GENETIC RESOURCES UTILIZATION AND BIOMETRIC ANALYSIS IN GROUNDNUT (*Arachis hypogaea* L.)

BY

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DECLARATION

I hereby declare that this thesis entitled "Genetic resources utilization and biometric analysis in groundnut (*Arachis hypogaea* L.)" is a bonafide record of research work done by me during the course of research and that the thesis has not been previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title of any other University or Society.

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CERTIFICATE

Certified that this thesis entitled "Genetic resources utilization and biometric analysis in groundnut (*Arachis hypogaea* L.)" is a record of research work done independently by Shri. Pushkaran, K. under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to him.

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INTRODUCTION

INTRODUCTION

Oilseeds constitute the second major group of crops in this country. India has become today a country importing vegetable oils as against an oil exporting country in the past (Tiwari and Chahal, 1982). Oilseeds cover over 17 million hectares in India, engage about 14.5 million people for its cultivation and hence play a vital role in the national economy. Among the seven edible annual oilseed crops cultivated in India, groundnut is the most important and accounts for about 60 per cent of the total oilseeds production.

Although India ranks first in the world in groundnut area and production it is only 10th in per hectare productivity (Reddy, 1982). The present level of productivity is less than the world average. This reveals the enormous potential to escalate the productivity of this crop in India. Considering the national importance and urgency for increasing groundnut production, massive research and development efforts have already been initiated. In such a programme, the genetic improvement works have rightly taken its leading place.

In Kerala, groundnut is cultivated in an area of about 17500 hectares, mostly in Chitoor taluk of Palghat district with an average yield of 1300 to 1400 kg per hectare. It is traditionally grown as a rainfed crop during kharif (April-May to August-September). A non-traditional but potential area for commercial cultivation in the State is the double crop rice fallows during summer where groundnut can be grown successfully with the available residual moisture or with marginal irrigation facilities. Crop sequence studies have already proved the efficacy of including groundnut in the summer rice fallows. The lack of high yielding and short duration varieties as pointed out by Nair (1978) is the major constraint for its successful cultivation in rice fallows. Besides, stability in the productivity of cultivars deserves attention as groundnut production suffers from proverbial instability.

Raising productivity of groundnut, as in any other crop, calls for the employment of suitable techniques of plant breeding. Genetic variability in a crop forms the primary requisite to achieve genetic improvement. A collection of germplasm and its critical evaluation for desirable attributes with reference to the breeding objectives can lead to the identification of genotypes specific to the situations and requirements. The observed phenotype is a correlated response of the heritable and non-heritable factors. Only the heritable portion of the variability contribute to genetic improvement through selection. The extent of genetic variability can be estimated by the genotypic coefficient of variation. Heritability in combination with genetic advance would be more useful in predicting the results of selection.

Selection for complex characters like yield can be effectively made by employing biometric techniques which will indicate the relative importance of the different components. In the development of improved genotypes, the breeder should have a definite understanding of the genetic architecture of yield and its components with reference to the situation. The extent of relationship between attributes is measured by correlation coefficient at the genotypic and phenotypic levels. When the correlations of a number of characters are considered simultaneously the results become more complex due to their mutual associations. The path coefficient analysis provides a means to find out the relative contribution of each component towards yield and is an effective tool to detect the specific forces acting to produce a given correlation. The correlation coefficients are thus partitioned into the direct and indirect effects.

Testing of adapted promising varieties to select out the best suited one for the traditional uplands during kharif and the potential rice fallows during summer is planned in this programme, with immediate practical utility. Since the summer rice fallows have a span of only 90 days or less, mutation breeding technique to induce earliness in selected promising genotypes is also envisaged as a part of the programme.

In Kerala, though groundnut is the most important annual oilseed crop, no attempt was done in the past for its genetic improvement. This programme is the beginning of a systematic breeding approach to satisfy the varietal requirements for the two major areas in the State with high production potential. It is hoped that the informations gathered and conclusions drawn will be of considerable practical importance in the future works on genetic improvement of this crop.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Groundnut ranks 13th in importance among the world food crops and is the most important food legume (Vernell and McCloud, 1975). Rao (1980) stated that as a crop it is well adapted and as a food it is readily accepted. It is cultivated in about 80 countries, extending from the tropical to the temperate zones. Gibbons (1980), estimated that nearly 18.92 million hectares were planted with groundnut during 1978 and 18.87 million tonnes were harvested giving a mean yield of 998 kg per hectare. Asia is the largest producer (10.9 million tonnes) followed by Africa (5.2 million tonnes), North and Central America (1.98 million tonnes) and South America (0.8 million tonnes). Of the individual countries, India is the largest producer in the world (6.2 million tonnes), followed by China (2.8 million tonnes), U.S.A. (1.8 million tonnes), Senegal (1.0 million tonnes), Sudan (0.8 million tonnes) and Nigeria (0.7 million tonnes). Approximately 80 per cent of world production comes from the developing countries. Sixty seven per cent of the total is produced in the semi-arid tropics.

Groundnut is well known as the king of oilseeds in India because it constitutes about 60 per cent of the total oilseed production in the country. Fluctuations in the production of groundnut, therefore, influence the availability and price of oil in the market (Patil, 1978). Hence the oilseed economy of India is dependent on groundnut production. The importance of groundnut as a major oilseed crop of the nation needs no emphasis. The country had made significant achievements in the production of cereal grains and is self-sufficient in food grain production, thanks for the 'Green Revolution'. But because of shortage in oilseed production, considerable amount of foreign exchange is being spent on the import of oils. In fact the import bill of oilseeds is now even more than that of grains earlier (Bhumbala, 1979).

Groundnut production in India suffers from proverbial instability and low yields. But the rapid spread of the crop in our country, though a relatively recent introduction, accounts for its wide adaptability (Prasad and Kaul, 1980a). It is well known that groundnut is an unpredictable legume and Patra (1980) stated that its performance depends upon the action and interaction of a number of factors. The groundnut plant is much different from others essentially due to the fact that it possesses a combination of perenniating habit and subterranian pod bearing nature which essentially promote survival than productivity as evidenced by its long evolutionary history. Added to this, lack of clearcut relationship between canopy characters and yield components comes in the way of development of appropriate selection criteria in breeding work (Prasad and Kaul, 1980a).

The average yield of groundnut in India at the present is around 820 kg of pods per hectare as compared to the very high yield levels obtained in Israel (2857 kg/ha) and U.S.A. (2603 kg/ha). Being a major oilseed crop, the low yield levels of groundnut are reflected in the per capita consumption of vegetable oil in India which is only 3 kg per adult per annum as against the consumption requirement of 11 kg recommended by the National Commission on Science and Technology. To set up the yield levels of this crop, Reddy (1980) stressed the need for strengthening of research efforts, particularly on the varietal front. Between 1951 and 1971, the average yield of groundnut pods in U.S.A. rose from 935 kg/ha to 2293 kg/ha and today yields of over 5500 kg/ha are not uncommon there (Prasad and Kaul, 1980a). In India, Singh (1979) reported that the productivity of groundnut, as a result of research and developmental activities, increased from 642 kg/ha in 1952 to only 772 kg/ha in 1968. Peanut is now grown under varied situations of soil, climate, seasons, crop combinations as well as sequences in India. The arena is expected to be wider with the newer cultivars as stated by Misra (1980).

Ramanathan (1980) pointed out that plant habit in groundnut deserves attention of plant physiologists and breeders alike. It is our experience that most of the cultivars are excessively vegetative for the yields they give and there is waste of considerable energy for unproductive purposes. It is therefore necessary to spell out the plant type in groundnut that would be more efficient in utilizing the nutrients from soil and solar energy. Investigations on the development of optimum canopy structure conducive to maximum pod formation per unit area will be rewarding as suggested by Misra (1980).

In India, breeding for earliness was specified as an objective in groundnut improvement even by early workers such as Singh (1952) and Seshadri (1962). Nair (1978) had brought out that in Kerala, there is considerable scope for cultivating groundnut in non-traditional areas such as intercrop in coconut gardens, companion crop with tapioca and catch crop during third crop season (Summer) in double crop paddy fields. He emphasised the urgent need for evolving short duration varieties for rice fallows. Nigam et al. (1980) had indicated that groundnuts which mature earlier than the current cultivars and possessing high yield potential, together with good quality will be highly useful in areas of semi-arid tropics which have short growing seasons. Gibbons (1980) had also aptly stated that there is scope for fitting early maturing groundnuts into relay or sequential cropping systems, particularly in South East Asia by utilizing the residual moisture after the harvest of the rice crop. The importance and significance of early maturing groundnut varieties to meet the requirements of multiple cropping in rice fallows had also been stressed by Ramachandran et al. (1980).

The crop sequence trials conducted at the Rice Research Station, Kayamkulam (Kerala) had proved that groundnut can be grown profitably as a third crop in the rice fallows of Onattukara in Kerala (Anon., 1979a). The trials in farmer's fields conducted by the Kerala Agricultural University, through the Village Adoption Programme, had demonstrated the possibility for extensive cultivation of groundnut as a commercial crop in the rice fallows. The trials conducted under the National Demonstrations have also exposed similar possibilities (Anon., 1978c). The paddy-paddy-groundnut sequence has opened new vistas in the production of groundnut in this State. It is projected further that there are about five lakh hectares under rice fallows in Kerala, out of which two lakh hectares can immediately be brought under groundnut (Anon., 1978b).

Sasidhar (1978) found that maximum economic returns were obtained from the cropping pattern rice-rice-groundnut in wetlands. The groundnut crop showed maximum efficiency in the utilization of phosphorus and potash for dry matter production. Also the highest protein yield was obtained from rice-rice-groundnut cropping pattern. This cropping pattern, in general, also improved the physical and chemical properties of the soil. He concluded that rice-rice-groundnut was the most efficient and suitable cropping pattern for the wetlands.

No doubt, summer rice fallows in Kerala presents immense scope for groundnut production. However, to have an appreciable coverage, high yielding short duration varieties, maturing in 90 days or less with compact shallow burried pods, are a badly felt prerequisite. Despite the fact that breeding work in groundnut was carried out for over the past five decades and breeding research was given the place of priority in the multi-disciplinary approach under the coordinated set up, the progress is but limited as indicated by Dorairaj (1980).

The literature pertaining to the various aspects covered in the present investigation is abundant. Therefore only relevant literature on groundnut in tune with the objectives of the work are reviewed.

A. Genetic Resources

It is well known that the success of modern cultivars, the population explosion and the disturbances of the ecosystem have together tended to reduce the genetic variability in plants available to man. The plant breeder, to meet the demands of the grower, processor, distributor and consumer, has reduced the genetic diversity in crop species. This has often resulted in increased genetic vulnerability in crops and this tempted Rao (1980) to remark that plant breeders have become the victims of their own success. The suggestion made by Jensen (1967) that genetic and phenotypic diversity of crops should be accepted as a desirable goal in plant breeding programmes, can be taken as complementary to the above remarks.

Rao (1980) pointed out that with modernization and urbanization, the natural environments of wild and weedy species have been disturbed and some have become extinct. Natural habit destruction, which occurs only slowly, can be seen happening today in South America as far as Arachis species are concerned. It is imperative that whatever genetic diversity remains should be assembled and conserved. This may be for immediate utilization in crop improvement or for future utilization when the situation is expected to be even more alarming. Harlan (1976) has indicated the limitations of our potential genetic resources in the light of the possible genetic wipe out of the centre of diversity and Hawkes (1979) clearly described the way in which such a wipe out may occur. The genetic diversity in cultivated groundnut has been continuously eroded in the groundnut growing countries since crop improvement work started.

Arachis genetic resources include all the wild species and the cultivars. Genetic improvement of any crop is dependant upon the availability of germplasm resources. Quite often groundnut breeders in India complain of lack of genetic variability in this crop and therefore much progress could not be achieved in varietal improvement (Reddy, 1980).

Efforts have been made to collect and conserve the groundnut germplasm at a few places around the world. Germplasm collections are being maintained at 7 centres in U.S.A., 2 each in Argentina, Brazil, Senegal, Israel and India and one each in Venezuela, Nigeria, Malawi, South Africa, Zimbawe, Sudan, Japan, China, Indonesia, Australia and Malayasia. Realising the urgent need to collect and conserve genetic resources, to cope with the present and future groundnut improvement programmes, the International Crop Research Institute for the Semi-Arid Tropics (ICRISAT) at Hyderabad, India, has been designated by the Consultative Group on International Agricultural Research (CGIAR) as the major repository for Arachis germplasm and has been charged with responsibilities of genetic resources activities. Upto mid-1980, 8498 accessions have been assembled at ICRISAT, apart from 1536 accessions under quarantine inspection (Rao, 1980). The Directorate of Oilseed Research, India, at Hyderabad has shared its collection of 4948 entries with the ICRISAT. The National Research Centre for Groundnut (India), started functioning very recently at Junagad, Gujarat, is being developed as the second important centre for maintenance and evaluation of germplasm in the country (Singh, 1980).

(i) Collection

Groundnut is a crop introduced into India during the first half of the sixteenth century. Its speedy spread in this country accounts for its remarkably high level of adaptability. Obviously there are no indigenous land races in the country and the ones which have been adopted for cultivation are a few from the wide array of genetic material scattered in the world. There is urgent need to evaluate under local conditions, promising and high yielding cultivars from those countries where unit area production seem phenominal as compared to ours (Misra, 1980).

Norden (1980a) stated that introduction and selection is still a satisfactory means for genetic improvement in groundnut. The cases of successful introductions are many. In India, where groundnut is now cultivated and produced to the maximum, it is an introduction. Baily (1968) estimated that 75 to 80 per cent of the peanuts grown in U.S.A. were derived wholly or in part from groundnuts introduced from other countries.

The Waspada cultivar maturing in 4 to 6 months, when introduced into Java by Holle in 1875, has completely replaced native cultivars maturing in 8 to 9 months (Hammons, 1973). 'Mukula Red', a 'green revolution variety', when introduced into Zambia and Rhodesia from U.S.A. proved to be a miraculous success (Smartt, 1979). The famous mutant variety of Gregory, 'NC-4X', was introduced to almost all groundnut growing countries of the world. Asirya Mwitunda, Small Japan, Spanish, Exotic-I and Exotic-5 are a few among a large number of notable introductions made to our country. The varieties now under recommendation in Kerala - TMV-2, TMV-7, Pollachi-1 are all introductions from the neighbouring state of Tamil Nadu.

Dorairaj (1979) stated that the foundation for any breeding programme is in the maintenance of a germplasm bank. A properly planned crop improvement programme will, no doubt, start with the assemblage of an exhaustive germplasm containing maximum variability.

(ii) Evaluation and testing

Norden (1980a) pointed out that to accomplish the development of improved cultivars the breeder must have a clear knowledge of the botany, genetics and ecological requirements of the crop. He should establish sound breeding objectives, collect or create a range of genetic variability and develop or devise the most suitable breeding method to fulfill the objectives. He further stated that the heart of a breeding programme is the evaluation or screening of the breeding materials.

The genetic resources collection, maintenance and conservation have significance in elucidating taxonomic status and evolutionary relationships between and within the species. But the main justification for genetic resource conservation is for utilization in crop improvement. At ICRISAT, a multidisciplinary approach is followed and the available groundnut collection is evaluated by all the groundnut scientists (Rao, 1980).

Groundnut varieties are relatively insensitive to day length. So cultivars developed any where in the world can be evaluated at any latitude as suggested by Vernell and McCloud (1975). Rao (1980) had stressed that collection and evaluation are pre-requisites before varieties are properly utilized in crop improvement programmes.

Dorairaj (1980) had brought out that the yield performance of one and the same variety varies considerably from place to place and from season to season. In groundnut, stability in yield appears to be an important problem. He pointed out that multilocation tests are essential and stability parameters should be worked out to identify stable and promising varieties. This might have lead Hammons (1976) to suggest that the key feature of the breeding system should be incorporation of environmental stability while retaining genetic diversity.

Rao (1980) while discussing on the genetic resources at ICRISAT, has stated that the key to successful utilization of variability from broad genetic pools requires the knowledge of desirable traits available in the germplasm. This requires a systematic evaluation of the germplasm.

For rapid multilocation testing of promising material and to assess its suitability for different agroclimatic zones or adaptability at national level, a four-tier system of testing was formulated by Singh (1980). According to this, each genotype has to be tested in the first and second stage - Initial Yield Evaluation Trial (IYET) and Preliminary Varietal Trial (PVT) - each at a minimum of one season. Two seasons trial at the third stage of Co-ordinated Varietal Trial (CVT) and one season at the final stage of National Evaluation Trial (NET) have been fixed as optimum.

By x-ray irradiation on the variety, Spanish Improved, six mutant varieties viz., TG-1, TG-2, TG-3, TG-4, TG-5 and TG-6 were developed at the Biology Division, Bhabha Atomic Research Centre, Trombay, Bombay (Patil and Thakare, 1969). Large scale yield trials with these mutants were conducted at Talaja, Gujarat, during 1967 and 1968. Three of the mutants produced over 19 per cent increased pod yield. TG-1 consistently yielded 25 per cent more which was statistically significant at 1 per cent level of probability. In a comparative yield trial of three mutant varieties, viz., TG-I, TG-3 and TG-17 including local check by Patil (1978) at farmers field, found that all the three mutant varieties are far superior than the locals. TG-1 under irrigated condition gave yield as high as 5000 kg/ha and TG-3, 4500 kg/ha while the check varieties yielded 3200 kg/ha and 2000 kg/ha respectively.

In a varietal trial involving seven varieties, conducted at the Rice Research Station, Kayamkulam, Gangapuri had yielded highest green pod yield (8739 kg/ha) followed by TMV-2 (7844 kg/ha) and Pollachi-1 (7483 kg/ha)(Anon., 1978a). A comparative evaluation trial to identify the best variety for the partially shaded coconut gardens under rainfed conditions, laid out at the Research Station and Instructional Farm, Mannuthy, Kerala, showed that all the four varieties tried, viz., TMV-2, TMV-7, Pollachi-I and Pollachi-2 were on par in pod yield, though Pollachi-1 had yielded the maximum (Anon., 1979a).

In the National Elite Trial of bunch types with 8 entries, the highest yield of 2192 kg/ha was given by J-11 (Anon., 1980c). The shelling percentage was the highest in X-1-21-B with 78.75. Dh-7 gave the highest yield of 2784 kg/ha followed by TG-17 with 2551 kg/ha and OSN-2 with 2476 kg/ha in the Initial Evaluation Trial with 19 entries. In the Multilocational Trial of bunch varieties, an entry from Dharwar, 2-18 gave the highest yield of 1977 kg/ha followed by Ah-8312 giving 1961 kg/ha. A large scale yield trial revealed that Dh-42 in group-I and Dh-40 in group-II gave the maximum yield of 2250 kg/ha and 2341 kg/ha respectively.

Through an Initial Evaluation Trial of 16 spanish bunch entries at 14 locations, the Culture J-1, besides giving the maximum mean yield of 1540 kg/ha, ranked first at 6 locations, second at 2 locations and third in one location. In another trial consisting of 10 entries at 12 locations, the culture G-201 (of Uttar Pradesh) has ranked first in the mean yield of pods (1402.2 kg/ha) followed by Robout-33-1 (1381.4 kg/ha). The national check, M-13 ranked first with 1379.6 kg/ha in an Initial Evaluation Trial of 10 Virginia runner types in 13 locations. In the natioal trial of Virginia bunch varieties/cultures with 5 cultures, laid out at 12 locations, the culture 28-206 of Kadiri (Andhra Pradesh) proved to be promising (Anon., 1980 d).

Bolton (1980) reported that the results of yield trials carried at four sites in Tanzania in 1978-79 with 12 varieties showed that the culture 69-62-2-5 was top ranking with an overall mean of 1342 kg kernel/ha followed by 70-1-1-1 with 1337 kg kernel/ha. In another trial with 10 varieties at four locations, during 1979-80. he noted that the culture 69-62-2-5 was top ranking in kernel yield. During the 1980 trial with 16 entries, at two locations, 69-62-2-5 was the most promising with a mean yield of 1865 kg kernel/ha.

By a varietal trial in Senegal for five years from 1975 to 1979 with four varieties, Gautreau and De Pins (1980) concluded that the variety 57-422 was having the highest mean yield. In another trial, they reported that V-55 had given 47 per cent more yield than the best control line. Recently a number of introductions were made to Senegal and a varietal trial with seventeen introductions for four years from 1976 to 1979 revealed that Starr, 57-422, Spanhoma and TG-7 are promising. In yet another trial of introduced materials for five years from 1975 to 1979, the varieties found superior were Tifspan, Spancross and Comet.

Nigam et al. (1980) reported that a trial of 11 selections under low fertility and rainfed conditions in 1979 showed that FESR 8- P 12-B1-B1-B1 ranked at the top. From an yield evaluation of six advanced cultures, they could isolate very high yielding ones with an average yield of more than 3800 kg/ha. Considerable differences were noticed in yield and shelling percentage among eight natural hybrid selections from the parent variety Robout 33-1 and some of the selections were superior to the parent.

In a preliminary yield trial with 8 cultures, Patra (1980) reported that OG-9-5 yielded the maximum with 1954 kg/ha and OG-71-3 ranked second with 1710 kg/ha. But in the comparative yield trial, OG-71-3 was found top ranking followed by OG-3-24.

Ramachandran and Venkateswaran (1980) had evaluated 'Gangapuri' with six other varieties at Tindivanam, Tamil Nadu. Gangapuri ranked first with 64 per cent more yield than the check TMV-9 in kharif 1973 but in 1974 its yield was 13% less. They reported that Gangapuri showed great variability in germination, pod yield per plant, 100 pod weight, plant height, pigmentation of the stem, size and colour of the leaves, size of pod and kernel and colour of testa. This according to them indicated the prevalence of residual heterozygosity in the variety.

Yield trials in Malawi by Sibale and Kisyombe (1980) involving 4 varieties revealed that E385/1/4A in 1977-78, E879/6/4 in 1978-79 and Chalimbana in 1979-80 were top ranking with average pod yield of 5089 kg/ha, 4829 kg/ha and 3096 kg/ha respectively. While assessing the average yield response of two groundnut varieties under different management practices, Singh (1980) reported that the recommended package of practices gave 33.23% with M-13 and 37.31% with PG-1 over the local practices.

A bunch culture Ah-316/S, maturing in 85 days was isolated from the cross TG-3 x AH-8068 by Sridharan et al (1980). The comparative performance of this culture with better parent TG-3 and standard strain TMV-9 showed that its yield was far below than that of TG-3 and slightly less than that of TMV-9 also. Attempts are under way to step up yield potential of this culture by further breeding.

In a Comparative Yield Trial with 13 varieties at 9 centres, Co-1 occupied the 1st rank at 4 centres, TMV-2 at one place and GAUG-1 at one centre (Anon., 1981a). In another Comparative Yield Trial involving 11 new entries, conducted at 10 locations Robout 33-1, Dh-3-20, J-11, TG-14, G-201 and X-1-21-B proved to be better varieties. Based on the overall performance, Robout-33-1 and Dh-3-20 were observed to be superior to the national check J-11. In an AICORPO-ICRISAT Co-operative Yield Trial with 17 ICRISAT cultures, No.15 was superior to Robout - 33-1 as judged from the overall performance, although the difference was not statistically significant at any of the centres (Anon., 1981a).

B. Biometric Analysis

Evolution of superior genotypes, as in any other crop, is the prime responsibility of the groundnut breeder. Selection is an intrinsic part of this process. The application of statistical techniques to biological investigations, the quantitative biology now termed as biometrics, has aided the breeder to reliably understand the polygenic basis of economic characters which generally exhibit continuous variation.

To improve yield, a complex character, information on the nature and magnitude of variation in the available material, association of characters with yield and among themselves and the extent of environmental influence on these characters are necessary. Fisher (1918) illustrated how biometrical findings could be interpreted in terms of Mendelian factors and this served as the foundation of Biometrical Genetics.

A sizable part of the phenotypic variation is caused by environmental influences. The phenotypic variability is the result of variability in the genetic constitution of the individuals in a population - the genotypic variability upon which superimposed is the variability due to the effect of environment in which the individual genotype perpetuates and survives. Swaminathan (1969) stated that variability for any character occurring in a population is conditioned to a great extent by the selection sieves-natural and human, through which the population has passed during its phylogenetic history.

According to Evans (1978), each physiological or morphological character may affect yield in many ways, the net effect of which depends on other characters and environmental conditions. Selection based on yield alone is usually not very efficient, but when based on its component characters as well, could be more efficient.

(i) <u>Scope</u>

Estimation of variability and relationship among the characters is done by using various genetic parameters. The genetic or heritable portion of the phenotypic variability can be assessed by the genetic parameters such as genotypic coefficient of variation, heritability and genetic advance. Panse (1957) had showed that high heritability and high genetic advance indicate genetic control with additive genes.

Different characters of a plant are often associated. This may be either due to pleiotropy or due to genetic linkage (Harland, 1939). The coefficient of correlation give a measure of the relationship between two characters and those characters related to yield can be of use to the breeder in making effective and dependable selection. In this context it appears relevent to quote Leopold and Kriendemann (1975), "although species vary enormously in their assimilative abilities, growth control inherent in plants still exert powerful effects over their general performance. Physical inputs sustain growth, but biological regulation dictates the pattern of its utilization and ultimate expression. If we are to understand the nature of this regulation at a whole plant level and appreciate the interaction between plants and their environments, we need more detailed measurements than simply final yield".

The utility of correlation studies is very high in a crop like groundnut where the yield factor is concealed. The requirement of more and more studies in this line is justified by the statement made by Prasad and Kaul (1980 a) that lack of clearcut relationship between canopy characters and yield components comes in the way of development of appropriate selection in breeding work.

(ii) Variability

Plant breeding in a sense is the efficient management and utilization of variability. Frankel (1970) pointed out that variation is the essence of like and genetic variation is universal. The restriction to variation tends to limit the evolutionary potential. The survey and assessment of genetic variability is a primary requirement of plant breeding programmes.

Venketeswaran (1966) reported considerable variation in yield, flower production, weight of haulms and total leaf area per plant in the spreading type. In the semi-spreading type, number of kernels per plant and yield showed the maximum variation. The height of main axis, total leaf area per plant, weight per kernel and yield showed marked variation in the bunch type. Chandramohan et al. (1967) noticed profound variation in number of mature pods, weight of haulms and yield. Fiftynine errect types of groundnut were studied by Jaswal and Gupta (1967) to evolve selection criteria. They observed high variability in total branch length, number of primary branches, number of needles (pegs), number of mature pods, pod weight and finally the yield.

During their study Basu and Ashokraj (1969) found high genotypic coefficient of variation for number of days to flower, number of pods and haulms weight per plant. A comparatively high genotypic coefficient of variation was recorded by Majumdar et al. (1969) for number of branches, number of leaves, number of nodes, number of peg bearing nodes, number of pod bearing nodes and pod length.

In the errect group, Sangha and Sandhu (1970) noted high genotypic coefficient of variation for number of secondary branches, number of primary branches, number of fruiting nodes per secondary branch and number of nodes. Similarly for grain (kernel) weight, number of pods, yield of pods and number of one seeded pods in the spreading group of varieties. High genotypic coefficient of variation was recorded for number of secondary branches, green and dry weight of mature pods by Dixit et al. (1971). In a study with 30 spreading varieties, Khangura and Sandhu (1973) found that the phenotypic coefficient of variation was high for pod yield and pod number and moderate for number of fruiting nodes per secondary branch, number and length of primary and secondary branches, lateral spread and 100 seed weight. But for shelling percentage, seed protein and oil content, the phenotypic coefficient of variation was low.

Kushwaha and Tawar (1973) while analysing various characters reported high to moderate genotypic coefficient of variation for days to 50 per cent flowering, height of main axis, number of mature pods and dry weight of fodder. Days to maturity, 100 pod weight, shelling percentage and percentage of oil had only low genotypic coefficient of variation. Mohammed et al. (1973) recorded high coefficient of variation for kernel weight and shelling percentage in semi-spreading and spreading types respectively. In the spreading groundnut varieties, Sangha (1973) obtained the highest estimates of phenotypic and genotypic coefficient of variation for 100 kernel weight and number of pods per plant. Shettar (1974) found high genetic variability for number of secondary branches, total number of nodes in secondary branches and number of pods, in his study of the variability pattern and formulation of selection index for yield. In the analysis of genetic variability in certain metric traits, Sivasubramonian et al. (1977) noticed high values for genotypic coefficient of variation for height of main stem and number of pods per plant. This showed that these characters can be relied upon for selection.

After an elaborate study of variability of 100 kernel weight and shelling percentage in 234 bunch, 170 semi-spreading and 268 prostrate (spreading) varieties, Natarajan et al. (1978) concluded that variation in kernel weight was generally higher in semi-spreading and prostrate varieties while variation in shelling percentage was the highest in prostrate varieties. High variability in harvest index was noted by Natarajaratnam (1979). It ranged from 20 to 47 in bunch, 3 to 31 in semi-spreading and 10 to 22 in spreading varieties. Shany (1979), after studying nine varieties and five crosses reported that protein and oil content varies considerably. The highest protein content (30 to 31%) was obtained from spanish and valencia types. The oil content ranged from 50 to 58 per cent.

Norden (1980 a) had stated that there is considerable amount of variability available in the cultivated species, especially in morphological and chemical characteristics. The oil content of different types varied from less than 40 per cent to over 60 per cent and the fatty acid composition of the oil of the different lines also showed considerable variability.

Rao (1980) had raised 220 bunch varieties in a randomised block design with two replications at the Regional Research Station, Raichur, during kharif 1977-78 to assess the range of variation. The yield of pod, number of pods, number of nodes in the main axis, shelling percentage and 100 seed weight showed wide differences between phenotypic and genotypic coefficient of variations. The phenotypic coefficient of variation ranged from as low as 2.37 for leaf breadth to as high as 129.00 for pod yield. The genotypic coefficient of variation varied from 1.38 for leaf breadth to 51.00 for shelling percentage. He pointed out that the influence of environment on these characters is appreciable.

Venketeswaran (1980) examined the variability in a number of lines/varieties belonging to the three habit groups, viz., spreading, semi-spreading and bunch. Yield was taken by him to mean the yield of kernels, being more steady and reliable than yield of pods. He found that the pattern of variability in the different characters varied among the three habit groups and among the different varieties of one and the same habit group. This made him to suggest separate discriminant function for each habit type. It is reported by Venketeswaran et al. (1980) that considerable differences in harvest index exist between different varieties. Varietal variations in physiological efficiency have also been reported. The strain Co-1 has high harvest index of

50.1 per cent, whereas Gangapuri has a low harvest index of 35.2 per cent. Ah-35 is reported to be a highly physiologically efficient variety. They have noted that shelling out-turn is a highly variable genetic character influenced considerably by environmental factors.

In the analysis of yield components for making selection index, Kuriakose (1981) recorded significant differences in respect of all the fifteen characters studied, namely pod yield, height of main axis, number of primary branches, number of leaves, days to 50 per cent flowering, duration to flowering, number of flowers per plant, number of productive nodes, number of mature pods, dry weight of haulms, number of seeds per pod, 100 pod weight, 100 kernel weight, shelling percentage and oil content. High genotypic coefficient of variation was shown by 100 pod weight, 100 kernel weight, number of seeds per pod and number of primary branches whereas the value was low for days to 50 per cent flowering, oil content and shelling percentage. Pod yield showed moderate value for genotypic coefficient of variation, but higher values for environmental and phenotypic coefficient of variation. In the case of genotypic variance too, number of flowers per plant and 100 pod weight recorded high values. The genotypic variance was low for pod yield, number of primary branches, days to 50 per cent flowering, number of seeds per pod, shelling percentage and oil content. The environmental variance was highest for number of flowers per plant followed by number of leaves. At the phenotypic level, the variance was high for 100 pod weight, number of flowers per plant and number of leaves and low for number of primary branches, days to 50 per cent flowering, number of seeds per pod, shelling percentage and oil content.

In the F_2 of a cross between TMV-7 and Arachis villosulicarpa, Muralidharan et al. (1980) found that the variability was directed towards an association of attributes, desirable for selection in the light of the concept of new plant form in groundnut. The improved level of productivity was concomitant with the emergence of secondary branches and increase in the number of basal primary nodes. In their breeding studies involving Arachis hypogaea and A. monticola, Muralidharan and Raman (1980) observed that the average number of flowers produced in A. hypogaea (61.8) was far below than in A. monticola (349.9). TMV-7 produced 105.6 flowers while Pollachi-1 produced 99.0 flowers. The number of pegs per leaf axil also varied in the parents and hybrids. The number of pegs per plant showed a phenominal increase in the hybrids. The percentages of one seeded and two seeded pods varied among the different hybrids. In all hybrids, the number of pods realised, far exceeded the level of A. monticola. The weight of pods per plant in the spanish groundnuts varied from a minimum of 16.4 g in Pollachi-1 to a maximum of 31.9 g in OSN-1. In A. monticola it was 13.6 g. The hybrids presented a noticeable enhancement in respect of this trait, the maximum being 52.9 g in hybrids of OSN.2 as against 17.5 in the variety itself. The hybrid of OSN.1 gave only 29.3 g in contrast to the value of 31.9 g for the variety.

Ramanathan (1980) in his investigation in populations of an interspecific hybrid reported that genetic variance for days to flowering has been largely additive while that for number of branches to be largely of the dominance type.

In their studies in the F_1 and F_2 of six bunch varieties crossed each other, Sridharan and Marappan (1980) analysed height of main stem, number of primaries, number of secondaries, number of nodes in the main stem, length of primaries, leaf area, 100 kernel weight, number of pods per plant and yield of pods per plant. The genetic coefficients of variability were generally high for number of secondaries and pod yield. It was also observed that the genetic coefficient of variability was determined to a great extent by certain specific parental combinations since the differences in such combinations were found to be significantly large. The extent of variability noted in F_2 progenies was considerably large with transgressive segregations for most of the characters which would suggest polygenic control of these traits. Skewness for the characters, namely, height of main stem, number of secondaries and yield of pod was observed. The mean value and the variability noted in the backcross progenies indicated considerable amount of non-additive besides additive gene action. However, the predominant additive gene action involved for pod yield in most of the crosses revealed that this trait may be amenable for improvement through intensive phenotypic selection.

Prasad and Kaul (1980 b) studied M_2 generation after treatment with gamma rays, EMS and NMU in different doses and concentrations in TMV-2, J-11, JH-113, MK-374, RS-I and M-13. The M_2 mutants showed variability in number of branches, total number of nodes per plant, number of nodes per branch, average number of pegs per node, number of effective pods per plant and kernel yield per plant.

(iii) Heritability and genetic advance

Heritability is an index of transmissability of characters from generation to generation. It provides a measure of the value of selection for different traits in various genotypes. The total variance of a character consists of a heritable portion, an environmental portion and a portion due to genotype-environment interaction; the heritable portion in turn include the additive genetic variance which is fixable and the dominance and epistatic variances which are non-fixable. The term heritability was first introduced by Fisher (1918) and defined it as the ratio of the fixable (additive genetic) variance to the total genetic variance. Robinson et al. (1949) defined heritability as the "additive genetic variance in per cent of the total variance". Heritability was defined both in the broad and narrow sense by Lush (1940). Heritability in the broad sense estimates the percentage of total genotypic variance over phenotypic variance whereas in the narrow sense it is the ratio of additive genetic variance to total variance. The estimate of heritability is useful to the breeder for exercising selection based on the genotypic worth of a trait.

Bernard (1960) recorded that percentage of immature pods, weight per pod and shelling percentage have high heritability estimates than seed yield per plant. High heritability estimates for height of main shoot, number of branches, number of developed pods, number of undeveloped pods and total number of pods were noted by Kulkarni and Albuquerque (1967). In the analysis of variability Basu and Ashokaraj (1969) observed high heritability for days to flower, leaves per main stem, pods per plant and 100 pod weight; but moderate heritability for shelling percentage and haulms weight per plant. However, only low heritability was obtained for pod yield. Further, high heritability was found for number of days to flower and number of pods per plant. Haulms weight per plant showed moderate heritability with high genetic advance.

Majumdar et al. (1969) reported high heritability estimates for days to first flowering, period of flowering, number of branches, number of leaves, number of nodes, breadth and length of leaflets, number of peg bearing nodes, 100 pod weight, number of kernels per pod, length and breadth of pod and days to maturity. The number of pod bearing nodes and the shelling percentage had recorded moderate heritability while that of number of mature pods and pod yield had only low values. High heritability together with high genetic advance was shown by number of branches, number of leaves and number of nodes. This suggests that these characters are controlled by additive gene action. Dixit et al. (1970) observed that number of primary branches, green weight of mature pods, 100 pod weight, 100 kernel weight and average number of kernels per pod had high heritability values when compared to that for dry weight of mature pods per plant, shelling percentage, height and number of nodes on main axis and fodder weight per plant. Both high heritability and high genetic advance were shown by 100 pod weight and 100 kernel weight. Only a low value for genetic advance was recorded by green weight of mature pods, dry weight of mature pods and fodder weight per plant. Raman et al. (1970) reported high heritability and genetic advance for length of primaries, number of secondaries and yield of pod.

In the erect (bunch) group, Sangha and Sandhu (1970) obtained high value for genetic advance for number of secondary branches, number of primary branches, number of fruiting nodes per secondary branch and pod number. Same trend was maintained by grain (kernel) weight, pod number, pod yield and number of one-seeded pods in the spreading group. During the analysis of various characters, Dixit et al. (1971) noticed high genetic advance combined with heritability for height of main axis and number of secondary branches. Number of mature pods per plant had moderate genetic advance and low heritability. Very high heritability with low genetic advance was given by number of primary branches. In their studies on variability, Kushwaha and Tawar (1973) found high heritability for days to maturity, followed by 100 pod weight, days to 50 per cent flowering, 100 kernel weight and shelling percentage. Pod yield, number of mature pods and dry weight of fodder per plant recorded medium heritability values. Number of immature pods, number of primary branches, height of main axis and percentage of oil gave only low heritability values. They also reported very high genetic advance for yield of pod per plant, number of mature pods and 100 kernel weight. Sangha (1973) recorded high heritability and genetic advance for number of pods per plant and 100 kernel weight. While formulating selection index for yield, Shettar (1974) noted moderate heritability for pod yield and low heritability for number of mature pods.

Heritability in the broad sense and genetic gain were found to be high for yield per plant by Patra (1975), suggesting additive gene effects. In their assessment of the genetic variability in certain metric traits, Sivasubramonian et al. (1977) noticed high estimates of heritability and genetic advance for height of main stem and number of pods per plant. The results indicated that these characters can be relied upon for selection.

While studying the inheritance of yield components, Cahaner (1978) had reported high heritability for pod weight. As a result of their investigations on seven semi-spreading varieties, Dorairaj et al. (1979) observed high heritability estimates coupled with high genetic advance for number of flowers, yield of pod, 100 pod weight and 100 kernel weight. The height of main stem had high heritability value with moderate genetic advance. It was indicated that number of flowers, yield of pod, 100 pod weight and 100 kernel weight are useful in selection.

After analysing 220 bunch varieties, Rao (1980) reported that number of pegs and length of first primary branch showed highest heritability. Number of flowers, number of pods, nodes on the main axis, shelling percentage and yield showed moderate values of heritability. Leaf length and breadth showed high expected genetic advance whereas the number of pegs showed moderate value. He concluded that selection based on number of flowers, pegs and pods will be rewarding. In the studies with twenty six bunch varieties of groundnut, Kuriakose (1981) obtained high heritability combined with genetic advance for 100 pod weight, 100 kernel weight, number of seeds per pod and number of primary branches. Low values of heritability and genetic advance were given by dry weight of haulms, pod yield and height of main axis. Shelling percentage and days to 50 per cent flowering presented high heritability but low genetic advance.

In an interspecific hybrid, Ramanathan (1980) reported high estimates of heritability for days to flower and relatively low for number of pods and weight of pods per plant. While studying the F_1 and F_2 of six varietal crosses, Sridharan and Marappan (1980) found the highest heritability values for height of main stem, number of primaries and yield of pod per plant in TMV-9 x Dwarf mutant, number of secondaries in TG-3 x Ah-8068 and number of nodes on main stem in POL-2 x Ah.7522. In general, the value for genetic advance were fairly high for number of secondaries and pod yield. The crosses, TMV-9 x Dwarf mutant for plant height and number of primaries, POL-2 x Ah-8068 for number of secondaries, TMV-9 x Ah.7522 for number of nodes in main stem and POL-2 x Dwarf mutant for pod yield, recorded high genetic advance. It could be suggested, therefore, that for effective improvement of these traits, intensive selection should be practiced in these respective crosses. Since high heritability and high genetic advance in respect of most of the characters were observed in the crosses POL-2 x Dwarf mutant and TMV-9 x Dwarf mutant, exploitation of the progenies in these crosses for improvement of yield would be highly useful. They pointed out that the predominant additive gene action involved for pod yield in most of the crosses revealed that this trait may be amenable for improvement through intensive phenotypic selection.

(iv) Correlation

The economic networth of a crop is primarily judged from its yield which, in turn is dependent upon a number of several other characters. These characters are quantitative and are often controlled by a large number of genes which individually do not have pronounced effect and to a large extent obliterated by changes in the environment. It has been recognised that a knowledge of the relationships among these characters could provide the crop improvement programme, with a sound scientific basis.

Comstock and Robinson (1952) recorded that plant height, number of flowers and number of pods showed positive significant correlation with yield. In the analysis of yield and its related characters, Ling (1954) reported that number of pods per plant and number of seeds per pod have pronounced influence on yield. Mistra (1958) noticed strong association between yield, size of seed, number of pods and number of kernels per pod. In his attempt for the formulation of selection index for yield, Dorairaj (1962) found significant positive correlation of weight of pods with number of pods and number of secondary branches in the spreading variety TMV-1. Significant positive correlation was noticed for weight of pods with pod number, mean number of nodes in the primaries, height of main axis and number of nodes in the main axis in the bunch variety TMV-2.

While studying 75 spreading types, Jaswal and Gupta (1966) observed that pod yield per plant was positively correlated with the number of mature pods, total number of gynophores, number of secondary branches and the lateral spread. Mahapatra (1966) found positive correlation of yield with shoot weight, root weight and nodule number of the plant and negative correlation with shoot length. Chandramohan et al. (1967) reported that among the characters studied, number of mature pods and weight of plant (haulms) have high positive correlation with yield. These two characters also exhibited high association between each other. In an investigation with 4 varieties, Elsaeed (1967) recorded a negative correlation between oil percentage and seed weight.

Fifty nine erect (bunch) types were studied by Jaswal and Gupta (1967) for devicing selection criteria. They found that pod weight was correlated positively with number of primary branches, needles, mature pods and total branch length. In their study with 173 varieties, Lin and Chen (1967) noticed that number of pods per plant and average weight of pod had positive correlation of low magnitude. Prasad and Srivastava (1968) concluded that yield of unshelled nuts per plant was positively correlated with the number of branches, leaves, nodes, flowering nodes, pods per plant and 100 nut weight.

In 30 early erect varieties, Lin et al. (1969) analysed seven component characters and reported that number of pods per plant was negatively correlated in the autumn with length of main stem and positively in spring with the number of branches per plant. The length of internode was negatively correlated with the number of pods per plant and the shelling percentage but positively with average weight of pod. They also observed positive correlation between the number of pods per plant and yield of pods in autumn crop. The number of pods per plant was correlated with shelling percentage in the spring crop. Sanjeeviah et al. (1970) observed that number of nodes within 10 cm from the ground was positively correlated with pod yield per plant.

In the spreading group, Sangha and Sandhu (1970) noted that pod yield was negatively correlated with lateral spread and number of vegetative nodes per primary and secondary branch, but was positively associated with pod number in the erect (bunch) group. Pod yield was positively correlated with grain (kernel) weight but negatively with number of primary and secondary branches in the spreading group. A negative correlation between seed length and shelling percentage was noticed by Merchant and Munshi (1971) in a study involving 15 cultivars with erect growth habit.

Positive significant correlation of pod yield with number of pods, number of branches, shelling percentage, weight of kernels and 100 kernel weight were found by Dholaria et al. (1972). There was high positive correlation between number of pods and number of branches. Significant but negative association was seen between shelling percentage and 100 kernel weight. Khangura and Sandhu (1972), while studying genotypic and phenotypic correlation in 30 spreading varieties, concluded that pod yield had strong association with the number and length of primary and secondary branches, lateral spread, number of mature pods and shelling percentage.

Patil (1972) in his studies observed that kernel yield was highly correlated with number of pods per plant and days to flower. The coefficient of correlation between oil content and kernel weight was negative. While analysing various characters, Kushwaha and Tawar (1973) reported a strong positive correlation of pod yield with plant height, number of mature pods, primary branches and straw (haulms) weight and negative value with days to flowering and maturity. The coefficient of correlation between days to flowering and 100 kernel weight was positive. There was strong positive correlation between plant height and mature pods and number of primary branches and straw weight. It was noted that the number of mature pods was positively associated with number of mature pods was positively associated with number of immature pods, straw weight and shelling percentage. Significant negative correlation was exhibited by shelling percentage with 100 kernel weight and 100 pod weight. The correlation coefficient between the number of primary branches and straw weight was positive and significant.

Merchant and Munshi (1973) observed significant correlation between leaf length and breadth, pod length and breadth and seed length and weight. Patra (1973), in his studies found that fertility coefficient and pod yield were negatively correlated and concluded that a high yielding form will have shorter internodes at the flowering stage with a low fertility coefficient. Positive correlation between pod yield and 100 kernel weight was noticed by Sangha (1973). Mohammed et al. (1973) concluded that high oil content was positively associated with small kernels. Ooffelt and Hammons (1974) reported that yield of pod was having significant correlation with number of pods, flowers and plant height. Length of primary branch was also correlated with yield of pod.

It was noted by Shettar (1974) that pod yield was positively correlated with height of main axis, mean length of primary branches, number of secondery branches, number of nodes in secondary branches, number of mature pods and 100 seed weight. But pod yield was negatively correlated with number of days to flowering and shelling percentage. Strong positive association for days to maturity and shelling percentage with pod yield was found by Kumar and Yadav (1978) in their studies using 18 bunch strains. Nair (1978) in his studies with two bunch varieties (TMV-2 and TMV-9) recorded that yield of haulms, number of pegs per plant, number of pods per plant and 100 pod weight were significantly and positively correlated with yield. The yield and nine yield components were investigated by Dorairaj et al. (1979) in seven semi-spreading varieties. Significant positive correlation was observed between yield and number of mature pods. Positive and strong association was found between number of flowers per plant and number of primary branches. The height of main axis was seen positively and significantly correlated with 100 pod weight and 100 kernel weight. Mohammed (1979) reported positive correlation of maturity and pod size with seed yield. Shany (1979), based on his studies with 9 varieties and 5 crosses, concluded that forms with a high protein content tended to have low oil content and vice-versa. He also found that oil content was positively correlated with percentage of mature pods and negatively with number of pods per plant and seed weight.

In a study of the germplasm of 220 bunch varieties, Rao (1980) recorded that number of pegs, length of first primary branch and leaf breadth were positively correlated with yield and the correlations were highly significant. Number of pods and flowers and plant height also showed positive significant correlation with yield. This suggested that selection for the above characters will be useful for achieving high yields. Venketeswaran (1980) examined the character association in a number of lines/varieties belonging to the three habit groups, viz., spreading, semi-spreading and bunch. The yield of kernels was taken by him to mean yield as it is more steady and reliable than yield of pods. He observed that the total correlation coefficients between the various morphological characters and the yield varied in magnitude and direction between the habit types. Hence he considered the three groups separately for formulating the selection indices. In the spreading type, yield was found correlated positively and significantly with kernel weight and negatively and significantly with the number of flowers produced. In the semi-spreading type, yield was positively and significantly correlated with the number of flowers and weighted total number of pods while negatively and significantly correlated with number of nodes on basal primaries. Significant positive correlation of yield with shelling percentage, height of main axis and weighted total number of pods was observed in the bunch type.

Kuriakose (1981) studied fifteen characters in twenty six bunch varieties and the association of these characters at the genotypic and phenotypic level were recorded. Genotypic correlation of pod yield was positive with number of primary branches, duration of flowering, number of productive nodes, number of mature pods, 100 pod weight, 100 kernel weight, shelling percentage and oil content. It was negative with height of main axis, number of leaves, days to 50 per cent flowering, number of flowers, dry weight of haulms and number of seeds per pod. Only the correlation coefficient of yield with number of mature pods and oil content were significant. All the characters except height of main axis and number of seeds per pod showed positive phenotypic correlation with yield. The correlation was significant with number of leaves, number of productive nodes, number of mature pods, dry weight of haulms and oil content.

Raman et al. (1970) reported high positive genotypic and phenotypic correlation coefficient between yield and number of primaries and shelling percentage in F_2 generation. Sandhu and Khehara (1977 b) recorded close association for pod yield with number of mature pods and number of secondary branches in a cross between C-501 and AK-12-24. But in a cross between C-501 and Ah-6595, pod yield was associated with number of mature pods and number and length of both primary and secondary branches. In a study of F_2 population of a cross involving a spreading and a bunch variety, Singh et al. (1979) noticed that pod yield was positively and highly associated with number of pods and 100 kernel weight and significantly with number of fruiting nodes per secondary branch. At genotypic level, primary branches, secondary branches, fruiting nodes per secondary branch, number of pods and 100 kernel weight were highly associated with each other. Pod yield had positive and highly significant partial correlation with number of pods and 100 kernel weight.

The phenotypic and genotypic correlation coefficients were worked out by Patra (1980) for 32 hybrid derivatives with three standards. Considering the yield components, none of the characters was significantly correlated with yield. Number of immature and mature pods per plant showed positive association with yield whereas shelling percentage and days to maturity were negatively correlated. Number of immature pods per plant showed very poor association. In general, genotypic correlations were higher than phenotypic ones except in the character pairs, number of mature pods per plant vs. pod yield per plant, number of immature pods per plant vs. average plant height and number of immature pods per plant vs. number of primary branches per plant. There was significant association between shelling percentage and average plant height; number of primary branches per plant and number of immature pods per plant and shelling percentage and number of pods per plant. All these character pairs were negatively correlated except shelling percentage vs. average plant height. In the populations of an interspecific hybrid, Ramanathan (1980) obtained significant positive correlation between shelling percentage and pod weight and kernel weight and percentage of well filled kernels. Correlation coefficients were computed between yield and yield attributes in the F_1 and F_2 of six varieties crossed each other by Sridharan and Marappan (1980). The coefficient of correlation of yield and total number of mature pods as well as with number of primaries indicated that these two characters may primarily be used for selection towards the improvement of yield.

Dorairaj (1979), while exploring the possibility of altering the nature of association of quantitative characters by individual and combined effects of hybridization and irradiation, concluded that irradiation of varieties increased the frequency of new character associations, but irradiation of hybrids brought about more instances of alterations in the strength of existing correlations. In the spanish type, yield of pods had positive correlation with number of pods and number of kernels. Positive correlation of yield with height of main stem, length of primary branches and negative association with shelling out-turn was observed in the M_3 of spanish. In valencia type, pod yield exhibited positive correlation with pod number and kernel number in the parent and this remained so in the M_3. In the virginia bunch, yield of pod was positively correlated with pod number, kernel number and reproductive efficiency in the parent as well as in the M_3. But in the virginia spreading, in the parent and in the M_3, yield of pod showed positive and significant correlation with pod number and kernel number, while the M_3 gained significant association between yield of pods and mean length of primary branches and number of secondary branches. He suggested that the correlated response of desirable yield components can be taken advantage of by effecting selection for positively associated traits.

(v) Path analysis

Path coefficient analysis, developed by Wright (1921) is a standardised partial regression analysis, specifies the relative influence of one variable on another, besides partitioning the correlation coefficients into direct and indirect effects. It analyses the cause-effect relationship so that complex quantitative characters like yield could be understood in a simpler and better way. The two characters whose relationship is being measured, may not exist by themselves alone, but an intricate system of path way can be involved, in which various other attributes also contribute. Therefore, it would be desirable to separate out the direct contribution of each yield component and the indirect contribution it makes through its relationship with other attributes. This will aid the breeder as an efficient tool in effecting reliable selection.

Li (1955) further elaborated the basic features of the technique of path analysis and its applications. According to him, when the causal factors are uncorrelated, the path-coefficient is simply the correlation between the two variables concerned. The separation of the correlation coefficient into various components is one of the main utility of path-coefficient analysis. The implications and significance of this technique has been stressed by Bhatt (1973). Consequently path analysis has been done in quite a large number of crop plants.

In their studies with 59 errect varieties of groundnut over two seasons, Jaswal and Gupta (1967) observed that the number of mature pods per plant and total branch length are the most important selection criteria. Khangura and Sandhu (1972) in a study made on 30 spreading varieties noted that length of primary branch was the most important character having the highest direct effect on pod yield. It was seen that all other characters affected pod yield through this character. The path analysis studies in 60 spreading varieties made by Badwal and Singh (1973) revealed that number of mature pods per plant and 100 seed weight were the most important yield components.

Chandola et al. (1973) observed that the number of pods per plant was the most important character with high direct effect on yield. All the yield components contribute to yield through the number of pods per plant. The number of primary branches and green weight of pods too had a direct effect, while the number of secondary branches had a negative direct effect. It was suggested that number of pods per plant can be taken as an index for selection. In selecting for improved yield in varieties with a spreading habit of growth, Dholaria et al. (1973) found that branch number was more important, while pod number was more important for bunch types. The greatest contribution to kernel yield was made by pod weight per plant both in spreading and bunch types.

In his study with 26 bunch varieties, Kuriakose (1981) made a path analysis involving five characters, viz., number of mature pods, dry weight of haulms, number of seeds per pod, 100 pod weight and 100 kernel weight. Twenty six different combinations of the above five characters were analysed for path coefficients. The residual effect, which accounts the effect of other factors not considered in the causal scheme were also worked out. The number of pods had the highest direct effect in all the fifteen combinations wherever it was considered as a component. In seven other causal schemes where number of mature pods was not considered as a component, the highest direct effect was shown by 100 pod weight. In three other combinations 100 kernel weight expressed highest direct effect where number of mature pods and 100 pod weight were not considered. In the remaining one combination, dry weight of haulms showed maximum direct effect, but negative. He noted that number of mature pods and 100 pod weight showed the highest positive direct effect on yield. The direct effect were comparatively low and negative for dry weight of haulms, number of seeds per pod and 100 kernel weight. The indirect effect of number of mature pods through all other characters were positive except through 100 pod weight which was negative. Dry weight of haulms, number of seeds per pod and 100 kernel weight showed a negative indirect effect through all other characters except through 100 pod weight which was positive. The indirect effect of 100 pod weight through all other characters was negative. The causal scheme involving number of mature pods had the lowest residual effect.

In the crosses of semi-spreading x bunch and semi-spreading x semi-spreading, Sandhu and Khehra (1977 b) found that number of mature pods had the highest direct effect on pod yield, the contribution of the remaining traits being mostly through the number of mature pods. Oil content and protein content were found to be associated with almost all other characters; but not significantly. Singh et al. (1979) in their analysis of the F_2

population of a cross involving a spreading and bunch variety had shown that number of pods and 100 kernel weight had got the maximum contribution to pod yield.

C. Induced mutagenesis

Mutation breeding has been clearly defined as an important complementary method of crop improvement (Nair, 1971). Sigurbjornsson and Micke (1969) in a detailed analysis of the specific rôle of induced mutation in plant breeding have clearly projected out mutation breeding as one of the indispensable methods of plant breeding. Mutation studies have been carried out extensively in cereals like barley, wheat and rice. There are several reports on induced mutagenesis in groundnut. Excellent reviews were made by Gustaffsson and Gadd (1965), Gregory (1968) and Norden (1973, 1980 b). Only literature relevant to the present investigation are reviewed here.

(i) Scope

According to Hammons (1973), despite a long history of cultivation, broad subspecific variability and wide geographic distribution of the cultivated peanut, defects in its composition with respect to the requirements of man are wide spread and for many of these no remedial genetic resources are known to exist among its varietal forms. Therefore induced mutagenesis could form a potent genetic tool to develop new genes for various characters. As groundnut is generally relegated to marginal and submarginal holdings in our country, the genes for high yields have gradually eroded from the populations and have given way for the genes conferring adaptability (Reddy, 1980).

The groundnut plant is much different from others due to the fact that it possesses a combination of pereniating habit and subterranian pod bearing nature which essentially promote survival than productivity as evidenced by its long evolutionary history (Prasad and Kaul, 1980 a). The delicate floral structure, restricted recombination and heriditary instability are some of the factors frustrating the breeder's efforts through conventional breeding methods. Added to these are the limited natural variability for the economic characters (Rathnaswamy, 1980). Prasad and Kaul (1980 b) stated that a combination of breeding methods involving induced genetic variability and its further use in recombination breeding would be invaluable in groundnut improvement.

Attempts for groundnut improvement by induced mutagenesis has been numerous (Gustaffsson and Gadd, 1965; Gregory, 1968; Norden, 1973, 1980 b). The crop has a delicately balanced system of genetic units and a rugged biochemical system capable of polydirectional changes as stated by Gregory (1956 b). The embryo of dormant seed is well developed (Yarbrough, 1949) with several potential mutation sites. Groundnut has the capacity to be multimutable and yet maintain its phenotypic stability (Gregory, 1956 b, 1961).

Ashri and Goldin (1965) pointed out that the advantages and disadvantages that go with polyploids are felt in groundnut because of the presence of many duplicate loci. The multivalents and trivalents that were reported to occur at meiosis would also greatly influence the population dynamics and mutation frequency. The plant is highly autogamous and hence suited for mutation works.

In groundnut, induction of mutation has been proved to be a good means for obtaining useful genetic diversity (Gregory, 1956 b) and a potent source of genetic variation for certain specific characteristics (Norden, 1973). Misra (1980) suggested induced mutagenesis as a tool for breeding for earliness.

(ii) Mutagens

Both physical and chemical mutagens were employed by several groundnut mutation workers throughout the world; the most notable being the North Carolina group which include Gregory, the most eminent groundnut mutation breeder. Gamma irradiation was employed by Tuchlenski (1958), Shivaraj and Rao (1963), Sanjeeviah (1967), Menon et al. (1970), Prasad and Kaul (1980 b) and Ratnaswamy (1980). Other physical mutagens such as neutrons and x-rays were employed by Gregory (1955), Cooper and Gregory (1960), Bhatt et al. (1961), Bliquex and Martin (1961), Patil and Bora (1963), Emery et al. (1965), Patil (1966), Perry (1968), Arzumanova (1970), Patil (1976) and Sivasubramoniam (1979). Different chemical mutagens were used by various workers such as Ashri and Goldin (1965), ~~Ashri (1967)~~, Prasad (1972), Ashri and Levy (1974), Sivasubramoniam (1979) and Prasad and kaul (1980 b).

Differential response of genotypes to the various mutagenic agents and to varying doses were observed by Gregory (1956 b), Lin (1960), Bliquex et al. (1961), Loesch (1964), Ashri and Goldin (1965), Prasad (1972), Sivasubramoniam (1979), Dorairaj (1979) and Ratnaswamy (1980).

(iii) M_1 effects

The conspicuous M_1 effects reported were lethality, injury and sterility as in other crops. Bliquex et al. (1961) reported that irradiation with x-rays at 8000 R stimulated germination but at 40,000 R, the germination was reduced. Sivasubramoniam (1979) found a progressive reduction in germination with increasing doses of gamma rays in all the three varieties studied. Reduced germination following gamma ray irradiation was also reported by Dorairaj (1979). Ratnaswamy (1980) reported differential germination after irradiation.

Injury of various types resulting from irradiation were reported by many workers, the most common being a reduction in plant height (Gregory, 1957; Shivaraj and Rao, 1963; Patil, 1966; Gregory, 1968; Perry, 1968; Sinha and Roy, 1969; Sivasubramoniam, 1979; Dorairaj, 1979 and Ratnaswamy, 1980).

Following mutagenic treatment, the survival of plants was also found to be reduced and a linear dose-effect relationship was noticed by Bliquex et al. (1961), Patil (1966), Sanjeeviah (1967), Gregory (1968), Sivasubramoniam (1979), Dorairaj (1979) and Ratnaswamy (1980).

Increased pollen sterility consequent to mutagenesis was reported to be mostly dose dependent by Anon. (1960), Bhatt et al. (1961), Gregory (1968), Prasad (1972) and Mouli and Patil (1976).

(iv) Macromutations

Chlorophyll mutations of various sorts and other drastic morphological mutants of academic and economic significance have been reported by quite a large number of investigators.

Patil et al. (1963) described xantha and virescent mutants after x-irradiation. A number of chlorophyll mutants have been observed by Patil (1966). Gregory (1968) recorded chlorophyll mutants including 'light green' and 'albino'. Patil (1973 a) reported a chlorophyll deficient mutant, the 'chlorina'. Three chlorophyll deficient mutants - 'lutescens', 'aureus' and 'virescent' were described by Tai et al. (1977). Sivasubramoniam (1979) noted few chlorophyll mutations. He reported that chlorophyll mutation frequency showed an increase with the increasing dose of gamma rays. Further, the frequency of chlorophyll mutations varied significantly among the varieties.

Quite a large number of viable mutations have been reported by groundnut mutation breeders. Hammons (1953 a) recorded a 'Cup mutant' following x-ray treatments at 18500 R. This mutant was characterised by a complex of morphological features which were ascribed to pleiotropic effects of a single gene. The epoch making attempts of Gregory (1956a) with x-ray irradiation of about One lakh (one bushel) seeds, in the R_2, a large number of mutants were observed in a very large population examined.

Several morphological variants such as plants with creeping habit from bunch parent, plants with bushy habit from trailing parent, small leaved and dwarf types have been reported (Anon., 1960). Bhatt et al. (1961) noticed changes in growth habit, stem thickness and other morphological characteristics as a result of irradiation. The Israeli breeders, Ashri and Goldin (1965) found major deviants to growth habit affecting more than one character through diethyl sulphate treatment. They observed mutations involving two or three characters at a time and suggested that this may be a pleiotropic mutant with a syndrome effect.

The macromutants termed as 'Flab', 'Cup', 'Illex', 'Hedara' and 'Corduary' were described by Emery et al. (1965). They reported that the first three were simply inherited while the last two were inherited by duplicate recessive genes. Large number of mutations affecting plant height, leaf characters, floral parts and seed germinability have been isolated by Patil (1966). A multicarpellary mutant with pegs transformed into branches had been isolated for the first time by him.

Gregory (1968) recognised as many as 24 classes of visible changes due to x-irradiation, altering almost all the morphological characters. As a result of gamma irradiation, two mutants, viz., 'double vexellum' and 'Virescent', having changes in morphology and habit were described by Sinha and Roy (1969). Arzumanova (1970) had also recognised changes in morphological characters and habit after seed irradiation in M_2 generation. An x-ray induced monosomic was identified and described by Menon et al. (1970). A 'variegated' mutant was reported by Patil and Mouli (1975). Mouli and Patil (1976) have obtained a mutant with suppressed growth of primary branches and reduced pod setting.

While comparing the induced mutagenesis in homozygous and heterozygous genotypes, Doraizaj (1979) found that irradiation of hybrid seeds brings about the highest variability for all the characters, except reproductive efficiency. Irradiation of varieties increased the frequency of new character associations as a desirable effect. Dwarf-I and 'Gigas' mutants were first reported. Also mutants with foliaceous stipule, white bold seed, chocolate colour testa and early maturity were obtained.

Prasad and Kaul (1980 b) recorded a mutant with narrow leaves, increased number of nodules in the deeper areas of root zone, reduced susceptibility of leaf spots, increased pod number and non-dormant seeds. Also mutants with compact canopy, short internode, large number of pods, high yield and mutants combining a compact canopy with larger number of pods, worthy of exploitation, were isolated.

(v) <u>Micromutations</u>

The pioneering investigations undertaken by Gregory and his colleagues in North Carolina, U.S.A., on micromutations have paved the way for understanding the mutation events in a better way and to utilize the technique in attaining the goals of the plant breeder. Gregory started his studies in 1949 through x-ray irradiations in the virginia bunch variety, NC-4, Gregory (1961) recognised that irradiation frequently caused genetic background mutations which gave rise to a series of modifier mutations or micromutations. He analysed the effect of selection on yield, a quantitative character, among the progenies of randomly selected normal appearing mutant plants. A spectrum of deviation from normal existed within mutants and such a graded expression of the same mutation in different X_1 families of self pollinating plants was adduced to modifying effects of the background genotype. This lead him to hypothesise that 'the normal appearing members of irradiated population might be variously mutated with a large number of small individually inconsequential changes, which in the whole, form a sound basis for artificial and natural selection'. Thus the mutant grade variability resulted from a modification of the background genotype concurrently with the induction of major gene mutations. He stated that the ionising effects were polydirectional and quantitative in nature, affecting heritable changes in the polygenic system of the background genotype. His hypothesis was tested and proved to be correct by Loesh (1964), Emery et al. (1965) and Sivasubramoniam (1979).

(vi) Achievements

The first achievement in groundnut through mutation breeding was the evolution of the mutant variety 'NC-4X' by x-ray irradiation of the variety NC-4. The mutant variety was high yielding with better pod and seed quality than the parent (Gregory, 1957). Mutants resistant to leaf spot disease caused by *Cercospora personata* and *Cercospora arachidicola* were developed from X_2 and X_3 generations and the resistance was maintained over nine generations with high yield and fertility (Cooper and Gregory, 1960). Bliquex et al. (1965) reported a mutant with increased oil content.

Mutation research leading to the development of improved TG(Trombay Groundnut) varieties at the Biology and Agriculture Division of Bhabha Atomic Research Centre, India, is an illustration of research benefits to the nation (Patil, 1978). Quite a number of mutations were induced using x-ray irradiation in the variety Spanish Improved (Patil, 1966). Subsequently true breeding mutants and their sibs were screened for high yielding ability and other desirable attributes. This resulted in the isolation of six mutant lines which were afterwards released as mutant varieties, TG-1 to TG-6 (Patil and Thakare, 1969). Intercrossing radiation induced mutants was found to be useful and rewarding. New varieties, viz., TG-7 to TG-20 were selected during 1969-75 based on oil content, seed size, yield and maturity. TG-14 was evolved by hybridization between 'Darker green' and 'Virescent' mutant. TG-17 was obtained from the cross TG-1 X 'Darker green' and TG-19 from the cross TG-1 x TG-17. In a crop competition for groundnut organised by the Department of Agriculture, Karnataka, two farmers growing TG-3 and TG-14 have won first prize by producing 6000 kg and 5000 kg in Chitadurga and Davergere taluks respectively. In the field trials, six varieties, viz., TG-1, 3, 14, 16, 17 and 19 were found consistantly superior in Gujarat, Maharashtra, Karnataka and Madhya Pradesh. The exporters of HSP (Hand Picked Selection) grade groundnut are very much interested in TG-1 and TG-9 which are preferred for table purpose (Patil, 1978).

Popov and Dimitrov (1966) selected an early large fruited high oil groundnut. Dwarf mutant-I was reported as a promising groundnut variety by Yadav and Singh (1977). Through gamma ray irradiation of homozygous and heterozygous genotypes, Dorairaj (1979) could identify nine selections with yigh yield. Four of them had high shelling percentage and bold seed. The remaining five had high oil content. An early maturing mutant from Pol.1, worthy of exploitation was also recorded by him.

Sivasubramoniam (1979) isolated five high yielding mutant lines which recorded around 40 per cent increased yield than the check which confirms the effectiveness of selection for micro-mutations in increasing yield potential through induced mutagenesis.

Few economically viable mutants including a nondormant mutant, worthy of utilization was observed by Prasad and Kaul (1980 b). Two high yielding mutants, following gamma irradiation were identified by Ratnaswamy (1980).

MATERIALS AND METHODS

MATERIALS AND METHODS

Preliminary evaluation of varieties under upland conditions was conducted at the Department of Plant Breeding, College of Agriculture, Vellayani, during kharif 1980. The remaining experiments were conducted at the Research Station and Instructional Farm, Mannuthy, attached to the College of Horticulture, Vellanikkara, from summer 1981 to rabi 1982.

A. MATERIALS

The genetic material consisted of 93 varieties of groundnut collected from the following sources.

1) Forty three varieties from the Regional Centre, National Bureau of Plant Genetic Resources, Vellanikkara, Trichur.
2) Two varieties from Gujarat Agricultural University.
3) Two varieties from Punjab Agricultural University.
4) Three varieties from Groundnut Breeder, Agricultural College, Dharwad, Karnataka.
5) One variety from Groundnut Breeder, Khargone, Madhya Pradesh.
6) Twenty three varieties from the Agricultural Experiment Station, Tindivanam, Tamil Nadu.
7) Four varieties from Bhabha Atomic Research Centre, Bombay.
8) Four varieties from the Rice Research Station, Kayamkulam, Kerala.
9) Six varieties from the Assistant Oilseeds Specialist, Dholi, Bihar.

Thus a total of 88 varieties were collected as the first set of germplasm. Subsequently five more varieties were collected from the Regional Centre, National Bureau of Plant Genetic Resources, Vellanikkara, Trichur, making a total of 93 varieties.

These varieties included exotic and indigenous types coming under the habit group of spreading (8 Nos.), semi-spreading (13 Nos.) and bunch (72 Nos.). The list of groundnut varieties, their habit and source, are presented in table 1.

B. METHODS

a) Preliminary Evaluation.

The 88 varieties collected in the first set of germplasm were grown for preliminary evaluation in uplands during kharif 1980. Of these, 67 varieties were bunch in habit, 13 semi-spreading and 8 spreading. They were grown in single rows of 25 plants each with a spacing of 30 cm within rows and 50 cm between rows. All the 93 varieties were put to preliminary evaluation in wetland rice fallows during summer 1981.

Observations were made on germination, vigour, canopy, flowering, branching, leaf, pod and kernel characters, aerial pegging, root nodulation, seed dormancy and reaction to pests and diseases. Data on the following economic traits were collected.

1) Pod yield per plant

2) Haulms yield per plant

3) Duration upto maturity

b) Biometric analysis.

Eighty varieties were selected for biometric studies

Table 1. Groundnut varieties, their habit and source.

Type No.	Name of variety	Habit	Source (Centre of collection)
1.	EC.21127	Bunch	Regional Centre, National Bureau of Plant Genetic Resources, Vellanikkara, Trichur.
2.	EC.21118	,,	
3.	EC.24397	Semi-spreading	
4.	EC.116596	Bunch	,,
5.	EC.11064	,,	,,
6.	ICG-3859	,,	,,
7.	EC.21089	,,	,,
8.	EC.115546	Semi-spreading	,,
9.	EC.21126	Bunch	,,
10.	EC.24412	,,	,,
11.	EC.24420	Semi-spreading	,,
12.	EC.36892	Spreading	,,
13.	EC.115678	Bunch	,,
14.	EC.25188	,,	,,
15.	EC.24395	,,	,,
16.	EC.117872	Spreading	,,
17.	EC.39544	Semi-spreading	,,
18.	EC.21082	Bunch	,,
19.	IC.9811	,,	,,
20.	EC.36009	Semi-spreading	,,
21.	EC.24431	Bunch	,,
22.	EC.21095	,,	,,
23.	S-59-27	Semi-spreading	,,
24.	A-674	Bunch	,,
25.	S-7-5-13	,,	,,
26.	EC.2100	Semi-spreading	,,
27.	EC.21121	,,	,,
28.	EC.66134	,,	,,
29.	EC.24446	,,	,,
30.	EC.112027	,,	,,
31.	EC.36890	Spreading	,,
32.	B-353	Bunch	,,

continued..

Table 1(continued)

Type No.	Name of variety	Habit	Source (Centre of collection)
33.	EC.117873	Spreading	Regional Centre, National Bureau of Plant Resources, Vellanikkara, Trichur.
34.	EC.1132	Bunch	
35.	IC.9808	,,	
36.	EC.21079	,,	
37.	EC.20954	Spreading	,,
38.	EC.66138	,,	,,
39.	EC.35999	Bunch	,,
40.	EC.21052	,,	,,
41.	EC.119704	,,	,,
42.	AH-6915	,,	,,
43.	EC.24450	,,	,,
44.	GAU-1	,,	Gujarat Agricultural
45.	J-11	,,	University.
46.	M-13	Spreading	Punjab Agricultural
47.	M-37	,,	University.
48.	Spanish Improved	Bunch	Groundnut Breeder, Agricultural College, Dharwad, Karnataka.
49.	S-206	,,	
50.	Dh-3-30	,,	,,
51.	Jyothi	,,	Groundnut Breeder, Khargone, Madhya Pradesh.
52.	Exotic-6	,,	Agricultural Experiment Station, Tindivanam, Tamil Nadu.
53.	TMV-9	,,	
54.	TMV-10	Semi-spreading	
55.	No.297	Bunch	,,
56.	AH-8253	,,	,,
57.	AK-811	,,	,,
58.	EC.21078	,,	,,
59.	No.70	,,	,,
60.	USA-63	,,	,,
61.	G-270	,,	,,
62.	Russia-319	,,	,,

continued..

Table 1 (continued)

Type No.	Name of variety	Habit	Source (Centre of collection)
63.	TMV-12	Bunch	Agricultural Experiment Station, Tindivanam, Tamil Nadu.
64.	Almel No.1	,,	
65.	TMV-2	,,	,,
66.	KG-61-240	,,	,,
67.	USA-123	,,	,,
68.	TMV-11	,,	,,
69.	Pollachi-2	,,	,,
70.	AH-4218	,,	,,
71.	TG-3	,,	Bhabha Atomic Research Centre, Bombay.
72.	TG-14	,,	,,
73.	TG-17	,,	,,
74.	TG-19	,,	,,
75.	EC.21088	,,	Agricultural Experiment Station, Tindivanam, Tamil Nadu.
76.	Kanki-X-10-17	,,	
77.	Spanish peanut	,,	,,
78.	Red Spanish	,,	,,
79.	Pollachi-1	,,	Rice Research Station, Kayamkulam, Kerala.
80.	Exotic-1	,,	
81.	TMV-7	,,	,,
82.	Gangapuri	,,	,,
83.	Big Japan	Semi-spreading	Assistant Oilseeds Specialist, Dholi, Bihar.
84.	EC.20957	Bunch	
85.	No.293	,,	,,
86.	AH-4128	,,	,,
87.	Co.1	,,	,,
88.	Uganda local	,,	,,
89.	EC.21147	Bunch	Regional Centre, National Bureau of Plant Genetic Resources, Vellanikkara, Trichur.
90.	EC.38279	,,	
91.	EC.21125	,,	
92.	EC.21075	,,	,,
93.	EC.21070	,,	,,

from the ninety three available in the germplasm. They included exotic and indigenous types as well as improved and local varieties. They exhibited wide variability in morphological and metric characters and include 62 bunch, 11 semi-spreading and 7 spreading types (All types except Type Nos. 3, 5, 12, 25, 28, 41, 52, 72, 73 and 89 to 92 in table 1). These varieties were grown in a Randomised Block Design, replicated thrice during kharif 1981 in uplands. In each variety and replication, three rows of ten plants each were grown at a spacing of 20 cm within and 30 cm between rows.

Five observational plants were selected at random from each variety in each replication avoiding the border plants. The following characters were studied on these plants.

1. Duration upto flowering
2. Plant height on the 50th day
3. Number of branches on the 50th day
4. Number of leaves on the 50th day
5. Duration upto maturity
6. Number of flowers
7. Spread of flowering
8. Height of main shoot
9. Length of top
10. Number of basal primary branches
11. Number of branches
12. Fresh weight of pods
13. Haulms yield
14. Number of leaves

15. Number of mature pods
16. Percentage of pod set
17. Number of immature pods
18. Dry pod yield
19. Dryage percentage of pods

Data on the following characters were collected from bulk samples of dry pods in each variety and replication.

20. 100 pod weight
21. 100 kernel weight
22. Shelling percentage
23. Oil content

The study was repeated in wetlands during summer 1982.

e) Comparative yield trials.

On the basis of general adaptability, pod yield and other desirable attributes in the preliminary evaluation in uplands and wetland rice fallows, 30 varieties (Type Nos. 2, 6, 12, 25, 30, 32, 39, 41, 42, 46, 48, 50, 51, 52, 53, 54, 57, 65, 66, 68, 69, 71, 72, 73, 74, 79, 81, 82, 83 and 87 in table 1) were selected for detailed evaluation. Of these, 25 were bunch, 3 semi-spreading and 2 spreading. The trial in uplands was conducted during kharif 1981 in a Randomised Block Design with three replications. The plot size was 2.4 x 2.0 m with plants at a spacing of 20 x 20 cm.

Data on the following characters were collected from five plants per variety per replication, selected at random, avoiding the border plants.

1. Duration upto flowering
2. Duration upto maturity
3. Length of top
4. Number of branches
5. Number of mature pods
6. Number of immature pods

The following were assessed in the net plot of 2.0 x 1.6 m, leaving one row all around as border.

7. Fresh weight of pods
8. Haulms yield
9. Dry pod yield

Data on the following traits were recorded on random samples in each variety in each replication.

10. 100 pod weight
11. 100 kernel weight
12. Dryage percentage of pods
13. Shelling percentage
14. Oil content
15. Protein content

The trial was repeated as such in the rice fallows during summer 1982.

d) Details of characters studied.

The methods followed for the study of the different characters are detailed below.

1. Duration

Duration upto flowering was the number of days from sowing to the first appearance of flowers on observational plants.

Duration upto maturity was the number of days from sowing to the date of maturity of observational plants. In arriving at maturity, the appearance of plants, senescence of leaves, nature of pods, shell characters, pod filling, kernel characters and the internal colour of the shell were considered.

2. Plant height on the 50th day

Height was measured from the base to the tip of the plant on the 50th day after sowing on observational plants.

3. Number of branches

The total number of branches were counted on the 50th day after sowing on observational plants.

The number of branches on the main stem upto a height of 10 cm from the cotyledonary node were counted at the time of harvest on observational plants and recorded as the number of basal primary branches.

All the branches - primary, secondary and tertiary were also counted on the observational plants at harvest.

4. Number of leaves

The total number of leaves and nodes from which leaves have dropped, if any, were counted on the 50th day after sowing on observational plants.

The total number of leaves per observational plant was determined at harvest by adding the number of leaves and the number of nodes from which the leaves had already dropped.

5. Number of flowers

The number of flowers produced by the individual observational plants were counted daily and were added up to obtain the total number of flowers per plant.

6. Spread of flowering

The number of days between the first and last flowering in the individual observational plants were taken as the spread of flowering.

7. Height of main shoot

At the time of harvest the height of main shoot was measured from the base to the tip on observational plants.

8. Length of top

The length of the longest branch of each observational plant was measured from the cotyledonary node to the tip at the time of harvest.

9. Fresh weight of pods

The mature pods of individual observational plants were separated at harvest, cleaned and fresh weight was recorded.

The fresh weight of pods per plot was determined by collecting the mature pods from all the plants of the net plot and weighing after proper cleaning.

10. Haulms yield

The haulms of each observational plant were weighed fresh after removing mature and immature pods at harvest.

The haulms yield (green) per plot was recorded by weighing the haulms from the net plot.

11. Number of mature pods

The number of mature pods per plant was counted at harvest on all observational plants.

12. Percentage of pod set

This was calculated for every observational plant as follows:

$$\text{Percentage of pod set} = \frac{\text{Number of mature pods}}{\text{Number of flowers}} \times 100$$

13. Number of immature pods

The number of immature pods in each observational plant was counted at harvest.

14. Dry pod yield

The mature pods of the individual observational plants were sundried and weight recorded.

The pods collected from all the plants in the net plot were sundried and weighed to obtain the dry pod yield per plot.

15. Dryage percentage of pods

The mature pods of individual observational plants were weighed fresh. After drying, the dry weight was also recorded. From those two weights, the dryage percentage was worked out for the individual plants.

Considering the fresh weight of pods and dry pod yield per plot, it was calculated on the per plot basis.

16. 100 pod weight

A random sample of 100 dry pods was drawn from each variety per replication and weighed.

17. 100 kernel weight

Hundred kernels were drawn at random from a sample of dry kernels from each variety per replication and weight recorded.

18. Shelling percentage

A random sample of 200 grams of dry pods per variety per replication was shelled. Shelling percentage was estimated as the weight of kernels as a percentage of the weight of pods.

19. Oil content

The oil content of the different varieties in the representative samples in each of the three replications was estimated by cold percolation method (Kartha and Sethi, 1957) and expressed as percentage to the weight of kernels.

20. Protein content

Representative samples of dry kernels were taken from each variety in each replication and nitrogen was estimated by the micro-kjeldahl method given by Jackson (1973). The percentage of protein was then calculated by multiplying the nitrogen content with the factor 6.25 (Black and Weiss, 1956).

c) Statistical analysis

The data collected were tabulated and subjected to statistical analysis. Varieties in respect of the characters studied were compared by employing the analysis of variance proposed by Cochran and Cox (1957) and presented in table 2.

Table 2. Analysis of variance

Source of variation	D.F.	S.S.	M.S.	F
Replications	(r-1)	SS_R	MS_R	$\frac{MS_R}{MS_E}$
Varieties	(v-1)	SS_V	MS_V	$\frac{MS_V}{MS_E}$
Error	(r-1) (v-1)	SS_E	MS_E	

Where r Number of replications

v Number of varieties

SS_R Replication sum of squares

SS_V Variety sum of squares

SS_E Error sum of squares

MS_R Replication mean square

MS_V Variety mean square

MS_E Error mean square

The significance of the computed values for 'F' was tested with reference to the table values (Fisher and Yates, 1957).

The significance of the means of the characters between the varieties was tested with reference to the critical difference (C.D.).

$$CD = t_{df(e)}(.05) \times \sqrt{\frac{2\,MS_E}{r}}$$

Where $t_{df(e)}(.05)$ is the table value for t (Fisher and Yates, 1957) at .05 level of significance for degrees of freedom for 'Error'.

The data on comparative yield trial during kharif in uplands and summer in rice fallows were subjected to pooled analysis for all the fifteen characters studied, following the procedure proposed by Cochran and Cox (1957). The pooled analysis of variance is furnished in table 3.

Table 5. Pooled analysis of variance

Source of variation	D.F.	S.S.	M.S.	F
Situations	(S-1)	SS_S	s_S^2	s_S^2/s_{PE}^2
Varieties	(V-1)	SS_V	s_V^2	s_V^2/s_{PE}^2
Situations x Varieties	(S-1)(V-1)	SS_{SV}	s_{SV}^2	s_{SV}^2/s_{PE}^2
Error	$d_1 + d_2$	SS_{PE}	s_{PE}^2	

Where S = Number of situations

V = Number of varieties

d_1 = d.f. of error in the 1st situation

d_2 = d.f. of error in the 2nd situation

SS_S = Situation sum of squares

SS_V = Variety sum of squares

SS_{SV} = Situations x Variety sum of squares

SS_{PE} = Pooled error sum of squares

s_S^2 = Situation mean square

s_V^2 = Variety mean square

s_{SV}^2 = Situation x Variety mean square

s_{PE}^2 = Pooled error mean square

The calculated value for 'F' was tested for significance as in the above case.

In the case of five characters, viz., dry pod yield per plot, fresh weight of pods per plot, dryage percentage of pods, number of mature pods per plant and 100 pod weight for which the error variances in the two situations were not homogeneous, weighted analysis was done with reference to Cochran and Cox (1957).

Genotypic, phenotypic and environmental variances were estimated as described below (Singh and Chaudhary, 1977).

Estimate of environmental variance, $V_e = MS_E$

Estimate of genotypic variance, $V_g = \frac{MS_V - MS_E}{r}$

Estimate of phenotypic variance, $V_p = V_g + V_e$

Genotypic coefficient of variation, $CV_g = \frac{\sqrt{V_g}}{Mean} \times 100$

Phenotypic coefficient of variation, $CV_p = \frac{\sqrt{V_p}}{Mean} \times 100$

Environmental coefficient of variation, $CV_e = \sqrt{\frac{V_e}{Mean}} \times 100$

Heritability in the broad sense (h^2) expressed as percentage was estimated with reference to the formula suggested by Hanson et al. (1956).

i.e.

$$h^2 = \frac{V_g}{V_p} \times 100$$

Expected genetic advance under selection was estimated according to Allard (1960).

Genetic advance due to selection = $\frac{k \times h^2 \times \sqrt{V_p}}{Mean}$

Where

k = Selection differential expressed in phenotypic standard deviation which is 2.06 in the case of 5 per cent intensity of selection in large samples (Singh and Chaudhary, 1977).

Correlation between all characters under study, at genotypic and phenotypic levels were worked out by using the variance co-variance matrix in which the total variability was split up into components due to replications, varieties and error as given in table 4.

Table 4. Analysis of co-variance

Source of variation	D.F.	Mean sum of products	
		Observed	Expected
Between replications	r-1	MP_1	
Between varieties	v-1	MP_2	$COV_e + r \times COV_g$
Error	(r-1)(v-1)	MP_3	COV_e

Where COV_g = genotypic covariance

COV_e = environmental covariance

MP_1 = replication sum of products

MP_2 = variety sum of products

MP_3 = error sum of products

The genotypic and phenotypic covariances were calculated as

$$COV_g = \frac{MP_2 - MP_3}{r}$$

$$COV_p = COV_g + COV_e$$

$$COV_e = MP_3$$

These covariance components were substituted in the following formula to calculate the genotypic (r_g) and phenotypic (r_p) correlation coefficients (Al-jibouri, et. al. 1958).

Genotypic correlation between characters x and y

$$r_{xy}(g) = \frac{COV_{xy}(g)}{\sqrt{V_{g_x} \times V_{g_y}}}$$

Where V_{g_x} = genotypic variance of character x

V_{g_y} = genotypic variance of character y

Phenotypic correlation coefficient between character x and y

$$r_{xy}(p) = \frac{COV_{xy}(p)}{\sqrt{V_{p_x} \times V_{p_y}}}$$

V_{p_x} = phenotypic variance of character x

V_{p_y} = phenotypic variance of character y

The significance of correlation coefficients were tested by using the student's 't' test with degrees of freedom, equal to that of error.

Path-coefficient analysis for pod yield at the genotypic level was carried out on 80 genotypes using the following eight characters.

1. Number of flowers (X_6)
2. Length of top (X_9)
3. Number of basal primary branches (X_{10})
4. Fresh weight of pods (X_{12})
5. Haulms yield (X_{13})

6. Number of leaves (X_{14})
7. Number of mature pods (X_{15})
8. 100 pod weight (X_{20})

The estimates of direct and indirect effects of the eight characters on pod yield were computed as suggested by Wright (1921) and elaborated by Dewey and Lu (1959) using the model

$$Y = a_1 x_1 + a_2 x_2 + a_3 x_3 \ldots\ldots\ldots + a_k x_k$$

where Y and x's are the standardised variates corresponding to yield and the 1 to k characters respectively. The following set of simultaneous equations were formed and solved for estimating the various direct and indirect effects.

$$r_{1y} = P_{1y} + r_{12} P_{2y} + r_{13} P_{3y} + \ldots\ldots\ldots + r_{1k} P_{ky}$$

$$r_{2y} = r_{21} P_{1y} + P_{2y} + r_{23} P_{3y} + \ldots\ldots\ldots + r_{2k} P_{ky}$$

$$r_{3y} = r_{31} P_{1y} + r_{32} P_{2y} + P_{3y} + \ldots\ldots\ldots + r_{3k} P_{ky}$$

$$\vdots$$

$$r_{ky} = r_{k1} P_{1y} + r_{k2} P_{2y} + r_{k3} P_{3y} + \ldots\ldots\ldots + r_{k-1,k} P_{k-1,y} + P_{ky}$$

Where r_{1y} to r_{ky} denote coefficients of correlation between causal factors 1 to k and the dependant character.

r_{12} to $r_{k-1,k}$ denotes coefficients of correlation among all possible combinations of causal factors and

P_{1y} to P_{ky} denote direct effects of characters 1 to k on the character Y.

The above equations can be written in the matrix form as shown below:-

$$\begin{bmatrix} r_{1y} \\ r_{2y} \\ r_{3y} \\ \vdots \\ r_{ky} \end{bmatrix} = \begin{bmatrix} r_{11} & r_{12} & r_{13} & \cdots & r_{1k} \\ r_{21} & r_{22} & r_{23} & \cdots & r_{2k} \\ r_{31} & r_{32} & r_{33} & \cdots & r_{3k} \\ \vdots & \vdots & \vdots & & \vdots \\ r_{k1} & r_{k2} & r_{k3} & \cdots & r_{kk} \end{bmatrix} \begin{bmatrix} P_{1y} \\ P_{2y} \\ P_{3y} \\ \vdots \\ P_{ky} \end{bmatrix}$$

$$A \quad = \quad B \quad x \quad C$$

Where

$$r_{ij} = r_{ji}, \; r_{ii} = 1$$

$$A = BC \text{ hence } C = B^{-1}A,$$

Where B^{-1} is the inverse of B.

The residual factor which measures the contribution of rest of the characters not included in the causal scheme was obtained by the formula $(1-R^2)^{\frac{1}{2}}$

Where

$$R^2 = \sum_{i=1}^{k} P_{iy}^2 + 2 \sum_{i} \sum_{j} P_{iy} P_{jy} r_{ij} \qquad i < j$$

f) Induced mutagenesis

Evaluation of the thirty varieties in uplands during kharif and in rice fallows during summer have brought out that TG-14 and Spanish Improved are two promising varieties having desirable attributes and substantially higher and stable yields than the varieties recommended in the state, viz., TMV-2 and TMV-7. The duration of these two varieties in summer rice fallows is around 107 days.

As TG-14 and Spanish Improved were generally satisfactory in all respects except duration, mutational rectification appeared to be the best approach. Hence TMV-2, the recommended standard variety, TG-14 and Spanish Improved, the two consistently promising varieties were selected for corrective breeding through induced mutagenesis employing gamma irradiation.

TMV-2 was evolved at the Agricultural Experiment Station, Tindivanam, Tamil Nadu, through mass selection from a Spanish type, Gudihatham (Ah-32). It is a spanish bunch variety with light purple stem, light green and large leaves, medium thick and long gynophore, small, 1 to 2 seeded pods with prominent veins, shallow to deep pod constriction, distinct beak, thin shell, and small rounded plumpy kernels with light rose testa.

Spanish Improved is a selection from Spanish peanut and it is spanish bunch in habit. The leaves are medium in size, oblong and green. The pods are medium in size with beak and veins and constricted shallow. Pods are generally with two plumpy kernels of rose testa. TG-14 is a cross from mutant parents (Dark green x Virescent) induced in Spanish Improved by x-rays at the Bhabha Atomic Research Centre, Bombay. This too is a bunch variety. The leaves are relatively larger in size with dark green colour. The pods are medium with prominent beak and veins and the pod constriction is shallow to medium.

Generally 2 bold kernels are seen per pod and the kernels are fleshy in colour.

Three doses of gamma rays, viz., 20(T_1), 30 (T_2) and 40 (T_3) krad were employed in treating the genotypes TMV-2 (V_1), TG-14 (V_2) and Spanish Improved (V_3). The untreated controls were also included.

For every treatment, hundred freshly shelled kernels of uniform maturity and size were selected. Gamma irradiation was done in the 'Gamma Unit' at the School of Genetics, Tamil Nadu Agricultural University, Coimbatore, utilizing the cobalt 60 source.

The irradiated seeds were sown in well prepared field on the 2nd day after irradiation, adopting a Randomised Block Design, replicated twice, during kharif 1982. Fifty seeds were sown in each replication for every treatment at a spacing of 20 cm on either side. Uniform care and management was given for the different treatments.

i) M_1 studies

The following observations and studies were made on the M_1 population.

1) Germination of seeds

Germination counts were taken from the fourth day onwards and continued upto the 15th day after sowing.

2) Survival of plants

The total number of plants surviving per treatment per replication were counted 30 days after sowing and the percentage of survival on the basis of total number of seeds sown was calculated.

3) Plant height

Ten plants each from every treatment and replication were selected at random and the height of these plants was measured from the surface of soil to the tip of the plant and the mean height per plant was estimated.

4) Pollen fertility

Pollen fertility was studied in 10 plants per treatment per replication. Mature flowers produced at the peak period of flowering were selected early in the morning. Anthers were collected and the pollen grains were stained in glycerine acetocarmine. The well filled standard sized and properly stained grains were counted as fertile and others as sterile. Twenty microscopic fields in each of the slides were scored and the data recorded. Pollen fertility was then estimated as the number of fertile grains to the total number of grains scored and expressed as a percentage.

5) Chlorophyll chimeras

Plants with chlorophyll deficient patches on leaves were counted in the populations resulting from each treatment.

6) Morphological abnormalities

The M_1 population was examined regularly and morphological abnormalities were recorded.

ii) M_2 studies

All the M_1 plants were harvested, mature pods collected and dried individually. In the untreated control, ten plants only were selected. The number of seeds obtained from each of the M_1 plant was recorded. The M_2 generation was raised during rabi 1982 under uniform conditions as M_1 progenies. These progenies were sown in rows at a spacing of 20 cm within rows and 30 cm between rows.

1) Chlorophyll mutations

The M_2 seedlings were observed in the morning from the 3rd day onwards upto the 30th day and the chlorophyll mutations were scored. The progenies segregating for mutations were scored first and the chlorophyll mutation frequency on M_1 plant basis was estimated as the number of progenies segregating per 100 M_1 progenies.

The number of mutants in each segregating progeny was counted separately. The number of normal plants in each of the segregating and non-segregating progenies were also noted. Then the mutation frequency on M_2 plant basis was estimated as the number of mutants per 100 M_2 plants.

Mutagenic effectiveness was calculated as a function of the mutation frequency on M_1 plant basis in relation to radiation doses. Mutagenic efficiency was calculated as a function of mutation frequency in relation to M_1 damage such as lethality, injury and sterility as suggested by Konzak et al. (1965).

2) Viable mutations

The progenies segregating for viable mutations were scored. Early mutants were spotted by noting the days to first flowering and on the duration upto maturity. Other mutants were scored on the basis of canopy characters and various morphological features during the crop growth and were labelled and described.

Further, mutations affecting pod characters were scored and described at the time of harvest. The morphological description of individual mutants isolated has been recorded.

RESULTS

RESULTS

The experimental data collected were subjected to statistical analysis, wherever required and the results are presented under the following main heads.

A. Preliminary Evaluation

In any planned programme for the genetic improvement of a crop, the first step is the collection of genetic resources. This should follow a judicious evaluation in relation to the objectives. In case, any genotype is found to satisfy the general or immediate requirements of the breeder, the same can directly be utilized. If on the other hand, varieties with one or a few defects are identified, corrective breeding technique can be employed to rectify the defects. However, if recombination and complete rearrangement of genetic material is required, then appropriate breeding technology has to be resorted to.

The groundnut genetic resources now available are numerous. In this investigation, an attempt is made to collect and evaluate an exhaustive germplasm that can be of use in achieving the objectives. A total of 93 varieties including all the three habit groups, exotic and indegenous, improved varieties and cultures including promising and popular cultivars were utilized.

The varieties collected were evaluated for general adaptability and performance under the two major situations of groundnut cultivation in the state, for identifying generally adapted and promising varieties with desirable agronomic and varietal attributes.

The major and traditional area for groundnut production in Kerala is the uplands cultivated during the kharif season (April-May to August-September). This period is marked by heavy and continuous rains with humid and cloudy atmosphere. Rice fallows during summer (January-April) is the other potential area providing immense scope for extensive cultivation of groundnut. The warm and clear weather of the season is highly desirable for the crop, but marginal irrigation facilities are required for better performance.

During kharif 1980, the adaptability and performance of the first set of 88 varieties were studied in uplands. These 88 and the later collection of 5 varieties, making a total of 93 were evaluated in the wetland rice fallows during summer 1981. General adaptability and desirability of the different varieties was studied through observations on germination, seedling, vigour, nature of branching, canopy features, size and colour of leaves, flowering attributes, aerial pegging, root nodulation, pod setting, pod maturity, pod burial, pod filling, shell and kernel characters, seed dormancy and reaction to pests and diseases. The varietal differences were very conspicuous in respect of these general characteristics. All the varieties came up satisfactorily both under upland conditions during kharif and rice fallow conditions during summer and proved that they are generally adapted to these situations.

Data collected on yield of pod and haulms per plant and days to maturity in uplands and rice fallows with general mean and range are presented in table 5. A wide varietal diversity for these important economic traits is indicated by the differences in the mean at both the situations. The response of individual

Table 5. Preliminary evaluation of groundnut varieties.

Type No.	Name of variety	Upland (kharif) Dry pod yield per plant (g)	Upland (kharif) Green haulms yield per plant (g)	Upland (kharif) Days to maturity	Rice fallow (summer) Dry pod yield per plant (g)	Rice fallow (summer) Green haulms yield per plant (g)	Rice fallow (summer) Days to maturity
1.	EC.21127	15.06	54.05	123	18.20	90.44	110
2.	EC.21118	30.71	58.57	120	22.43	116.13	108
3.	EC.24397	12.50	40.01	125	19.04	110.43	110
4.	EC.116596	28.57	50.00	128	14.85	147.59	116
5.	EC.11064	10.00	48.32	120	14.93	63.53	110
6.	ICG-3859	42.78	77.78	118	28.35	186.67	110
7.	EC.21089	15.50	42.50	120	15.16	136.67	110
8.	EC.115546	24.32	38.66	125	16.77	141.42	120
9.	EC.21126	7.78	70.00	108	11.20	166.94	105
10.	EC.24412	7.50	95.00	125	19.68	98.10	110
11.	EC.24420	17.14	71.42	120	15.00	79.88	108
12.	EC.36892	29.86	97.69	125	29.64	246.75	118
13.	EC.115678	19.38	71.25	125	15.05	125.04	110
14.	EC.25188	27.50	76.56	120	20.22	208.45	120
15.	EC-24395	30.36	94.29	106	9.06	111.27	103
16.	EC.117872	24.00	58.00	125	19.65	155.00	110
17.	EC.39544	22.00	46.02	125	17.10	93.36	108
18.	EC.21082	16.67	75.05	115	11.94	77.57	110
19.	IC.9811	28.64	55.45	120	17.32	175.55	120
20.	EC.36009	26.32	38.53	125	19.00	145.92	110

Table 5 (continued)

Type No.	Name of variety	Upland (kharif) Dry pod yield per plant (g)	Upland (kharif) Green haulms yield per plant (g)	Upland (kharif) Days to maturity	Rice fallow (summer) Dry pod yield per plant (g)	Rice fallow (summer) Green haulms yield per plant (g)	Rice fallow (summer) Days to maturity
21.	EC.24431	25.00	50.08	120	8.95	154.00	108
22.	EC.21095	18.18	37.50	125	13.54	69.11	111
23.	S-59-27	15.02	53.33	125	14.32	179.11	111
24.	A-674	10.04	36.87	120	16.40	66.60	110
25.	S-7-5-13	40.26	89.99	120	24.66	240.23	115
26.	EC.2100	10.25	67.50	125	23.00	119.33	110
27.	EC.21121	24.09	100.00	130	21.57	205.43	120
28.	EC.66134	36.67	101.66	128	15.98	77.95	112
29.	EC.24446	30.23	56.82	120	10.00	115.41	106
30.	EC.112027	36.47	57.08	120	21.55	71.73	108
31.	EC.36890	34.17	55.07	128	18.95	203.75	110
32.	B-353	40.00	68.50	118	22.67	99.53	107
33.	EC.117873	15.05	55.09	132	10.50	203.91	120
34.	EC.11132	29.33	61.32	128	7.45	86.23	111
35.	IC.9808	25.83	56.68	125	9.84	81.10	110
36.	EC.21079	30.75	59.06	125	18.90	38.22	110
37.	EC.20954	31.25	75.02	130	15.06	233.90	120
38.	EC.66138	15.67	88.66	125	23.00	209.44	118
39.	EC.35999	28.25	72.54	125	30.20	120.95	115
40.	EC.21052	30.00	71.75	128	10.80	78.29	114

Table 5 (continued)

Type No.	Name of variety	Upland (kharif)			Rice fallow (summer)		
		Dry pod yield per plant (g)	Green haulms yield per plant (g)	Days to maturity	Dry pod yield per plant (g)	Green haulms yield per plant (g)	Days to maturity
41.	EC.119704	29.82	82.38	123	28.00	221.48	112
42.	AH.6915	45.31	86.25	125	26.53	130.63	112
43.	EC.24450	20.25	50.00	120	11.45	111.60	120
44.	GAUG-1	19.47	70.53	110	12.68	78.96	110
45.	J-11	37.50	59.00	120	12.75	73.37	111
46.	M-13	45.02	85.09	120	24.69	200.00	115
47.	M-37	30.36	55.71	122	18.68	164.46	122
48.	Spanish Improved	44.64	69.07	120	32.73	93.49	115
49.	S-206	17.78	55.68	121	15.97	63.75	110
50.	Dh-3-30	28.69	96.92	118	27.40	77.29	112
51.	Jyothi	28.08	64.06	120	27.94	81.11	110
52.	Exotic-6	27.69	51.53	125	26.00	72.90	112
53.	TMV-9	22.63	84.21	123	19.48	80.84	110
54.	TMV-10	31.25	93.25	130	25.98	128.45	115
55.	No.297	16.07	78.57	125	12.34	79.39	113
56.	AH-8253	30.00	88.46	120	20.80	82.95	112
57.	AK-811	38.86	66.00	120	25.74	92.82	112
58.	EC.21078	16.33	53.33	121	22.95	102.30	111
59.	No.70	29.17	80.03	125	20.46	150.51	113
60.	USA-63	14.69	96.25	125	16.85	81.05	110

Table 5 (continued)

Type No.	Name of variety	Upland (kharif) Dry pod yield per plant (g)	Upland (kharif) Green haulms yield per plant (g)	Upland (kharif) Days to maturity	Rice fallow (summer) Dry pod yield per plant (g)	Rice fallow (summer) Green haulms yield per plant (g)	Rice fallow (summer) Days to maturity
61.	G-270	16.01	101.60	110	22.40	202.16	110
62.	Russia-319	15.09	100.05	128	16.02	180.50	116
63.	TMV-12	17.50	62.50	130	17.34	145.45	118
64.	Almel No.1	11.06	56.66	128	23.47	206.43	118
65.	TMV-2	25.68	80.04	118	27.36	163.33	113
66.	KG-61-240	42.01	120.05	120	19.61	99.81	112
67.	USA-123	21.60	80.80	115	10.46	119.10	103
68.	TMV-11	26.81	76.92	120	25.78	126.96	115
69.	Pollachi-2	24.50	70.05	120	24.95	180.63	108
70.	AH-4218	32.27	81.82	118	15.00	51.78	110
71.	TG-3	28.06	91.43	120	35.67	179.74	113
72.	TG-14	39.86	98.64	120	32.33	166.35	112
73.	TG-17	43.00	88.00	121	30.04	183.60	115
74.	TG-19	25.86	120.04	125	32.88	171.65	115
75.	EC.21088	8.13	112.50	130	20.95	219.23	118
76.	Kanki-X-10-17	9.44	94.44	130	13.50	44.62	116
77.	Spanish peanut	12.50	100.02	125	13.42	51.19	113
78.	Red Spanish	13.57	114.28	130	18.06	69.62	115
79.	Pollachi-1	23.90	75.02	118	23.40	135.00	110
80.	Exotic-1	11.00	80.06	120	16.99	119.12	118
81.	TMV-7	23.50	62.00	118	21.89	177.88	112

Type No.	Name of variety	Upland (kharif) Dry pod yield per plant (g)	Upland (kharif) Green haulms yield per plant (g)	Upland (kharif) Days to maturity	Rice fallow (summer) Dry pod yield per plant (g)	Rice fallow (summer) Green haulms yield per plant (g)	Rice fallow (summer) Days to maturity
82.	Gangapuri	28.75	102.51	120	21.70	207.50	110
83.	Big Japan	37.13	82.82	125	22.85	209.21	116
84.	EC.20957	30.02	74.29	122	17.05	183.06	115
85.	No.293	18.08	88.46	130	11.75	173.32	120
86.	AH-4128	20.77	78.60	125	17.34	100.42	118
87.	Co.1	27.14	75.65	120	23.08	104.17	108
88.	Uganda local	13.00	100.05	118	18.12	141.48	112
89.	EC.21147	-	-	-	16.46	123.27	118
90.	EC.38279	-	-	-	19.63	61.45	118
91.	EC.21175	-	-	-	17.98	68.90	116
92.	EC.21075	-	-	-	18.04	125.00	115
93.	EC.21070	-	-	-	19.95	53.33	108
	Range	7.50 to 45.31	36.87 to 120.05	106 to 132	7.45 to 35.67	38.22 to 246.75	103 to 122
	General Mean	24.77	74.36	122.41	19.43	128.06	112.72

variety vary in the two situations.

In the uplands during kharif, dry pod yield per plant ranged from as low as 7.50 g in EC.24412 (T_{10}) to as high as 45.31 g in AH-6915 (T_{42}). The recommended varieties, TMV-2 (T_{65}) and TMV-7 (T_{81}) yielded 25.68 g and 23.50 g respectively. Under the rice fallow conditions, dry pod yield per plant ranged from 7.45 g to 35.67 g. Maximum pod yield of 35.67 g was recorded by TG-3 (T_{71}) while the minimum of 7.45 g was recorded by EC.11132 (T_{34}). TMV-2 and TMV-7 produced 27.36 and 21.89 g pod per plant respectively.

Spanish Improved (T_{48}), TG-14 (T_{72}) and TG-17 (T_{73}) were very promising in both the situations. Spanish Improved yielded 44.64 g in uplands and 32.73 g in rice fallows. TG-14 gave 39.86 g in uplands and 32.33 g in rice fallows, while TG-17 yielded 43.00 g and 30.04 g respectively. AH-6915 was top ranking with 45.31 g in uplands but a comparatively poor yielder in rice fallows with 26.53 g. TG-3 recorded the highest yield of 35.67 g in rice fallows but only 28.06 g in uplands. KG-61-240 (T_{66}) yielded a relatively high yield of 42.01 g in uplands but was poor in rice fallow with 19.61 g.

The green haulms yield per plant ranged from 36.87 g to 120.05 g in the upland conditions. The highest yield of haulms per plant was recorded by KG-61-240 (T_{66}) with 120.05 g closely followed by TG-19 (T_{74}) with 120.04 g while the lowest was recorded by A-674 (T_{24}) with 36.87 g. Under the rice fallow conditions the highest haulms yield of 246.75 g was recorded by EC.36892 (T_{12}) followed by 240.23 g in S-7-5-13 (T_{25}). The lowest yield of 38.22 g was recorded by EC.21079 (T_{36}).

The duration upto maturity in the uplands varied from 106 days for EC.24395 (T_{15}) to 132 days for EC.117873 (T_{33}). In the summer rice fallows the shortest duration of 103 days was for EC.24395 (T_{15}) and USA-123 (T_{67}) followed by EC.21126 (T_{9}) with 105 days while the longest duration of 122 days was for M-37 (T_{47}).

A comparison of the trend of diversity among the varieties in the two situations for economic traits indicate that the performance of the genotypes in general varies considerably in the two situations. It was seen that certain varieties are more or less uniform in both the situations whereas certain others were more promising in one situation than in the other.

B. Biometric Analysis

Twenty three characters were studied on 80 varieties in uplands during kharif and rice fallows during summer. The varieties exhibited high variability in almost all characters in the two situations revealing the profound influence of the environment. As such the biometric studies were made for the two situations independantly.

a. Uplands during kharif

(i) Variability

The analysis of variance was done for all the twenty three characters to test the significance of the differences between the varieties. The varieties exhibited significant differences for all the 23 characters studied as shown by the 'F' ratio for varieties abstracted in table 6. This proved that there were inherent differences among the varieties for all the characters. The mean values of the various characters of the

Table 6. Analysis of variance for 23 characters in 80 varieties in uplands during kharif.

Sl. No.	Characters	Mean squares: Replications	Varieties	Error	'F' (Varieties)
	D.F.	2	79	158	
1	Duration upto flowering	13.63	16.69	2.95	5.66**
2	Plant height on the 50th day	52.59	154.42	25.92	5.96**
3	Number of branches ,,	7.23	11.08	2.35	4.71**
4	Number of leaves ,,	65.81	315.89	139.28	2.26**
5	Duration upto maturity	75.00	157.80	3.80	41.53**
6	Number of flowers	690.00	2202.79	226.34	9.73**
7	Spread of flowering	14.97	281.62	4.80	58.75**
8	Height of main shoot	111.50	505.41	115.48	4.38**
9	Length of top	123.50	490.92	94.77	5.18**
10.	Number of basal primary branches	0.63	6.17	1.57	3.93**
11	Number of branches	3.98	31.36	3.89	8.06**
12	Fresh weight of pods	80.94	130.39	27.14	4.80**
13	Haulms yield	875.00	2357.14	377.17	6.25**
14	Number of leaves	513.00	541.87	177.98	3.04**
15	Number of mature pods	20.81	83.16	13.51	6.16**
16	Percentage of pod set	7.44	97.49	4.01	24.31**
17	Number of immature pods	0.42	2.62	0.87	3.01**
18	Dry pod yield	22.41	52.92	9.19	5.76**
19	Dryage percentage of pods	12.09	93.60	2.33	40.16**
20	100 pod weight	12.00	985.04	0.65	1515.44**
21	100 kernel weight	8.88	132.70	0.36	368.61**
22	Shelling percentage	19.00	133.77	0.41	326.27**
23	Oil content	10.63	21.42	0.17	126.00**

**Significant at 1 per cent level of probability eighty varieties with C.D are presented in Appendix I. A comparison of the mean values for the different varieties for each of the characters further testify the wide variability between varieties. The parameters of variability such as genotypic, phenotypic and environmental coefficients of variation, heritability and genetic advance for the twenty three characters are presented in table 7.

The genotypic coefficient of variation (g.c.v.) was the highest for percentage of pod set (31.41) followed by number of branches (29.35), haulms yield (25.72) and number of mature pods (24.35). Other characters having relatively high g.c.v. were number of flowers, number of immature pods, and dry pod yield. Oil content (5.58) had the lowest g.c.v. followed by duration upto maturity (6.18) and duration upto flowering (6.70). The highest phenotypic coefficient of variation (p.c.v.) was showed by number of immature pods (36.27) followed by number of branches (35.03). As in the case of g.c.v., oil content had the lowest p.c.v. of 6.38 followed by duration upto maturity (6.40) and duration upto flowering (8.59). For all the characters the p.c.v. were higher than the respective g.c.v. Environmental coefficient of variation (e.c.v.) was the highest for number of immature pods (28.05) and the lowest for duration upto maturity (1.66) followed by shelling percentage (3.01). For certain characters such as number of leaves on the 50th day, number of basal primary branches and number of immature pods the e.c.v. was even higher than the g.c.v. The p.c.v. and e.c.v. for pod yield were relatively high.

Table 7. Genotypic, phenotypic and environmental coefficients of variation, heritability and genetic advance for 23 characters in 80 varieties in uplands during kharif.

Sl. No.	Characters	Coefficients of variation Geno-typic	Pheno-typic	Environ-mental	Herita-bility	Genetic advance
1.	Duration upto flowering	6.70	8.59	5.37	60.87	10.77
2.	Plant height on the 50th day	14.55	18.43	11.32	62.30	23.65
3.	No.of branches ,,	20.43	27.46	18.36	55.31	31.29
4.	No.of leaves ,,	14.50	26.64	22.35	29.64	16.27
5.	Duration upto maturity	6.18	6.40	1.66	93.27	12.30
6.	No. of flowers	21.89	25.38	12.83	74.43	38.91
7.	Spread of flowering	16.05	16.46	3.66	95.06	32.24
8.	Height of main shoot	12.00	16.48	11.30	52.95	17.98
9.	Length of top	12.09	15.85	10.24	58.22	19.00
10.	No. of basal primary branches	15.84	22.53	16.02	49.42	22.94
11.	No. of branches	29.35	35.03	19.13	70.19	50.65
12.	Fresh weight of pods	20.06	26.83	17.82	55.91	30.90
13.	Haulms yield	25.72	33.19	19.44	63.63	42.26
14.	No. of leaves	11.61	18.24	14.06	40.53	15.22
15.	No. of mature pods	24.35	30.62	18.57	63.22	39.88
16.	Percentage of pod set	31.41	33.37	11.26	88.61	60.92
17.	No. of immature pods	23.00	36.27	28.05	40.21	30.04
18.	Dry pod yield	22.21	28.40	17.63	61.34	35.83
19.	Dryage percentage of pods	9.34	10.54	4.89	78.55	17.06
20.	100 pod weight	18.84	19.46	4.88	92.72	37.17
21.	100 kernel weight	16.29	17.15	5.37	90.21	31.87
22.	Shelling percentage	9.05	9.53	3.01	90.11	17.69
23.	Oil content	5.58	6.38	3.09	76.50	10.05

Heritability in the broad sense was medium to high for most of the characters. It was the highest for spread of flowering (95.06) followed by duration upto maturity (93.27), 100 pod weight (92.72), 100 kernel weight (90.21) and shelling percentage (90.11). Pod yield showed the heritability value of 61.34.

Genetic advance expressed as percentage of mean was maximum for pod set (60.92) followed by number of branches (50.65), haulms yield (42.26), number of mature pods (39.88) and number of flowers (38.91). Oil content recorded the lowest value of 10.05 followed by duration upto flowering (10.77) and duration upto maturity (12.30).

High heritability estimates with high values of g.c.v. and genetic advance were recorded by percentage of pod set and number of branches. Relatively high values of heritability coupled with genetic advance were recorded by number of flowers, haulms yield and 100 pod weight. Moderate heritability and genetic advance were found for pod yield and number of mature pods. High heritability and moderate genetic advance were noted for spread of flowering, plant height and 100 kernel weight while high heritability with low genetic advance was seen for dryage and shelling percentage, duration upto flowering and maturity and oil content. Both heritability and genetic advance were low for number of leaves on the 50th day and number of immature pods.

(ii) Correlation

Analysis of covariance was done for all the possible combinations of the twenty three charaters under study. The genotypic and phenotypic variance and co-variance components were calculated from which the genotypic and phenotypic correlation coefficients were computed. The genotypic and phenotypic correlation coefficients of various characters with yield and among themselves are presented in table 8.

Correlation between yield and its components

The genotypic correlation coefficient for yield was positive and highly significant with fresh weight of pods (0.8969), haulms yield (0.2142), number of mature pods (0.6905), percentage of pod set (0.5720), number of immature pods (0.4927) and dryage percentage (0.3383) while it was significant only at 5 per cent level with duration upto maturity (0.1601) and 100 pod weight (0.1684). Thus very high positive correlation coefficients with yield were given by percentage of pod set, number of mature pods and fresh weight of pods. The genotypic correlation coefficient of pod yield was negative, but highly significant with plant height on the 50th day and significant at 5 per cent with height of main shoot and length of top. The genotypic correlation of yield was positive, but non-significant with all other characters except oil content with which the relationship was negative.

At the phenotypic level, the coefficient of correlation was found to be positive and highly significant with number of flowers, fresh weight of pods, haulms yield, number of mature pods, percentage of pod set, number of immature pods and dryage percentage, but significant only at 5 per cent level of probability with number of basal primary branches. The phenotypic coefficients of correlation were found to be very high and positive with fresh weight of pods, number of mature pods and

Table 8. Genotypic and phenotypic correlation coefficients between yield and 22 characters and among themselves in uplands during kharif.

Sl. No.	Characters	Dry pod yield (X_{18})	Duration upto flowering (X_1)	Plant height on the 50th day (X_2)
X_{18}	Dry pod yield	—	0.0858	-0.2450**
X_1	Duration upto flowering	0.0688	—	-0.6880 **
X_2	Plant height on the 50th day	-0.1032	-0.4620**	—
X_3	No. of branches ..	0.1144	0.4203**	-0.2243**
X_4	No. of leaves ..	0.0626	0.2803**	-0.0530
X_5	Duration upto maturity	0.1105	0.5866**	-0.4508**
X_6	No. of flowers	0.2197**	0.2945**	-0.2452**
X_7	Spread of flowering	0.0997	-0.0057	0.0306
X_8	Height of main shoot	-0.0526	-0.0435	0.3127**
X_9	Length of top	-0.0473	-0.1000	0.3422**
X_{10}	No. of basal primary branches	0.1520*	0.3778**	-0.3330**
X_{11}	No. of branches	0.0848	0.4691**	-0.3605**
X_{12}	Fresh weight of pods	0.9315**	0.1536**	-0.1197
X_{13}	Haulms yield (green)	0.2453**	0.3159**	-0.2058**
X_{14}	No. of leaves	0.0732	0.2423**	-0.1565*
X_{15}	No. of mature pods	0.7305**	-0.0646	-0.6379**
X_{16}	Percentage of pod set	0.5193**	-0.2002*	0.1101
X_{17}	No. of immature pods	0.4554**	-0.0146	-0.0288
X_{19}	Dryage percentage of pods	0.2606**	-0.2038**	0.0548
X_{20}	100 pod weight	0.1294	0.0635	0.1732*
X_{21}	100 kernel weight	0.0415	0.3158**	-0.1901*
X_{22}	Shelling percentage	0.0867	0.1248	-0.1924*
X_{23}	Oil Content	-0.1177	-0.0001	-0.1369

Table 8 (continued) -2-

Sl. No.	No. of branches on the 50th day (X_3)	No. of leaves on tht 50th day (X_4)	Duration upto maturity (X_5)	No. of flowers (X_6)	Spread of flowering (X_7)
X_{18}	0.1275	0.0422	0.1601*	0.0111	0.0345
X_1	0.7067**	0.6489**	0.6617**	0.0965	-0.0205
X_2	-0.5546**	-0.4819**	-0.5919**	-0.3850**	0.0294
X_3	—	1.0011**	0.6203**	0.5543**	-0.0689
X_4	0.7726**	—	0.6949**	0.5711**	-0.0781
X_5	0.4588**	0.3834**	—	0.03078**	-0.0887
X_6	0.3939**	0.3102**	0.2536**	—	-0.2468**
X_7	-0.0309	-0.0166	-0.0813	0.2952	—
X_8	0.0540	0.0650	-0.0370	-0.0721	-0.1905*
X_9	-0.0337	-0.0020	-0.1096	-0.1309	-0.2248**
X_{10}	0.7246**	0.5074**	0.4182**	0.2812**	-0.1143
X_{11}	0.8260**	0.5763**	0.5237**	0.3853**	-0.0813
X_{12}	0.1645*	0.0903	0.1976*	0.2286**	0.1114
X_{13}	0.5709**	0.4003**	0.3929**	0.2465**	-0.0314
X_{14}	0.6379**	0.6243**	0.3440**	0.2749**	-0.0714
X_{15}	-0.0633	-0.0760	-0.1657*	0.1541*	0.1823*
X_{16}	-0.2457**	-0.1970*	-0.2618**	-0.4721**	-0.1234
X_{17}	-0.0049	-0.0572	-0.0793	0.0421	-0.0322
X_{19}	-0.0760	-0.0230	-0.2396**	0.0074	-0.0096
X_{20}	0.1740*	0.1757*	0.1801*	0.0219	-0.1632*
X_{21}	0.3859**	0.2697**	0.4498**	0.2053**	-0.1972*
X_{22}	0.1240	0.0641	0.0108	-0.0173	0.0198
X_{23}	0.0662	-0.0104	-0.0397	-0.1367	-0.1076

Table 8 (continued)

Sl. No.	Height of main shoot (X_8)	Length of top (X_9)	No. of basal primary branches (X_{10})	No. of branches (X_{11})	Fresh weight of pods (X_{12})
X_{18}	-0.1878*	-0.1901*	0.0379	0.0177	0.8969**
X_1	-0.0414	-0.1195	0.6501**	0.6754**	0.2371**
X_2	0.4358	0.5107**	-0.5561**	-0.5891**	-0.2859**
X_3	0.0056	-0.0911	0.9631**	1.0037**	0.2123**
X_4	0.0955	0.0064	0.9927**	0.9996**	0.1105
X_5	-0.0493	-0.1256	0.5836**	0.6284**	0.2938**
X_6	-0.2236**	-0.3025**	0.3411**	0.4690**	-0.0008
X_7	-0.3119**	-0.3344**	-0.1970*	-0.1211	0.0432
X_8	—	0.9928**	0.0271	-0.0055	-0.1742*
X_9	0.9377**	—	-0.0974	-0.1058	-0.1950*
X_{10}	0.0112	-0.0556	—	0.9770**	0.1002
X_{11}	0.0536	-0.0293	0.8546**	—	0.1032
X_{12}	-0.0336	0.0333	0.2026**	0.1449	—
X_{13}	0.3021**	-0.2475**	0.6082**	0.6287**	0.2873**
X_{14}	0.1085	0.0394	0.5806**	0.6199**	0.1286
X_{15}	-0.1127	-0.0758	-0.0288	-0.1414	0.7188**
X_{16}	-0.0492	0.0203	-0.1453	-0.3079**	0.5046**
X_{17}	0.1411	0.1745*	0.0231	0.0212	0.4068**
X_{19}	-0.2613**	-0.0036	-0.0668	-0.1034	-0.0868
X_{20}	0.2939**	0.2441**	0.2092**	0.2510**	-0.0780
X_{21}	0.0820	0.0023	0.2152**	0.4527**	0.1374
X_{22}	-0.2068**	-0.1908*	0.1182	0.1147	0.0532
X_{23}	0.0024	-0.0010	0.1128	0.1037	-0.0551

Table 8 (continued) -4-

Sl. No.	Haulms yield (X_{13})	No. of leaves (X_{14})	No. of mature pods (X_{15})	Percentage of pod set (X_{16})	No. of immature pods (X_{17})
X_{18}	0.2142**	0.0307	0.6905**	0.5720**	0.4927**
X_1	0.5623**	0.5895**	-0.1231	-0.2428**	-0.0628
X_2	-0.2729**	-0.3913**	-0.1506	0.0993	-0.2128**
X_3	0.8514**	0.8199**	-0.2254**	-0.4028**	-0.1149
X_4	0.9082**	0.9727**	-0.3452**	-0.4982**	-0.2732**
X_5	0.4953**	0.5375**	-0.2012*	-0.2782**	-0.1899*
X_6	0.2521**	0.4475**	-0.1249	-0.6275**	-0.1872*
X_7	-0.0792	-0.1469	0.1224	-0.1455	-0.1518**
X_8	0.3383**	0.1891*	-0.3109**	-0.0382	0.0763
X_9	0.2635**	0.0625	-0.2489**	0.0563	0.1480
X_{10}	0.7647**	0.7885**	-0.2951**	-0.3184**	-0.1596*
X_{11}	0.7924**	0.7855**	-0.3221**	-0.4292**	-0.1145
X_{12}	0.2700**	0.1345	0.2541**	0.5609**	0.3778**
X_{13}	—	0.6772**	-0.0871	-0.1338	0.1313
X_{14}	0.4315**	—	-0.3449**	-0.4176**	-0.2990**
X_{15}	0.0699	-0.0873	—	0.8188**	0.5143**
X_{16}	-0.0628	-0.2010*	0.7358**	—	0.5449**
X_{17}	0.2078**	-0.0454	0.4988**	0.4044**	—
X_{19}	-0.0348	-0.0889	0.0868	0.0627	0.1586
X_{20}	0.2053**	0.2149**	-0.4562**	-0.3776**	-0.1191
X_{21}	0.3039**	0.3433**	-0.3546**	-0.3682**	-0.1645*
X_{22}	0.0506	0.0057	0.1082	0.1329	-0.0303
X_{23}	0.0626	-0.0012	-0.0436	-0.0006	0.1207

Table 8 (continued) -5-

Sl. No.	Dryage percentage of pods (X_{19})	100 pod weight (X_{20})	100 kernel weight (X_{21})	Shelling percentage (X_{22})	Oil content (X_{23})
X_{18}	0.3385**	0.1684*	0.0511	0.1096	-0.1435
X_1	-0.2642**	0.0821	0.4243**	0.1780*	0.0163
X_2	0.0703	0.2232**	0.2365**	-0.2402**	-0.1520*
X_3	-0.1074	0.2298**	0.5186**	0.1628*	0.1160
X_4	-0.0896	0.3117**	0.5093**	0.1122	-0.0012
X_5	-0.2552**	0.1112	0.4737**	0.0255	-0.0283
X_6	0.0289	0.0265	0.2422**	-0.0176	-0.1563*
X_7	-0.0013	-0.1668*	-0.2023**	0.0216	-0.1102
X_8	0.0072	0.4086**	0.1168	-0.2776**	0.0081
X_9	0.0384	0.3250**	0.0091	-0.2503**	-0.0064
X_{10}	-0.0910	0.2933**	0.5844**	0.1788*	0.1662*
X_{11}	-0.1368	0.2960**	0.5394**	0.1436	0.1298
X_{12}	-0.0998	-0.1076	0.1827*	0.0686	-0.0603
X_{13}	-0.0088	0.2565**	0.3819**	0.0709	0.0740
X_{14}	-0.1538*	0.3339**	0.5214**	-0.0036	-0.0032
X_{15}	0.1464	-0.5764**	-0.4538**	0.1395	-0.0328
X_{16}	0.0781	-0.4033**	-0.3920**	0.1455	0.0048
X_{17}	0.3004**	-0.1860*	-0.2700**	-0.0462	0.1967*
X_{19}	—	-0.1088	-0.2413**	0.0737	-0.1743*
X_{20}	-0.1075	—	0.7249**	-0.3050**	-0.0102
X_{21}	-0.2342**	0.7214**	—	-0.0430	-0.0085
X_{22}	0.0627	-0.3057**	-0.0429	—	0.1393
X_{23}	-0.1696*	-0.0134	-0.0145	0.1294	—

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

Genotypic correlation coefficients above the diagonal.
Phenotypic correlation coefficients below the diagonal

percentage of pod set. The relationship of pod yield was negative, but non-significant with plant height on the 50th day, height of main shoot, length of top and oil content. With the remaining characters, pod yield recorded positive non-significant correlation.

Correlation among characters

The genotypic correlation coefficient of duration upto flowering was positive and significant with number of branches and leaves on the 50th day, duration up to maturity, number of basal primary branches, number of branches, fresh weight of pods, haulms yield, number of leaves, 100 pod weight and shelling percentage while it was negative and significant with plant height on the 50th day, percentage of pod set and dryage percentage. The phenotypic correlation of duration upto flowering was positive and significant with number of branches and leaves on the 50th day, duration up to maturity, number of flowers, number of basal primary branches, number of branches, fresh weight of pods, haulms yield, number of leaves and 100 kernel weight; but negative and significant with plant height on the 50th day, percentage of pod set and dryage percentage.

Plant height on the 50th day had significant positive genotypic and phenotypic correlation with height of main shoot, length of top and 100 pod weight. Hundred kernel weight also had positive significant correlation with plant height on the 50th day. The genotypic correlation of plant height on the 50th day was negative and significant with number of branches and leaves on the 50th day, duration upto maturity, number of flowers, number of basal primary branches, number of branches, fresh weight of pods, haulms yield, number of leaves and immature pods, shelling percentage and oil content. The association of this character at the phenotypic level was negative and significant with number of branches on the 50th day, duration upto maturity, number of flowers, basal primary branches and branches, haulms yield, number of leaves and mature pods, 100 kernel weight and shelling percentage.

At the genotypic level, number of branches on the 50th day was correlated significantly and positively with number of leaves on the 50th day, duration upto maturity, number of flowers, basal primary branches and branches, fresh weight of pods, haulms yield, number of leaves, 100 pod weight, 100 kernel weight and shelling percentage; but negatively with number of mature pods and percentage of pod set. At the phenotypic level, the trait gave significant positive correlation with number of leaves on the 50th day, duration upto maturity, number of flowers, basal primary branches and branches, fresh weight of pods, haulms yield, number of leaves, 100 pod and kernel weight but negative with percentage of pod set.

Number of leaves on the 50th day recorded significant positive genotypic correlation with duration upto maturity, number of flowers, basal primary branches and branches, haulms yield, number of flowers, 100 pod and kernel weight and negative significant correlation with number of mature pods, percentage of pod set and number of immature pods. It had positive significant phenotypic correlation with duration upto maturity, number of flowers, basal primary branches and branches, haulms yield, number of leaves, 100 pod weight and 100 kernel weight and negative with percentage of pod set.

Duration upto maturity was correlated significantly in the positive direction at the genotypic level with number of flowers, basal primary branches and branches, fresh weight of pods, haulms yield, number of leaves and 100 kernel weight, but in the negative direction with number of mature pods, percentage of pod set, number of immature pods and dryage percentage of pods. In addition to 100 pod weight, all the characters having significant positive genotypic correlation had showed significant positive phenotypic correlation too with duration upto maturity. Except number of immature pods, all the other characters exhibiting genotypic negative correlation had phenotypic negative correlation also with this character.

Number of basal primary branches, number of branches, haulms yield, number of leaves and 100 kernel weight registered significant positive genotypic correlation with number of flowers when spread of flowering, height of main shoot, length of top, percentage of pod set, number of immature pods and oil content had registered significant genotypic correlation in the negative direction. Spread of flowering, number of basal primary branches, number of branches, fresh weight of pods, haulms yield, number of leaves and mature pods and 100 kernel weight have positive significant phenotypic correlation with number of flowers while percentage of pod set was correlated negatively and significantly with number of flowers.

Significant negative genotypic correlation of spread of flowering was noticed with height of main shoot, length of top, number of basal primary branches, number of immature pods, 100 pod weight and 100 kernel weight. The phenotypic correlation coefficient of spread of flowering was noted to be significant and positive with number of mature pods and negative and significant with height of main shoot, length of top, 100 pod weight and 100 kernel weight.

The genotypic coefficient of correlation of height of main shoot was positive and significant with length of top, haulms yield, number of leaves and 100 pod weight but negative with fresh weight of pods, number of mature pods and shelling percentage. This trait was correlated significantly in the positive direction at the phenotypic level with all characters as at the genotypic level, except number of leaves but in the negative direction with dryage percentage and shelling percentage.

Length of top exhibited significant positive genotypic correlation with haulms yield and 100 pod weight while negative and significant with fresh weight of pods, number of mature pods and shelling percentage. It was positive and significant at the phenotypic level with haulms yield, number of immature pods and 100 pod weight, but with shelling percentage the association was negative.

Positive significant genotypic correlation of number of basal primary branches with number of branches, haulms yield, number of leaves, 100 pod weight, 100 kernel weight, shelling percentage and oil content was noticed. The correlation of number of basal primary branches at the genotypic level was significant, but negative with number of mature pods, percentage of pod set and number of immature pods. Positive significant phenotypic correlation of number of primary branches was found with number of branches, fresh weight of pods, haulms yield, number of leaves, 100 pod weight and 100 kernel weight.

Number of branches showed significant positive genotypic and phenotypic correlation with haulms yield, number of leaves, 100 pod weight and 100 kernel weight and negative significant correlation with number of mature pods and percentage of pod set. The phenotypic correlation of this character was significant and negative with percentage of pod set.

It was seen that fresh weight of pods had significant positive genotypic and phenotypic correlations with haulms yield, number of mature pods, percentage of pod set and number of immature pods, whereas 100 kernel weight showed significance only at the genotypic level.

Both at the genotypic and phenotypic levels, haulms yield was correlated positively and significantly with number of leaves, 100 pod weight and 100 kernel weight. Haulms yield also showed positive significant phenotypic correlation with number of immature pods.

The genotypic correlation of number of leaves with 100 pod weight and 100 kernel weight were positive and significant, but was negative and significant with number of mature pods, percentage of pod set, number of immature pods and dryage percentage. At the phenotypic level too, 100 pod weight and 100 kernel weight recorded positive significant correlation, but negative with percentage of pod set.

The correlation coefficient of number of mature pods was positive and significant with percentage of pod set and number of immature pods, but negative and significant with 100 pod weight and 100 kernel weight, both at the genotypic and phenotypic levels.

The genotypic and phenotypic coefficients of correlation for percentage of pod set with number of immature pods was positive and significant whereas it was negative and significant with 100 pod weight and 100 kernel weight.

Number of immature pods was correlated positively and significantly with dryage percentage and oil content at the genotypic level and with dryage percentage only at the phenotypic level. Negative significant genotypic correlation was found with 100 pod weight and 100 kernel weight, but at the phenotypic level with 100 kernel weight only.

Dryage percentage of pods had negative significant genotypic and phenotypic coefficients of correlation with 100 kernel weight and oil content.

Significant positive genotypic and phenotypic correlation between 100 pod weight and 100 kernel weight were seen whereas 100 pod weight and shelling percentage were significantly but negatively correlated at both the phenotypic and genotypic levels.

(iii) Path analysis

The path analysis provides a means to find out the relative contribution of each component towards yield. The characters considered in the causal scheme are the number of flowers (X_6), length of top (X_9), number of basal primary branches (X_{10}), fresh weight of pods (X_{12}), haulms yield (X_{13}), number of leaves (X_{14}), number of mature pods (X_{15}) and 100 pod weight (X_{20}). The genotypic correlations between yield of pod and the eight yield components were partitioned into their corresponding direct and indirect effects. The results obtained are presented in table 9. The path coefficients and the genotypic correlation coefficients are diagramatically represented in figure 1.

Fresh weight of pods had the highest positive direct effect of 0.9238. The direct effect of this trait on pod yield was based on its very high positive genotypic correlation coefficient of 0.8969 with pod yield. This yield component had positive indirect effects through length of top, haulms yield and number of mature pods. But number of flowers, number of basal primary branches, number of leaves and 100 pod weight exerted negative indirect effects via this character.

The second character having a high positive direct effect of 0.3737 on pod yield was 100 pod weight. The genotypic correlation coefficient of 0.1684 between yield and 100 pod weight which was significant at 5 per cent level of probability accounts for the relatively high magnitude of the direct effect. 100 pod weight showed positive indirect effects via haulms yield and number of mature pods and negative indirect effects viz all other characters viz., number of flowers, length of top, number of basal primary branches, fresh weight of pods and number of leaves.

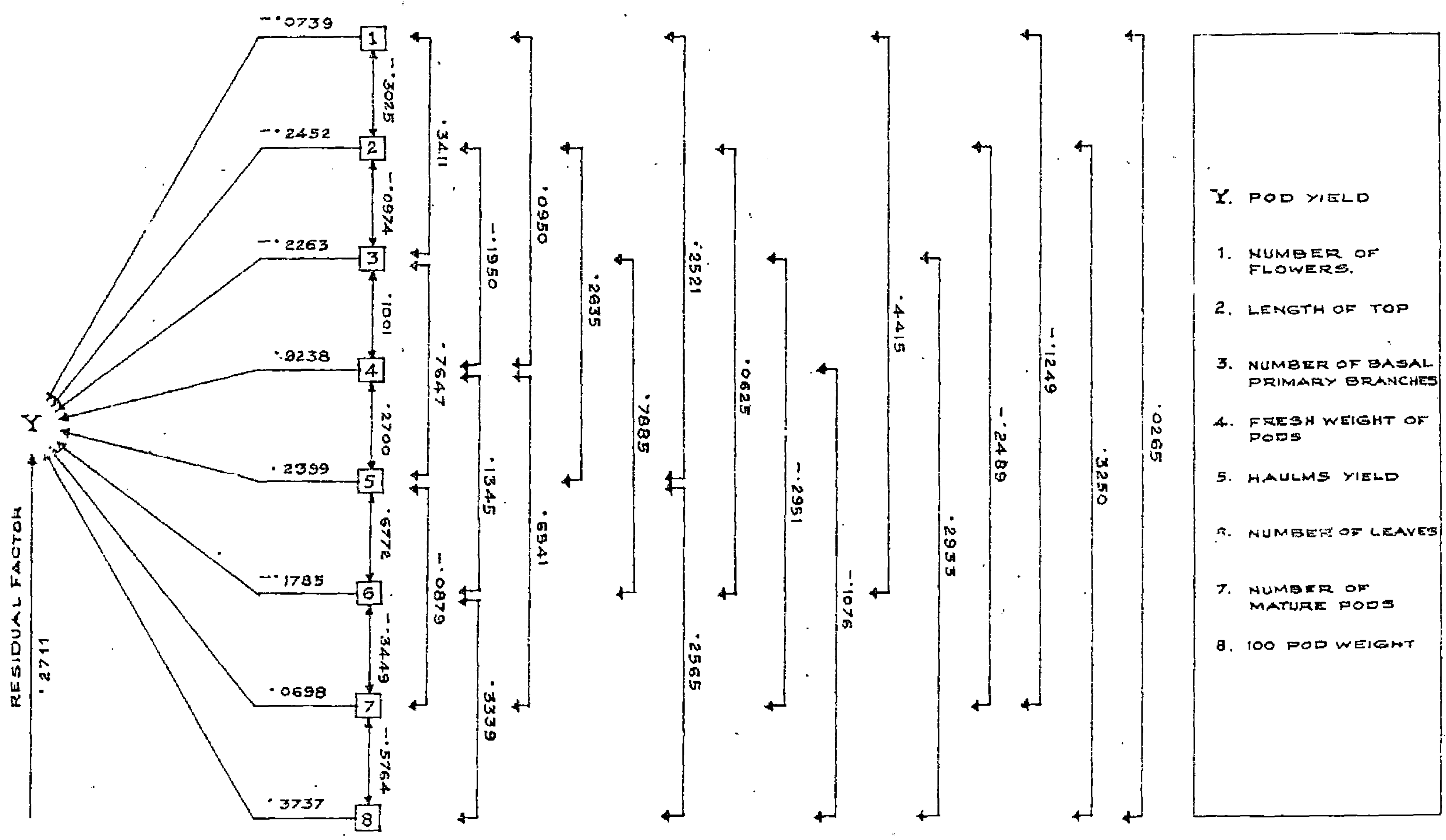
The third character with profound positive direct effect of 0.2399 was haulms yield which had registered a positive significant genotypic correlation of 0.2142 with pod yield suggesting that the correlation explains the true relationship. The indirect effects of haulms yield via fresh weight of pods,

Table 9. Direct and indirect effects of eight component characters on pod yield under upland conditions during kharif.

Sl. No.	Components	Direct effects	Indirect effects via								Total corre-lations
			No. of flowers	Length of top	No. of basal primary bran-ches	Fresh weight of pods	Haulms yield	No. of leaves	No. of mature pods	100 pod weight	
1.	No. of flowers	-0.0739	-	0.0742	-0.0772	0.0878	0.0605	-0.0790	0.0097	0.0090	0.0111
2.	Length of top	-0.2452	0.0224	-	0.0220	-0.0708	0.0632	-0.0112	0.0174	0.0121	-0.1901
3.	No. of basal primary branches	-0.2263	-0.0252	0.0239	-	0.0926	0.1835	-0.1407	0.0206	0.1096	0.0379
4.	Fresh weight of pods	0.9238	-0.0070	0.0478	-0.0227	-	0.0648	-0.1152	0.0456	-0.0402	0.8969
5.	Haulms yield	0.2399	-0.0186	-0.0646	-0.1730	0.2494	-	-0.1209	0.0061	0.0958	0.2142
6.	No. of leaves	-0.1785	-0.0326	-0.0153	-0.1784	0.1243	0.1625	-	0.0241	0.1248	0.0307
7.	No. of mature pods	0.0698	0.0092	0.0610	0.0668	0.6042	-0.1207	0.0616	-	-0.0615	0.6905
8.	100 pod weight	0.3737	-0.0019	-0.0797	-0.0664	-0.0994	0.0615	-0.0596	0.0402	-	0.1684

Residue = 0.2711

FIG.1. PATH DIAGRAM SHOWING THE DIRECT EFFECTS AND INTERRELATIONSHIPS BETWEEN YIELD AND 8 SELECTED COMPONENT CHARACTERS IN GROUNDNUT IN UPLANDS DURING KHARIF.



number of mature pods and 100 pod weight were positive of which that via fresh weight of pods was the highest. The indirect effect of this trait on pod yield through number of flowers, length of top, number of basal primary branches and number of leaves were negative.

Number of mature pods per plant had positive, but low direct effect of 0.0698 on pod yield though the character had got very high positive significant genotypic correlation of 0.6905. The very high positive indirect effect of 0.6042 for number of mature pods via fresh weight of pods which contribute the highest direct effect accounts for the high positive correlation. Other characters having positive indirect effects via number of mature pods are the number of flowers, length of top, number of basal primary branches and number of leaves. Haulms yield and 100 pod weight had produced negative indirect effect via number of mature pods.

Number of flowers, length of top, number of basal primary branches and number of leaves exerted negative direct effects on yield, of which that by length of top had the highest negative effect of -0.2452 closely followed by number of basal primary branches (-0.2263). But the genotypic correlation coefficients of pod yield with number of flowers, number of basal primary branches and number of leaves were positive and non-significant whereas that with length of top was negative and significant at 5 per cent level of probability. Length of top had positive indirect effects via number of flowers, number of basal primary branches, haulms yield, number of mature pods and

100 pod weight and negative indirect effects via fresh weight of pods and number of leaves. Number of basal primary branches showed positive indirect effects through length of top, fresh weight of pods, haulms yield, number of mature pods and 100 pod weight and negative indirect effects through number of flowers and number of leaves. Number of leaves with negative direct effect of -0.1785 on pod yield had positive indirect effects via fresh weight of pods, haulms yield, number of mature pods and 100 pod weight and negative indirect effects via number of flowers, length of top and number of basal primary branches. Number of flowers with the lowest negative direct effect had exerted positive indirect effects through length of top, fresh weight of pods, haulms yield, number of mature pods and 100 pod weight when it had negative indirect effects through number of basal primary branches and number of leaves.

The residual effect which accounts for the contribution of the characters not included in the causal scheme was only 0.2711 indicating that the component characters in total contribute 92.65 percentage towards genetic variability in pod yield by this model. The very low value for the residual effect showed that this model is quite suitable under the upland conditions during kharif.

b. Rice fallows during summer

(i) Variability

The analysis of variance revealed that there were significant differences between the varieties for all the twenty three characters under study. The abstract of the analysis of variance are presented in table 10 and the mean values of the 80 varieties for the 23 characters are given in Appendix II with C.D. for comparison. The wide variability in respect of all these characters for the different varieties is clearly demonstrated by the differences in mean values. Coefficients of genotypic, phenotypic and environmental variations, heritability in the broad sense and genetic advance of the 23 characters in the 80 varieties are presented in table 11.

Number of branches on the 50th day showed the highest g.c.v. of 47.71 followed by number of branches (39.17) and percentage of pod set (31.88). The g.c.v. was the minimum for duration upto maturity (5.26) followed by oil content (5.47), shelling percentage (6.59) and duration upto flowering (7.08). The p.c.v. was the highest for number of branches on the 50th day (57.52) followed by number of branches (44.85) and number of immature pods (43.59). It was the lowest for duration upto maturity (5.82) followed by oil content (6.27), shelling percentage (7.78) and duration upto flowering (7.99); keeping the same trend as that for g.c.v. The e.c.v. was the maximum for number of immature pods (35.37) followed by number of branches on the 50th day (32.11), while it was the minimum for duration upto maturity (2.49) followed by oil content (3.06), duration upto flowering (3.71) and dryage percentage (4.41). Pod yield showed relatively high p.c.v. and e.c.v. than g.c.v.

In general, the g.c.v. was less than the corresponding p.c.v. for all the characters. In respect of plant height on the 50th day, height of main shoot, length of top, fresh weight of pods, haulms yield, number of mature and immature pods and

Table 10. Analysis of variance for 23 characters in 80 varieties in rice fallows during summer.

Sl. No.	Characters	Mean squares: Replications	Varieties	Error	F (varieties)
	D.F.	2	79	158	
1.	Duration upto flowering	23.42	13.28	1.11	11.96**
2.	Plant height on the 50th day	785.72	141.50	39.54	3.58**
3.	No.of branches ..	52.10	48.04	22.47	2.13**
4.	No.of leaves ..	764.19	556.50	127.80	4.35**
5.	Duration upto maturity	50.50	96.44	6.68	14.44**
6.	Number of flowers	308.50	2391.29	272.96	8.76**
7.	Spread of flowering	45.00	256.62	13.42	19.13**
8.	Height of main shoot	2697.09	308.71	98.51	3.13**
9.	Length of top	1429.00	283.63	107.52	2.64**
10.	No. of basal primary branches	16.92	6.67	1.11	6.05**
11.	Number of branches	16.87	28.81	2.71	10.64**
12.	Fresh weight of pods	72.53	44.00	22.08	1.99**
13.	Haulms yield	1045.88	464.61	165.65	2.80**
14.	Number of leaves	3234.50	4022.37	518.25	7.76**
15.	No. of mature pods	11.82	29.77	10.88	2.73**
16.	Percentage of pod set	64.15	76.55	6.65	11.52**
17.	No. of immature pods	5.25	4.55	1.78	2.56**
18.	Dry pod yield	32.20	19.07	9.00	2.12**
19.	Dryage percentage of pods	10.09	85.43	1.49	57.34**
20.	100 pod weight	10.00	1518.35	0.33	4601.06**
21.	100 kernel weight	8.13	85.38	0.17	502.34**
22.	Shelling percentage	17.00	78.19	10.58	7.39**
23.	Oil content	11.84	26.90	0.15	179.33**

**Significant at 1 per cent level of probability

Table 11. Genotypic, phenotypic and environmental coefficients of variation, heritability and genetic advance for 23 characters in 80 varieties in rice fallows during summer.

Sl. No.	Characters	Coefficients of variation Geno-typic	Pheno-typic	Environ-mental	Herita-bility	Genetic advance
1.	Duration upto flowering	7.08	7.99	3.71	78.46	12.92
2.	Plant height on the 50th day	12.46	18.33	13.44	46.22	17.45
3.	No.of branches ,,	47.71	57.52	32.11	40.53	48.02
4.	No.of leaves ,,	19.96	27.47	18.88	52.76	29.86
5.	Duration upto maturity	5.26	5.82	2.49	81.76	9.80
6.	No. of flowers	25.49	30.01	16.02	72.12	44.60
7.	Spread of flowering	18.70	20.18	7.61	85.80	35.68
8.	Height of main shoot	12.89	20.00	15.29	41.53	17.11
9.	Length of top	10.27	17.28	13.90	35.32	12.58
10.	No.of basal primary branches	21.27	26.88	16.43	62.64	34.69
11.	No. of branches	39.17	44.85	21.85	76.28	70.48
12.	Fresh weight of pods	11.82	24.24	21.16	23.80	11.88
13.	Haulms yield	19.05	31.09	24.57	37.56	24.06
14.	No. of leaves	30.50	36.64	20.31	69.27	52.29
15.	No. of mature pods	17.07	28.20	22.45	36.64	21.28
16.	Percentage of pod set	31.88	36.15	17.03	77.81	57.94
17.	No.of immature pods	25.50	43.59	35.37	34.21	30.72
18.	Dry pod yield	13.19	25.31	21.01	27.16	14.16
19.	Dryage percentage of pods	7.55	8.74	4.41	74.60	17.11
20.	100 pod weight	21.78	23.64	9.50	84.85	45.81
21.	100 kernel weight	11.29	13.36	7.14	71.41	27.36
22.	Shelling percentage	6.59	7.78	4.52	68.05	11.20
23.	Oil content	5.47	6.27	3.06	76.20	12.68

dry pod yield, the e.c.vs were higher than the respective g.c.vs.

Heritability in the broad sense was the highest for spread of flowering (85.80) followed by 100 pod weight (84.85), duration upto maturity (81.76) and duration upto flowering (78.46). It was found to be the lowest for fresh weight of pods (23.80) followed by dry pod yield (27.16).

Number of branches gave the highest genetic advance of 70.48 followed by percentage of pod set (57.94), number of leaves (52.29), number of branches on the 50th day (48.02) and 100 pod weight (45.81). Genetic advance was the least for duration upto maturity with 9.80 followed by shelling percentage (11.20). A relatively low value of 14.16 for genetic advance was recorded for pod yield.

G.c.v., heritability in the broad sense and genetic advance were high for number of branches, number of flowers, number of leaves and percentage of pod set. Heritability and genetic advance were high for number of flowers, spread of flowering, number of branches, number of leaves, percentage of pod set and 100 pod weight. High heritability, but low genetic advance was seen for duration upto flowering and maturity, 100 kernel weight, shelling percentage and oil content.

(ii) Correlation

As in the upland conditions during kharif, analysis of covariance was done for all the possible combinations of the 23 characters. The variances and covariances at the genotypic and phenotypic levels were calculated from which the genotypic and phenotypic correlation coefficients, respectively, were computed.

The genotypic and phenotypic correlation coefficients of various characters and among themselves are presented in table 12.

Correlation of yield and its components

Pod yield at the genotypic level was correlated positively at 1 per cent level of significance with plant height on the 50th day, height of main shoot, length of top, fresh weight of pods, number of mature pods, percentage of pod set, number of immature pods, dryage and shelling percentage and at 5 per cent level with oil content. Haulms yield and 100 kernel weight showed non-significant positive correlation with pod yield. At 1 per cent level, duration upto flowering, number of branches and number of leaves on the 50th day and number of flowers were negatively and significantly correlated with pod yield. Number of basal primary branches and number of branches showed significant but negative correlation at 5 per cent level. Duration upto maturity, spread of flowering, number of leaves and 100 pod weight showed negative, but non-significant correlation with pod yield.

At the phenotypic level, pod yield exhibited positive significant correlation at 1 per cent level with plant height on the 50th day, number of flowers, length of top, fresh weight of pods, haulms yield, number of mature pods, percentage of pod set, number of immature pods and dryage percentage. At 5 per cent level, pod yield showed positive significant correlation with number of branches on the 50th day and height of main shoot. Number of leaves on the 50th day, spread of flowering, number of basal primary branches, number of leaves, 100 kernel weight,

Table 12. Genotypic and phenotypic correlation coefficients between yield and 22 characters and among themselves in rice fallows during summer.

Sl. No.	Characters	Dry pod yield (X_{18})	Duration upto flowering (X_1)	Plant height on the 50th day (X_2)
X_{18}	Dry pod yield	--	-0.2087**	0.5057**
X_1	Duration upto flowering	-0.1510*	--	-0.6465**
X_2	Plant height on the 50th day	0.2356**	-0.3926**	--
X_3	No.of branches ,,	0.1549*	0.1866*	-0.1352
X_4	No.of leaves ,,	0.0978	0.4426**	-0.2087**
X_5	Duration upto maturity	-0.0583	0.5637**	-0.2403**
X_6	No. of flowers	0.2528**	0.0523	-0.1261
X_7	Spread of flowering	0.1345	-0.1517*	-0.0001
X_8	Height of main shoot	0.1969*	-0.1351	0.6021**
X_9	Length of top	0.2095**	0.0404	0.4956**
X_{10}	No. of basal primary branches	0.0580	0.5302**	-0.2760**
X_{11}	No. of branches	-0.0140	0.5225**	-0.3968**
X_{12}	Fresh weight of pods	0.9211**	-0.0195	0.1635*
X_{13}	Haulms yield (green)	0.3206**	0.2408**	-0.0766
X_{14}	No. of leaves	0.0721	0.5057**	-0.2443**
X_{15}	No. of mature pods	0.6674**	-0.0458	0.1058
X_{16}	Percentage of pod set	0.2415**	-0.0331	0.0641
X_{17}	No.of immature pods	0.2945**	0.0539	0.0114
X_{19}	Dryage percentage of pods	0.2457**	-0.3884**	0.2388**
X_{20}	100 pod weight	-0.0279	-0.1224	0.0909
X_{21}	100 kernel weight	0.0205	0.2184**	-0.0648
X_{22}	Shelling percentage	0.1417	-0.1327	0.1303
X_{23}	Oil content	0.0838	0.2098**	-0.0199

Table 12 (continued) -2-

Sl. No.	No. of branches on the 50th day (X_3)	No. of leaves on the 50th day (X_4)	Duration upto maturity (X_5)	No. of flowers (X_6)	Spread of flowering (X_7)
X_{18}	-0.3016**	-0.3465**	-0.0306	-0.2719**	-0.0388
X_1	0.8271**	0.6912**	0.5159**	0.1204	-0.1754*
X_2	-0.8517**	-0.7029**	-0.3479**	-0.4737**	-0.0556
X_3	—	0.8357**	0.2883**	-0.0157	-0.4642**
X_4	0.3375**	—	0.5967**	0.3282**	-0.0491
X_5	0.1028	0.3880**	—	0.1063	0.1222
X_6	0.6967**	0.3489**	0.6447**	—	0.2085**
X_7	-0.0954	0.0282	-0.1173	0.2857**	—
X_8	-0.0660	-0.0629	0.1243	-0.1305	0.0920
X_9	-0.0111	0.1839*	0.2182**	0.1033	0.0919
X_{10}	0.3196**	0.7793**	0.3898**	0.2558**	-0.0911
X_{11}	0.2924**	0.7466**	0.4159**	0.3518**	-0.0242
X_{12}	0.1681*	0.2208**	0.1103	0.2590**	0.1806*
X_{13}	0.2186**	0.4575**	0.2639**	0.3022**	0.2473**
X_{14}	0.2764**	0.7391**	0.5264**	0.2868**	0.0151
X_{15}	0.1388	0.0383	0.0052	0.1217	0.0543
X_{16}	0.0379	-0.1922*	0.0043	-0.6086**	-0.1828*
X_{17}	0.0785	0.2883**	0.2221**	0.1567**	0.0289
X_{19}	-0.0506	-0.3152**	-0.5044**	0.0109	-0.1137
X_{20}	0.0942	0.1882*	0.1686*	-0.0340	0.1345
X_{21}	0.2486**	0.3952**	0.3289**	0.0719	0.0179
X_{22}	-0.0545	-0.1979*	0.0537	-0.1126	-0.1436
X_{23}	0.0227	0.0785	0.1804*	-0.1816*	-0.2842**

Table 12 (continued) -3-

Sl. No.	Height of main shoot (X_8)	Length of top (X_9)	No. of basal primary branches (X_{10})	No. of branches (X_{11})	Fresh weight of pods (X_{12})
X_{18}	0.3295**	0.2214**	-0.1806*	-0.1853*	0.7825**
X_1	-0.2812**	0.0522	0.7574**	0.6929**	0.1038
X_2	0.6757**	0.3278**	-0.6069**	-0.7322**	0.3499**
X_3	0.4757**	-0.0913	1.0539**	0.8868**	-0.2459**
X_4	-0.3381**	0.1492	1.0031**	0.9636**	-0.0839
X_5	0.2143**	0.4421**	0.5457**	0.5458**	0.3683**
X_6	-0.3329**	0.0346	0.2548**	0.4203**	-0.3285**
X_7	0.1111	0.0844	-0.1893*	-0.0464	0.0347
X_8	--	0.8259**	-0.3511**	-0.3759**	0.3615**
X_9	0.7733**	--	0.0565	0.0382	0.4365**
X_{10}	-0.1719*	0.1026	--	0.9062**	0.1133
X_{11}	-0.2036**	0.0884	0.8478**	--	0.1008
X_{12}	0.2125**	0.2763**	0.1962*	0.1159	--
X_{13}	0.1667*	0.3424**	0.4725**	0.5358**	0.4466**
X_{14}	0.0097	0.2933**	0.8046**	0.8402**	0.2244**
X_{15}	0.1720*	0.1326	0.0028	-0.0494	0.6277**
X_{16}	0.1787*	0.0225	-0.1550*	-0.2328**	0.2223**
X_{17}	0.0782	0.1716*	0.3007**	0.3206**	0.3689**
X_{19}	-0.0102	-0.1517*	-0.3451**	-0.3472**	-0.0935
X_{20}	0.0998	0.1159	0.1559*	0.1645*	0.1191
X_{21}	0.1068	0.2013*	0.4572**	0.3927**	0.1288
X_{22}	0.1844*	0.1026	-0.2333**	-0.2110	0.0299
X_{23}	0.0352	0.0368	0.1009	0.1239	0.0881

Table 12 (continued)

Sl. No.	Haulms yield (X_{13})	No. of leaves (X_{14})	No. of mature pods (X_{15})	Percentage of pod set (X_{16})	No. of immature pods (X_{17})
X_{18}	0.0939	-0.1500	0.5092**	0.4333**	0.2288**
X_1	0.4825**	0.6687**	-0.0013	-0.0471	0.1600*
X_2	-0.3161**	-0.5821**	0.2027**	0.1576*	-0.0156
X_3	0.8030**	0.8088**	-0.8032**	-0.2475**	0.0111
X_4	0.6824**	0.9689**	-0.3825**	-0.3309**	0.3319**
X_5	0.4865**	0.6952**	0.0532	-0.0184	0.4568**
X_6	0.2313**	0.2932**	-0.3194**	-0.7922**	0.0414
X_7	0.3024**	-0.0159	-0.1252	-0.2198**	-0.1036
X_8	-0.0253	-0.0619	-0.2582**	0.3119**	-0.0355
X_9	0.3739**	0.3272**	0.1078	0.0458	0.0928
X_{10}	0.6439**	0.8899**	-0.2298**	-0.2293**	0.2416
X_{11}	0.7817**	0.9139**	-0.1992*	-0.2840**	0.3534**
X_{12}	-0.0319	0.1763*	0.3624**	0.4055**	0.4445**
X_{13}	--	0.8318**	-0.0985	-0.1853*	0.4371**
X_{14}	0.5315**	--	-0.1028	-0.1644*	0.2399**
X_{15}	0.1879*	0.0616	--	0.7506**	0.0872
X_{16}	-0.0924	-0.1012	0.5989**	--	-0.0331
X_{17}	0.2667**	0.3599**	0.2104**	-0.0145	--
X_{19}	-0.2899**	-0.4086**	0.1692*	0.0887	-0.1926*
X_{20}	0.1867*	0.1748*	-0.3543**	-0.2689**	0.1874*
X_{21}	0.3032**	0.4738**	-0.2438**	-0.2167**	0.1128
X_{22}	-0.1771*	-0.1449	0.2258**	0.2362**	0.0732
X_{23}	0.0794	0.1354	0.0699	0.1341	0.1812*

Table 12 (continued) -5-

Sl. No.	Dryage percentage of pods (X_{19})	100 pod weight (X_{20})	100 kernel weight (X_{21})	Shelling percentage (X_{22})	Oil content (X_{23})
X_{18}	0.4962**	-0.0491	0.0387	0.3763**	0.1637*
X_1	-0.4515**	-0.1424	0.2482**	-0.2026**	0.2620**
X_2	0.3831**	0.1414	0.0828	0.2217**	-0.0188
X_3	-0.1174	0.2560**	0.0887**	-0.2664**	0.0897
X_4	-0.4258**	0.2613**	0.5429**	-0.3704**	0.1189
X_5	-0.5651**	0.1852*	0.3633**	0.0527	0.2148**
X_6	0.0306	-0.0397	0.0801	-0.1506	-0.1448
X_7	-0.1171	0.1440	0.0159	-0.1832*	-0.3041**
X_8	0.0326	0.1561*	0.1753*	0.2776**	0.0653
X_9	-0.2400**	0.1984*	0.3453**	0.1040	0.0810
X_{10}	-0.4278**	0.1967*	0.5773**	-0.3407**	0.1313
X_{11}	-0.4098**	0.1886*	0.4518**	-0.3003**	0.1429
X_{12}	-0.1391	0.2463**	0.2665**	0.1135	0.1949*
X_{13}	-0.4739**	0.2984**	0.4791**	-0.3775**	0.1366
X_{14}	-0.4838**	0.2085**	0.5681**	-0.2282**	0.1658*
X_{15}	0.3267**	-0.5844**	-0.3969**	0.5134**	0.1327
X_{16}	0.1122	-0.3048**	-0.2403**	0.3486**	0.1606*
X_{17}	-0.3263**	0.3155**	0.2856**	0.1404	0.3081**
X_{19}	---	0.4053**	-0.3271**	0.5656**	-0.0182
X_{20}	-0.3978**	---	0.5317**	-0.3566**	-0.1221
X_{21}	-0.3219**	0.5312**	---	-0.2343**	-0.0863
X_{22}	0.3069**	-0.2789**	-0.1915*	---	0.0056
X_{23}	-0.0229	-0.1352	-0.0933	0.0025	---

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

Genotypic correlation coefficients above the diagonal
Phenotypic correlation coefficients below the diagonal

shelling percentage and oil content recorded positive non-significant correlation with pod yield. There was significant negative correlation at 5 per cent level between pod yield and duration upto flowering. Duration upto maturity, number of branches and 100 pod weight recorded negative, non-significant correlation with pod yield.

Correlation among different characters

Significant positive genotypic correlation of duration upto flowering was noticed with number of branches and number of leaves on the 50th day, duration upto maturity, number of basal primary branches, number of branches, haulms yield, number of leaves, number of immature pods, 100 kernel weight and oil content. Negative significant correlation of duration upto flowering was seen with plant height on the 50th day, spread of flowering, height of main shoot, dryage percentage and shelling percentage at the genotypic level. At the phenotypic level, duration upto flowering was found to be positively and significantly correlated with all the characters at the genotypic level except number of immature pods. Plant height at the 50th day, spread of flowering and dryage percentage showed negative significant correlation with duration upto flowering.

The genotypic correlation of plant height on the 50th day was positive and significant with height of main shoot, length of top, fresh weight of pods, number of mature pods, percentage of pod set, dryage percentage and shelling percentage, but negative with number of branches and leaves on the 50th day, duration upto maturity, number of flowers, number of branches, haulms yield and number of leaves. The phenotypic correlation of the character was positive and significant only with height of main shoot, length of top, fresh weight of pods and dryage percentage whereas it was negative with number of leaves on the 50th day, duration upto maturity, number of basal primary branches, number of branches and number of leaves.

Number of leaves on the 50th day, number of basal primary branches, number of branches, haulms yield, number of leaves and 100 kernel weight registered significant positive correlation with number of branches on the 50th day, both at genotypic and phenotypic levels. In addition to the above traits, duration upto maturity and 100 pod weight at the genotypic level and number of flowers and fresh weight of pods at the phenotypic level showed significant positive correlation with number of branches on the 50th day. It was negatively correlated with spread of flowering, height of main shoot, fresh weight of pods, number of mature pods, percentage of pod set and shelling percentage at the genotypic level.

Regarding number of leaves on the 50th day, there was positive significant genotypic correlation with duration upto maturity, number of flowers, number of basal primary branches, number of branches, haulms yield, number of leaves, number of immature pods, 100 pod weight and 100 kernel weight while the correlation was negative with height of main shoot, number of mature pods, percentage of pod set, dryage percentage and shelling percentage. In addition to the above characters, at the genotypic level, length of top and fresh weight of pods recorded positive significant phenotypic correlation with number of branches on the 50th day. Negative significant phenotypic correlation was seen between number of leaves on the 50th day and percentage of pod set, dryage percentage and shelling percentage.

Significant positive genotypic correlation of duration upto maturity was found with height of main shoot, length of top, number of basal primary branches, number of branches, fresh weight of pods, haulms yield, number of leaves, number of immature pods, 100 pod weight, 100 kernel weight and oil content and negative with dryage percentage. Duration upto maturity exhibited positive phenotypic correlation with number of flowers, length of top, number of basal primary branches, number of branches, haulms yield, number of leaves, number of immature pods, 100 pod weight, 100 kernel weight and oil content and negative with those characters as at the genotypic level.

Number of flowers had positive genotypic correlation with spread of flowering, number of basal primary branches, number of branches, haulms yield and number of leaves and negative correlation with height of main shoot, fresh weight of pods, number of mature pods and percentage of pod set. At the phenotypic level it was correlated positively and significantly with all characters as at the genotypic level and fresh weight of pods and number of immature pods but in the negative direction with percentage of pod set and oil content.

Genotypic correlation coefficient between spread of flowering and haulms yield was positive and significant while that between spread of flowering and number of basal primary branches, percentage of pod set, shelling percentage and oil content were negative. Phenotypic correlation of spread of flowering with fresh weight of pods and haulms yield were positive and significant while that with percentage of pod set and oil content were negative.

Positive significant genotypic and phenotypic correlations were recorded by height of main shoot with length of top, fresh weight of pods, percentage of pod set and shelling percentage. At genotypic level 100 pod weight and 100 kernel weight and at phenotypic level haulms yield and number of mature pods also recorded positive significant correlation with height of main shoot. Number of basal primary branches and branches at genotypic and phenotypic levels in addition to mature pods at genotypic level showed negative significant correlation with height of main shoot.

Length of top recorded positive significant genotypic and phenotypic correlations with fresh weight of pods, haulms yield, number of leaves and 100 kernel weight but negative with dryage percentage. Length of top also recorded positive significant phenotypic correlation with number of immature pods and genotypic correlation with 100 pod weight.

The coefficient of correlation at the genotypic level was positive and significant between number of basal primary branches and number of branches, haulms yield, number of leaves, number of immature pods, 100 pod weight, 100 kernel weight and oil content whereas it was negative with number of mature pods, percentage of pod set, dryage percentage and shelling percentage.

The correlation of number of basal primary branches at the phenotypic level was positive and significant with all characters at the genotypic level except oil content. The phenotypic correlation between number of basal primary branches and fresh weight of pods was positive and significant. The relationship was negative and significant with percentage of pod set, dryage percentage and shelling percentage.

Both genotypic and phenotypic correlation coefficients of number of branches with haulms yield, number of leaves, number of immature pods, 100 pod weight and 100 kernel weight were positive and significant but negative with percentage of pod set and dryage percentage. Number of mature pods and shelling percentage were also found to be correlated negatively with number of branches at the genotypic level.

Number of leaves, number of mature pods, percentage of pod set, number of immature pods, 100 pod weight, 100 kernel weight and oil content were correlated positively and significantly with fresh weight of pods and negatively with haulms yield at the genotypic level. Fresh weight of pods registered positive significant phenotypic correlation with haulms yield, number of leaves, number of mature pods, percentage of pod set and number of immature pods.

The coefficient of correlation of haulms yield with number of leaves, number of immature pods, 100 pod weight and 100 kernel weight were positive and significant at the genotypic and phenotypic levels. At the genotypic level, oil content and at the phenotypic level, number of mature pods also showed positive significant correlation with haulms yield. Negative significant genotypic and phenotypic correlations were shown by percentage of pod set, dryage percentage and shelling percentage with haulms yield. But number of mature pods was also negatively correlated with haulms yield at the genotypic level.

Number of immature pods, 100 pod weight and 100 kernel weight at the phenotypic level and all these characters and oil content at the genotypic level were correlated positively with number of leaves. At the genotypic level, number of mature pods, percentage of pod set, dryage percentage and shelling percentage were correlated negatively with number of leaves; but at the phenotypic level dryage percentage showed significance.

Number of mature pods was positively correlated with percentage of pod set, dryage percentage and shelling percentage at the genotypic and phenotypic levels. Number of immature pods also showed positive significant phenotypic correlation with number of mature pods. Both at the genotypic and phenotypic levels, 100 pod weight and 100 kernel weight recorded significant negative correlation with number of mature pods.

In addition to oil content at the genotypic level, shelling percentage was correlated significantly at the genotypic and phenotypic levels with percentage of pod set. Number of immature pods at the genotypic level and 100 pod weight and 100 kernel weight at the genotypic and phenotypic levels were correlated with percentage of pod set in the negative direction.

Hundred pod weight and 100 kernel weight and oil content at the genotypic level whereas 100 pod weight and oil content at the phenotypic level showed significant positive correlation with number of immature pods. Negative significant genotypic and phenotypic correlations were noticed between number of immature pods and shelling percentage.

Significant positive correlation of dryage percentage was seen with shelling percentage at the genotypic and phenotypic levels and negative significant correlation with 100 pod weight and 100 kernel weight at genotypic and phenotypic levels.

Hundred pod weight showed positive significant genotypic and phenotypic correlations with 100 kernel weight and negative significant genotypic and phenotypic correlations with shelling percentage.

There was significant negative correlation between 100 kernel weight and shelling percentage at the genotypic and phenotypic levels.

(iii) Path analysis

Considering the eight components as in uplands during kharif as causal factors and the dry pod yield as the effect, the path coefficient analysis was done at the genotypic level for the rice fallow conditions during summer. The corresponding genotypic correlation coefficients between pod yield and the causal factors were aportioned into their direct and indirect effects and the results obtained are presented in table 13. The path diagram showing the direct effects and the inter-relationships between the effect and the causes is given in figure 2.

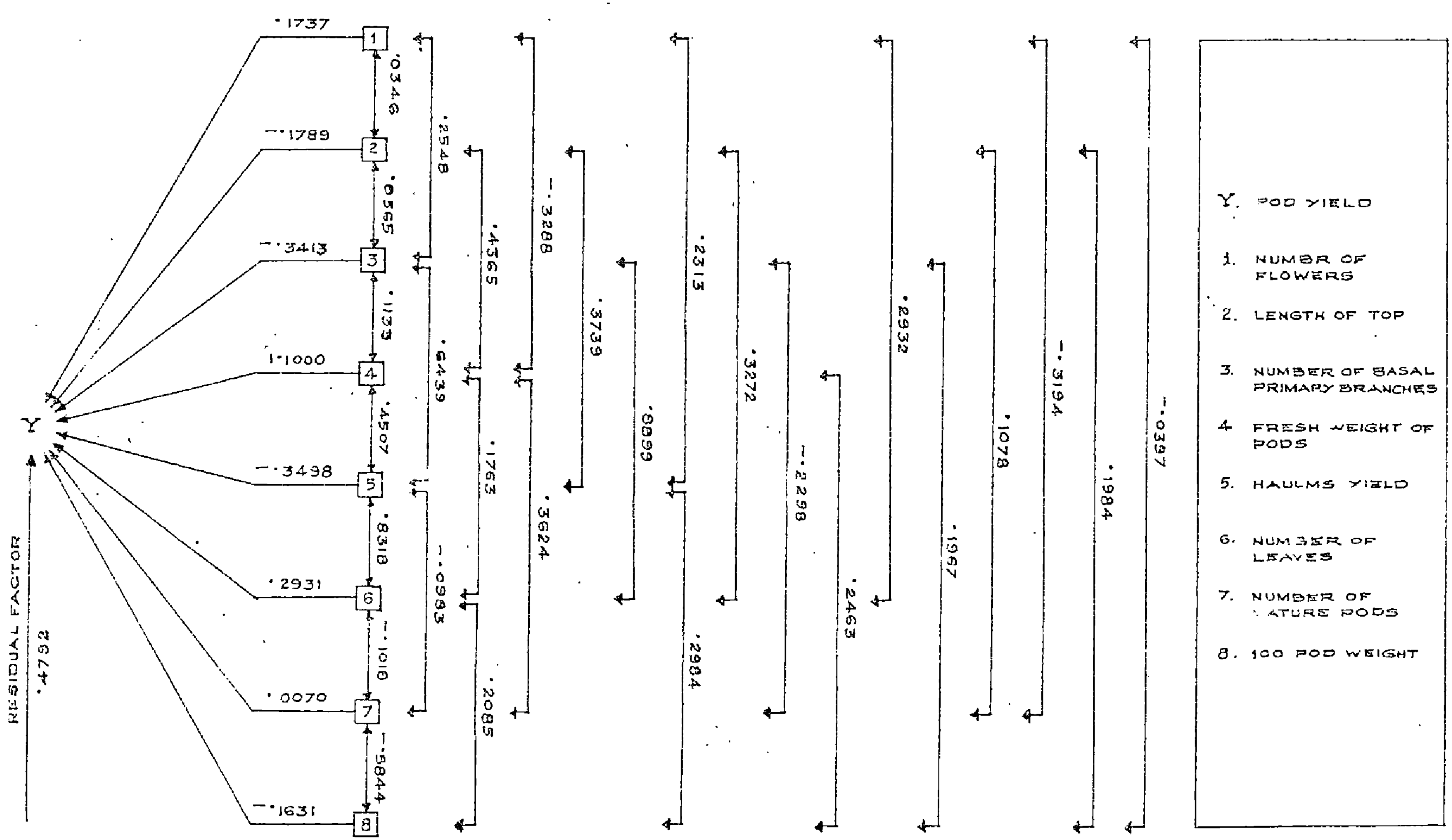
As that in the upland conditions during kharif, fresh

Table 13. Direct and indirect effects of eight component characters on pod yield under rice fallow conditions during summer.

Sl. No.	Components	Direct effects	Indirect effects via: No. of flowers	Length of top	No. of basal primary branches	Fresh weight of pods	Haulms yield	No. of leaves	No. of mature pods	100 pod weight	Total correlations
1.	No. of flowers	0.1737	-	-0.0063	-0.0869	-0.3617	-0.0809	0.0859	-0.0022	0.0065	-0.2719
2.	Length of top	-0.1789	0.0060	-	-0.0193	0.4802	-0.1308	0.0959	0.0008	-0.0324	0.2214
3.	No.of basal primary branches	-0.3413	0.0443	-0.1684	-	0.1246	-0.0670	0.2609	-0.0016	-0.0321	-0.1806
4.	Fresh weight of pods	1.1000	-0.0571	-0.0781	-0.0387	-	-0.1577	0.0517	0.0025	-0.0402	0.7825
5.	Haulms yield	-0.3498	0.0402	-0.0669	-0.2197	0.4958	-	0.2438	-0.0007	-0.0487	0.0939
6.	No. of leaves	0.2931	0.0509	-0.0586	-0.3037	0.1939	-0.2910	-	-0.0007	-0.0340	-0.1500
7.	No. of mature pods	0.0070	-0.0555	-0.0193	0.0784	0.3987	0.0345	-0.0298	-	0.0953	0.5092
8.	100 pod weight	-0.1631	-0.0069	-0.0355	-0.0671	0.2709	-0.1044	0.0611	-0.0041	-	-0.0491

Residue = 0.4792

FIG.2. PATH DIAGRAM SHOWING THE DIRECT EFFECTS AND INTERRELATIONSHIPS BETWEEN YIELD AND 8 SELECTED COMPONENT CHARACTERS IN GROUNDNUT IN SUMMER RICE FALLOWS.



weight of pods had the highest positive direct effect of 1.100 on pod yield. The magnitude of the effect of fresh weight of pods on pod yield was closely dependant on the high positive genotypic correlation coefficient of 0.7825. It also had exerted positive indirect effects via number of leaves and number of mature pods. But the indirect effects of this important component through number of flowers, length of top, number of basal primary branches, haulms yield and 100 pod weight were negative with relatively low magnitudes.

Number of leaves had the second highest positive direct effect of 0.2931 on pod yield. But the character had only negative non-significant correlation with pod yield. It had positive indirect effects through number of flowers and fresh weight of pods while that through length of top, number of basal primary branches, haulms yield, number of mature pods and 100 pod weight were negative with varying degrees. The negative indirect effects of this trait through number of basal primary branches was the highest (-0.3037) followed by haulms yield (-0.2910).

Under the rice fallow conditions during summer, the number of flowers had appreciable positive direct effect on pod yield (0.1737). However, this trait registered negative significant correlation with pod yield. It can be due to the high negative indirect effect of this character via fresh weight of pods which in turn had the highest contribution towards pod yield. The indirect effects of number of flowers via number of leaves and 100 pod weight were positive when that via length of top, number of basal primary branches, fresh weight of pods, haulms yield and number of mature pods were negative.

The one remaining component with positive, but very low direct effect was number of mature pods per plant (0.0070) which recorded highly significant positive correlation with pod yield due to its high positive indirect effect via fresh weight of pods which was the causal factor with the highest positive direct effect. In addition to fresh weight of pods, the number of mature pods per plant had positive indirect effects via number of basal primary branches, haulms yield and 100 pod weight while that through number of flowers, length of top and number of leaves were negative.

Length of top, number of basal primary branches, haulms yield and 100 pod weight had negative direct effects on pod yield of which that by haulms yield was the highest (-0.3498) followed by number of basal primary branches (-0.3413). Pod yield recorded positive significant correlation with length of top, negative significant correlation at 5 per cent level with number of basal primary branches and non-significant positive and negative correlations with haulms yield and 100 pod weight respectively. The high positive indirect effect (0.4802) of length of top via fresh weight of pods explains the significant positive correlation between length of top and pod yield. Including fresh weight of pods, length of top exerted positive indirect influences through number of flowers, number of leaves and number of mature pods and negative indirect influence through number of basal primary branches, haulms yield and 100 pod weight. Number of basal primary branches had positive indirect effects on pod yield via number of flowers, fresh weight of pods and number of leaves among which that through the last one was the maximum (0.2609). Haulms yield exerted positive indirect influence on pod yield via number of flowers, fresh weight of pods and number of leaves, out of which that through the fresh weight of pods was the highest (0.4958) in magnitude. It had negative indirect effects via length of top, number of basal primary branches, number of mature pods and 100 pod weight of which that through number of basal primary branches was the maximum (-0.2197). 100 pod weight exerted positive indirect effects via fresh weight of pods and number of leaves which were having the highest and the second highest positive direct effects respectively on pod yield. It had negative indirect effects of varying magnitude on pod yield through number of flowers, length of top, number of basal primary branches, haulms yield and number of mature pods per plant.

Of the total genetic variability for pod yield in groundnut under the rice fallow conditions during summer, 77.04 per cent was covered by this model since the residual effect was 0.4792. This testify that a very high proportion of the genetic variability which contribute towards yield under the situation in question had been included in the analysis.

C. Comparative Yield Trials

Thirty varieties were selected on the basis of their general adaptability, yield, duration and other desirable attributes in the preliminary evaluation in uplands during kharif and rice fallows during summer. The selected varieties recorded satisfactory pod yield in both the situations or high pod yield in any one of the situations along with other desirable attributes. These varieties were critically evaluated and compared for further selection and utilization. They were tested in uplands during kharif and rice fallows during summer. Data on the 15 characters collected were analysed and interpreted. The analyses of variance for uplands during kharif are summarised in table 14, for rice fallows during summer in table 15 and for the pooled data in table 16. An average plant harvested at maturity from each of the variety in rice fallows is presented in figure 3 and their pods and kernels in figure 4.

The 'F' ratio for varieties in the separate analysis with 29 d.f. shows the significance of the varietal means for the character concerned. The 'F' ratio for situations in the pooled analysis with 1 d.f. pertains to the significance of the over all mean of the character under the two situations. The 'F' for varieties in the pooled analysis with 29 d.f. tests the significance of the varietal means of the character in the two situations taken together. But the 'F' for situations x varieties with 29 d.f. indicates the significance of the varietal means in one situation Vs. the other. This is useful to assess the stability of the varieties under the two situations.

Table 14. Analysis of variance for 15 characters in 30 varieties in uplands during kharif.

Sl. No.	Characters	Mean squares: Replications	Mean squares: Varieties	Mean squares: Error	F (Varieties)
	D.F.	2	29	58	
1.	Duration upto flowering	3.81	9.67	0.63	15.35**
2.	Duration upto maturity	3.74	144.75	6.97	20.76**
3.	Length of top	10.52	199.59	90.01	2.22**
4.	Number of branches	10.13	36.86	1.91	19.29**
5.	Number of mature pods	31.26	43.17	9.62	4.49**
6.	Number of immature pods	11.64	3.37	2.06	1.64*
7.	Fresh weight of pods per plot	64116.53	233848.45	42217.00	5.54**
8.	Haulms yield (green) per plot	0.01	1.74	0.26	6.69**
9.	Dry pod yield per plot	29758.14	104636.34	19170.55	5.47**
10.	100 pod weight	0.45	592.34	0.99	598.32**
11.	100 kernel weight	1.87	366.53	0.69	531.20**
12.	Dryage percentage of pods	0.19	66.65	1.54	43.43**
13.	Shelling percentage	1.40	85.69	0.42	204.02**
14.	Oil content	1.06	24.72	0.24	102.78**
15.	Protein content	1.35	10.13	0.56	18.08**

*Significant at 5 per cent probability

**Significant at 1 per cent probability

Table 15. Analysis of variance for 15 characters in 30 varieties in rice fallows during summer.

Sl. No.	Characters	Mean squares: Replications	Mean squares: Varieties	Mean squares: Error	F (Varieties)
	D.F.	2	29	58	
1.	Duration upto flowering	3.73	26.01	0.87	29.89**
2.	Duration upto maturity	7.65	105.74	2.66	39.75**
3.	Length of top	3555.29	174.07	70.66	2.46**
4.	Number of branches	5.11	24.68	1.83	13.49**
5.	Number of mature pods	18.62	19.27	5.05	3.81**
6.	Number of immature pods	13.72	5.54	2.45	2.26**
7.	Fresh weight of pods per plot	221341.34	78516.48	18658.21	4.21**
8.	Haulms yield (green) per plot	7.69	2.32	0.32	7.24**
9.	Dry pod yield per plot	83164.04	50224.63	7254.00	6.92**
10.	100 pod weight	0.02	975.24	0.77	1266.54**
11.	100 kernel weight	3.38	156.18	4.26	36.65**
12.	Dryage percentage of pods	2.93	43.00	2.97	14.48**
13.	Shelling percentage	0.89	79.38	0.50	158.76**
14.	Oil content	0.04	20.14	0.21	95.90**
15.	Protein content	0.34	6.95	0.43	16.16**

**Significant at 1 per cent probability

Table 16. Pooled analysis for 15 characters in 30 varieties in uplands during kharif and rice fallows during summer.

Sl. No.	Character	Source	Sum of squares	D.F.	Mean squares	F
1.	Duration upto flowering	Situations	15.65	1	15.65	2.93*
		Varieties	786.57	29	27.12	5.08**
		Situations x Varieties	154.94	29	5.34	7.13**
		Error	86.91	116	0.75	
2.	Duration upto maturity	Situations	6325.06	1	6325.06	252.81**
		Varieties	6588.56	29	227.19	9.08**
		Situations x Varieties	725.56	29	25.02	5.19**
		Error	558.54	116	4.82	
3.	Length of top	Situations	25948.08	1	25948.08	322.98**
		Varieties	922.70	29	273.19	3.40**
		Situations x Varieties	2753.81	29	94.96	1.18
		Error	9319.15	116	80.34	
4.	Number of branches	Situations	155.35	1	155.35	82.58**
		Varieties	1761.96	29	60.76	20.11**
		Situations x Varieties	87.58	29	3.02	1.62**
		Error	216.75	116	1.87	
5.	Number of mature pods	Situations	1433.12	1	1433.12	81.95**
		Varieties	1311.18	29	45.21	2.59**
		Situations x Varieties	507.17	29	17.49	2.39**
		Error	850.86	116	7.34	

Table 16 (continued) -2-

Sl. No.	Character	Source	Sum of squares	D.F.	Mean squares	F
6.	Number of immature pods	Situations	0.23	1	0.23	0.06
		Varieties	119.80	29	4.13	0.99
		Situations x Varieties	121.23	29	4.18	1.85**
		Error	261.71	116	2.26	
7.	Fresh weight of pods per plot	Situations	1715808.20	1	1715808.20	17.51**
		Varieties	6258395.20	29	215806.73	2.20**
		Situations x Varieties	2841587.79	29	97985.77	3.22**
		Error	3530748.26	116	30437.49	
8.	Haulms yield (green) per plot	Situations	13.21	1	13.21	6.53*
		Varieties	52.19	29	1.71	0.85
		Situations x Varieties	58.63	29	2.02	6.90**
		Error	33.94	116	0.29	
9.	Dry pod yield per plot	Situations	1223640.45	1	1223640.45	36.00**
		Varieties	3518423.05	29	121324.93	3.57**
		Situations x Varieties	985591.05	29	33985.89	2.57**
		Error	1532623.32	116	13212.27	
10.	100 pod weight	Situations	15321.44	1	15321.44	51.17**
		Varieties	33495.09	29	1155.01	3.86**
		Situations x Varieties	8682.03	29	299.38	11.77**
		Error	2951.42	116	25.44	

Table 16 (continued) -3-

Sl. No.	Character	Source	Sum of squares	D.F.	Mean squares	F
11.	100 kernel weight	Situations	793.67	1	793.67	5.56*
		Varieties	11522.59	29	397.33	2.78**
		Situations x Varieties	4141.67	29	142.82	57.70**
		Error	287.15	116	2.48	
12.	Dryage percentage of pods	Situations	282.53	1	282.53	14.96**
		Varieties	2632.39	29	90.77	4.81**
		Situations x Varieties	547.58	29	18.88	8.38**
		Error	261.29	116	2.25	
13.	Shelling percentage	Situations	50.05	1	50.05	1.25
		Varieties	3417.69	29	117.85	2.94**
		Situations x Varieties	1393.59	29	40.06	87.27**
		Error	53.32	116	0.46	
14.	Oil content	Situations	7.99	1	7.99	2.29
		Varieties	1201.23	29	41.42	11.91**
		Situations x Varieties	100.85	29	3.48	15.32**
		Error	26.31	116	0.23	
15.	Protein content	Situations	5.34	1	5.34	2.84
		Varieties	442.53	29	15.26	8.12**
		Situations x Varieties	54.51	29	1.88	3.78**
		Error	57.69	116	0.50	

*Significant at 5 per cent probability

**Significant at 1 per cent probability

Fig.3. An average plant harvested at maturity from each of the 30 varieties in CYT from rice fallows:

V_1. EC.21118

V_2. ICG.3859

V_3. EC.36892

V_4. S-7-5-13

V_5. EC.112027

V_6. B-353

V_7. EC.35999

V_8. EC.119704

V_9. AH-6915

V_{10}. M-13

V_{11}. Spanish Improved

V_{12}. Dh-3-30

V_{13}. Jyothi

V_{14}. Exotic-6

V_{15}. TMV-9

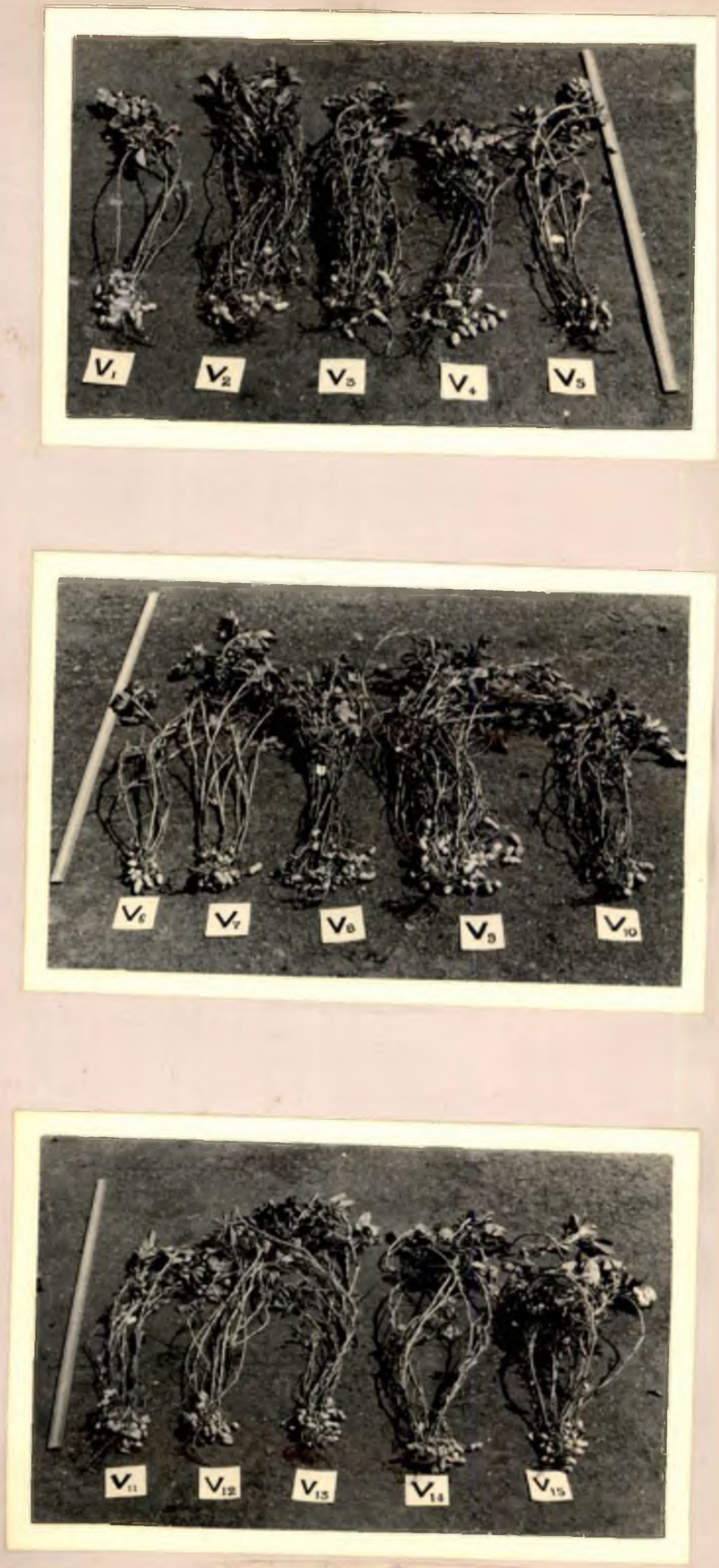


Fig. 3

Fig.3 (continued)

V_{16}. TMV-10

V_{17}. AK-811

V_{18}. TMV-2

V_{19}. KG-61-240

V_{20}. TMV-11

V_{21}. Pollachi-2

V_{22}. TG-3

V_{23}. TG-14

V_{24}. TG-17

V_{25}. TG-19

V_{26}. Pollachi-1

V_{27}. TMV-7

V_{28}. Gangapuri

V_{29}. Big Japan

V_{30}. Co-1

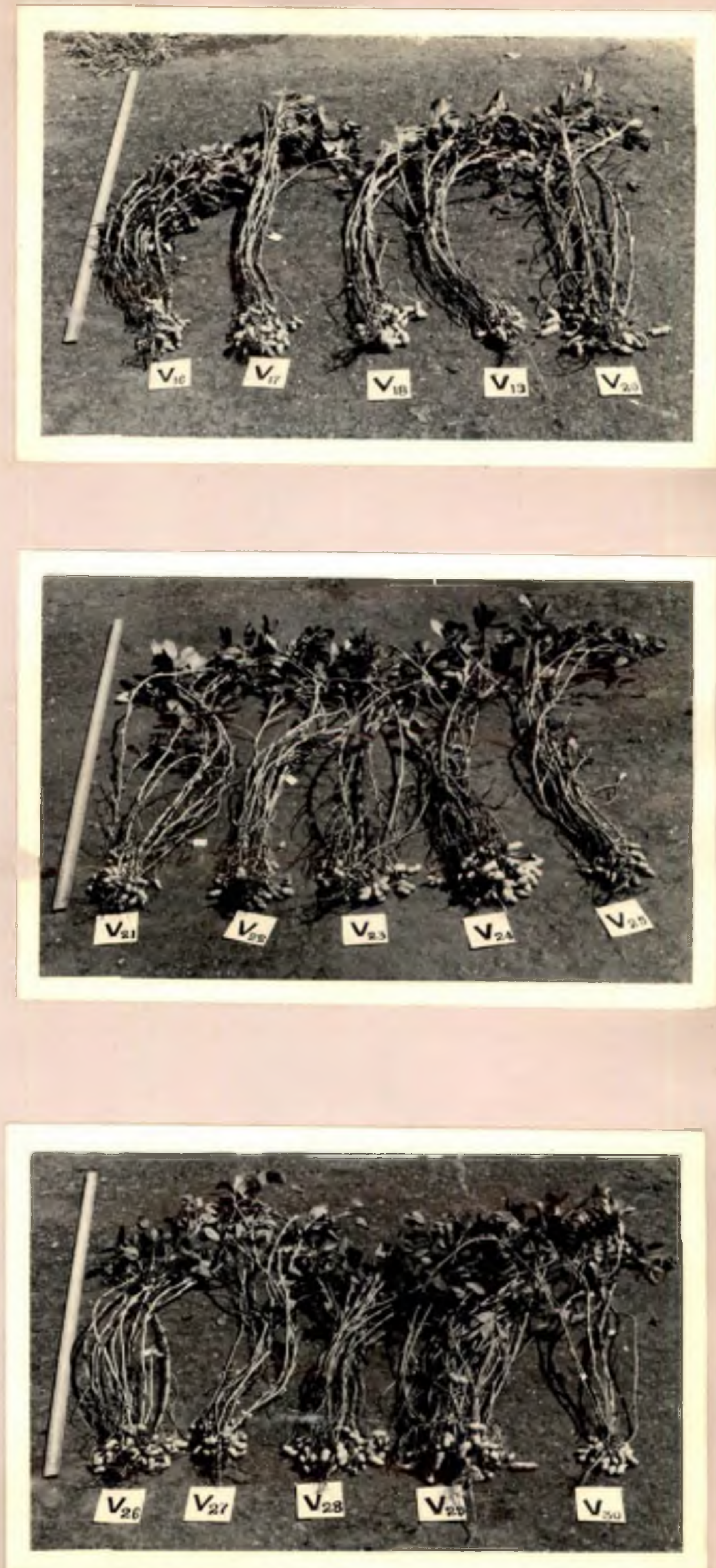


Fig. 3 (Continued)

Fig.4. Pod and kernel characters of the 30 varieties in CYT in rice fallows:

V_1. EC.21118

V_2; ICG-3859

V_3. EC.36892

V_4. S-7-5-13

V_5. EC.112027

V_6. B-353

V_7. EC.35999

V_8. EC.119704

V_9. AH-6915

V_{10}. M-13

V_{11}. Spanish Improved

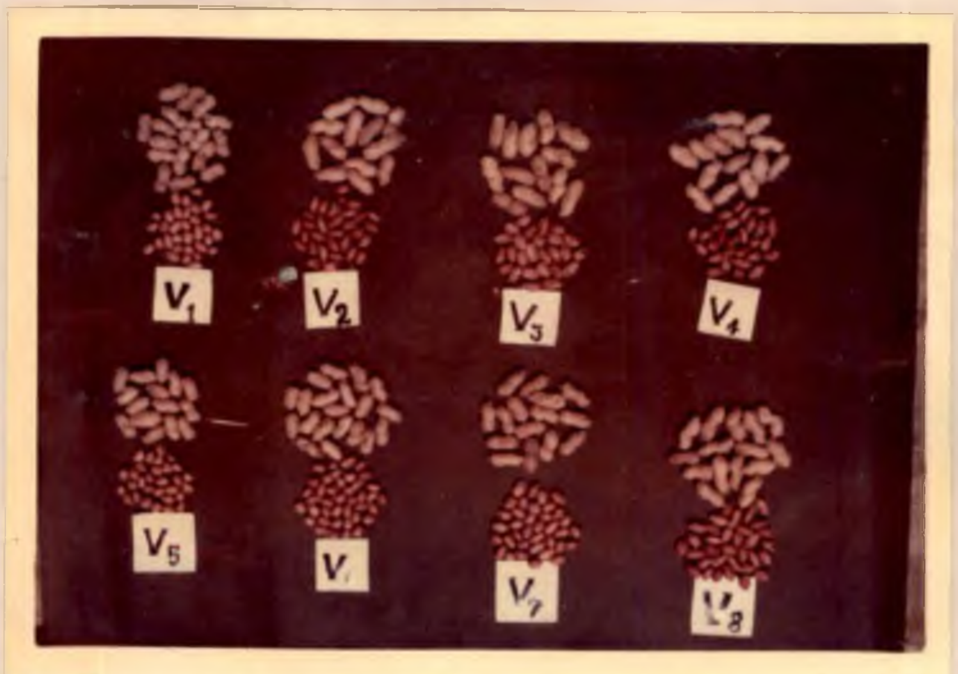
V_{12}. Dh-3-30

V_{13}. Jyothi

V_{14}. Exotic-6

V_{15}. TMV-9

V_{16}. TMV-10



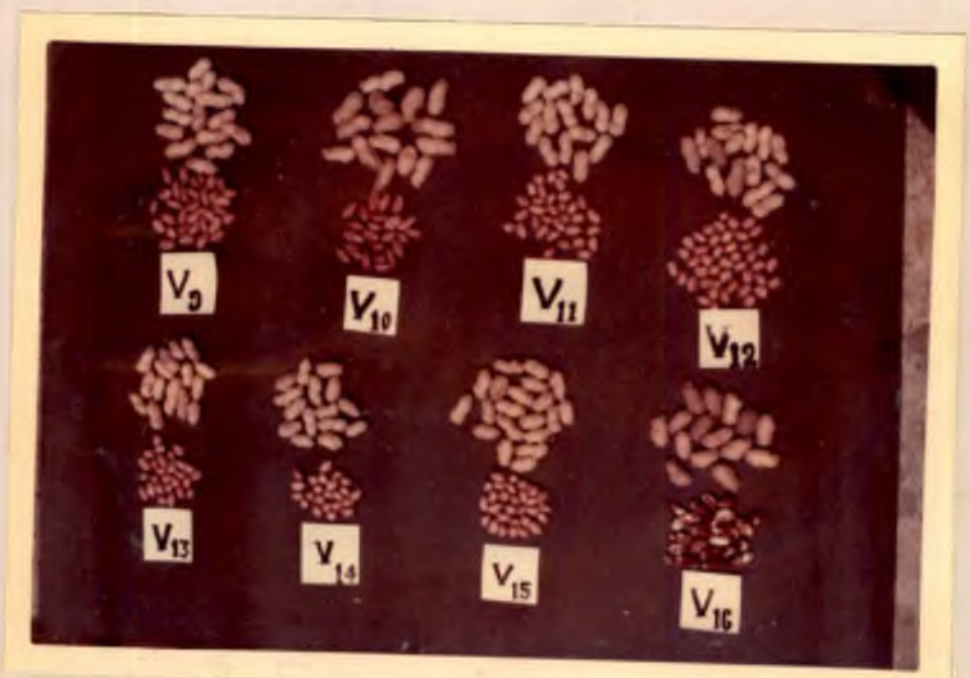


Fig.4

Fig.4. (continued)

V_{17}. AK-811

V_{18}. TMV-2

V_{19}. KG-61-240

V_{20}. TMV-11

V_{21}. Pollachi-2

V_{22}. TG-3

V_{23}. TG-14

V_{24}. TG-17

V_{25}. TG-19

V_{26}. Pollachi-1

V_{27}. TMV-7

V_{28}. Gangapuri

V_{29}. Big Japan

V_{30}. Co-1

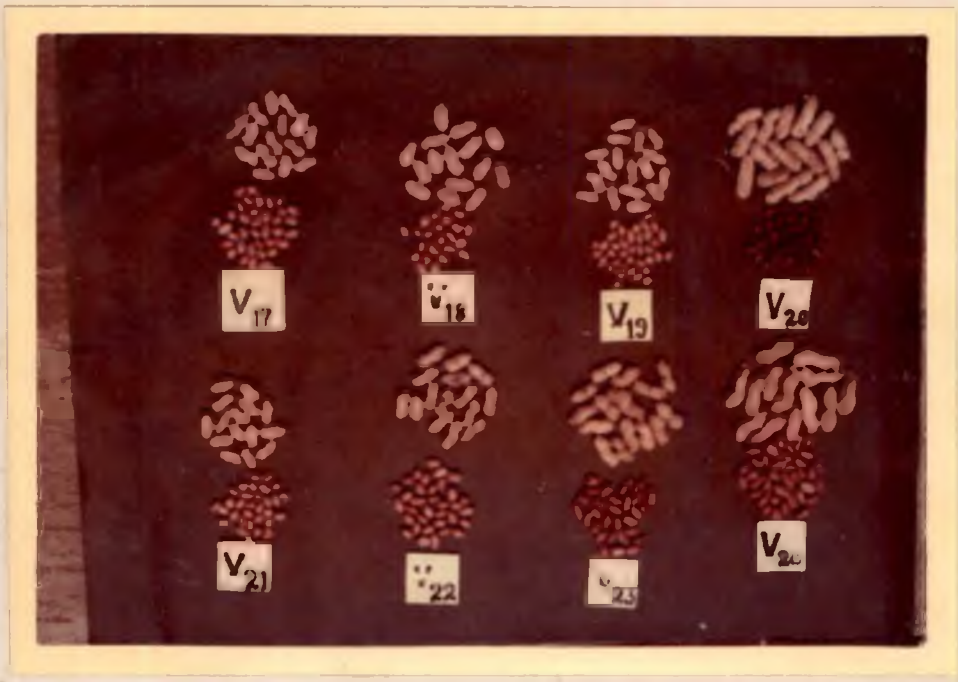


Fig. 4 (Continued)

In the separate analysis for uplands and rice fallows, all the characters showed significance at 1 per cent probability except number of immature pods in uplands which showed significance only at 5 per cent level. In the pooled analysis all the characters except duration upto flowering, number of immature pods, shelling percentage, oil content and protein content showed significance for situations. Except number of immature pods and haulms yield, for all the 13 characters the 'F' for varieties in the pooled analysis showed significance. This indicates that the varieties differ significantly in the two situations in respect of these 13 characters. The 'F' ratio for situations x varieties was significant for all the characters except length of top which illustrates that these characters vary considerably with the situations.

(1) Duration upto flowering

The varieties varied significantly at the two situations. The 'F' value for situations x varieties in the analysis of the pooled data was significant indicating that the character in each variety varies with the situations. The mean at the two situations are presented in table 17.

Under upland conditions during kharif, Exotic-6 had taken the minimum of 28.7 days to flowering. However 14 other varieties including TMV-7 were on par with Exotic-6. M-13 had the longest duration of 34.3 days closely followed by S-7-5-13 with 34.0 days. These two varieties however were on par.

During summer rice fallows, TG-17 and EC.35999 were the earliest in flowering, both with 27.0 days. As in uplands, M-13 was the latest with 36.0 days followed by ICG-3859 with 35.0 days

Table 17. Duration.

Code No.	Name of variety	Upto flowering (days)		Upto maturity (days)	
		Uplands	Rice fallows	Uplands	Rice fallows
V_1	EC.21118	31.3	28.7	111.3	100.7
V_2	ICG-3859	33.0	35.0	127.7	108.0
V_3	EC.36892	32.3	34.3	125.7	111.3
V_4	S-7-5-13	34.0	34.3	127.7	111.7
V_5	EC.112027	29.7	27.3	110.7	96.3
V_6	B-353	29.0	27.3	108.7	106.0
V_7	EC.35999	29.3	27.0	114.0	98.7
V_8	EC.119704	31.0	32.3	120.0	112.3
V_9	AH-6915	31.3	34.7	121.7	113.0
V_{10}	M-13	34.3	36.0	130.7	116.7
V_{11}	Spanish Improved	29.3	27.3	112.3	98.7
V_{12}	Dh-3-30	29.3	27.3	111.7	98.0
V_{13}	Jyothi	29.0	27.7	106.0	97.7
V_{14}	Exotic-6	28.7	28.7	109.3	95.0
V_{15}	TMV-9	29.7	30.7	112.3	100.0
V_{16}	TMV-10	30.7	28.3	110.7	105.7
V_{17}	AK-811	30.7	28.7	112.3	101.7
V_{18}	TMV-2	30.0	28.7	115.0	106.7
V_{19}	KG-61-240	29.7	31.0	106.0	98.7
V_{20}	TMV-11	29.7	27.3	121.0	108.7
V_{21}	Pollachi-2	29.7	32.0	108.7	97.3
V_{22}	TG-3	29.7	27.3	116.7	98.7
V_{23}	TG-14	30.7	28.0	116.0	106.0
V_{24}	TG-17	29.3	27.0	113.7	101.3
V_{25}	TG-19	29.3	27.3	111.7	98.3
V_{26}	Pollachi-1	31.3	29.0	110.0	100.0
V_{27}	TMV-7	29.7	30.0	107.7	98.3
V_{28}	Gangapuri	32.7	32.0	116.0	97.7
V_{29}	Big Japan	32.0	34.3	127.3	110.0
V_{30}	Co-1	29.0	28.0	112.3	106.0
	C.D.	1.29	1.49	4.31	2.66

and AH-6915 with 34.7 days. These three varieties were statistically on par. TMV-2 and TMV-7, the two recommended varieties, had taken 28.7 and 30.0 days respectively.

In general, the varieties in summer rice fallows flowered earlier than in uplands during kharif. Exotic-6 had the same duration at both the situations.

(2) Duration upto maturity

The highly significant 'F' value for varieties in the independent analysis indicatesthat the varieties differ in duration at both the situations. The significant 'F' for the interaction between situations and varieties in the pooled analysis brought out that the character in each variety varies considerably at the two situations. In general, duration was longer in uplands than in rice fallows. The mean days to maturity of the thirty varieties in uplands and rice fallows are furnished in table 17 and in figure 5.

Under the upland conditions, KG-61-240 and Jyothi were the earliest, maturing in 106.0 days followed by TMV-7 in 107.7 days and B-353 and Pollachi-2 in 108.7 days. M-13, one of the spreading varieties, was the latest in maturity, requiring 130.7 days followed by ICG-3859 and S-7-5-13, both with 127.7 days. TMV-2 had taken 115.0 days while the two promising varieties TG-14 and Spanish Improved had taken 116.0 and 112.3 days respectively. These three varieties however were on par.

The earliest maturing variety in rice fallow was Exotic-6, requiring 95.0 days. However EC.112027 maturing in 96.3 days and Pollachi-2 maturing in 97.3 days were on par with Exotic-6. Gangapuri and Jyothi had taken 97.7 days. As in uplands, M-13

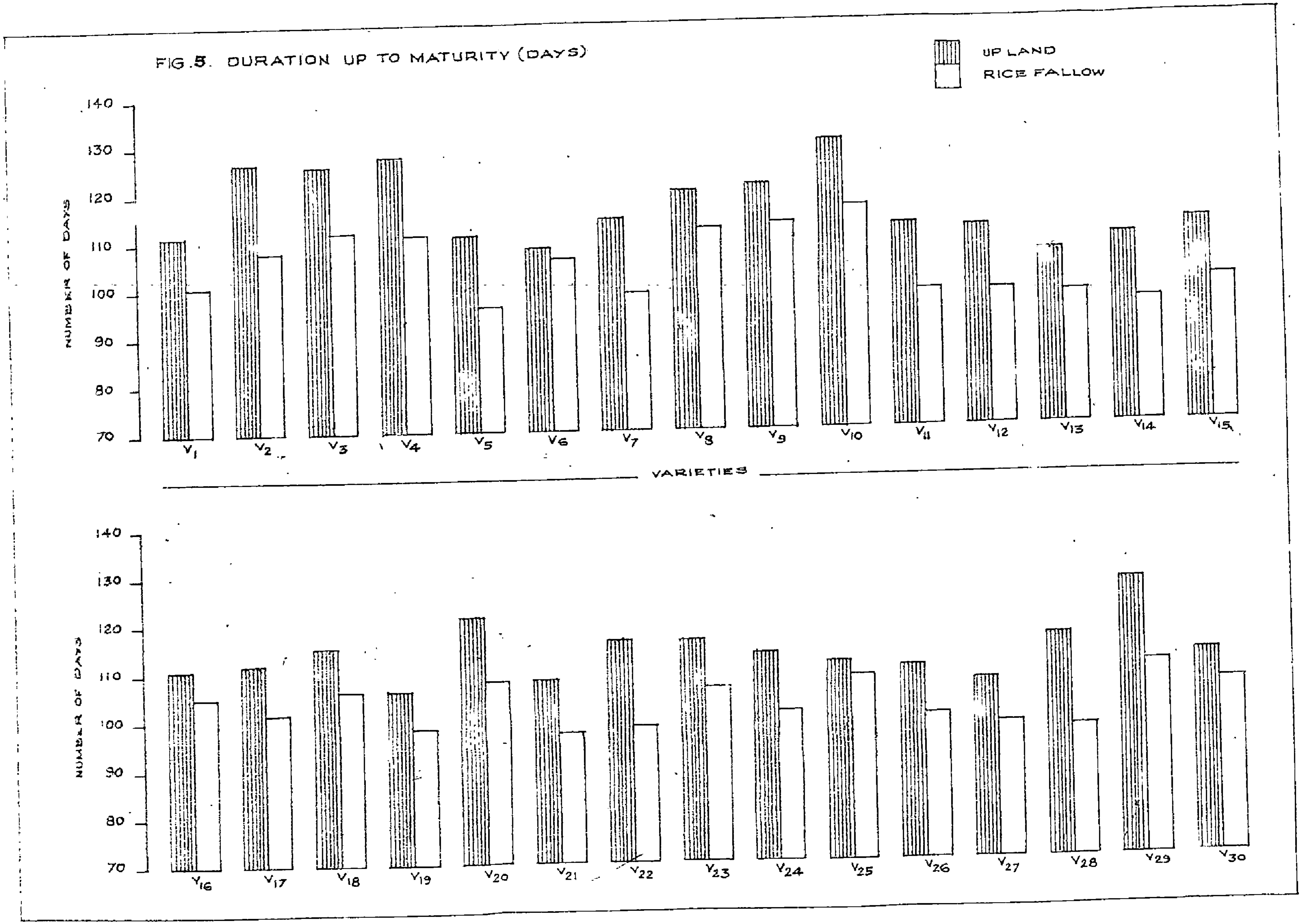


FIG.5. DURATION UP TO MATURITY (DAYS)
UP LAND
RICE FALLOW
NUMBER OF DAYS
140
130
120
110
100
90
80
70
V1 V2 V3 V4 V5 V6 V7 V8 V9 V10 V11 V12 V13 V14 V15
VARIETIES
V16 V17 V18 V19 V20 V21 V22 V23 V24 V25 V26 V27 V28 V29 V30

was the latest in duration, requiring 116.7 days for maturity in rice fallows. Thus M-13 maintained the same trend with regard to duration upto flowering and maturity, both in uplands and rice fallows. TMV-2 required 106.7 days when TMV-7 required 98.3 days only to attain maturity. TG-14 and Spanish Improved have taken 106.0 and 98.7 days respectively. It may be noted that TG-14 was on par with TMV-2 and Spanish Improved was on par with TMV-7.

(3) Length of top

The significant F ratio in the analysis of variance indicated that the varieties differed significantly in uplands and rice fallows. The pooled analysis showed that the interaction between situations and varieties was not significant suggesting that the character in each variety did not vary with the situations. The varieties can, therefore, be compared based on the pooled means as well. The means for the character in the two situations as well as the pooled means are provided in table 18.

In uplands, the length of top varied from as low as 79.3 cm in TG-14 to as high as 119.6 cm in TMV-9. It varied from 59.1 cm in TMV-2 to 89.8 cm in Gangapuri under the rice fallow conditions. The length of top was generally more in uplands than in rice fallows.

The pooled means indicate that TMV-9 (101.3 cm) had the longest top followed by TMV-7 (96.7 cm), Gangapuri (96.5 cm), AH-6915 (94.7 cm) and EC.36892 (93.7 cm). All these varieties were on par. TG-14 was the shortest with 74.5 cm followed by TMV-2 with 74.6 cm.

Table 18. Length of top and number of branches.

Code No.	Name of variety	Length of top (cm) Uplands	Rice fallows	Pooled	Number of branches Uplands	Rice fallows
V_1	EC.21118	103.5	73.7	88.6	8.7	7.1
V_2	ICG-3859	96.1	77.5	86.8	17.6	14.8
V_3	EC.36892	111.6	75.7	93.7	11.8	12.2
V_4	S-7-5-13	90.5	64.1	77.3	15.7	13.5
V_5	EC.112027	92.1	66.2	79.1	6.6	6.1
V_6	B-353	81.5	70.1	75.8	7.7	5.1
V_7	EC.35999	97.7	74.4	84.6	8.9	6.5
V_8	EC.119704	92.9	87.1	90.0	18.0	11.8
V_9	AH-6915	101.3	88.1	94.7	16.7	12.3
V_{10}	M-13	96.7	77.7	87.2	15.8	12.9
V_{11}	Spanish Improved	99.1	74.0	86.5	8.5	6.8
V_{12}	Dh-3-30	94.7	71.8	83.3	7.3	5.9
V_{13}	Jyothi	104.4	75.6	90.0	8.6	6.1
V_{14}	Exotic-6	100.4	77.6	89.0	7.9	6.9
V_{15}	TMV-9	119.6	82.9	101.3	8.5	6.1
V_{16}	TMV-10	92.6	74.4	83.5	9.1	8.5
V_{17}	AK-811	96.5	72.5	84.5	8.3	7.3
V_{18}	TMV-2	90.0	59.1	74.6	8.3	6.3
V_{19}	KG-61-240	93.5	66.8	80.2	7.5	6.5
V_{20}	TMV-11	101.2	64.4	82.8	6.9	6.5
V_{21}	Pollachi-2	95.4	66.7	81.1	7.9	6.2
V_{22}	TG-3	96.5	70.5	83.5	8.5	6.9
V_{23}	TG-14	79.3	69.6	74.5	7.4	6.5
V_{24}	TG-17	96.7	70.7	83.7	7.6	5.8
V_{25}	TG-19	99.4	72.8	86.1	8.6	6.0
V_{26}	Pollachi-1	92.9	60.4	76.7	8.0	6.3
V_{27}	TMV-7	113.6	79.7	96.7	9.4	6.3
V_{28}	Gangapuri	103.2	89.8	96.5	14.4	11.1
V_{29}	Big Japan	98.4	78.1	88.3	13.1	10.7
V_{30}	Co-1	99.6	75.4	87.0	7.7	5.5
	C.D.	15.51	13.74	10.63	2.26	2.21

(4) Number of branches

The analysis of variance in uplands and rice fallows revealed that the varieties varied significantly at both the situations. The 'F' ratio for situations x varieties in the analysis of pooled data was significant indicating that the character in each variety varied with situations. The mean number of branches are included in table 18 and presented in figure 6.

In the uplands, the number of branches varied from a minimum of 6.6 in EC.112027 to a maximum of 18.0 in EC.119704 followed by ICG-3859 (17.6) and AH-6915 (16.7). The three top ranking varieties were on par and had significantly larger number of branches than in TMV-2 and TMV-7. Spanish Improved and TG-14 produced 8.5 and 7.4 branches per plant respectively.

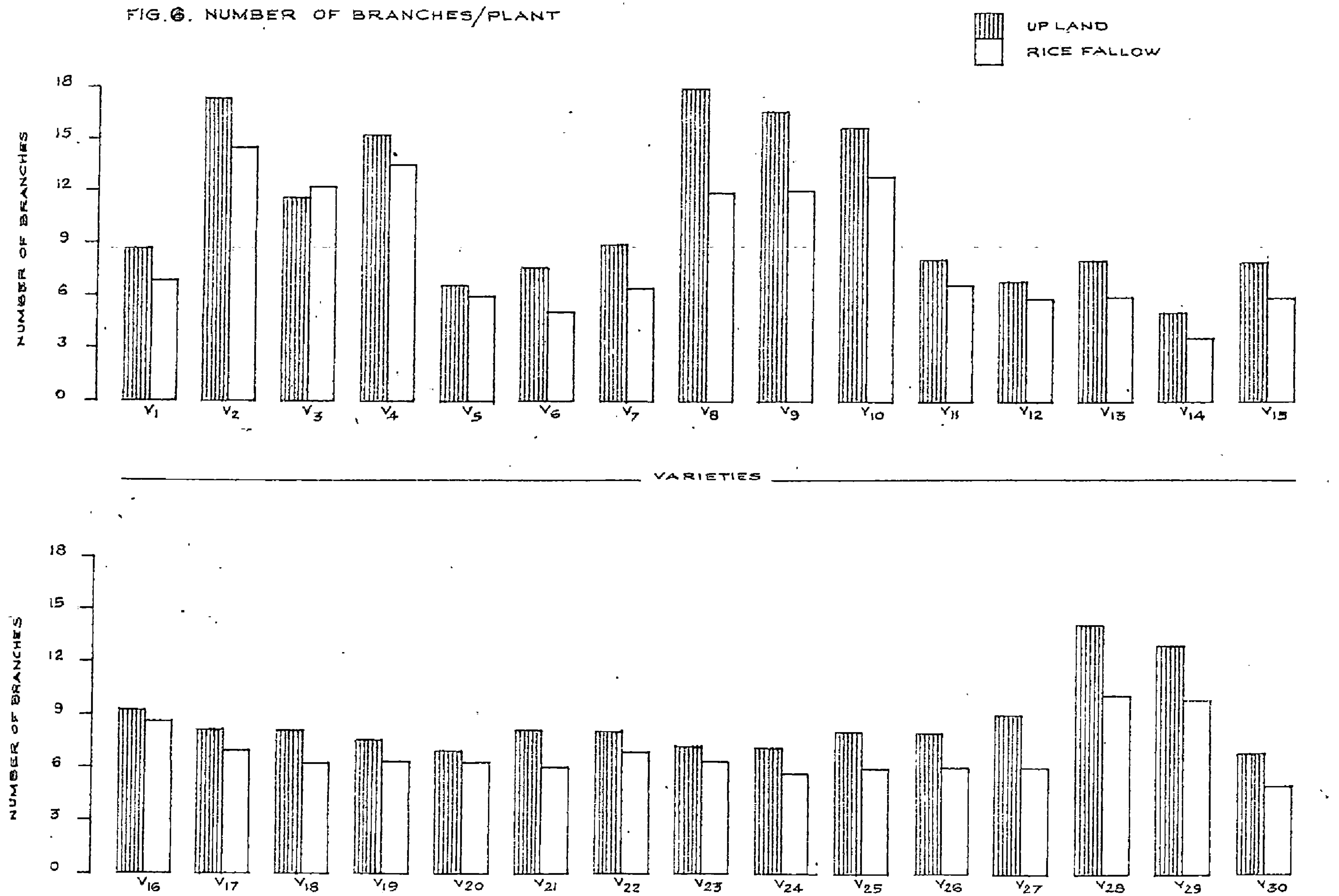
The number of branches under rice fallow conditions varied from 5.1 to 14.8. B-353 (5.1) produced the lowest number of branches followed by Co-1 (5.5). It was the highest in ICG-3859 (14.8) followed by S-7-5-13 (13.5) and M-13 (12.9). These 3 varieties were on par. TMV-2 and TMV-7 produced 6.3 branches per plant. Spanish Improved and TG-14 produced 6.8 and 6.5 branches per plant respectively.

In general, branching was more in uplands than in rice fallows. But ICG-3859 produced larger number of branches at both the situations with first rank in rice fallows (14.8) and second rank in uplands (17.6).

(5) Number of mature pods

The varieties differed significantly at the two situations as indicated by analysis of variance. The pooled analysis showed

FIG. 6. NUMBER OF BRANCHES/PLANT



that there was significant interaction between the situations and varieties and hence the number of mature pods in each variety varied with the situation. The means for the two situations are provided in table 19 and represented in figure 7.

The variability with respect to this character under upland conditions was from 10.57 to 29.10 pods per plant. The highest mean of 29.10 pods per plant for TG-14 was significantly superior to all other varieties. The other varieties in the order of rank are Pollachi-2 (23.90), EC.112027 (22.89), Spanish Improved (22.83), EC.119704 (22.47) and TG-3 (21.40). The lowest rank was held by AH-6915 (10.57) followed by S-7-5-13 (11.23), TMV-11 (13.40) and M-13 (14.87). These four varieties were on par. The recommended varieties, TMV-2 and TMV-7 produced a mean number of 17.27 and 19.80 mature pods per plant respectively.

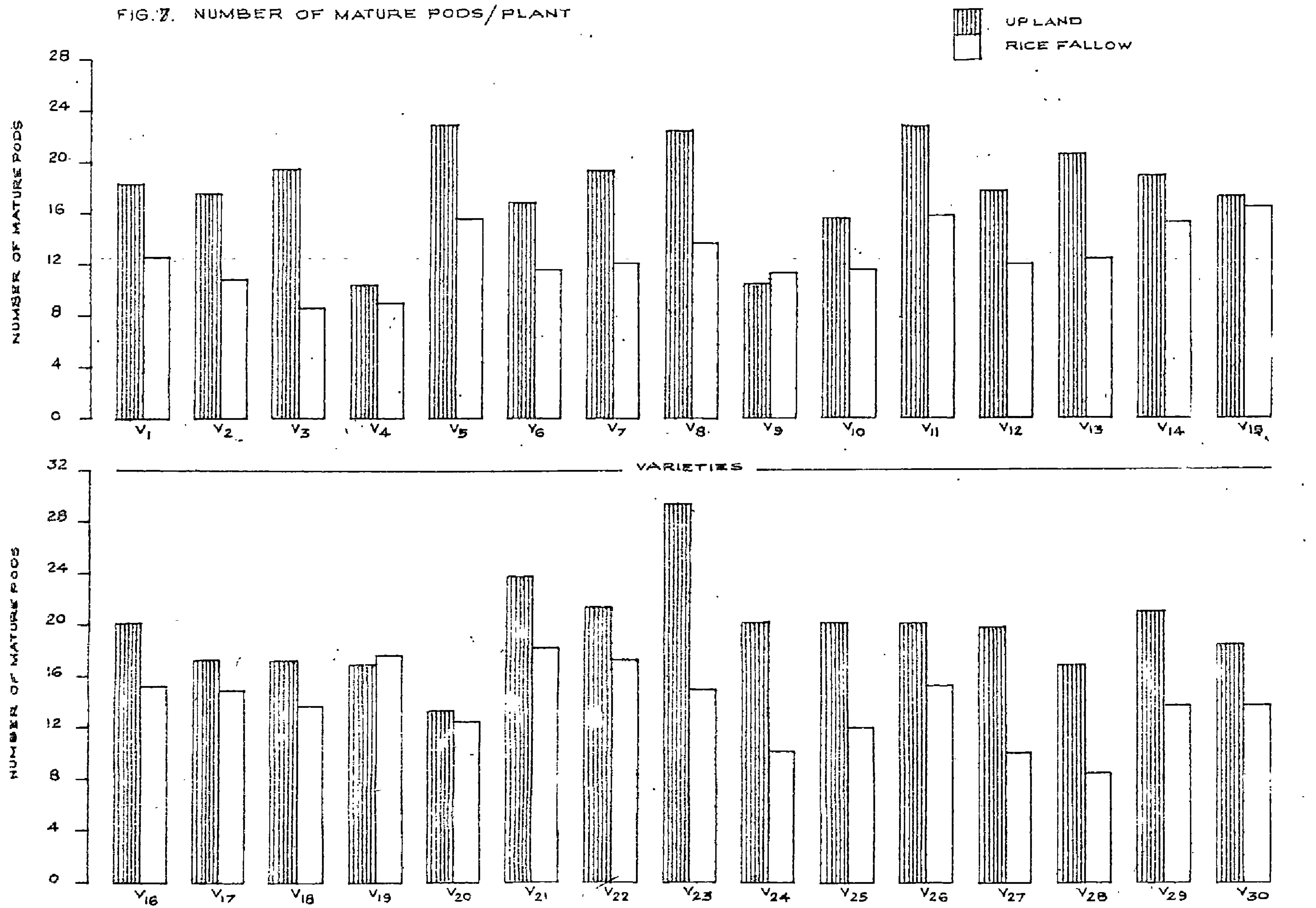
In the different varieties under comparison, the mean number of mature pods per plant in rice fallows varied from a minimum of 8.33 to a maximum of 18.25. The maximum of 18.25 was produced by Pollachi-2 closely followed by KG-61-240 (17.07), TG-3 (16.87), TMV-9 (16.63), Spanish Improved (15.97), EC.112027 (15.47), Exotic-6 (15.40) and TG-14 (15.17). Statistically all these varieties were on par. Gangapuri occupied the last rank with 8.33. The number of mature pods produced by TMV-2 and TMV-7 were 13.80 and 10.40 respectively.

In general, the number of mature pods per plant was more in uplands than in rice fallows. TG-14 ranking first in uplands was on par with the top ranking variety in rice fallows. Pollachi-2 ranking top in rice fallows was 2nd in uplands.

Table 19. Number of pods

Code No.	Name of variety	Mature pods Uplands	Mature pods Rice fallows	Immature pods Uplands	Immature pods Rice fallows
V_1	EC.21118	18.13	12.90	2.40	7.93
V_2	ICG-3859	17.73	10.80	4.93	4.40
V_3	EC.36892	19.80	8.37	2.97	2.73
V_4	S-7-5-13	11.23	9.13	4.80	4.40
V_5	EC.112027	22.89	15.87	3.71	4.93
V_6	B-353	16.43	10.93	2.97	2.93
V_7	EC.35999	19.20	12.00	4.47	3.73
V_8	EC.119704	22.47	12.93	3.73	6.53
V_9	AH-6915	10.57	10.80	2.83	3.87
V_{10}	M-13	14.87	11.73	3.73	3.73
V_{11}	Spanish Improved	22.83	15.97	3.40	4.67
V_{12}	Dh-3-30	17.60	12.13	4.07	4.60
V_{13}	Jyothi	20.77	14.53	2.93	3.60
V_{14}	Exotic-6	19.07	15.47	4.60	4.33
V_{15}	TMV-9	17.40	16.63	3.87	1.78
V_{16}	TMV-10	20.00	15.03	4.93	2.87
V_{17}	AK-811	17.07	15.00	3.80	4.73
V_{18}	TMV-2	17.27	13.80	2.90	2.87
V_{19}	KG-61-240	16.73	17.07	2.80	3.60
V_{20}	TMV-11	13.40	12.80	6.33	2.80
V_{21}	Pollachi-2	23.90	18.25	2.47	3.47
V_{22}	TG-3	21.40	16.87	4.47	4.07
V_{23}	TG-14	29.10	15.40	6.20	4.33
V_{24}	TG-17	19.96	9.70	5.33	4.67
V_{25}	TG-19	20.40	12.27	4.57	4.47
V_{26}	Pollachi-1	20.20	15.17	4.07	2.47
V_{27}	TMV-7	19.80	10.40	4.53	2.33
V_{28}	Gangapuri	16.93	8.33	4.93	4.47
V_{29}	Big Japan	20.93	13.40	2.73	3.07
V_{30}	Co-1	18.70	13.80	2.93	1.83
	C.D.	5.07	3.67	2.35	2.56

FIG. 7. NUMBER OF MATURE PODS/PLANT



(6) Number of immature pods

In the analysis of variance for upland, the 'F' value showed significance only at 5 per cent level while that for rice fallow indicated significance even at 1 per cent level. The character varied with situations in each variety as indicated by significant 'F' for situations x varieties in the pooled analysis. The mean number of immature pods per plant produced by the varieties at the two situations are presented in table 19.

The number of immature pods per plant varied from a minimum of 2.40 in EC.21118 to a maximum of 6.33 in TMV-11 under upland conditions. TMV-2 and TMV-7 recorded 2.90 and 4.53 immature pods per plant respectively.

Under the summer rice fallow conditions, the highest number of 7.93 was found in EC.21118 followed by EC.119704 with 6.53. Statistically they were on par. The bare minimum of 1.78 was noted in TMV-9 closely followed by Co-1 (1.83).

In contrast to the number of mature pods per plant, the number of immature pods per plant was higher in rice fallows than in uplands.

(7) Fresh weight of pods

From the analysis of variance it was evident that the varieties differed significantly in fresh weight of pods in uplands and rice fallows. The pooled analysis showed that fresh weight of pods varied in each variety at the two situations. The mean fresh weight of pods per plot and per hectare in uplands and rice fallows are presented in table 20.

Fresh weight of pods per plot ranged from as low as 1066 g for ICG-3859 to as high as 2223 g for EC.119704 in uplands during

Table 20. Fresh weight of pods.

Code No.	Name of variety	Per plot (g) Uplands	Per plot (g) Rice fallows	Per hectare (kg) Uplands	Per hectare (kg) Rice fallows
V_1	EC.21118	1411	1057	4413	3303
V_2	ICG-5859	1066	1271	3332	3972
V_3	EC.36892	1250	1382	3906	4319
V_4	S-7-5-13	1117	1283	3491	4009
V_5	EC.112027	1643	1321	5134	4128
V_6	B-353	1215	935	3797	2922
V_7	EC.35999	1547	1377	4834	4303
V_8	EC.119704	2223	1320	6947	4125
V_9	AH-6915	1158	1279	3619	3997
V_{10}	M-13	1445	1267	4516	3959
V_{11}	Spanish Improved	2045	1448	6391	4525
V_{12}	Dh-3-30	1557	1298	4866	4056
V_{13}	Jyothi	1266	1427	3934	4459
V_{14}	Exotic-6	1156	1279	3488	3997
V_{15}	TMV-9	1403	1318	4384	4119
V_{16}	TMV-10	1425	1257	4453	3928
V_{17}	AK-811	1556	1369	4863	4278
V_{18}	TMV-2	1532	1157	4788	3616
V_{19}	KG-61-240	1429	1268	4457	3963
V_{20}	TMV-11	1583	1226	4947	3831
V_{21}	Pollachi-2	1487	1471	4647	4597
V_{22}	TG-3	1604	1584	5013	4950
V_{23}	TG-14	2129	1557	6653	4866
V_{24}	TG-17	1763	1261	5509	3941
V_{25}	TG-19	1464	1305	4575	4078
V_{26}	Pollachi-1	1445	1395	4516	4359
V_{27}	TMV-7	1287	893	4022	2791
V_{28}	Gangapuri	1215	939	3797	2931
V_{29}	Big Japan	1348	1237	4213	3866
V_{30}	Co-1	1558	1289	4869	4028
	C.D.	335.9	223.1	1049.4	696.9

kharif. TG-14 with 2129 g and Spanish Improved with 2045 g ranked second and third. The three top ranking varieties, viz., EC.119704, TG-14 and Spanish Improved were on par and far superior to the recommended ones. TMV-2, the better of the two recommended varieties, gave 4788 kg/ha while the top ranking variety, EC.119704, gave 6947 kg/ha.

During summer in rice fallows, the fresh weight of pods per plot ranged from 893 g to 1584 g. The maximum was obtained from TG-3 (1584 g) followed by TG-14 (1557 g), Pollachi-2 (1471 g), Spanish Improved (1448 g), Jyothi (1427 g), Pollachi-1 (1395 g), EC.36892 (1382 g), EC.35999 (1377 g) and AK-811 (1369 g). All these varieties were on par and superior to the recommended varieties. It was lowest for TMV-7 (893 g) followed by B-353 (935 g). The top ranking variety TG-3 produced 4950 kg fresh pods per hectare, whereas one of the recommended varieties (TMV-7) gave the lowest yield of 2791 kg/ha.

(8) Haulms yield (green)

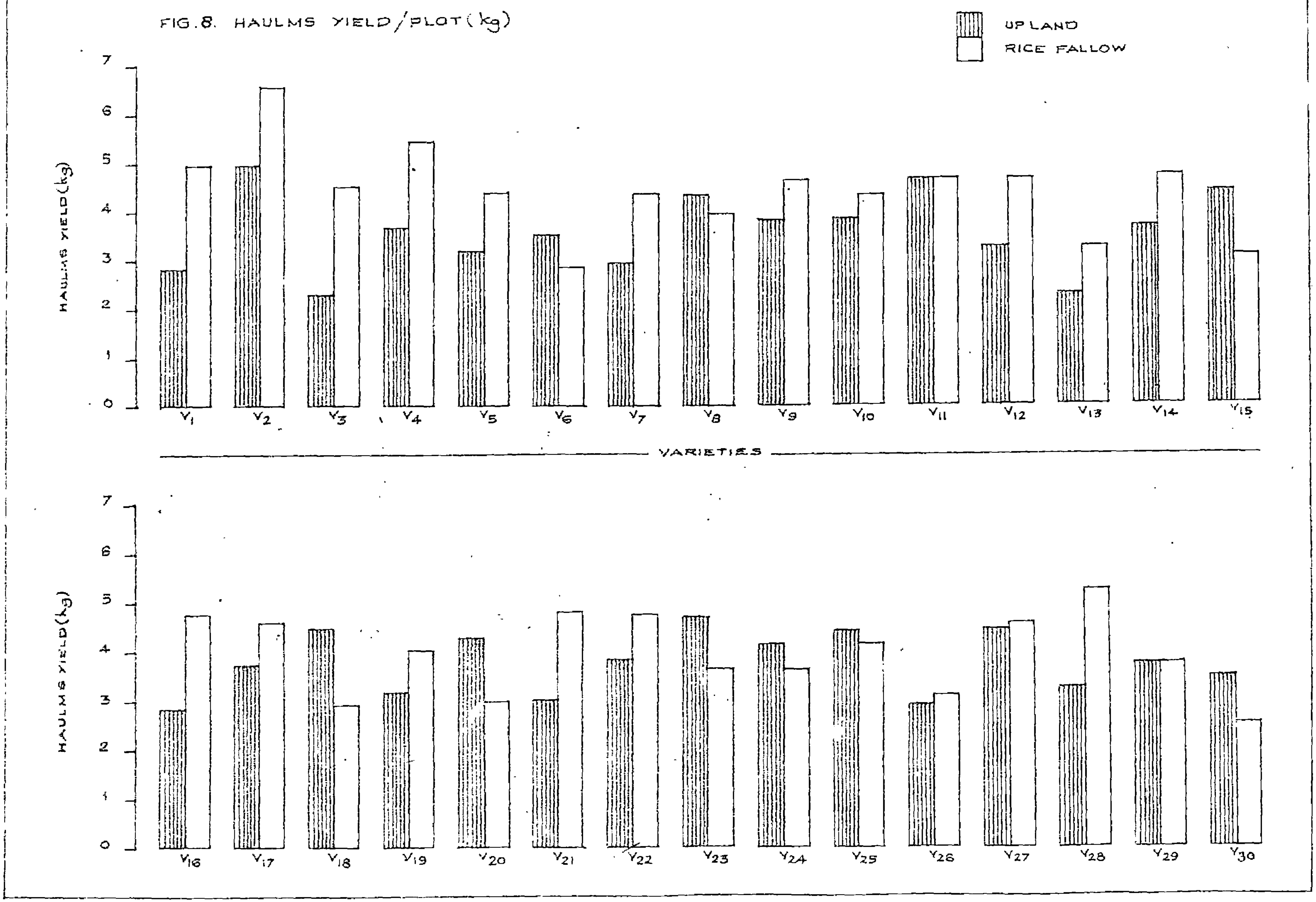
The varieties differed significantly in green haulms yield per plot both in uplands and rice fallows as evidenced by the significant 'F' values in the separate analysis of variance. The 'F' ratio for situations x varieties was significant in the pooled analysis and hence the haulms yield varied significantly in each of the variety at the two situations. The mean haulms yield per plot and per hectare for the two trials are presented in table 21. In figure 8 the haulms yield per plot in the two situations is graphically represented.

Under upland conditions, the highest haulms yield per plot was recorded by ICG-3859 (4.97 kg) followed by TG-14 (4.67 kg),

Table 21. Haulms yield (green).

Code No.	Name of variety	Per plot (kg) Uplands	Per plot (kg) Rice fallows	Per hectare (kg) Uplands	Per hectare (kg) Rice fallows
V_1	EC.21118	2.83	4.93	8854	15406
V_2	ICG-3859	4.97	6.57	15495	20531
V_3	EC.36892	2.29	4.53	7070	14156
V_4	S-7-5-13	3.67	5.40	11490	16875
V_5	EC.112027	3.17	4.27	7781	13343
V_6	B-353	3.53	2.87	11539	8969
V_7	EC.35999	2.97	4.37	9267	13656
V_8	EC.119704	4.30	3.90	13417	12188
V_9	AH-6915	3.77	4.63	11703	14469
V_{10}	M-13	3.83	4.30	11995	13438
V_{11}	Spanish Improved	4.60	4.57	14293	14281
V_{12}	Dh-3-30	3.23	4.60	10181	14375
V_{13}	Jyothi	2.27	4.20	7107	13125
V_{14}	Exotic-6	3.60	4.67	11234	14594
V_{15}	TMV-9	4.37	2.97	13648	9375
V_{16}	TMV-10	2.86	4.73	8891	14781
V_{17}	AK-811	3.73	4.57	11609	14281
V_{18}	TMV-2	4.47	2.90	13981	9063
V_{19}	KG-61-240	3.17	4.00	9865	12500
V_{20}	TMV-11	4.27	2.97	13307	9281
V_{21}	Pollachi-2	3.00	4.83	9292	15094
V_{22}	TG-3	3.83	4.77	11922	14906
V_{23}	TG-14	4.67	3.60	14594	11250
V_{24}	TG-17	4.10	3.63	12727	11344
V_{25}	TG-19	4.43	4.10	13851	12812
V_{26}	Pollachi-1	2.90	3.07	8984	11468
V_{27}	TMV-7	4.40	4.50	13802	14063
V_{28}	Gangapuri	3.23	5.20	10068	16250
V_{29}	Big Japan	3.73	3.70	11688	11656
V_{30}	Co-1	3.40	2.50	10557	7813
	C.D.	0.83	0.93	2593.8	2906.3

FIG. 8. HAULMS YIELD/PLOT (kg)



Spanish Improved (4.60 kg), TMV-2 (4.47 kg), TG-19 (4.43 kg), TMV-7 (4.40 kg), TMV-9 (4.37 kg), EC.119704 (4.30 kg) and TMV-11 (4.27 kg). All these nine varieties were however on par. The haulms yield was the lowest in Jyothi (2.27 kg). ICG-3859 gave a haulms yield of 15495 kg/ha, whereas TMV-2 and TMV-7 gave 13981 kg and 13802 kg/ha respectively.

Under the summer rice fallow conditions, the highest haulms yield per plot was obtained from ICG-3859 (6.57 kg) followed by S-7-5-13 (5.40 kg) and Gangapuri (5.20 kg). All these varieties were on par. It was lowest in Co.1 with 2.50 kg. TMV-2 had produced a haulms yield of only 9063 kg/ha while TMV-7 produced 14063 kg/ha. But the variety giving the highest haulms yield produced 20531 kg/ha.

Both in uplands and rice fallows, ICG-3859 produced the highest haulms yield. In the uplands, TG-14 and Spanish Improved occupied second and third places while in rice fallows they were at the 24th and 11th places respectively.

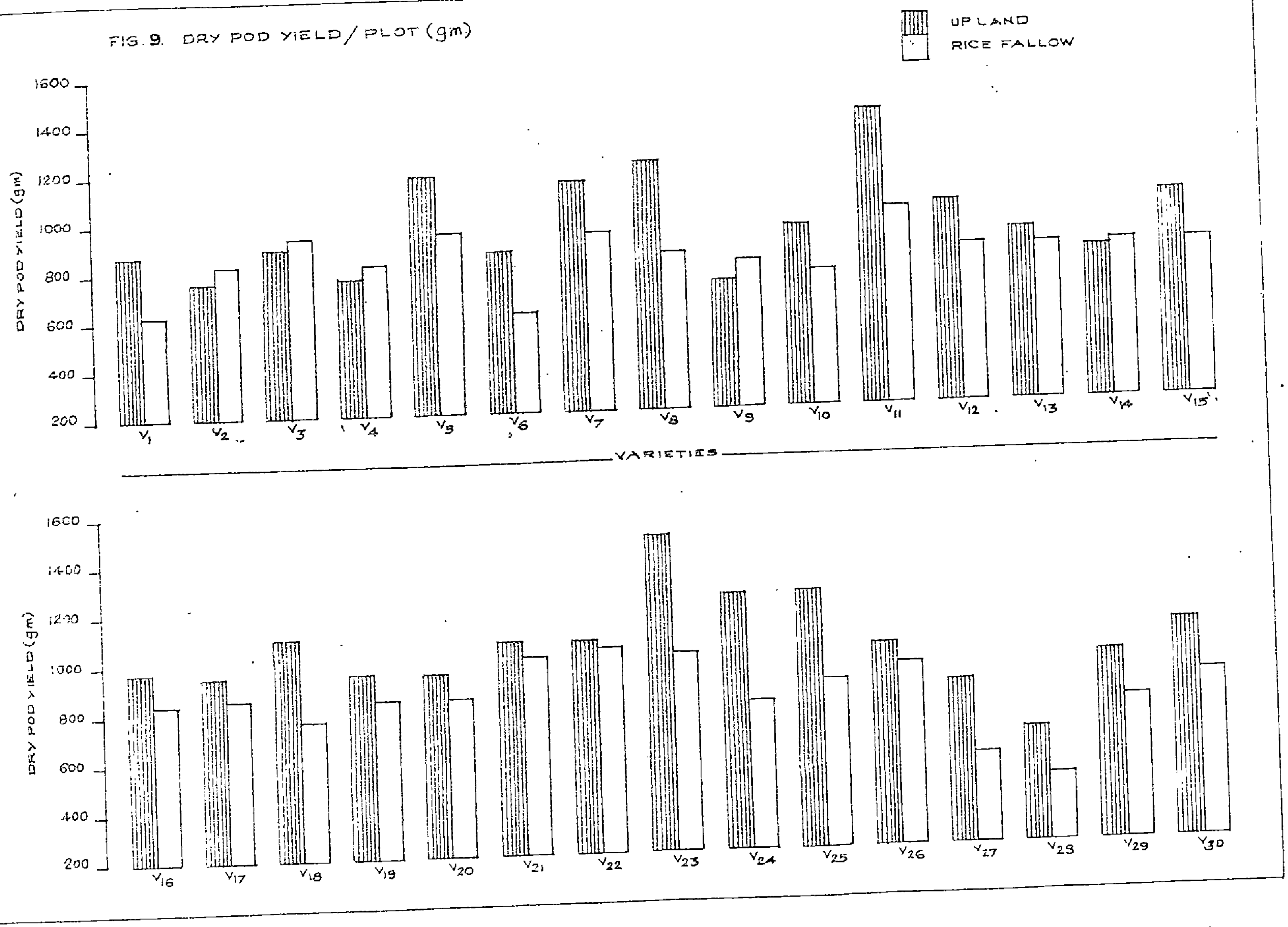
(9) Dry pod yield

The analysis of variance indicated that the varieties differed significantly in pod yield in uplands and rice fallows. The pooled analysis revealed that there was significant interaction for situations x varieties. This showed that pod yield of each variety varied significantly with the situations. Thus the varieties differed in yield performance at the two situations. The mean dry pod yield per plot and per hectare for the two situations are presented in table 22. The yield per plot in the two situations are shown in figure 9.

Table 22. Dry pod yield.

Code No.	Name of variety	Per plot (g) Uplands	Per plot (g) Rice fallows	Per hectare (kg) Uplands	Per hectare (kg) Rice fallows
V_1	EC.21118	883	651	2759	2034
V_2	ICG-3859	755	821	2359	2566
V_3	EC.36892	890	928	2781	2900
V_4	S-7-5-13	765	817	2391	2553
V_5	EC.112027	1193	945	3728	2953
V_6	B-353	856	601	2678	1878
V_7	EC.35999	1143	934	3572	2919
V_8	EC.119704	1218	840	3806	2625
V_9	AH-6915	726	804	2269	2513
V_{10}	M-13	951	772	2972	2413
V_{11}	Spanish Improved	1401	999	4356	3122
V_{12}	Dh-3-30	1075	868	3356	2713
V_{13}	Jyothi	906	846	2834	2644
V_{14}	Exotic-6	813	845	2453	2641
V_{15}	TMV-9	1024	939	3200	2934
V_{16}	TMV-10	972	843	3038	2634
V_{17}	AK-811	951	850	2972	2656
V_{18}	TMV-2	1092	761	3428	2378
V_{19}	KG-61-240	947	824	2959	2575
V_{20}	TMV-11	945	817	2953	2553
V_{21}	Pollachi-2	1065	1008	3328	3150
V_{22}	TG-3	1065	1036	3328	3238
V_{23}	TG-14	1488	998	4650	3119
V_{24}	TG-17	1234	793	3856	2478
V_{25}	TG-19	1047	878	3272	2744
V_{26}	Pollachi-1	1024	942	3203	2944
V_{27}	TMV-7	863	569	2694	1778
V_{28}	Gangapuri	668	476	2088	1488
V_{29}	Big Japan	963	789	3009	2466
V_{30}	Co-1	1094	876	3419	2738
	C.D.	226.3	139.0	706.3	434.4

FIG. 9. DRY POD YIELD/PLOT (gm)



During kharif in uplands, the pod yield per plot was the highest for TG-14 (1488 g) followed by Spanish Improved (1401 g), TG-17 (1234 g) and EC.119704 (1218 g). EC.112027 (1193 g) ranked fifth followed by EC.35999 (1143 g), Co.1 (1094 g) and TMV-2 (1092 g). The lowest yield was recorded by Gangapuri with 668 g followed by AH-6915 with 726 g. The two top ranking varieties were found to be statistically on par and were far superior to the recommended varieties, viz., TMV-2 and TMV-7. When the yield per hectare of the better recommended variety, TMV-2 was 3428 kg/ha, that of the top ranking variety, TG-14, was 4650 kg/ha followed by Spanish Improved with 4356 kg/ha. TMV-7 had yielded only 2694 kg/ha which was statistically on par with the lowest yielding variety, Gangapuri, with 2088 kg/ha.

In the rice fallows, the top rank was for the variety TG-3 yielding 1036 g per plot followed by Pollachi-2 (1008 g), Spanish Improved (999 g), TG-14 (998 g), EC.112027 (945 g), Pollachi-1 (942 g), TMV-9 (939 g), EC.35999 (934 g) and EC.36892 (928 g). However all these nine varieties were on par, but superior to the recommended varieties (TMV-2 and TMV-7). It was interesting to note that Gangapuri had yielded the least (476 g) in rice fallows too. TMV-2, the better of the two recommended varieties, yielded 2378 kg/ha in comparison to the highest yielding variety (TG-3) yielding 3238 kg/ha. The yield per hectare of TMV-7 was only 1778 kg and this was on par with the lowest yielding variety, Gangapuri, with 1488 kg.

In general, the yield in uplands was found to be more than that in rice fallows. This was so with number of mature pods too. TG-14 and Spanish Improved were promising at both the situations.

TG-3 and Pollachi-2 ranking first and second in rice fallow were ranking 11th and 10th respectively in uplands. TG-17 and EC.119704 ranked 3rd and 4th in uplands while they were 23rd and 17th in rice fallows.

(10) <u>100 pod weight</u>

Highly significant variation was observed between the varieties at both the locations with respect to 100 pod weight. The analysis of variance for the pooled data showed that the 'F' for situations x varieties was significant. This indicated that 100 pod weight in each variety differed in uplands and rice fallows. The mean 100 pod weights in the thirty varieties are given in table 23 and figure 10.

The mean 100 pod weight was the highest in M-13 (113.3 g) and the lowest in Pollachi-2 (59.7 g). The second rank was held by TG-17 (110.7 g) followed by TMV-11 (96.7 g) and AH-6915 (95.5 g). The latter two varieties were on par, but TG-17 was significantly superior to both. The 100 pod weight recorded by the standard varieties, TMV-2 and TMV-7, were 85.4 and 80.7 g respectively. In the two promising varieties, TG-14 and Spanish Improved, the weights were 91.4 g and 74.2 g respectively.

The variety which recorded the maximum 100 pod weight in summer rice fallows was EC.36892 with 142.4 g followed by AH-6915 (140.2 g), TMV-11 (124.8 g) and TG-17 (120.5 g). KG-61-240 recorded the lowest 100 pod weight of 70.6 g. The mean 100 pod weight of TMV-2 was 107.5 g whereas that for TMV-7 was 83.6 g. TG-14 and Spanish Improved had 100 pod weights of 101.9 g and 90.9 g respectively. The weight for the different varieties was

Table 23. Pod and kernel weights.

Code No.	Name of variety	100 pod weight (g)		100 kernel weight (g)	
		Uplands	Rice fallows	Uplands	Rice fallows
V_1	EC.21118	79.5	82.1	67.1	34.1
V_2	ICG-3859	75.4	109.8	48.2	46.4
V_3	EC.36892	88.7	142.4	57.4	56.8
V_4	S-7-5-13	89.0	103.2	48.9	50.3
V_5	EC.112027	62.8	89.9	35.9	36.4
V_6	B-353	66.2	82.6	40.7	36.4
V_7	EC.35999	92.4	100.7	51.7	49.4
V_8	EC.119704	87.3	113.0	52.9	57.1
V_9	AH-6915	95.5	140.2	49.5	55.8
V_{10}	M-13	113.3	106.6	78.7	46.6
V_{11}	Spanish Improved	74.2	90.9	52.4	40.2
V_{12}	Dh-3-30	83.5	87.3	51.4	40.4
V_{13}	Jyothi	66.1	102.9	39.2	41.2
V_{14}	Exotic-6	68.9	78.4	37.8	38.7
V_{15}	TMV-9	65.2	87.5	37.1	38.2
V_{16}	TMV-10	89.3	88.1	59.2	52.0
V_{17}	AK-811	71.1	86.3	42.5	45.1
V_{18}	TMV-2	85.4	107.5	49.4	53.4
V_{19}	KG-61-240	70.6	70.6	37.0	35.7
V_{20}	TMV-11	96.7	124.8	59.1	55.7
V_{21}	Pollachi-2	59.7	83.4	34.0	39.1
V_{22}	TG-3	89.9	98.8	57.3	41.1
V_{23}	TG-14	91.4	101.9	55.1	55.8
V_{24}	TG-17	110.7	120.5	73.4	55.3
V_{25}	TG-19	80.6	91.7	45.5	42.5
V_{26}	Pollachi-1	80.0	113.2	51.7	49.7
V_{27}	TMV-7	80.7	83.6	42.7	40.8
V_{28}	Gangapuri	62.7	91.7	37.7	42.4
V_{29}	Big Japan	71.5	97.9	48.5	40.2
V_{30}	Co-1	65.9	89.9	36.1	35.4
	C.D.	1.59	1.40	1.33	3.37

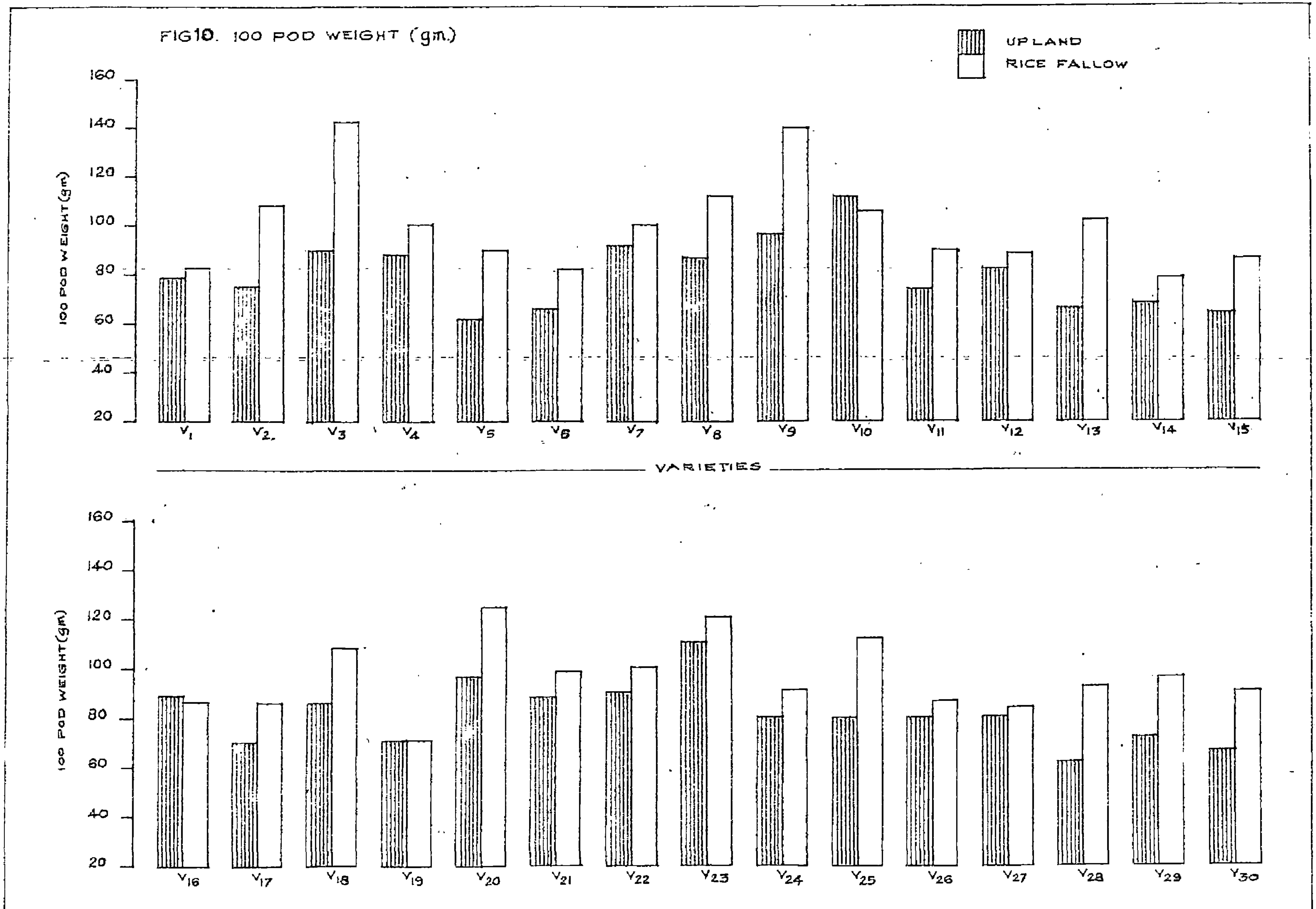


FIG10. 100 POD WEIGHT (gm.)
UPLAND
RICE FALLOW
100 POD WEIGHT (gm)
160
140
120
100
80
60
40
20
V1
V2
V3
V4
V5
V6
V7
V8
V9
V10
V11
V12
V13
V14
V15
VARIETIES
V16
V17
V18
V19
V20
V21
V22
V23
V24
V25
V26
V27
V28
V29
V30

generally high in summer rice fallows as compared to that in uplands during kharif.

(11) <u>100 kernel weight</u>

There were significant differences among varieties during kharif in uplands and summer in rice fallows. The highly significant 'F' value in the pooled analysis for the interaction between situations and varieties showed that 100 kernel weight exhibited profound variation within each variety at the two situations. The varietal means are given in table 23.

As in the case of 100 pod weight, the first and second ranks for 100 kernel weight in uplands were taken by M-13 (78.7 g) and TG-17 (73.4 g). The third place was occupied by EC.21118 (67.1 g). These three varieties differed significantly in kernel weight but were significantly superior to all other varieties. The lowest weight was recorded by Pollachi-2 (34.0 g) and was statistically inferior to all other varieties. 100 kernel weight for TMV-2 was 49.4 g whereas for TMV-7 it was 42.7 g. For TG-14 and Spanish Improved the kernel weights were 55.1 g and 52.4 g respectively.

In summer rice fallows the highest value of 57.1 g for 100 kernel weight was registered by EC.119704, followed closely by EC.36892 (56.8 g), AH-6915 and TG-14 (55.8 g each), TMV-11 (55.7 g) and TG-17 (55.3 g). All these six varieties were statistically on par. The lowest 100 kernel weight of 34.1 g was recorded by EC.21118 followed by Co.1 (35.4 g), KG-61-240 (35.7 g) and EC.112027 and B-353 (36.4 g each). These five varieties, however, were on par. Of the recommended varieties, TMV-2 recorded 53.4 g and TMV-7 40.8 g.

(12) Dryage percentage of pods

The analysis of variance had revealed that the varieties exhibited significant differences at both the situations. The significant 'F' ratio for situations x varieties in the analysis of the pooled data indicated that dryage percentage was highly influenced by the situations. The mean values in respect of this trait in uplands and rice fallows are presented in table 24.

Under the upland conditions during kharif, the highest percentage of 73.2 was obtained in TMV-9 closely followed by EC.35999 (73.1), ICG-3859 (71.6), EC.112027 and Jyothi (71.5 each), and TMV-2 (71.4). All these six varieties were on par. The dryage percentage was the lowest in Gangapuri (56.0) followed by EC.119704 (56.2). These two varieties were on par and significantly inferior to all other varieties. The very low value (56.2) for the variety EC.119704 had lowered its top rank in fresh weight of pods to the 8th position in dry pod yield.

During summer in rice fallows, EC.112027 had registered the highest dryage percentage of 71.6 followed by TMV-9 (71.1), Spanish Improved and Jyothi (69.0 each). These varieties were on par. Gangapuri, as in uplands, had recorded the lowest value of 51.3 and was significantly inferior to all other varieties, followed by M-13 (60.9). The dryage percentage for TMV-2 and TMV-7 were 65.9 and 63.6 respectively.

(13) Shelling percentage

The analysis of variance for shelling percentage revealed that there were wide variation among the varieties at both the situations. Further, the pooled analysis indicated that shelling

Table 24. Dryage and shelling percentages.

Code No.	Name of variety	Dryage percentage Uplands	Dryage percentage Rice fallows	Shelling percentage Uplands	Shelling percentage Rice fallows
V_1	EC.21118	62.4	61.7	73.6	77.9
V_2	ICG-3859	71.6	64.7	72.6	67.3
V_3	EC.36892	70.5	67.2	61.0	70.3
V_4	S-7-5-13	67.8	63.7	72.5	61.4
V_5	EC.112027	71.5	71.6	75.6	77.5
V_6	B-353	71.0	65.2	77.4	76.0
V_7	EC.35999	73.1	68.0	77.4	75.4
V_8	EC.119704	56.2	64.0	74.2	69.3
V_9	AH-6915	62.5	63.0	75.9	66.6
V_{10}	M-13	65.8	60.9	73.3	69.2
V_{11}	Spanish Improved	68.4	69.0	74.4	72.9
V_{12}	Dh-3-30	69.0	66.8	71.2	72.7
V_{13}	Jyothi	71.5	69.0	78.9	76.2
V_{14}	Exotic-6	70.6	66.0	75.7	78.1
V_{15}	TMV-9	73.2	71.1	75.9	75.2
V_{16}	TMV-10	67.3	67.0	74.9	70.2
V_{17}	AK-811	61.2	62.1	76.2	78.2
V_{18}	TMV-2	71.4	65.9	71.5	74.5
V_{19}	KG-61-240	66.5	64.9	80.2	81.4
V_{20}	TMV-11	59.5	66.6	70.0	71.7
V_{21}	Pollachi-2	70.9	68.6	77.6	77.6
V_{22}	TG-3	66.5	62.8	76.0	73.1
V_{23}	TG-14	69.8	64.1	75.0	70.2
V_{24}	TG-17	69.6	62.5	72.6	71.4
V_{25}	TG-19	71.1	67.4	72.7	72.6
V_{26}	Pollachi-1	70.3	67.6	73.7	69.5
V_{27}	TMV-7	66.3	63.6	78.3	76.5
V_{28}	Gangapuri	56.0	51.3	52.3	68.8
V_{29}	Big Japan	71.1	63.8	71.3	57.4
V_{30}	Co-1	70.5	67.8	77.1	76.3
	C.D.	2.02	2.82	1.06	1.13

percentage differed significantly and widely in each variety at the two situations as the 'F' ratio for situations x varieties was significant. The mean shelling percentage for the varieties under upland and rice fallow conditions are included in table 24 and presented in figure 11.

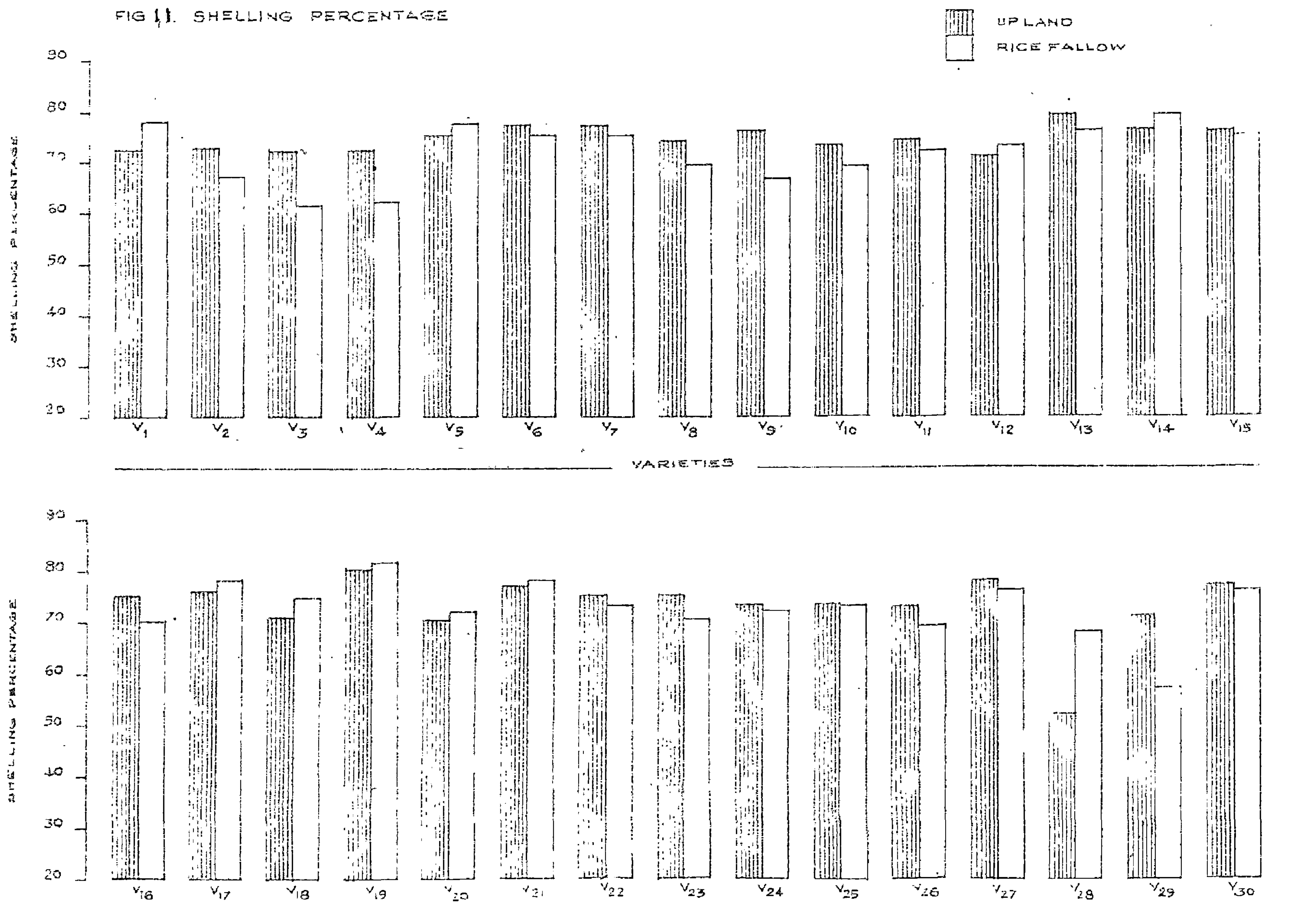
The top ranking variety with a shelling percentage of 80.2 under the upland conditions was KG-61-240 which was significantly superior to all other varieties. The 2nd and 3rd ranks were held by Jyothi and TMV-7 with shelling percentages of 78.9 and 78.3 respectively. These varieties, however, were on par. TMV-2 had a shelling percentage of 71.5. As in dryage percentage, Gangapuri ranked the last (52.3) in shelling percentage also followed by EC.36892 (61.0). The shelling percentage of the two promising varieties, TG-14 and Spanish Improved were 75.0 and 74.4 respectively.

KG-61-240 had the highest shelling percentage of 81.4 in summer rice fallows, thus keeping the same position as in uplands. This was significantly superior to all other varieties and was followed by AK-811 (78.2), Exotic-6 (78.1), EC.21118 (77.9), Pollachi-2 (77.6) and EC.112027 (77.5). Statistically these varieties were on par. Big Japan was inferior to all other varieties in shelling outturn with the lowest value of 57.4, followed by S-7-5-13 (61.4). The shelling percentages for TMV-2 and TMV-7 were 74.5 and 76.5 respectively. Spanish Improved recorded a shelling percentage of 72.9 while TG-14 recorded 70.2.

(14) Oil content

From the significant 'F' ratio for varieties in the separate analysis of variance and situations x varieties in the

FIG 11. SHELLING PERCENTAGE



pooled analysis, it was evident that the varieties differed significantly in oil content in upland and rice fallows and that the oil content of each variety varied widely with locations. The mean oil percentage of the varieties under study are presented in table 25.

The oil content in uplands was the highest in the variety AH-6915 (53.6) followed by S-7-5-13 (53.3) and these two varieties were on par and significantly superior to all other varieties. TMV-10 yielded 52.2 per cent oil and ranked third and Jyothi with 51.4 per cent ranked the fourth. The oil recovery was the lowest in EC.36892 (42.3) followed by KG-61-240 (42.8). The oil content of Spanish Improved was 48.4 per cent and that of TG-14 was 48.2. The oil content of TMV-2 was 47.6 per cent which was on par with that of TG-14, but significantly lower than that of Spanish Improved. The oil percentage of TMV-7 was only 45.0.

In the summer rice fallows, S-7-5-13 gave the highest oil content of 54.2 per cent and was superior to all other varieties, followed by AH-6915 with 52.8 per cent. But TMV-10 with 51.6 per cent remained in the third rank as in uplands. Co-1 and Jyothi (50.2 each) were placed in the fourth position. The oil content was the lowest in M-13 (42.1) followed by EC.36892 (42.6). The last two varieties had also interchanged their ranks for oil content in rice fallows with that in uplands. The oil recovery from TMV-2 was 47.0 per cent while that of TMV-7 was 48.4 per cent. The oil content in Spanish Improved was 47.9 per cent which was on par with that in TMV-7. TG-14 gave 46.9 per cent oil which was on par with that of TMV-2.

Table 25. Oil and protein contents.

Code No.	Name of variety	Oil content (%) Uplands	Oil content (%) Rice fallows	Protein content (%) Uplands	Protein content (%) Rice fallows
V_1	EC.21118	45.8	46.3	27.4	24.9
V_2	ICG-3859	49.1	49.2	24.3	24.6
V_3	EC.36892	42.3	42.6	27.4	28.5
V_4	S-7-5-13	53.3	54.2	24.5	26.2
V_5	EC.112027	47.0	47.2	23.5	23.2
V_6	B-353	48.0	49.0	24.6	26.0
V_7	EC.35999	47.5	46.7	25.4	25.5
V_8	EC.119704	45.7	46.6	26.8	27.5
V_9	AH-6915	53.6	52.8	26.4	27.0
V_{10}	M-13	42.8	42.1	31.5	29.6
V_{11}	Spanish Improved	48.4	47.9	26.5	26.2
V_{12}	Dh-3-30	48.0	48.6	25.8	25.3
V_{13}	Jyothi	51.4	50.2	28.8	26.0
V_{14}	Exotic-6	45.9	48.2	27.1	27.0
V_{15}	TMV-9	48.4	47.0	27.8	25.8
V_{16}	TMV-10	52.2	51.6	22.5	22.9
V_{17}	AK-811	47.9	48.3	25.5	26.9
V_{18}	TMV-2	47.6	47.0	25.6	24.9
V_{19}	KG-61-240	42.8	47.4	26.2	25.5
V_{20}	TMV-11	43.5	43.4	25.1	25.2
V_{21}	Pollachi-2	45.0	46.3	26.0	25.3
V_{22}	TG-3	50.3	47.3	25.0	24.2
V_{23}	TG-14	48.2	46.9	25.8	25.5
V_{24}	TG-17	47.5	49.0	29.5	28.9
V_{25}	TG-19	47.7	48.2	27.0	26.2
V_{26}	Pollachi-1	45.4	45.4	25.5	25.1
V_{27}	TMV-7	45.0	48.4	26.3	25.0
V_{28}	Gangapuri	46.9	49.1	26.6	26.4
V_{29}	Big Japan	45.9	48.2	29.1	28.1
V_{30}	Co-1	49.2	50.2	25.3	25.5
	C.D.	0.78	0.74	1.23	1.07

(15) Protein content

By the analysis of variance of protein percentage in uplands during kharif and rice fallows during summer, it was found that the varieties had wide diversity in protein content in uplands as well as rice fallows. The pooled analysis of the data at the two situations had brought out that the protein content of the varieties varied considerably with the situations. The mean protein percentages of the thirty varieties in the two situations are presented in table 25.

The protein content in the different varieties in the uplands during kharif ranged from as low as 22.5 to as high as 31.5 percentages. M-13 had yielded the highest protein percentage of 31.5 which was superior to all other varieties. The 2nd, 3rd and 4th ranks were taken by TG-17 (29.5), Big Japan (29.1) and Jyothi (28.8) and these three varieties were on par. In protein content, TMV-10 (22.5) was the lowest followed by EC.112027 (23.5) which were on par. TMV-2 and TMV-7 recorded a protein content of 25.6 and 26.3 per cent respectively. 26.5 and 25.8 were the percentages of protein in Spanish Improved and TG-14 respectively.

Under the rice fallow conditions the protein recovery ranged from 22.9 per cent in TMV-10 to 29.6 in M-13. As under uplands, M-13 and TG-17 held the first and second rank in rice fallows where as TG-17 was on par with M-13. TMV-10 (22.9) remained to be the last in rank followed by EC.112027 (23.2) in rice fallows also. These, however, were on par. Spanish Improved recorded 26.2 per cent protein while TG-14 gave 25.5. They were statistically on par. But TMV-7 and TMV-2 yielded 25.0 and 24.9 per cent of protein which were on par, but significantly less than that in Spanish Improved, but on par with that in TG-14.

D. Induced Mutagenesis

The effects of gamma irradiation on three selected genotypes of groundnut, viz., TMV-2, TG-14 and Spanish Improved in the M_1 and M_2 generations at three doses each, viz., 20, 30 and 40 krad were investigated and the results presented below.

a) Effects in the M_1 generation

1) Germination of seeds

The germination percentages are presented in table 26. Germination was reduced by gamma irradiation in all the three genotypes. In general, a progressive reduction in germination with increasing doses of gamma rays was found in all the three varieties. A differential response among the three genotypes could also be noticed. The reduction in germination was the maximum in Spanish Improved and minimum in TMV-2 at all the 3 doses. Germination was also delayed at all the doses. This delay was directly proportional to the doses of radiation in all the genotypes.

2) Survival of plants

The percentages of survival recorded on the 30th day after sowing are included in table 26. The survival was reduced by gamma rays in all the three genotypes. The reduction in survival was very drastic at the higher doses. A difference in response among the genotypes was evident. As in the case of germination, Spanish Improved suffered the maximum in survival and TMV-2 the

Table 26. Germination and survival in the M_1 generation.

Genotypes and gamma ray doses (krad)	Germination		Survival at the 30th day	
	%	% of the control	%	% of the control
1. TMV-2				
0	96	100	93	100
20	94	97.9	92	98.9
30	91	94.4	87	93.6
40	89	92.7	81	87.1
2. TG-14				
0	90	100	88	100
20	87	96.7	82	93.2
30	81	90.0	69	78.4
40	81	90.0	67	76.1
3. Spanish Improved				
0	86	100	86	100
20	80	93.0	75	87.2
30	77	89.5	69	80.2
40	70	81.4	60	69.8

minimum.

3) Plant height

The mean plant height measured on the 30th and 45th days after sowing are presented in table 27. A reduction in plant height was noticed in all the three genotypes on the 30th day. But the reduction on the 45th day was negligible.

4) Pollen fertility

The percentages of pollen fertility estimated in the different treatments are given in table 27. The fertility decreased with increasing doses of gamma rays in all the genotypes. However maximum reduction in fertility was noticed in TG-14.

The M_1 effects are graphically represented in figure 12.

5) Chlorophyll chimeras

Chlorophyll deficient patches were seen on the leaves of certain M_1 plants in all the treatments. The frequency of such chimeric (mosaic) plants was however very low and did not bear any relation with doses of gamma rays.

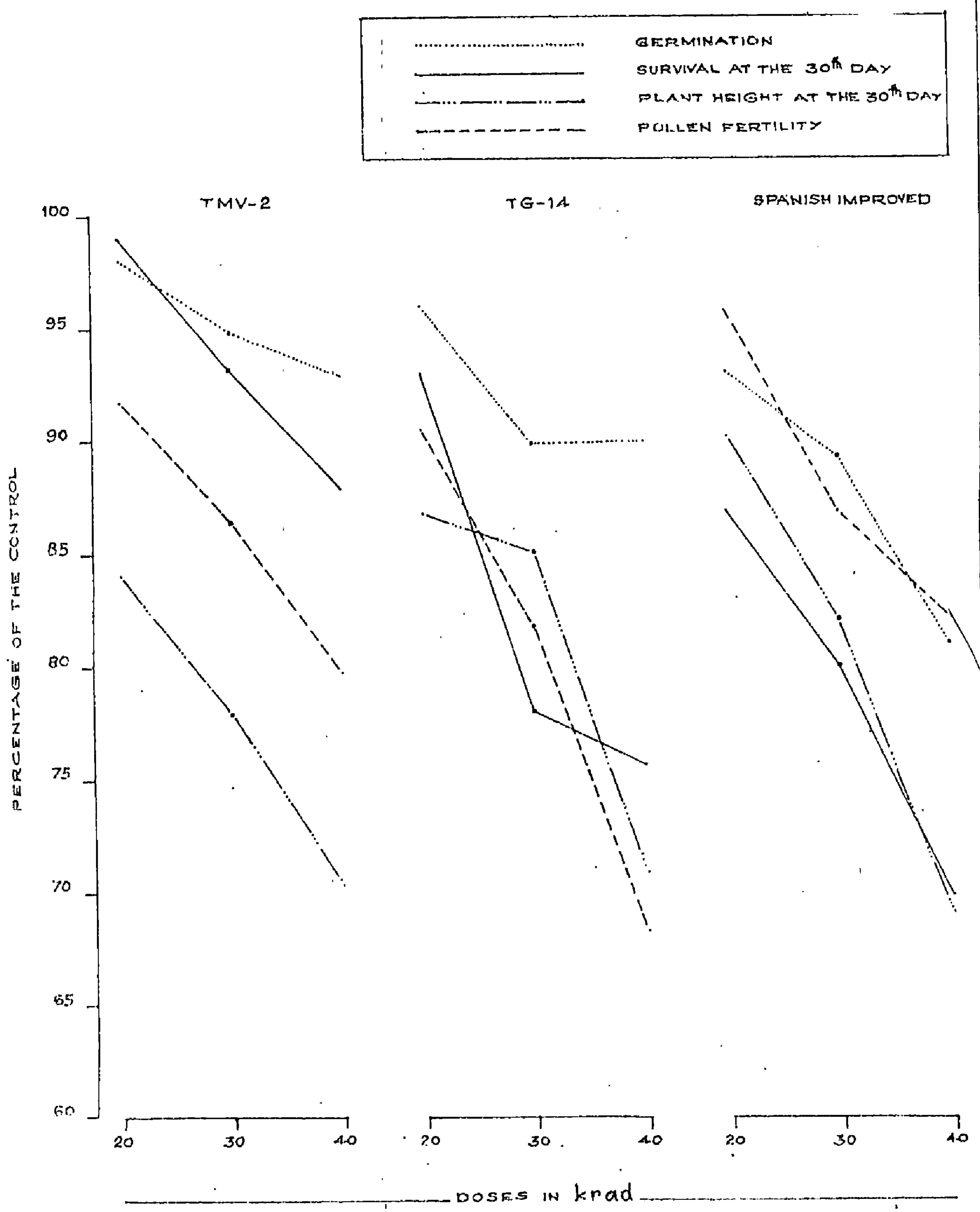
6) Morphological abnormalities

A variety of morphological abnormalities were observed on the M_1 plants. Alterations in the number, size and shape of leaflets in the first leaf were observed in all the three genotypes particularly at higher doses. However, these plants recovered and produced normal leaves later. Stunted plants, dwarf plants and weak plants were also present in the M_1 generation. Plants with irregular leaf margins, crinkled leaves and mottled leaves were also observed.

Table 27. Plant height and pollen fertility in the M_1 generation.

Genotypes and Gamma ray doses (krad)	Plant height				Pollen fertility	
	30th day		45th day		%	% of the control
	cm	% of the control	cm	% of the control		
1. TMV-2						
0	22.8	100	34.1	100	94.3	100
20	19.3	84.3	33.9	99.4	87.1	92.3
30	17.9	78.5	32.9	96.6	81.3	86.7
40	16.1	70.5	31.9	93.6	74.7	79.2
2. TG-14						
0	21.9	100	32.9	100	93.0	100
20	19.1	87.0	32.9	100	84.6	90.9
30	18.6	85.0	32.2	97.8	77.5	82.2
40	15.6	71.1	32.0	97.0	64.0	68.8
3. Spanish Improved						
0	22.2	100	34.3	100	93.8	100
20	20.0	90.2	34.1	99.7	90.0	95.9
30	18.3	82.4	33.2	96.9	82.0	87.3
40	15.4	69.4	32.8	95.8	77.1	82.2

FIG 12. EFFECTS OF GAMMA RAYS IN THE M_1 GENERATION.



b) Effects in the M_2 generation

1) Chlorophyll mutations

Chlorophyll mutations in the M_2 generation were scored at the seedling stage.

(i) Frequency

The frequency of chlorophyll mutations estimated as the number of mutations per 100 M_1 plants and the number of mutants per 100 M_2 plants are presented in table 28 and in figure 13. The mutation frequency estimated on M_1 plant basis, increased with increasing doses of gamma rays in all the three genotypes, even though the frequencies differed between the genotypes. On M_2 plant basis too, the mutation frequency showed a similar trend. Both on M_1 and M_2 plant basis, the highest mutation frequency was recorded in TG-14 at all the doses.

(ii) Spectrum

The different types of chlorophyll mutants observed are albino (white), xantha (yellow), chlorina (yellow green) and viridis (light green). The spectrum of chlorophyll mutants (the relative percentage of the different types) at the three doses for each of the three varieties are furnished in table 29. Viridis was the most frequent type of chlorophyll mutation at all doses in all the genotypes. Albinos were the least.

(iii) Mutagenic effectiveness and efficiency

The mutagenic effectiveness and efficiency of three doses of gamma rays in inducing chlorophyll mutations in the three genotypes were estimated and presented in table 30. No definite relationship was found between doses of radiation and mutagenic

Table 28. Frequency of chlorophyll mutations in the M_2 generation.

Genotypes and Gamma rays doses (krad)	M_1 plant basis			M_2 plant basis		
	No. of M_1 plant progenies Scored	Segregating	No. of mutations per 100 M_1 plants	No. of M_2 plants scored	No. of mutants	No. of mutants per 100 M_2 plants
1. TMV-2						
0	10	Nil	-	-	-	-
20	53	2	3.77	208	2	0.96
30	69	3	4.35	319	3	0.94
40	53	5	9.43	234	5	2.14
2. TG-14						
0	10	Nil	-	-	-	-
20	63	3	4.76	260	3	1.15
30	40	5	12.50	113	5	4.42
40	53	8	15.09	158	8	5.06
3. Spanish Improved						
0	10	Nil	-	-	-	-
20	34	1	2.94	179	2	1.12
30	28	3	3.57	144	3	2.08
40	35	4	11.43	125	4	3.20

FIG.13 FREQUENCY OF CHLOROPHYLL MUTATIONS IN THE M_2 GENERATION.

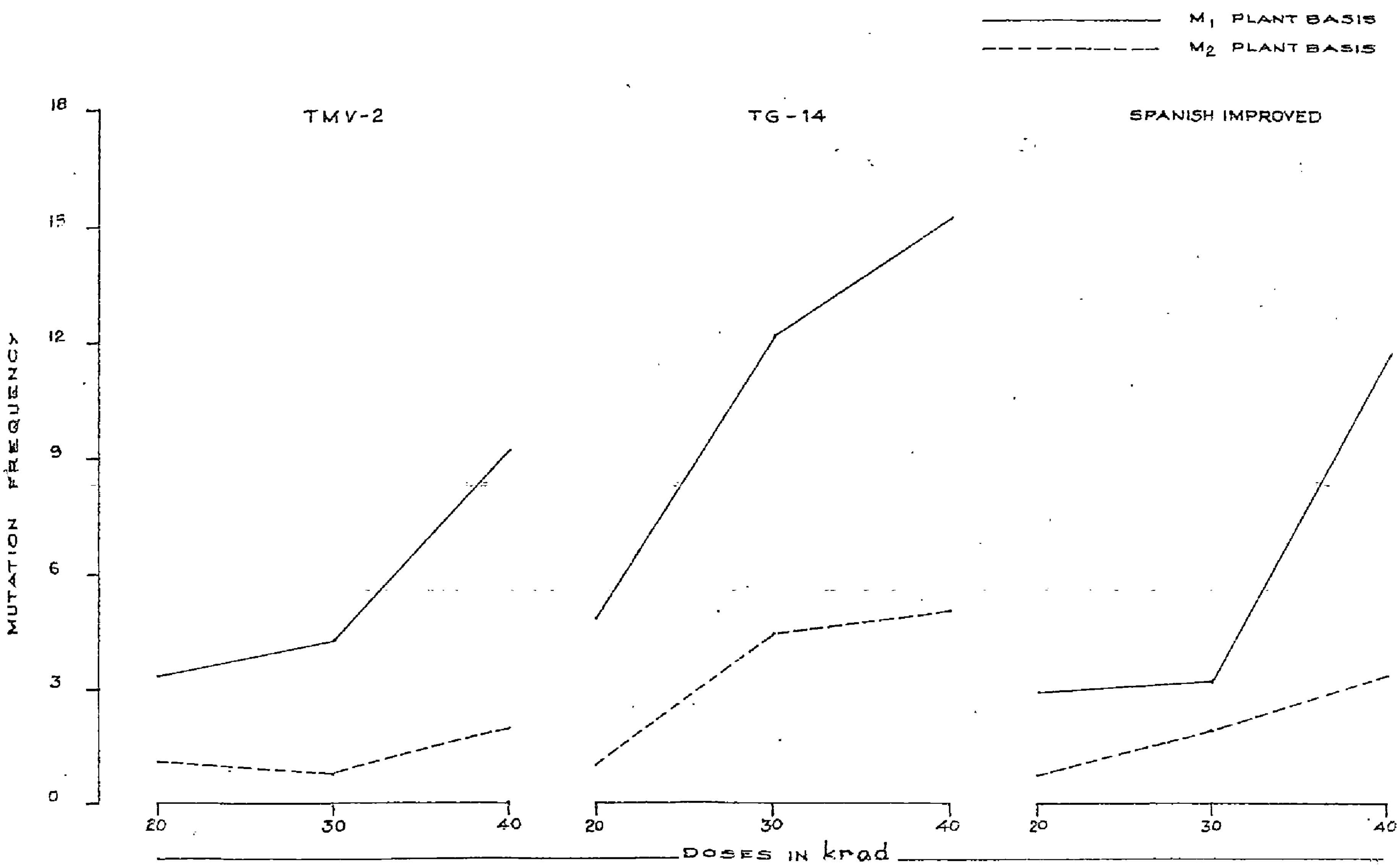


Table 29. Spectrum of chlorophyll mutants in the M_2 generation.

Genotypes and Gamma ray doses (krad)	No. of chloro-phyll mutants	Relative percentage of chlorophyll mutants			
		Albino	Xantha	Chlorina	Viridis
1. TMV-2					
20	2	-	-	-	100
30	3	-	-	-	100
40	5	20	20	20	40
2. TG-14					
20	3	-	-	33.3	67.7
30	5	-	20	40	40
40	8	12.5	12.5	25	50
3. Spanish Improved					
20	2	-	-	-	100
30	3	-	-	33.3	67.7
40	4	-	25	25	50
Total	35	5.7	11.4	22.9	60.0

Table 30. Mutagenic Effectiveness and Efficiency.

Genotypes and gamma ray doses (krad)	Mutation frequency (M_1 plant basis)	M_1 damage: Lethality (Survival reduction at 30th day) (L)	M_1 damage: Injury (Height reduction at 30th day) (I)	M_1 damage: Sterility (pollen fertility reduction) (S)	Mutagenic effectiveness $\frac{M \times 100}{dose}$	Mutagenic efficiency: $\frac{M \times 100}{L}$	Mutagenic efficiency: $\frac{M \times 100}{I}$	Mutagenic efficiency: $\frac{M \times 100}{S}$
1. TMV-2								
20	3.77	1.08	15.72	7.71	18.85	349.07	23.98	48.90
30	4.35	6.45	21.50	13.35	14.50	67.44	20.23	32.58
40	9.43	12.91	29.55	20.82	23.58	73.04	31.91	45.29
2. TG-14								
20	4.76	6.82	13.05	9.11	23.80	69.79	36.48	51.81
30	12.50	21.59	14.97	17.76	41.67	57.90	83.50	70.38
40	15.09	23.86	28.92	21.23	37.73	63.24	52.18	48.32
3. Spanish Improved								
20	2.94	12.79	9.78	4.14	14.70	22.99	30.37	71.74
30	3.57	19.77	17.63	12.66	11.90	18.05	20.25	28.20
40	11.43	30.33	30.61	17.81	28.58	37.69	64.18	64.18

effectiveness. However, effectiveness was maximum in TG-14.

Mutagenic effeciency too, did not show any definite relationship with radiation doses.

2) Viable mutations

A variety of viable mutants affecting one or a constellation of morphological characters were identified. The more important of them are enumerated below.

(i) Early flowering mutant

In the untreated control of Spanish Improved, the first flowering was noted on the 25th day after sowing and in TMV-2 and TG-14 on the 26th day. In the M_2 generation the first flowering appeared on the 20th day in two plants of Spanish Improved and on the 21st day in five plants (one in TMV-2, three in TG-14 and one in Spanish Improved). On the 22nd day after sowing a total of 8 plants flowered in the different genotypes.

(ii) Early maturing mutant

Twelve mutants maturing in as early as 85 days were isolated, of which six were from TMV-2 and three each from TG-14 and Spanish Improved. Twenty two mutants maturing in 90 days and 19 mutants maturing in 95 days were also isolated. TMV-2 and TG-14 had taken 106 days and Spanish Improved 104 days for maturity. Thus all the three genotypes have yielded early mutants. These early mutants included plants with desirable canopy and pod characters and high pod yield. Some of them were dwarf and compact types as compared to their parents.

(iii) Late flowering mutant

A few late flowering mutants were also noted. Two plants had taken 38 days in TG-14 and three plants of Spanish Improved had taken 36 days for flowering.

(iv) Late maturing mutant

Three very late maturing mutants, maturing in 132 days, were found of which one was in TG-14 and the remaining two were in Spanish Improved.

(v) Dwarf mutant

Dwarf mutants of various types, i.e. having 25 to 75 per cent reduction in plant height have been observed. Some of these dwarfs had a more desirable plant type than the parent varieties since they had moderate vegetative growth with compact canopy.

(vi) Stunted mutant

Four very stunted mutants were scored, two in TMV-2 and one each in TG-14 and Spanish Improved.

(vii) Tall mutant

Three tall mutants, two in Spanish Improved and one in TG-14 were observed.

(viii) Compact mutant

A very compact mutant with dark green leaves was identified in TG-14. The plant, however, did not set any pod.

(ix) Non-branching mutant

Four non-branching mutants were obtained, of which three had yielded pods and one failed to set pod. Of the three non-branching mutants with pods, one was in TMV-2 and two in Spanish Improved. The one with no pod was in TMV-2. The three non-branching mutants bearing pods are presented in figure 14a.

(x) Semi-spreading mutant

Two semi-spreading mutants were identified in the bunch variety, TG-14.

(xi) Little leaf mutant

One very small leaved and two comparatively smaller leaved mutants were detected in TG-14.

(xii) Curly leaf mutant

Two mutants with curled leaves were identified in TG-14.

(xiii) Narrow leaf mutant

A mutant with very narrow leaves was identified in Spanish Improved (figure 14b).

(xiv) Dark green mutant

Mutants with very dark green leaves were noticed in all the three genotypes. Two such mutants were seen in TMV-2, nine in TG-14 and six in Spanish Improved. A mutant from TG-14 is presented in figure 14c.

(xv) Multiple leaflet mutant

Normally the groundnut leaves have four leaflets of more or less equal size. A mutant with six leaflets was detected in TMV-2 (figure 14d).

(xvi) Sterile mutant

Mutants without pod set were identified. One such mutant was seen in TMV-2 and two in TG-14.

(xvii) Small poded mutant

Four small poded mutants were isolated from TMV-2 and Spanish Improved. One minute poded mutant in which the pods were very small was obtained in TMV-2.

(xviii) Bold poded mutant

Three mutants with bolder pods than the parent variety were isolated in TMV-2.

Fig. 14. A few mutants observed in the M_2 generation

a. Three non-branching mutants bearing pods

(i) from TMV-2

(ii) } from Spanish Improved
(iii) }

b. A narrow leaf mutant (From Spanish Improved)

Fig. 14 a

Fig. 14 b

Fig. 14 (continued)

c. A dark green mutant (from TG-14)

d. A multiple leaflet mutant
(from TMV-2)

Fig.14 c

Fig. 14 d

(xix) Deeply pod constricted mutant

The pod constriction in the three genotypes under study were comparatively shallow. In TMV-2, a very deeply pod constricted mutant was obtained.

(xx) Shallow pod setting mutant

One mutant in which all the pods were attached to the very base of the plant just below the soil surface was isolated in TMV-2. This extraordinary shallow and compact pod burial might facilitate easy harvesting.

(xxi) Single kernel mutant

One mutant with only single kernelled pods was isolated in Spanish Improved which generally produced two kernelled pods.

(xxii) Dormant mutant

Eight M_1 seeds germinated only 35 days after sowing. This delay in germination might be due to mutations induced for seed dormancy. However, this has to be further tested and confirmed in the subsequent generations.

DISCUSSION

DISCUSSION

Groundnut is the most important annual oilseed crop in our country. There is urgent need for increasing the production of this crop on economic and nutritional grounds. In attaining high productivity for any crop, the dominating role of genetic improvement is universally accepted. A planned programme for genetic improvement invariably begins with collection and evaluation of the genetic resources. This will provide the base materials and the basic informations required to choose and proceed with the appropriate breeding methods.

A knowledge on the genetic variability present in the available germplasm, heritability of characters with expected genetic advance through selection and an insight into the nature of gene action operating in their expression are of great practical value. The study of association of component characters with yield and among themselves and their direct and indirect effects on the economic trait will be effective in the exploitation of variability through selection. Such informations will also enable the formulation of ideal 'plant types'.

The germplasm evaluation leads to the identification of generally adapted varieties for specific situations with information on the merits and demerits of the genotypes. The adapted varieties so identified can be critically evaluated further for yield and other important economic traits in specific situations so that the best variety for each situation can be selected. Moreover, specific defects, if any can also be identified in such varieties so that appropriate corrective breeding techniques can be employed.

The present investigation has been undertaken with these objectives in a widely divergent collection of indigenous and exotic varieties of groundnut.

Biometric analysis

The application of statistical techniques in biological research opened up new vistas in understanding the problems in a better way. In the development of superior genotypes, selection is the fundamental but intricate process. Though selection is as old as cultivation itself, the reliability of selection quite often poses problems to the breeder. Selection is based on the variability in the crop which may be either natural or induced. Frankel (1970) stated that variation is the essence of life and genetic variation is universal. The variation we find in a population is both heritable and non-heritable and the former alone is significant to the breeder.

To improve yield, a complex character, exhibiting continuous variation and having polygenic control, information on the nature and magnitude of variation in the available materials, association of characters with yield and among themselves and the extent of heritability and genetic advance are of high practical utility. According to Evans (1978), selection based on yield alone is usually not very efficient, but when based on its components as well could be more efficient. The economic produce in groundnut is concealed and as such selection for yield is all the more difficult. Identification of some canopy characters reflecting productivity will be highly advantageous in this case. If such traits are evaluated at the early stage of crop growth itself, it will aid early selection. Therefore correlation studies are very important in groundnut. More and more studies on these lines are suggested in groundnut by Prasad and Kaul (1980 a) due to the lack of clearcut relationships between canopy characters and yield components.

The present investigation on biometric analysis was done separately under upland conditions during kharif as a rainfed crop and in rice fallows during summer as an irrigated crop, since the trend of variability for yield and other characteristics in the different varieties varied widely in the two situations. Uplands during kharif is a traditional area for groundnut cultivation in the State and rice fallows during summer is a non-traditional, but highly potential area for commercial cultivation of this crop. The studies in both the situations were taken up in 80 varieties of divergent origin and with wide diversity, to find out the range of variability in important quantitative characters, their heritability in the broad sense, genetic advance, interrelationships and to assess the direct and indirect effects of related characters on yield. The results obtained at the two situations are discussed and conclusions drawn.

(i) Variability

The analysis of variance done separately for the two situations revealed that the 80 varieties differ significantly from each other in respect of all the 23 characters studied in uplands during kharif and rice fallows during summer. The wide variability in respect of all these characters in both the situations is demonstrated further by the vast differences in mean values. Significant variability for various characters in groundnut had been reported by Venketeswaran (1966), Chandramohan et al. (1967), Jaswal and Gupta (1967), Sangha and Sandhu (1970), Kushwaha and Tawar (1973), Sivasubramoniam et al. (1977), Norden (1980 a) and Kuriakose (1981). The observed variability in any quantitative character is due to genic and non-genic factors. The interaction between heritable and non-heritable factors makes the trait more complex. The heritable portion of the phenotypic variability for quantitative characters can be assessed with the help of genetic parameters such as genotypic coefficient of variation, heritability and genetic advance. These parameters for the different characters showed differences in the same situation and also between the situations.

Genotypic coefficient of variation (g.c.v.) is useful to assess and compare the range of genetic diversity for a quantitative character. In the uplands the g.c.v. was the highest for percentage of pod set whereas in rice fallows it was for number of branches on the 50th day followed by number of branches at harvest. The high g.c.v. for number of branches observed at both the situations is in consonance with the reports of Majundar et al. (1969), Sangha and Sandhu (1970) and Kuriakose (1981). High g.c.v. for haulms yield in uplands is in conformity with the findings of Ashokraj (1969) and Kushwaha and Tawar (1973). Number of mature pods registered high g.c.v. as reported by Ashokraj (1969), Sangha and Sandhu (1970), Khangura and Sandhu (1973), Sangha (1973) and Sivasubramoniam et al. (1977). Relatively high g.c.v. was obtained for number of flowers, number of immature pods and dry pod yield. Sangha and Sandhu (1970) and Dixit et al. (1971) also reported high g.c.v. for dry pod yield. High g.c.v. for green weight of pods noticed by Dixit et al. (1971) is in conformity with the present result. The g.c.v. was low for oil content, duration upto flowering and maturity in both the situations. These results are in agreement with the reports of Kushwaha and Tawar (1973) and Kuriakose (1981).

The phenotypic coefficient of variation (p.c.v.) gives a measure of the total variability. The p.c.v. was the highest for number of immature pods in uplands and number of branches on the 50th day in rice fallows. The p.c.v. was generally very high for number of immature pods, number of branches, number of flowers, haulms yield, number of mature pods, percentage of pod set, fresh weight of pods and dry pod yield. For number of mature pods high p.c.v. was reported earlier by Khangura and Sandhu (1973). The high p.c.v. observed for number of branches is in conformity with the reports of Majumdar et al. (1969) and Sangha and Sandhu (1970). The high p.c.v. obtained for dry pod yield is in agreement with the result of Khangura and Sandhu (1973). In general, the p.c.v. was low for duration upto flowering and maturity, 100 kernel weight, shelling percentage and oil content at both the situations. The low p.c.v. for 100 kernel weight, shelling percentage and oil content are in consensus with the reports of Khangura and Sandhu (1973) and that for duration upto flowering and maturity with that of

Kuriakose (1981).

In both the situations the g.c.v. was lower than the corresponding p.c.v. for all the characters which illustrates the strong influence of the environment on the genotypes. Generally high values of g.c.v. and p.c.v. were recorded for number of branches, flowers, fresh weight of pods, haulms yield, number of mature pods, percentage of pod set, number of immature pods, dry pod yield and 100 pod weight suggesting that there is scope for improvement of these characters through selection.

The extent of variability contributed by the environmental effects is the environmental coefficient of variation (e.c.v.). The e.c.v. was the highest for number of immature pods and the lowest for duration upto maturity at both the situations. This indicatesthat the environmental factors have the maximum influence on number of immature pods per plant while they had the minimum influence on duration upto maturity. In the uplands and rice fallows the e.c.v. were generally high for number of branches on the 50th day, number of branches, fresh weight of pods, number of mature pods, haulms yield and dry pod yield and low for duration upto flowering, spread of flowering, 100 pod weight, 100 kernel weight, shelling percentage and oil content. This is in agreement with the results of Kuriakose (1981).

High genotypic, phenotypic and environmental coefficients of variation for certain characters such as number of branches, haulms yield, number of mature pods and number of immature pods at both the situations indicate that the observed phenotypic values are the expressions of the genotypic variability modified by environment. Number of flowers and percentage of pod set had comparatively high g.c.v. and p.c.v. with low e.c.v. in uplands whereas in rice fallows they have high g.c.v., p.c.v. and e.c.v. The results indicate that these characters are influenced more by environmental factors in rice fallows than in uplands. Dry pod yield recorded high values for all the three parameters in uplands and comparatively low g.c.v. and high p.c.v. and e.c.v. in rice fallows showing that genetic variability for the most important economic produce is comparatively more in uplands than in rice fallows and that the expression of the character is strongly influenced by the environmental factors at both the situations. Therefore, selection for pod yield can be comparatively more rewarding in uplands than in rice fallows. This can probably be due to the fact that the varieties under study are selected or evolved mostly for the upland conditions rather than for the specific summer rice fallows. High g.c.v. and p.c.v. with low e.c.v. for spread of flowering, 100 pod and kernel weights at both the situations indicated that the observed variability was mostly due to the genotype itself and that the environment had only meagre influence. Under both the situations, duration upto flowering and maturity, shelling percentage and oil content had low values for all the three parameters of variability illustrating that genetic variability and environmental effects are generally low on the expression of these characters. This result is in line with that of Kuriakose (1981).

As a matter of fact, however, the results show that estimation of heritable variation with g.c.v. alone is not efficient. Burton (1952) had suggested that g.c.v. together with heritability estimates would be better for estimating heritable variation, thereby exercising selection. The heritable portion of the variability is determined by the heritability estimates in the broad sense. The heritability estimate was the highest for spread of flowering in uplands as well as rice fallows. This is in conformity with the report of Majumdar et al. (1969). Besides spread of flowering, high heritability estimates at both the situations were recorded by duration upto maturity and 100 pod weight, indicating that the observed variability is predominantly genotypic and as such is heritable and that the environment had only very little influence on these characters. For duration upto maturity, high heritability was reported earlier by Majumdar et al. (1969) and Kushwaha and Tawar (1973) and for 100 pod weight by Basu and Ashokraj (1969), Dixit et al. (1970), Kushwaha and Tawar (1973) and Dorairaj et al. (1979). In the uplands during kharif, percentage of pod set, 100 kernel weight and shelling percentage have also registered high heritability values. As seen in the present study, high heritability estimate for 100 kernel weight was reported by Dixit et al. (1970), Kushwaha and Tawar (1973), Cahaner (1978) and Dorairaj et al. (1979) and for shelling percentage by Bernard (1960) and Kuriakose (1981). But in the case of 100 kernel weight and shelling percentage moderate heritability was recorded in rice fallows. This is in line with the reports by

Basu and Ashokraj (1969), Majundar et al. (1969) and Kushwaha and Tawar (1973). The heritability estimate was the lowest for number of leaves on the 50th day followed by number of immature pods in uplands and fresh weight of pods followed by dry pod yield in rice fallows showing that these characters are influenced to a great extent by environmental or non-heritable factors. The very high influence of environmental effects on these characters wase further evidenced by the high e.c.v. Pod yield, the economic trait, had moderate heritability in uplands during kharif. This is in consensus with the reports of Kushwaha and Tahar (1973), Shettar (1974) and Rao (1980). But in the rice fallows, dry pod yield had only low heritability as reported by Majundar et al. (1969), Basu and Ashokraj (1969) and Shettar (1974). This again testify that selection for pod yield can be more effective in uplands than in rice fallows. However, Dixit et al. (1970) reported comparatively higher heritability value for green weight of pods than dry pod yield in contrast to the result in the present study at both the situations. The low heritability value for number of mature pods per plant in rice fallows is in accordance with the report by Majundar et al. (1969) and Dixit et al. (1971) and moderate heritability in uplands is in line with the report by Kushwaha and Tawar (1973). The moderate heritability observed for haulms yield under the upland conditions is in conformity with the reports by Basu and Ashokraj (1969), Dixit et al. (1970) and Kushwaha and Tawar (1973) and low heritability estimate under summer rice fallow conditions is in agreement with the result of Kuriakose (1981).

In both the situations, moderate heritability was obtained for oil content while only low heritability was recorded by Kushwaha and Tawar (1973).

According to Johnson et al. (1955), heritability estimate in the broad sense alone is not enough in predicting the resultant effect of selection and that heritability along with genetic advance is more useful for effecting selection. The genetic advance was the highest for percentage of pod set in uplands and number of branches in rice fallows. Both in uplands and rice fallows, percentage of pod set, number of branches, number of flowers, number of mature pods, 100 pod weight, number of immature pods, haulms yield and 100 kernel weight recorded high genetic advance. Majumdar et al. (1969) and Sangha and Sandhu (1970) obtained similar results for number of branches. High genetic advance for number of mature pods was reported by Sangha and Sandhu (1970), Kushwaha and Tawar (1973) and Sangha (1973); for number of flowers by Dorairaj et al. (1979); for haulms yield by Basu and Ashokraj (1969) and for 100 pod and kernel weights by Kuriakose (1981). Oil content and duration upto maturity recorded the lowest values for genetic advance in uplands and rice fallows respectively. The low value for genetic advance for oil content is in conformity with the result of Kuriakose (1981). Low genetic advance for shelling percentage as seen in the present study under rice fallow conditions was also recorded by Kuriakose (1981), whereas in the uplands, shelling percentage registered comparatively high genetic advance. The low genetic advance for fresh weight of pods in rice fallows is in conformity with the report by Dixit et al. (1970) while in uplands the character had recorded high genetic advance. Dry pod yield had a higher value for genetic advance in uplands than in rice fallows. This further confirms that selection for pod yield would be more effective in uplands than in rice fallows.

Very high heritability estimates with high values of g.c.v. and genetic advance were recorded by pod set and number of branches in uplands. Relatively high values of heritability coupled with genetic advance were shown by number of flowers, haulms yield and 100 pod weight. Moderate heritability and genetic advance were noticed for dry pod yield and number of mature pods. Spread of flowering, plant height on the 50th day and 100 kernel weight recorded high heritability and moderate genetic advance. In the summer rice fallows, g.c.v., heritability and genetic advance were high for number of branches, number of flowers, spread of flowering, number of leaves, pod set and 100 pod weight. Moderate heritability and genetic advance were recorded by 100 kernel weight and dryage percentage of pods. High to moderate heritability with high genetic advance were reported for number of branches and leaves by Majunder et al. (1969); for number of flowers by Cahaner (1978) and Dorairaj et al. (1979); for haulms yield by Ashokraj (1969); for 100 pod weight by Dixit et al. (1970), Cahaner (1978) and Dorairaj et al. (1979); for pod yield by Patra (1975) and Dorairaj et al. (1979); for number of pods by Sangha (1973) and Sivasubramoniam et al. (1977) and for 100 kernel weight by Dixit et al. (1970), Sangha

(1973) and Dorairaj eta al. (1979). According to Panse (1957), the characters with high heritability and high genetic advance were controlled by additive gene action and hence are easily amenable to genetic improvement through selection. High heritability but low genetic advance were seen for duration upto flowering and maturity, shelling percentage and oil content at both the situations. Kuriakose (1981) recorded similar results for all the above characters except duration upto maturity. Number of leaves on the 50th day and number of immature pods in uplands and fresh weight of pods and dry pod yield in rice fallows had low values of both heritability and genetic advance indicating that these characters are under the profound influence of environmental factors. This is further confirmed by the very high values of e.c.v.

The economic trait in groundnut, viz., dry pod yield had recorded comparatively more g.c.v., heritability and genetic advance in uplands during kharif than in summer rice fallows. This strongly suggests that genetic improvement for dry pod yield in groundnut through the process of selection will yield better results in uplands than in rice fallows. The comparatively higher e.c.v. for dry pod yield in rice fallows than in uplands further strengthen the above conclusion. As mentioned earlier, the selection or evolution of the varieties under study was done under upland conditions in general as against the specific rice fallow situation.

From the foregoing discussions, it is quite clear that though groundnut is a predominantly self fertilized crop, high variability, both heritable and non-heritable, is still available in respect of a large number of economically important quantitative characters. The effect of environment on a number of characters is very strong so that the genotype is altered considerably. In general, the various parameters of variability for the different characters and their means showed variation between the two situations illustrating the differences in the general pattern of variability at the two situations. Genetic improvement in the upland conditions during kharif can be achieved through selection for pod set, number of branches, number of flowers, haulms yield, 100 pod weight, dry pod yield and number of mature pods. Dry pod yield, being one among the characters lending scope for improvement through selection, there is good scope for selecting better yielders for the upland conditions. In the summer rice fallows genetic improvement to a large extent can be achieved through selection for number of branches, number of flowers, number of leaves, percentage of pod set, spread of flowering, 100 pod weight and 100 kernel weight.

(ii) <u>Correlation</u>

The studies on correlation provide information on the nature and extent of relationship of characters among each other. This will aid the breeder in effecting reliable selection for complex polygenic characters like yield. The correlation coefficients were computed at the genotypic and phenotypic levels between yield and the other twenty two characters and also among themselves for the uplands during kharif and rice fallows during summer.

At the genotypic level in uplands during kharif, the coefficient of correlation of dry pod yield was positive and significant with fresh weight of pods, haulms yield, number of mature pods, percentage of pod set, number of immature pods, duration upto maturity and 100 pod weight. At the phenotypic level, dry pod yield was significantly and positively correlated with all the above characters except duration upto maturity and 100 pod weight. In addition it was correlated with number of flowers and number of basal primary branches. In the summer rice fallows, both at the genotypic and phenotypic levels pod yield was highly correlated positively with plant height on the 50th day, length of top, fresh weight of pods, number of mature pods, percentage of pod set, number of immature pods and dryage percentage of pods. Besides, pod yield was significantly and highly correlated at the genotypic level with height of main shoot and shelling percentage and at the phenotypic level with number of flowers and haulms yield. Moderately significant positive correlation was also seen at the genotypic level between pod yield and oil content. Positive significant genotypic and phenotypic correlation between pod yield and number of mature pods observed in the present analysis at both the situations is in agreement with the results of Comstock and Robinson (1952), Ling (1954), Mistra (1958), Dorairaj (1962), Jaswal and Gupta (1966 and 1967), Chandramohan et al. (1967), Prasad and Sreevastava (1968), Sangha and Sandhu (1970), Dholaria et al. (1972), Khangura and Sandhu (1972), Kushwaha and Tawar (1973), Coffelt and Hammons (1974), Shettar (1974), Nair (1978), Dorairaj et al. (1979), Rao (1980) and Kuriakose (1981). Significant positive genotypic and phenotypic correlation of pod yield with haulms yield as obtained in the present study in uplands was reported earlier by Mahapatra (1966), Chandramohan et al. (1967), Kushwaha and Tawar (1973) and Nair (1978). Pod yield was positively and significantly correlated with duration upto maturity at the genotypic level in uplands and this is in conformity with the results of Kumar and Yadav (1978) and Mohammed (1979). In accordance with the present result, significant positive correlation was seen at the genotypic level between pod yield and 100 pod weight by Prasad and Sreevastava (1968) and Nair (1978). Both in uplands and rice fallows, dry pod yield was highly and positively correlated with fresh weight of pods at the genotypic and phenotypic levels. This is in conformity with the report by Chandola et al. (1973). Positive correlation of pod yield at the phenotypic level with number of flowers obtained in the present study support the reports by Comstock and Robinson (1952), Coffelt and Hammons (1974) and Rao (1980). Significant positive correlation at the phenotypic level between yield and number of primary branches was also recorded by Jaswal and Gupta (1967), Prasad and Sreevastava (1968), Dholaria et al. (1972), Khangura and Sandhu (1972) and Kushwaha and Tawar (1973). Dorairaj (1962) and Kushwaha and Tawar (1973) found significant positive correlation between plant height and yield. This is comparable to the present result of positive significant correlation between pod yield and plant height on the 50th day both at the genotypic and phenotypic levels in rice fallows. Likewise, the reported correlation between length of first primary branch and yield by Rao (1980) is in agreement with the present correlation between yield and length of top at the genotypic and phenotypic levels. Positive significant correlation noticed at the genotypic level between pod yield and oil content is in consonance with the earlier surmise of Kuriakose (1981). The observed significant positive genotypic correlation of yield with shelling percentage is in accordance with the findings of Dholaria et al. (1972), Khangura et al. (1972) and Kumar and Yadav (1978).

Negative significant correlation at the genotypic level was seen for pod yield with plant height on the 50th day, height of main shoot and length of top in uplands as against positive significant relationships for the characters in the rice fallows. This shows that in uplands, pod yield decreases with increasing plant height on the 50th day, height of main shoot and length of top whereas in the rice fallows pod yield increases with increasing plant height on the 50th day, height of main shoot and length of top. The change in direction in the relationships between the two situations can be due to the vast differences in the agro-climatic conditions. In agreement with the result in uplands, Lin et al. (1969) and Kuriakose (1981) recorded significant negative correlation between pod yield and height of main axis at the genotypic level. In the summer rice fallows, the negative significant correlation obtained at the genotypic level between duration upto flowering and pod yield is in agreement with the report of Shettar (1974) whereas it does not agree with the report of Patil (1972). Significant negative correlation noticed by Sangha and Sandhu (1970) between pod yield and number of branches is in general agreement with the present results which suggests that too much of branching as seen in some of the varieties, has unfavourable influence on pod yield.

The very high genotypic and phenotypic correlation of fresh weight of pods and number of mature pods with pod yield at both the situations is quite logical as they are direct yield components. Therefore selection for these two characters will lead to increased pod yield. The fresh weight of pods had positive significant genotypic correlation with duration upto flowering, number of branches on the 50th day, haulms yield, number of mature pods, percentage of pod set, number of immature pods and 100 kernel weight in uplands and with plant height on the 50th day, duration upto maturity, height of main shoot, length of top, number of mature pods, percentage of pod set, number of immature pods, 100 pod weight and 100 kernel weight in rice fallows. The direct relationship of this yield component with a number of characters related to yield is highly significant. The number of mature pods per plant is correlated significantly at the genotypic level with fresh weight of pods, percentage of pod set and number of immature pods in uplands and with plant height on the 50th day, fresh weight of pods, percentage of pod set and shelling percentage in rice fallows. As such number of mature pods and fresh weight of pods are correlated with a number of important traits which in turn are correlated highly with pod yield. The significant correlation between number of mature pods and immature pods in uplands is in agreement with the finding of Kushwaha and Tawar (1973). The number of mature pods per plant is correlated negatively and significantly at the genotypic level with 100 pod weight and 100 kernel weight at both the situations indicating that as number of pods increases, weight of pods and kernels decrease and vice versa. Negative correlation of number of pods with 100 pod and kernel weights and positive with shelling percentage were reported earlier by Kushwaha and Tawar (1973).

In the rice fallows, plant height on the 50th day and length of top were mutually correlated positively at the genotypic level. Plant height on the 50th day was also correlated positively at the genotypic level with height of main shoot, fresh weight of pods, number of mature pods, percentage of pod set, dryage and shelling percentages and length of top with duration upto maturity, height of main shoot, percentage of pod set and 100 pod and kernel weights and shelling percentage. Height of main shoot is positively correlated with plant height on the 50th day, duration upto maturity, length of top, fresh weight of pods, percentage of pod set, 100 pod and kernel weights and shelling percentage and negatively with number of branches on the 50th day, number of leaves, flowers and basal primary branches. In general, the relationship indicates that as height of main shoot increases, the number of branches decreases which leads to reduction in number of leaves and flowers.

In the uplands during kharif, haulms yield was correlated significantly with duration upto flowering, number of branches and leaves on the 50th day, duration upto maturity, number of flowers, height of main shoot, length of top, number of basal primary branches, fresh weight of pods, number of leaves, 100 pod and kernel weights. This shows that genotypes with higher haulms yield will be longer in duration upto flowering and maturity, having large number of branches and leaves and will be tall in statute. Result of a similar trend was reported by Kushwaha and Tawar (1973).

Number of flowers at the phenotypic level and percentage of pod set at the genotypic level were correlated with pod yield in uplands. As number of mature pods increases pod set increases and hence the correlation of pod yield with number of mature pods, immature pods and pod set are consequential. Pod yield was correlated moderately at the genotypic level with duration upto maturity which in turn was found to be correlated significantly with duration upto flowering, number of branches and leaves on the 50th day, number of flowers, number of basal primary branches, fresh weight of pods, haulms yield, number of leaves, 100 pod weight and 100 kernel weight. Most of these characters were also correlated with each other. As expected, late flowering varieties tend to be late in maturity and longer the duration, higher the yield in uplands. But this relationship does not pose any practical problem in uplands as longer duration varieties can very well be grown in uplands without any field problem.

Yield of pods was correlated positively at the phenotypic level with number of basal primary branches, which in turn was correlated at the genotypic level with duration upto flowering and maturity and number of branches and leaves on the 50th day, number of flowers and branches, haulms yield, number of leaves, 100 pod and kernel weights, shelling percentage and oil content in uplands. The observation of Sanjeeviah et al. (1970) that number of nodes within 10 cm from the ground was positively correlated with pod yield per plant is complementary to the present result.

In addition to pod yield, 100 pod weight registered significant positive genotypic correlation with plant height, number of branches and leaves on the 50th day, height of main shoot, length of top, number of branches, haulms yield, number of leaves and 100 kernel weight. The relationship of 100 pod weight with spread of flowering, number of mature and immature pods, pod set and shelling percentage were negative and significant. Similar to the present result, Dorairaj et al. (1979) reported positive correlation between 100 pod weight and height of main axis. Negative correlation between 100 pod weight and shelling percentage and high positive correlation between 100 pod weight and 100 kernel weight reported by Kushwaha and Tawar (1973) and Kuriakose (1981) are in conformity with the results in uplands. In the rice fallows, shelling percentage was correlated positively with pod set, dryage percentage of pods and number of mature pods and negatively with 100 pod and kernel weights. This association indicates that as pod size increases, kernel size also increases; but shelling percentage decreases. Pods of medium size are therefore desirable in general.

Pod yield was highly but negatively correlated at the genotypic level with plant height on the 50th day which in turn was correlated positively with height of main shoot, length of top, 100 pod and 100 kernel weights in uplands. It could be seen that height of main shoot and length of top which were correlated negatively with pod yield were positively correlated with plant height on the 50th day. These results indirectly support the conclusion made by Patra (1973) that high yielding forms will have shorter internodes at the flowering stage.

Oil content, which was correlated positively with pod yield in summer rice fallows, was positively correlated with haulms yield, duration upto flowering and maturity, fresh weight of pods, number of leaves and percentage of pod set at the genotypic level. The report of Elsaeed (1967) and Patil (1972) that the coefficient of correlation between oil content and kernel weight was negative was found to be so in the present investigation as well at both the situations. This corroborates the report of Shany (1979) that forms with bigger kernels will yield less oil in general and confirms the report of Mohammed et al. (1973) that high oil content was positively correlated with small kernels.

Significant negative correlation at the genotypic level between pod yield and duration upto flowering and highly significant positive correlation between duration upto flowering and maturity, but negative non-significant correlation between pod yield and maturity, under the rice fallow conditions had got very high implications of practical utility in the breeding of high yielding short duration genotypes for this specific situation. The summer rice fallow in normal season is short with a span of nearly 90 days. None of the adapted promising varieties are found to mature in 90 days. Hence short duration high yielding genotypes for the rice fallows remain to be developed. It is evident from the present investigations that early flowering as well as early maturing groundnut genotypes combining high yield can be developed for summer rice fallows through suitable breeding methods as duration upto maturity was not correlated with pod yield. This provides confidence in the attainment of one of the main breeding objectives of high practical value in the present work, viz., the development of high yielding short duration groundnut genotypes suited to the summer rice fallows. Negative correlation between yield and duration upto maturity was recorded earlier by Patra (1980).

The studies on correlations on the two situations have brought out that there are differences in the direction and strength of correlations between yield and majority of the characters and among themselves at the genotypic and phenotypic levels in the uplands during kharif and the rice fallows during summer. The differences in the pattern of variability for the different characters between the two situations are reflected in the correlations also. The requirement and utility of correlation studies separately for the two situations is thus amply justified.

(iii) Path analysis

The association between characters become more complex in the correlation table when a number of variables are considered simultaneously. Further more, the correlation coefficient estimates only the nature and extent of relationship between the two variables at a time. The path-coefficient analysis helps to detect the specific forces acting behind a given correlation and measures the relative contribution of each causal factor towards the effect by estimating the direct and indirect effects of a causal factor. The path analysis at the genotypic level was done by considering eight selected characters as the causes and dry pod yield as the effect for the upland crop during kharif and rice fallow crop during summer.

At both the situations, fresh weight of pods had the highest direct effect on pod yield which was based on its very high positive genotypic correlation with pod yield. It can be seen that the path and correlation coefficients are almost equal in uplands as well as rice fallows. Therefore a direct selection on this trait will result in the improvement of yield as stated by Singh and Chaudhary (1977) that if the correlation between a causal factor and the effect is almost equal to its direct effect, then correlation explains the true relationship and a direct selection through this trait will be effective. Chandola et al. (1973) reported appreciable positive direct effect on pod yield by weight of green pods. Fresh weight of pods had positive indirect effects via length of top, haulms yield and number of mature pods in uplands and number of leaves and mature pods in rice fallows.

In the uplands, next to fresh weight of pods, 100 pod weight had the highest positive direct effect on pod yield.

This corresponds to the result of Kuriakose (1981). The relatively low correlation coefficient when compared to the direct effect can probably be due to the negative indirect effect of this character through fresh weight of pods, number of flowers and number of basal primary branches. However, the moderately significant correlation between the effect and this causal factor account for the direct effect. 100 pod weight exerted positive indirect effects through haulms yield and number of mature pods, both in turn were highly correlated with yield.

Next to fresh weight of pods, in summer rice fallows, number of leaves had the highest positive direct effect, though the character had only negative non-significant correlation with yield. The observed direct effect of number of leaves on pod yield can probably be due to its significant positive correlation with number of flowers, length of top, fresh weight of pods, 100 pod and 100 kernel weights. Number of leaves had positive indirect effects via number of flowers and fresh weight of pods whereas that via length of top, number of basal primary branches, haulms yield, number of mature pods and 100 pod weight were negative. In this case, restrictions are to be imposed during selection to nullify the undesirable indirect effects in order to make use of the direct effect as indicated by Singh and Chaudhary (1977).

Haulms yield registered appreciable positive direct effect which itself had recorded significant positive genotypic correlation with yield in uplands. This is at variance with the report of Kuriakose (1981) on negative direct effect by dry haulms yield. It also exerted positive indirect effects through fresh weight of pods, number of mature pods and 100 pod weight which were directly correlated with pod yield as well. Since the direct effect and the coefficient of correlation are almost equal, direct selection for this trait will be effective.

Another character with appreciable direct positive effect in rice fallows is the number of flowers even though the trait recorded negative significant correlation with pod yield. The number of flowers exerted positive indirect effects via number of leaves and 100 pod weight whereas that via length of top, fresh weight of pods, haulms yield and number of mature pods were negative. The positive significant correlation of number of flowers with number of leaves on the 50th day, number of basal primary branches, number of leaves, 100 pod weight, 100 kernel weight and oil content appears to be the cause of the positive direct effect on pod yield. As pointed out by Singh and Chaudhary (1977), the negative indirect effects through the yield components such as fresh weight of pods and number of mature pods can be the cause of the negative correlation. Here also, restricted selection so as to nullify the undesirable effects can only yield fruitful results.

Number of mature pods had only a low positive direct effect in uplands and rice fallows, even though the character recorded very high positive genotypic and phenotypic correlation with yield. This is in disagreement with the results of Jaswal and Gupta (1967), Badwal and Singh (1973), Chandola et al. (1973), Sandhu and Khehara (1977 b) and Singh et al. (1979) and Kuriakose (1981). They reported that number of mature pods had the highest positive direct effect on pod yield. However, the very high positive indirect effect of this character through fresh weight of pods which contributed to the highest positive direct effect in the present study at both the situations justifies the high positive correlation. This appears to be logical as well. Singh and Chaudhary (1977) indicated that if the correlation coefficient is positive, but the direct effect is negative or negligible, the indirect effects seems to be the cause of correlation. In addition to fresh weight of pods, number of flowers, length of top, number of basal primary branches and number of leaves in uplands and number of basal primary branches, haulms yield and 100 pod weight in rice fallows had positive indirect effects via this character. In exercising selection in this case, along with number of mature pods, fresh weight of pods also has to be considered and in fact selection for one will follow the other because of their strong positive mutual association. As such selection in breeding works for these characters do not require special attention and that a direct selection on number of mature pods will result in the genetic improvement for yield in uplands and rice fallows.

In the uplands, the highest negative direct effect was produced by length of top which also recorded a negative correlation, balancing the position. Number of flowers, number of basal primary branches and number of leaves also exerted negative influence, all of which in turn had positive, but low correlation with yield. However, the indirect effects of these traits via the most important yield component, viz., fresh weight of pods were found to be positive, indicative of some significance to these characters. The positive correlation of these characters can be attributed to the positive indirect effects via fresh weight of pods.

The highest negative direct effect on pod yield was exerted by haulms yield in summer rice fallows whereas it had exerted high positive direct effect in uplands. The effect of haulms yield in rice fallows on pod yield is in agreement with the results obtained by Kuriakose (1981). Haulms yield had a very low positive correlation with pod yield and the negative direct effect can likely be due to its significant negative correlation with certain yield components like plant height on the 50th day, pod set and dryage percentage of pods. Number of basal primary branches also had appreciable negative direct effect and the negative correlation noted between the character and yield explains the direct effect. Another component with negative direct effect is length of top, though it had positive significant correlation with yield. It had profound positive indirect effects via fresh weight of pods and number of mature pods which accounts for the significant positive correlation. In exercising selection in this case, fresh weight of pods and number of mature pods have also to be considered simultaneously as suggested by Singh and Chaudhary (1977). 100 pod weight had the lowest negative direct effect on pod yield and was based on the negative correlation of the trait with yield as against positive direct effect and positive correlation with pod yield in uplands. But the trait had some positive indirect effect through the most important yield component, viz., fresh weight of pods in rice fallows.

The results so far discussed provide the clues for skeltoning a "plant type" for groundnut for the uplands to be cultivated in the cloudy and rainy kharif season. The breeding approach should be to develop genotypes of medium duration having medium compact canopy with large number of basal primary branches of short internodes with moderate number of dark green leaves, producing moderate number of flowers, setting more number of medium sized heavy pods thereby giving a high yield of fresh pods with high dryage percentage so that a bumper harvest is obtained.

From a critical perusal of the results and discussions made above for the summer rice fallow crop, it is possible to visualise an ideal 'plant type' for the rice fallow conditions during summer. The efficient "plant type" in this case will be one with compact medium tall canopy with moderate number of basal primary branches of short internodes and moderate number of dark green leaves, early in flowering, producing more flowers and setting more number of medium sized pods with heavy kernels of high oil content. The plant will mature early and give a heavy yield of fresh pods with high dryage and shelling percentages. In unit area, more number of such plants can be accommodated efficiently which will result in a high level of productivity per unit area per unit time.

The biometric investigations revealed that there exists considerable variability for exploitation through selection in groundnut for the two major areas of production of this crop in Kerala, viz., uplands during kharif and rice fallows during summer. The various biometric parameters varied generally from one situation to the other. It testify that the separate analysis for the two specific situations is quite essential to have a clear insight into the genotype in relation to the environment in the two situations to be utilized efficiently in the selection and breeding of varieties with reference to the situations. The present study also indicates that the crop is not very efficient, in general, in its production potential of economic produce when compared to its vegetative luxuriance and total dry matter production. It is quite relevant to quote Ramanathan (1980) "Plant habit in groundnut deserves attention of plant physiologists and breeders alike. It is our experience that most of the cultivars are excessively vegetative for the yield they give and there is waste of considerable energy for unproductive purposes". This study further strengthen the necessity of the investigations on the development of optimum canopy structure conducive to maximum pod yield per unit area per unit time for which the 'plant type' in groundnut would be more efficient in utilizing the nutrients and solar energy as suggested by Misra (1980). It is hoped that the present study has thrown light on some of these aspects in relation to the two potential areas for commercial groundnut production in the State.

Varietal evaluation

The role of germplasm collection, maintenance and evaluation in the genetic improvement of crop plants needs no emphasis. According to Norden (1980 a), the heart of a breeding programme is the evaluation or screening of the breeding materials. The success in plant breeding often depends on the appropriate evaluation of variability in the different characters. Rao (1980) also had pointed out that the key to successful utilization of variability from broad genetic pools depends on the knowledge of desirable traits available in the germplasm through a systematic evaluation of the germplasm. A four-tier system of testing was formulated by Singh (1980) for rapid multilocation testing of promising groundnut materials and for the assessment of suitability to the different agro-climatic zones. According to this, each genotype has to be tested in the first and second stage - IVET and PVT - for a minimum of one season. Two seasons trial at the third stage of CVT and one season at the final stage of NET have been fixed as the optimum.

In Kerala, groundnut is cultivated traditionally as a rainfed crop during kharif in uplands. Rice fallows in summer is a non-traditional area of high potential for large scale cultivation. The soil and agroclimatic conditions prevailing in the two situations are entirely different. As such varietal evaluation had been taken up independantly for the two situations. Eighty eight varieties collected from various centres possessing wide varietal diversity were evaluated in uplands during kharif and ninety three varieties were evaluated in the rice fallows during summer.

The varietal diversity in respect of growth, general vigour, branching, leaf and canopy features, pod and kernel characters, seed dormancy and reaction to pests and diseases was very conspicuous in both the situations. All the 88 varieties in uplands and 93 varieties in rice fallows have come up satisfactorily indicating the wide adaptability of the crop as stated by Prasad and Kaul (1980 a). However, these varieties exhibited high variability at both the situations. The mean values for the three important characters, viz., pod and haulms yield and duration upto maturity very well reflected the trend of variability among varieties within and between the two situations. Varietal diversity for yield and other important attributes have been reported in preliminary trials by Jaswal and Gupta (1967), Natarajan et al. (1978), Anon. (1980 d, 1981 a and 1982), Bolton (1980), Gautreau and Depins (1980), Patra (1980) and Rao (1980). It is evident that the varieties exhibit wide diversity in performance and that they perform differently in the two situations. Hence it appears proper to do selection for the two situations independantly. But certain varieties which were stable at the two situations can be utilized with advantage.

The two important varieties of groundnut recommended in Kerala are TMV-2 and TMV-7. Both of them are bunch varieties released in Tamil Nadu and introduced to this State. They mature in uplands by 110-115 days and in rice fallows by 100-105 days. Thirty varieties including the above two recommended varieties were selected for critical evaluation of yield and other important attributes from among the 93 varieties on the basis of their performance in the preliminary evaluation. The testing of different varieties of diverse origin is justified by the fact that groundnut is relatively insensitive to day length. As such cultivars developed anywhere in the world can be evaluated at any other latitude (Vernell and McCloud, 1975). According to Misra (1980), there is urgent need to evaluate under local conditions, promising and high yielding cultivars from those countries where unit area production seems phenominal.

The 30 varieties differed significantly in duration upto flowering in uplands during kharif and rice fallows during summer. The character also showed variation in individual varieties at the two situations. As expected, the varieties in general flowered earlier in summer rice fallows than in kharif uplands. Exotic-6 was the earliest to flower in uplands and had the same duration at both the situations. It was on par with TMV-7, one of the recommended varieties. TG-17 was the earliest to flower in the summer rice fallows. Here the recommended varieties had taken significantly more number of days than the earliest variety. Under both the situations, M-13, a spreading variety, was the longest in duration. Significant differences between varieties for duration upto flowering were reported by Basu and Ashokraj (1969), Majumdar et al. (1969), Kushwaha and Tawar (1973), Ramachandran and Venkateswaran (1980) and Kuriakose (1981).

The differences for duration up to maturity among the varieties in both the situations and between the situations in individual varieties were highly significant. The duration ranged from 106.0 days in KG-61-240 and Jyothi to 130.7 days in M-13 in uplands and from 95.0 days in Ecotic-6 to 116.7 days in M-13 in summer rice fallows. M-13 was the latest in flowering and maturity under both the situations. TMV-7 was on par with the earliest maturing variety and TMV-2 was longer in duration in uplands. In rice fallows both TMV-7 and TMV-2 were longer in duration than the earliest variety. The two promising varieties, viz., TG-14 and Spanish Improved and the recommended variety, TMV-2 were on par in uplands. But in the rice fallows, Spanish Improved was on par with TMV-7 and TG-14 was on par with TMV-2. Basu and Ashokraj (1969), Majundar et al. (1969), Kushwaha and Tawar (1973), Kumar and Yadav (1978), Ramachandran and Venketeswaran (1980), Rao (1980), Sridharan et al. (1980) and Anon. (1982) have also reported significant variation between varieties in duration upto maturity.

In line with the duration upto flowering, the duration upto maturity was generally longer in uplands than in rice fallows. The climatic factors, particularly the cloudy and rainy conditions in kharif as against the clear and warm conditions in summer might have accounted for this difference. Late flowering varieties, generally were late maturing as well in both the situations. None of the varieties matured in 90 days under the summer rice fallow conditions and as such the promising varieties require further genetic improvement for earliness since the vast majority of rice fallows in Kerala have a maximum fallow period of 90 days after the second crop rice. Thus the urgent need for evolving high yielding short duration varieties for rice fallows felt by Nair (1978) has proved to be valuable.

The length of top showed variation between varieties but the character did not vary in individual varieties between the two situations. Under uplands and rice fallows the varieties with the maximum top length are TMV-9 and Gangapuri while those with the minimum length are TG-14 and TMV-2 respectively. The pooled means of the varieties over the two situations ranged from 74.5 cm in TG-14 to 101.3 cm in TMV-9. TMV-7 was on par with the variety with the longest top and TMV-2 was on par with the variety with the shortest top. Results of similar trend were reported by Venkateswaran (1966), Khangura and Sandhu (1973), Sivasubramoniam et al. (1977) and Sridharan et al. (1980).

Significant variation among varieties for number of branches was observed at both the situations. The character in each variety also varied with the situations. Wide variation in number of branches between varieties was reported by earlier workers such as Chandramohan et al. (1967), Jaswal and Gupta (1967), Majumdar et al. (1969), Sangha and Sandhu (1970), Khangura and Sandhu (1973), Shettar (1974) and Venkateswaran (1980). Branching in general was more in uplands than in rice fallows. Number of branches was the maximum in EC.119704 (18.0) and ICG-3859 (14.8) and the minimum in EC.112027 (6.6) and B.353 (5.1) in uplands and rice fallows respectively. TMV-2 and TMV-7 were on par and were having lesser number of branches than the top ranking varieties at both the situations. Further, both the recommended varieties in rice fallows were statistically on par with the variety producing the minimum number of branches. TG-14 and Spanish Improved were grouped with the lowest ranking variety under both the situations suggesting that too much of branching as seen in some varieties do not have any advantage towards yield of pods.

Number of mature pods per plant exhibited high variability at both the situations and between the situations in individual variety. It varied from 10.57 to 29.10 in uplands and 8.33 to 18.25 in rice fallows. Generally the number of mature pods per plant was more in uplands than in rice fallows. TG-14 produced the maximum number of pods and was superior to all other varieties under upland conditions. Spanish Improved and TG-14 were on par with the top ranking variety, viz., Pollachi-2 in rice fallows. TMV-2 and TMV-7 produced lower number of pods at both the situations. In the rice fallows, TMV-7 was on par with Gangapuri producing the lowest number of pods. Chandramohn et al. (1967), Jaswal and Gupta (1967), Basu and Ashokraj (1969), Sangha and Sandhu (1970), Khangura and Sandhu (1973), Kushwaha and Tawar (1973), Sangha (1973), Shettar (1974), Sivasubramoniam et al. (1977), Sridharan et al. (1980) and Anon. (1982) have also reported significant variation between varieties in number of pods per plant. The variation in this major yield component has reflected in the yield of the different varieties.

The varieties varied with respect to the number of immature pods per plant in uplands and rice fallows. The character also differed with the situations in each variety. The varietal variation seen in the production of immature pods per plant is in consonance with the reports of Bernard (1960) and Kushwaha and Tawar (1973). EC.21118 and TMV-9 produced the minimum whereas TMV-11 and EC.21118 produced the maximum number of immature pods in uplands and rice fallows respectively. Interestingly EC.21118 produced the minimum number of immature pods in uplands and the maximum in rice fallows showing that the variety exhibited the highest variation between the two situations. It can be seen that the number of immature pods per plant was more in rice fallows than in uplands in contrast to the number of mature pods per plant. The vast differences in the soil and climatic factors which prevailed in the two situations and the interaction of the varieties with these factors might have contributed to this variability. One of the reasons for the relatively low pod yield in rice fallows than in uplands can be the differential expression of this character in the two situations.

The varietal differences in fresh weight of pods were highly significant at the two situations in each variety the values varied with the situations. The high variability reported in green pod weight by Dixit et al. (1971) and Chandola et al. (1973) is in agreement with this finding. Fresh weight of pods per hectare ranged from 3332 to 6947 kg in uplands and from 4022 to 5013 kg in rice fallows. EC.119704 in uplands and

TG-3 in rice fallows recorded the maximum fresh weight of pods. TG-14 and Spanish Improved were among the top ranking varieties under both the conditions and were superior to the recommended varieties. Like number of mature pods per plant, fresh weight of pods had a higher value in uplands than in rice fallows. This has reflected directly on dry pod yield.

Haulms yield showed significant variation among the varieties in the two situations and in each variety between the situations. This is in line with the reports of Venketeswaran (1966), Chandramohn et al. (1967), Basu and Ashokraj (1969), Kushwaha and Tawar (1973) and Anon. (1980 d). The lowest haulms yield per hectare were 7107 kg in Jyothi and 7813 kg in Co-1, while 15495 kg and 20531 kg, both in ICG-3859 were the highest in uplands and rice fallows respectively. TG-14, Spanish Improved, TMV-2 and TMV-7 in uplands whereas S-7-5-13 and Gangapuri in rice fallows were among the top ranking varieties. However, in the rice fallows, TMV-2 was among the low yielding varieties. Spanish Improved and TMV-7 had relatively higher haulms yield than TG-14 in rice fallows. In general, the haulms yield was higher in rice fallows than in uplands. This is mainly due to the fact that in rice fallows the varieties had low incidence of tikka leaf spot and consequently larger number of green leaves were retained at harvest than in uplands. Higher haulms yield and larger number of immature pods were seen in rice fallows. A larger proportion of the products of photosynthesis would have been retained in the plant body without being translocated into the pods resulting in larger number of immature pods and higher haulms yield under rice fallow conditions. Agroecological, soil and physiological factors might also be responsible for this situation. Timely irrigations given in the favourable warm season for the crop might be another factor for the added vegetative luxuriance in summer rice fallows than in the cloudy and rainy kharif.

The varieties differed significantly in dry pod yield in the uplands during kharif and rice fallows during summer. Pod yield also showed variation in individual varieties at the two situations. Significant differences between varieties in pod yield was reported by a large number of investigators. Dorairaj (1980) observed that yield performance of one and the same variety varies considerably from place to place and from season to season as observed in the present trials. Dry pod yield per hectare ranged from 2088 to 4356 kg in uplands and from 1488 to 3238 kg in summer rice fallows. Pod yield in general was higher in uplands than in rice fallows as that of fresh weight of pods and number of mature pods, the two major yield components. The higher yield in uplands can be attributable mostly to the highly fertile upland soil in which the crop was raised. TG-14 and Spanish Improved were on par in dry pod yield in uplands and were among the top ranking varieties in rice fallows as well. TG-17, EC.119704, EC.112027, EC.35999, Co-1 and TMV-2 follows in order of yield in uplands. The highest yielding variety in rice fallows was TG-3. In the preliminary evaluation also TG-3 was top ranking. Spanish Improved, TG-14, Pollachi-2, EC.112027, Pollachi-1, TMV-9, EC.35999 and EC.36892 were however on par with TG-3. Pollachi-2 ranking 2nd in rice fallow was 10th in uplands and TG-17, ranking 3rd in uplands was 23rd in rice fallows. The two top ranking varieties in uplands, viz., TG-14 and Spanish Improved and the nine top ranking varieties including Spanish Improved and TG-14 in rice fallows were far superior at both the situations to TMV-2, the better of the two recommended varieties. It is thus evident that TG-14 and Spanish Improved are very promising in both the situations. Such varieties stable in yield performance are of great value since groundnut production suffers proverbial instability as stated by Prasad and Kaul (1980 a).

TG-14 and TG-3, the highest yielding varieties in uplands and rice fallows respectively gave 36.45 and 36.14 per cents more yield over the better standard variety, TMV-2. Spanish improved out-yielded TMV-2 by 28.30 per cent in uplands and 31.27 per cent in rice fallows. Pollachi-2 and TG-14 yielded 32.46 and 31.14 per cents over TMV-2 in rice fallows. It is seen that the number of mature pods generally bears a direct relationship with pod yield in the different varieties in uplands and rice fallows. In tune with the present results, in a comparative yield trial involving 11 entries, conducted at 10 locations, TG-14 has proved to be one of the better varieties (Anon., 1981 a). The report of Sridharan et al. (1980) that TG-3 is far better than TMV-9 and Ah-316/S supports the present results. TG-3 and TG-17 which produced 3200 kg/ha and 2000 kg/ha respectively were superior to the locals (Patil, 1978). In further trials he reported that TG-3, TM-14 and TG-17 were consistently superior and produced over 20 per cent more yield than the local varieties in Gujarat, Maharashtra, Karnataka and Madhya Pradesh. It is also reported by him that in a crop competition for groundnut production organised by the Department of Agriculture, Karnataka, two farmers growing TG-3 and TG-14 have won first prizes by producing 6000 and 5000 kg/ha. Patil and Thakare (1969) reported that TG-3 gave higher pod yield than its parent, viz., Spanish Improved. In a large scale varietal trial with 17 cultures, the highest yielding culture (EC.42550) was found to be on par with Spanish Improved, indicative of the high yield potential of this variety (Anon., 1982). In another trial with 20 cultures also, Spanish Improved was one of the higher yielding varieties. These reports further confirm the superiority of the promising varieties as seen in the present investigation. Patil and Mouli (1978) recorded that TG-17 which had bold kernels and high yield potential produced 14 to 90 per cent more pod yield than the local varieties at six places in Maharashtra, Gujarat and Tamil Nadu. In another trial with 19 entries, Anon. (1980 c) reported that Dh-7 gave the highest yield followed by TG-17. These reports are also in general agreement with the present results, particularly in uplands where TG-17 ranked third.

Co-1 and TMV-2 ranking seventh and 8th in uplands in the present trials were reported to occupy the first rank at four centres and at one centre respectively in a trial with 13 varieties at 9 centres (Anon., 1981 a). These varieties, however were better than many varieties in the present study, but not the leading ones as reported. At both the situations, Gangapuri had given the lowest pod yield and the reported highest pod yield of this variety in a trial with 7 varieties (Anon. 1978 a) is not in agreement with the present performance. In another trial with 7 varieties, Ramachandran and Venketeswaran (1980) reported that Gangapuri ranked first with 64 per cent more yield than the check, TMV-9 in kharif 1973; while in 1974, its yield was 13 per cent less. This report is also not in conformity with the results in the present trials.

In addition to the above reports of great varietal diversity for pod yield, Chandramohan et al. (1967), Patil and Thakare (1969), Dixit et al. (1971), Sivasubramoniam et al. (1977), Anon. (1979 a, 1980 d, 1981 a, 1982), Bolton (1980), Gautreau and Depins (1980), Nigam et al. (1980), Patra (1980), Rao (1980) and Sibale and Kisyombe (1980) have also reported wide variation among varieties for pod yield in groundnut.

The varieties showed significant variation for 100 pod weight among themselves in the two situations. The character also varied between the two situations in every variety. Similar to the present observation, significant differences between varieties in 100 pod weight were reported by Venketeswaran (1966), Jaswal and Gupta (1967), Majumdar et al. (1969), Dixit et al. (1970), Sangha (1973), Patil (1978), Ramachandran and Venketeswaran (1980), Rao (1980), Sridharan et al. (1980) and Anon. (1981 a, 1982). Pod weight in the present trial was generally more in the rice fallows than in the uplands.

Relatively lower number of pods in rice fallows might have lead to the higher pod weight than in uplands. 100 pod weight ranged from as low as 59.7 g in Pollachi-2 and 70.6 g in KG-61-240 to as high as 113.3 g in M-13 and 142.4 g in EC.36892 in uplands and rice fallows respectively. In a trial with 20 varieties, Anon. (1982) reported that 100 pod weight varied from 63 to 121 g. Pod weight in the top ranking varieties were far higher than that in the two recommended varieties.

100 kernel weight of the varieties was different in the two situations. The trait also showed significant interaction between varieties and situations. In consensus with the present result, differences between varieties in 100 kernel weight were recorded by Venketeswaran (1966), Sangha (1973), Natarajan et al. (1978), Ramachandran and Venketeswaran (1980), Rao (1980), Sridharan et al. (1980) and Anon. (1981 a, 1982). Varieties with higher pod weight are generally having higher kernel weight as per expectation. Similar to 100 pod weight, 100 kernel weight was also the highest for M-13 in uplands whereas in rice fallows it was the highest for EC.119704. 100 kernel weight of TMV-2 and TMV-7 was lower at both the situations. TG-14 recorded high kernel weight.

Highly significant differences were seen among the varieties with respect to dryage percentage of pods in the two situations and between the situations in the same variety. Dixit et al. (1971) and Chandola et al. (1973) also noticed varietal variation in dryage percentage. TMV-9 in uplands and EC.112027 in rice fallows had the maximum dryage percentage whereas the minimum was in Gangapuri at both the situations. The low value of 56.2 for EC.119704 had lowered this variety from its first rank in fresh weight of pods to the 8th rank in dry pod yield. TMV-2 was on par with the top ranking varieties in uplands. In the rice fallows TMV-2 and TMV-7 were on par but had lower values.

Shelling percentage, one of the important economic traits in groundnut, showed high variability between varieties in the two situations and between situations in individual varieties. In conformity with this result, Venketeswaran et al. (1980) noted that shelling out turn is a highly variable genetic character influenced considerably by environmental factors. Dixit et al. (1970), Khangura and Sandhu (1973), Kushwaha and Tawar (1973), Mohammed et al. (1973), Kumar and Yadav (1978), Anon. (1980 d, 1982), Nigam et al. (1980) and Rao (1980) have also reported wide varietal diversity in shelling percentage. The shelling percentage ranged from the minimum of 52.3 in Gangapuri and 57.4 in Big Japan to the maximum of 80.2 and 81.4 in KG-61-24 in both uplands and rice fallows respectively. For Gangapuri, Ramachandran and Venketeswaran (1980) also recorded low shelling percentage. Kuriakose (1981) recorded that shelling percentage ranges from 74.93 to 82.90 per cent in twenty six varieties studied by him while Anon. (1982) reported that it ranges from 66.75 to 75.45 per cent in seventeen varieties tried. The two recommended varieties (TMV-2 and TMV-7) and the two promising varieties (TG-14 and Spanish Improved) have high shelling out turns at both the situations. It is seen generally that higher the pod and kernel weights, lower is the shelling percentage. Therefore the negative correlation reported by Kushwaha and Tawar (1973) and Kuriakose (1981) between shelling percentage and pod and kernel weights holds good in this case. Hence pods and kernels of medium size are desirable.

The differences between varieties in oil content in the two situations and between the two situations in individual varieties were significant. Khangura and Sandhu (1973) and Kushwaha and Tawar (1973) also reported high variability with regard to oil content among varieties. EC.36892 (42.4%) in uplands and M-13 (42.1%) in rice fallows gave the lowest while AH-6915 (53.6%) in uplands and S-7-5-13(54.2%) in rice fallows gave the highest oil recovery. Shany (1979) and Kuriakose (1981) reported a range of 50 to 58 per cent and 43.6 to 52.6 per cent respectively for oil content. But Norden (1980 a) reported a higher range for oil content from less than 40 to over 60 per cent. In the uplands, the oil contents of TMV-2 and TG-14 were on par but lower than that of Spanish Improved. In the rice fallows, TMV-7 and TMV-2 were on par with Spanish Improved and TG-14 respectively. Thus all the promising varieties had high oil contents.

Varieties with higher oil content had generally smaller kernels and vice-versa. This is in agreement with the reports of Elsaeed (1967) that there was negative correlation between oil content and seed weight; and that of Patil (1972) that oil content and 100 kernel weight had negative correlation. Mohammed et al. (1973) also reported that high oil content was positively correlated with small kernels.

Both under upland and rice fallow conditions, the varieties differed in their protein contents. In individual varieties it also varied with the situations. The highest protein content was recorded in M-13 followed by TG-14 at both the situations. TMV-2 and TMV-7 had given low protein values as compared to those with high protein recovery. Such significant differences between varieties in protein content were recorded by Khangura and Sandhu (1973), Kushwaha and Tawar (1973) and Shany (1979). The protein content ranged from 22.5 to 31.5 per cent in uplands and from 22.9 to 29.9 per cent in rice fallows. Under both the situations, TMV-10 yielded the lowest protein cut-turn (22.5 and 22.9 per cent respectively).

A critical evaluation of the oil and protein contents in the different varieties revealed that, in general, oil content was low in varieties with high protein content and vice-versa at both the situations. This is in conformity with the observation by Shany (1979) that forms with high protein content tend to have low oil content and vice-versa. Moreover, protein content is generally more in bigger kernels in both the situations whereas oil content was more in small kernels. These associations indicates that selection and breeding for high oil content and high protein content has to be taken up separately and the possibility of developing genotypes combining the two traits is remote.

The performance of the thirty selected varieties including the two standard varieties, viz., TMV-2 and TMV-7 revealed that the varieties varied profoundly in yield and all other characteristics under the traditional uplands during kharif and the potential non-traditional rice fallows during summer. Under the upland conditions, TG-14 (4650 kg/ha) gave the highest pod yield followed by Spanish Improved (4356 kg/ha). Both of them were far superior to the recommended varieties, viz., TMV-2 (3428 kg/ha) and TMV-7 (2694 kg/ha). In the case of other attributes of economic importance such as number of mature pods per plant, haulms yield, duration upto maturity, 100 pod and kernel weights, shelling percentage, oil and protein contents the two promising varieties are either superior to or on par with the recommended varieties indicating that they are generally desirable. In number of mature pods per plant TG-14 ranked first and Spanish Improved fourth and in haulms yield they were second and third respectively. In duration upto maturity the two promising varieties are on par with the better of the two standard varieties, viz., TMV-2. The pod and kernel weights are also desirable. The shelling percentage of the varieties was also high with 75.0 and 74.4 respectively. The oil and protein contents were also satisfactory. TG-14 and Spanish Improved recorded 48.2 and 48.4 per cent oil and 25.8 and 26.9 per cent protein respectively.

In the summer rice fallows, the highest pod yield was obtained from TG-3 (3238 kg/ha) followed by Pollachi-2, Spanish Improved, and TG-14. All these varieties were significantly superior to the recommended varieties TMV-2 and TMV-7. Here also, the top ranking varieties were either superior to or on par with the recommended varieties in other important characters like number of mature pods per plant, haulms yield, duration upto maturity, 100 pod and kernel weights, shelling percentage, oil and protein contents. The number of mature pods per plant was the maximum in Pollachi-2 (18.25) followed by TG-3 (16.87). Spanish Improved, TG-14 and TMV-2 produced 15.97, 15.17 and 13.80 pods per plant respectively. As in uplands, generally higher yielding varieties produced more number of mature pods per plant in rice fallows also. In duration upto maturity, the promising varieties compares more or less well with the recommended varieties. But none of the varieties were found to mature in 90 days or less. Therefore the promising varieties have to be corrected for earliness since the majority of the rice fallows have a maximum gap period of only 90 days. The pod and kernel weights and haulms yield of the promising varieties were also high. The shelling out-turn of TG-3, Pollachi-2, Spanish Improved, TG-14 and TMV-2 were 73.1, 77.6, 72.9, 70.2 and 76.5 percentages respectively. The oil content in the above varieties was 47.3, 46.3, 47.9, 46.9 and 47.0 respectively. The protein content of the promising varieties was also satisfactory.

The pooled analysis of data for the two situations revealed that the varieties vary significantly from each other for all the characters except number of immature pods per plant and haulms yield. This analysis had further brought out the profound influence of the environment on yield and other important characters by the significant 'F' ratio for situations x varieties. Thus it is quite intruguing that all the important characters differ considerably from the uplands during kharif to the rice fallows during summer. Therefore, programmes of improvement in this crop can be efficient if only it is situation specific.

It is well known that groundnut is an 'unpredictable legume' and Patra (1980) has correctly stated that its performance depends upon the action and interaction of a number of factors. This can be one of the major reasons for the proverbial instability in groundnut production as remarked by Prasad and Kaul (1980 a). The observation made by Dorairaj (1980) that the yield performance of one and the same variety varies from place to place and from season to season and his suggestion for the multilocational testing of varieties holds good in this context. By and large, the idea of Hammons (1976), that the key feature of the breeding system should be the incorporation of stability to environmental variations while retaining genetic diversity is immensely meaningful. The opinion of Jensen (1967) that genetic and phenotypic diversity of crops should be accepted as a desirable goal in plant breeding programmes appears complementary to the above ideas. In the present evaluation, though the varieties varied abundantly in yield and other attributes of economic importance from one situation to the other, TG-14 and Spanish Improved were found to be consistently superior in yield both under upland and rice fallow conditions. In the preliminary evaluation too, these varieties were promising uniformly in uplands and rice fallows. Besides their higher yields in the two situations, these two varieties are also better in other economic attributes such as haulms yield, 100 pod and kernel weights, shelling percentage, oil and protein contents. In short, it is clear that the presently recommended varieties can efficiently be substituted by these two varieties so that the productivity of the crop in the state can be enhanced to a considerable extent in the immediate future. The statement of Norden (1980 a) that introduction and selection is still a satisfactory means for the genetic improvement in groundnut is thus amply substantiated.

Induced mutagenesis

Mutation breeding has been generally accepted as a complementary method of crop improvement. It is probably the best method where the objective is to effect a specific change in otherwise acceptable genotypes. TG-14 and Spanish Improved were found to be adapted and promising with more or less stable performance and yield potential under upland conditions during Kharif as well as in rice fallows during summer. But they are longer in duration by about 15 days under summer rice fallow conditions as there is a gap of only around 90 days available during this season. Rice fallows in Kerala is one of the non-traditional potential areas for large scale cultivation of groundnut. But as pointed out aptly by Nair (1978), the lack of adapted promising varieties maturing in 90 days or less is the limiting factor for commercial production of groundnut in summer rice fallows. As such, the prime objective for induced mutagenesis in the present investigation is to evolve promising genotypes maturing in 90 days or less to fit in the rice based cropping system during the summer season. The efficiency of groundnut in increasing production, economic returns and soil fertility when included in wetlands during summer had been proved by Anon. (1978 b) and Sasidhar (1978).

The recommended variety TMV-2 and the two promising varieties, viz., TG-14 and Spanish Improved were treated with three doses each of gamma rays, viz., 20, 30 and 40 krad and the results of the study are discussed below.

(i) Effects in the M_1 generation

Germination of seeds was reduced by gamma rays and a progressive decline in germination with increasing dose was noticed in all the varieties. This is in consonance with the earlier findings of Dorairaj (1979) and Sivasubramoniam (1979). The reduction in germination can be due to the effect of irradiation on the chromosome compliment or due to adverse physiological effects.

The survival was reduced by gamma rays in all the three varieties. The relationship between the percentage of survival and dose of radiation was inverse. This is in tune with the earlier reports by Gregory (1968), Sivasubramoniam (1979) and Ratnaswamy (1980). The frequency of survival could be an index of the post germination mortality as a result of physiologic or toxic effects of radiation.

Reduction in plant height was observed in all the three varieties on the 30th day and the effect was dose dependent. This observation is in line with the earlier reports by Shivaraj and Rao (1963), Patil (1966), Perry (1968), Sinha and Roy (1969) and Dorairaj (1979). The inhibition of growth could be due to cytological and physiological changes induced in the cell. Jagathesan and Puri (1965) have observed changes in auxin levels. Inactivation of vital enzymes, especially those concerned with respiration was noted by Casarett (1968). The height reduction noticed on the 45th day was negligible indicating that the deleterious effects of radiation would have been overcome through replacement of damaged zones in the affected plants by the uninjured meristem.

Kivi (1962) had stated that reduction in pollen fertility in M_1 plants is a reliable parameter indicating the effectiveness of mutagenic treatment. In the present investigation, the fertility decreased with increasing doses of gamma rays, though the pattern of reduction was different in the three varieties. Results of similar trend were recorded by Bhatt et al. (1961), Gregory (1968), Prasad (1972) and Mouli and Patil (1976). According to Gaul et al. (1966), the cryptic structural changes in the chromosomes and chromosomal aberrations are the causes for M_1 sterility following radiation treatments. Mutagen induced sterility may be caused by chromosome mutations, factor mutations, cytoplasmic mutations and physiological effects.

Plants with chlorophyll deficient sectors were found in the M_1 generation in all the three varieties in low frequencies. Such chimeric plants had been reported by Bliquex et al. (1961), Patil (1966) and Sinha and Roy (1969). Gaul (1961) reported that the type of chimerism varied with the dose of mutagens. Consequent to mutagenic treatments, chlorophyll deficient spots were observed in the M_1 generation of legumes by Blixt and

Gelin (1965). They observed a close correlation between leaf spotting and mutation rate and advocated its use as a criterion for selecting M_1 plants for securing a higher yield of mutations in the M_2 generation.

Various sorts of morphological abnormalities were detected on the M_1 plants of all the three varieties. Among the abnormal plants, stunted and dwarfs are important. Earlier workers like Ashri and Goldin (1965), Sanjeeviah (1967), Prasad (1972) and Mouli and Patil (1976) also had recorded different types of abnormal plants. Production of dwarfs may be due to the inactivation of respiratory enzymes by radiation.

(ii) <u>Effects in the M_2 generation</u>

Chlorophyll mutations have been widely employed for assessing the effectiveness of mutagenic treatments in higher plants. The frequency of chlorophyll mutations increased with increasing doses of gamma rays in all the three varieties. This finding is in agreement with the earlier reports of Arzumanova (1970) and Sivasubramoniam (1979).

Albino, Xantha, Chlorina and Viridis are the chlorophyll mutants observed and the relative percentages of these mutants varied in the different treatments. A wide spectrum of chlorophyll mutations have been recorded by Patil and Bora (1963), Gregory (1968), Patil (1973), Tai et al. (1977) and Sivasubramoniam (1979). In the present study viridis was the most frequent type of chlorophyll mutation whereas albino was the least.

The effectiveness and efficiency of mutagenic agents depend on the nature of the organism as a whole as well as the specific properties of the tissue treated in addition to the properties of the mutagenic agent. Groundnut had been proved to be an apt material for genetic improvement through induced mutagenesis and gamma irradiation was utilized successfully by many workers like Shivaraj and Rao (1963), Sanjeeviah (1967), Menon et al. (1970), Dorairaj (1979), Sivasubramoniam (1979), Prasad and Kaul (1980 b) and Ratnaswamy (1980).

No definite relationship was seen in the present study in any of the varieties between doses of radiation and mutagenic effectiveness. In TMV-2 and Spanish Improved, effectiveness was the highest at the highest dose of radiation tried (40 krad) and in TG-14, it was at the intermediate dose (30 krad).

The biological parameters such as lethality, injury and sterility were considered in determining the mutagenic efficiency. As in the case of mutagenic effectiveness, mutagenic efficiency too did not show any specific relationship with radiation doses in the three varieties. Sivasubramoniam (1979) concluded that 30 krad is the most efficient dose of gamma rays. Differential response of genotypes to varying doses of mutagens were reported by many workers like Bliquex et al. (1961), Loesh (1964), Ashri and Goldin (1965), Prasad (1972), Dorairaj (1979) and Ratnaswamy (1980).

A number of mutants of practical utility were isolated during the present investigation. Early flowering and early maturing mutants were recovered from all the three genotypes. Generally early flowering plants were early maturing as well.

Six mutants in TMV-2 and three each in TG-14 and Spanish Improved, maturing as early as in 85 days were isolated. It may be noted that TMV-2 and TG-14 had taken 106 days and Spanish Improved 104 days for maturity. Thus a reduction of 19 to 21 days in maturity was seen in the early mutants. Twenty two mutants maturing in 90 days and another 19 mutants maturing in 95 days were also isolated. Early mutants were reported earlier by Patil and Thakare (1969) and Dorairaj (1979). The exigent varietal requirement was thus achieved by isolating mutants maturing in 85 to 95 days. Some of the early mutants combine desirable atrributes like short and compact canopy, larger number of pods and dark green leaves. They could be used directly or in cross-breeding programmes and no doubt, will pave the way for the efficient harvest of sunshine falling abundantly unhindered on the summer rice fallows as vegetable oil and protein.

Late flowering and late maturing mutants were also isolated. Such mutants were reported by earlier workers like Patil (1966) and Gregory (1968). As expected, all the late flowering mutants were late in maturity as well.

Some of the stunted and dwarf mutants had short stature and profuse branching giving them a bushy appearance. In such plants the main shoot apex stops growth and differentiation very early in the ontogeny while the axillary buds carry on further growth. Sanjeeviah (1967) observed varying frequencies of dwarf mutants under different doses of radiations. They reported that such mutants were more frequent with gamma rays than with x-rays, suggesting that the locus or loci concerned are more sensitive to gamma rays than x-rays. Anon. (1960), Patil (1966), Mouli and Patil (1976) and Dorairaj (1979) have also reported dwarf mutants.

Tall mutants as well as a very compact mutant were isolated in the present study. The increased height in the tall mutant was due to the longer internodes. The compact mutant was with dark green leaves and failed to set pod. The very compact nature of the mutant is due to the retarded growth of the main shoot. The internodes and petioles were compressed. Hammons (1953 a) reported a 'Cup mutant' characterised by a complex of morphological features which were ascribed to pleiotropic effects of a single gene. Mouli and Patil (1976) had isolated a mutant with suppressed growth of primary branches and reduced pod setting.

The non-branching mutants observed during the present investigation are rare in groundnut. Semi-spreading mutants were obtained from bunch parent. Mutants with altered habit of growth had been reported by Anon. (1960), Gregory (1968), Sinha and Roy (1969) and Arzumanova (1970).

Viable mutants with changed leaf size, shape, colour and leaflets such as little leaf mutant, curly leaf mutant, narrow leaf mutant, dark green mutant and mutant with six leaflets were noticed in the present work. Leaf mutants of these sorts were reported by groundnut mutation breeders like Gregory (1956), Anon. (1960), Bhatt et al. (1961), Emery et al. (1965), Gregory (1968), Dorairaj (1979) and Prasad and Kaul (1980b).

Mutants with altered pod characteristics were also isolated. These include small poded mutant, bold poded mutant, deeply pod constricted mutant, shallow pod setting mutant and single kernel mutant. Such mutants have been reported by Gregory (1956 b), Patil (1966), Mouli and Patil (1976) and Dorairaj (1979). Dormant mutants were also detected during this study as reported earlier by Patil (1966) and Prasad and Kaul (1980 b).

In some of the viable mutants isolated several characters have simultaneously changed. Hammons (1953 a) recorded a 'Cup mutant' characterised by a complex of morphological features which were ascribed to pleiotropic effects of a single gene. Ashri and Goldin (1965) observed mutations involving two or three characters at a time and suggested that this may be a pleiotropic mutant with syndrome effect. The loss of a chromosome segment may also result in such effects as stated by Patil (1966). According to Muller (1956) such multiple phenotypic effects of mutation might be due to the pleiotropic gene action or 'mutation clusters due to the clustering effect of mutagenic ionizations'.

In the present investigation on induced mutagenesis, in three selected groundnut genotypes, a wide spectrum of both academically and economically significant viable mutants have been isolated for immediate and future use. The results indicate that groundnut is highly suitable for genetic improvement through induced mutagenesis as suggested by Gregory (1956 b) and Norden (1973). The suggestion of Misra (1980) that induced mutagenesis is a tool for breeding for earliness in groundnut, has proved to be significant.

The present investigation has thus brought out certain valuable informations of immediate and future utility in the genetic improvement of groundnut. The studies on variability, heritability, genetic advance, correlation and path analysis involving 80 divergent varieties in the traditional uplands and in the non-traditional but highly potential rice fallows during summer indicate the relative importance of the various components of yield. This information will serve as a valuable tool in effecting reliable selection for identifying varieties suited to uplands and wetlands. It is evident that there is enormous genetic variability for the important characters and as such ample scope for genetic improvement of this crop. Further more, the study has enabled the formulation of the concept of a 'Plant type' in groundnut for the rainy and cloudy kharif in uplands as well as the hot and clear summer in rice fallows.

The evaluation of varieties under the upland and rice fallow conditions brought out that the varieties varied widely within and between the situations and that the environment plays a vital role in the expression of the different characters. TG-14 in uplands and TG-3 in rice fallows are the highest yielding and were far superior to the recommended varieties. However, TG-14 and Spanish Improved are consistently superior at both the situations. The high yield potential of these varieties can be further confirmed by multilocational testing and then recommended for large scale cultivation. This will enhance the production of the crop in the State in the immediate future. Certain varieties are giving satisfactory pod yield as well as very high haulms yield. Hence the possibility of utilising such varieties as 'dual purpose varieties' for vegetable oil and green matter has to be explored.

A large number of mutants of academic and practical significance were isolated following gamma irradiation. Early maturing mutants fitting well with the rice based cropping system are of great practical utility. Some of them are dwarf and compact with larger number of pods. They can be utilized directly for the summer rice fallows or can be used as the genetic basis for further cross breeding programmes. The yield potential of these mutants have to be further evaluated. It is sure that these early mutants will pave the way for the efficient and wide spread harvest of sunshine from the rice fallows of our State. The dwarf and compact mutants isolated can be more ideal for companion cropping with tapioca and deserves further evaluation in this line. The popular varieties are generally too excessive in vegetative luxuriance and as such have low harvest index. Some of the mutants isolated are dwarf as well as compact with dark green leaves without excessive vegetative growth and such mutants are worthy of exploitation. The genetic resources gathered and evaluated in the present endeavour will thus be of great value in future programmes for the genetic improvement of the crop in the State.

SUMMARY

SUMMARY

Enhancing the productivity of groundnut, the most important oil seed crop of the country, is an urgent need from economic and nutritional points of view. Groundnut is a legume with wide adaptability having a number of advantageous attributes. In Kerala, the crop is traditionally cultivated in uplands during kharif. A non-traditional, but potential area for this crop in the State is the summer rice fallows. However, no systematic work for the genetic improvement of this crop has been undertaken in this State. Collection and evaluation of germplasm is an essential pre-requisite for an efficient breeding programme. Biometric studies on economic attributes with reference to the specific situations will be of great value to the breeder in effecting selection. Evaluation of available materials can yield results of immediate utility. The deficiencies, if any, in the materials so identified could be rectified by corrective breeding proceedures. The present investigation was planned and undertaken with the above objectives. The salient results obtained and conclusions drawn are summarised here.

A germplasm of 88 divergent varieties of groundnut belonging to the three habit groups were collected from various centres and put to preliminary evaluation in uplands during kharif 1980. Five more varieties were collected and the entire germplasm of 93 entries were evaluated in rice fallows during summer 1981.

Eighty varieties were selected for biometric studies in the uplands during kharif and rice fallows during summer. The trials were laid out in Randomised Block Design, replicated thrice, at both the situations for the estimation of parameters of variability correlation and path analysis. Data were recorded on 23 metric characters. Analysis of variance was done to test the significance of varietal differences for all the characters at the two situations. Estimates of genotypic, phenotypic and environmental coefficients of variation, heritability in the broad sense, genetic advance at 5 per cent intensity of selection and correlation coefficients at genotypic and phenotypic levels between yield and the other twenty two characters and among themselves were computed. Path coefficient analysis for pod yield at the genotypic level was also made for the two situations considering eight characters as causal factors, viz., number of flowers, length of top, number of basal primary branches, fresh weight of pods, haulms yield, number of leaves, number of mature pods and 100 pod weight.

The varieties differed significantly for all the 23 characters in uplands during kharif and rice fallows during summer. The wide variability in respect of all these characters between the varieties at both the situations was further demonstrated by the vast differences in the mean values. The varieties gave differential performance at the two situations. The influence of the environment on the expression of the various characters, in general, was very high. The parameters of variability showed considerable differences among the characters within and between the situations. There were also differences in the direction and strength of relationship between characters from one situation to the other.

During kharif in uplands, the g.c.v. was the highest for pod set followed by number of branches, haulms yield and number of mature pods. Dry pod yield showed moderate g.c.v. Oil content, duration upto flowering and maturity had low g.c.v. and p.c.v. Number of immature pods and branches had very high p.c.v. E.c.v. was the highest for number of immature pods and the lowest for duration upto maturity followed by shelling percentage. Heritability was high for spread of flowering, duration upto maturity, 100 pod weight, 100 kernel weight and shelling percentage. Pod yield had got moderate heritability. Genetic advance was high for pod set, number of branches, haulms yield, number of mature pods and flowers. Oil content, duration upto flowering and maturity recorded low genetic advance. High heritability combined with high genetic advance and g.c.v. was seen for pod set and number of branches. High heritability coupled with high genetic advance was shown by number of flowers, haulms yield and 100 pod weight. Moderate heritability and genetic advance were noticed for pod yield and number of mature pods. High heritability and moderate genetic advance were found for spread of flowering, plant height on the 50th day and 100 kernel weight whereas high heritability and low genetic advance were seen for dryage and shelling percentages, duration upto flowering and maturity and oil content.

Yield was highly correlated positively with fresh weight of pods, number of nature pods, pod set, number of immature pods and dryage percentage of pods at the genotypic and phenotypic levels. Days to maturity and 100 pod weight moderately at the genotypic level and number of flowers highly and number of basal primary branches moderately at the phenotypic level were also correlated with pod yield. Highly significant negative correlation of pod yield was seen with plant height on the 50th day and moderately significant negative correlation with height of main shoot and length of top at the genotypic level. The fresh weight of pods was found to be correlated significantly and positively with duration upto flowering, number of branches on the 50th day, haulms yield, number of mature pods, pod set, number of immature pods and 100 kernel weight. Number of mature pods was correlated positively and significantly with fresh weight of pods, pod set and number of immature pods. Significant negative correlation of number of mature pods with 100 pod weight and 100 kernel weight was noticed. Haulms yield registered significant positive correlation with duration upto flowering and maturity, number of branches and leaves on the 50th day, number of flowers, height of main shoot, length of top, number of basal primary branches, fresh weight of pods, number of leaves and 100 pod and kernel weights. There was negative correlation for 100 pod and kernel weights with shelling percentage; but high positive correlation was seen between 100 pod and 100 kernel weights. The correlation between oil content and 100 kernel weight was negative.

Fresh weight of pods, 100 pod weight, haulms yield and number of mature pods had direct positive effects on pod yield. Fresh weight of pods had positive indirect effects via length of top, haulms yield, and number of mature pods. The indirect effects by 100 pod weight through haulms yield and number of mature pods were positive. Haulms yield was noticed to exert positive indirect effects on pod yield via fresh weight of pods, number of mature pods and 100 pod weight. Number of mature pods had positive indirect effects via all characters except haulms yield and 100 pod weight. But length of top, number of basal primary branches, number of leaves and number of flowers exerted negative direct influence on pod yield. The residual value obtained was very low indicating that this model covers almost the entire genetic variability for pod yield.

The studies on correlation and path analysis indicated that genotypes of medium duration with medium compact canopy, large number of basal primary branches of short internodes, moderate number of dark green leaves, moderate number of flowers and setting more number of medium sized pods of heavy weight will give a high yield of fresh pods which with a high dryage percentage will result in a bumper crop in the uplands during kharif.

In summer rice fallows, the number of branches on the 50th day showed the highest g.c.v. followed by number of branches and pod set whereas it was the lowest for duration upto maturity followed by oil content, shelling percentage and duration upto flowering. P.c.v. was the maximum for number of branches on the 50th day while it was the minimum for duration upto maturity. Number of immature pods recorded the highest e.c.v. while duration upto maturity recorded the lowest. Pod yield registered high p.c.v. and e.c.v. than g.c.v. Generally g.c.v. was less than the corresponding p.c.v. for all the characters as that in uplands indicating the profound influence of environmental effects on all these characters.

Spread of flowering had got the highest heritability in the broad sense followed by 100 pod weight, duration upto maturity and flowering. Fresh weight of pods recorded the lowest heritability followed by dry pod yield. Genetic advance was the highest for number of branches followed by pod set. It was the lowest for duration upto maturity followed by shelling percentage and pod yield. G.c.v., heritability and genetic advance were high for number of branches, flowers, leaves and pod set. Both heritability and genetic advance were high for number of flowers, spread of flowering, number of branches, leaves, pod set and 100 pod weight. High heritability, but low genetic advance was seen for duration upto flowering and maturity, 100 kernel weight, shelling percentage and oil content.

Both at the genotypic and phenotypic levels, yield was highly and positively correlated with plant height on the 50th day, length of top, fresh weight of pods, number of mature pods, pod set, number of immature pods and dryage percentage. At the genotypic level, pod yield had high positive correlation with height of main shoot and shelling percentage and at the phenotypic level with number of flowers and haulms yield. Moderately significant positive correlation was also seen at the genotypic level between pod yield and oil content. At the genotypic level, pod yield showed highly significant negative correlation with duration upto flowering, number of branches and leaves on the 50th day and number of flowers whereas it was moderately significant with number of basal primary branches and number of branches. There was significant negative correlation at phenotypic level between pod yield and duration upto flowering.

Fresh weight of pods was correlated significantly and positively with plant height on the 50th day, duration upto maturity, height of main shoot, length of top, number of mature pods, pod set, number of immature pods and 100 pod and kernel weights. The number of mature pods was correlated significantly and positively with plant height on the 50th day, fresh weight of pods, pot set and shelling percentage. Length of top had positive correlation with plant height on the 50th day, duration upto maturity, height of main shoot, pod set, 100 pod and kernel weights and shelling percentage. Haulms yield, duration upto flowering and maturity, fresh weight of pods, number of leaves and pod set were positively correlated with oil content. Height of main shoot is positively correlated with plant height on the 50th day, duration upto maturity, length of top, fresh weight of pods, pod set, 100 pod and kernel weights and shelling percentage. Shelling percentage recorded positive significant correlation with dryage percentage and number of mature pods and negative correlation with 100 pod and kernel weights. 100 pod weight and 100 kernel weight had negative, non-significant correlation with oil content. Highly significant positive correlation was seen between duration upto flowering and maturity and negative non-significant correlation was seen between pod yield and duration upto maturity suggesting the possibility of obtaining genotypes combining high yield with short duration.

Fresh weight of pods had the highest positive direct effect as in the uplands. It also had exerted positive indirect effects via number of leaves and number of mature pods. Number of leaves had the second highest positive direct effect and it had positive indirect effects through number of flowers and fresh weight of pods and negative indirect effects through length of top, number of basal primary branches, haulms yield, number of mature pods and 100 pod weight. Number of flowers exerted appreciable positive direct effect and the indirect effects of number of leaves and 100 pod weight via this character were also positive. The direct effect of number of mature pods on pod yield was positive, but low when compared to its very high positive correlation. Length of top, number of basal primary branches, haulms yield and 100 pod weight had negative direct effects on pod yield of which that by haulms yield was the highest followed by number of basal primary branches. The low residual effect testify that a very high proportion of the genetic variability towards pod yield had been included in the analysis.

The correlation and path analysis studies had given the clues for visualising an ideal plant type for the summer rice fallows. A plant with compact medium tall canopy with moderate number of basal branches of short internodes, moderate number of dark green leaves and early in flowering, producing more number of flowers and setting more number of medium sized pods with heavy kernels of high oil content, will mature early and produce a heavy yield of fresh pods of high dryage and shelling percentages. Such a plant can be accommodated in less space so that productivity can be enhanced considerably from unit area in unit time.

In the preliminary evaluation at both the situations, all the varieties came up satisfactorily, revealing the wide adaptability of the crop. The varieties exhibited great variability in all characters in general and economic attributes like duration, yield of pods and haulms in particular at both the situations. The response of individual varieties also differed considerably with the situation suggesting that separate selection should be done for each situation. Under upland conditions, the highest pod yield was recorded in AH-6915 followed by M-13 and in summer rice fallows in TG-3 followed by TG-19. However, a few varieties such as TG-14 and Spanish Improved were consistent in yield at both the situations and at both the situations they were superior to the two recommended varieties, viz., TMV-2 and TMV-7. Thirty promising varieties including the recommended ones were selected and critically evaluated under both the situations.

The analysis of variance for the characters done separately for the two situations revealed that the varieties differ significantly in all the 15 characters in the uplands during kharif and rice fallows during summer. The pooled analysis showed that all the characters except length of top had changed according to situations. This again indicates that selection for the two situations has to be made separately. Generally varieties were earlier in flowering and in maturity in rice fallows than in uplands. In the uplands, Exotic-6 and in the rice fallows TG-17 and EC.35999 were the earliest in flowering while M-13 was the lattest at both the situations. KG-61-240 and Jyothi were the earliest to mature in uplands (106.0 days) whereas Exotic-6 was the earliest in rice fallows (95.0 days). TMV-2 and TMV-7 had taken 115.0 and 107.7 days in uplands and 106.7 and 98.3 days in rice fallows respectively. At both the situations, M-13 was the lattest in duration. Late flowering varieties were found to be late in maturity as well.

In length of top, TG-14 was the shortest while TMV-9 was the longest in the uplands. Under the rice fallows, TMV-2 was the shortest and Gangapuri the longest. The length of top was generally more in uplands than in rice fallows. The pooled mean of the character ranged from 74.5 cm in TG-14 to 101.3 cm in TMV-9. The number of branches ranged from the minimum of 6.6 in EC.112027 to the maximum of 18.0 in EC.119704 in uplands and 5.1 in B-353 to 14.8 in ICG-3859 in rice fallows. TMV-2 and TMV-7 produced significantly lower number of branches than the top ranking varieties at both the situations. In general, branching was more in uplands than in rice fallows.

The number of mature pods per plant ranged from as low as 10.57 in AH-6915 to as high as 29.10 in TG-14 in uplands and from 8.23 in Gangapuri to 18.25 in Pollachi-2 in rice fallows.

The recommended varieties produced only significantly lower number of mature pods then the better varieties. The number of immature pods per plant ranged from 2.40 to 6.33 in uplands and from 1.78 to 7.93 in rice fallows. Number of mature pods were generally higher in uplands than in rice fallows as against the case of immature pods.

EC.119704 and ICG-3859 produced the maximum of 2223 g and the minimum of 1066 g respectively of fresh pods per plot in uplands whereas TG-3 and TMV-7 produced the maximum of 1584 g and the minimum of 893 g in rice fallows. The three top ranking varieties in uplands, viz., EC.119704, TG-14 and Spanish Improved were on par. The top ranking variety in rice fallows, viz., TG-3 was followed by 8 other varieties including TG-14 and Spanish Improved which were on par. Hence TG-14 and Spanish Improved were among the top ranking varieties in fresh weight of pods at both the situations. They were superior to the recommended varieties at both the situations. The fresh weight of pods per plot was higher in uplands then in rice fallows as the number of mature pods per plant.

The haulms yield per plot was the highest for ICG-3859 at both the situations. In the uplands, TMV-2 and TMV-7 were statistically on par with the top ranking varieties, but in the rice fallows, both of them were inferior to the top ranking variety. Contrary to fresh weight of pods, haulms yield was more in rice fallows than in uplands.

During kharif in uplands, the pod yield per plot was the highest for TG-14 followed by Spanish Improved, TG-17 and

EC.112027. The two top ranking varieties were on par and were superior to the recommended varieties. When the yield of the better recommended variety, viz., TMV-2 was 3428 kg/ha, that of the top ranking variety, viz., TG-14, was 4650 kg/ha followed by Spanish Improved with 4356 kg/ha. Thus TG-14 yielded 36.45 percentage over TMV-2. TG-3 was the highest yielding variety in summer rice fallows followed by Pollachi-2, Spanish Improved, TG-14, EC.112027, Pollachi-1, TMV-9, EC.35999 and EC.36892. All these nine varieties were statistically on par. They were superior to both of the recommended varieties. The yield per hectare of TG-3 was 3238 kg while that of TMV-2, the better of the two recommended varieties was 2378 kg/ha. Thus the percentage increase of yield of the top ranking variety over the better standard variety was 36.14. TG-14 and Spanish Improved were found to be, however, consistently high yielding at both the situations. As the number of mature pods per plant and fresh weight of pods, pod yield was generally more in uplands than rice fallows.

Pollachi-2 and M-13 in uplands whereas KG-61-240 and EC.36892 in rice fallows had the lowest and the highest 100 pod weight respectively; the range being from 59.7 to 113.3 g and 70.6 to 142.4 g. 100 pod weight of TMV-2 and TMV-7 in uplands were 85.4 g and 80.7 g and in rice fallows was 107.5 and 83.6 g respectively. In the case of 100 kernel weight also in uplands, Pollachi-2 and M-13 and in rice fallows, EC.21118 and EC.119704 were the lowest and the highest, the range being 34.0 to 78.7 g and 34.1 to 57.1 g respectively. 100 kernel weight of TMV-2 and TMV-7 in uplands was 49.4 and 42.7 g and in rice fallows was

53.4 and 40.8 g.

The dryage percentage was the highest in TMV-9 (73.2) in uplands whereas in the rice fallows it was the highest in EC.112027 (71.6). Both in uplands and rice fallows, Gangapuri had the lowest with 56.0 and 51.3 percentages respectively. The shelling percentage ranged from 52.3 in Gangapuri to 80.2 in KG-61-240 in uplands. In rice fallows it was the lowest in Big Japan (57.4) and the highest in KG-61-240 (81.4).

The oil content ranged from 53.6 in AH-6915 to 42.3 per cent in uplands while in rice fallows it ranged from 42.1 per cent in M-13 to 54.2 in S-7-5-13. The oil recovery from TMV-2 was 47.6 per cent and that from TMV-7 was 45.0 in uplands and 47.0 and 48.4 per cent in rice fallows respectively. In respect of protein content, both in uplands and rice fallows, M-13 was the highest with 31.5 and 29.9 per cents respectively. Protein recovery was the lowest for TMV-10 in uplands and rice fallows with 22.5 and 22.9 per cents respectively.

The performance of the 30 selected varieties in the uplands during kharif and rice fallows during summer revealed that varieties vary in respect of the different characters at the two situations and that the characters varied from one situation to the other. The promising varieties for upland conditions were TG-14 and Spanish Improved and for summer rice fallows were TG-3, Pollachi-2, Spanish Improved and TG-14, in that order. However, TG-14 and Spanish Improved were found to be promising consistently at both the situations with other desirable attributes like high shelling percentage, 100 pod and 100 kernel weights.

The oil and protein recovery were also high. In yield, they are superior to the recommended varieties and are more or less equal in duration with them. As such these varieties can be utilised at both the situations with advantage as stability in yield in groundnut is a quite desirable varietal requirement.

However, none of the varieties were found to mature in 90 days so as to fit well to the summer rice fallows which are generally having a maximum fallow period of 90 days. There fore a corrective breeding programme was initiated to rectify the defect of late maturity in TMV-2, the better recommended variety and the two promising varieties, viz., TG-14 and Spanish Improved through induced mutagenesis by treating seeds with gamma rays at three doses each viz., 20, 30 and 40 krad.

Germination of seeds was reduced by gamma rays and a progressive decline in germination with increasing doses was noticed in all the varieties in the M_1 generation. The survival was also reduced in all the three varieties and the relationship between the percentage of survival and doses of irradiation was inverse. A reduction in plant height was noticed in all the varieties on the 30th day and the effect was dose dependant. It was also noted that pollen fertility decreased with increasing doses of gamma rays, though the pattern of reduction was different in the three varieties. Plants with chlorophyll deficient sectors were obtained. A variety of morphological abnormalities were noticed, of which, stunted plants, dwarfs and leaf variants were the majority.

The frequency of chlorophyll mutations in the M_1 and M_2 plant basis increased with increasing doses of gamma rays in all the three varieties, the maximum being from TG-14. Albino, Xantha, Chlorina and Viridis were the chlorophyll mutants observed and Viridis was the most frequent type whereas Albino was the least. No definite relationship was seen in any of the varieties between dose of radiation and mutagenic effectiveness. In TMV-2 and Spanish Improved, effectiveness was maximum at the highest dose of radiation, whereas in TG-14 it was at the intermediate dose. Mutagenic efficiency too did not show any specific relationship with radiation doses in the three varieties. TMV-2 and TG-14 at 20 krad and Spanish Improved at 40 krad recorded the maximum mutagenic efficiency based on lethality. Based on injury the highest efficiency was recorded at 40 krad by TMV-2 and Spanish Improved and at 30 krad by TG-14. In relation to sterility, mutagenic efficiency was the highest at 20 krad in TMV-2 and Spanish Improved whereas in TG-14, it was at 30 krad.

A wide range of viable mutants were isolated in the M_2 generation such as early flowering, early maturing, late flowering, late maturing, dwarf, stunted, tall, compact, non-branching, semi-spreading, little leaf, curly leaf, narrow leaf, dark green, multiple leaflet, sterile, small poded, bold poded, deeply pod constricted, shallow pod setting, single kernel and dormant seed mutants. In some of the mutants, simultaneous changes in a constellation of characters were noticed. The non-branching mutants observed are of a rare nature. The early maturing mutants isolated from all the three varieties are of great practical significance. Some of them combine desirable attributes like short and compact canopy, dark green leaves and larger number of pods so that they can efficiently fit into the rice fallows during summer. They will facilitate the efficient harvest of sun shine getting abundantly unhindered in the rice fallows as quality vegetable oil and protein.

The studies on variability, correlation and path analysis thus indicated the comparative importance of the different components of yield in groundnut to be made use of in the breeding of varieties suited to the two major areas. The studies also yielded clues for suggesting the 'plant type' for both the situations. The possibility of obtaining better varieties for the two situations through the exploitation of genetic variability through selection has been highlightened. The varieties now identified as high yielders in uplands and rice fallows and the ones with stable yield performance will be of immediate utility in enhancing productivity. The various viable mutants isolated can be employed to develop varieties which satisfy our requirements. The short duration types isolated will aid the efficient utilization of the wetlands during summer, being kept mostly fallow at the present.

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*Originals not seen

APPENDIX

Appendix I. Mean values for 23 characters in 80 varieties in uplands during kharif.

Sl. No.	Name of varieties	Duration upto flowering (days)	Plant height on the 50th day (cm)	No. of branches on the 50th day	No. of leaves on the 50th day	Duration upto maturity (days)	No. of flowers
		1	2	3	4	5	6
1.	EC.21127	29.0	48.3	8.7	58.4	110.0	126.0
2.	EC.21118	33.0	45.0	8.7	52.4	114.3	122.0
3.	EC.116596	31.0	47.9	5.3	38.0	110.7	76.3
4.	ICG-3859	37.0	42.5	17.7	105.9	130.0	167.0
5.	EC.21089	30.0	40.1	7.5	44.7	109.3	113.7
6.	EC.115546	34.7	29.2	10.2	53.1	127.7	153.7
7.	EC.21126	29.0	58.3	7.7	53.1	107.0	100.7
8.	EC.24412	31.3	54.9	5.4	40.7	116.3	114.3
9.	EC.24420	31.3	46.3	6.4	42.5	122.7	80.0
10.	EC.115678	29.7	63.0	6.9	44.0	112.0	87.3
11.	EC.25188	35.7	35.3	9.9	59.1	127.7	146.7
12.	EC.24395	33.3	43.5	8.6	53.5	109.0	160.0
13.	EC.117872	39.7	48.7	10.7	63.5	127.7	164.0
14.	EC.39544	32.3	43.6	7.5	43.7	109.3	103.3
15.	EC.21082	30.3	45.5	8.6	57.0	114.3	140.3
16.	IC.9811	33.3	34.3	13.4	76.8	129.3	141.0
17.	EC.36009	30.0	43.9	8.0	49.9	105.3	100.0
18.	EC.24431	31.7	47.3	8.4	50.1	105.0	154.0
19.	EC.21095	31.7	43.4	8.4	55.3	112.3	136.0
20.	S-59-27	31.3	41.0	7.5	48.7	112.3	100.7
21.	A-674	32.0	42.4	8.2	51.5	114.0	98.7
22.	EC.2100	33.3	45.7	7.2	49.7	109.3	97.0
23.	EC.21121	37.3	42.8	11.4	57.9	130.0	130.7
24.	EC.24446	29.0	49.9	6.9	48.9	120.7	109.3
25.	EC.112027	31.7	44.7	7.7	47.2	112.3	156.0
26.	EC.36890	32.3	31.7	8.1	70.1	127.7	130.0
27.	B-353	29.7	49.1	8.5	55.8	114.7	141.3
28.	EC.117873	30.3	35.8	9.5	47.8	115.0	140.3

Appendix I (continued)

Sl. No.	Name of varieties	Duration upto flowering (days)	Plant height on the 50th day (cm)	No. of branches on the 50th day	No. of leaves on the 50th day	Duration upto maturity (days)	No. of flowers
		1	2	3	4	5	6
29.	EC.11132	29.0	55.5	6.9	46.7	110.0	153.3
30.	IC.9808	29.3	49.7	6.5	49.3	115.3	133.3
31.	EC.21079	33.7	38.0	9.3	56.7	122.3	124.3
32.	EC.20954	39.0	36.7	13.2	70.3	130.7	94.0
33.	EC.66138	33.3	37.2	8.7	48.7	129.3	106.7
34.	EC.35999	30.3	49.3	9.4	52.9	111.7	74.0
35.	EC.21052	31.3	44.0	8.9	59.9	110.0	160.0
36.	AH-6915	31.7	42.1	10.1	62.3	120.0	108.0
37.	EC.24450	31.7	44.9	7.8	49.7	110.0	94.6
38.	GAUG-I	32.7	38.2	7.1	39.1	108.3	114.7
39.	J-11	32.0	43.3	7.9	53.8	116.3	101.0
40.	M-13	37.0	32.8	13.9	80.4	131.0	170.3
41.	M-37	35.7	31.4	10.2	76.9	130.7	141.3
42.	Spanish Improved	32.0	45.1	8.8	55.9	114.0	116.7
43.	S-206	29.7	51.9	8.7	50.5	117.7	110.3
44.	Dh-3-30	30.7	40.0	6.9	42.3	117.7	99.3
45.	Jyothi	30.3	52.1	6.5	48.7	109.3	118.3
46.	TMV-9	34.7	46.6	7.6	44.2	110.0	92.2
47.	TMV-10	32.0	32.6	10.6	51.8	112.3	111.0
48.	No.297	33.3	42.3	6.8	41.8	121.7	103.7
49.	AH-8253	32.3	46.7	7.5	48.9	107.7	130.7
50.	AK-811	32.0	38.9	5.9	38.5	118.7	104.7
51.	EC-21078	33.3	43.9	7.3	45.4	109.3	94.3
52.	No.70	31.3	47.8	7.4	43.7	110.0	103.3
53.	USA-63	35.0	29.4	6.8	41.9	110.7	130.0
54.	G.270	28.7	60.5	8.3	51.3	108.3	92.3
55.	Russia-319	29.0	59.4	6.5	47.9	107.7	90.0
56.	TMV-12	32.3	47.1	7.4	56.7	120.7	107.7
57.	Almel No.1	32.7	43.9	9.7	53.9	114.7	121.3

Appendix I (continued)

Sl. No.	Name of varieties	Duration upto flowering (days)	Plant height on the 50th day (cm)	No. of branches on the 50th day	No. of leaves on the 50th day	Duration upto maturity (days)	No. of flowers
		1	2	3	4	5	6
58.	TMV-2	31.0	43.5	6.9	49.8	116.0	84.0
59.	KG-61-240	32.0	45.1	7.5	44.8	110.0	138.7
60.	USA-123	29.7	58.4	8.4	55.4	105.0	88.7
61.	TMV-11	29.0	52.9	6.7	47.7	116.0	111.7
62.	Pollachi-2	32.7	48.2	7.3	46.5	107.7	105.3
63.	AH.4218	31.3	49.9	7.5	49.6	111.7	87.3
64.	TG-3	26.7	48.9	8.2	44.9	114.3	102.0
65.	TG-19	30.0	50.3	9.1	58.9	113.3	92.0
66.	EC.21088	31.0	55.9	7.6	49.7	124.0	93.0
67.	Kanki-K-10-17	33.0	47.0	7.0	47.9	121.7	95.0
68.	Spanish peanut	32.7	40.3	8.3	53.4	119.3	140.7
69.	Red Spanish	32.3	44.1	7.6	47.2	122.3	148.7
70.	Pollachi-1	31.0	51.4	7.9	60.3	109.3	88.3
71.	Exotic-1	30.3	46.7	8.5	53.9	118.7	133.0
72.	TMV-7	31.0	46.7	6.8	49.5	113.3	94.3
73.	Gangapuri	34.0	38.1	8.5	56.8	123.0	65.3
74.	Big Japan	34.3	34.3	11.0	60.2	126.0	140.7
75.	EC.20957	31.0	52.3	8.6	51.7	110.0	174.3
76.	No.293	30.3	50.3	7.5	55.5	112.3	124.3
77.	AH-4128	34.3	37.0	7.9	50.1	126.0	132.3
78.	Co-1	31.0	42.5	7.2	48.1	117.7	93.3
79.	Uganda local	29.3	46.7	7.7	50.1	109.3	108.0
80.	EC.21070	30.0	49.4	8.6	52.9	109.3	100.7
	Range	26.7 - 39.7	29.2 - 58.4	5.33 - 17.7	38.0 - 105.9	105.0 - 131.0	74.0 - 174.3
	C.D.	2.77	8.23	2.48	19.08	3.11	24.32

Appendix I (continued)

Sl. No.	Spread of flowering (days)	Height of main shoot (cm)	Length of top (cm)	No.of basal primary branches	No.of branches	Fresh weight of pods (g)	Haulms yield (green) per plant (g)	No.of leaves	No. of mature pods per plant
	7	8	9	10	11	12	13	14	15
1.	74.0	83.7	88.5	6.9	9.3	29.6	82.8	89.1	22.9
2.	69.3	90.9	87.3	8.5	10.9	32.1	99.4	91.1	21.3
3.	49.7	117.5	117.5	6.1	6.6	21.6	79.9	68.0	13.2
4.	55.3	117.3	106.3	12.5	24.1	32.1	206.3	145.3	16.1
5.	42.3	90.9	105.1	7.3	9.8	30.1	121.9	87.9	27.1
6.	56.0	103.9	86.3	9.6	14.4	34.3	111.9	123.1	11.6
7.	68.3	95.0	93.0	7.9	10.1	8.8	111.6	101.3	4.4
8.	70.0	104.1	109.5	4.9	6.1	27.8	100.4	83.4	14.9
9.	55.7	85.7	85.6	5.4	7.5	25.5	58.6	76.7	14.7
10.	60.0	121.6	123.6	6.5	8.1	26.8	75.8	91.7	15.7
11.	73.3	83.6	83.4	8.4	12.7	26.3	122.1	98.5	15.1
12.	68.7	102.5	102.5	7.7	9.6	31.0	111.2	96.9	21.9
13.	46.0	108.5	106.5	8.3	11.9	31.1	95.3	105.3	10.5
14.	57.3	89.7	91.2	6.7	8.2	24.8	104.2	89.1	18.3
15.	67.7	102.4	97.7	7.9	9.7	33.6	126.0	104.9	31.7
16.	60.3	66.1	66.1	11.1	18.3	27.9	119.3	106.6	13.8
17.	57.0	99.7	99.8	7.5	8.3	28.9	83.4	89.0	28.5
18.	62.7	104.5	97.9	7.6	8.8	30.8	78.7	84.1	21.5
19.	66.3	75.7	75.8	7.3	8.4	32.4	70.1	92.9	22.9
20.	64.3	97.6	98.6	7.7	8.5	38.7	117.7	80.7	29.4
21.	45.0	92.1	95.5	7.7	8.9	34.4	69.0	98.2	32.7
22.	64.0	88.2	88.2	8.0	9.8	27.1	77.3	85.8	18.9
23.	73.3	81.7	81.7	9.3	13.3	30.2	127.7	86.9	19.5
24.	67.0	113.3	113.3	7.0	8.1	32.1	108.9	88.3	20.7
25.	76.3	94.9	94.8	6.3	8.5	36.1	86.8	86.1	20.9
26.	54.0	96.6	96.6	7.5	10.5	21.8	77.1	111.6	12.3
27.	61.0	87.7	87.7	7.4	9.5	27.2	107.3	83.7	21.8
28.	66.3	78.3	78.6	7.6	13.0	28.1	76.0	93.5	18.2

Appendix I (continued)

Sl. No.	Spread of flowering (days)	Height of main shoot (cm)	Length of top (cm)	No. of basal primary branches	No. of branches	Fresh weight of pods (g)	Haulms yield (green) per plant (g)	No. of leaves	No. of mature pods per plant
	7	8	9	10	11	12	13	14	15
29.	56.0	103.6	103.6	6.5	8.5	24.7	94.1	83.6	14.1
30.	67.0	107.8	107.8	7.2	8.3	33.8	90.5	88.2	19.4
31.	66.7	93.0	93.7	7.5	9.6	30.2	102.7	90.1	22.2
32.	64.0	109.9	109.9	11.5	20.1	47.1	185.3	126.9	21.3
33.	55.3	86.1	81.2	11.3	14.0	26.7	104.4	96.8	13.3
34.	40.3	109.6	109.6	8.5	10.1	38.3	115.1	102.7	21.9
35.	64.3	88.6	89.4	7.7	9.7	34.3	112.5	100.2	24.7
36.	52.3	99.1	90.8	8.8	12.5	31.7	128.3	108.3	18.9
37.	51.0	76.7	76.7	7.9	9.1	26.2	81.4	91.8	19.3
38.	69.0	80.1	80.1	7.6	9.5	32.0	104.9	77.3	28.1
39.	70.3	93.7	93.7	8.1	9.4	36.3	99.9	84.7	27.9
40.	46.0	83.9	83.9	12.9	22.2	33.9	161.9	126.8	17.7
41.	55.0	83.0	83.0	4.5	13.7	28.1	101.4	123.5	14.1
42.	62.0	72.9	72.9	8.1	9.5	39.7	69.6	108.5	24.6
43.	55.3	94.9	94.9	8.0	12.3	27.4	84.5	101.1	22.0
44.	67.3	93.4	93.4	7.6	9.5	39.3	106.5	108.7	22.5
45.	69.0	83.7	97.0	6.3	8.3	31.1	71.1	68.2	25.3
46.	50.3	81.2	114.5	7.8	9.5	23.1	92.1	111.1	16.0
47.	46.0	103.8	103.7	11.3	17.7	28.7	145.3	98.7	18.3
48.	63.3	116.3	116.3	7.0	8.0	27.5	115.5	81.5	21.7
49.	65.3	89.4	89.4	7.3	8.4	28.8	79.9	81.1	24.9
50.	55.0	76.8	76.8	6.7	7.7	29.7	82.2	78.5	20.3
51.	67.7	98.0	98.0	7.9	9.7	10.4	102.3	89.1	8.9
52.	55.7	107.9	107.9	6.3	8.5	29.7	100.5	77.9	19.6
53.	76.3	62.0	62.0	7.3	10.3	25.9	60.2	89.6	23.0
54.	56.3	112.2	112.2	7.8	9.7	12.3	90.5	100.3	9.3
55.	55.7	103.3	103.3	7.0	8.1	28.5	77.1	99.3	21.1
56.	71.7	104.3	104.3	7.7	8.5	41.9	109.2	101.9	29.1
57.	69.3	104.0	104.0	8.5	11.5	32.6	128.3	99.9	19.9

Appendix I (continued)

Sl. No.	Spread of flowering (days)	Height of main shoot (cm)	Length of top (cm)	No. of basal primary branches	No. of branches	Fresh weight of pods (g)	Haulms yield (green) per plant (g)	No. of leaves	No. of mature pods per plant
	7	8	9	10	11	12	13	14	15
58.	53.3	88.2	98.3	7.0	7.7	34.3	95.5	96.1	18.3
59.	71.7	81.9	83.2	6.5	8.5	24.7	68.9	76.9	22.3
60.	57.3	106.5	106.6	7.5	9.0	26.3	86.7	85.7	16.6
61.	60.7	71.7	71.3	6.5	7.8	30.1	78.9	93.9	17.3
62.	62.7	92.4	94.3	6.6	8.5	35.1	110.5	85.0	27.7
63.	36.7	81.5	88.2	7.7	8.9	34.3	91.3	92.2	22.1
64.	44.6	93.9	93.9	8.5	9.9	31.7	106.6	75.5	18.9
65.	67.3	105.9	106.5	7.7	9.4	32.0	116.3	101.9	22.5
66.	59.7	95.7	95.7	7.7	9.2	42.5	107.9	94.5	22.0
67.	56.0	94.7	94.7	5.3	8.3	22.5	115.0	84.5	21.7
68.	52.3	84.7	84.7	7.4	10.2	38.9	106.1	88.3	23.4
69.	57.7	98.7	98.7	7.7	9.6	28.7	105.3	80.0	22.2
70.	55.7	99.9	99.9	8.6	8.8	26.0	95.5	95.2	18.4
71.	59.0	96.5	97.2	7.6	9.7	23.9	89.6	101.6	21.9
72.	54.0	91.9	95.6	6.7	7.7	26.5	83.1	101.9	20.1
73.	34.0	114.1	114.3	9.6	12.1	20.8	115.5	89.6	14.9
74.	49.0	107.6	107.6	8.4	15.9	25.3	100.7	104.8	11.7
75.	63.3	103.6	103.6	8.4	11.4	16.9	83.1	103.5	14.1
76.	59.3	120.9	120.9	7.3	8.9	20.3	104.1	108.0	14.7
77.	56.7	79.7	79.9	6.8	8.3	24.7	89.4	86.9	24.7
78.	46.7	89.3	89.3	5.7	8.2	23.1	58.4	84.5	16.9
79.	69.3	76.7	79.4	7.5	9.3	24.7	71.0	95.9	19.1
80.	54.7	87.5	87.5	7.9	9.6	23.6	64.1	90.5	17.5
Range	34.0 - 76.3	62.0 - 121.6	62.0 - 123.6	4.9 - 12.9	6.13 - 24.1	8.8 - 47.1	58.4 - 206.3	68.0 - 145.3	4.4 - 32.7
C.D.	3.54	17.47	15.74	2.03	3.19	8.42	31.40	21.57	5.94

Appendix I? (continued)

Sl. No.	Percentage of pod set	No. of immature pods	Dry pod yield per plant (g)	Dryage percentage of pods	100 pod weight (g)	100 kernel weight (g)	Shelling percentage	Oil content (%)
	16	17	18	19	20	21	22	23
1.	18.2	3.6	18.0	60.7	65.7	30.4	77.1	47.0
2.	17.5	3.6	19.5	60.9	104.6	44.9	74.1	46.0
3.	16.3	5.6	12.8	59.5	119.8	37.1	51.3	52.1
4.	9.7	4.3	19.4	60.4	77.5	44.8	73.7	48.3
5.	23.2	6.1	19.1	63.3	111.9	34.6	62.9	48.4
6.	9.2	3.7	19.9	57.7	139.0	61.6	53.3	50.1
7.	4.4	1.1	5.7	64.7	119.0	38.4	66.3	47.8
8.	13.0	3.7	17.8	64.5	138.6	42.7	64.4	42.9
9.	18.5	2.1	14.2	55.6	81.0	34.1	68.9	44.5
10.	17.2	2.7	12.1	45.3	121.6	36.1	60.0	48.3
11.	10.8	2.3	12.2	47.3	81.5	42.4	61.1	48.7
12.	13.4	4.1	19.7	64.3	76.8	32.9	66.9	46.9
13.	6.4	2.4	14.1	45.4	139.3	65.4	70.2	46.7
14.	17.3	3.6	14.3	57.6	84.3	35.3	67.8	48.1
15.	22.7	3.7	18.5	55.0	78.3	30.7	70.6	46.4
16.	9.9	2.8	15.7	56.5	112.6	52.6	73.2	52.3
17.	28.6	3.9	16.3	56.6	93.1	43.4	77.7	46.5
18.	13.9	2.5	16.7	54.2	87.2	41.3	73.3	44.7
19.	15.8	2.5	17.8	54.9	82.7	36.0	62.5	51.3
20.	29.2	5.2	21.4	55.4	81.5	30.0	67.1	50.2
21.	33.8	4.1	20.3	59.0	59.0	24.3	78.8	51.3
22.	21.1	3.8	15.5	58.1	80.6	35.4	69.0	47.1
23.	11.8	2.8	18.0	58.7	81.1	37.7	71.3	46.9
24.	18.7	4.7	16.1	50.0	94.3	31.5	60.6	50.3
25.	16.6	4.3	23.8	65.6	79.0	32.6	70.9	47.2
26.	9.4	1.7	13.4	61.3	82.3	43.3	67.1	43.8
27.	15.4	2.5	17.1	62.8	71.7	36.0	75.3	48.5
28.	12.8	2.7	15.4	54.6	91.2	42.2	72.0	47.8

Appendix I (continued)

Sl. No.	Percentage of pod set	No. of immature pods	Dry pod yield per plant (g)	Dryage percentage of pods	100 pod weight (g)	100 kernel weight (g)	Shelling percentage	Oil content (%)
	16	17	18	19	20	21	22	23
29.	10.4	2.6	13.5	54.5	96.9	40.3	69.6	43.5
30.	14.9	2.8	19.7	58.3	95.7	38.1	61.1	45.8
31.	18.0	3.8	19.2	63.6	80.9	37.4	71.6	42.7
32.	22.3	3.9	21.9	46.6	102.2	47.2	71.6	49.1
33.	12.5	1.7	14.9	55.7	88.5	42.6	75.1	47.6
34.	29.6	3.7	22.6	61.3	98.9	41.4	59.2	46.6
35.	17.6	3.9	18.5	54.3	91.3	37.5	65.4	46.2
36.	16.7	3.1	17.8	56.0	118.2	48.5	66.4	53.2
37.	20.4	2.3	13.6	51.4	80.9	36.0	77.3	46.3
38.	24.5	4.7	18.6	58.1	85.9	36.7	79.9	50.3
39.	27.5	3.9	23.9	64.7	76.7	36.8	65.3	42.3
40.	10.4	3.4	21.4	63.2	127.5	53.6	75.2	42.3
41.	10.0	2.7	14.3	50.8	94.2	42.6	74.9	52.6
42.	21.4	4.1	26.4	66.6	90.5	35.4	67.5	48.2
43.	19.2	4.3	15.7	57.5	80.4	31.2	61.6	44.3
44.	22.3	4.2	24.7	62.8	96.9	42.9	79.3	47.5
45.	21.4	4.9	19.7	63.4	113.3	37.3	78.1	50.6
46.	17.4	3.8	14.8	64.0	92.8	39.1	76.6	48.5
47.	15.4	3.2	17.8	61.8	113.8	46.0	77.3	52.1
48.	20.8	3.7	15.7	57.2	83.3	34.4	76.5	45.5
49.	18.9	3.1	18.9	65.7	72.3	32.1	76.6	50.1
50.	19.8	4.6	16.8	56.3	87.4	36.4	68.4	47.2
51.	9.4	2.3	6.4	61.3	93.1	34.6	74.4	50.0
52.	19.0	2.7	19.0	64.7	87.7	40.2	77.0	51.4
53.	17.5	3.6	12.0	50.5	69.4	31.1	73.1	49.1
54.	10.5	1.9	8.6	69.6	137.6	45.8	59.0	47.1
55.	23.4	3.6	14.6	51.1	104.9	37.5	59.7	46.0
56.	27.1	2.5	26.6	63.5	109.3	40.8	71.5	42.8
57.	16.4	2.3	16.5	50.5	77.1	37.2	76.7	49.7

Appendix I (continued)

Sl. No.	Percentage of pod set	No. of immature pods	Dry pod yield per plant (g)	Dryage percentage of pods	100 pod weight (g)	100 kernel weight (g)	Shelling percentage	Oil content (%)
	16	17	18	19	20	21	22	23
58.	21.8	2.9	22.3	65.0	94.5	38.6	75.2	47.2
59.	16.0	3.1	17.2	69.7	74.5	31.3	61.3	43.1
60.	18.6	2.2	13.8	52.9	116.1	40.0	70.8	49.2
61.	15.5	1.7	16.3	54.2	129.0	50.3	72.0	43.5
62.	26.3	3.9	23.3	66.5	75.6	33.0	61.8	45.1
63.	25.5	3.5	18.4	53.5	85.1	39.8	77.6	48.1
64.	18.4	5.0	22.3	70.2	99.7	45.8	73.7	50.5
65.	24.5	5.2	21.3	65.3	78.9	32.4	83.1	48.1
66.	23.7	2.5	21.4	50.4	99.7	47.7	62.1	48.4
67.	22.5	3.1	13.3	52.4	77.7	34.7	76.2	51.7
68.	20.2	3.5	25.9	60.6	83.4	36.1	67.4	47.1
69.	14.9	3.7	18.4	63.8	78.8	32.1	76.8	49.7
70.	20.4	3.7	16.8	64.5	86.4	32.7	74.3	45.0
71.	16.3	3.1	15.9	66.3	88.1	33.4	57.6	47.4
72.	21.3	3.6	16.4	61.6	90.2	39.3	74.0	45.6
73.	22.8	3.1	12.6	60.5	111.1	45.1	73.5	47.3
74.	8.3	3.3	15.2	60.1	97.7	40.4	75.7	46.5
75.	8.1	2.7	10.6	62.7	91.8	37.6	65.8	49.8
76.	11.9	2.4	11.5	56.7	91.2	37.2	61.4	48.0
77.	19.4	3.5	14.0	59.8	77.7	32.3	68.3	48.1
78.	17.9	3.3	13.9	60.3	78.8	32.9	76.9	50.7
79.	17.7	3.2	14.2	57.7	80.8	37.2	75.9	51.1
80.	17.4	2.1	13.1	55.7	84.8	37.2	75.5	47.5
Range	4.4 - 33.8	1.1 - 6.1	5.7 - 26.6	45.3 - 70.2	59.0 - 139.3	24.3 - 65.4	51.3 - 83.2	42.3 - 53.2
C.D.	3.24	1.51	4.90	2.47	1.81	0.98	1.04	0.67

Appendix II. Mean values for 23 characters in 80 varieties in rice fallows during summer.

Sl. No.	Name of varieties	Duration upto flowering (days)	Plant height on the 50th day (cm)	No. of branches on the 50th day	No. of leaves on the 50th day	Duration upto maturity (days)	No. of flowers
		1	2	3	4	5	6
1.	EC.21127	32.7	36.0	5.1	47.5	96.3	88.7
2.	EC.21118	29.7	51.0	6.1	56.1	102.3	149.0
3.	EC.116596	27.3	47.9	5.3	49.8	110.7	91.0
4.	ICG-3859	33.0	38.7	11.7	99.4	111.3	106.0
5.	EC.21089	26.3	43.2	5.5	50.9	105.7	78.3
6.	EC.115546	33.3	41.0	9.1	95.6	109.3	71.7
7.	EC.21126	24.7	51.8	6.1	50.2	100.3	113.7
8.	EC.24412	26.0	44.8	5.3	49.3	99.7	102.0
9.	EC.24420	27.3	38.8	5.8	59.0	98.7	90.0
10.	EC.115678	26.0	49.9	5.4	57.3	101.3	88.0
11.	EC.25188	27.7	51.4	5.7	60.5	112.3	86.7
12.	EC.24395	29.7	50.3	4.4	46.3	95.3	91.7
13.	EC.117872	33.0	33.7	9.5	90.7	111.0	130.7
14.	EC.39544	28.0	53.3	6.1	58.7	105.7	97.0
15.	EC.21082	27.0	49.6	5.1	48.2	102.0	94.3
16.	IC.9811	30.7	36.1	9.1	79.6	112.3	96.7
17.	EC.36009	28.3	38.3	5.5	60.3	106.0	72.0
18.	EC.24431	29.0	53.0	5.4	52.9	102.3	113.0
19.	EC.21095	27.3	49.4	6.3	57.6	94.7	67.3
20.	S-59-27	29.0	45.5	5.3	55.4	102.0	126.7
21.	A-674	28.3	43.7	5.7	56.9	107.3	96.7
22.	EC.2100	27.7	48.8	4.9	45.9	98.7	112.3
23.	EC.21121	33.0	40.5	7.9	64.3	110.7	76.7
24.	EC.24446	27.0	42.0	5.0	50.3	103.7	64.0
25.	EC.112027	28.3	46.3	5.7	54.1	100.3	115.0
26.	EC.36890	30.0	36.0	7.5	82.2	107.7	207.0
27.	B-353	27.7	48.9	4.9	47.1	96.3	105.7
28.	EC.117873	29.0	24.1	8.9	85.1	106.0	213.0

Appendix II (continued)

Sl. No.	Name of varieties	Duration upto flowering (days)	Plant height onthe 50th day (cm)	No. of branches on the 50th day	No. of leaves on the 50th day	Duration upto maturity (days)	No. of flowers
		1	2	3	4	5	6
29.	EC.11132	26.0	53.9	5.4	56.3	97.0	72.0
30.	IC.9808	28.0	50.4	5.0	46.9	109.0	92.3
31.	EC.21079	28.0	47.3	9.3	84.4	99.3	88.3
32.	EC.20954	34.0	37.2	9.8	89.7	114.0	110.7
33.	EC.66138	29.3	41.2	8.1	80.5	107.7	152.3
34.	EC.35999	27.0	48.5	6.9	69.1	103.0	66.7
35.	EC.21052	28.3	47.5	5.7	54.7	104.3	92.7
36.	AH-6915	29.3	47.4	8.3	85.4	109.0	50.3
37.	EC.24450	27.7	46.9	5.7	54.7	106.7	139.3
38.	GAUG-1	28.7	51.0	5.5	48.0	95.7	108.0
39.	J-11	27.7	50.1	6.5	58.8	97.0	172.0
40.	M-13	31.3	36.1	9.4	78.9	116.0	115.3
41.	M-37	33.0	38.8	9.8	93.4	119.7	135.7
42.	Spanish Improved	28.3	50.5	6.7	66.2	100.3	107.3
43.	S-206	27.7	44.9	5.1	47.1	104.0	97.0
44.	Dh-3-30	27.0	50.5	8.1	75.7	107.0	106.3
45.	Jyothi	28.3	49.8	5.3	56.3	100.7	80.7
46.	TMV-9	27.0	52.5	5.3	57.3	95.7	97.7
47.	TMV-10	30.3	37.5	8.0	63.5	109.0	133.7
48.	No.297	28.0	49.1	5.1	47.2	106.7	78.3
49.	AH-8253	28.0	53.4	5.2	49.7	103.0	105.7
50.	AK-811	29.0	53.6	5.9	55.0	102.0	106.3
51.	EC.21078	28.3	49.5	5.9	60.4	104.3	118.0
52.	No.70	29.7	50.3	5.9	51.0	104.7	80.0
53.	USA-63	30.3	32.5	5.9	51.6	110.0	79.3
54.	G-270	24.0	57.8	5.5	59.5	96.0	84.3
55.	Russia-319	25.3	55.7	5.5	62.6	97.3	109.0
56.	TMV-12	28.0	48.8	6.3	56.1	100.0	119.7

Appendix II (continued)

Sl. No.	Name of varieties	Duration upto flowering (days)	Plant height on the 50th day (cm)	No. of branches on the 50th day	No. of leaves on the 50th day	Duration upto maturity (days)	No. of flowers
		1	2	3	4	5	6
57.	Almel No.1	29.3	52.1	5.7	51.8	112.3	80.3
58.	TMV-2	28.7	44.5	5.9	56.1	97.0	74.3
59.	KG-61-240	29.3	50.5	5.1	49.0	96.7	107.3
60.	USA-123	24.3	60.5	4.6	56.3	99.7	132.3
61.	TMV-11	25.0	39.8	5.2	49.0	98.7	127.7
62.	Pollachi-2	28.3	47.7	5.1	52.9	104.0	70.7
63.	AH-4218	28.0	50.6	5.0	49.9	105.7	89.7
64.	TG-3	25.7	52.4	5.8	57.3	104.0	113.7
65.	TG-19	26.0	49.5	6.5	68.0	105.0	133.0
66.	EC.21088	28.3	53.2	5.7	51.7	101.0	126.0
67.	Kanki-X-10-7	29.0	52.1	5.6	51.7	111.0	96.3
68.	Spanish peanut	28.0	43.9	5.7	54.9	109.7	93.0
69.	Red Spanish	28.0	50.1	5.2	44.5	103.7	69.3
70.	Pollachi-1	30.3	50.9	5.4	55.6	99.3	103.7
71.	Exotic-1	25.0	48.9	4.9	46.1	95.7	104.3
72.	TMV-7	28.3	49.2	5.7	52.4	106.0	99.7
73.	Gangapuri	27.7	60.8	6.5	71.9	114.0	99.7
74.	Big Japan	34.0	33.6	8.9	84.7	104.3	110.7
75.	EC.20957	28.7	59.3	5.3	53.6	108.3	124.7
76.	No.293	29.0	44.8	6.1	60.3	111.3	123.3
77.	AH.4128	29.7	50.8	5.9	53.0	109.0	74.0
78.	Co.1	29.0	37.9	5.2	46.6	95.7	67.3
79.	Uganda local	28.7	48.3	6.7	52.9	96.0	136.3
80.	EC.21070	29.0	44.9	5.3	49.0	101.3	71.7
Range		24.0 - 34.0	24.1 - 60.8	4.4 - 11.7	45.9 - 99.4	94.7 - 119.7	64.0 - 213.0
C.D.		1.71	10.17	7.66	18.28	4.18	27.0

Appendix II (continued)

Sl. No.	Spread of flowering (days)	Height of main shoot (cm)	Length of top (cm)	No. of basal primary branches	No. of branches	Fresh weight of pods (g)	Haulms yield (green) per plant	No. of leaves	No. of mature pods per plant
	7	8	9	10	11	12	13	14	15
1.	59.3	50.7	56.3	5.1	5.3	17.3	39.4	79.9	15.3
2.	51.3	67.4	71.9	6.1	6.5	24.1	48.5	92.3	16.8
3.	31.0	68.7	79.6	5.3	5.5	22.1	52.8	93.9	10.3
4.	48.7	65.3	82.7	10.8	15.5	24.3	86.3	209.8	16.9
5.	30.0	67.7	70.9	4.7	5.6	25.7	51.3	89.9	17.4
6.	49.7	56.9	74.4	11.1	18.2	27.2	49.7	215.5	13.3
7.	51.3	61.4	65.5	5.7	6.3	21.8	39.8	79.1	12.1
8.	51.3	57.8	62.3	4.7	5.7	19.5	56.5	96.5	10.5
9.	64.7	57.9	85.7	5.4	6.0	21.7	58.2	79.8	13.2
10.	61.7	74.3	91.2	5.6	5.9	24.2	52.4	95.4	11.5
11.	55.0	82.1	87.4	6.0	6.4	21.0	39.7	122.8	12.2
12.	56.0	67.8	71.8	4.5	4.8	15.6	60.6	71.9	11.1
13.	44.7	49.4	73.1	11.1	16.5	26.3	47.3	194.1	10.1
14.	51.7	68.4	78.1	5.9	6.3	24.9	40.4	104.5	16.5
15.	35.7	58.9	66.9	5.2	5.6	19.3	38.9	93.9	16.7
16.	39.3	59.4	68.1	6.9	9.8	18.5	45.1	140.7	15.4
17.	52.7	61.5	68.7	5.9	6.3	22.7	58.4	108.3	15.3
18.	56.3	83.7	85.7	6.2	7.2	29.4	38.7	135.5	17.3
19.	36.7	64.8	65.5	6.7	6.9	16.1	43.6	93.6	11.5
20.	59.3	72.5	70.1	5.6	5.9	23.1	45.7	86.2	16.3
21.	39.0	56.5	64.0	6.3	6.5	26.5	41.1	109.2	24.5
22.	43.7	53.9	68.9	5.1	5.3	20.8	78.3	83.5	17.4
23.	46.3	68.3	74.7	7.9	10.5	18.9	36.4	160.4	14.3
24.	37.0	58.4	66.5	5.2	5.8	14.3	47.7	99.9	13.1
25.	49.3	72.3	78.9	6.1	6.2	22.3	50.3	93.7	15.7
26.	49.3	58.4	85.6	7.9	10.3	16.8	52.0	177.1	9.3
27.	38.3	57.7	76.8	4.9	5.2	18.5	74.8	82.6	14.5
28.	58.3	38.5	66.5	8.3	21.5	22.5	90.5	205.3	15.3

Appendix II (continued)

Sl. No.	Spread of flowering (days)	Height of main shoot (cm)	Length of top (cm)	No. of basal primary branches	No. of branches	Fresh weight of pods (g)	Haulms yield (green) per plant (g)	No. of leaves	No. of mature pods per plant
	7	8	9	10	11	12	13	14	15
29.	44.0	71.9	79.0	5.5	5.7	19.8	43.1	92.2	11.3
30.	55.7	87.0	89.6	5.2	6.5	20.2	45.5	120.7	15.3
31.	31.0	52.7	63.7	9.7	10.2	18.9	50.4	131.3	16.7
32.	39.0	62.4	75.7	8.7	9.9	19.0	56.4	106.8	10.0
33.	44.7	57.5	73.7	7.2	8.8	21.3	45.6	128.9	12.3
34.	45.3	67.4	78.9	7.7	8.3	25.5	51.3	135.8	15.6
35.	60.7	60.4	61.5	6.1	11.7	23.5	52.3	113.1	14.7
36.	40.3	76.1	82.3	8.1	8.9	23.9	74.8	157.7	15.0
37.	55.0	69.0	82.2	6.3	6.7	19.1	54.5	108.6	14.0
38.	45.0	38.7	68.6	6.6	7.3	19.9	36.3	77.1	14.6
39.	52.0	57.9	66.9	6.1	10.9	21.1	54.7	90.4	18.1
40.	49.0	47.9	61.3	8.3	12.7	21.5	51.3	125.9	11.3
41.	51.7	57.1	81.7	7.9	9.9	23.1	69.5	186.4	11.6
42.	29.7	57.7	68.1	7.2	8.9	23.7	39.6	101.6	18.9
43.	32.3	61.1	63.7	5.4	10.2	19.8	37.9	70.5	14.5
44.	40.7	69.1	81.0	8.9	8.9	25.1	56.7	165.8	14.4
45.	46.7	68.5	80.7	5.5	5.8	26.7	43.0	110.9	16.8
46.	56.0	69.5	77.2	5.5	11.9	22.6	45.0	86.7	16.0
47.	47.7	65.9	71.2	8.2	8.2	17.1	57.9	137.5	9.6
48.	39.3	71.7	77.2	5.0	5.6	17.8	43.0	84.7	10.9
49.	49.7	66.5	73.6	5.5	6.4	21.8	44.9	95.8	16.8
50.	50.7	69.3	67.9	5.9	7.9	21.4	48.8	104.4	12.6
51.	40.3	72.2	78.8	7.1	8.0	27.8	51.5	109.9	18.3
52.	29.7	68.9	75.3	5.9	6.5	21.7	61.6	97.7	13.3
53.	62.7	38.3	60.2	5.6	5.9	22.9	42.9	131.1	21.3
54.	58.3	70.7	79.3	5.4	5.9	21.0	55.5	105.6	12.5
55.	59.7	68.1	78.1	5.7	6.8	17.1	56.7	81.8	9.7
56.	50.0	62.1	73.5	6.5	7.6	19.7	48.0	103.1	10.4

Appendix II (continued)

Sl. No.	Spread of flowering (days)	Height of main shoot (cm)	Length of top (cm)	No. of basal primary branches	No. of branches	Fresh weight of pods (g)	Haulms yield (green) per plant (g)	No. of leaves	No. of mature pods per plant
	7	8	9	10	11	12	13	14	15
57.	39.0	81.1	88.3	6.3	7.1	23.3	54.7	94.6	18.0
58.	36.7	63.9	71.3	6.8	7.2	25.4	63.5	107.5	14.6
59.	39.3	65.7	70.7	4.8	5.2	17.3	39.5	73.0	10.6
60.	61.3	81.1	94.9	5.2	5.5	23.3	55.5	98.2	13.1
61.	65.3	41.3	53.5	5.4	5.7	21.8	52.7	79.1	10.6
62.	57.3	79.0	93.1	5.7	6.0	25.9	57.1	105.1	21.5
63.	54.0	66.9	71.5	5.1	7.3	25.5	43.3	81.9	15.7
64.	42.3	66.7	71.7	7.8	8.3	30.7	56.0	129.1	18.3
65.	57.7	78.4	91.2	5.9	6.8	28.2	70.2	125.9	20.8
66.	54.3	60.1	79.8	6.1	6.4	32.9	75.5	84.5	14.1
67.	53.0	69.1	80.0	5.8	6.5	27.3	64.3	97.2	16.5
68.	51.7	58.7	67.7	6.1	6.7	29.8	43.5	95.4	10.6
69.	35.0	65.7	68.5	5.4	6.7	29.9	36.7	72.4	15.9
70.	56.0	56.3	72.0	6.2	6.3	17.2	69.5	108.3	21.5
71.	58.0	58.9	64.9	4.9	7.0	18.2	45.5	76.1	13.3
72.	40.3	50.4	94.8	5.8	8.3	22.4	57.5	113.9	17.7
73.	57.7	98.9	103.3	6.1	10.7	29.8	71.2	138.7	16.3
74.	43.3	47.7	79.3	9.0	12.5	19.5	56.7	117.0	11.7
75.	41.7	71.8	83.1	6.2	7.7	25.1	47.7	118.0	17.9
76.	50.3	72.4	82.9	6.7	7.0	23.8	57.1	168.6	16.4
77.	31.0	56.7	76.0	5.9	6.1	22.2	45.4	104.1	14.5
78.	53.7	59.3	69.5	5.2	5.5	21.5	53.3	82.1	14.5
79.	48.7	51.5	61.2	5.9	6.8	21.4	49.7	75.5	12.9
80.	53.0	61.3	65.5	5.5	5.7	22.9	49.3	98.2	16.6
Range	29.7 - 65.3	38.5 - 98.9	56.3 - 103.3	4.5 - 11.1	4.8 - 21.5	14.3 - 32.9	36.4 - 90.5	70.5 - 213.5	9.3 - 21.5
C.D.	5.92	16.05	16.76	1.70	2.66	7.70	20.81	36.80	5.33

Appendix II (continued)

Sl. No.	Percentage of pod set	No. of immature pods	Dry pod yield per plant (g)	Dryage percentage of pods	100 pod weight (g)	100 kernel weight (g)	Shelling percentage	Oil content (%)
	16	17	18	19	20	21	22	23
1.	17.4	2.9	11.1	64.3	71.6	30.7	73.4	46.6
2.	11.4	3.8	15.8	65.2	91.5	37.6	74.6	46.3
3.	11.1	5.3	11.8	53.5	109.5	39.8	77.1	53.4
4.	15.9	7.5	13.7	56.5	105.3	40.4	68.4	50.2
5.	22.4	3.7	16.5	64.2	93.0	36.7	74.9	50.0
6.	18.5	3.9	14.8	54.4	125.8	53.7	66.0	50.2
7.	10.7	4.7	14.2	65.6	143.0	35.5	65.2	45.3
8.	10.2	2.5	12.2	62.4	160.6	48.0	66.4	42.8
9.	14.6	4.5	12.2	56.6	82.7	35.4	76.9	45.8
10.	13.3	3.9	12.7	52.6	138.6	39.1	64.3	49.6
11.	14.2	4.3	10.5	50.0	143.6	45.1	67.8	44.8
12.	12.0	1.7	10.5	67.4	72.3	33.4	59.3	48.2
13.	7.8	4.3	13.4	50.1	160.8	52.0	63.4	45.8
14.	17.0	5.8	16.0	64.5	93.6	37.4	74.5	49.7
15.	17.2	3.4	11.9	62.3	93.1	36.1	77.9	50.2
16.	15.8	3.9	11.7	63.5	102.7	40.9	68.5	54.3
17.	21.3	2.2	14.0	61.5	90.9	39.1	74.0	44.7
18.	14.9	3.7	18.0	61.4	110.7	42.6	70.6	44.5
19.	17.2	3.4	10.6	65.6	85.7	36.5	74.1	51.7
20.	12.9	2.8	14.3	62.5	87.5	36.4	76.4	51.2
21.	25.7	3.3	17.1	64.4	60.6	25.5	74.1	52.2
22.	15.5	3.8	12.7	60.0	87.8	36.7	76.8	45.1
23.	18.7	3.8	9.2	48.8	95.0	38.6	66.5	43.5
24.	19.5	4.2	7.6	53.6	123.2	31.4	68.3	51.5
25.	13.6	2.6	12.9	57.9	91.3	38.0	72.9	47.6
26.	4.5	2.5	10.5	62.0	103.4	47.7	68.4	42.4
27.	13.5	4.5	11.3	61.5	75.9	33.0	74.7	48.5
28.	7.1	5.9	13.8	61.6	99.2	35.2	71.7	48.9

Appendix II (continued)

Sl. No.	Percentage of pod set	No.of immature pods	Dry pod yield per plant (g)	Dryage percentage of pods	100 pod weight (g)	100 kernel weight (g)	Shelling percentage	Oil content (%)
	16	17	18	19	20	21	22	23
29.	15.8	3.7	11.5	57.6	132.5	34.9	71.3	42.5
30.	16.6	4.1	13.0	64.4	92.5	47.8	75.5	45.3
31.	19.0	1.9	12.6	66.8	88.4	47.3	64.9	44.0
32.	9.0	4.3	11.1	58.7	126.8	53.3	69.5	51.2
33.	8.1	4.7	13.6	63.7	111.0	42.4	73.2	48.0
34.	23.6	6.4	15.1	59.3	116.3	48.9	74.7	47.1
35.	15.8	4.9	15.5	66.4	104.1	39.4	72.7	49.6
36.	28.8	5.3	14.0	58.7	117.3	47.6	67.5	53.1
37.	10.0	2.5	11.5	60.4	82.3	40.5	69.6	48.2
38.	13.5	5.3	13.6	68.3	101.0	34.8	74.7	51.6
39.	10.5	3.1	14.1	67.1	75.0	36.9	67.7	43.2
40.	9.9	5.0	11.0	51.3	114.1	40.2	68.8	41.4
41.	8.4	4.7	12.0	53.1	91.0	40.8	68.8	53.8
42.	17.9	4.2	16.3	68.5	80.9	32.2	71.1	47.7
43.	14.9	2.7	12.7	64.5	86.2	37.5	75.1	44.2
44.	13.8	4.7	15.5	61.9	117.7	48.9	73.4	48.4
45.	21.0	4.1	15.8	59.2	88.3	39.9	77.9	51.3
46.	16.3	5.0	14.7	64.8	110.6	41.9	79.0	47.3
47.	7.4	3.0	10.2	59.4	119.2	47.9	72.5	51.1
48.	13.9	2.5	11.8	66.4	106.0	41.4	77.3	46.6
49.	15.9	3.7	12.8	58.8	92.8	34.2	76.0	45.3
50.	10.6	4.0	14.9	69.4	97.8	39.4	75.2	48.5
51.	15.5	4.1	17.4	62.7	99.8	44.8	77.3	52.3
52.	16.5	4.9	12.7	60.0	127.5	42.6	73.1	53.0
53.	26.8	2.3	13.6	60.1	78.6	33.4	80.7	46.8
54.	12.3	2.3	14.5	69.3	158.3	42.3	72.8	48.6
55.	8.9	1.9	10.1	59.3	125.3	41.4	66.7	44.2
56.	10.7	2.4	13.9	70.6	93.6	34.5	78.6	42.9

Appendix II (continued)

Sl. No.	Percentage of pod set	No. of immature pods	Dry pod yield per plant (g)	Dryage percentage of pods	100 pod weight (g)	100 kernel weight (g)	Shelling percentage	Oil content (%)
	16	17	18	19	20	21	22	23
57.	22.3	3.6	13.2	56.4	99.2	42.1	75.2	47.7
58.	19.5	2.6	17.2	67.8	119.0	49.7	74.5	46.9
59.	10.5	1.7	12.2	70.6	67.0	32.9	79.5	47.6
60.	10.1	2.6	14.6	62.7	117.0	46.3	70.7	46.1
61.	8.4	3.7	13.0	59.2	132.1	43.3	69.1	43.1
62.	30.4	2.7	15.7	60.7	89.3	39.4	74.5	46.6
63.	17.3	5.4	15.2	60.0	151.5	38.4	70.7	46.1
64.	15.9	7.3	19.8	64.7	108.3	42.1	70.4	47.8
65.	15.4	4.5	21.2	75.5	89.9	36.2	81.0	47.9
66.	11.3	5.1	18.5	56.4	125.2	40.1	61.1	51.1
67.	17.2	3.9	16.5	60.5	94.2	39.1	76.1	48.0
68.	11.0	3.4	18.8	63.1	101.5	40.9	74.5	46.3
69.	23.4	2.4	20.0	66.2	97.3	36.8	75.2	51.5
70.	19.7	4.2	10.1	59.4	93.2	41.6	73.5	45.4
71.	12.7	3.0	12.5	69.4	84.0	36.4	73.2	48.9
72.	17.8	4.1	15.5	68.9	69.0	38.1	76.9	48.3
73.	16.3	4.0	16.4	56.5	146.1	38.0	69.8	48.9
74.	10.6	2.9	11.6	58.3	90.3	35.8	67.6	48.5
75.	14.2	4.5	15.7	62.9	92.3	38.1	78.1	51.2
76.	13.3	3.5	13.6	57.2	104.5	45.1	72.5	48.9
77.	19.7	3.5	13.3	60.2	93.0	36.8	77.4	50.2
78.	21.4	1.8	13.6	63.4	78.6	39.6	57.9	50.3
79.	9.5	1.5	14.3	66.8	84.7	36.3	56.3	52.8
80.	23.4	3.5	16.1	65.4	97.9	42.7	70.0	49.1
Range	4.5 - 30.4	1.5 - 7.5	7.6 - 21.2	50.0 - 75.5	60.6 - 160.8	25.5 - 53.7	56.3 - 81.0	41.4 - 54.3
C.D.	4.17	2.16	4.85	1.97	1.93	0.97	5.26	0.63

GENETIC RESOURCES UTILIZATION AND BIOMETRIC ANALYSIS IN GROUNDNUT (*Arachis hypogaea* L.)

BY

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ABSTRACT OF THE THESIS
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ABSTRACT

Maximising the production of vegetable oils in the country is one of the badly felt national needs for which the improvement in the productivity of groundnut, the major oilseed crop of the country, deserves the best attention. As a crop, groundnut has wide adaptability and a number of other favourable attributes. Breeding improved varieties suited to the two major areas of groundnut cultivation viz., the traditional uplands during kharif and the non-traditional, but potential rice fallows during summer is an immediate necessity for popularising the crop in this State. Germplasm collection, evaluation and utilisation constitute the basic approaches in the genetic improvement of any crop. Hence this investigation.

Eighty eight divergent varieties of groundnut were collected from different sources and subjected to preliminary evaluation in uplands during kharif. Ninety three varieties were evaluated in rice fallows during summer. These varieties showed wide variability in general performance, yield and other attributes within and between the situations. AH-6915 in uplands and TG-3 in rice fallows were the highest yielders. Several varieties were better in yield than the recommended varieties, viz., TMV-2 and TMV-7. A few varieties such as TG-14 and Spanish Improved were consistently superior at both the situations.

Eighty divergent varieties from the germplasm were studied in Randomised Block Design with 3 replications under the traditional uplands during kharif and the non-traditional, but potential

rice fallows during summer for the estimation of genetic parameters. Twenty three characters were studied at both the situations. Means, genotypic, phenotypic and environmental coefficients of variation, heritability in the broad sense, genetic advance, correlation coefficients at the genotypic and phenotypic levels and path analysis for yield at the genotypic level were estimated.

The varieties varied significantly for all the 23 characters in uplands and rice fallows. The characters, in general, showed differences in the pattern of variability in the two situations reflecting the profound influence of the environment on the expression of the characters. The various genetic parameters for the different characters exhibited variation between the two situations. The parameters also showed differences among characters in each situation.

In the uplands, the percentage of pod set, number of branches, haulms yield and number of mature pods had high genotypic coefficient of variation. For pod yield, the g.c.v. was moderate. Oil content, duration upto flowering and maturity had low g.c.v. and p.c.v. Number of immature pods and branches had very high p.c.v. E.c.v. was the highest for number of immature pods and the lowest for duration upto maturity. Heritability estimates in the broad sense were high for spread of flowering, duration upto maturity, 100 pod and kernel weights and shelling percentage, whereas it was moderate for pod yield. Number of branches, haulms yield, number of mature pods and flowers recorded high genetic advance. High heritability combined with high genetic advance and g.c.v. was observed for percentage of pod set and number of branches. Pod yield and number of mature pods had registered moderate heritability and genetic advance. It is evident that though groundnut is a highly self fertilized crop, genetic variability is still available in a number of important characters. Pod set, number of branches and flowers, haulms yield, 100 pod weight, number of mature pods and pod yield are expected to respond to selection.

Pod yield was highly and positively correlated with fresh weight of pods, number of mature pods, pod set, number of immature pods and dryage percentage of pods at the genotypic and phenotypic levels in uplands. Days to maturity at the genotypic level and number of flowers and basal primary branches at the phenotypic level were also correlated positively with pod yield. Significant negative correlation was seen between pod yield and plant height on the 50th day, height of main shoot and length of top. Number of mature pods was correlated negatively with 100 pod and kernel weights whereas the pod and kernel weights were correlated positively. The correlation of 100 pod and kernel weights with shelling percentage and that between oil content and 100 kernel weight were negative.

The path analysis revealed that fresh weight of pods had the highest positive direct effect on dry pod yield followed by 100 pod weight, haulms yield and number of mature pods. Number of mature pods had exerted positive indirect effects via fresh weight of pods, 100 pod weight, number of flowers, length of top, number of basal primary branches and leaves. Length of top, number of basal primary branches, leaves and flowers exerted negative direct effects on pod yield. The residual value obtained was very low indicating that the model covers almost the entire variability for yield in uplands. It is visualised that in uplands, genotypes of medium duration with medium compact canopy, larger number of basal primary branches of short internodes, moderate number of dark green leaves and flowers and setting more number of medium sized heavy pods with high dryage percentage will give high yield of pods.

In the rice fallows during summer both g.c.v. and p.c.v. were the highest for number of branches on the 50th day and the lowest for duration upto maturity. Number of branches and pod set had high g.c.v. while oil content and shelling percentage had low values. Number of immature pods and duration upto maturity registered the highest and the lowest e.c.v. Pod yield recorded high p.c.v. and e.c.v. than g.c.v. Spread of flowering, 100 pod weight and duration upto maturity showed high heritability while that for pod yield was low. Genetic advance was the highest for number of branches followed by pod set and the lowest for duration upto maturity. G.c.v., heritability and genetic advance were high for number of branches, flowers, leaves and pod set. Spread of flowering and 100 pod weight also recorded high heritability coupled with genetic advance. As in the uplands, variability for the different characters in summer rice fallows had enormous heritable component. Genetic improvement through selection can therefore be expected for number of branches, flowers, leaves, pod set, spread of flowering, 100 pod and 100 kernel weights.

Both at the genotypic and phenotypic levels, yield was highly correlated positively with plant height on the 50th day, length of top, fresh weight of pods, number of mature pods, pod set, number of immature pods and dryage percentage. At the genotypic level, pod yield was also correlated positively with height of main shoot, shelling percentage and oil content and at phenotypic level with number of flowers and haulms yield. Pod yield showed negative significant correlation with duration upto flowering, number of branches and leaves on the 50th day, flowers and branches at the genotypic level. Moderate significant correlation was seen between pod yield and duration upto flowering at the phenotypic level. Fresh weight of pods was highly correlated positively with number of mature pods which in turn was correlated positively with plant height on the 50th day, pod set and shelling percentage and negatively with number of branches and leaves on the 50th day, height of main shoot and 100 pod and kernel weights. The possibility of combining high yield with short duration for summer rice fallows was strengthened by the lack of significant correlation between pod yield and duration upto maturity.

Fresh weight of pods had recorded the highest positive direct effect on pod yield in rice fallows as in uplands. Number of leaves, flowers and mature pods also had positive direct effects in that order. Number of mature pods had positive indirect effects via fresh weight of pods, number of basal primary branches, haulms yield and 100 pod weight. The direct effect on pod yield by length of top, number of basal primary branches, haulms yield and 100 pod weight were negative. The plant type for the rice fallows should have compact medium tall canopy, moderate number of basal primary branches of short internodes, moderate number of dark green leaves, early flowering and maturity, producing more number of flowers and setting larger number of medium sized pods with heavy kernels of high oil content so that a heavy yield of fresh pods with high dryage and shelling percentage, resulting in high yield of dry pods.

Thirty varieties including the two recommended varieties, viz., TMV-2 and TMV-7 were selected for critical evaluation in uplands and rice fallows. They were evaluated under both the conditions in Randomised Block Design with 3 replications and 15 characters were studied. The analysis of variance revealed that the varieties had high variability for all the characters at both situations. The pooled analysis showed that all the characters except length of top changed in individual varieties from one situation to the other suggesting very high influence of the environment. As such, programmes for selection to be effective should be situation specific.

In the uplands, the highest pod yielding variety was TG-14 followed by Spanish Improved and these were on par. They were superior to the recommended varieties. TG-14 and Spanish Improved out yielded the better recommended variety, viz., TMV-2 by 36.45 and 28.30 per cent respectively. In haulms yield also they ranked 2nd and 3rd. In other important attributes like duration upto maturity, fresh weight of pods, number of mature pods, 100 pod and kernel weights, shelling percentage, oil and protein contents, these two varieties were either superior to or on par with the recommended ones.

In the rice fallows, TG-3 was the top ranking variety in dry pod yield which was on par with Pollachi-2, Spanish Improved and TG-14. All these varieties were superior to the recommended varieties. The percentage increase of pod yield over TMV-2, the better standard, were 36.14, 32.46, 31.27 and 31.14 for TG-3, Pollachi-2, Spanish Improved and TG-14 respectively. These varieties were also either superior to or on par with the recommended varieties in other economic characters such as duration upto maturity, fresh weight of pods, haulms yield, number of mature pods, 100 pod and kernel weights, shelling percentage, oil and protein contents.

Thus TG-14 for uplands and TG-3 for rice fallows were the highest yielding varieties. However, it is seen that TG-14 and Spanish Improved were consistently among the top ranking varieties in uplands during kharif and in rice fallows during summer. As stability in yield performance in groundnut is very desirable, these varieties can be utilised in both the situations with advantage.

None of the varieties under testing matured in 90 days. In the summer rice fallows, usually there is only a gap of 90 days in most of the areas. Therefore the two promising as well as stable varieties, viz., TG-14 and Spanish Improved and the better of the two recommended varieties, viz., TMV-2 were irradiated with gamma rays at 3 doses viz., 20, 30 and 40 krad for induction of earliness.

Germination of seeds, survival and plant height on the 30th day were reduced in the M_1 and were dose dependent in all the three varieties. Pollen fertility decreased with increasing doses of gamma rays. A variety of morphological devients such as leaf variants, stunted plants and dwarfs were also noticed in the M_1 generation.

The frequency of chlorophyll mutations in the M_2 generation increased with increasing doses of gamma rays in all the varieties. Mutagenic effectiveness and efficiency did not show any definite relationship with doses of radiation. A wide range of viable mutants of academic and practical value were isolated from all the three varieties. In some of the macromutants a constellation of characters such as plant height, canopy compactness, duration upto flowering and maturity and pod characters were noticed to be changed simultaneously. The early maturing mutents isolated from all the three varieties maturing in 90 days or less are of great practical value as they are particularly suited to the summer rice fallows.

The results of the biometric studies can serve as dependable criteria for effecting selection for high yield in programmes for breeding varieties for the two potential areas of groundnut production in the State. The superior varieties now identified will lead to an increase in the productivity of the crop in the near future. The viable mutants isolated especially the short duration ones will open up new vistas in the production of groundnut in the summer rice fallows.