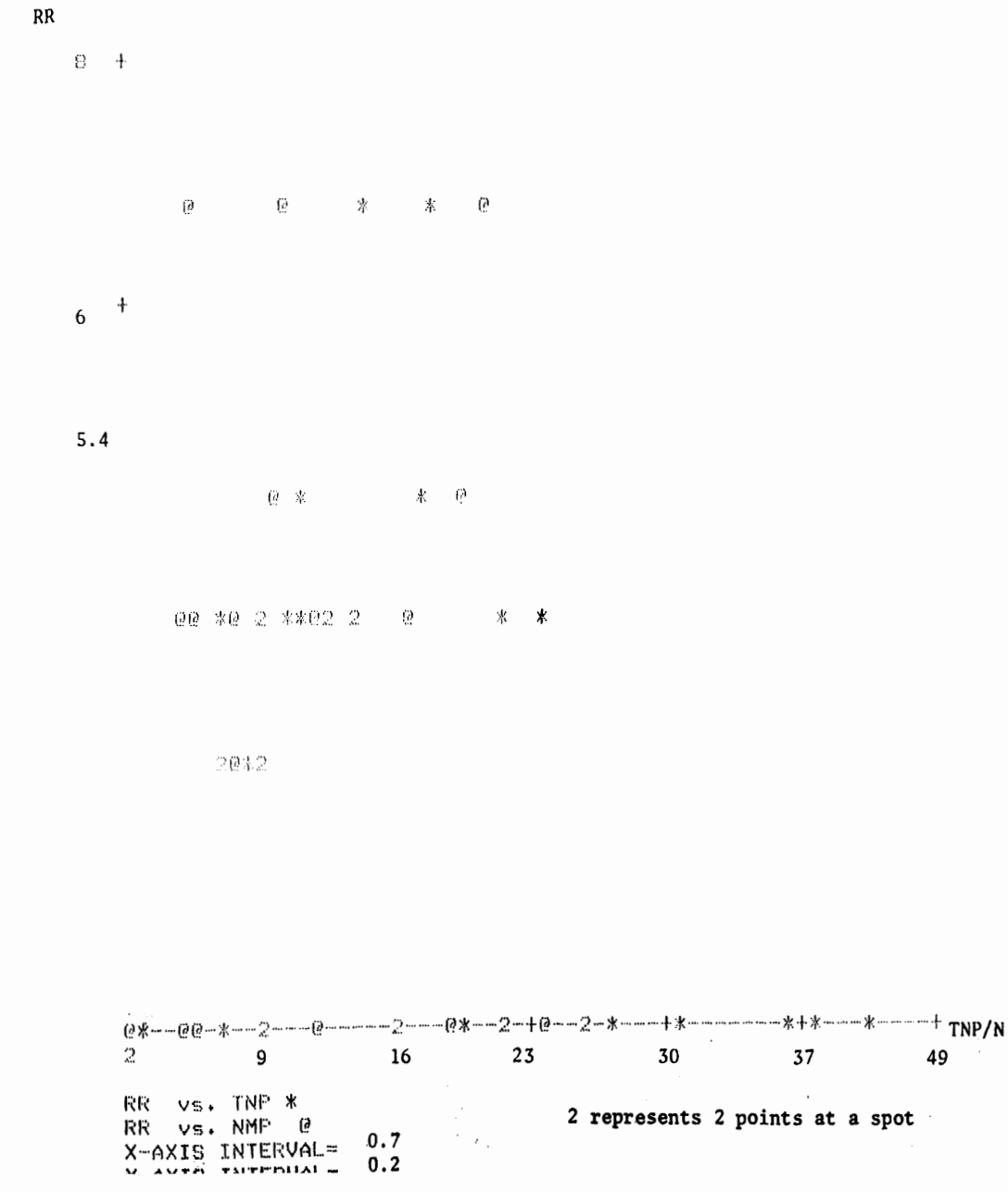


Fig. 11. COMPARISON OF RUST RATING WITH KERNEL WEIGHT (WK) AND POD WEIGHT (PWT) PER PLANT.

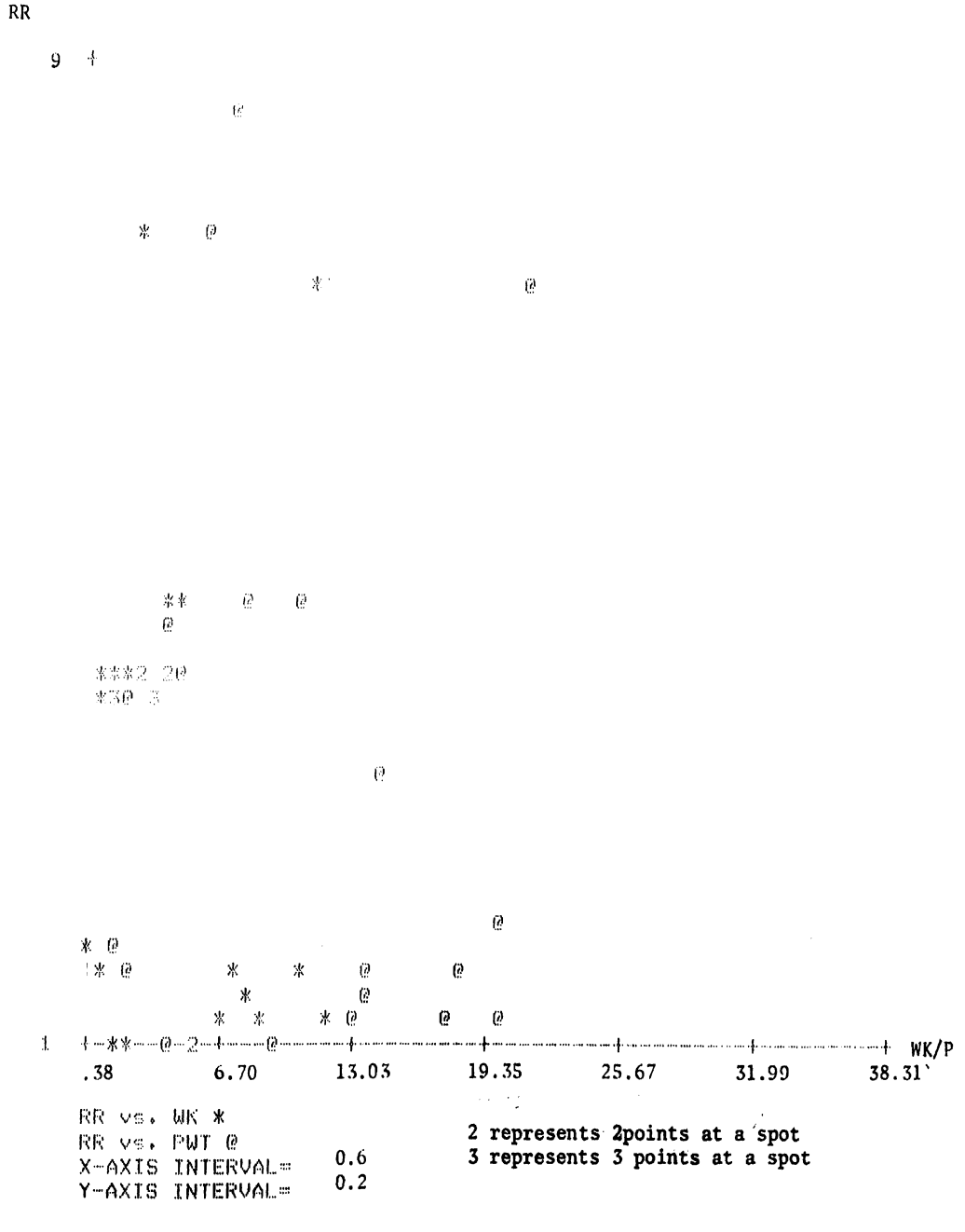
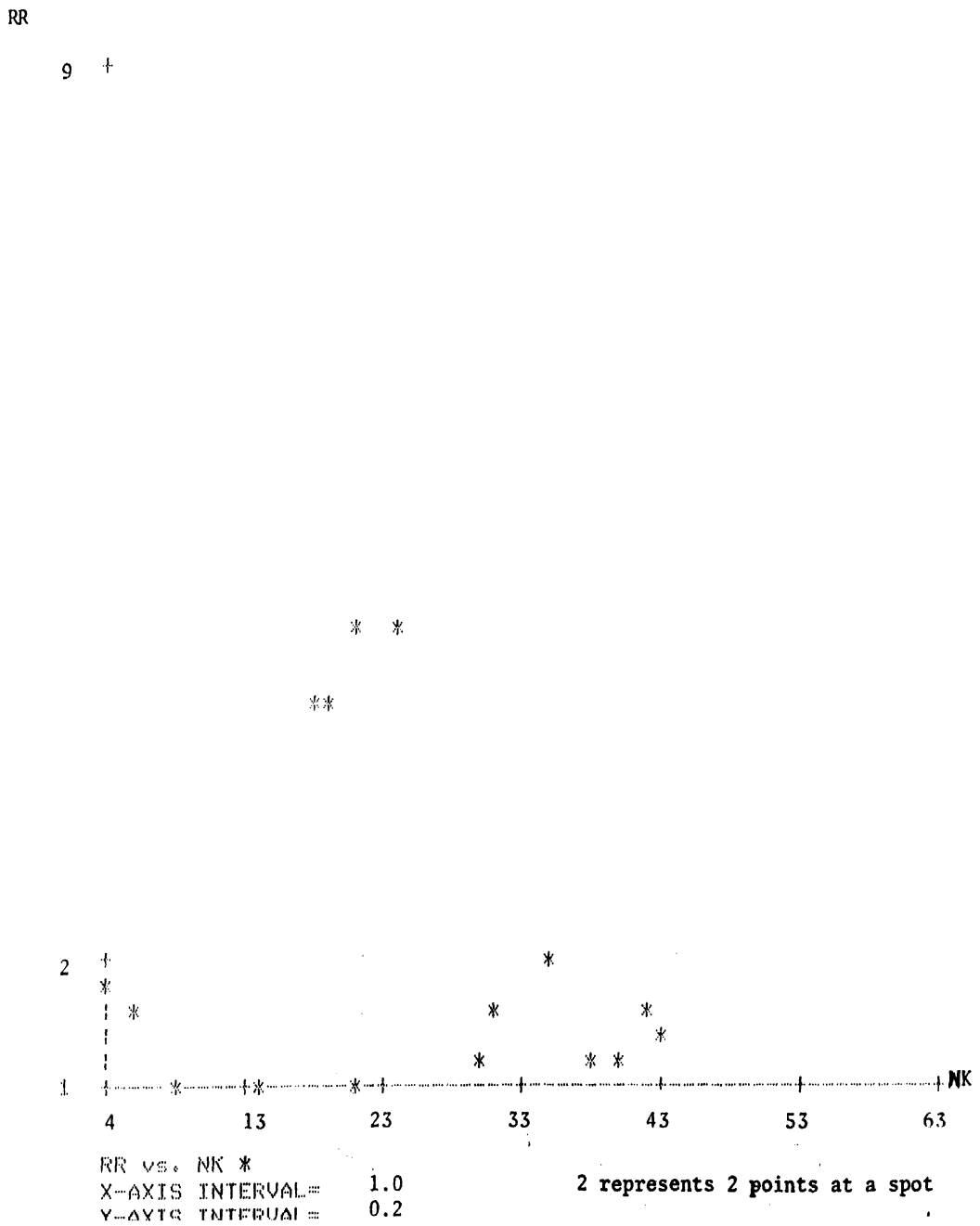


Fig. 12. COMPARISON OF RUST RATING WITH NO. OF KERNEL (NK)



Dormancy Percentage:

An examination of 56 varieties by Lin and Chen (1970) indicated that there were significant differences existing in the duration of dormancy among the varieties. However, in this study under discussion the analysis of variance table (Appendix 7) showed no significant differences between the various genotypes used. Most of the treatments were completely dormant. The genotype which exhibited the highest sprouting, even had over 88 percent dormancy. This is a good attribute, especially of the progenies of interspecific origin which can be taken advantage of in future hybridization program, especially to improve on the dormancy level of some of the cultivars.

A look at table 3 shows that increase in dormancy percentage is non significantly, but positively correlated with increase in the level of single seeded pods. It might be possible that dormancy as a variable is associated with wild characteristics. Further, increase in dormancy level resulted in a non significant increase in yield characters like number of matured pods and weight of pods produced per individual plant.

Total Number of Pods:

The productivity of the various genotypes, in terms of numbers of mature and immature pods varied greatly. There was coefficient of variation of over 38 percent. Diversity within the genotypes and other environmental factors might have been the cuase. There were significant differences among the genotypes at 5% level of probability (Appendix 8). Table 9 below gives the ranked means for the 10 top genotypes.

Table 9. Ranked Adjusted Means for Some Top Genotypes - Total Number of Pods Produced.

S.No.	Treatment Nos.	Mean of No. of Pods Produced
1.	33	44
2.	2	43
3.	3	41
4.	8	38
5.	27	38
6.	28	36
7.	16	34
8.	4	31
9.	34	29
10.	21	28

Grand mean = 21 C.D. at 5% = 13 C.V.% = 38

Out of the 10 most productive lines in terms of pod numbers produced, only T_{33} and T_{34} (Robut 33-1 and M-13) were standard cultivars. Thus despite most of the derivatives of wild *Arachis* species being low yielding there were some which produced higher pod numbers.

There were highly positive significant correlations between total number of pods produced and the following:

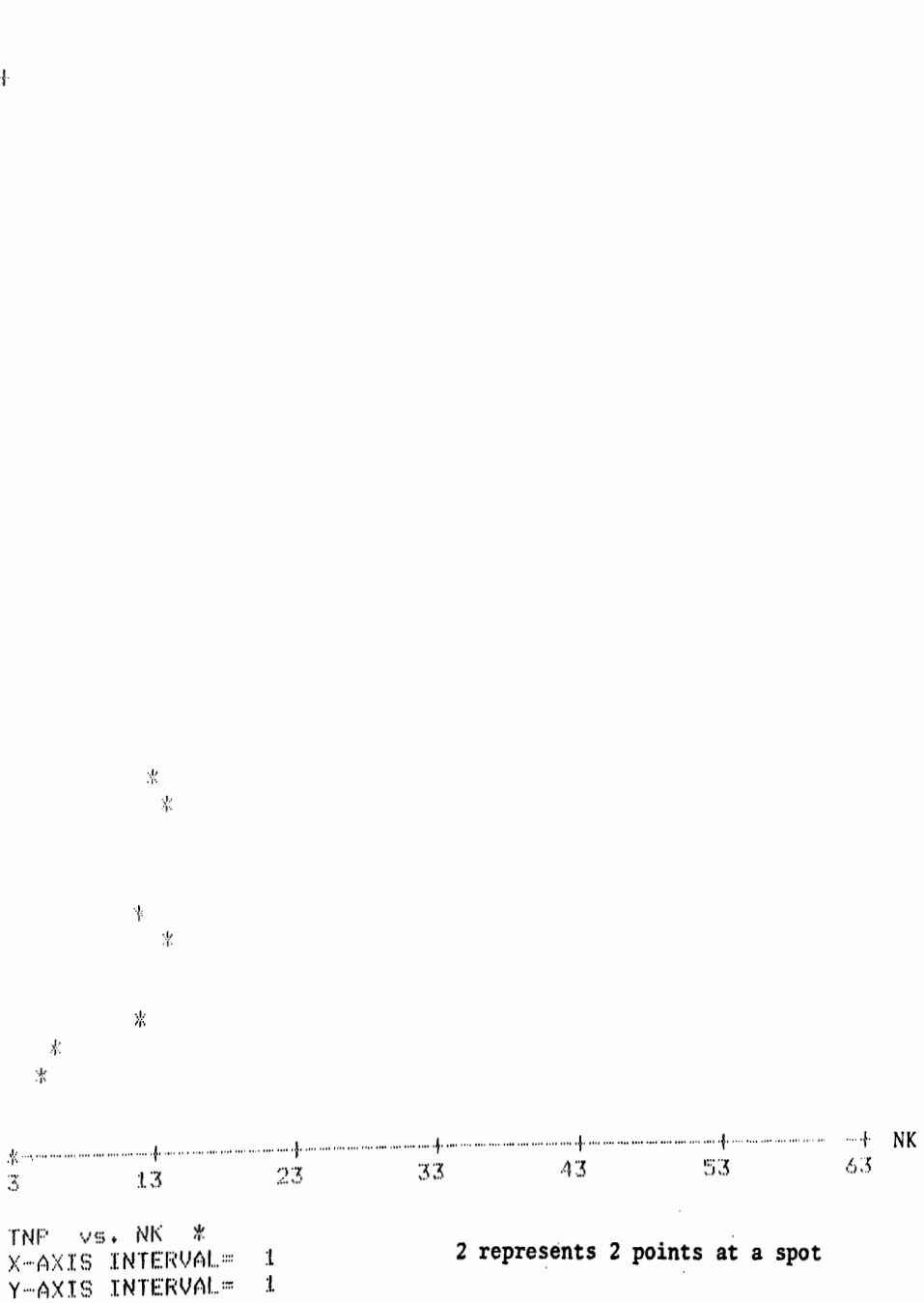
(a) Number of matured pods produced (r=0.94)

(b) Pod weight per plant (r=0.87)

(c) Number of kernels produced per plant (r=0.94)

(d) Weight of kernels (r=0.89)

Fig. 13. COMPARISON OF TOTAL NO. OF PODS PRODUCED PER PLANT (TNP) WITH NO. OF KERNELS (NK) PER PLANT.



(e) Pod length and width (r=0.43 and 0.45 respectively)

(f) Percentage double seeded pods (r=0.34)

(g) Shelling percentage (r=0.38)

(h) Weight per 100 seeds (r=0.50)

Thus, increase in total number of pods produced per plant is closely associated with bolder pods and higher number of bilobed pods. The higher total number of pods produced resulted in a decrease in the level of oil content probably as a result of physiological factors. A scatter diagram of total number of pods produced shows a positive correlation with number of kernels produced per plant (Fig. 13).

Number of Matured Pods:

Table 3 shows that with the exception of single seeded pods and trilobed pods which showed non significant and negative correlations with number of matured pods produced per plant; there were significant positive correlations with (a) Maturity percentage (b) Pod length (c) Pod width (d) Pod weight (e) Number of kernels produced per plant (f) Weight per kernel (g) Shelling percentage and (h) Weight per 100 seeds with number of matured pods. These observations may be interpreted that those yield parameters are linked with number of matured pods produced per plant. Reference to the scatter diagram of number of matured pods with weight of kernel shows that there is a significant positive correlation between them (Fig. 14). Moreover, most of points are concentrated at the lower levels of numbers of matured pods and weight of kernels produced, these points representing a substantial amount of the derivatives of the wild species. However, there were other wild species derivatives like Treatments 2 and 28 at the top right hand corner

indicating higher yields by them.

Table 10 reveals that treatment 33, a cultivar, which produced the highest number of pods also had the highest number of matured pods indicating a highly significant positive correlation. Further there were substantial numbers of the entries of interspecific origin which produced sizeable numbers of matured pods.

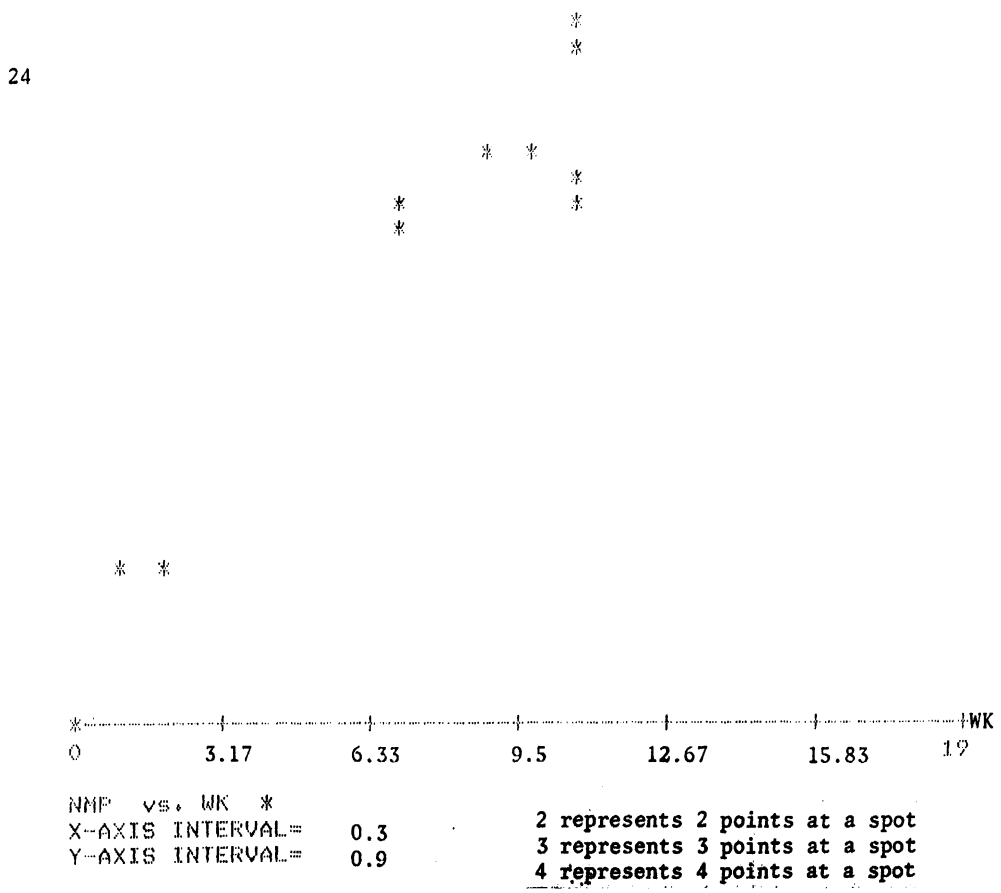
Table 10. Ranked adjusted means for the top 10 genotypes (No. of matured pods)

S.No.	Treatment Nos.	Mean of no. of matured pods produced
1.	33	38
2.	2	34
3.	28	27
4.	16	26
5.	3	25
6.	27	23
7.	4	23
8.	8	23
9.	34	22
10.	14	21

Grand mean = 15 C.D. at 5% = 10

C.V.% = 44

Fig. 14. COMPARISON OF NO. OF MATURE PODS(NMP) WITH KERNEL WEIGHT (WK) PER PLANT



Maturity Percentage:

Maturity percentage gives an idea of the proportion of the total number of pods produced that reach full maturity. It has been observed that the protein content of groundnut is positively correlated with percentage of matured pods that are produced, and subsequently negatively correlated with oil content (Shanny, 1977). However, in our experiment under discussion (Table 3); it was realised that an increase in maturity level of the pods resulted in a non significant increase in the level of oil content. It was also realized that increase in maturity percentage resulted in a decrease in the level of pod rot incidence. With the exception of number of kernels produced per plant that had positive significant correlation (r=0.34) with pod maturity; all the other variables had non significant relationships. A look at the scatter diagram of maturity percentage with shelling percentage shows that all the points were almost concentrated at the top right hand corner indicating that most of the entries that were investigated not only had high maturity percentages, but also higher shelling percentages(Fig. 15).

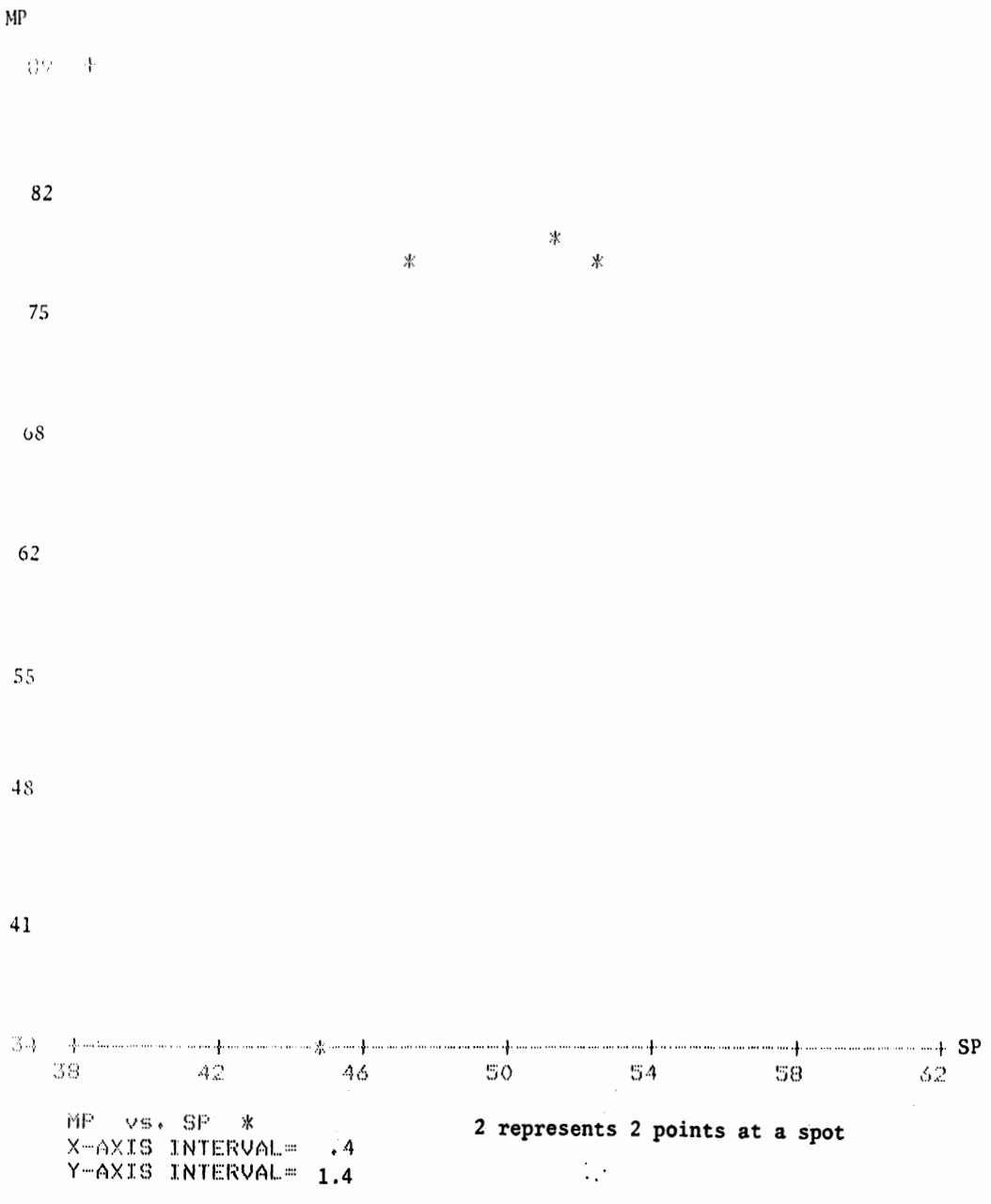
There were significant differences between the entries at 5% level of probability (Appendix 10). When the various genotypes were ranked, it was realised that Treatment 24; a hexaploid which is a derivative of A.*chacoense* had the highest maturity percentage of over 91 percent. T_{36}, a cultivar, had the lowest maturity (34.32%). This may, probably be due to the fact that the latter might have required a longer period to reach full maturity than the time harvested, or being a new introduction here, it is yet to get

Table 11: Ranked Adjusted Means for Percentage Maturity

S.No.	Treatment Nos.	Mean of Maturity Percentage	S.No.	Treatment Nos.	Mean of Maturity Percentage
1	24	91.57	19	35	65.76
2	14	87.20	20	3	65.63
3	33	85.80	21	1	65.24
4	13	81.29	22	12	64.22
5	9	79.79	23	31	62.63
6	29	78.38	24	26	60.84
7	2	78.04	25	11	60.80
8	4	74.46	26	27	60.45
9	23	75.99	27	30	60.13
10	10	75.57	28	8	58.30
11	17	73.13	29	15	57.95
12	28	72.87	30	7	57.55
13	16	72.55	31	5	56.57
14	18	72.36	32	19	55.27
15	34	71.35	33	6	52.00
16	21	70.46	34	22	50.66
17	32	66.93	35	25	42.11
18	20	66.17	36	36	34.32

Grand Mean = 66.87 C.V.% = 19.94 C.D.at 5% = 21.93

Fig. 15. COMPATISON OF MATURITY PERCENTAGE (MP) WITH SHELLING PERCENTAGE (SP)



acclimatized to the conditions prevailing here. Apart from T_{33} which is a cultivar; the top 14 entries exhibiting high percentage maturities were all derivatives of wild *Arachis*. This may be a good attribute of wild species of groundnut that can be utilised.

Pod Length:

Pod length as a character has been observed by Coffelt and Hammons in 1974 to be highly heritable. The analysis of variance (Appendix 11) on pod length shows significant differences at 5 percent level of probability. There was the general observation that quite a large proportion of the entries of interspecific origin had shorter pod lengths. This perhaps, is due to the single poddedness of most of the wild type derivatives. This is exemplified by the non significant negative correlation between pod length and percentage of single seeded pods. Thus an increase in length of pod is associated with a decrease in percentage of single seeded pods (Table 3). It was also evident that with decrease in pod length; this resulted in a negative significant decrease in the pod weight, percentage of trilobed pods, pod width, number of kernels, weight of kernels, average kernel content and weight per 100 seeds. However, increase in pod length resulted in a non significant decrease in oil content. A look at the scatter diagram of pod length with yield indicates that most of the pods had lengths within 1.8 and 3.2 cm. It also showed significant positive correlation (Fig. 16).

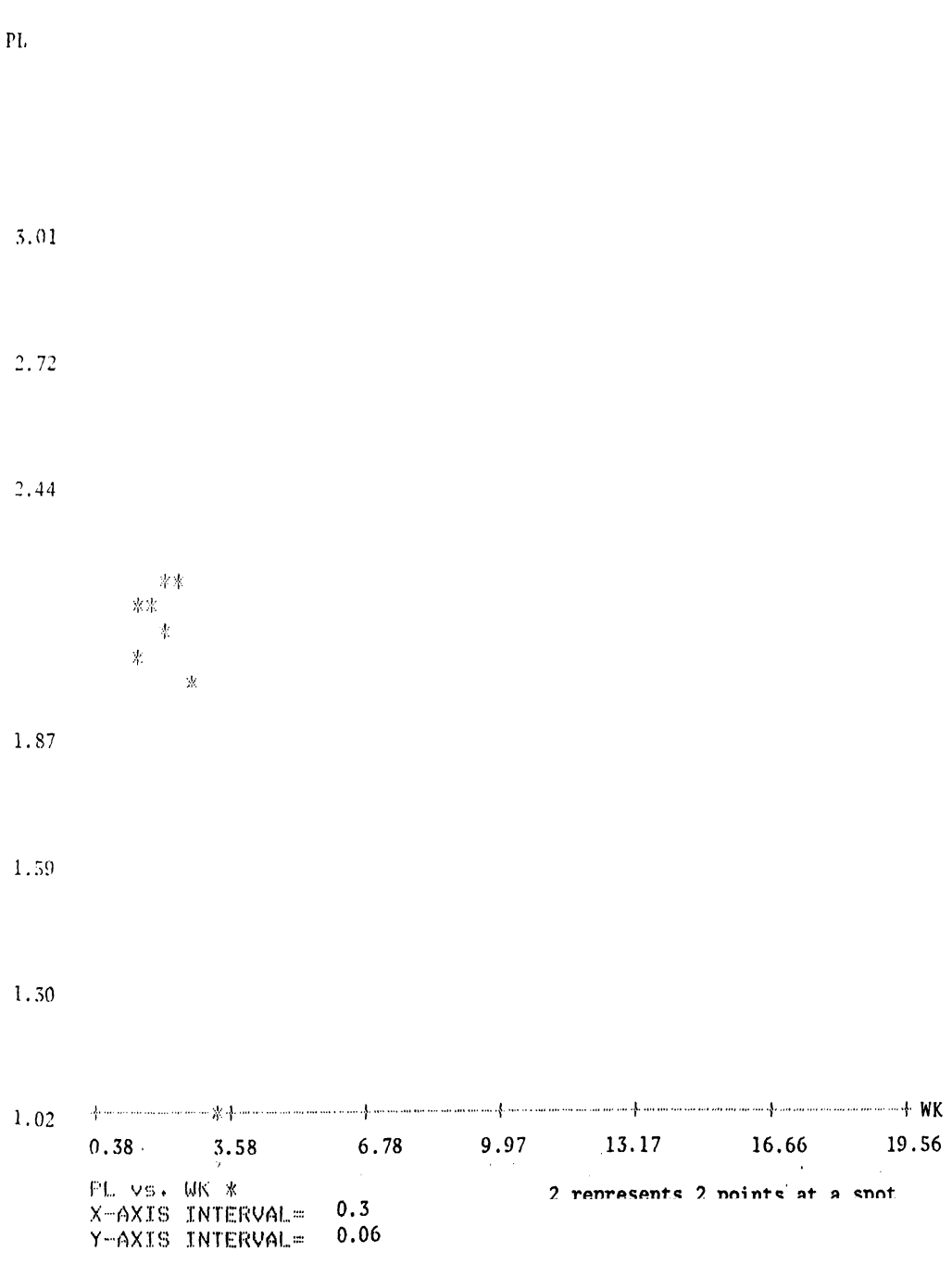
Table 12 indicates that 2 of the standard cultivars, Gangapuri (T_{35}) and M 13 (T_{34}) produced the longest pods. There were, however, some entries of the interspecific origin which also had long pods. These included T_4, T_8 and T_{12} which all had average pod lengths exceeding 3 cm. The entries T_{24}, T_{26} and T_{25} which were all hexaploids were among the entries with shortest pod lengths.

Table 12. Ranked Adjusted Means for Pod Length (in cm)

S.No.	Treatment Nos.	Mean of pod Length	S.No.	Treatment Nos.	Mean of pod Length
1	34	3.27	19.	3	2.44
2.	35	3.16	20.	16	2.32
3.	4	3.16	21.	20	2.26
4.	8	3.13	22.	11	2.22
5.	12	3.07	23.	14	2.20
6.	7	2.94	24.	19	2.19
7.	2	2.89	25.	23	2.17
8.	27	2.82	26.	32	2.15
9.	17	2.78	27.	29	2.08
10.	36	2.73	28.	30	2.06
11.	21	2.70	29.	13	2.04
12.	18	2.65	30.	6	2.01
13.	15	2.63	31.	1	2.00
14.	28	2.63	32.	9	1.89
15.	10	2.53	33.	24	1.84
16.	33	2.52	34.	26	1.80
17.	5	2.50	35	31	1.78
18.	22	2.48	36.	25	1.03

Grand Mean = 2.42 C.V.% = 13.47 C.D.at 5% = 0.54

Fig. 16. COMPARISON OF POD LENGTH (PL) WITH KERNEL WEIGHT (WK)



Pod Width:

Pod width, like pod length was non significantly correlated with oil content. Thus, bilobed and trilobed pods had a lesser amount of oil content compared with single lobed pods. There may be the possibility of oil content being linked with wild characteristics. An increase in pod width, on the other hand resulted in increase in yields. For example, with increase in pod width, there were significant increases in yield components like pod weight, number of kernel, weight of kernel, shelling percentage, average kernel content and weight per 100 seeds (Table 3). A scatter diagram of pod width and weight per 100 seeds (WPS) showed highly significant positive correlation. In addition, the width of the pods tended to be within the range of 0.73 to 1.27 cm whilst the weights per 100 seeds were between 7.7 and 38.8 g ..(see Fig. 17).

The analysis of variance (Appendix 12) for pod width indicates that there were significant differences at 5% level of probability. A look at Table 13 reveals that most of the cultivars were bolder in pod size. The treatment numbers T_{26}, T_{31} and T_{25} produced the thinnest pods. This further confirms the fact that the hexaploids still possessed strong wild characters.

Fig. 17. COMPARISON OF POD WIDTH(PW) WITH WEIGHT PER 1oo SEEDS (WPS)

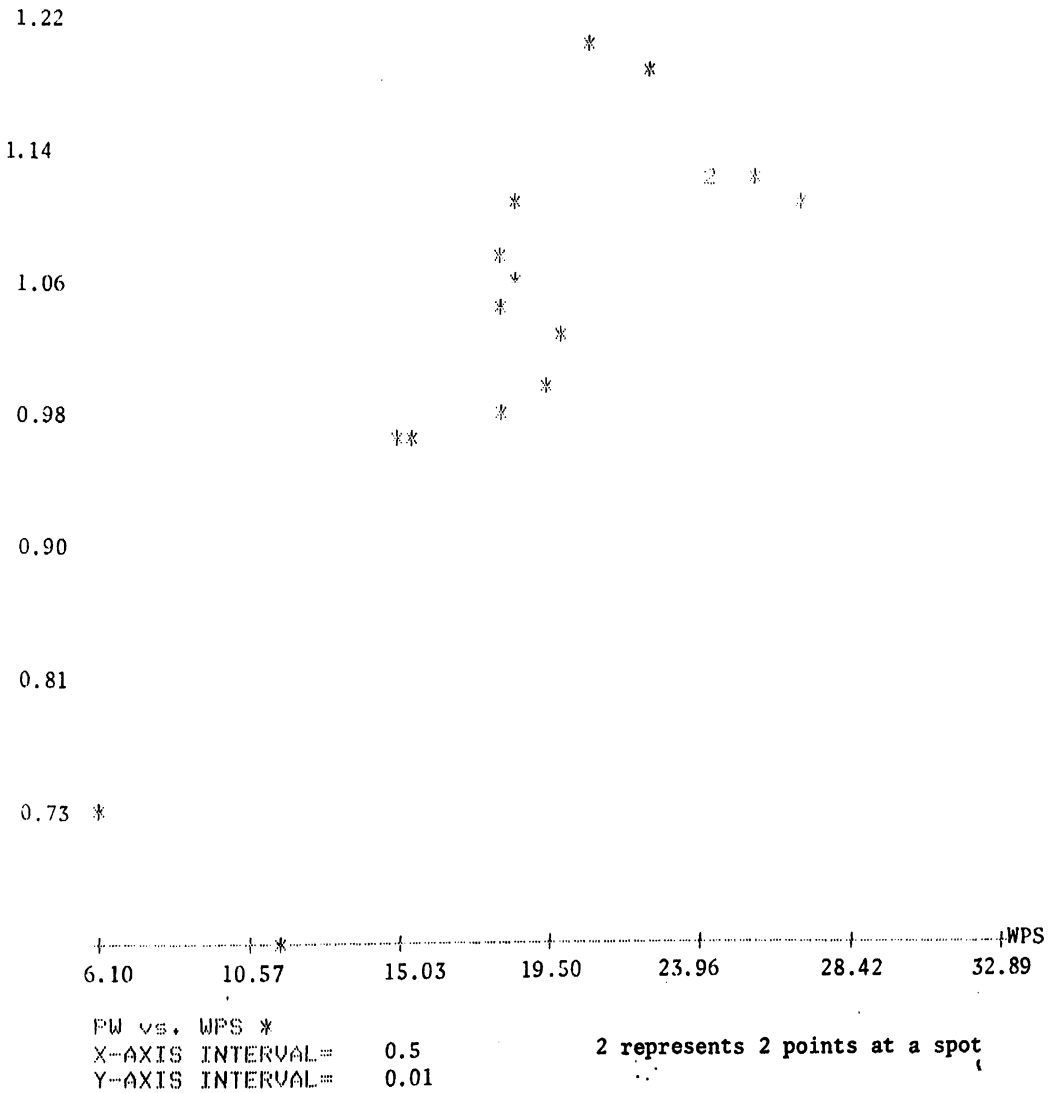


Table 13. Ranked Adjusted Means for Five Largest and Five Smallest Genotypes for Pod Width

S.No.	Treatment Nos.	Mean of Pod Width (cm)
1.	34	1.32
2.	36	1.27
3.	33	1.25
4.	4	1.22
5.	35	1.19
32.	11	0.88
33.	19	0.82
34.	26	0.79
35.	31	0.77
36.	25	0.64

Grand Mean = 1.02 C.V.% = 13.63 C.D. at 5% = 0.23

Percentage Single Seeded Pods:

Appendix 13 which is the analysis of variance table for the variable percentage single seeded pods - indicates significant differences at 5 percent level of probability.. A table of ranked adjusted means (Table 14) for some of the genotypes for the above variable shows that whilst most of the lines of interspecific origin showed single seed podedness, the proportion of the cultivars that had one seed in a pod was very low. Thus it may be possible that single seeded pod is a character that is

linked with wildness. Once more; treatments T_{26} and T_{24} which are hexaploids showed the highest percentages of single lobed pods. This may further indicate how these hexaploids closely resemble their wild parents. The cultivars T_{35}, T_{32} and T_{36} in that order had the least percentage of single lobed pods among the entries.

Aside from shelling percentage which exhibited a non significant positive correlation with single seeded pods; all the other variables showed negative correlations; with those of double seeded pods and average kernel content being significant (Table 3). Thus it is clear that the character single seeded pods is closely associated with lower yields since increase in the percentage of single seeded pods resulted in decrease in the level of the yield parameters. Thus if we are doing selection with the aim on improving yields; then single lobed pods might not be helpful to us. However, sight must not be lost of the fact that some of the single seeded pods had higher shelling percentages.

The scatter diagram of level of single seeded pods with average kernel content indicates a significant negative correlation. Furthermore, the points are scattered within average pod content of 1 and 2 whilst most of the entries had below 50 percent single seeded pods (Fig. 18).

Fig. 18. COMPARISON OF PERCENTAGE SINGLE LOBED PODS (SSP) WITH KERNEL CONTENT(KC)

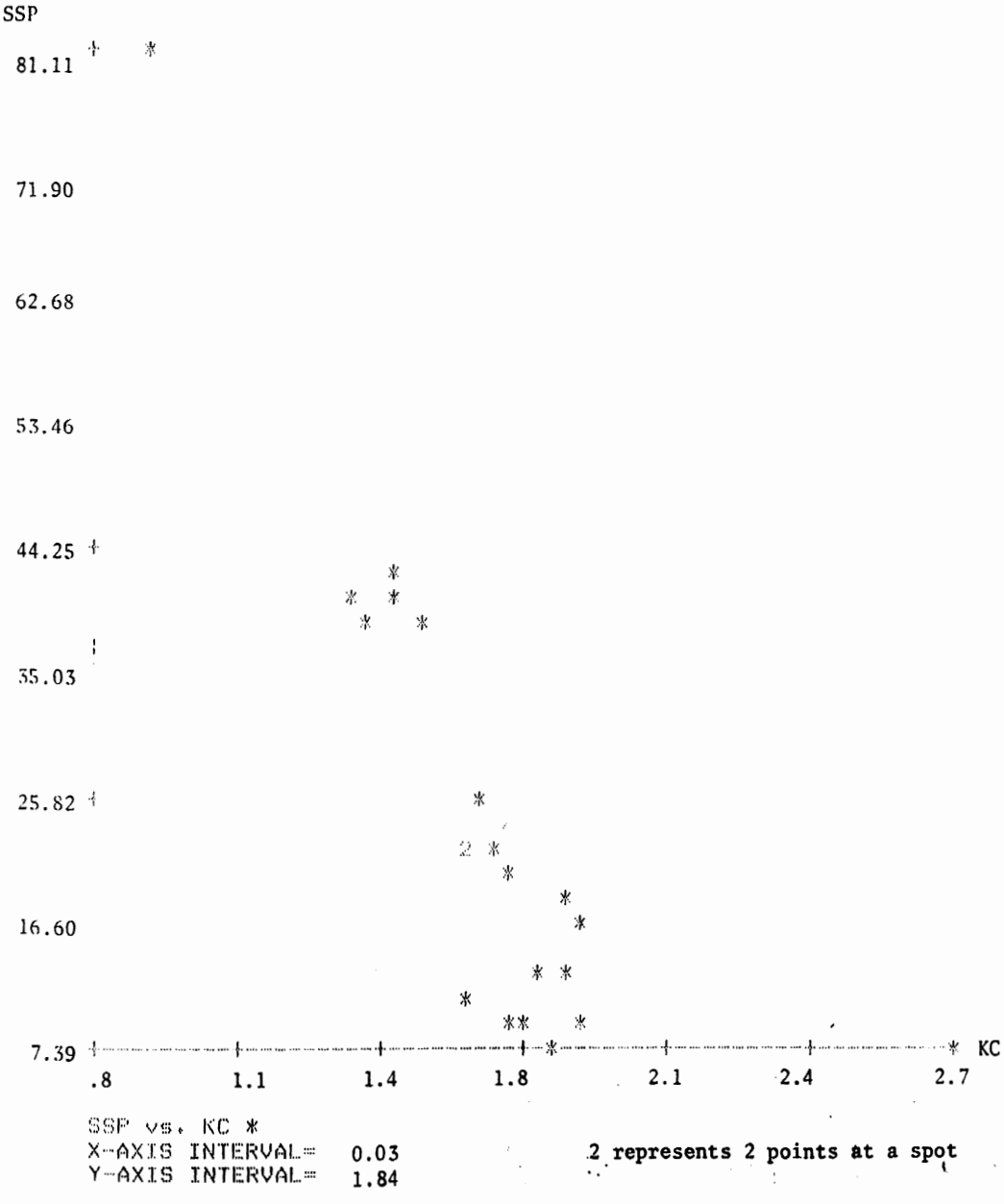


Table 14: Ranked Adjusted Means for the Top 5 and Lowest 5 Genotypes from the Character - Percentage Single Seeded Pods

S.No.	Treatment Nos.	Mean of Percentage of Single Seeded Pods
1.	26	79.69
2.	24	69.10
3.	23	63.14
4.	6	49.14
5.	25	48.59
32.	8	11.85
33.	18	9.74
34.	36	8.65
35.	32	8.28
36	35	5.88

Grand Mean = 29.28 C.D.at 5% = 29.31

C.V. % = 60.69

Percentage of Double Seeded Pods:

The analysis of variance for the character - percentage of double seeded pods - revealed that there were significant differences between some of the genotypes at 5% level of probability. Table 15 shows that apart from T_{35} (a cultivar which had 17.81% bilobed pods); T_{25} and T_{26} which had 17.37

and 8.39 percentages respectively of bilobed pods (being the least bilobed pods percentages) were all hexaploids. T_{35} had most of its pods as trilobed whilst T_{25} and T_{26} were mainly single lobed pods. Treatments 32 and 36 which produced the highest level of bilobed pods were all cultivars. Treatments 16, 18 and 5 which also produced substantial percentages of bilobed pods were all of *A.batizocoi* origin.

A look at the correlation coefficient between percentage double seeded pods and number of kernels produced (Table 3), indicates that an increase in the level of bilobed pods resulted in a significant increase in the number of kernels produced. Other yield parameters like pod weight, weight of kernel, Average kernel content and weight per 100 seeds showed non significant but positive correlations with percentage bilobed pods. Further, increase in the proportion of bilobed pods led to a significant decrease in the proportion of trilobed pods (see Thomas *et al.* 1974). Here, the coefficient of variation (28%) was moderate. This was again probably due to the high heterogeneity of the genotypes that were tested.

Table 15. Ranked Adjusted Means for the Genotypes for the Character Percentage of Double Seeded Pods

S.No.	Treatment Nos.	Mean of the Percentage of Double Seeded Pods
1	32	94.35
2.	36	93.52
3.	16	86.27
4	.18	82.83
5.	33	81.31

Table 15. Contd/....

S.No.	Treatment Nos.	Mean of the Percentage of Double Seeded Pods
6	5	78.92
7.	19	78.36
8.	2	77.36
9.	31	76.36
10.	8	73.65
11.	3	73.62
12.	27	70.99
13.	34	70.45
14.	14	69.70
15.	20	69.29
16.	15	69.07
17.	12	67.85
18.	4	67.66
19.	22	66.41
20.	28	66.07
21.	21	64.28
22.	30	59.07
23.	17	58.37
24.	29	57.96
25.	11	54.80
26.	9	54.48
27.	10	53.41
28.	13	53.26
29.	1	52.09
30	7	49.18
31.	6	39.45
32.	24	32.12
33.	23	31.09
34.	35	17.81
35.	25	17.37
36.	26	8.39

Grand Mean = 61 C.V.% = 28 C.D.at 5% = 29

PERCENTAGE OF TRILOBED PODS:

A look at Appendix 15 which gives the analysis of variance for the factor, percentage trilobed pods, shows significant differences among the various genotypes under test (P=0.05). However, T_{35}, a cultivar produced the highest percentage of trilobed pods (see Table 16). The diversity within the materials once again accounted for a very high coefficient of variation. Ten of the entries produced almost a negligible amount of trilobed pods. Out of these, 3 were cultivars (Treatments 32, 33 and 36).

A decrease in the level of percentage trilobed pods resulted in a highly significant decrease in the level of the average kernel content (Table 3). All the other factors but pod weight had a non significant but positive correlations with percentage trilobed pods.

The scatter diagram of percentage 3 seeded pods with average kernel content indicates that just one entry had over 50% of its pods carrying 3 seeds.(Fig. 19).

From the comparison of the result for percentage single lobed, bilobed and trilobed pods, it can be concluded that the greatest proportion of the genotypes were bilobed. This was followed by single seeded pods with just a very minor percentage being trilobed.

Fig. 19. COMPARISON OF TRILOBED PODS (TSP) WITH KERNELS PER POD(KC)

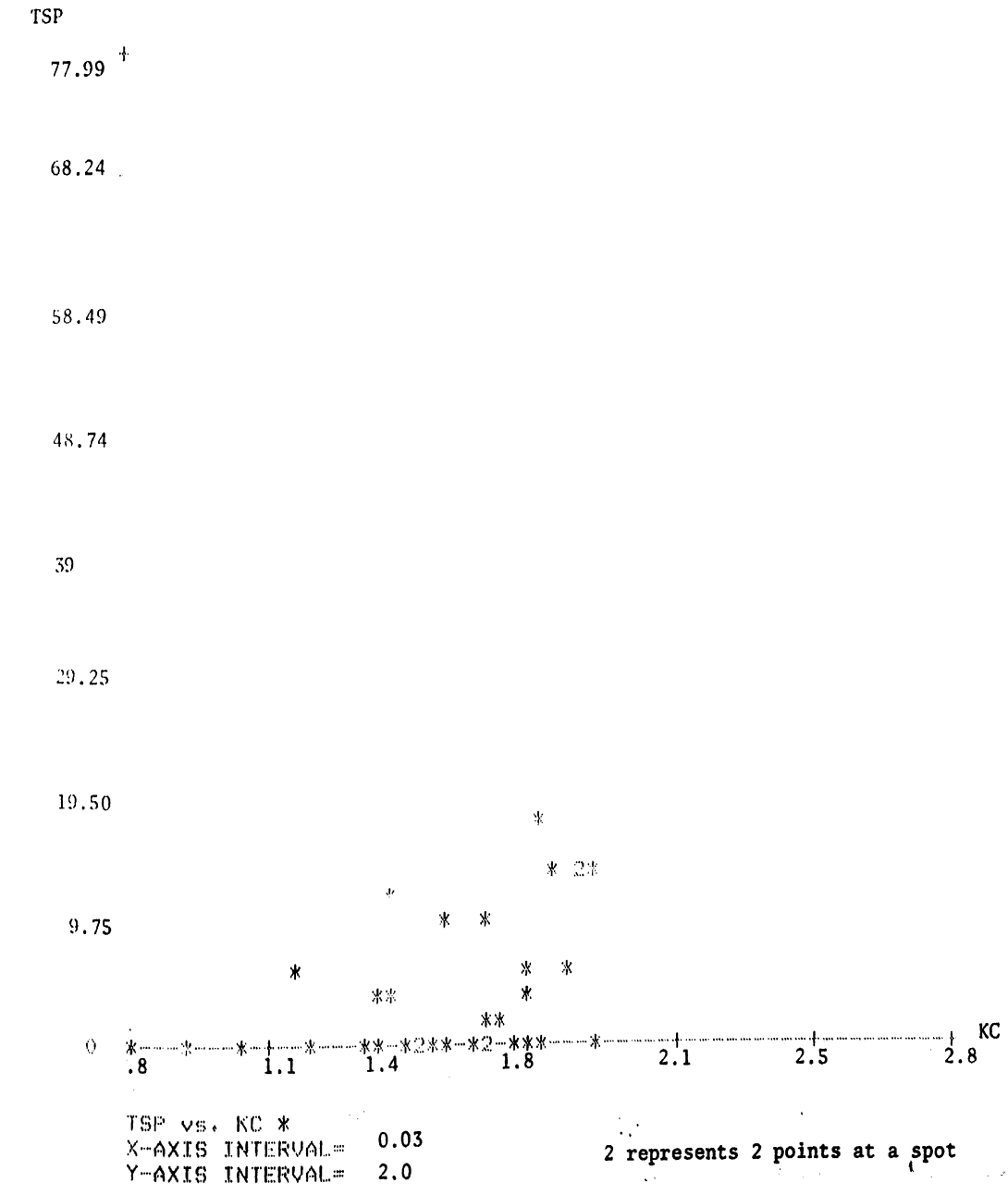


Table 16. Ranked Adjusted Means for the Genotypes for the Character Percentage of 3 Seeded Pods

S.No.	Treatment Nos.	Mean of Percentage of 3 Seeded Pods	S.No.	Treatment Nos.	Mean of Percentage of 3 Seeded Pods
1.	35	77.24	19.	9	1.38
2.	7	30.57	20.	30	1.04
3.	10	17.88	21.	25	0.85
4.	27	14.81	22.	19	0.60
5.	12	14.69	23.	31	0.58
6.	8	14.43	24.	5	0.23
7.	20	13.71	25.	15	0.15
8.	11	11.56	26.	24	0.11
9.	21	11.52	27.	2	-0.008
10.	4	10.48	28.	22	-0.03
11.	14	6.52	29.	16	0.16
12.	18	6.52	30.	32	-0.16
13.	23	6.43	31.	33	-0.23
14.	13	5.45	32.	6	-0.25
15.	3	4.78	33.	36	-0.29
16.	17	3.98	34.	29	-0.37
17.	34	3.35	35.	28.	-0.45
18.	1	2.89	36.	26	-0.46

Grand Mean = 7.20 C.V.% = 134.21 C.D.at 5% = 15.88

Pod Weight:

Although the most productive line in terms of pod weight per plant was a standard cultivar (T_{33}) i.e. Robut 33-1; there were other equally high yielding lines which were of interspecific origin. These included

treatments 16, 8, 4 and 18 which were derivatives of *Arachis batizocoi;* and treatments 2 and 28 of A.*cardenasii* origin. Out of the 4 lowest yielders of pod weight; 2 of them were hexaploids i.e. T_{24} and T_{26}. All the other low yielding lines were mainly A.*cardenasii* derivatives.

The analysis of variance for the pod weight (Appendix 16) showed significant differences among the various genotypes that were investigated(5% level of probability).

The coefficient of variation was over 48%. This high phenotypic variability supports earlier observations made by Kushwaha *et al.* (1973) and Majumdar *et al.* (1969) who obtained very high coefficients of variability for pod yield per plant.

The correlation analysis between pod weight and the characters below show that all but oil content increased with increase in pod weight. The factors were:

(a) Number of kernels per plant (r=0.94**)

(b) Percentage of pod rot (r=0.04)

(c) Weight of kernels per plant (r=0.99**)

(d) Oil content (r=-0.06)

(e) Shelling percentage (0.30)

(f) Average kernel content (r=0.29)

(g) Pod weight (r=0.66**)

** Significance at 1% level of probability.

The above results support earlier observations made by Ramanathan *et al.* in 1968 and also that of Coffelt and Hammons (1974). The scatter diagrams

of pod weight with number of kernels and weight of kernels per plant exhibited an almost perfect positive correlations (Fig. 20).

Since the total yield of groundnut depends largely on weight of sound pods per plant among other factors (Oram, 1958) the importance of pod weight cannot be over emphasized. Thus genotypes yielding high pod weight are desirable.

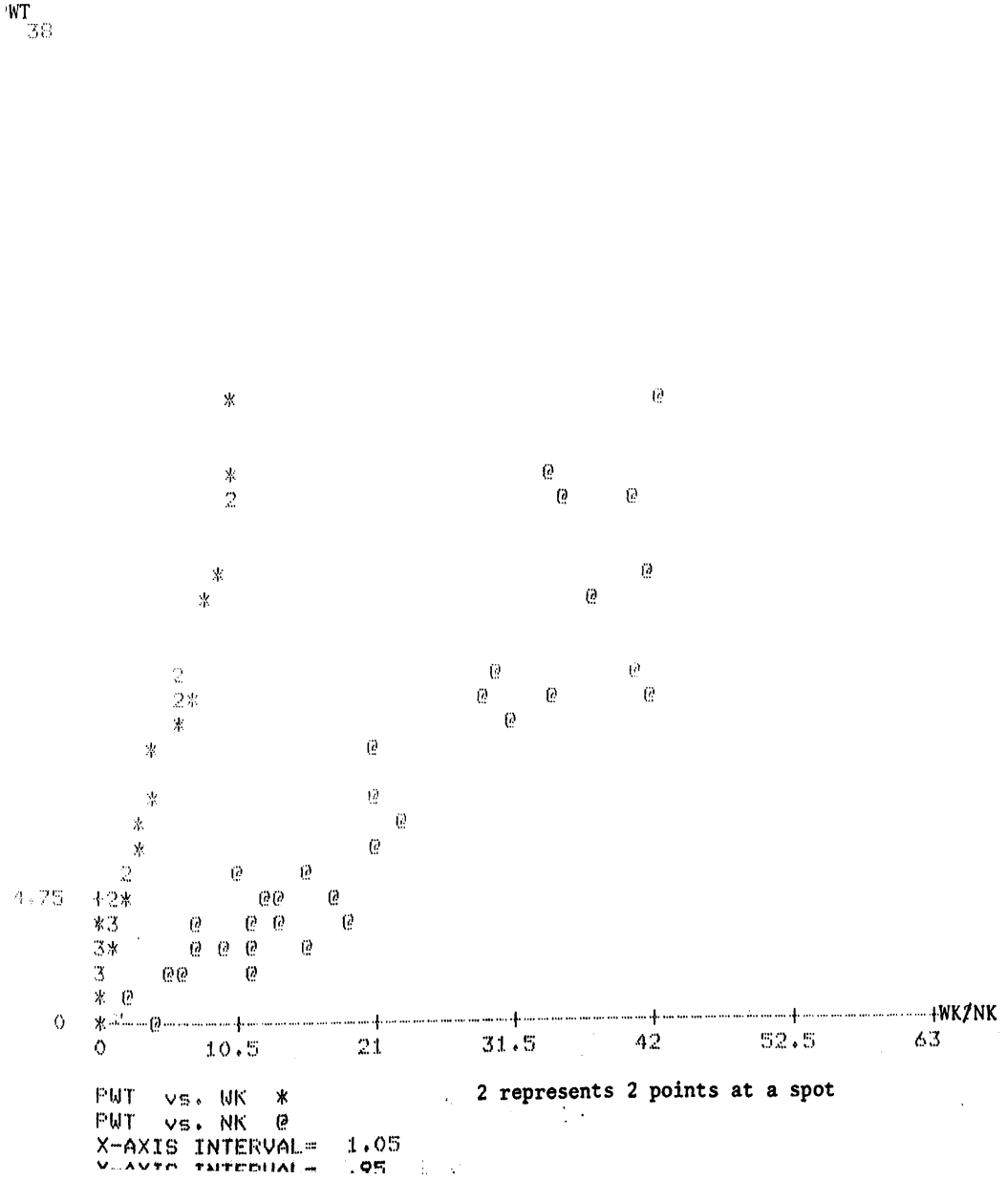
Table 17. Ranked Adjusted Means for 10 Most Productive Genotypes (in terms of Pod weight per plant) (g)

S.No.	Treatment Nos.	Pod weight in g
1	33	38.41
2.	2	29.68
3.	16	24.52
4.	34	21.64
5.	18	20.33
6.	28	20.32
7.	8	18.37
8.	4	18.19
9.	27	14.64
10.	21	14.39

Grand Mean = 10.55 C.D. at 5% = 8.35

C.V.% = 48.17

Fig. 20. COMPARISON OF POD WEIGHT WITH KERNEL WEIGHT (WK) AND NO. OF KERNELS(NK) PER PLANT.



Number of Kernels per Plant:

Generally, it was observed that an increase in number of kernels a plant produced was accompanied by a proportionate increase in the levels of

1) Percentage of pod rot (r=0.05)
2) Weight of kernel per plant (r=0.95)**
3) Oil content (r=0.04)
4) Shelling percentage (r=0.39)*
5) Average kernel content (r=0.37)*
6) Weight for 100 seeds (r=0.53)**

* Signifies significance at 5% level of probability

** Shows significance at 1% level of probability

These show that number of kernels is closely linked with yields of groundnut.

Since in developing countries, there is lack of experience on the part of peasant farmers in maintaining pure stocks; the importance of lines with a high number of seeds per plant is very important; (Sauger and Boufil, 1955), and also since natural selection is beneficial to strains producing largest number of viable seeds, this further confirms the advantages of high kernel productivity lines. In this investigation, it was observed that,(Table 18) apart from Robut 33-1 which is a cultivar, the remaining 9 highest productivity lines in terms of number of kernels

produced were all progenies of interspecific crosses of *A.cardenasii* and *A.batizocoï* with *Arachis hypogaea*. Thus it is clear the contributions such genotypes can make in developing countries.

The analysis of variance for the variable, number of kernels produced per plant (Appendix 17) shows that there were significant differences between the lines at the 5% level of probability. There was also high coefficient of variability among the lines.

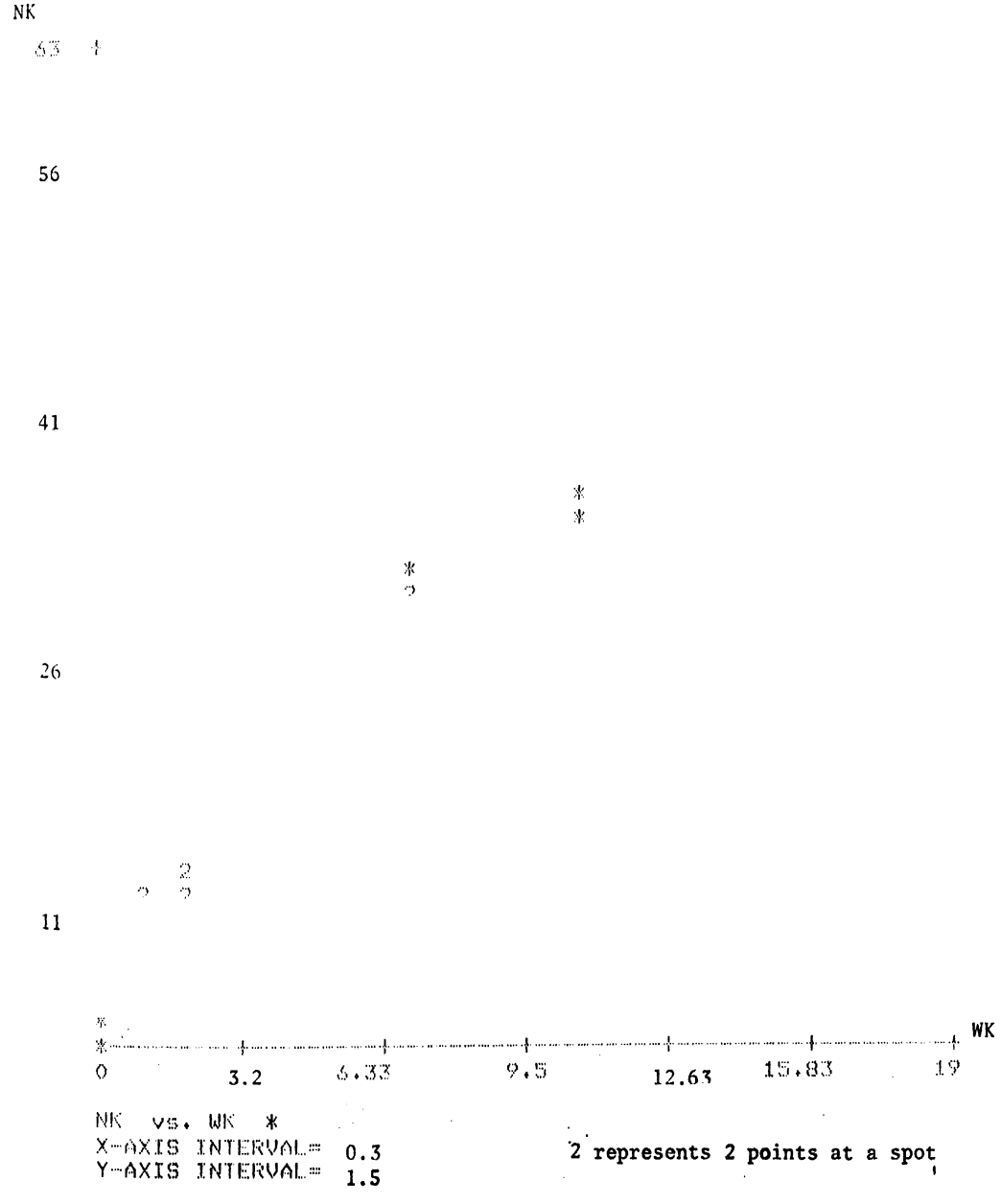
The scatter diagram of kernels produced by individual plants with kernel weight showed a significant positive correlation(Fig. 21).

Table 18. Ranked Adjusted Means for 10 Most Productive Genotypes (of the Variable No. of Kernels Produced per Plant)

S.No.	Treatment Nos.	Mean of No. of Kernels Produced
1.	33	64
2.	2	58
3.	3	45
4.	16	44
5.	8	42
6.	27	41
7.	28	41
8.	4	40
9.	14	37
10.	18	36

Grand Mean = 24.36 C.V.% = 41.68 C.D.at 5% = 16.86

Fig. 21. COMPARISON OF NO. OF KERNELS (NK) WITH KERNEL WEIGHT (WK) PER PLANT



Percentage Pod Rot:

Results of the analysis of variance for percentage pod rot did not show any significant differences among the treatments (P=0.05). In fact, treatments 34,19,22,31,17,29,33,10,23,11,1 and 25 almost showed negligible percentages of pod rot among the number of pods that they produced. However, the treatments shown in Table 19 had more than 10 percent pod rot incidence.

Table 19. Ranked Adjusted Means for Genotypes with More than 10% Pod Rot Incidence (in Ascending Order)

S.No.	Treatment Nos.	Mean Percentage Pod Rot
1.	12	10.24
2.	18	11.06
3.	6	11.21
4.	28	15.55
5.	35	15.91
6.	4	16.53
7.	8	23.50
8.	32	23.64

Grand Mean = 4.71 C.V.% = 231.08 C.D. at 5% = 17.94

Except oil content which decreased non significantly with increase in percentage of pod rot; all the other factors shown in Table 3 had non significant positive correlations with pod rot.

As has already been stated elsewhere in this report; Walker and Cserios in 1980 observed that severe pod rot occurred on plots receiving no gypsum; but the severity decreased for all cultivars as the rate of gypsum applied was increased. In this experiment; perhaps, as a result of gypsum application, pod rot incidence was reduced to manageable levels, though the line that was severely attacked by pod rot incurred an average loss of around 24%. Probably, the gypsum increased the maturity level of the pods as increase in maturity level of pods leads to a decrease in the proportion of rotten pods.

Weight of Kernels per Plant:

Table 20 shows that apart from Robut 33-1 which was a cultivar, there were many genotypes of interspecific origin which yielded high kernels weight. These interspecific progenies were mainly those of *A.cardenasii* and *A.batizocoi* origin. At the bottom of the table were treatments 24, 26 and 31 with the first 2 being hexaploids. This again confirms the low yields of the hexaploids that were tested in this experiment.

Appendix 19 shows that the weight of kernels produced by the various treatments differed significantly from each other (at P=0.05). There was also a very high Coefficient of variability (49.3%). This may be explained as due to heterogeneity of the materials that were tested. An increase in weight of kernel per plant led to a non significant decrease in oil content. However, similar increases in kernel weight resulted in a non significant, significant and highly significant increases in average kernel content, shelling percentage and weight per 100 seeds respectively. This

can be interpreted that kernel weight is closely associated with yields. Ramanathan *et al.* (1968), Coffelt and Hammons (1974) had earlier on obtained significant positive correlations between kernel weight and shelling percentage.

Table 20. Ranked Adjusted Means for Weight of Kernels Produced (in g) for the Various Treatments.

S.No.	Treatment Nos.	Mean of Weight of Kernels (g)
1.	33	19.57
2.	2	15.96
3.	16	11.93
4.	28	11.86
5.	34	11.25
6.	18	11.12
7.	8	10.78
8.	4	9.06
9.	3	8.06
10.	27	7.90
11.	21	7.75
12.	35	7.48
13.	12	7.30
14.	14.	7.10
15.	5	5.51
16.	22	5.28
17.	13	4.60
18.	32	4.24
19.	25	3.34
20.	9	3.08
21.	36	3.06
22.	15	2.82

Table 20. Contd/...

S.No.	Treatment Nos.	Mean of weight of kernels (g)
23.	6	2.70
24.	20	2.31
25.	11	2.21
26.	1	2.05
27.	29	2.01
28.	10	1.84
29.	17	1.72
30.	23	1.64
31.	30	1.56
32.	7	1.43
33.	19	1.39
34.	24	1.35
35.	26	0.89
36.	31	0.38

Grand Mean = 5.63 C.V.% = 49.3 C.D. at 5% = 4.54

Oil Content:

In the investigations undertaken, it was realized that a decrease in oil content was associated with non significant decrease in shelling percentage and the average pod content; whilst an increase in oil content was associated with a decrease in the weight per 100 seeds.

The analysis of variance for the percentage oil content for the genotypes that were tested are presented in Appendix 20. It showed significant differences existed between the genotypes at 5 percent level of probability Similar significant differences in oil content have been obtained among 250 varieties that were tested between 1970 and 1974 at the Taiwan Agricultural

Research Station (Anonymous, 1975).

Table 21 shows that most of the lines of interspecific origin possessed high oil content. They were all derivatives of *A.cardenasii* and *A.batizocoi*. Treatments 11 and 29 which showed the highest percentages of oil content were Virginia semispreading bunch types whilst T_9, another high oil content line was Virginia erect type. These indications may be compared with the results obtained by Belovan in 1970.

The oil content levels which were obtained for the entries compare favourably with that of Cherry (1975) who observed percentage oil in seed meals from wild species to range from 46.5 to 63.1%, while those of the cultivars ranged from 43.6 to 55.5%. Fourteen of the wild species derivatives in this experiment ranked above the best cultivar. From earlier observations it looks perhaps oil content is linked with wild characters. The coefficient of variation was quite low.

Table 21. Ranked Adjusted Means for Percentage of Oil Content for the Genotypes Used.

S.No.	Treatment Nos.	Mean of percentage of Oil content
1.	29	53.44
2.	9	51.20
3.	11	51.17
4.	14.	51.02
5.	18	50.86
6.	20	50.31
7.	13	50.08
8.	2	50.05
9.	7	49.30
10.	1	49.13

Table 21. Contd./...

S.No.	Treatment Nos.	Mean of Percentage of Oil Content
11.	30	49.11
12.	3	48.49
13.	28	48.35
14.	24	48.32
15.	36	47.33
16.	12	47.02
17.	8	46.88
18.	21	46.41
19.	4	46.31
20.	16	46.27
21.	35	45.57
22.	17	45.39
23.	6	45.32
24.	23	44.68
25.	25	44.59
26.	32	44.48
27.	27	44.47
28.	34	44.42
29.	22	44.33
30.	31	44.01
31.	10	43.97
32.	26	43.71
33.	5	43.25
34.	19	43.12
35.	15	42.62
36.	33	42.02

nd Mean = 46.86 C.V.% = 0.26 C.D. at 5% = 0.20

Shelling Percentage:

The analysis of variance table (Appendix 21) shows that there were no significant differences between the treatments at 5% level of probability for the variable shelling percentage. Table 22 shows that treatment 35, which exhibited the highest shelling percentage among the cultivars was 13th in the descending order of ranked adjusted means. This augurs well for the lines of interspecific origin, as the ratio of sound kernels to pods (shelling percentage) is one of the main factors that contributes towards total yields of groundnuts (Oram, 1958). The 3 lines with the highest shelling percentages were T_{18} (Spanish erect bunch), T_8 (Virginia erect bunch) and T_3 (Virginia semispreading bunch).

This observation somewhat contradicts what Jaya Mohan Rao and his associates observed in India in 1975. They reported that varieties of the spreading form had higher shelling percentages than bunch form. However, they further observed that the Virginia bunch forms had heavier and larger kernels. The higher shelling percentage obtained for the bunch types T_{18}, T_8 and semi-spreading type T_3 on the other hand supports observations made by Varisai Mohammed *et al.* (1973) that bunch types give higher shelling percentage. They also further observed that larger kernels tended to be associated with lower shelling percentage.

It was observed in the investigations under discussion that shelling percentage was significantly positively correlated with average pod content and weight per 100 seeds (Table 3). This means an increase in shelling percentage was accompanied by increases in average pod content and weight per 100 seeds. Similar observations have been made by Ramanathan *et al.* in 1968. The scatter diagram of shelling percentage

with weight per 100 seeds indicates a significant positive correlation. Furthermore, most of the entries had an average shelling percentage within the range of 40 and 60(Fig. 22).

Table 22. Ranked Adjusted Means for Shelling Percentage

S.No.	Treatment Nos.	Mean of the Sheeling Percentage
1.	18	63.28
2.	3	58.69
3.	8	58.13
4.	19	57.92
5.	1	56.07
6.	28	54.09
7.	12	53.76
8.	27	53.33
9.	24	53.10
10.	2	52.93
11.	9	52.86
12.	21	52.81
13.	35	52.66
14.	15	52.66
15.	23	52.09
16.	5	51.41
17.	16	51.27
18.	13	51.16
19.	34	50.90
20.	33	50.62
21.	32	50.40
22.	14	49.80
23.	20	49.71
24.	30	49.54

Table 22. Contd./....

S.No.	Treatment Nos.	Mean of the Shelling Percentage
25.	10	46.75
26.	36	46.31
27.	29	45.61
28.	6	45.44
29	22	44.23
30.	4	43.17
31.	7	42.78
32.	26	42.55
33.	31	42.34
34.	11	41.53
35.	25	39.08
36.	17	38.83

Grand Mean = 49.94 C.V.% = 18.82 C.D. at 5% = 15.66

Average Kernel Content:

The average kernel content gives an idea about the average number of kernels found in a pod. The analysis of variance (Appendix 22) indicates significant differences between the genotypes as to the average number of kernels that a pod contains at 5% level of probability. Table 22 shows that only two cultivars among the ten best entries, and that T_{35}, a cultivar, had the highest average kernel content. Treatments 25, 26 and 24 (not shown in Table 23) which were hexaploids, had the least number of kernels in their pods. An increase in the average kernel content was closely linked with higher weights for every 100 seeds. Thus this variable is closely aassociated with yield. Pods with higher number of kernels would therefore result in higher yeilds.

Fig. 22. COMPARISON OF SHELLING PERCENTAGE (SP) WITH WEIGHT PER 100 SEEDS(WPS)

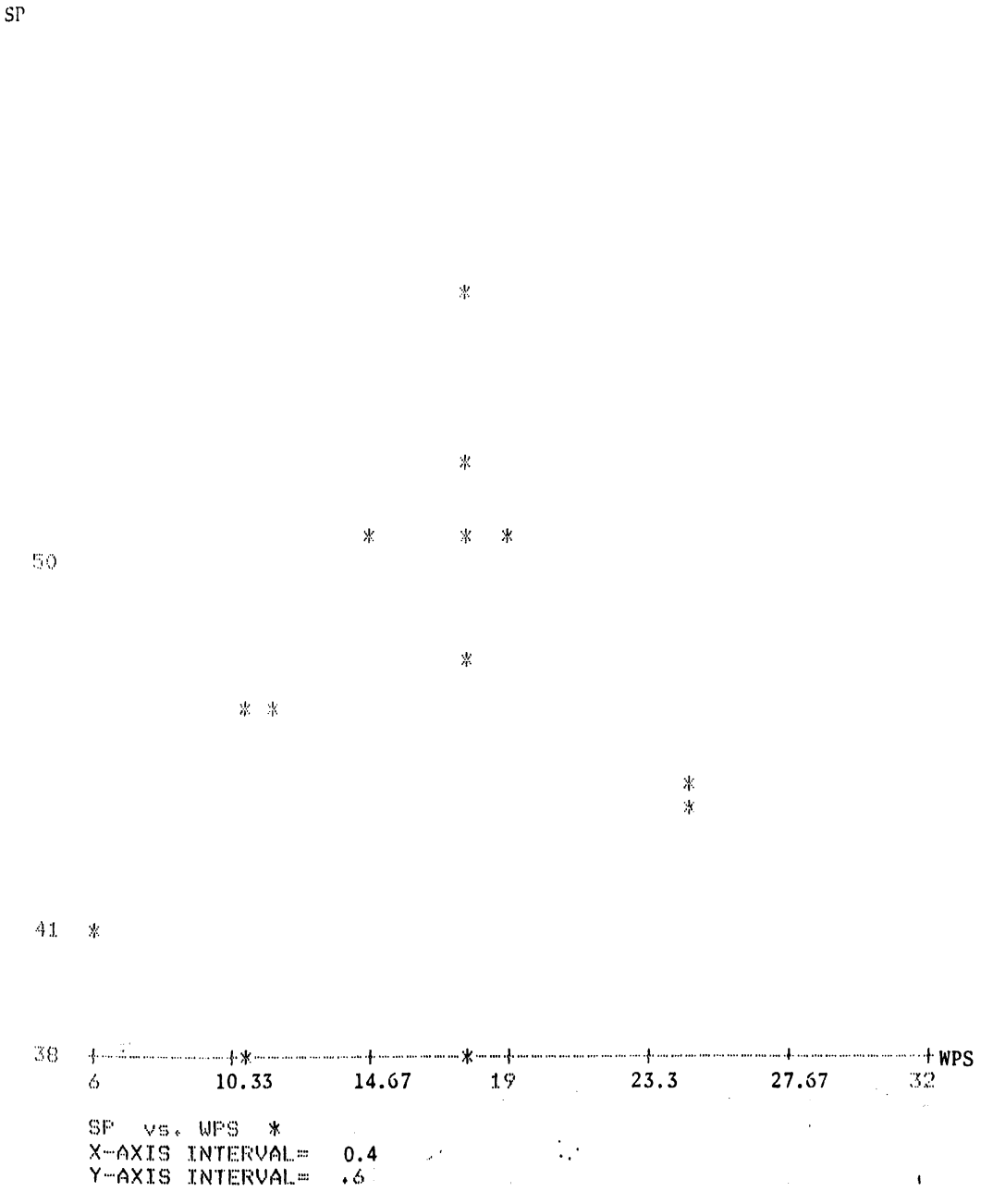


Table 23. Ranked Adjusted Means for the 10 Top Genotypes for Average Pod Content.

S.No.	Treatment Nos.	Mean of the Average kernel Content
1.	35	3
2.	31	2
3.	7	2
4.	8	2
5.	20	2
6.	12	2
7.	18	2
8.	27	2
9.	36	2
10.	10	2

Grand Mean = 2 C.V.% = 15 C.D. at 5% = 0.39

Weight for 100 Seeds:

One of the most important attributes to weight per 100 seeds is its high heritability as reported by Coffelt and Hammons in 1974.

In this variable; the genotype which showed the heaviest weight per 100 seeds was T_{34} (M 13) which is a cultivar. Table 24 shows ranked adjusted means for weight per 100 seeds with a number of wild species derivatives comparing favourably with the cultivars. Appendix 23 shows that there were significant differences between the various treatments with respect to the weight per 100 seeds produced by each genotype.

The coefficient of variability was 26% (quite low when heterogeneity between the entries is considered). However, this seems to support Kushwaha and his colleagues' observation in which they had the least coefficient of variability for 100 pod weight (Note that there was highly significant positive correlations between seed and pod weights).

Table 24. Ranked Adjusted Means (in gms) for Weight per 100 Seeds

S.No.	Treatment Nos.	Mean of Wt. per 100 seeds	S.No.	Treatment Nos.	Mean of Wt. per 100 seeds
1.	34	32.96	19	27	18.79
2.	18	30.85	20.	3	18.40
3.	33	29.98	21.	17	18.12
4.	28.	27.23	22.	6	17.92
5.	2	26.11	23.	23	17.71
6.	36	26.03	24.	19	16.09
7.	8	25.88	25.	13	15.55
8.	26	25.04	26.	32	15.36
9.	21	24.85	27.	10	14.68
10.	16	24.64	28.	1	13.61
11.	22	23.48	29.	11	13.23
12.	12	22.86	30.	9	13.02
13.	35	22.51	31.	29	12.50
14.	4	21.09	32.	7	12.25
15.	5	20.36	33.	25	11.64
16.	24	19.99	34.	30	11.26
17.	14	19.58	35.	20	11.05
18.	15	18.81	36	31	6.21

Grand Mean = 19.43 C.V.% = 26 C.D.at 5% = 8.45

Plant Habit:

Table 25. Plant Habits of the Genotypes Used

S.No.	Treatment Nos.	Plant Habit
1.	1	Virginia semispreading bunch
2.	2	Spanish erect bunch
3	3	Virginia semi spreading bunch
4.	4	Virginia semispreading bunch
5.	5	Virginia erect bunch
6.	6	Virginia semispreading runner
7.	7	Virginia erect bunch
8.	8	Virginia erect bunch
9.	9	Virginia erect bunch
10.	10	Virginia semispreading bunch
11.	11	Virginia semispreading bunch
12.	12	Virginia erect bunch
13.	13	Virginia semispreading bunch
14.	14	Valencia semispreading runner
15.	15	Virginia erect bunch
16.	16	Virginia semispreading runner
17.	17	Virginia semispreading runner
18	18	Spanish erect bunch
19.	19	Spanish erect bunch
20.	20	Virginia semispreading bunch
21.	21	Virginia semispreading bunch
22.	22	Virginia semispreading runner
23.	23	Virginia runner
24.	24	Virginia semispreading bunch
25.	25	Valencia runner
26	26	Virginia erect bunch
27	27	Virginia erect bunch
28.	28	Virginia erect bunch

Table 25. Contd/...

S.No.	Treatment Nos.	Plant habits
29.	29	Virginia semispreading bunch
30.	30	Virginia erect bunch
31.	31	Virginia semispreading bunch
32.	32	Spanish (erect) bunch
33.	33	Virginia semispreading bunch
34.	34	Virginia semispreading runner
35.	35	Valencia bunch
36.	36	Virginia bunch

Although there have been conflicting reports concerning the best plant types which are very productive in terms of higher number of pods produced, seed weight, seed size, pod size and pod weight (Varisai Mohammed *et al.* 1973), Jaya Mohan Rao *et al.* 1975, Ramanathan *et al.* (1968); there is however, the general consensus among scientists of the various plant types that give high oil content (Varisai Mohammed *et al.* 1973 and Belovan, 1970). Higher oil yields have been reported in upright forms of *Arachis hypogaea* (Belovan 1970); so also in Spanish and Valencia groups (Varisai Mohammmed *et al.*).

In this experiment; it was observed that the high productivity lines in terms of pod weight, seed weight, pod number and oil content were either semispreading bunch in nature or erect in character.

Seed Testa Colour:

Table 26. Seed Testa Colours of Genotypes Tested

Treatment Numbers	Seed Testa Colour
1.	Tan
2	Reddish-purple
3	Light Tan
4	Light Tan
5	Light Tan
6	Tan
7.	Tan
8	Light Tan
9	Tan
10	Purple, Tan & Variegated (Tan/purple)
11	Tan
12	Tan
13	Light Tan
14	Rose
15	Tan
16	Rose
17	Rose and Tan
18	Light Tan
19	Light Tan
20	Tan
21	Light Tan
22	Tan
23	Light Tan
24	Light Tan
25	Tan
26	Light Tan
27	Light Tan
28	Red

Table 26. Contd/...

Treatment Numbers	Seed Testa Colour
29	Tan
30	Rose and Tan
31	Red Tan
32	Light Tan
33	Light Tan
34	Light Tan
35	Red
36	Red Tan

With the aid of charts of the Royal Horticultural Society, the above colour descriptions were assigned to the various treatments. There were wide range of colours observed. In Malawi (Anonymous) it has been observed that plants with red colour which were derivatives from Mani Pintar bred true.

Seed coat colour may be of value as an aid to resistance of the seeds to *Aspergillus flavus*, a toxin producing strain on seeds of various groundnut accessions. (Refer to Mixon, 1977; Mixon and Rogers, 1973; Bartz *et al.* 1978 and Jackson, 1965).

CONCLUSIONS

A comparison of a wide range of growth parameters of wild species derivatives, mostly at the tetraploid level, with cultivars showed that many parameters were correlated. For instance, although number of flowers produced was correlated with yield parameters like number of pods and kernels, pod and kernel weight and pod size, an analysis of daily flower production showed that some low yielding lines were identical to high yielding lines in rate and number of flowers produced, though pod production was reduced in the low yielding lines. The hexaploids flowered well, but gave poor pod yields probably as a result of low pollen or ovule fertility. This low fertility may be due to either slow growth of pollen tubes or other factors yet to be investigated. However, for most of the wild species derivatives, an increase in number of pegs produced per plant resulted in increased pod and kernel productivity, greater pod size, more double seeded pods, increased weight of pods and kernels per plant and increased 100 kernel weight.

Although many of the wild species derivatives gave poor yields, 16 of them outyielded the poorest cultivar in terms of kernel weight; and though the highest yielder was a cultivar, six of the derivatives of the wild species gave yields better than the mean of the five cultivars used. The poor yields of the majority were possibly due tc poor number of pegs produced and the characters correlated with that parameter. However, this was compensated for to some extent by the

high percentages of the pods of the wild species derivatives that were able to reach full maturity. Apart from one cultivar (T 33); the top 14 entries exhibiting high percentages of maturity were all derivatives of wild *Arachis* species.

High oil content, as has been mentioned above, is associated with the wild species derivatives; thus it is possibly a characteristic of the wild species, as has been reported previously. Similarly high shelling percentages were identified with most of the entries of interspecific origin. As with time of flowering, the wild species derivatives were showing diversity with regard to plant habit and its association with other characters, possibly due to different linkage patterns.

Although small and single seeded pods are undesirable wild species characters, many single seeded lines had higher oil content and shelling percentage. Since increase in pod length and width resulted in significant increases in yield components like pod weight, number of kernels, weight of kernels and average pod content, the tiny, single seeded pod characters should be some of the undesirable characters to be eliminated to make the wild species derivatives acceptable as good sources of high yielding material. However, because single seeded pod character tends to be associated with the wild type derivatives, there is the need to investigate whether such genes are closely linked with other desirable characters like high oil content and high shelling percentages also closely associated with the lines of interspecific origin. The fact that the hexaploids

which incorporate all the genes for wild species showed the character single poddedness in intense form indicates that this character can express itself when associated with the *A.hypogaea* genome. However, the near tetraploid lines that were tested had the greatest proportion as bilobed pods; but still had better oil content and shelling percentage, showing that these wild characters can be transferred independently of the single podded character, and are also able to express themselves in the presence of *A.hypogaea* genome.

From the high dormancy shown by most of the lines derived from wild species, it looks as though dormancy is also a character that has been introgressed into the cultivated groundnut and has increased the dormancy levels of these interspecific hybrids.

The two major diseases that were assessed indicate that whilst almost all the cultivars were susceptible to *Cercospora* leaf spot and rust, a greater part of the derivatives of wild species were resistant to these diseases. Thus it may be possible that the resistance to these diseases might have been transferred from the wild species into these interspecific hybrids. In addition, some of the wild species derivatives produced comparable yields to the cultivars. Of the 6 highest yielding wild species derivatives, two treatments (2 and 16) were susceptible (similar to the cultivars) but the other four were resistant. These lines thus have a greater potential for areas where diseases are prevalent.

Finally it may be concluded that, in the crosses of wild species with cultiyated groundnuts, apart from the fact that the wild species increased the diversity among the genotypes of the resultant progenies, there were many characters in which the incorporation of such wild genes improved the desirability of the hybrids. For example; it has clearly been established how the incorporation of such wild genes increased the disease resistance levels of the cultivated groundnuts. Furthermore, the average shelling percentage which is a desirable character of importance in yields, had its level increased in the resultant hybrids. Similarly, the oil contents were also increased.

However, the single lobed character which tended to persist in some of the derivatives; therefore depressing yields, is the major bottleneck to be overcome to make the desirability of these wild species derivatives complete. In this aspect, future programmes should aim at increasing the size of the pods hence the percentages of bilobed and trilobed pods within the lines of interspecific origin. When this problem has been overcome, there is every hope of such lines not only being resistant to the common diseases like *Cercospora* leaf spot and rust, but also higher yielding as a consequence of the resultant higher shelling percentage which is a character that has been transferred from the wild species into the cultivated species. Further, the oil contents will be higher to help improve on the supply position of edible oils which are in short supply especially in the developing countries.

The tetraploid lines were selected from progenies derived from interspecific hybrids. These lines vary in the expression of both desirable (e.g. disease resistance) and undesirable (e.g. single podded) characters. Therefore they have not compared well in all characters with the cultivars; their greatest value is probably as parents for the genetic improvement of A.*hypogaea*.

SUMMARY:

In this study, which was carried out at the ICRISAT Research Centre during the rainy season of 1980, the breeding and agronomic performance of 36 lines were assessed. Thirty one of these lines were of interspecific origin, and were at or near the hexaploid or tetraploid level. Most of these had been selected for their disease resistance. The other five lines were standard cultivars for comparison. The entries were sown in a Triple Lattice Design layout and the following data collected: number of days to germination, number of days to first flowering, number of flowers produced, number of pegs, total number of pods produced and the percentage of these pods that reached full maturity. Other variables on which data were taken were *Cercospora* and rust ratings, dormancy percentage, pod length and width, percentage of single, double and trilobed pods, pod weight and number of kernels produced per plant. The others were kernel weight, oil content, shelling percentage and weight per 100 seeds produced.

The entries were compared to find the differences between the cultivars and the wild species derivatives, and to what extent the inclusion of wild species germplasm had increased the variability within the entries, providing valuable germplasm for breeders, or whether undesirable wild characters have persisted in the populations.

The results showed that, for both resistances to *Cercospora* and rust fungi, most of the lines of interspecific origin were highly

resistant. In fact, three of such lines were completely resistant to rust, *Puccinia arachidis*. Treatments 28 and 15 which were derivatives of *Arachis cardenasii* and *Arachis batizocoi* respectively were found to possess high resistance for both *Cercospora* and leaf rust simultaneously. Such lines may be useful for future investigations on mechanisms of resistance to these fungi.

The best lines in terms of production of mature pods included Treatment 33 (a cultivar) and Treatments 2 and 28 which were of interspecific origin. Although treatment 24, a hexaploid, was among the entries that produced the least number of pods; nevertheless, most of its pods were able to reach full maturity.

Dormancy is a character associated with wild species. It has non-significant positive correlations with other wild characters like single lobed pods, higher oil and shelling percentages. In this experiment, it was observed that most of the species that were derivatives of wild species were highly dormant. These included entries such as T_{30}, T_{22}, T_9, T_{24}, and T_5.

Although it was realized that single lobed pods were generally low yielders, they however, possessed high oil content and shelling percentages. Since higher numbers of seeds per pod are closely linked with higher yields it is always advisable to select double or trilobed pods. Despite the wild species having fewer seeds per pod, the derivatives T_{16}, T_{18}, T_7 and T_{10} produced higher percentages of bilobed

and trilobed pods.

Pod weight, which is one of the main contributors of groundnut yields indicates that aside from Treatment 33, a cultivar; Treatments 2, 16, 18 and 28 have good promise as future materials in terms of higher pod weights exhibited by them.

High yielding lines with respect to number of kernels and weight of kernels produced indicate that there are good sources of such characters among the genotypes of interspecific origin; T_2, T_{16} and T_{28} especially.

Another factor for which the genotypes derived from wild species showed very high performance was their oil content, most of them had quite an appreciable content of oil. T_{29}, which had the highest oil content of over 53% was followed by Treatments 9, 11, 14 and 18 in that order.

It was also observed that the first 12 genotypes with the highest shelling percentages were all of interspecific origin; with Treatment 18 showing as high as 63.21 shelling percentage.

With regard to weight per 100 seeds produced by individual plants, Treatment 34 which was a cultivar was the best line. However, Treatments 18, 28 and 2 all progenies of interspecific crosses, were among the top performers in this character.

Treatment 28, which was classified as a low yielder (based on its productivity in the previous season), strangely proved to be an "all-round" top performer. The reason for its classification as low yielding might have been due to the heavy bud necrosis incidence depressing yields in the previous rainy season, and the entry might possibly be a low yielder in rabi (post rainy) season. This makes it necessary for a replicated yield trial to be run in future to confirm this and other observations. This is so because the poor germination in some of the lines tested, coupled with high incidence of bud necrosis which killed some of the plants later on left a population less than optimum in some of the treatments. In such yield test to be conducted in future, high performance lines that have been mentioned above must be included in order to be able to assess fully their yield potentials.

Finally, it may be concluded that, most of the lines derived from wild species performed well in most of the variables that were studied and the range of variation was often greater than that found in *A. hypogaea*, thus it is worthwhile including most of them in our future breeding programme; especially where disease resistance is one of the main objectives of such a programme. Nevertheless, there were undesirable characters like high single seeded pods which resulted in low production levels of pod weight, number of kernels, kernel weight and weight per 100 seeds of most of the wild species derivatives. Thus, future programmes should aim at improving the general yield levels of most of these disease resistant but low yielding interspecific progenies

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APPENDIX 1: ANALYSIS OF VARIANCE FOR THE VARIABLE NO. OF DAYS TO GERMINATION

Source of Variation	Df.	Sum of squares	Mean sum of squares	F-value	Significance
Replication	2	2.132	1.066		
Genotype	35	327.984	9.371		
Blocks (Adjusted)	15	8.321	0.555		
Intra Block Error	55	23.621	0.429		
Treatments (Adjusted)			9.54	22.22	Significant at 5%
Total	107	362.058			

Effective Error Variance: 0.45

Efficiency of lattice over RBD is 101.35%

S.E. of diff. of means for genotype appearing in the same block = 1
C.D. at 5% = 1
S.E. of diff. of means for genotype not appearing in the same block = 1
C.D. at 5% = 1

APPENDIX 2: ANALYSIS OF VARIANCE FOR THE VARIABLE DAYS TO FLOWERING

Source of Variation	Df.	Sum of squares	Mean sum of squares	F-value	Significance
Replication	2	44.212	22.106		
Genotype	35	1839.271	52.551		
Blocks(Adjusted)	15	79.886	5.326		
Intra Block Error	55	351.976	6.400		
Treatments(Adjusted)			55.92	8.74	Significant at 5%
Total	107	2315.345			

Effective Error Variance 6.12

Efficiency of lattice over RBD is 100.76%

S.E. of Diff. of means for genotype appearing in the same block = 2
C.D. at 5% = 4
S.E. of Diff. of means for genotype not appearing in the same block = 2
C.D. at 5% = 4

APPENDIX 3: ANALYSIS OF VARIANCE FOR THE VARIABLE NO.OF FLOWERS

Source of variation	Df.	Sum of squares	Mean sum of squares	F-Value	Significance
Replication	2	4020.451	2010.225		
Genotype	35	588165.139	16804.718		
Blocks(Adjusted)	15	57001.602	3800.107		
Intra Block Error	55	166479.725	3026.904		
Treatments(Adjusted)			17439.24	5.76	Significant at 5%
Total	107	815666.917			

Effective Error Variance = 3158.88

Efficiency of lattice over RBD is 101.07%

S.E. of Diff. of means for genotype appearing in the same block = 46
C.D. at 5% = 92
S.E. of Diff. of means for genotype not appearing in the same block = 46
C.D. at 5% = 92

APPENDIX 4: ANALYSIS OF VARIANCE FOR THE VARIABLE NO.OF PEGS

Source of variation	Df.	Sum of squares	Mean sum of squares	F-Value
Replication	2	8541.243	4270.621	
Genotype	35	164787.598	4708.217	
Blocks(Adjusted)	15	12354.211	823.614	
Intra Block Error	55	38013.064	691.147	
Treatments(Adjusted)			4881.45	7.06*

Significant at 5%

Effective Error Variance = 714.97

Efficiency of lattice over RBD is 100.64%

S.E. of Diff. of means for genotype appearing in the same block = 22
C.D. at 5% = 44
S.E. of Diff. of means for genotype not appearing in the same block = 22
C.D. at 5% = 44

APPENDIX 5: ANALYSIS OF VARIANCE FOR *Cercospora* RATING

Source of Variation	Df.	Sum of squares	Mean sum of squares	F-Value
Replication	2	1.986	0.993	
Genotype	35	238.924	6.826	
Blocks(Adjusted)	15	10.840	0.723	
Intra Block Error	55	37.002	0.673	
Treatments(Adjusted)			7.06	10.50*
Total	107	288.752		

* Significant at 5% level of probability

Effective Error Variance = 0.68

Efficiency of lattice over RBD is 100.11%

S.E. of Diff. of means for genotype appearing in the same block = 0.67
C.D. at 5% = 1.35

S.E. of Diff. of means for genotype not appearing in the same block = 0.68
C.D. at 5% = 1.35

APPENDIX 6: ANALYSIS OF VARIANCE FOR RUST RATING

Source of Variation	Df.	Sum of squares	Mean sum of squares	F-Value
Replication	2	19.323	9.661	
Genotype	35	517.070	14.773	
Blocks(Adjusted)	15	24.518	1.635	
Intra Block Error	55	61.838	1.124	
Treatments(Adjusted)			15.57	13.85**

** Significant at 1% level of probability

Effective Error Variance = 1.20

Efficiency of lattice over RBD is 102.85%

S.E. of the diff. of means for genotype appearing in the same block = 0.89
C.D. at 5% = 3.08

S.E. of the diff. of means for genotype not appearing in the same block = 0.89
C.D. at 5% = 3.13

APPENDIX 7: ANALYSIS OF VARIANCE FOR THE VARIABLE DORMANCY PERCENTAGE

Source of Variation	Df.	Sum of squares	Mean sum of squares	F-Value	Significance
Replication	2	28.004	14.002		
Genotype	35	850.395	24.297		
Blocks(Adjusted)	15	409.402	27.293		
Intra Block Error	55	1514.258	27.532		
Treatments(Adjusted)			24.33	0.88	Not Significant
Total	107	2802.060			

Effective Error Variance = 27.48

Efficiency of lattice over RBD is 100.002%

S.E. of Diff. of means for genotype appearing in the same block = 4.28
C.D. at 5% = 8.58

S.E. of Diff. of means for genotype not appearing in the same block = 4.28
C.D. at 5% = 8.58

APPENDIX 8: ANALYSIS OF VARIANCE FOR THE TOTAL NO.OF PODS(PRODUCED PER PLANT)

Source of Variation	Df.	Sum of squares	Mean sum of squares	F-Value	Significance
Replication	2	195.981	97.990		
Genotype	35	13135.707	375.306		
Blocks(Adjusted)	15	706.490	47.099		
Intra Block Error	55	3845.585	69.420		
Treatments(Adjusted)			456.95	6.54	Significant at 5%
Total	107	17883.763			

Effective Error Variance = 62.66

Efficiency of lattice over RBD is 103.78%

S.E. of Diff. of means for genotype appearing in the same block = 7
C.D. at 5% = 13

S.E. of Diff. of means for genotype not appearing in the same block = 7
C.D. at 5% = 13

APPENDIX 9: ANALYSIS OF VARIANCE FOR THE VARIABLE NO.OF MATURED PODS(PER PLANT)

Source of Variation	Df.	Sum of squares	Mean sum of squares	F-Value	Significance
Replication	2	63.313	31.657		
Genotype	35	7730.102	220.860		
Blocks(Adjusted)	15	554.611	36.974		
Intra Block Error	55	2311.106	42.020		
Treatments(Adjusted)			232.21	5.53	Significant at 5%
Total	107	10659.132			

Effective Error Variance = 40.79

Efficiency of lattice over RBD is 100.36%

S.E. of Diff. of means for genotype appearing in the same block = 5
C.D. at 5% 11

S.E. of Diff. of means for genotype not appearing in the same block = 5
C.D. at 5% = 10

APPENDIX 10: ANALYSIS OF VARIANCE FOR MATURITY %

Source of Variation	Df.	Sum of squares	Mean sum of squares	F-Value
Replication	2	2533.662	1266.831	
Genotype	35	15691.899	488.340	
Blocks(Adjusted)	15	3622.548	241.503	
Intra Block Error	55	9167.764	166.687	
Treatments(Adjusted)			465.93	2.80*
Total				

Significant at 5% level of probability

Effective Error Variance = 177.75

Efficiency of lattice over RBD is 102.79%

S.E. of Diff. of means for genotypes appearing in the same block = 10.81
C.D. at 5% = 21.66

S.E. of Diff. of means for genotypes not appearing in the same block = 10.94
C.D. at 5% = 21.93

APPENDIX 11: ANALYSIS OF VARIANCE FOR THE POD LENGTH

Source of variation	Df.	Sum of squares	Mean sum of squares	F-Value	Significance
Replication	2	0.181	0.091		
Genotype	35	25.316	0.723		
Blocks(Adjusted)	15	1.258	0.084		
Intra Block Error	55	6.348	0.115		
Treatments(Adjusted)			0.80	6.92	Significant at 5%
Total	107	33.103			

Effective Error Variance 0.11

Efficiency of lattice over RBD is 102.39%

S.E. of diff. of means for genotype appearing in the same block = 0.26
C.D. at 5% = 0.54
S.E. of diff. of means for genotype not appearing in the same block = 0.26
C.D. at 5% = 0.53

APPENDIX 12: ANALYSIS OF VARIANCE FOR THE POD WIDTH.

Source of variation	Df.	Sum of squares	Mean sum of squares	F-Value
Replication	2	0.027	0.014	
Genotype	35	2.202	0.063	
Blocks(Adjusted)	15	0.206	0.014	
Intra Block Error	55	1.246	0.023	
Treatments(Adjusted)			0.09	3.97*
Total	107	3.681		

* Significant at 5% level of probability

Effective Error Variance = 0.02

Efficiency of littice over RBD is 106.44%

S.E. of diff. of means for genotype appearing in the same block = 0.12
C.D. at 5% = 0.23
S.E. of diff. of means for genotype not appearing in the same block = 0.11
C.D. at 5% = 0.23

APPENDIX 13: ANALYSIS OF VARIANCE FOR % SINGLE SEEDED PODS

Source of Variation	Df.	Sum of squares	Mean sum of squares	F-Value	Significance
Replication	2	171.619	85.809		
Genotype	35	31239.852	892.567		
Blocks(Adjusted)	15	3849.304	256.620		
Intra Block Error	55	18653.710	339.158		
Treatments(Adjusted)			949.64	2.80	Significant at 5%
Total	107	53914.485			

Effective Error Variance 315.78

Efficiency of lattice over RBD is 101.80%

S.E. of Diff. of means for genotype appearing in the same block = 14.63
C.D. at 5% = 29.32

S.E. of Diff. of means for genotype not appearing in the same block = 28.89
C.D. at 5% = 28.89

APPENDIX 14: ANALYSIS OF VARIANCE FOR % DOUBLE SEEDED PODS

Source of Variation	Df.	Sum of squares	Mean sum of squares	F-Value
Replication	2	524.321	262.160	
Genotype	35	44318.008	1266.229	
Blocks(Adjusted)	15	3352.167	223.478	
Intra Block Error	55	18227.947	331.417	
Treatments(Adjusted)			1439.18	4.34*
Total	107	66422.443		

Significant at 5% level of probability

Effective Error Variance = 297.12

Efficiency of lattice over RBD is 103.76%

S.E. of Diff. of means for genotype appearing in the same block = 14.25
C.D. at 5% = 28.56

S.E. of Diff. of means for genotype/appearing in the same block = 13.94
not

APPENDIX 15: ANALYSIS OF VARIANCE FOR % 3 SEEDED PODS

Source of Variation	Df.	Sum of squares	Mean sum of squares	F-Value	Significance
Replication	2	80.660	40.330		
Genotype	35	20584.225	588.121		
Blocks(Adjusted)	15	1246.424	83.095		
Intra Block Error	55	5331.605	96.938		
Treatments(Adjusted)			605.21	6.24	Significant at 5%
Total	107	27242.914			

Effective Error Variance 93.48

Efficiency of lattice over RBD is 100.53%

S.E. of Diff. of means for genotype appearing in the same block = 7.93
C.D. at 5% = 15.88

S.E. of Diff. of means for genotype not appearing in the same block = 7.86
C.D. at 5% = 15.77

APPENDIX 16: ANALYSIS OF VARIANCE FOR POD WEIGHT

Source of variation	Df.	Sum of squares	Mean sum of squares	F-Value	Significance
Replication	2	24.691	12.346		
Genotype	35	7986.785	228.194		
Blocks(Adjusted)	15	347.726	23.182		
Intra Block Error	55	1470.230	26.731		
Treatments(Adjusted)			241.34	9.03	Significant at 5%
Total					

Effective Error Variance 25.85

Efficiency of lattice over RBD is 100.45%

S.E. of diff. of mean for genotype appearing in the same block = 4.17
C.D. at 5% = 8.35

S.E. of diff. of mean for genotype not appearing in the same block = 4.14
C.D. at 5% = 8.29

APPENDIX 17: ANALYSIS OF VARIANCE FOR THE NO.OF KERNELS PER PLANT

Source of Variation	Df.	Sum of squares	Mean sum of squares	F-Value	Significance
Replication	2	269.764	134.882		
Genotype	35	24719.652	706.259		
Blocks(Adjusted)	15	1126.668	75.111		
Intra Block Error	55	6444.458	117.172		
Treatments(Adjusted)			904.12	7.72	Significant at 5% level
Total	107	32559.941			

Effective Error Variance = 103.11

Efficiency of lattice over RBD is 104.89%

S.E. of Diff. of means for genotype appearing in the same block = 8.42
C.D. at 5% = 16.81 not
S.E. of Diff. of means for genotype/appearing in the same block = 8.20

APPENDIX 18: ANALYSIS OF VARIANCE FOR THE % ROTTEN PODS

Source of Variation	Df.	Sum of squares	Mean sum of squares	F-Value
Replication	2	129.973	64.986	
Genotype	35	4887.222	139.635	
Blocks(Adjusted)	15	1491.379	99.425	
Intra Block Error	55	6913.513	125.700	
Treatments(Adjusted)			153.35	1.22^{NS}
Total	107	13422.087		

NS = Not significant at 5% level of probability

Effective Error Variance = 118.58

Efficience of lattice over RBD is 101.26%

S.E. of Diff. of means for genotype appearing in the same block = 8.95
C.D. at 5% = 17.94
S.E. of Diff. of means for genotype not appearing in the same block = 8.85
C.D. at 5% = 17.73

APPENDIX 19: ANALYSIS OF VARIANCE FOR THE WEIGHT OF KERNEL

Source of Variation	Df.	Sum of squares	Mean sum of squares	F-Value	Significance
Replication	2	18.007	9.003		
Genotype	35	2263.404	64.669		
Blocks(Adjusted)	15	113.430	7.562		
Intra Block Error	55	425.262	7.732		
Treatments(Adjusted)			65.17	8.43	Significant at 5% level
Total					

Effective Error Variance = 7.69

Efficiency of lattice over RBD is 100.01%

S.E. of Diff. of means for genotype appearing with same block = 2.27
C.D. at 5% = 4.54
S.E. of Diff. of means for genotype not appearing with same block = 2.26
C.D. at 5% = 4.54

APPENDIX 20: ANALYSIS OF VARIANCE FOR THE OIL CONTENT

Source of Variation	Df.	Sum of squares	Mean sum of squares	F-Value	Significance
Replication	2	0.169	0.084		
Genotype	35	917.26	26.208		
Blocks(Adjusted)	15	0.394	0.026		
Intra Block Error	55	0.743	0.014		
Treatments(Adjusted)			27.82	20.599	Significant at 5%
Total	107	918.582			

Effective Error Variance 0.01

Efficiency of lattice over RBD is 108.91%

S.E. of Diff. of means for genotype appearing in the same block = 0.99
C.D. at 5% = 0.19
S.E. of Diff. of means for genotype not appearing in the same block = 1.00
C.D. at 5% = 0.20

APPENDIX 21: ANALYSIS OF VARIANCE FOR THE SHELLING PERCENTAGE

Source of Variation	Df.	Sum of squares	Mean sum of squares	F-Value	Significance
Replication	2	312.200	156.100		
Genotype	35	3200.637	91.452		
Blocks(Adjusted)	15	929.182	61.945		
Intra Block Error	55	5663.964	102.981		
Treatments(Adjusted)			111.77	1.09	Not significant
Total	107	10106.183			

Effective Error Variance = 88.36

Efficiency of lattice over RBD is 106.59%

S.E. of Diff. of means for genotype appearing in the same block = 7.82
C.D. at 5% = 15.66

S.E. of Diff. of means for genotype not appearing in the same block = 7.57
C.D. at 5% = 15.17

APPENDIX 22: ANALYSIS OF VARIANCE FOR THE AVERAGE KERNEL CONTENT

Source of Variation	Df.	Sum of squares	Mean sum of squares	F-Value	Significance
Replication	2	0.001	0.001		
Genotype	35	11.822	0.338		
Blocks(Adjusted)	15	0.767	0.051		
Intra Block Error	55	3.173	0.058		
Treatments(Adjusted)			0.35	5.99	Significant at 5% level
Total	107	15.763			

Effective Error Variance = 0.06

Efficiency of lattice over RBD is 100.32%

S.E. of Diff. of means for genotypes showing in the same block = 0.19
C.D. at 5% = 0.39

S.E. of Diff. of means for genotypes not showing in the same block = 0.19
C.D. at 5% = 0.39

APPENDIX 23: ANALYSIS OF VARIANCE FOR THE WEIGHT PER 100 SEEDS

Source of Variable	Df.	Sum of squares	Mean sum of squares	F-Value
Replication	2	179.950	89.975	
Genotype	35	4227.638	120.790	
Blocks(Adjusted)	15	370.097	24.673	
Intra Block Error	55	1489.868	27.089	
Treatments(Adjusted)			123.88	4.57*
Total	107	6267.552		

* Significant at 5% level of probability

Effective Error Variance = 26.52

Efficiency of lattice over RBD is 100.19%

S.E. of Diff. of means for genotypes appearing in the same block = 4.22
C.D. at 5% = 8.45

S.E. of Diff. of means for genotypes not appearing in the same block = 4.20
C.D. at 5% = 8.41

** The T value for 55 df. for all the above ANOVA tables is 2.

PEDIGREE OF GENOTYPES STUDIED

Treatment No.	Pedigree
1.	82x34-115M/1-23-3/10 (10+11+19)
2.	82x34-9B/5-7-4/10 (3+5+7+8+10+13+19)
3.	82x34-9B-513/1976 SRS 45/(F19-8/17)(6+7)
4.	82x19-48C 512/1976 SRS 44/(F-23-4/27) (2+3+7+8+15+18)
5.	HP12-8B 513/1976 SRS 45/15-5-11/58 (6+7+8+9+11+13)
6.	27HP14-18/9-53 (12+13)
7.	29HP43-1A/5-36 (2+4+8+9+10+19)
8.	HP12-8B SRS 45/16-263-11-5 (9+10+11+12+13)
9.	88x19x8 523/1976 SRS 92/17-17-5/34 (4+7+12)
10.	28HP 41/1-57 (11+12+13)
11(a)	HP43-1A/3-11-b/18-3
(b)	HP43-1A/3-11-b/21-6
(c)	HP43-1A/3-11-b/18-18
12(a)	HP14-M/13-101-3/59-9
(b)	HP14-M/13-101-3/60-18
13	30-44x10017-42 (1+4+5+6+7+8+10+11+13+16)
14	501-181/67-2/41 (2+6)
15	HP12-8B 513/1976 SRS 45/15-5-11/60 (1+6)
16.	27HP14-18/9-52-12
17.	HP12-8B 537/1976 132 8-37N.P.N./41 (13+15)
18.	HP14/13-101-6/61 (15+19)
19.	HP43-1A/7-31-5/51-9
20.	82x34-115M/2-43-11/36 (3+18)
21.	82x34-9B 513/1976 SRS 45/CF19-8/17 (1+12)
22.	Mutant M-13/53 (7+10)
23(a)	*Monticola* x M-13/58-7
(b)	*Monticola* x M-13/60-3
24(a)	HIC 215/99-3/57 (5+10)
(b)	HIC 215/5-13/51-8

Treatment No.	Pedigree
(c)	HIC 192/2077/52-4
(d)	HIC 192/255-11/30 (4+6)
25(a)	HIL 626/179-3/47 (1+12)
(b)	HIL 61/11-5/42 (4+16)
(c)	HIL 83/89-9/17 (13+14+12+16)
26(a)	HJK 389/17-6/39 (5+11)
(b)	HJK 389/17-14/40 (10+13)
(c)	HJK 22+12-8
(d)	HJK 10/61-14
27(a)	82x19-48C SRS 44/5-165-6/29 (1+2+3+4+6+9+10+12+14+15)
(b)	82x19-48C SRS 44/5-165-6/30 (7+11)
28(a)	82x34-9B I 321/4-41-11/5 (7+9+11+15)
(b)	82x34-9B I 321/4-41-10/4 (16+15)
29(a)	HP43-1A/5-5-7/42 (9+11+12+13+14+15)
(b)	HP43-1A/5-5-2/40 (1+4+7)
30	HP43-1A 262/CF41-10/55 (1+2+3+6+7+9+17+19)
31(a)	82x34-115M/4-11-10/45 (3+5+10)
(b)	82x34-115M/4-11-11/46 (4+5+9+15)
(c)	82x34-115M/4-11-11/47 (8+11+16)
32	Spanish bunch
33	Virginia bunch
34	Virginia runner
35	Valencia bunch
36	Virginia bunch