GENETIC VARIATIONS AND ROSETTE RESISTANCE IN EARLY GENERATIONS OF GROUNDNUT (Arachis hypogaea L.) VARIETIES IRRADIATED WITH GAMMA RAYS

BY

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A thesis submitted to the Faculty of Agriculture, Ahmadu Bello University, Zaria, in partial fulfillment for the degree of Master of Science in the Department of Plant Science.

August, 1999

DECLARATION

I hereby declare that this thesis entitled "GENETIC VARIATIONS AND ROSETTE RESISTANCE IN EARLY GENERATIONS OF GROUNDNUT (Arachis hypogaea L.)VARIETIES IRRADIATED WITH GAMMA RAYS" has been written by me and it is a record of my own research work. It has not been presented before in any previous application for higher degree.

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The above declaration is confirmed.

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Chairperson, Supervisory Committee.

CERTIFICATION

This thesis entitled "GENETIC VARIATIONS AND ROSETTE RESISTANCE IN EARLY GENERATIONS OF GROUNDNUT (Arachis hypogaea L.)VARIETIES IRRADIATED WITH GAMMA RAYS" by Ogunlade Olukemi T. E. meets the regulations governing the award of the degree of Master of Science of Ahmadu Bello University, Zaria, and is approved for its contribution to scientific knowledge and literary presentation.

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DEDICATION.

This thesis is dedicated to my dear, faithful and patient parents, Presiding elder and Deaconess I.A. Ogunlade and my brothers and sisters, Mr and Mrs Adeyemo, Kayode, Bolanle, Kola, Tunbosun and Funmilola for their love, care and sacrifice.

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ABSTRACT

Seeds of groundnut, *Arachis hypogaea L.* were treated with gamma rays. Two sets of irradiations were performed. The first set consisted of irradiating five varieties (two early maturing, SAMNUT 14 and 18, one medium maturing, UGA-7, and two late maturing, SAMNUT 21 and 10) at 10, 35, 45, and 50 krads with cobalt 60(C^{60}) source. An F_2 population, Ex RM12 (derived from an Ex-Dakar X RMP 12 Cross) was used as control in the set. Only lOkr treated plants survived for all the varieties, these were evaluated for increased variability, agronomic performance and for resistance to groundnut rosette disease at M_2 and M_3 populations. The second set of Irradiation was done at lower doses 15, 20, 25, 30 and 35kr with 0 dose serving as control using the 5 varieties. Varieties survivity under all these lower doses and were evaluated in M^1 and M_2 populations as the first set. These varieties were grown under two field conditions: rosette and rosette free.

Results indicate wide ranges and coefficients of variability for the characters studied. Population means showed significant differences in performance of irradiated populations and control within each variety for the characters measured. Effects of doses produced more detrimental changes in the M_2 than in the M_2. Increases in yield and components were seen within varieties for the lower doses 15kr, 20kr and 25kr than at higher doses 30 and 35kr especially at M_2. Significant (P= 0.05) effects were record

for the doses used and for the varieties planted. Interaction of varieties and doses were not significant. Estimates of genetic variance were large in the populations, interaction variance were negative or small. Abnormally high broad sense heritability estimates were obtained for the M_2. Positive and highly significant (P=0.01) correlations between yields and its components were recorded in M_2 except between one hundred seed weight and shelling percentage.

Effects of the mutagenic agents on the varieties were similar on rosette infested and rosette free fields. The irradiated populations of each variety showed variations in their reactions to disease infections.

The performance of irradiated populations compared with control indicated that doses 15, 20 and 25kr generally produced more beneficial, significant changes in plants while dose lOkr was not too far from the control and dose 30 and 35kr produced more detrimental effects on characters studied. Selections from M_3 and higher generations of populations irradiated with 15, 20, and 25kr may produce higher yielding and disease (rosette) resistant mutants.

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CHAPTER 1

INTRODUCTION

Groundnut, a self - pollinating leguminous crop, originated in South America and is now found in all tropical and sub-tropical countries. It belongs to the genus *Arachis* which has more than seventy wild species existing in nature of which only *Arachis hypogeae* is commonly cultivated (Purseglove, 1977). Groundnut is grown on over 18 million hectares throughout the world in the warm temperate and tropical zones. Leading producers are India, China, the United States, Sudan, Senegal, Nigeria and Indonesia (Porter *et al.*, 1990).

It is an important food crop in Nigeria: it's seeds are high in calories and contains protein (22 - 30%) and oil (42 - 60%). It provides a significant source of cash income through sale of the seeds, cake, dietary oil and haulms. Green haulms make excellent fodder and hay. The Nigerian groundnut has figured prominently in the world trade. In the fifties, Nigeria was contributing 50% of African exports and 30% of world exports. Groundnut served as one of the most significant source of employment in most parts of Northern Nigeria (Adesimi, 1973). Commercial groundnut producing areas in Nigeria include the Sahel (12^{o} - 14^{o} N),Sudan (10^{o} - 30^{o} N), Northern Guinea Savannah (8^{0} - 11^{0} N) and southern Guinea Savannah

(6° - 8°N) with a rainfall season lasting 75 - 250 days and a range of 500-1650 mm (Yayock and Owonubi,1985).

In Nigeria, an estimated one to two and half million hectares of land are planted to groundnut annually. As the groundnut became more economically important, emphasis in production shifted from minimal input to intense input, which resulted in high yields and improved seed quality. The production intensity has been restricted by factors such as diseases, drought and erratic rainfall. Among all groundnut diseases, rosette is the most serious in Africa particularly in the wetter parts (Farrell, 1976;Purseglove, 1977). Storey and Bottomley (1928) established that the disease was caused by a virus transmitted by the aphid, *Aphis craccivora* (Koch). The prevalence of this disease has led to serious losses in groundnut production. Yayock (1978) gave a report of a serious incidence of groundnut rosette virus damage during 1975 planting season which led to a loss in yield of an estimated 560,000 metric tonnes. Regional epidemics had also occurred in 1983, 1985 and 1988 which has led to a severe decline in groundnut production. The use of pesticide is a possible method of control: aphicides are available to control the vector by spraying the planted fields at intervals of 10-14 days until the pods are formed. This is very expensive especially for farmers. Agricultural operations such as cultivation during dry season under full irrigation has led to relative freedom from leafspot and rust

diseases but is highly discouraged because of the risk that such irrigated crops may serve as a reservoir for aphids and sources of rosette virus which would infect the main crop in the following rainy season. Early planting will reduce possibility of severe disease but it is not a sure way of getting healthy crop Mercer (1977). The use of tolerant and resistant cultivars would be more economically acceptable and pave the way for cultivation of groundnut under full irrigation during the dry season and as a rainfed crop (Klesser, 1966; Yayock and Owonubi, 1985).

Plant breeding is concerned with the creation, identification, isolation, multiplication and management of genetic variability towards improved cultivars. On account of the intensive and continuous improvement work on groundnut, there is a need for new sources of genetic variability within the existing germplasm which breeders can exploit for increased productivity. Mutation breeding is an integral part of plant breeding and is another way of creating genetic diversity for further selection and hybridization (Ashri, 1970).

Inducing mutation in crop plants has been of scientific and commercial interest especially when the genes of a desired trait is present in nature but is not attainable due to some barriers which may be geographical or biological and also when the improvement is to be done for a single character in a highly developed variety and the use of conventional breeding may disturb the balanced

combination of genes.

In Nigeria, the varieties with resistance to common pest and diseases are late maturing varieties which do not appropriately suit the Sahel, Sudan and Northern Guinea Savannah production zones. There is a need for short season disease resistant varieties which will effectively cope with the insufficient rainy season.

Since there appears to be a tight linkage existing between late maturity and rosette resistance genes in groundnut, mutation breeding offers a promising tool to break this undesirable linkage. As a result of the outcome of the work done on conventional breeding for rosette resistance plus earliness, a new strategy to achieve this important goal was devised and the mutation project started with the following objectives as part of the specifics for achieving this goal:

1. To study the genetic variation observed in groundnut varieties exposed to gamma irradiation at different dosages.
2. To analyse the disease reactions of early generations of locally adapted groundnut varieties subjected to varying doses of gamma rays irradiation with the aim of selecting for earliness and resistance to rosette.

CHAPTER TWO

LITERATURE REVIEW

2.1. Mutation Breeding

Spontaneous mutations are the basis of crop improvement by conventional method but the frequency of occurrence is very low and does not often include the full range of possible variability (Smith, 1958). The outstanding work of Muller (1927) and Stadler (1928) gave birth to mutation breeding which involves the use of different mutagens to create artificially sudden heritable changes in plants.

Beneficially, mutation induction in crop plants especially when the desire is to improve one or two easily identifiable characters in an otherwise well adapted variety is a very valuable supplementary approach to plant breeding. The basic genotype of the variety is only usually slightly altered as compared with hybridization of two distinct varieties, while the improved character is added and the time required to breed the improved variety can also be shorter. A desired mutation can be recovered in a homozygous state already in the M_2 or M_3 generation compared with the F_6 or F_7 generation in the case of hybridization.

Induced mutation has resulted in the release of varieties in crops such as wheat after three and a half years, rice, after six years, barley after five years from initial mutagen treatment thus reducing considerably the time required for breeding (Briggs and Knowles, 1967; Ashri, 1970).

Mutation breeding has been used widely in self-pollinated crops because of the homozygousity found in such crops with restriction to selection until and unless some variation is either present or created artificially. Mutants of self pollinated crops can be easily detected on account of purity and true breeding nature of the progeny.

Groundnut when compared with the tropical legumes and oil seeds has been used more frequently in mutation breeding experiments. Using this method for improvement of characters such as yield and other components as kernel size, number of seeds per pod and shelling percentage has been reported in USA and India (Pathiriana *et al.*,, 1986) - Advantageously too, groundnut has embryos easily exposed to mutagens, the embryo has six to eight leaf primordia in their axils making several potential targets available (Ashri and Levy, 1974).

Mutation breeding has been most successful in improving grain legumes in many countries all over the world. Peas and faba beans were among the pioneering objects of mutation research. Many breeding objectives have been reached leading to released mutants

with different improved disease or insect pest resistance, earlier or later maturity, higher yield, higher protein or oil content, reduced toxic compounds such as alkaloids and glucosides (Micke, 1992 and 1997).

2.2 Traits Improved using Mutation Breeding

2.2.1 Physiological traits

Physiological traits improvement in crop plants started as early as 1934 when Gustaffsson and other workers in Sweden produced dense eared, stiff strawed barley mutants using irradiation. Since then traits such as earliness, flower appearance, days to maturity, photoperiods have been beneficially manipulated in different crop plants.

Improvement work at Shandong Peanut Research Institute (SPRI), Laixi, China, produced groundnut mutants with earliness of only 73-75 days to maturity. Mutants that reach maturity twenty days earlier than the popular early maturing cultivar and seven days earlier than 'Chico' which was believed to be the earliest maturing groundnut variety in the world has been developed using irradiation. Mutants with leaves showing different 'sleep movements' Carcadian rhythyms), decreased or increased number of stomata, fewer bundles in the leaf stalks compared to the original varieties has been observed (Quingshu *et al.*,, 1994).

Work done by Rajput (1974) on M_2 population of gamma

irradiated mung beans showed that a flowering delay occured with increase in dosage. A highly significant positive correlation (r + 0.9304) was observed, a plant flowered eleven days (36.0 days) earlier than the control (47.0 days) at 30kr. The coefficient of variability was greater in the irradiated materials than the control. Work done on pea bean *Phaseolus vulgaris* produced a beneficial mutant with earlier maturity and bushy habit (Down and Andersen, 1956).

In a study aimed at using radiation to produce new genetic combinations by Papa, *et al.*, (1961) in soybean varieties, neutron and X-rays produced greater variation in the irradiated populations than the non-irradiated population for maturity. Significant differences were obtained between selected and unselected populations in the irradiated treatments although the actual number of days gained by selection were relatively small.

Alcantara *et al.* (1994) also on soybeans treated with gamma rays, selected a mutant that matured 34 days earlier than the parent variety and was homozygous for earliness in the M_3, M_4 and M_5 generations.

2.2.2 *Growth habit*

Beneficial modification of growth habit using mutation has been reported by Micke, (1997) leading to a release of groundnut mutants with dwarf habit, without secondary branching, higher yield and higher harvest index.

Studies by Rajput (1974), showed a marked plant height reduction occuring from 25kr and above in mungbeans. Correlation studies reflected a negative, significant plant height/dosage correlation (r = -0.7604). Similar plant height reduction had been observed by other workers such as Bajaj *et al.* (1970) with work on seed irradiation of *Phaseolus vulgaris* using gamma rays.

Work on *Stylosanthes guyanensis*, a leguminous plant using gamma rays led to the discovery of a morphological mutant in the M generation with an upright growing habit, extremely different from the prostrate, parental type (Alcantara *et al.*, 1994).

On germination, irradiation with gamma rays of three field bean varieties at 3, 5 and 7krads resulted in germination percentages non-significantly different from the control (86-89%). Seeds subjected to 3 and 5kr had a range of 83.38-90.63% while the 7kr had a more deleterious effect producing a range of 52.88-72.38% for the field germination tests. The laboratory tests did not show any significant difference between the treated seeds and the control (Abdel-Hak and Kamel, 1973).

2.2.3 Yield and yield components

Earlier work of scientists like Gregory on yield in groundnuts showed that variation which is quantitative can be increased by radiation sufficiently beyond the natural variability to increase the efficacy of selection. A four fold increase in genetic variance

among progeny of X_2 plants using X-rays was achieved. Five best mutant selection was carried out with yield tests for the X_4 generation and these lines maintained a measurable superiority over the control.

The stability of the mutants were tested using family progeny test and progeny to progeny variance in yield within each family was not significant. He effectively showed that phenotypically constructive mutations affecting a quantitative character can be induced by mutation and accumulated beneficially by selection (Gregory 1955, Smith, 1958).

Rawlings *et al.* (1958) worked on soybeans using irradiation with neutrons and X-rays. Effects on yield and seed size were examined in the two varieties studied. Significant amount of genetic variability was present for all the characters measured in the treatments except for yields in the control. Results on estimated genetic variance of the M_2 averaged five times as large as those in the control. For yield (g/plot) in the variety 'Adam' the genetic variance was 1,422, 1477 and 412 for the neutron treatment, X-ray treatment and the control respectively. For the variety 'Hawkeye', genetic variance was 774, 1,082 and 120 for the neutron, X-ray treatment and control, respectively.

Mean seed weights of the irradiation treatments were higher than the corresponding control, progeny means ranged from 12.25g - 16.5g/100 seed weight for the irradiated to 13.0g - 14.75g for the

controls. In 'Adams" neutron treatments resulted in a seed weight with mean of 14.1g significantly greater than the control of 13.8g. In the Hawkeye variety, neutron treatments yield a seed weight with mean of 16.4g, significantly greater than either the control of 16.0g and X-ray of 16.1g.

In a study on various agronomic characters in natural variants and induced mutants of some legumes, there was a wide range of in variability of components such as branching habit, pods per plant and grain weight as seen by large coefficient of variabilities among the various mutants which indicates an ample scope for selection of desirable plant types with coefficient of variability (CV) as high as 47% for mungbean and 20% for lentils which was the lowest for the legumes studied (Shaikh *et al.*, 1977).

Ojomo and Chheda (1972), worked on the variation of some characters in cowpea, following irradiation with X rays and neutrons at various doses. Observations were recorded on the yield of dry beans, time of flowering and number of pods per plant. Mean squares and genetic variability were estimated. Results showed for 'Westbred' , an exotic, significant mean square for yield in the control, X-rays produced significant variability for pods per plant. In 'Local brown', a native, X-rays produced significant increases in line mean squares for yield and pods per plant and neutrons caused significant increases for pods per plant and days to flowering.

Using F values to compare, in "West bred", variability was higher in irradiated population than the control. In Local brown, genetic variability increased significantly 2-8 times in the irradiated populations except for yield in the neutron treated population, where variability was higher than control by only 7%. Heritability estimates also showed higher values in irradiated populations for local brown, 0.32 and 0.05 for the x-ray and neutron treated populations, respectively, while in the "West bred" higher heritability was recorded for control (0.38) than 0.14 and 0.08 for x-ray and neutron treated population, respectively.

For pods per plant, heritability values were highest in West bred, 0.61 for X rays and 0.06 for the control the trend was similar for Local brown with 0.57, 0.20 and negative results for X-ray, neutron treated population and control, respectively.

Yield Improvements were obtained by Pathiriana *et al.* (1986) in irradiation work in groundnut. Selections from M$_3$ led to two mutants which yielded an increase of 19.8% and 8.3% over the recommended cultivar. The mutants had higher mean pod yield across the locations used for the advanced yield trials, in the various seasons during which the trials were carried out.

2.2.4 Pest and Disease Resistance.

Cooper and Gregory (1960) worked on groundnut to explore the possibility of recovering mutants immune or highly resistant to the

host specific pathogens, *Cercospora arachidicola* Hori and *Cercospora personata*. Seeds were irradiated with X-rays from 10kr to 18.5Kr and disease scores were taken on the field grown populations of X_2 and X_3 for leaf spot induced defoliation, the scores indicated both increase and decrease in resistance. Triplicate planting of selected X_3 plants in X_4 and X_5 gave significant differences in defoliation between X_5 score classes. The entries differed significantly in defoliation, number and ratio of lesions caused, with two exceptions. Selections carried into X_7, X_8 and X_9 were stable for the defoliation characteristics.

Studies on two mungbean varieties by Gupta *et al.*, (1996) using acute doses of gamma rays, ethyl-methyl-sulphonate (EMS) and the combination, to produce resistance or tolerance to mungbean yellow mosaic virus (MYMV) resulted in a released mutant with higher degree of disease tolerance and yields greater than the parents used for the study and this mutant advanced up to M_6 generation showed stability in the tolerance to MYMV in multilocation trials.

Sharma and Bhatnagar (1996) worked on induced mutants of soyabean varieties following irradiation with gamma rays. These were evaluated for stem fly resistance on the basis of stem tunneling (Increase in stem tunneling and damage indicates susceptibility) and seed yield. From the M_6 generation, a mutant was derived with significantly less susceptibility to stem flies

compared with the control (16.53% less) and 21.27% increased yield.

2.2.5 Protein Content, Nutritional Values or Processing Properties.

Mutagenic treatment were given to two varieties of the bean, *Phaseolus Vulgaris* using gamma rays and ethyl-methane-sulphonate (EMS). The seed were planted in the field and selection was carried out to M6 with repeated protein analyses and continual discarding of drastic mutants and other undesirable mutants. Comparison with the control showed that the average protein content of the treated material at 24Kr was higher in each generation for one variety while for the second variety, two generations M_5 and M_6 showed a significantly higher protein content than the controls at 32Kr (Crocomo *et al.*, 1977).

Screening work was done on natural variants and induced mutants of mungbeans (*Vigna radiata*), lentils (*Lens culinaris*), Chick peas (*Cicer arietinium*) and grass peas (*Lathyrus satius*) for protein content and yielding potential. Protein content was found to be negatively correlated with yield or any of its components. Comparative studies of ten elite mutants (M_3) of Chickpeas and lentils carried over three generations for yield and protein contents revealed a few mutants that promised higher seed yield and protein content than the respective mother varieties. The results gave differences in the degree of variation with chickpeas having the highest coefficient of variability of 10% and lentils having

the highest coefficient of variability of 10% and lentils having the lowest of 3% for protein content among the legumes studies. Marked differences were obtained in the mean protein content of the various species. Grass peas showed the highest mean of 30.40% while lentils had the lowest of 16.00% (Shaikh *et al.*, 1977).

In a study on a radiomutant derived from a *Vicia faba* variety in Austria, subjected to gamma rays treatment of the seeds, Nagl (1977) reported substantially increased variability in different desirable agronomic traits. Highest values were obtained for grain size and protein content with comparison between the initial population and the mutant population. For grain weight, genetic coefficient of variation was increased from 11.65% to 68.16%, while the protein content was increased from 7.30% to 91.20% without significant change in the population mean, offering good prospects for selection.

CHAPTER 3.

MATERIALS AND METHODS

3.1. Experimental Materials

Genetic variability was created in five locally adapted varieties with gamma (γ) rays from a cobalt source (Co^{60}). Another material used also in the study was an F_2 population from a cross of late and susceptible varieties. A brief description of these varieties is given in Table 1.

3.2. Experimental Methods

Irradiation

Dry seeds were exposed to the rays at Biological Control Unit (BICOT), Vom, Jos, Plateau State. 500g of each variety except the F_2 population was irradiated.

M_1 Generation

The first irradiation was done in 1995: the five varieties were exposed to 10, 35, 45 and 50 kr, and were planted along side with the F_2 population in the field. The survival was very low at these dosages: only plants irradiated at 10 kr survived for all the varieties. Higher doses were lethal except for Ex-Dakar for which 35 kr had surviving plants and MDR8-19 with few plants surviving at 50 kr alongside with the 10 kr dosage. These surviving M_1 seeds were bulked.

The second irradiation was done in 1997, due to the lethality

at higher doses, lower exposures of 15, 20, 25, 30 and 35krads were used. The treated seed were also sown in the field with the control or zero dose in 1997 planting season. The surviving M_1 seeds were harvested and bulked separately according to the dosage.

M_2 and M_3 Generations:

The M_1 seeds were sown in 1997 for the surviving plants of the first irradiation now as M_2 population for the 10kr, while those of the lower exposures of the second irradiation were also advanced to M_2 population. Survival in the field at these lower exposures was higher, all dosages produced seeds for planting the next generation though more seeds were produced at lower doses of 15, 20 and 25 kr than at 30 and 35 kr. Experimental field conditions were established to determine the response of these irradiated materials to groundnut rosette disease. The M_2 plants that survived under the disease conditions were advanced to M_3 population. Both M_2 and M_3 were screened for resistance to rosette disease and earliness. All generations used in the study, M_1,M_2 and M_3 were evaluated for the following traits: germination percentage, Days to first flower appearance, Days to fifty percent flowering, plant height at harvest, number of plants at harvest, number of mature pods per plant, pod yield, haulm yield, one hundred seed weight and shelling percentage. Disease incidence and severity were observed under rosette disease conditions for M_2 and M_3. Mean values were estimated for comparative analysis.

Table 1: Description of the varieties used in the study:

Genetic materials	Descriptions
SAMNUT 14 (Ex-Dakar)	Spanish erect bunch type. Early maturing. 90-100 days. Rosette susceptible, leaf spot susceptible, drought tolerant. Pale green leaves small kernels, pale tan in colour. High yielding, 2000kg/ha
SAMNUT 18 (RRB)	Spanish erect bunch type. Early maturing. 100-110 days. Rosette and leaf spot susceptible, drought tolerant, pale green leaves. Small kernels, red in colour.High yielding, 2000kg/ha
SAMNUT 10 (RMP 12)	Virginia semi erect bunch type. Late maturing. 130-150 days. Rosette resistant. Dark green leaves. Large variegated kernels, light russet brown in colour. High yielding, 3000kg/ha
UGA - 7	Virginia semi erect bunch type. Medium maturing. 110-120 days. Rosette resistant. Dark green leaves. Large kernels, russet brown in colour. High yielding, 2800kg/ha
SAMNUT 21(MDR 8 - 19)	Virginia semi erect bunch type. Multiple disease (leaf spot, rust and rosette) resistant variety. Medium - late maturing 120 - 140 days. Large kernels, russet brown in colour. 3000kg/ha.
F2 (Ex-Dakar x RMP-12)	Segregating population

3.3. Experimental Design

In both years, the design was Randomized Complete Block Design (RCBD) with two replicates. Plots were four rows for all varieties except where seeds were not sufficient and number of rows were reduced to two. Single seeds were placed in holes, 20 cm apart on four metre ridges, 75 cm apart. For the disease screening fields in both years, plots were six rows for all varieties and the different treatments in an arrangement of two rows of test lines alternated with an infector row used to give uniform disease spread and valid results in the screening.

3.4 Cultural Practices

Fields used for these studies were located at the Institute for Agricultural Research, Samaru, Zaria. The herbicide, 'Round Up' containing glyphosate was used for precrop planting to control the weeds. Fertilizer application was done with single super phosphate (SSP) at the recommended rate of 300 kg/hectare. The land was harrowed twice, ridged and other herbicides used to control the weeds were Septa and Dual at 2,51/15 litres of water. Pesticides, Karate and Dimethoate were used to control ants and aphids, respectively. Seeds were dusted with fungicide, Apron Plus, against fungal attacks. Benlate at the rate of 300 g of Benomyl/hectare was used because of prevalence of leaf spot diseases.

Weeding was done as needed till the time of pegging when weeding was restricted to hand pulling to have maximum pegging and pod setting. Harvesting was done manually, plants were air dried on the fields or carried to ventilated store houses for drying before picking and cleaning.

3.5. Data Collection

The following characters were measured and recorded for the purpose of analysis using a random sample of ten plants per plot for the irradiated population and resultant progenies. For data collection on the rosette fields, individual plant evaluation for symptom expression was carried out. Regular disease counts were done and disease severity scores taken using the internationally recommended rating scale for virus infected plants.

Germination Percentage (GP): Number of plants that emerged were counted per plot and recorded after 10 to 14 days of planting to ensure up to 90% emergence. The percentage was calculated as:

$$\text{Germination percentage} = \frac{\text{Number of plants at Emergence}}{\text{Number of stands per plot}} \times 100$$

Days to first flower appearance (DTFFA): Days from planting to the days the first flower was observed on each plot.

Days to 50% flowering (DTFF): Daily observations were done when flower initiation started and days from planting to when 50% of the plants in each plot have at least one flower were recorded.

Plant Height at Harvest (PHAH): Plant height was measured from the ground to the top of the main axis in cm.

Number of Plants at Harvest (NPAH): Number of plants within each

treatment plot was counted at harvest.

Number of Mature Pods per Plant (NMPP): The mature pods on ten consecutive plants were counted during harvest to estimate the mean number of mature pods per plant.

Pod Yield (PY): The air dried cleaned pods in each plot were weighed.

100 Seed Weight (OSW): A random sample of 100 seeds was taken from the havested bulk and weighed.

Shelling Percentage (SP): The weight of seeds obtained from the weight of pods that are randomly drawn from the bulk sample was used.

$$\text{Shelling percentage (\%)} = \frac{\text{Seed weight}}{\text{Pod weight}} \times 100$$

Disease Incidence: Proportion of plant units affected by rosette disease as a percentage of the total plant units assessed.

$$\text{Disease Incidence} = \frac{\text{Number of plants affected per plot}}{\text{Number of plants assessed}} \times 100$$

Disease Severity: Each plant was assessed for disease severity using the following disease rating system: 1 = no symptoms, 2 = discernable leaf symptoms (no stunting), 3 = rosette leaf symptoms plus stunting ranging from about 30% the size of symptomless plants, 4 = rosette leaf symptoms plus stunt ranging from about 30 to 70% and 5 = rosette leaf symptoms plus stunt greater than 70%.

Disease index values were determined using a rating system described by Kuhn and Smith (1977) as follows A + 2B + 3C + 4D + 5E/total number of plants assessed per plot, where A, B, C, D and E equal number of plants with ratings of 1, 2, 3, 4 and 5,

respectively. These index values show the different reactions of the irradiated materials under rosette disease conditions and the resulting resistance.

3.6 Statistical Analysis

The data collected in these studies was analysed to obtain means, coefficient of variability (%), variances and components of variance for the characters measured. The irradiated populations M_1 and M_2, were also evaluated in rosette free environment, the statistical model used for the analysis of variance (ANOVA) was:

$$Y_{ijk} = \mu + G_i + D_j + R_k + (GD)_{ij} + e_{ijk}$$

Where

μ = Overall mean
G_i = Effect of ith variety i=1,2,.....5
D_j = Effect of jth dose of irradiation j =1,2,.....6
R_k = Effect of kth replication , k=1,2.
$GD)_{ij}$= Interaction effect of ith variety with jth dose
D_j ~ NID (0, σD)
G_i ~ NID (0 σG)
e_{ijk} ~NID(0,σ)

Both varieties and doses were treated as fixed effects, since the doses and the varieties were selected for the purpose of this study (Obi,1986). The form of analysis of variance (ANOVA) used for comparison with the degrees of freedom, mean squares and expected mean squares which were used for estimation of the genetic parameters is shown below.

TABLE 2: Form of ANOVA with expected mean squares (EMS) in one environment for each character studied in M_1 and M_2 population.

Sources of Variation	d.f	MS	EMS	F test
Replication	(r-1)			
Variety	(g-1)	M_1	$\sigma^2 + rdk^2_1$	M_1/M_2
Doses	(d-1)	M_2	$\sigma^2 + rgk^2_2$	M_2/M_3
Variety x Dose	(g-1)(d-1)	M_{12}	$\sigma^2 + rgk^2_{12}$	M_{12}/M_3
Error	(dg-1)	M_3	σ^2	

K^2 = variance f the fixed effect
σ^2 = variance of the random effect.
r = number of replications
g = number of varieties
d = number of doses.
σ^2 = Error variance.
σ^2_g=Genetic variance among varieties.
σ^2_d=Dosage variance among varieties.
σ^2_{gd}=Variety x dosage interaction variance.
Msubscript=The observed mean square of the subscripted effect.

Variance components were estimated from the expected mean squares for each character using the observed mean squares (Lukhele,1981; Hallauer and Miranda, 1986; Adjadi,1996). Thus:

$$\sigma^2 = M_e \quad with \quad S.E = \sqrt{\frac{2(M_e)^2}{df+2}}$$

$$\sigma^2_d = \frac{M_d - M_e}{rg} \quad with \quad S.E = \sqrt{(\frac{1}{rg})^2 \left[\frac{2(M_d)^2}{df+2} + \frac{2(M_e)^2}{df+2}\right]}$$

$$\sigma^2_g = \frac{M_g - M_e}{rd} \quad with \quad S.E = \sqrt{(\frac{1}{rd})^2 \left[\frac{2(M_g)^2}{df+2} + \frac{2(M_e)^2}{df+2}\right]}$$

$$\sigma^2_{gd} = \frac{M_{gd} - M_e}{r} \quad with \quad S.E = \sqrt{(\frac{1}{r})^2 \left[\frac{2(M_{gd})^2}{df+2} + \frac{2(M_e)^2}{df+2}\right]}$$

$$\sigma^2_{ph} = \frac{\sigma^2}{rd} + \sigma^2_g \quad with \quad S.E = \sqrt{(\frac{1}{rd})^2 \left[\frac{2(M_g)^2}{df+2}\right]}$$

The form of analysis of variance above was used for the analysis of each population generated and planted out in the rosette field during the 1997 and 1998 planting seasons. The studies on response of irradiated materials to rosette disease, were carried in the rosetted field. A different form of analysis of variance was used to compare performance of the groundnut varieties under these two field conditions and is shown in Table 3.

The statistical model used for this analysis of variance was:

$$Y_{ijk} = \mu + E_i + G_j + R_k + (GE)_{ij} + e_{ijk}.$$

Where:

μ = Overall mean.
E_i = Effect of the ith environment, i=1,2
G_j= Effect of the jth variety ,j=1,2.....5
R_k= Effect of the kth replication, k=1,2.
$(GE)_{ij}$= Interaction effect between jth variety and the ith environment
$E_i \sim NID (0, \sigma E)$
$G_j \sim NID (0\ \sigma G)$
$e_{ijk} \sim NID(0,\sigma^2)$

The environment (rosetted and rosette-free) was treated as random effect while the variety is fixed. Form of analysis of variance with the degrees of freedom, expected mean squares is shown below:-

TABLE 3: Form of ANOVA with expected mean squares (EMS) for each character in the M2 and M3 populations at 10 kr under rosette and rosette free conditions.

Source of variation	df	MS	EMS	F-Test
Replication	(r-1)			
Environments	(l-1)	M_l	$\sigma^2 + rg\sigma^2_l$	M_l/M_e
Variety	(g-1)	M_g	$\sigma^2 + r\sigma^2_{gl} + rlk^2_g$	M_g/M_e
Env .x Var.	(g-1)(l-1)	M_{gl}	$\sigma^2 + r\sigma^2_{gl}$	M_{gl}/M_e
Error	(r-1)(gl-1)	M_e	σ^2	

l=number of environments
r= number of replications
g= number of varieties
M subscript = observed mean squares of subscripted effect.
σ^2_{gl} =Variety x environment interaction variance.
σ^2 =Error variance

To compare performance of the irradiated materials under rosette and rosette free field conditions, including the doses as a source of variation, the following statistical model was used for the analysis of variance:-

$$Y_{ijkl} = \mu + G_i + D_j + E_k + R_l + (GD)_{ij} + (GE)_{ik} + (DE)_{jk} + (GDE)_{ijk} + e_{ijkl}$$

where

μ = overall mean.
G_i = Effect of i^{th} variety ,i=1,2,....5
D_j = Effect of j^{th} dose of irradiation ,j=1,2,.....6
E_k = Effect of k^{th} environment, k=1,2
R_l = Effect of l^{th} replication, l=1,2
$(GD)_{ij}$ = Effect of i^{th} variety and j^{th} dose of irradiation
$(GE)_{ik}$ = Effect of i^{th} variety in k^{th} environment.
$(DE)_{jk}$ = Effect of j^{th} dose in k^{th} environment.
$(GDE)_{ijk}$=Effect of j^{th} dose on i^{th} variety in k^{th} environment.

Environment (rosette and rosette free field conditions) was random, varieties and doses were fixed.

Table 4: Form of ANOVA with expected mean squares (EMS) for each character in M_2 Population at 0, 15, 20, 25, 30, 35 kr under rosette and rosette free field conditions.

Source of Variation	df	MS	EMS	F Test
Replication	(r-1)			
Env.(rosette)	(l-1)	M_l	$\sigma^2 + rgd\sigma^2_l$	M_l/M_e
Variety	(g-1)	M_g	$\sigma^2 + rd\sigma^2_{lg} + rldk^2_g$	M_g/M_e
Env x Variety	(l-1)(g-1)	M_{lg}	$\sigma^2 + rd\sigma^2_{lg}$	M_{lg}/M_e
Doses	(d-1)	M_d	$\sigma^2 + rg\sigma^2_{ld} + rlgk^2_d$	M_d/M_e
Env. x Doses	(l-1)(d-1)	M_{ld}	$\sigma^2 + rg\sigma^2_{ld}$	M_{ld}/M_e
Variety x Doses	(g-1)(d-1)	M_{gd}	$\sigma^2 + r\sigma^2_{lgd} + rlk^2_{gd}$	M_{gd}/M_e
Env.x Var.x Doses	(l-1)(g-1)(d-1)	M_{lgd}	$\sigma^2 + r\sigma^2_{lgd}$	M_{lgd}/M_e
Error	(r-1)(lgd-1)	M_e		

r=number of replications
g=number of varieties
d=number of doses
σ^2 =Error variance.
σ^2_g =Genetic variance among varieties.
σ^2_{gd}=Variety x dosage interaction variance.
σ^2_{gl}=Variety x environment interaction variance
σ^2_{ld} =Dosage x environment interaction variance
σ^2_{gld} =variety x environment x dosage interaction variance.

Correlation coefficients were calculated using the formular by Singh and Chaudary (1977):

$$r(x_1x_2) = \frac{Cov\,x_1x_2}{\sqrt{v(x_1)v(x_2)}}$$

Where:

$r(x_1x_2)$ = the correlation between characters x_1 and x_2

$cov(x_1x_2)$ = the covariance between x_1 and x_2

$v(x_1)$= the variance of character x_1, and

$v(x_2)$= the variance of character x_2

Heritability

The estimates of broad sense heritability (h^2_B) were made from the means of entries using the variance components, thus :

$$h^2_B = \frac{\sigma^2_g}{\sigma^2_{ph}} \quad with \quad SE = \frac{SE\ \sigma^2_g}{\sigma^2_{ph}}$$

CHAPTER 4

RESULTS

The results obtained in the study of these groundnut varieties *subjected to gamma irradiation* at different doses shows the following:

4.1 Population Means

Results on the grand means, standard error of the mean (S.E. X), ranges and the coefficients of variability (C.V.%) in the M_1 and M_2 populations are reflected in Table 5. Significant variation was observed for each character. In M_1 population, coefficient of variability ranged from 3.2% for days to fifty percent flowering to 33.2% for estimated pod yield. In M_2, the coefficients of variability for days to first flower appearance was lowest (2.2%) and highest for pod yield (23.34%). Wide ranges were observed in both populations for other characters such as number of mature pods per plant (6.50-20.00 and 18.00 - 51.00), plant height at harvest (17.00-44.50 cm and 19.30-44.20cm), haulm yield (1463-6903kg/ha and 2351-7253kg/ha) and pod yield (307 - 1108kg/ha and 635-2587kg/ha) in M_1 and M_2, respectively. The population showed variation for germination percentages, one hundred seed weight and shelling percentages.

4.2 Varietal Effects.

Mean performance of the varieties in the two populations

showed large differences between means of the control and the means of the irradiated populations (Tables 6 and 7). Germination percentages were found to decrease with increase in radiation doses. Short duration varieties (Ex-Dakar and RRB) had higher germination percentages than the medium variety (UGA7) and long duration varieties (MDR 8-19 and RMP 12) in both populations. Days to first flower appearance and days to fifty percent flowering showed a noticeable increase in number of days with increases in doses only in the M_1 population. All the varieties had increases in the number of days to first flower appearance and fifty percent flowering notably in irradiated populations of Ex-Dakar and RRB compared with the control.

Among the varieties studied; irradiated population of Ex-Dakar had the highest plant height at harvest (44.50cm and 44.20cm) under 15kr in both M_1 and M_2 respectively while RMP 12 had the lowest (17.00 at 35kr and 19.30cm at 30kr M_1 and M_2, respectively). The values obtained for yield and yield components were lower in M_1 than M_2 for the varieties studied. The medium and long duration varieties UGA-7, MDR8-19 and RMP12 yielded higher than Ex-Dakar and RRB in both populations except in M_1 where RMP12 had the lowest number of mature pods per plant (9.00) and in M_2 where Ex-Dakar had highest shelling percentage (66.75%).

4.3 Mutagenic Effects.

The effect of the doses on the characters studied in M_1 and M_2

are reflected in Table 8. Germination percentages in M_1, were highest (82.24%) at 15kr and lowest at 30 and 35kr (64.18 and 64.43%, respectively); in M_2 the lowest percentage (76.10%) was observed at 35kr.

Days to first flower appearance was affected by the doses. Increase in days were produced by all doses with 30 and 35kr resulting in the longest number of days in both M_1 and M_2. Days to fifty percent flowering was unaffected by the doses in M_2 but in M_1, 35kr produced longest number of days to fifty percent flowering (41 days) compared with 33 days observed at zero dose.

Effect on height of plants at harvest shows a distinct reduction in height with increase in doses in both populations. 15kr (28.40cm) produced similar effects with the control (29.80cm), 30 and 35kr produced the shortest plant (24.5 and 24.0 cm, respectively).Similar effects on plant height were seen in M_2.

Pod yield and haulm yield in M_1 did not reflect statistically significant difference among the doses but in M_2, increases in haulm yield of 240.14, 613.23 and 592.48kg/ha over the control (4473.56kg/ha) were recorded for 15,20 and 25kr, respectively. Increase in pod yield was only seen for 15kr with 41.92kg/ha higher than the control.

Dosage effects on one hundred seed weight and shelling percentage was more pronounced in M_1 than M_2 with a trend of reduced seed weight and shelling percentage as doses increased. Control

had the highest while 30kr had the lowest seed weight and shelling percentage.

Significant but negative character/dosage correlation coefficients were observed in the M_1 population for all the traits but days to first flower appearance and days to fifty percent flowering which had positive significant correlation coefficients. Non-significant positive correlation coefficients were observed in M_1 for all the traits except germination percentage and plant height at harvest which were negative. These coefficients are presented in Appendix I.

Table 5: Mean, Standard Errors, Ranges and Coefficients of variation for the M_1 and M_2 populations for nine characters.

	M_1				M_2			
Character	Mean ±	SE	Range	C.V(%)	Mean ±	SE	Range	C.V(%)
GP	72.60	6.42	49.00-97.50	8.90	84.90	4.99	60.50-99.60	8.31
DTFFA	31.78	1.67	26.50-37.50	5.20	27.00	0.41	25.00-29.50	2.20
DTFF	37.07	1.20	30.00-44.50	3.20	30.07	0.68	27.00-33.00	3.19
PHAH	26.53	2.25	17.00-44.50	8.50	28.17	1.99	19.30-44.20	9.98
NMPP	12.18	3.67	6.50-20.00	30.10	31.78	4.81	18.00-51.00	21.39
PY	613.46	202.1	307-1108	33.20	1427.77	235.64	635-2588	23.34
HY	3764.77	104.10	1463-6903	29.40	4651.60	654.96	2351-7253	19.91
OSW	36.94	3.40	21.00-55.90	9.20	35.23	1.65	23.20-43.4	6.64
SP	62.71	2.20	57.27-68.78	3.50	64.77	2.28	59.28-70.95	4.98

GP = Germination percentage
DTFFA= Days to first flower appearance
DTFF = Days to fifty percent flowering
PHAH = Plant height at harvest
NMPP = Number of mature pods per plant
PY = Pod yield
HY = Hadim yield
OSW = One hundred seed weight
S P= Shelling percentage

Table 6: Mean Performance of five groundnut varieties irradiated with 6 doses of gamma rays under field conditions during 1997 planting season at M_1 population.

VAR	DOSE	GP(%)	DTFFA	DTFF	PHAH	NMPP	PY (kg/ha)	HY (kg/ha)	OSW(g)	SP(%)
RRB	0	85.50	28	32	31.00	20	1108	2483	26.95	59.58
	15	88.00	31	35	25.00	18	742	2233	28.40	63.15
	20	80.50	32	36	28.00	17	692	1800	25.05	62.39
	25	82.50	32	36	24.50	20	637	2000	24.25	60.66
	30	69.00	34	37	22.50	12	518	1700	24.45	57.27
	35	60.00	34	38	23.50	13	550	1463	26.35	60.11
Mean		77.58	32	36	25.75	16	708	1947	25.91	60.53
SE		3.30	0.63	0.60	1.18	1.23	75.34	253	0.64	0.86
EX-DAKAR	0	87.50	27	30	40.00	15	621	2733	23.15	63.70
	15	97.50	29	33	44.50	12	548	2900	22.65	63.05
	20	83.00	31	34	39.00	12	360	2600	21.95	63.05
	25	75.00	30	36	32.00	11	449	2062	21.00	63.38
	30	86.50	30	34	36.50	18	524	3167	22.50	60.59
	35	70.00	33	35	38.00	8	487	2033	21.65	59.25
Mean		83.25	30	34	38.33	13	498	2583	22.15	62.17
SE		3.11	0.61	0.57	1.25	1.21	50.05	176	0.39	0.56
UGA7	0	79.00	29	36	25.50	11	777	4707	55.90	65.50
	15	80.88	33	38	26.00	11	579	4138	47.00	62.44
	20	85.00	33	38	25.50	9	652	4871	49.80	63.99
	25	85.50	34	40	25.00	11	527	3626	50.80	61.26
	30	54.00	35	40	23.00	8	474	3845	44.70	59.07
	35	69.00	32	42	22.50	11	671	4815	45.40	61.08
Mean		75.56	33	39	24.58	10	613	4334	48.93	62.45
SE		3.14	0.62	0.67	0.50	0.91	52.74	262	1.42	0.69
MDR8-19	0	70.50	29	35	27.00	12	773	4189	46.85	65.75
	15	77.50	31	37	23.00	14	770	4887	45.50	64.33
	20	77.50	33	38	23.00	16	836	5333	45.70	64.89
	25	62.50	32	39	22.50	16	724	5467	44.55	62.39
	30	58.00	32	38	22.50	12	634	4028	37.05	61.08
	35	71.50	31	43	19.00	10	570	2569	38.20	57.94
Mean		69.58	31	38	22.83	13	718	4412	42.97	62.73
SE		2.61	0.42	0.87	0.87	1.04	67.08	396	1.54	1.15
RMP12	0	59.00	32	36	25.50	8	606	5761	47.35	68.78
	15	66.50	32	37	23.50	9	611	4717	46.95	68.24
	20	49.00	35	37	19.50	10	513	6903	49.45	67.62
	25	64.00	33	39	18.50	11	591	4712	44.90	66.58
	30	51.50	36	43	19.50	10	30*	4810	40.65	62.99
	35	49.00	37	45	17.00	7	419	6161	40.05	62.55
MEAN		56.50	34	39	20.58	9	508	5511	44.89	66.13
SE		2.45	0.73	1.07	0.96	1.10	46.10	389	1.31	0.75

GP=Germination percentage
DTFF= Days to fifty percent flowering
NMPP= Number of mature pods per plant
HY=Haulm yield
SP= Shelling percentage

DTFFA=Days to first flower appearance
PHAH=Plant height at harvest
PY=Pod yield
OSW=One hundred seed weight

Table 7: Mean performance of 5 groundnut varieties irradiated with 6 doses of gamma rays under field conditions during 1998 planting season M

VAR	DOSE	GP(%)	DTFFA	DTFF	PHAH	NMPP	PY	HY	OSW	SP
RRB	0	99.0	26	28	28.65	30	1192.60	3009.25	25.20	64.35
	15	95.00	26	28	25.60	25	1043.75	3586.60	28.00	64.88
	20	97.50	26	28	29.65	35	1389.70	4057.05	28.50	66.40
	25	94.50	26	29	25.45	24	1206.15	2935.65	28.35	66.10
	30	92.00	27	29	23.05	22	888.55	2351.00	28.25	62.00
	35	97.00	27	29	23.65	25	848.20	2388.55	25.95	59.78
Mean		95.83	26	29	26.06	26	1095.00	3055.00	27.38	63.92
SE		1.02	0.21	0.26	1.11	2.67	122.06	242	0.71	1.04
Ex-Dakar	0	93.00	25	27	43.30	26	1071.80	5379.10	24.20	69.50
	15	97.50	25	28	44.20	24	1117.25	4122.20	24.35	68.53
	20	93.00	26	28	43.45	18	800.20	5014.90	23.45	66.90
	25	95.50	25	29	38.40	25	635.30	3510.10	23.20	62.30
	30	92.50	26	29	40.05	23	693.15	3492.05	27.50	68.00
	35	86.00	26	28	37.60	18	543.75	4021.15	24.00	65.25
Mean		92.92	26	28	41.14	22	810.00	4257.00	24.45	66.75
SE		1.57	0.15	0.28	0.98	2.29	101.43	250	0.57	1.16
UGA-7	0	86.50	29	32	23.60	29	1693.60	4013.45	42.80	62.58
	15	75.00	29	33	23.85	33	1848.00	5742.45	42.85	59.90
	20	80.50	28	32	26.05	24	1504.25	5068.90	43.05	61.08
	25	82.50	29	33	25.25	28	1335.80	5197.65	42.00	60.58
	30	91.50	29	32	20.40	25	1178.70	4274.40	41.45	59.90
	35	67.00	28	33	22.90	32	1716.75	3984.05	38.65	59.28
Mean		81.30	28	33	33.67	28	1546.00	4713.00	41.80	60.55
SE		2.73	0.14	0.24	0.73	1.25	95.90	269	0.71	0.69
MDR8-19	0	84.00	27	31	27.60	36	1307.25	4426.65	39.00	66.65
	15	95.00	27	30	28.20	33	1371.95	4312.00	40.55	67.75
	20	86.00	26	30	30.50	35	1732.90	4845.70	43.20	62.43
	25	85.00	27	30	26.35	37	1955.85	6448.40	43.45	67.93
	30	85.00	28	31	24.75	39	1351.10	4563.45	42.55	64.73
	35	60.50	28	31	24.15	39	1583.75	4490.00	39.35	70.95
Mean		82.67	29	30	26.62	37	1545.00	4848.00	41.35	66.74
SE		3.30	0.19	0.25	0.77	1.15	111.24	280	0.77	1.40
RMP12	0	79.50	28	31	29.10	51	2485.90	5539.35	40.40	69.13
	15	79.50	28	32	24.60	47	2579.60	5805.05	38.65	66.88
	20	75.00	29	33	21.80	48	2241.70	6447.40	42.05	67.90
	25	69.00	29	32	23.05	49	2587.90	7253.20	41.70	64.13
	30	62.50	30	31	19.30	39	1391.35	6527.80	42.60	65.10
	35	70.00	28	31	20.20	40	1566.20	6740.20	41.20	62.18
Mean		72.58	29	31	23.01	46	2142.00	6386.00	41.17	65.88
SE		3.24	0.22	0.36	1.21	2.68	176.60	355	0.55	1.07

GP=Germination percentage
DTFF= Days to fifty percent flowering
NMPP= Number of mature pods per plant
HY=Haulm yield
SP= Shelling percentage
DTFFA=Days to first flower appearance
PHAH=Plant height at harvest
PY=Pod yield
OSW=One hundred seed weight

Table 8: Average effect of the irradiation doses on the characters studied in the M_1 and M_2 generations.

Factor	Characters								
Doses	GP	DTFFA	DTFF	PHAH	NMPP	PY	HY	OSW	SP
					M_1				
0	76.25	28.70	33.60	29.80	13.00	777.31	3974.73	40.04	64.66
15	82.24	31.10	35.80	28.40	12.70	650.16	3785.04	38.10	64.24
20	74.75	32.60	36.40	27.00	12.70	637.6	4341033	38.19	64.39
25	73.75	31.80	37.90	25.50	13.50	585.69	3571.41	37.10	62.59
30	64.18	33.10	38.20	24.50	11.70	491.32	3509.84	33.87	60.20
35	64.43	33.40	40.50	24.00	9.50	538.69	3406.25	34.33	60.19
mean	72.6	31.78	37.07	26.53	12.18	613.460	3764.77	36.94	62.71
S.E	1.987	0.402	0.436	0.737	1.244	67.472	345.841	1.070	0.737
					M_2				
0	88.40	26.70	29.50	30.49	34.00	1550.23	4473.56	34.40	66.44
15	88.40	26.90	29.90	29.33	32.00	1592.15	4713.70	34.88	65.59
20	86.40	26.70	30.00	30.29	32.00	1533.75	5086.79	36.05	64.94
25	85.30	26.90	30.40	27.70	33.00	1544.20	5069.04	35.74	64.21
30	84.80	27.60	30.30	25.51	29.00	1100.57	4241.74	36.47	63.95
35	76.10	27.20	30.30	25.70	31.00	1245.73	4324.79	33.83	63.49
mean	84.90	27.00	30.07	28.17	31.78	1427.77	4651.60	35.23	64.77
S.E	2.231	0.183	0.304	0.889	2.150	205.383	292.908	0.739	1.020

GP =Germination percentage
DTFF =Days to fifty percent flowering
NMPP = Number of mature pods per plant
HY =Haulm yield
SP = Shelling percentage

DTFFA =Days to first flower appearance
PHAH =Plant height at harvest
PY =Pod yield
OSW =One hundred seed weight

4.4. Population Variability

Mean square values for the characters in the two populations are shown in Tables 9. The mean squares for the M_1 population shows significant differences in replications for days to fifty percent flowering, number of mature pods per plant and pod yield. In M_2, highly significant differences in replications were seen for number of mature pods per plant, pod yield and shelling percentage. Differences in doses were highly significant for germination percentage, days to first flower appearance, days to fifty percent flowering, plant height at harvest, one hundred seed weight and shelling percentage in M_2. In M_1 population, significant differences for doses were recorded in germination percentage, plant height days to first flower appearance and pod yield.

Highly significant differences were observed among varieties for all traits in both population. The differences in interaction between dose and variety were significant for only germination percentage and days to fifty percent flowering in M_1 population. No significant differences were observed in the interaction between doses and variety in M_2.

4.5 Estimates of Variance Components

Estimates of the genetic variance (σ_g), genotype x dosage interaction variance (σ_{gl}) components and their standard errors

Table 9: Mean squares from the ANOVA for the characters studied in the M_1 and M_2 generation in 1997 and 1998 planting seasons

SS	df	GP	DTFFA	DTFF	PHAH	NMPP	PY	HY	OSW	SP
					M_1 generation					
Replication	1	0.27	7.35	15.00**	0.82	74.82*	243156*	238359	11.35	11.84
Dose	5	521.31**	31.71**	55.67**	55.69**	20.74	93577	1152525	58.63**	43.34**
Variety	4	1234.23**	23.32**	70.18**	578.04**	103.27**	132703*	25845728**	1751.78**	50.84**
Dose x var.	20	110.02*	4.03	3.18*	9.12	12.09	20519	1025430	11.84	3.49
Error	29	41.27	2.79	1.45	5.08	13.44	40846	1218714	11.53	4.85
					M_2 generation					
Replication	1	77.07	0.27	3.27	30.82	828.82**	1952324**	1630861	4.99	194.76**
Dose	5	208.7*	1.20*	1.14	49.24**	27.74	414006*	1347982	10.48	12.27
Variety	4	1079**	21.21**	38.98**	665.10**	1020.36**	3091184**	17263936**	881.32**	82.65**
Dose x Var.	20	85.13	0.36	0.81	6.33	33.23	152292	974870	3.88	11.93
Error	29	49.79	0.34	0.92	7.90	46.23	111056	857948	5.47	10.40

*,** = Significant at 5 % and at 1% level of probability, respectively.
GP=Germination percentage DTFFA=Days to first flower appearance DTFF= Days to fifty percent flowering
PHAH=Plant height at harvest NMPP= Number of mature pods per plant PY=Pod yield
HY=Haulm yield OSW=One hundred seed weight SP= Shelling percentage

obtained from the analysis of variance for the M_1 and M_2 populations are reflected in Tables 10 and 11. The magnitude of σ^2_g was larger than that of σ^2_{gd} for all the characters. The genotype x dosage interaction variance component values were small or had negative values with larger standard errors than the estimates, except for germination percentage confirming the non-significance of interaction of genotype and dosage mean square values in the analysis of variance shown in Table 9. Days to fifty percent flowering, plant height at harvest, number of mature pods per plant and one hundred seed weight values were negative for M_2 (Table 11) while number of mature pods per plant, pod yield, haulm yield and shelling percentage were negative for this interaction in M_1 (Table 10).

Phenotypic variance estimates were larger than their standard errors; the error variance estimates were at least three times larger than their associated standard error estimates in both M_1 and M_2 population.

Heritability estimates were only estimated for M_2 population (Table 11). The estimates recorded were high for all the characters measured: highest values were for plant height at harvest (0.99) and one hundred seed weight (0.99). Standard errors of estimates were all smaller than the estimates for all the characters.

Table 10 : Estimates of genetic variance (σ^2_g), genotype x dose interaction (σ^2_{gd}), dosage variance (σ^2_d), phenotypic variance (σ^2_{ph}) and error variance (σ^2) for the nine characters studied at M_1 generation

Character	σ^2_g	σ^2_{gd}	σ^2_d	σ^2_{ph}	σ^2
GP	100.16 ± 59.81	34.38 ± 17.39	48.00 ± 27.88	103.59 ± 59.81	41.27 ± 0.48
DTFFA	1.711 ± 1.26	0.62 ± 0.70	2.89 ± 1.69	1.84 ± 1.12	2.79 ± 0.70
DTFF	5.73 ± 3.37	0.87 ± 0.51	5.42 ± 2.97	5.85 ± 3.37	1.45 ± 0.36
PHAH	47.75 ± 27.81	2.03 ± 1.51	5.06 ± 2.97	48.17 ± 27.80	5.06 ± 1.28
NMPP	7.49 ± 4.977	-0.68 ± 2.49	0.73 ± 1.15	8.60 ± 4.96	13.44 ± 3.41
PY	7654.75± 6442.74	-10163± 6039	5793 ± 10374	11058 ± 6384	40946 ± 10374
HY	2052251± 1243730	-96642± 154589	-6578 ± 61626	2153810 ±1243463	1218714± 309553
OSW	145.02 ± 84.28	0.16 ± 2.30	4.71 ± 3.14	145.98 ± 84.28	11.53 ± 3.24
SP	3.83 ± 2.44	-0.68 ± 0.81	3.85 ± 2.31	4.23 ± 2.44	4.85 ± 1.23

GP=Germination percentage
DTFFA=Days to first flower appearance
DTFF= Days to fifty percent flowering
PHAH=Plant height at harvest
NMPP= Number of mature pods per plant
PY= Pod yield
HY=Haulm yield
OSW=One hundred seed weight
SP= Shelling percentage

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Table 11 : Estimates of genetic variance (σ^2_g), genotype x dose interaction (σ^2_{gd}), dosage variance (σ^2_d), phenotypic variance (σ^2_{ph}) and error variance (σ^2) and broad sense heritability for the nine characters studied at M_2 generation.

Character	σ^2_g	$\sigma^2_{g\,d}$	σ^2_d	σ^2_{ph}	σ^2	h^2_b
GP	85.81 ± 51.95	1767 ± 14.30	15.89 ± 11.22	89.96 ± 51.9[illegible]	49.79 ± 2.64	0.95 ± 0.60
DTFFA	1.74 ± 1.02	0.01 ± 0.07	0.09 ± 0.06	1.77 ± 0.20	0.34 ± 0.08	0.98 ± 0.57
DTFF	3.17 ± 1.87	-0.06 ± 0.17	0.02 ± 0.06	3.25 ± 1.87	0.92 ± 0.23	0.98 ± 0.57
PHAH	54.77 ± 31.99	-0.78 ± 1.38	4.13 ± 2.64	55.43 ± 31.99	7.89 ± 2.00	0.99 ± 0.57
NMPP	81.18 ± 49.10	-6.50 ± 7.71	-1.85 ± 1.89	85.03 ± 49.09	46.23 ± 11.74	0.96 ± 0.57
PY	248343± 148738	20617 ± 26945	30294 ± 22308	257598± 148719	111056± 28208	0.96 ± 0.57
HY	1375419 ±830785	58461 ± 182952	49003 ± 75276	1446915 ±830587	857948± 217919	0.95 ± 0.57
OSW	72.99 ± 42.40	-0.80 ± 0.90	0.501 ± 0.57	73.45 ± 42.40	5.47 ± 1.38	0.99 ± 0.57
SP	6.02 ± 4.30	0.77 ± 2.23	0.19 ± 0.70	6.89 ± 3.97	10.40± 2.64	0.87 ± 0.62

GP=Germination percentage
DTFFA=Days to first flower appearance
DTFF= Days to fifty percent flowering
PHAH=Plant height at harvest
NMPP= Number of mature pods per plant
PY=Pod yield
HY=Haulm yield
OSW=One hundred seed weight
SP= Shelling percentage

4.6 Correlations

Phenotypic correlation coefficients between the characters measured in the M_1 and M_2 populations are presented in Table 12. These coefficients determine the association between the characters studied.

In M_1, the phenotypic correlations indicate highly significant (P=0.01) correlations between germination percentage, days to first flower appearance, days to fifty percent flowering and plant height at harvest. Positive correlations exist between days to first flower appearance and days to fifty percent flowering. The flowering traits had negative correlations with plant height at harvest, number of mature pods per plant and shelling percentage. They also had highly significant (P=0.01) but positive correlations with haulm yield and one hundred seed weight. It was seen that pod yield and other yield components (number of mature pods per plant, shelling percentage, haulm yield, one hundred seed weight) in this M_1 population showed some negative values. Number of mature pods had highly significant but negative correlations with one hundred seed weight, non significant negative correlations with haulm yield and shelling percentage. Non significant positive correlations were obtained between pod yield and haulm yield.

Results in M_2 differed from that of M_1, though highly significant correlations were also generally seen among most of the characters. Germination percentage had highly significant (P=0.01) correlations with all the other characters measured

except shelling percentage: those correlations were only positive for plant height at harvest. Highly significant (P=0.01) and positive correlations existed between days to first flower appearance and days to fifty percent flowering, as also observed in M_1. Negative and highly significant correlation were seen between the two flowering characters and plant height at harvest. Days to first flower appearance and days to fifty percent flowering had positive and highly significant (P=0.01) correlations with number of mature pods per plant, pod yield, haulm yield and one hundred seed weight. Negative correlations with shelling percentage in both populations indicated that the fewer the number of days to flowering, the fuller the pods. As in M_1, plant height at harvest was negatively correlated with number of mature pods per plant, pod yield, haulm yield and one hundred seed weight. Plant height correlation with these yield parameters were highly significant (P=0.01) except with haulm yield and shelling percentage. Pod yield and other yield components had significant and positive correlations with one another in this M_2 population except between one hundred seed weight and shelling percentage where negative correlations were recorded.

Table 12 : Phenotypic correlation coefficients between characters studied in the M_1 and M_2 populations N=60

	2	3	4	5	6	7	8	9
			M_1					
1	-0.6002**	-0.5404**	0.6605**	0.4544**	0.3036*	-0.4267**	-0.3225*	-0.0735
2		0.7137**	-0.5789**	-0.3891**	-0.3672**	0.3399**	0.3102*	-0.0789
3			-0.7349**	-0.3879**	-0.2691*	0.3249**	0.4465**	-0.1895
4				0.2528	-0.0276	-0.4017**	-0.6087**	-0.0738
5					0.5694**	-0.2520	-0.3567**	-0.1159
6						0.0398	0.1612	0.1474
7							0.6926**	0.5141**
8								0.4789**
9								
			M_2					
1	-0.6802**	-0.5718**	0.4564**	-0.5253**	-0.4787**	-0.6234**	-0.5825**	-0.1122
2		0.8412**	-0.7063**	0.4251**	0.4857**	0.4794**	0.7709**	-0.2071
3			-0.6427**	0.4394**	0.5668**	0.3983**	0.7740**	-0.2491
4				-0.2961*	-0.3343**	-0.1047	-0.6424**	0.3761
5					0.8312**	0.6303**	0.5462**	0.3728**
6						0.6691**	0.6305**	0.2351*
7							0.5410**	0.2599*
8								-0.1003
9								

*,** = Significant at 5% and 1% level of probability, respectively.

1 = Germination percentage
2 = Days to first flower appearance
3 = Days to fifty percent flowering
4 = Plant height at harvest
5 = Number of mature pod/ plant
6 = Pod yield
7 = Haulm yield
8 = One hundred seed weight
9 = Shelling percentage

4.7 Comparisons among Varieties under Rosette and Rosette Free Field Conditions

Mean performance and variabilities displayed by varieties.

The varieties with surviving plants at 10 kr obtained from the first set of irradiated materials were observed at M_2 and M_3 populations under rosette and rosette free field conditions. The analysis of variance is presented in Table 13. There were differences between the analysis of M_2 and M_3: M_2 was evaluated in 1997 and 1998 due to the low rosette incidence in 1997 caused by poor inoculation in the field. Two varieties (UGA7 and RMP12) could not be evaluated in due to poor germination. The remaining four varieties went through proper screening and gave valid results after being analysed alongside with the M_3 population which was also being evaluated for rosette resistance. Table 13 shows that there were highly significant differences in environments for all the characters measured except for days to fifty percent flowering in M_2.

Germination percent, Days to first flower appearance and pod yield were not affected by environment in M_2. Highly significant varietal differences were recorded for all the characters measured in the two populations. Mean performance of the varieties is shown in Appendix II. Performance in M_3 was better than M_2 probably due to better stability with advancement in generations. The results in Appendix II show that 10kr did not produce significantly different effects on the varieties. Pod yields in the rosette free(RF) fields for the long

Table 13: Mean squares from the ANOVA for characters studied in the M_2 and M_3 generations at (10kr) under rosette and rosette-free field conditions.

Source of variation	df	GP	DTFFA	DTFF	PHAH	NMPP	PY	HY	SP	OSW
					M_2					
Replication	1	1.56	0.00	2.25	5.69	71.93	238913	319075	468.1	27.56
Env.(Ros)	1	1785**	2.25**	2.25	830.30**	3513.33**	5991248**	73253528**	2004.8**	438.9**
Variety	3	2462**	2.17**	13.08**	66.82**	100.11**	639259**	9601600**	453.0	379.79**
Env.x Var.	3	48.06	1.08	0.75	48.71	61.91	178551*	1096319	596.4	97.16
Error	7.	11.56	0.29	0.54	12.90	20.18	43247	1067481	278.2	38.12
					M_3					
Replication	1	12.04	0.38	0.04	21.57*	47.04	10041	40109	2.84	0.16
Env.(Ros)	1	247.04	2.04**	1.04	900.99**	5353.11**	7841198	62038216**	5.62	136.33**
Variety	5	234.74	4.24**	8.44**	21.38**	258.84**	842257**	4839567**	39.11*	159.49**
Env.x var.	5	33.74	1.24**	1.24	42.52**	47.63	71533	327394	21.62	18.97
Error	11	19.59	0.1	0.41	3.28	17.13	32771	403228	11.42	6.64

*,** = Significant at 5% and 1% level of probability respectively.
GP=Germination percentage
DTFFA=Days to first flower appearance
DTFF= Days to fifty percent flowering
PHAH=Plant height at harvest
NMPP= Number of mature pods per plant
PY=Pod yield
HY=Haulm yield
OSW=One hundred seed weight
SP= Shelling percentage

duration varieties shows MDR 8-19 (1986 kg/ha), RMP 12 (1944 kg/ha) and UGA 7 (1962kg/ha) outyielded the unirradiated cross (1468kg/ha) and the short duration varieties RRB (1063kg/ha) and Ex-Dakar (679 kg/ha) yielded lower than the unirradiated cross, similar trends were seen for haulm yield, shelling percentage and one hundred seed weight.

In the rosette field (R) mean performance also showed that irradiation at 10kr did not particularly change the agronomic performance of the varieties studied compared with the unirradiated cross. Susceptible varieties RRB(9kg/ha) and Ex-Dakar (3kg/ha) showed the usual susceptibility and yielded lower than the unirradiated cross (63kg/ha) while the yields of resistant lines MDR 8-19 (780kg/ha), RMP 12 (559kg/ha) and UGA-7 (829kg/ha) were higher. From the known yields of these varieties when unirradiated, performance of these irradiated materials did not differ significantly. It shows that 10kr might not be very effective in altering significantly these varieties to produce exploitable genotypes with potentials for selection in the characters studied especially resistance to rosette.

The second irradiation done at other doses greater than 10kr were also evaluated under rosette and rosette free fields and the results are presented in Table 14 and 15. Table 15 shows the mean squares for the characters studied in the M population at 0, 15, 20, 25, 30 and 35 kr under rosette and rosette free conditions. Highly significant differences were observed in environments for all traits except days to first flower appearance

and one hundred seed weight. All the varieties performed better under rosette free conditions than rosette conditions for most of the characters measured.

Differences in varieties were highly significant for all the characters studied. Mean performance in Table 14 reveals how the varieties performed under the different field conditions. Germination percentage in the rosette free field was higher, RRB has the highest (95.83%) while RMP12 had the lowest (72.58%). In the rosette field Ex-Dakar had the highest percentage (84.25%) while MDR 8-19 and RMP 12 had the lowest of 73%. Results on days to first flower appearance and days to fifty percent flowering are similar. In the rosette and rosette free field, RRB and EX-Dakar initiated flower earlier than the other varieties, RMP-12 was the latest and had the longest days (28 and 33 days) in rosetted environments (28 and 31 days) in the rosette free environment.

Means of plant height at harvest shows RRB with shortest plants (12.52cm) and MDR 8-19 with the tallest (19.78cm) in the rosetted environment, while in the rosette free, RMP 12 had the shortest plants (23.0cm) while Ex-Dakar had the tallest (41.14cm). This is not surprising when one considers that this variety has an erect growth habit and the medium and long duration varieties UGA-7, MDR 8-19 and RMP-12 have semi erect habits.

Table 14: Mean performance of groundnut varieties in M at 0, 15, 20,25, 30 and 35kr under rosette and rosette free field conditions

VAR	DOSE	GP(%)		DTFFA		DTFF		PHAH	
		R	RF	R	RF	R	RF	R	RF
RRB	0	77.00	99.00	26	26	30	28	11.80	28.85
	15	89.00	95.00	27	26	30	28	13.95	25.80
	20	76.00	97.50	27	26	30	28	11.45	29.65
	25	85.00	94.50	26	26	30	29	14.80	25.45
	30	76.00	92.00	27	27	29	29	10.55	23.05
	35	74.00	97.00	26	27	29	29	12.55	23.65
Mean		80.00	95.83	26	26	30	29	12.52	26.06
Ex-Dakar	0	87.50	93.00	25	25	29	27	17.60	43.30
	15	87.00	97.50	26	25	30	28	19.00	44.20
	20	92.00	93.00	26	26	30	28	15.60	43.45
	25	84.00	95.50	25	25	30	29	16.20	38.40
	30	78.00	92.50	27	26	30	29	14.50	40.05
	35	83.00	86.00	26	26	30	28	16.70	37.60
Mean		84.00	92.92	26	26	29	28	16.59	41.14
UGA-7	0	78.50	86.50	28	29	31	32	22.00	23.60
	15	61.00	75.00	28	29	31	33	16.90	23.85
	20	73.00	80.50	28	28	33	32	18.10	26.05
	25	73.50	82.50	28	29	32	33	18.10	25.25
	30	97.50	91.50	29	29	33	32	19.90	20.40
	35	70.00	67.00	28	28	33	33	19.50	22.90
Mean		76.00	81.30	28	28	33	33	19.05	33.67
MDR8-19	0	77.50	84.00	27	27	30	31	21.30	27.60
	15	74.50	95.00	28	27	31	30	18.90	28.20
	20	76.00	86.00	28	26	31	30	19.80	30.50
	25	76.00	85.00	27	27	31	30	20.80	26.35
	30	61.00	85.00	28	28	33	31	18.30	24.75
	35	71.00	60.50	27	28	31	31	19.80	24.15
Mean		73.00	82.67	28	29	31	30	19.78	26.62
RMP12	0	81.00	79.50	29	28	33	31	20.30	29.10
	15	69.00	79.50	28	28	33	32	17.90	24.60
	20	84.50	75.00	28	29	34	33	15.50	21.80
	25	54.00	69.00	28	29	33	32	21.20	23.05
	30	91.50	62.50	28	30	34	31	15.90	19.30
	35	61.50	70.00	29	28	33	31	16.10	20.20
Mean		74.00	72.58	28	29	33	31	17.80	23.01

GP=Germination percentage DTFFA=Days to first flower appearance
DTFF= Days to fifty percent flowering PHAH=Plant height at harvest

Table 14:Continues:

VAR	DOSE	NMPP		PY		HY		OSW		SP	
		R	RF	R	RF	R	RF	R	RF	R	RF
RRB	0	3	30	54	1192	1090	3009	22.10	25.20	57.33	64.35
	15	2	25	17	1043	959	3586	20.90	28.00	57.29	64.88
	20	3	35	88	1389	836	4057	20.60	28.50	58.68	66.40
	25	2	24	104	1206	884	2935	20.35	28.35	54.41	66.10
	30	1	22	170	888	472	2351	22.63	28.25	56.02	62.00
	35	1	25	35	848	712	2388	23.00	25.95	57.05	59.78
Mean		2	26	78	1095	826	3055	21.60	27.38	56.79	63.92
Ex-	0	2	26	58	1071	1170	5379	22.55	24.20	66.90	69.50
Dakar	15	1	24	24	1117	1034	4122	19.00	24.35	66.17	68.53
	20	0	18	108	800	807	5014	28.83	23.45	58.37	66.90
	25	1	25	17	635	881	3510	20.60	23.20	68.17	62.30
	30	0	23	09	693	698	3492	22.00	27.50	52.93	68.00
	35	1	18	10	543	829	4021	20.00	24.00	64.70	65.25
Mean		1	22	38	810	903	4257	22.16	24.45	62.87	66.75
MDR8-	0	21	36	1152	1307	3198	4426	41.50	39.00	70.10	66.65
19	15	19	33	997	1371	2721	4312	39.10	40.55	70.68	67.75
	20	15	35	858	1732	2670	4845	40.40	43.20	70.30	62.43
	25	22	37	961	1955	2846	6448	40.05	43.45	67.20	67.93
	30	15	39	694	1351	2662	4563	41.10	42.55	68.80	64.73
	35	13	39	649	1553	2608	4490	37.30	39.35	67.40	70.95
Mean		17	37	885	1545	2784	4848	39.91	41.35	69.09	66.74
UGA-7	0	14	29	945	1693	3042	4013	39.15	42.80	66.10	62.58
	15	13	33	609	1848	2508	5742	39.10	42.85	64.78	59.90
	20	13	24	640	1504	2663	5068	41.90	43.05	63.55	61.08
	25	13	28	605	1335	2304	5197	38.50	42.00	64.40	60.58
	30	14	25	504	1178	3125	4274	43.00	41.45	56.25	59.90
	35	12	32	621	1716	2420	3984	39.65	38.65	64.98	59.28
Mean		13	28	654	1546	2677	4713	40.22	41.80	63.33	60.55
RMP12	0	16	51	1018	2485	3366	5539	39.90	40.40	70.78	69.13
	15	12	47	727	2579	2727	5805	38.60	38.65	69.55	66.88
	20	14	48	644	2241	2636	6447	37.40	42.05	68.78	67.90
	25	12	49	603	2587	2511	7253	40.00	41.70	69.73	64.13
	30	15	39	590	1391	2708	6527	39.60	42.60	72.75	65.10
	35	13	40	721	1566	4197	6740	39.70	41.20	68.57	62.18
Mean		14	45	718	2142	3024	6386	39.20	41.17	70.99	65.38

NMPP= Number of mature pods per plant PY=Pod yield
HY=Haulm yield OSW=One hundred seed weight
SP= Shelling percentage

Table 15: Mean squares from the ANOVA for characters studied in M_1 population at 0, 15, 20, 25, 30 and 35 kr.

Source of variation	df	GP	DTFFA	DTFF	PHAH	NMPP	PY	HY	SP	OSW
Replication	1	60.21	0.30	0.21	23.38	404.07**	1227803**	279276	81.52**	318.68**
Env.(Rosette)	1	1896.08**	0.00	35.21**	3638.92**	14976.74**	27264002**	204167168**	204.61**	2.88
Variety	4	1100.24**	36.32**	73.09**	342.68**	1472.63**	4392434**	28516314**	2016.88**	287.34**
Dose	5	300.75**	1.87**	3.53*	40.62**	31.37	361792**	506938	16.56**	33.09*
Env.x Variety	4	235.60**	0.46	1.31	418.55**	232.04**	522749**	2835122**	19.47*	145.70**
Env.x Dose	5	73.94	0.28	0.77	20.82	3.71	133297	1192258	4.63	8.31
Var.x Dose	20	151.35**	0.22	0.64	6.39	15.58	82039	693365	3.84	10.94
Env.xVar.xDose	20	125.68*	0.49	0.95	4.52	23.12	94307	521204	7.47	21.25
Error	59	56.92	0.37	1.09	9.16	32.73	80217	507783	6.37	11.55

*, ** Significant at 5% and1% level of probability, respectively.

GP=Germination percentage
DTFFA=Days to first flower appearance
DTFF= Days to fifty percent flowering
PHAH=Plant height at harvest
NMPP= Number of mature pods per plant
PY=Pod yield
HY=Haulm yield
OSW=One hundred seed weight
SP= Shelling percentage

From observation, the mutagens had more pronounced effect on shortening the plant height in the long duration varieties than the short duration varieties.

Ex-Dakar had the lowest number of mature pods per plant (1) and pod yield (38kg/ha) while MDR 8-19 had the highest number of mature pods per plant(17) and pod yield (885kg/ha) in the rosette field. In the rosette free field, Ex-Dakar still had the lowest number of mature pods per plant (22) and pod yield (810kg/ha) and RMP-12 had highest number of mature pods per plant (45)and pod yield (2142kg/ha). Haulm yield results showed RRB with the lowest (826 kg/ha and 3055kg/ha) and RMP-12 with the highest (3024kg/ha and 6386kg/ha) in the rosette and rosette free fields, respectively.

Results on shelling percentage and one hundred seed weight indicated RRB to have the lowest shelling percentage (56.79%) and one hundred seed weight (21.60g), RMP-12 had the highest shelling percentage (70.19%) and UGA-7 had the highest one hundred seed weight (40.22g) in the rosette environment. These results further confirm the susceptibility of early maturing varieties RRB and Ex-Dakar under rosette disease conditions. In the rosette free environment, UGA-7 had the lowest shelling percentage (60.55%) and Ex-Dakar the highest (66.75) while for seed weight, Ex-Dakar had the lowest (24.45g) and UGA-7 the highest (41.80g).

The performance of these varieties under these two environments differ greatly and these differences are further confirmed by the highly significant differences in interaction of

variety and environment (Table 15) for most of the characters studied. The observed differences in these characters are understandable since under disease conditions, height is greatly affected especially in susceptible varieties, also yield and components such as pods per plant, pod yield, haulm yield and seed weights. Days to first flowers appearance and to fifty percent flowering were unaffected across environments because the rosette disease does not stop flower initiation in the diseased plants.

The effects of the doses on the characters studied at the M population in rosetted environment was similar to that obtained in the rosette free environment (Table 14). This is further confirmed by the analysis of variance (Table 15) where the mean squares for all the characters studied showed non significant differences for the environment x dose interaction. The differences in interaction between environment, variety and doses were not significant for all characters except the germination percentage.

4.8 Disease reactions for irradiated varieties at M_2 grown in groundnut rosette field.

The results of the disease reactions of the varieties are presented in Fig 1 (a-e),and Appendix III. Disease incidence varied among the doses within each variety. In RRB, zero dose had the highest incidence (95.0%) followed by 35kr (88.0%) while dose 25kr had the lowest (78%) at 65 days after inoculation. The progress of the disease in this variety was observed to be more

rapid for the zero dose than the other doses. Incidence in Ex-Dakar showed that 15kr and 35kr produced the highest incidence of 96.0% and 30kr, the lowest (86.0%). Disease progress was found to be faster in lower doses for Ex-Dakar, while in 30kr progress was slow from a week after inoculation to 65 days at which the last record was taken. In MDR 8-19, incidence ranged from 12% for 20kr to 28% for 35kr, in RMP-12 the range was from 5% for dose zero to 22% for 30kr while in UGA-7, it ranged from 5% for 30kr to 39% for 25kr. Disease progress was faster at higher doses (30 and 35 kr) for the long duration varieties except for 30 kr in UGA-7. This was probably due to the ability of higher doses of gamma rays to cause disturbances in plants and also varying sensitivities to the radiation among the varieties. Disease index values (Table 16) show a similar trend as the disease incidence results. In RRB and Ex-Dakar disease index values were quite high (4-5). Plants with reduced stunting were observed for doses 15, 20 and 25 kr for RRB. Disease index values for MDR 8-19 ranged from 2.52 for zero dose to 3.18 for 35kr which produced the higher number of plants with stunt greater than 70%. Disease index values for UGA-7 ranged from 2.21 for zero dose to 2.89 for 35kr. Few highly stunted plants were recorded at higher doses of 30 and 35kr.

Zero dose in RMP12 had the lowest value of 1.48 followed by 1.52 for 35kr. 30kr had the highest of 2.52. For the M_1 and M_2 generations at 10kr, disease incidence and index values are also presented in Fig.2a and 2b and Table 16. Reaction of varieties

at this dose shows that, in M_2 the varieties had lower index values than in the M_1 population. It was observed that the values obtained in the irradiated population. were higher than that obtained for unirradiated population except in UGA-7 where there was a slight difference. This indicates that obtaining the desirable mutant showing resistance with 10kr might not be feasible.

Fig 1 (a-e): Disease progress curves of groundnut varieties (RRB, Ex-Dakar, MDR8-19, RMP12 and UGA-7) in M at 0, 15 20, 25, 30 and 35 kr under rosette disease field condition.

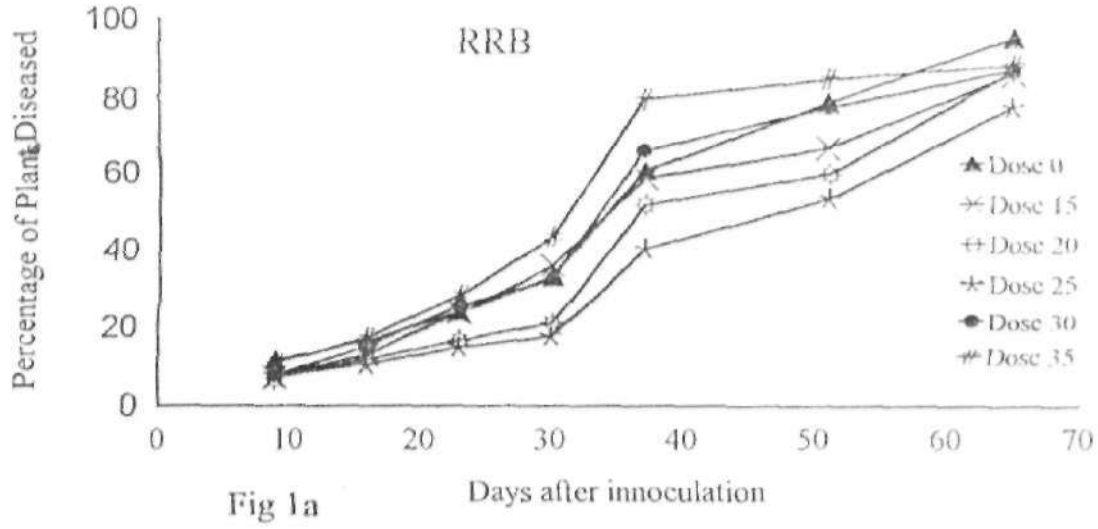


Fig 1a

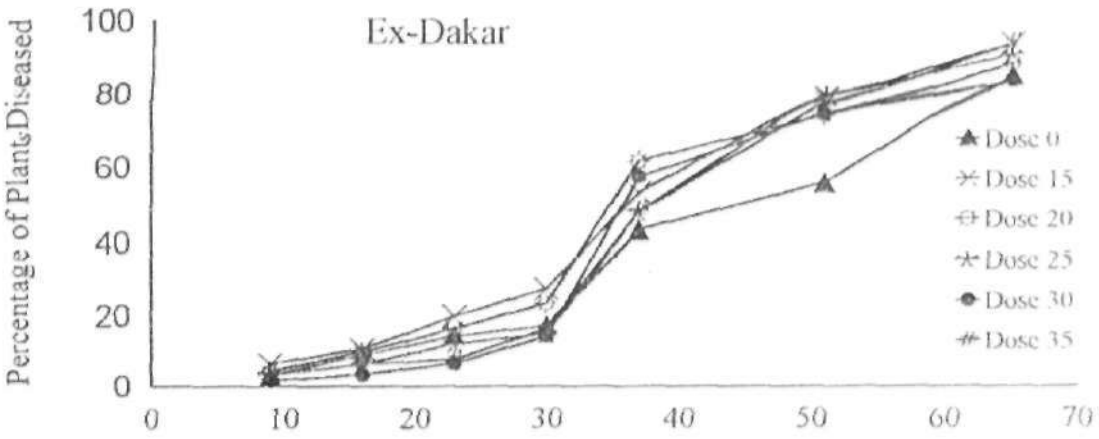


Fig 1b

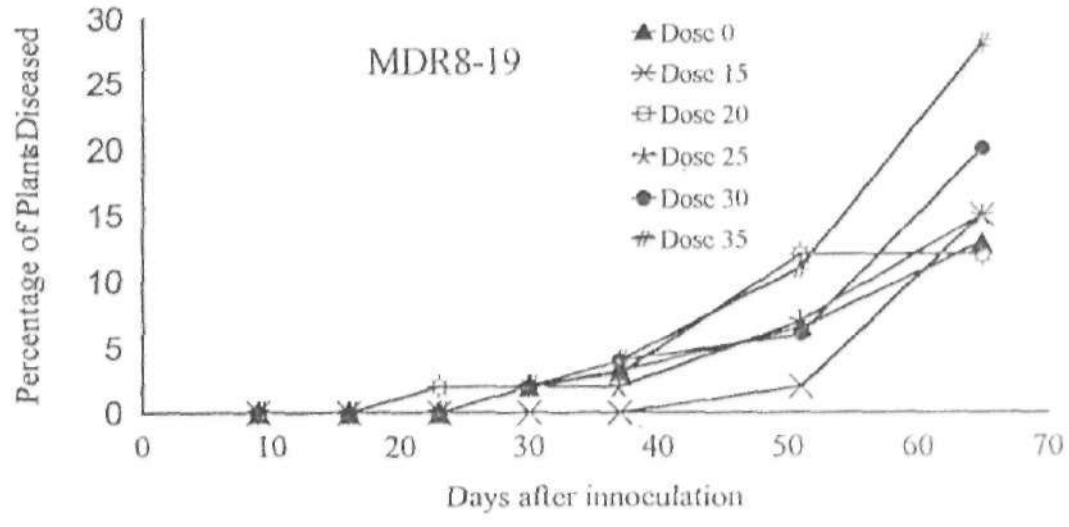


Fig 1c

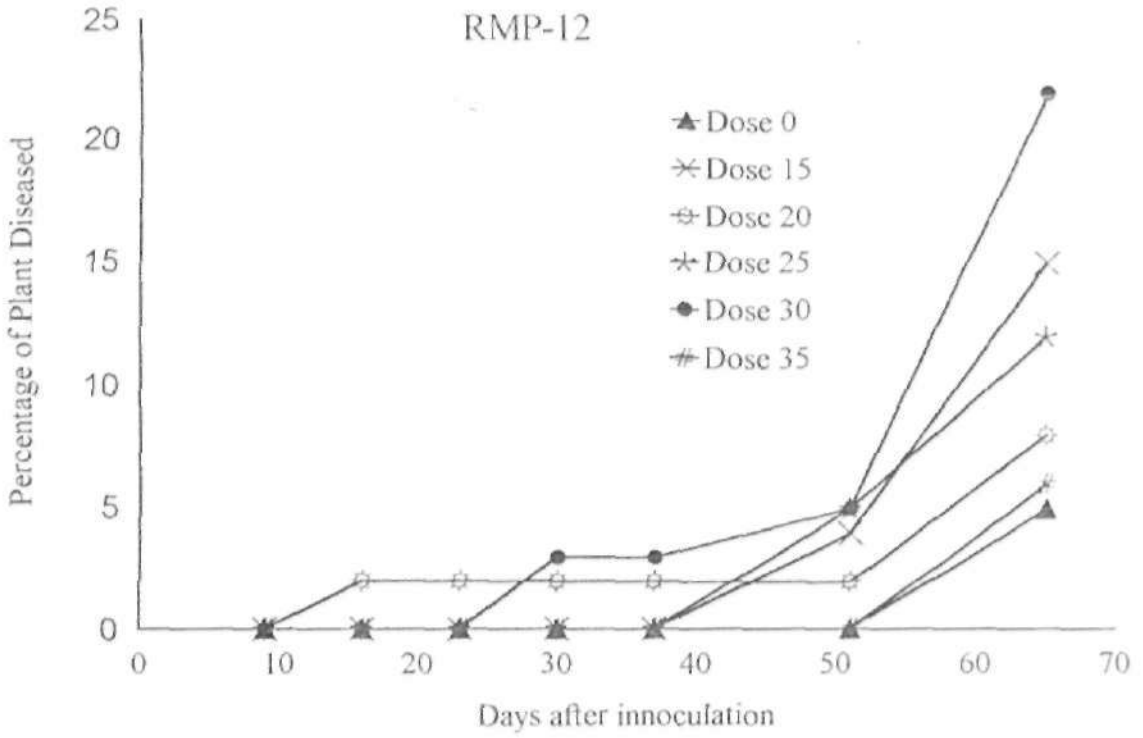

RMP-12
Percentage of Plant Diseased
Days after innoculation
Dose 0
Dose 15
Dose 20
Dose 25
Dose 30
Dose 35
0
5
10
15
20
25
0
10
20
30
40
50
60
70

Fig 1d

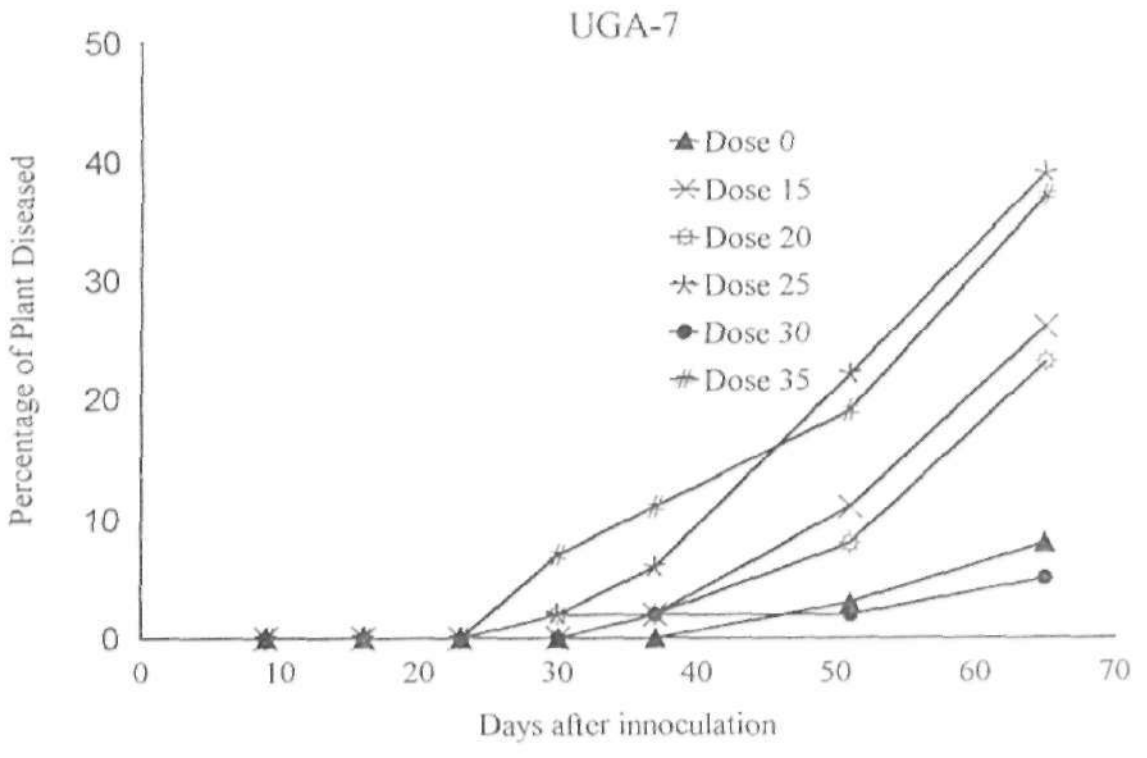

UGA-7
Percentage of Plant Diseased
Days after innoculation
Dose 0
Dose 15
Dose 20
Dose 25
Dose 30
Dose 35
0
10
20
30
40
50
60
70

Fig 1e

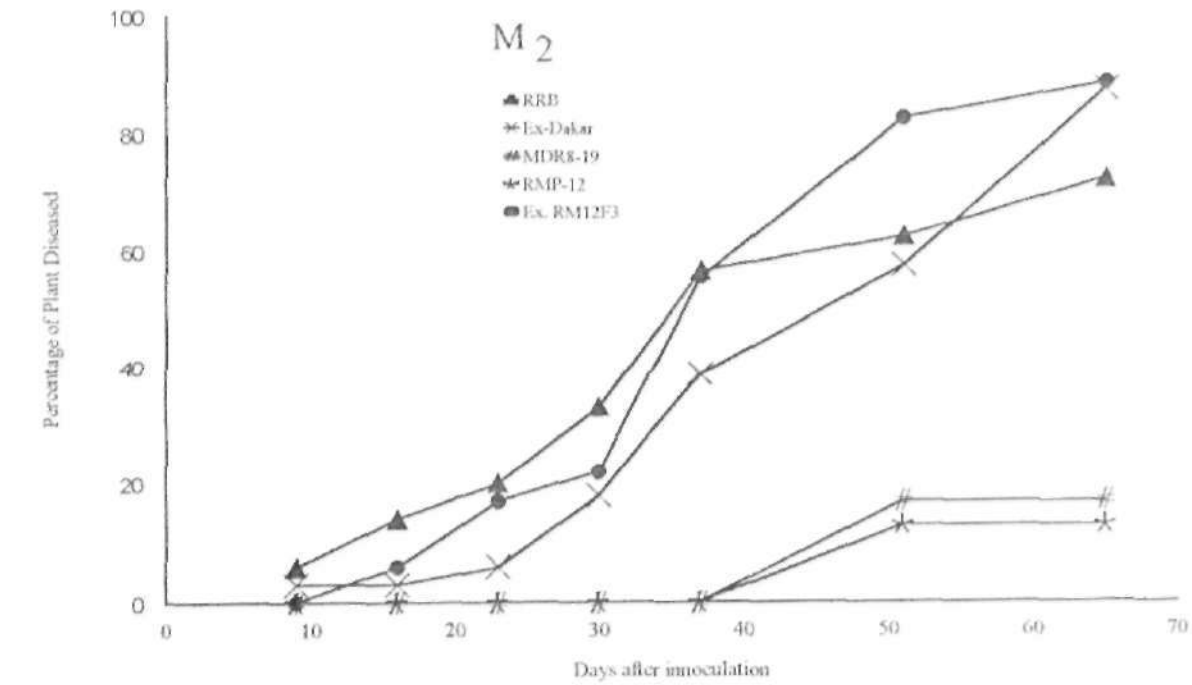

M 2
RRB
Ex-Dakar
MDR8-19
RMP-12
Ex. RM12F3
Percentage of Plant Diseased
Days after innoculation
0
20
40
60
80
100
0
10
20
30
40
50
60
70

Fig 2a

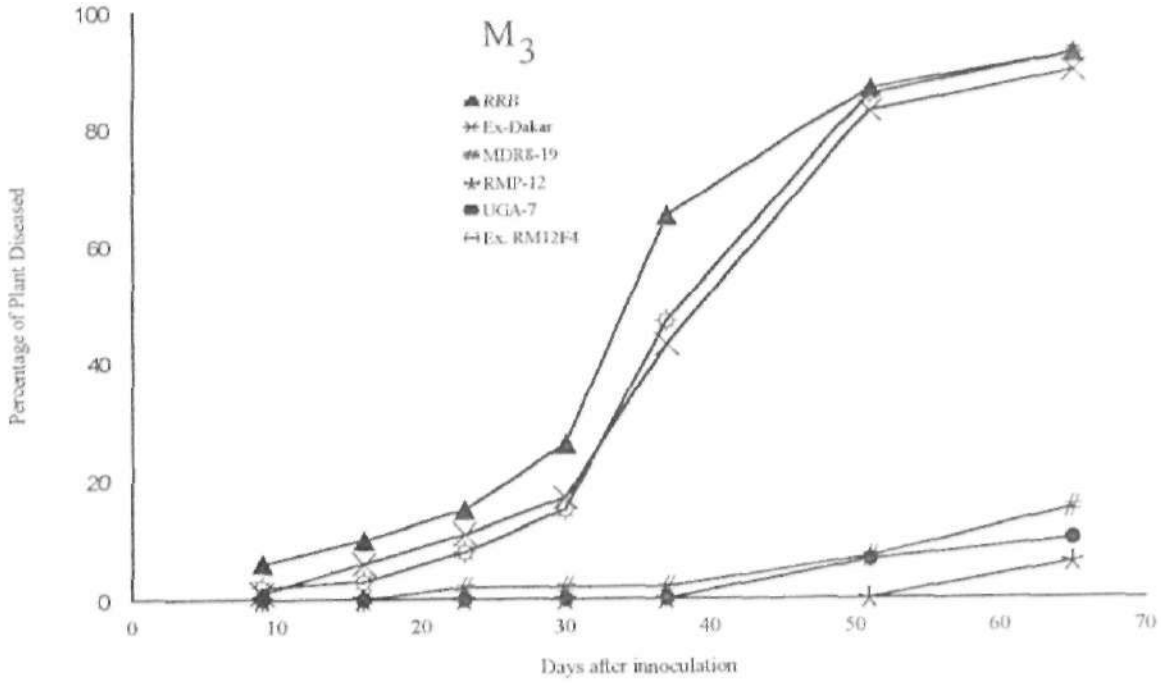

M 3
RRB
Ex-Dakar
MDR8-19
RMP-12
UGA-7
Ex. RM12F4
Percentage of Plant Diseased
Days after innoculation
0
20
40
60
80
100
0
10
20
30
40
50
60
70

Fig 2b

Table 16: Groundnut rosette disease rating number frequency and disease index of M. and M.population in field plots under severe disease condition in 1998.

		Plants (%) rating number					
		M. Population					
Variety	Dose	1	2	3	4	5	Disease index value
RRB	0	0	0	0	64	36	4.36
	15	0	0	5	65	30	4.26
	20	0	0	2	67	31	4.30
	25	0	0	3	66	31	4.28
	30	0	0	0	51	49	4.50
	35	0	0	0	59	41	4.42
Ex-Dakar	0	0	0	4	69	27	4.24
	15	0	0	2	69	29	4.33
	20	0	0	0	67	33	4.34
	25	0	0	2	74	24	4.32
	30	0	0	0	68	32	4.31
	35	0	0	0	73	27	4.28
MDR8-19	0	9	44	34	13	0	2.52
	15	5	46	36	11	2	2.55
	20	9	36	25	25	5	2.83
	25	0	30	42	26	2	3.00
	30	4	15	48	26	7	3.12
	35	2	8	36	32	8	3.18
RMP 12							
	0	71	17	3	9	0	1.48
	15	42	18	18	22	0	2.22
	20	55	13	17	15	0	1.90
	25	52	37	2	9	3	1.74
	30	28	27	21	21	0	2.52
	35	50	50	0	0	0	1.52
UGA 7							
	0	23	44	20	13	0	2.21
	15	20	13	36	29	2	2.41
	20	27	26	35	22	0	2.64
	25	32	12	10	36	10	2.80
	30	28	36	21	15	0	2.23
	35	27	12	18	37	6	2.89

Rating scale: 1= no symptoms,
2= leaf symptoms, no stunt.;
3= leaf symptoms plus stunt of 30% ;
4 = leaf symptoms plus stunting of30%-70%
5 = stunting greater than 70%.

Table 16: Continues

Variety	Dose	1	2	3	4	5	Disease index value
RRB	10	0	0	3	80	17	3.36
Ex-Dakar	10	0	0	0	64	36	4.33
MDR8-19	10	50	33	17	0	0	1.57
RMP12	10	70	0	30	0	0	1.80
ExRM12 (F3)	0	0	0	6	59	35	4.21
				M_1 Population			
RRB	10	0	0	2	59	39	4.40
Ex-Dakar	10	0	0	0	66	44	4.34
MDR8-19	10	3	37	31	26	3	2.86
RMP12	10	46	27	18	9	0	1.98
UGA 7	10	29	35	25	11	0	2.19
ExRM12 (E_4)	0	0	2	6	68	24	4.15

Rating scale: 1= no symptoms,
2= leaf symptoms, no stunt.;
3= leaf symptoms plus stunt of 30% ;
4 = leaf symptoms plus stunting of30%-70%
5 = stunting greater than 70%,

CHAPTER 5

DISCUSSIONS

The genetic variability in groundnut due to varying doses of gamma rays were evaluated in M_1, M_2 and M_3 populations. Variability is certain to have been created in these varieties as indicated by the wide ranges observed for the characters measured. The large variation in the values of the coefficients of variability (Table 5) is also an indication of large genetic variability present in these irradiated materials from which selection of new, beneficial, plant types can be made, since this variability forms the basis for crop improvement. Similar reports of increased variability on crops such as soybeans, mung beans, and cowpeas has been achieved with irradiation by Humphrey (1954); Rawlings *et al.* (1958), Hanway and Williams (1961), Bhatti *et al.* (1970), Ojomo and Chheda (1972), Rajput (1974) and Shaikh *et al.* (1977) and Pathirana (1991). The presence of variability created is also confirmed by the significant mean squares (Table 9) recorded for the doses used for most of the characters studied in M_1 and M_2. The varieties showed marked differences in their responses to the irradiation as reflected in their mean performances (Tables 6 and 7). Germination percentages were found to be affected at higher irradiation doses, 30 and 35 kr especially in the M_1. This is in agreement with earlier finding by

Abdel-Hak and Kamel (1973) and Kasimu (1992) who reported reduced germination in pop corn especially at M_1 and at higher doses. The flowering delay recorded in this study with increased dosage, notably at 30 and 35kr has also been reported by Rajput (1974) on mung beans. This delay could be attributed to profuse and persistent vegetative growth or mitotic arrest in the flower primordia as a result of the mutagenic effects on the plants. This delay is more pronounced in M_1, as indicated by the high and significant dosage/flowering correlation co-efficient obtained, except where the delay in flowering was genetic, plants were observed to recover from this flowering delay.

Though earliness was not recorded for this study in the M_1 and M_2, induced early flowering has been achieved using irradiation in crops such as soybeans by Rawlings et at. (1958), cotton by Raut *et al.* (1971), soybeans by Koo (1972), and pop corn by Kasimu (1992). Further selections in later generations might lead to early mutants.

Marked plant height reduction was also observed with increase in dosage in these populations for all the varieties studied; the correlation of height/dosage shows a negative estimate in both populations. In the short duration varieties, Ex-Dakar and RRB, it was observed that this reduction in height and modification of plant habit facilitated better pegging at lower doses of 15, 20 and 25kr for these erect varieties; though this does not mean a proportional yield increase but could contribute to yield increases as observed at M_2 in RRB at 15, 20

and 25 and Ex-Dakar at 15kr (Table 7), since better pegging leads to better pod set and ultimately increase in yield.

In the long duration varieties, height reduction and habit modification led to individual plants with spreading habit, especially in UGA-7 and RMP-12 which normally have semi-erect plant habit. This could also lead to better pegging and subsequent yields though this contribution can only be obtained in later yield selection practices, however in this work, increases in yield were seen within these irradiated varieties especially in the M_2. Such height reduction and habit modification at higher doses of gamma irradiation has been observed in studies by Bhatti *et al.* (1970) and Rajput (1974). Early mutation breeding work has led to profitable dwarf mutants as in common bean with bushy habit, peas with lodging resistance, lentils with spreading habit, vetch or adzuki beans with shorter stems (Micke, 1992). Reduction in height and production of plant s with spreading habit could be useful in developing varieties with shorter height especially in erect types provided yield is not adversely affected. The correlation of height with yield(Table 12) shows negative and significant correlations in both populations implying that selection for reduced height will not adversely affect yield in these varieties.

Effects of irradiation on number of mature pods per plant, pod yield, haulm yield, one hundred seed weight and shelling percentage shows a large variation in performance of the varieties, also confirmed by the large coefficient of variation

(Table 5) obtained especially for mature pods per plant, pod yield and haulm yield in both M_1 and M_2. The variation in yield and these yield components does not show a direct proportionality with the doses used on these populations. Similar reports on yield were also reported by Rajput (1974), Ojomo and Chheda (1972), and Kasimu (1992). No significant differences in mean squares for yield and its components in both populations except for one hundred seed weight and shelling percentage in M_1 and for pod yield in M_2(Table 9) The yield/dosage correlation coefficients (Appendix II) especially in M_2 showed positive and non significant correlations between the doses and yield with the components: this does not mean yield was unaffected by the mutagens but rather, since mutations affecting yield in groundnut have been reported by Gregory (1968), a pioneer worker in mutation breeding in groundnuts to be predominantly of small effects and are not easily detectable in earlier generations. The results obtained suggest that selection for number of pods per plant, pod yield, haulm yield, one hundred seed weight and shelling percentage in these irradiated varieties would be better exploited at later generations of M_3, M_4 and upwards as also suggested by Rajput (1974) and Chaudary (1984). Though statistically, yield seems unaffected by the mutagens, mean number of pods per plant especially in M_2 was recorded to have increased over the control or zero dose for 25, 30 and 35kr. In UGA-7 increases were observed in number of mature pods per plant for 15 and 35kr (Table 7). Similar increases in number of pods per plant in irradiated

plants compared to the control have been reported by Bhatti *et al.* (1970) and Rajput (1974). Also for pod yield and haulm yield, though statistically no difference was recorded, mean pod yield in M_2 of irradiated population when compared with control or zero dose was found to reflect increases at 15, 20 and 25kr. The same trend was seen for haulm yield for the varieties. Slight increases in mean seed weights were also observed between 15 kr and 30 kr (Table 7). From the trend observed for yield performance in this irradiated population, and the fact that the possibility of occurrence of polygenic mutations with small effects is seen for yield and in earlier works done in mutation breeding, supported also by this study, selection for yield in further generations should be carried out between 15 and 30 kr. This dose range varies with the varieties; since the varieties displayed different sensitivities to the gamma irradiation dose.

Variance components in the two populations, showed that the genotypic variance (σ^2_g) and phenotypic (σ^2_{ph}) variances were large for germination percentage, plant height at harvest, number of mature pods per plant, pod yield, haulm yield and one hundred seed weight compared to other characters. This shows the effects of the mutagens in increasing variability in these plants. Large genotypic variance among progenies of irradiated plants have been reported by several workers when irradiation with gamma rays and other mutagens had been used to create genetic variability. These include Gregory (1955), Rawlings *et al.* (1958), Miah and Yamaguchi (1965), Bhatti *et al.* (1970), and Ojomo and Chheda (1972). The

characters with large genetic variances were mostly quantitative in nature and such characters in crop plants treated with mutagens have been reported to show increased variability up to four times or more in the earlier generations such as M_1 and M_2 giving chances for ample selections until about M_3 when stability is achieved (Gregory, 1955; Rawlings *et al.*, 1958; and Aba, 1997).

The error variances obtained for germination percentages, number of mature pods per plant, pod yield and haulm yield were lower than the genotypic and phenotypic variance estimates and had small standard error estimates. All the characters had lower genotype x dosage interaction variance estimates than their respective genotypic, phenotypic and error variances. These low values were in conformity with the results of the analysis of variance (Table 9) which showed that for all the characters studied no significant differences were obtained for the mean squares of the genotype x dosage interaction. Negative estimates were obtained for days to fifty percent flowering, plant height at harvest, number of mature pods per plant and one hundred seed weight thus showing the smallness of the genotype x dosage interaction variance.

The observed heritability estimates (Table 11) were unusually high for all the characters measured. This was surprising though the estimates were derived using large genetic variances (which were made up of both additive and non-additive components) for most of the characters. Increased heritability estimates for irradiated populations have been given by Rawlings *et al.* (1958),

in soybeans for characters such as maturity, yield and seed weight with increases of up to twice the heritability estimates of the unirradiated population. Ojomo and Chheda (1972) also reported increase in heritability estimates in irradiated population for characters such as number of mature pods per plant where control population had 6% heritability estimate and the M_1 generation of irradiated cowpea had 61% for the same character.

Correlation coefficient estimates (Table 12) showed some differences with those obtained elsewhere in groundnut varieties especially in results obtained in M_1 (Table 12). This was probably due to the fact that at this stage or generation, the disturbances of the biological organization of the plants manifest in several ways from no changes to gross visible disturbances, though these changes may be temporal or permanent as would be discovered in further generations. The most significant correlations were those obtained between yield and other characters from a plant breeder's point of view. Yield in M_1 (Table 12) was positively correlated with germination percentage, number of mature pod per plant, haulm yield, one hundred seed weight and shelling percentage; but negatively correlated with days to first flower appearance, days to fifty percent flowering and plant height at harvest.This is in conformity with works by Ndoye (1988) and Izge (1998), who planted groundnut varieties under adequate moisture conditions. In the M_2 population (Table 12), yield was negatively correlated with plant height at harvest and germination percentage, while it was positively correlated and highly significant with days to first

flower appearance, days to fifty percent flowering contrary to other works on similar correlation except for Izge (1998) who obtained similar results in groundnuts subjected to moisture stress; this correlation results of yield with flowering can also be suggested to be due to effects of the mutagens on the plants. In the two populations, negative correlations were obtained between days to first and fifty percent flowering with shelling percentage implying, the fewer the number of days to flowering the fuller the pods. The positive, highly significant (P =0.01) correlations between pod yield, haulm yield, shelling percentage, number of mature pods per plant and one hundred seed weight in M_2 is in agreement with work by Izge (1998) under adequate, normal planting conditions for groundnut varieties used; this suggests that yield can be improved in this population though irradiated through its components. Continuous selection for these traits (number of mature pods per plant, haulm yield, shelling percentage, one hundred seed weight) will increased yield in the population studied.

Comparisons among varieties under rosette and rosette free field conditions shows differences among the varieties studied. The screening of the irradiated population for better performance under rosette disease conditions was done only at M_2 and not M_1 for the reasons that in the case of recessive mutants which are more frequent than dominant mutants in mutation studies, both loci are rarely mutated, therefore segregation must be permitted to let the plants come to homozygous conditions so that they can be isolated

(Chaudary 1984). Secondly screening in these studies was done at M_2 because in genetic studies on the inheritance of resistance to groundnut rosette disease, it has been found that two recessive genes control resistance as discovered by Harkness (1977), Nigam and Bock (1990), and Olorunju *et al.* (1992). Detection of mutants are easier in M_2 especially where efficient screening techniques have been developed in a material or where screening is easier as in disease resistance.

The analysis of variance (Table 15) showed that the varieties performed differently under rosette and rosette free field conditions for all the characters studied except for days to first flower appearance and days to fifty percent flowering. Performance under rosette disease free conditions was better for all characters studied. Table 14 showed that days to flower appearance and days to fifty percent flowering were similar in the two environments. This was due to the fact that under diseased conditions, rosetted plants do flower, though few of the pods grow and none bear seeds (Farali, 1977 and Mercer, 1977) especially for susceptible varieties. In this study, flowers were produced by all varieties under the disease conditions. Differences in flowering recorded were due to the fact that early and late maturing varieties were used for the study and irradiation doses caused delay in flowering. In these populations, evaluation for early maturing mutants did not produce any plant with spectacular earliness. Under rosette disease conditions, plant height of all varieties studied was affected, compared with height in the

rosette free field. Rosette resistant varieties (UGA-7, MDR8-19 and RMP-12) also showed height reduction in the rosette field (Table 14) confirming the fact that these varieties though resistant can be infected by the disease under severe disease conditions. Similar reports of infection of resistant varieties under such conditions have been given by Harkness (1977) and Olorunju (1990). Susceptible varieties, Ex-Dakar and RRB showed drastically reduced plant height (Table 14) in the rosette field, though irradiation done was targeted at producing resistant or tolerant mutants from these early varieties, results obtained on height shows that such mutants were not obtained in this M_2 population. In the rosette free field where environmental conditions were suitable, these varieties, RRB and Ex-Dakar had the highest plant height values .

Yield of all the varieties in the disease environment showed a reduction of yield and its components. The early, susceptible varieties, Ex-Dakar and RRB produced very few pods (Table 14). Only a few pods were harvested from these varieties at the various dosages in the rosette field. The irradiation did not yield any mutant with resistance to rosette within the two varieties in the M_2 population screened in this study.

Comparison of yield and its components for the resistant varieties (UGA-7, MDR8-19 and RMP-12) under disease conditions shows that the varieties yielded about 50% or below compared with the yield obtained in the disease free conditions (Table 14).Under severe diseased conditions these varieties do get infected though

virus multiplication is reduced and incubation period is longer. Yet yield in resistant varieties is also affected by the disease as reported in previous studies (Olorunju 1990). However, the yield recorded for these varieties in this M population cannot be totally attributed to disease effects, the radiation effects also had to be taken into consideration. For these three resistant varieties, it was seen that the radiation at higher doses notably 25, 30 and 35kr resulted in more diseased plants than for the lower doses (Table 16) except for 35kr in RMP 12 which produced similar effects with the control or zero dose and 30kr in UGA-7 which also produced effects similar to zero dose. This trend was more noticeable in MDR8-19. The disease trend obtained is similar to earlier results obtained in groundnuts by Cooper and Gregory (1960) using irradiation to explore possible recovery of mutants immune or highly resistance to early and late leaf spots. They reported that effects of mutagens on resistance in plants show increase and decreased resistance in the plant types in various forms, from which selections can now be carried out to recover plants showing resistance. Chaudary (1984) also reported that among all characters studied under mutation breeding, the one most susceptible to mutations is uncertain since all plant parts and processes are under genetic control and mutation may affect any known character, thus observing plants with extreme disease within the resistant varieties is not too surprising. It is therefore possible that the yield reduction recorded in this study could also be contributed to effects of the mutagen on individual

plants within the plots. This trend of response to mutagens in the rosette field is further confirmed by the results obtained on response to rosette disease as measured by disease incidence (Appendix III) and disease severity scores (Table 16) for individual plant assessment and thorough evaluation for resistant mutants. The results obtained showed that gamma rays used at 20, 25 and 30kr might lead to obtaining plants with increased resistance or even immune plants in further screening at M_2 generation upwards, since these are the doses that produced significantly different responses within each variety (Fig 1 and 2).

In RRB and Ex-Dakar where the search for resistant plants was more intense, since these varieties are agronomically acceptable but susceptible, the disease progress was retarded between doses 15 and 25kr. Screening plants at these doses in later generations, and if possible in larger populations (since the larger the populations, the better the chances of discovery of desired mutants), might lead to obtaining a resistant mutant. Such screening is also recommended for this population because one or more generations allows for the recessive resistant genes to express phenotypically in the population. The search for resistant mutant with earliness was more intense in the late maturing varieties, UGA-7, MDR8-19 and RMP-12. The measurements of flowering and maturity did not give any early plant earlier than the control. Further screening at these doses may give plants with the desired earliness.

CHAPTER 6

SUMMARY AND CONCLUSION

Dry seeds of groundnut, *Arachis hypogeae* L. were treated with gamma rays generated from Co^{60} source at dose levels 10,15,20,25,30 and 35 kilo rads and planted alongside with the control or zero dose in 1997 and 1998 planting seasons. Locally adapted varieties were used to conduct the study aimed at evaluating early generations, M_1 and M_2 for all doses, M_3 for just 10kr only, for increased variability, agronomic performance and resistance to rosette disease. Early maturing, rosette susceptible varieties (Ex-Dakar and RRB), a segregating population and Ex-RMP-12 at F2, and later maturing, rosette resistant varieties (UGA-7, MDR8-19 and RMP-12) were used. These were grown under two field conditions: rosette free and rosette field conditions. Planting in rosette-free field was aimed at observing the performance of irradiated plants at the different doses (dosage effect) and select plants with better agronomic performance, also to compare performance of plants grown in rosette free environment with those grown under rosette disease conditions. Growing plants in the rosette disease field was aimed at investigating the response of these irradiated plants to rosette disease and practise selection where resistance is observed.

Several agronomic characters were determined, these include germination percentage, days to first flower appearance, days to fifty percent flowering, plant height at harvest, number of mature pods per plant, pod yield, haulm yield, one hundred seed weight and shelling percentage in both fields. Disease incidence and disease severity scores were only measured in the rosette field.

Results show wide ranges and coefficients of variability (C.V) for most of the characters studied. Coefficients of variability followed similar trends in M_1 and M_2. Large coefficient of variability were obtained for number of mature pods per plant, pod yield and haulm yield while lowest coefficients of variation were obtained for days to first flower appearance and days to fifty percent flowering. Large differences were obtained between the means of control or zero dose and the irradiated populations. The variability created was further confirmed by the analysis of variance results. Significant differences were obtained for the doses for most of the characters studied in these populations; significant differences were also observed for the varieties. Correlations between gamma radiation and the characters studied showed the varying effects of the doses in both M_1 and M_2. Detrimental effects were recorded in higher dosages on gemination percentage and plant height at harvest especially in the M_1. Effects of dosages on yield and its components varied widely. The results of the study of these effects reveal that selection for yield and the components would be better exploited at later generations of M_3, M_4 and upwards and this selection

should be practiced between dosage levels 20 and 30kr because the increases recorded were obtained at these dosages and increased variability observed were at these dosages.

Genetic variance estimates were large in these irradiated populations for most of the characters studied. The estimates were positive for all the characters and larger than their associated standard error estimates indicating the increased variability created by the use of irradiation on these varieties.

Broad sense Heritability estimates derived only for the M_1 population were quite high due to the large genetic variance estimates used to obtain these values.

Correlations among the characters varied in M_1 and M_2. Yield in M_1 was negatively correlated with days to first flower appearance, and days to fifty percent flowering but in M_2, positive correlations were obtained between yield and these flowering parameters. Days to first flower appearance was positively and significantly correlated with days to fifty percent flowering. Plant height was negatively correlated with yield. Positive and highly significant correlations were obtained between number of mature pods per plant, pod yield, haulm yield and one hundred seed weight in M_2 but in M_1, negative correlations were obtained between number of mature pods per plant and other yield components due to the detrimental effects of the mutagens at this stage.

Comparisons among varieties under rosette and rosette free field conditions revealed interesting differences. Performance

in rosette-free field was better for all the characters studied. Effects on flowering characters were similar in the two environments. Plant height in the rosette environment was drastically reduced in the early maturing varieties, Ex-Dakar and RRB; less reduction in height was seen for the medium and late maturing varieties. Measurement of yield and its components under rosette conditions showed reduced yield for all the varieties measured. Early maturing varieties, Ex-Dakar, and RRB produced few or no seeds at all in this field. Later maturing varieties, UGA-7, MDR8-19 and RMP-12 yielded about 50% of the yield observed for them in the rosette free environments. Effects of the radiation dosages in the rosette environment were similar with that of the rosette free environment for all the characters measured.

Results on disease incidence and disease severity taken on these irradiated populations compared with the control dose showed that dosage levels 20 and 25kr may lead to obtaining plants with increased resistance in the early maturing varieties and RRB and plants with earliness and disease resistance in late maturing varieties, in further screening at M_1 upwards: the resistant recessive genes would express themselves phenotypically in the populations at the dosages that produced significantly different responses within each variety.

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Appendix I

Correlation between gamma irradiation dosage and various agronomic characters of groundnut varieties in M_1 and M_2

Correlation Coefficients (r)

Character	M_1	M_2
Germination percentage	-0.3561**	-0.2686*
Days to first flower appearance	0.6008**	0.1644
Days to fifty percent flowering	0.6233**	0.1554
Plant height at harvest	-0.2885*	-0.2346
Number of mature pod/ plant	-0.1870	0.1219
Pod per yield	-0.4003**	0.2079
Haulm yield	-0.1177	0.0378
One hunderd seed weight	-0.1750	0.0227
Shelling percentage	-0.4864**	0.2301

*,** = Significant at 5% and 1% level of probability respectively.

Appendix II :

Mean performance of groundnut varieties in M_2 and M_3 generation at (10kr) under rosette and rosette free field conditions.

Varieties	GP		DTFFA		DTFF		PHAH		NMPP		PY		HY		SP		OSW	
	R	RF	R	RF	R	RF	R	RF	R	RF	R	RF	R	RF	R	RF	R	RF
							M_2											
RRB	61.0	80.5	26.5	27.0	30.0	30.0	13.8	26.4	3	34	54	1260	841	5236	24.3	64.7	15.8	28.0
Ex-Dakar	41.0	67.0	27.5	26.5	30.5	29.0	17.3	36.4	2	27	18	778	1186	6550	24.3	70.9	14.6	25.1
MDR8-19	7.00	19.0	28.5	28.0	33.5	33.5	14.5	19.9	15	37	750	1895	3976	8485	66.3	66.6	36.4	32.7
Ex.RM 12 (F_3)	22.0	49.0	29.0	27.0	33.0	31.5	12.0	32.6	2	42	80	1865	1442	4291	60.5	62.9	26.0	28.6
							M_3											
RRB	84.5	93.0	25.5	27.5	29.5	29.5	12.0	28.5	1	25	9	1063	712	4718	67.5	62.6	27.5	25.5
Ex-Dakar	87.0	93.0	25.0	26.0	28.5	28.5	16.1	36.3	1	23	3	679	901	4060	60.6	66.2	20.1	27.0
MDR8-19	74.5	87.5	28.0	27.0	31.0	30.0	17.5	25.9	14	46	780	1986	2759	5645	70.8	71.3	37.5	39.4
UGA7	77.5	74.0	28.0	28.0	31.0	33.0	17.7	21.5	13	44	829	1962	2266	5390	66.6	65.0	35.2	40.4
RMP12	65.0	75.5	28.0	28.0	31.5	33.0	19.2	26.9	13	43	559	1944	3250	6958	69.9	68.9	33.8	40.0
Ex.RM 12 (F4)	82.5	86.5	25.5	27.2	30.0	30.0	14.2	31.9	2	43	63	1468	1185	3595	60.0	67.4	26.1	36.6

R , RF = Rosette and Rosette Free environments, respectively.

GP=Germination percentage
DTFFA=Days to first flower appearance
DTFF= Days to fifty percent flowering
PHAH=Plant height at harvest
NMPP= Number of mature pods per plant
PY=Pod yield
HY=Haulm yield
OSW=One hundred seed weight
SP= Shelling percentage

Appendix III:

Incidence of groundnut rosette(%) after inoculations in the field at M_2 and M_1 populations during 1998 planting season.

Variety	Dose	Days after inoculation						
		M_2 Population						
		9	16	23	30	37	51	65
RRB	0	11	16	24	34	61	79	95
	15	7	3	24	37	59	68	86
	20	7	12	16	21	53	61	87
	25	7	10	15	18	41	54	78
	30	7	15	26	33	67	78	87
	35	10	17	29	44	80	85	88
Ex-Dakar	0	3	9	14	17	43	56	87
	15	6	11	20	27	53	80	96
	20	4	10	16	23	62	74	90
	25	3	6	12	15	48	81	93
	30	2	3	6	14	57	75	86
	35	3	6	8	16	48	78	96
MDR8-19	0	0	0	0	2	3	7	13
	15	0	0	0	0	0	2	15
	20	0	0	2	2	3	12	12
	25	0	0	0	2	2	7	15
	30	0	0	0	2	4	6	20
	35	0	0	0	2	4	11	28
RMP 12	0	0	0	0	0	0	0	5
	15	0	0	0	0	0	4	15
	20	0	2	2	2	2	2	8
	25	0	0	0	0	0	5	12
	30	0	0	0	3	0	5	22
	35	0	0	0	0	3	0	6
UGA 7	0	0	0	0	0	0	3	8
	15	0	0	0	0	2	11	26
	20	0	0	0	2	2	8	23
	25	0	0	0	2	6	22	39
	30	0	0	0	0	2	2	5
	35	0	0	0	7	11	19	37

Appendix III continues:

Variety	Dose	9	16	23	30	37	51	65
RRB	10	6	14	20	33	57	63	73
Ex-Dakar	10	3	3	6	18	39	58	88
MDR8-19	10	0	0	0	0	0	17	17
RMP 12	10	0	0	0	0	0	13	13
Ex.RM12(F_3)	0	0	6	17	22	56	83	89
				M_3 population				
RRB	10	6	10	15	26	65	87	93
Ex-Dakar	10	1	6	11	17	43	83	90
MDR8-19	10	0	0	2	2	2	7	15
RMP 12	10	0	0	0	0	0	0	6
UGA 7	10	0	0	0	0	0	7	10
Ex.RM12(F_4)	0	2	3	8	15	47	86	93