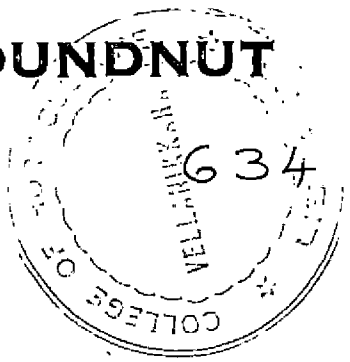
SEED DORMANCY IN GROUNDNUT



By

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THESIS

Submitted in partial fulfilment of the
requirement for the degree of

Doctor of Philosophy in Agriculture

Faculty of Agriculture
Kerala Agricultural University

Department of Agricultural Botany
COLLEGE OF HORTICULTURE
Vellanikkara, Thrissur

1992

DECLARATION

I hereby declare that this thesis entitled SEED DORMANCY IN GROUNDNUT' is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or any other similar title, of any other University or Society.

Presanna kumari

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Vellanikkara
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CERTIFICATE

Certified that this thesis entitled 'SEED DORMANCY IN GROUNDNUT' is a record of research work done independently by Smt. Presanna Kumari, K.T. under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to her.

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ACKNOWLEDGEMENT

I wish to place on record my deep sense of gratitude to Dr. K.M. Narayanan Namboodiri, Professor and Head, Department of Agricultural Botany and Chairman of my Advisory Committee for his valuable guidance, constant encouragement and sustained interest during the course of this investigation and preparation of the thesis.

I am deeply indebted to Sri. V.K.G. Unnithan, Associate Professor, Department of Agricultural Statistics and member of my Advisory Committee for his advice and help rendered in the statistical analysis of the data and subsequent interpretations.

I take this opportunity to express my deep sense of gratitude to Sri. K. Gopakumar, Professor and Head of Agricultural Botany, College of Agriculture, Vellayani, Dr. Luckins C. Babu, Associate Professor, College of Forestry and Dr. K. Pushkaran, Associate Professor, RARS, Pattambi, the members of my Advisory Committee, for the valuable suggestions and help rendered by them.

I am thankful to Dr. C.C. Abraham, Associate Dean, College of Horticulture, for providing necessary facilities for this investigation.

I gratefully acknowledge the valuable help and suggestions given by Dr. N.M. Nair, Principal Scientist, Division of Vegetable Crops, IARI, New Delhi.

I am immensely grateful to Dr. K.C. George, Professor and Head, Department of Statistics, College of Veterinary and Animal Sciences, Kerala Agricultural University for his helpful suggestions.

My sincere thanks are also due to my colleagues of the Department of Agricultural Botany for their whole hearted co-operation at various stages of my work.

I sincerely thank the Kerala Agricultural University for granting me study leave and part-time registration for pursuing the studies.

I owe a lot to my husband and children who sacrificed much for making this endeavour a success.

Presanna kumari

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Introduction

1. INTRODUCTION

Cultivated groundnut Arachis hypogaea L. now grown throughout the tropical and warm temperate regions of the world, originated in Brazilian-Paraguan Centre (Krapovickas, 1969). This is the only oil seed legume where the economic parts are borne under the ground. This subterranean fruit bearing habit hinders visualisation of yield potential of the plant before harvest. Hence it is described as an "unpredictable" legume.

On the basis of branching pattern, Gregory et al. (1951) and Krapovickas (1969) identified four botanical groups viz. hypogaea and hirsuta (Virginia peanuts) vulgaris (Spanish peanuts) and fastigiata (Valencia peanuts). According to them, only Virginia peanuts belonging to hypogaea and hirsuta groups possessed marked and long lasting seed dormancy unlike other two types.

Groundnut is cultivated in diverse agro-environmental conditions all round the world. In Semi-Arid Tropical areas or otherwise known as SAT areas like India, Senegal, Nigeria, Sudan etc. it is an important cash crop in subsistence farming. With 25 per cent protein and 50 per cent oil, it forms an important food

source as well. Within the SAT countries, India has the largest groundnut area and production. It produces about 52 per cent of the combined output of all the SAT countries.

In India groundnut occupies an area of 7.8 million ha. (1988-89) with a total production of 6.8 million tonnes. The productivity is 869.7 kg/ha.

In Kerala, groundnut is widely grown in Palghat District. Of late it is spreading to other districts also. The total area under groundnut in Kerala is 14894 ha. (89-90) and the total production is 14741 tonnes (89-90). More than 99 per cent of the area and production in Kerala is from Palghat, where two crops are mainly taken, first crop during May-June to August-September and second during September-October to January-February, with supplemented irrigation.

At the time of harvest of the first crop, monsoon showers are likely to occur. If the harvest coincides with rain, seeds of bunch type which are normally nondormant, begin to germinate in the field itself. Considerable loss occurs to the farmers by sprouting in the field. In such situations, dormant varieties are a boon to the cultivator.

A contrary situation is that seeds produced in one season cannot be utilised for succeeding season. Thus prolonged dormancy becomes a handicap in such situations. So we can rightly say that dormancy is an important factor in groundnut seed production. It can be beneficial when dormancy prevents mature seeds from sprouting before harvest. It can be detrimental when prolonged dormancy hampers taking a second crop immediately after harvest. As such, the ideal thing will be to have high yielding short duration types with short dormancy period of 20-30 days.

Considerable efforts are under way to improve the above situation, in recent years. It was in this background that the present investigation was undertaken in groundnut with the following objectives:

1. To screen the groundnut germplasm comprising of diverse genotypes for seed dormancy and to classify them into dormant and nondormant types.

2. To determine the period of dormancy of the genotypes.

3. To assess the role of different entities of seed in delaying germination.

4 To find out the effect of different presowing treatments in breaking dormancy.

5. To investigate the nature of inheritance of dormancy by using selected materials with contrasting traits to the maximum.

Review of Literature

2. REVIEW OF LITERATURE

2.1 Definition

Seed is the most important reproductive unit which develops from the ovule in flowering plants following fertilisation. The essential constituents of the seed are the embryo, seed coat and reserve food which may be stored in cotyledons, endosperm, perisperm or very rarely in hypocotyl.

One of the most important problems in seed physiology is the failure of otherwise viable seed to recommence development immediately when supplied with water and oxygen at a temperature favourable for plant growth. Such a failure to germinate is normally termed dormancy and is a wide spread phenomenon.

Harrington and Knowles (1939) have defined seed dormancy or after ripening as one which refers to the rest period of a mature seed in the presence of conditions favouring germination and no apparent physical impediment to germination.

According to Shanmugasundaram (1953), dormancy or after ripening of the grain is the character which

relates to the resting period from the time the seed is harvested till such time when good germination is obtained, if sown.

Vegis (1964) has reported that true dormancy is a condition in which growth cannot be resumed whatever external condition may be.

However, the seeds that are normally germinable, can be induced to become dormant if maintained at unfavourable environment for a time. This is termed secondary dormancy. The period during which the seed regains its ability to germinate was termed dormancy by Koller *et al*. (1962) while it was termed 'rest period' by Mayer and Anderson (1963).

Nobble and Havlein (1877) were the pioneer workers who reported dormancy in weed seeds. Subsequently a number of workers reported dormancy in various crops.

2.2 Dormancy in relation to plant characters in groundnut

Varieties of groundnut are classified into different botanical groups based on their growth habit. Seed dormancy in the case of groundnut depends on the

botanical variety. Early maturing bunch varieties have nondormant seed. It has also been found that runner types have long lasting dormancy (Stokes and Hull, 1930; John et al., 1948).

Gelmond and Nakamura (1963) while studying the effect of environmental conditions during growth on the dormancy of peanut seeds of 8 cultivars including Virgina, Spanish and Valencia observed that seeds of Spanish and Valencia types had only slight dormancy, lasting a few weeks. The Virginia types showed long lasting dormancy. The intensity of dormancy of Virginia types varied with countries though duration was unaffected.

From a study on 16 groundnut varieties, Patil (1967) indicated that the four varieties which were relatively more dormant, were from the semispreading and spreading types and had longer maturity periods. The others which were nondormant belonged to the bunch type.

Sreeramulu (1968) found that seeds of spreading groundnut TMV-3 were dormant immediately after harvest and needed 40 days of dry storage at 30-33^{o}C for normal germination.

Varisai Muhammad and Dorairaj (1968) screened 206 bunch groundnut varieties for dormancy under irrigated conditions. Only six varieties recorded 90 per cent or more dormancy over a period of 15-20 days after pod maturity. The popular bunch strain of Madras TMV-2 recorded 25 per cent seed dormancy. None of the bunch varieties studied was completely nondormant.

In contrast, Varisai Muhammad et al. (1969) from another experiment reported that bunch type groundnuts AH 7607 and AH 7608 had strong seed dormancy.

Lin and Chen (1970) on examination of 56 varieties, indicated that there existed significant differences in the length of dormancy period among the varieties. The varieties were classified into three groups according to the length of dormancy period and the fourth group having no dormancy. Dormancy per cent at two and fourteen days after harvest was significantly correlated with length of dormancy period. In general the post harvest after ripening period lasted from weeks to months depending on the variety.

Bailey and Bear (1973a) noticed that Spanish and Valencia types (ss. fastigiata, vars. vulgaris and fastigiata) were frequently lacking dormancy. Certain

Spanish and Valencia genotypes showed as much as 70 per cent seed dormancy and one Virginia type as little as 3 per cent when seeds were cured to a moisture content of 5-7 per cent in 8-16 days.

Sengupta et al. (1977) studied the germination behaviour and seed dormancy of nine varieties of groundnut. Bunch types were nondormant while spreading and semi-spreading types had prolonged seed dormancy. The period of dormancy varied among the varieties.

Sobhan and Khandakar (1980) reported that of the ten cultivars tested, only Dacca No.1 showed 100 per cent germination 52 days after harvest. All cultivars except Wadia No.5 had 80-100 per cent germination 70 days after harvest. The number of days required for germination after soaking was greater at 84 to 99 days after harvest than at 74 days.

Zade et al. (1986) studied the germination per cent of seeds of fourteen Virginia Runner and eleven Virginia Bunch cultivars, 25, 40, 55 and 70 days after harvest. In both groups, dormancy was broken by 55 days after harvest. Early dormancy break was observed in Virginia Runner cultivar, GAUG-10 and Virginia Bunch cultivars, UF 70-103, BG-1, BG-2 and T-64. Late

dormancy break was observed in Virginia Runner cultivars M-37 and Kadiri 71-1 and Virginia Bunch cultivar Kadiri-2. In some, the dormancy breaking was gradual while in others it was sudden notably in UF 70-103 and T-64 where the increase in germination per cent between 25-40 days after harvest was more than 90 per cent. The rapidity of dormancy breakage and duration of dormancy were not related.

Further more, the dormancy period of the variety varied from year to year (Gavrielith, 1962). Gautreau (1984) in a study on the variation in dormancy of six early and semi early groundnut cultivars, found that germination rate varied between years.

The dormancy of groundnut seed also appeared to depend on its position in the pod. The basal seed in a pod had more dormancy than the apical ones having comparable maturity (Shibuya, 1932; Toole et al., 1964 and Patil, 1967). The greater tendancy for dormancy of the basal seed than the apical one was also reported by Ketring and Morgan (1970).

2.3 Mechanism of dormancy

Causes of seed dormancy appear to vary in different crops. Mayer and Anderson (1963) had listed six possible causes of seed dormancy viz., (i) impermeability of seed coat to water, (ii) mechanical resistance of seed coat, (iii) impermeability of seed coat to oxygen, (iv) presence of rudimentary embryo, (v) dormancy of embryo and (vi) presence of germination inhibitors.

Nikolaeva (1977) had given a detailed classification of various mechanisms involved in primary seed dormancy.

(A) Exogenous/coat imposed dormancy

A-1 Physical - due to impermeability to water and O_2

A-2 Chemical - due to the presence of inhibitors in the coat

A-3 Mechanical - due to mechanical resistance of coat to embryo expansion

(B) Endogenous/Embryo dormancy

B-1 Morphological - due to immature embryo

B-2 Physiological - due to physiological inhibiting mechanisms in the seed

(C) combined dormancy - different dormancy causing mechanisms occur simultaneously

Seed coat characters in Leguminosae (Ewart 1908; White 1908) were found to be responsible for dormancy.

Comparatively less is known about the nature of dormancy in groundnut.

Stokes and Hull (1930) commented that dormancy in runner type groundnut varieties was not due to impervious seed coat.

Toole et al. (1964) noticed that seed coat provided a diffusion or permeable barrier since the removal of seed coat could increase germination of dormant groundnut seeds but the removal appeared secondary to subsequent conditions or seed treatments. Presence of germination inhibitors in the seed coat was also reported by them.

Patil (1967) studied the dormancy in relation to maturity of groundnut pods. He harvested the developing pods at 30, 40 and 60 days after flowering and seeds were kept for germination under different treatments. It was noticed that excised embryo

irrespective of the stage of development, had very high percentage of germination while intact seeds did not germinate. He, therefore, concluded that dormancy in the varieties was not associated with the dormancy of embryo.

Sreeramulu (1968) noted the presence of inhibitors in seed coat, cotyledons and embryo axes of dormant TMV-3 seeds of groundnut.

The problem of nongermination of freshly harvested nondormant TMV-2 groundnut seeds was studied by Sreeramulu and Rao (1968a). They found that nongermination was due to mechanical resistance of seed coat to the growing embryo axis and this could be eliminated by drying the seeds for 4 days at laboratory temperature (33-35^{o}C) or by treating them with ascorbic acid and thiourea.

Sreeramulu and Rao (1968b) reported that leaching of dormant TMV-3 groundnut seeds, entire, after removal of seed coat and of the excised embryo axes resulted in germination and growth although stunted in the latter two treatments, evidently due to leaching of growth inhibitors. The entire seeds leached or

unleached as also unleached seeds without seed coats and unleached embryo axes did not germinate or grow.

Sreeramulu and Rao (1971) suggested the possible role of endogenous inhibitors, phenolic acids and coumarin in the development of seed dormancy in groundnut.

Rao and Rao (1972) studied the influence of removal of seed coat and intensive leaching of dormant groundnut seeds of TMV-3 on germination and mobilisation of carbohydrate in the cotyledons. Decoating by itself induced germination (40%) and leaching improved it to 100 per cent. However, seeds with intact seed coat failed to germinate even after continuous leaching for six hours. Seed coat retarded the removal of inhibitors and even continuous leaching of intact seeds facilitated only partial removal of inhibitors as these seeds did not germinate.

A physiological comparison was made between dormant TMV-1 and nondormant TMV-2 groundnut varieties by Vaithialingam and Rao (1973a). The water absorption capacity of the nondormant variety was more than that of the dormant strain. Presence of inhibitors in the seed coats, cotyledons and the primary axes of dormant variety

was well established. The inhibitors were more in the embryo region than seed coats of TMV-1. These inhibitors had retarding effect on shoot and root development.

Sengupta et al. (1977) reported that tightly attached seed coat was one of the factors that delayed the germination in dormant groundnut varieties. Its removal enhanced germination in some cultivars studied.

2.4 Biochemical nature of dormancy in groundnut seed

Seed dormancy is still a puzzling phenomenon which challenges scientists to investigate the anatomical and physiological changes during dormancy breaking process.

It was indicated by Nagarajan and Gopalakrishnan (1958) that the nondormant nature of bunch type groundnut was related to the presence of water soluble auxin like substance in the seeds.

A comparative study of the catalase activity during the development of dormant var. TMV-3 and nondormant var. TMV-2 was made by Sreeramulu and Rao (1967). In both varieties, catalase activity in the

cotyledons increased during the development of the seed upto 40 days and then went down while in the embryonic axis a continuous rise was observed till maturity, in both. The catalase activity remained at higher level in the embryonic axis of the nondormant seed. A decrease was observed in the activity in the dormant ones at the same time.

Sreeramulu and Rao (1971) monitored seed development in groundnut cultivars TMV-2 (nondormant) and TMV-3 (dormant). The content of total phenols per seed increased as the seed matured, but at almost all stages the levels were higher in dormant ones. The contents of inhibitory phenolic acids were higher and that of synergistic ones lower in dormant ones than in nondormant ones at all stages of development. Dormant contained more coumarin than nondormant. Compared to phenolic acids, coumarin content was very high in dormant and nondormant seeds and was higher in the former. In mature seeds the activity of chlorogenic acid phenolase was higher than P-HBA phenolase and the levels of both these enzymes were higher in nondormant seeds.

Sreeramulu and Rao (1972) reported that GA like substances increased rapidly between 20 and 40 days of

development in the seeds of nondormant and dormant cultivars, the increase being greater in nondormant cultivars. This was followed by a decline, the rate being greater in dormant than nondormant cultivar. The peak of GA activity was observed just before the seeds reached their maximum weight.

The physiological differences between dormant TMV-1 and nondormant TMV-2 groundnut varieties in respect of sugar content, catalase activity and respiratory rates were studied by Vaithialingam and Rao (1973b). The dormant variety contained more sucrose in both cotyledons and primary axes which appeared to be one of the factors associated with dormancy. Under soaked conditions, the nondormant variety contained glucose in addition to sucrose. The catalase activity and respiratory rates were more in nondormant than dormant varieties.

Physiological comparisons of the dormant and nondormant groundnut varieties were made with particular reference to the distribution of amino acids and protein by Vaithialingam and Rao (1973c). The contents of total free amino acids in the primary axes of TMV-1 were more than that of TMV-2. The dry fractions of primary axes and cotyledons of TMV-1 contained more amino acids than

imbibed fractions. Dormant TMV-1 contained more of protein than the nondormant TMV-2. Thus they suggested that high accumulation of total free amino acids and protein might have an inhibitory influence on the germination of seeds.

The possibility that germination of peanut seeds (loss of dormancy) might be controlled by the level of RNA and/or protein synthesis was suggested by Ketring (1975).

Perl (1982a) found that cell free extracts of groundnut seeds synthesised 0.6, 0.1, 0.4 n mol ATP/min. on g protein in the presence of AMP+Phosphoenolpyruvate, $NADH_2$ + PEP and NAD + PEP respectively. Only with $NADH_2$ + PEP, there was higher activity in the extracts from nondormant than from dormant seeds.

Ripening and dormancy breaking of groundnut was accompanied by an increase, followed by a decrease, in the ability to accumulate ATP in the embryonic axes and cotyledons (Perl, 1982b). Concentration of ATP and also ADP decreased consequently during dormancy breaking. Germination ability was correlated with decrease of ATP in the embryo while dormancy breaking was associated with decrease of ATP in the cotyledons.

Huang and Fu (1983) observed that nondormant groundnut seeds produced ethylene during germination. The vigour of the seed was correlated with the amount and pattern of ethylene release.

Ketring and Pattee (1985) stored seeds of groundnut cultivar NC.13 at 2-5^{o}C for 193-242 days and tested them at 28 days interval for germination, ethylene production and lipoxygenase activity. Lipoxygenase activity was lower for mature than immature seeds and increased greatly during storage. Progressive increase in ethylene production and germination and decrease in the lipoxygenase activity after heat treatment of seeds led to the conclusion that ethylene production and germination occured simultaneously with lipoxygenase activity and that metabolites from latter might serve as substrate for ethylene production.

Swamy and Sandhyarani (1986) assayed the levels of (a) glucose, 6 - PO_4 dehydrogenase (b) 6 phospho-gluconate dehydrogenase and (c) aldolase in dormant and nondormant purelines of groundnut. In dormant lines, cotyledons showed increased levels of activity of (a) and (b) during dry storage after ripening, while the embryonic axis did not exhibit detectable levels of

enzyme activity immediately after harvest, the activity appeared after a period of dry storage. Kinetin treatment increased aldolase activity in the embryonic axis, compared with control. In nondormant types, activities of (a) and (b) increased sharply both in cotyledons and embryonic axis while activity of (c) decreased in the cotyledons and increased in the embryonic axis between 24-96 hours of germination. ABA inhibited enzyme activities.

2.5 Induction of dormancy in groundnut

Rao and Rao (1970) reported that NAA and MH (10 ppm) reduced water uptake by seeds. NAA inhibited seedling growth more strongly than MH in groundnut. MH reduced respiratory activity of the embryo axis to a greater extent.

Nagarjun and Radder (1983a) showed that MH sprayed 60 days after sowing was superior to that sprayed 75 or 90 days after sowing in inducing seed dormancy in groundnut. But 250 ppm sprayed 60 days after sowing was as good as higher concentrations sprayed at later stages in inducing seed dormancy. Reduction in moisture content and catalase activity were correlated with increase in the degree of seed dormancy.

Gupta et al. (1985) observed that foliar spray of 15 x 10^3 or 20 x 10^3 ppm MH applied to groundnut seeds 90 DAS increased seed dormancy.

2.6 Methods of breaking dormancy in groundnut

2.6.1 Predrying

Hull (1937) found that in seeds of Florida Runnder, the duration of dormancy was a function of storage temperature and age of seeds. The rest requirement dropped suddenly in the seeds stored at 20-25^{o}C and even more so in those stored at 40^{o}C.

Baily et al. (1958) observed that fresh seeds of Virginia bunch 67, when stored at 40^{o} - 50^{o}C had a shorter dormancy than those stored at 30^{o}C. Moisture content did not seem to be a decisive factor in after ripening.

McFarland and Smith (1966) found that predrying at 40^{o}C after stack drying in the field for one month completely overcame dormancy in Florigiant, Atkin runner and Va 56-R. Without stack drying 4 per cent and 1 per cent dormancy respectively, still remained in Atkin Runner and Va 56-R, the most dormant types.

Shacrir (1978) noticed a direct correlation between increased storage temperature and accelaration of after ripening in dormant groundnut seeds stored at temperature between five and 45°C. Piercing and pre-soaking had no effect on seeds in very deep dormancy or on intact seeds of K 131. As after ripening progressed, so did the increase in percentage of germinating seeds with mechanical damage as compared with undamaged control. It was suggested that dry storage at high temperature accelerated an oxidation mechanism involved in dormancy breaking and caused changes in permeability of seed tissues. Increased permeability enabled the exit of inhibitory substances from seed and also provided easy access of O_2 to the embryo. Such permeability changes took place during natural after ripening.

Rehim et al. (1980) compared the germination of groundnut variety Florunner seeds which were soaked in hot water (50°C) for 15-20 min. or aqueous acetone solution with that of dry seeds or seeds soaked in water at 25°C for 20 min. Germination and seedling vigour were highest with hot water or acetone treatments. Drying at 40°C after hot water or acetone treatment reduced fungal growth.

2.6.2 Effect of aqueous extract/leaching

Pillai (1966) found that germination of TMV-1 seeds increased with treatment of seeds with aqueous extracts from nondormant seeds of TMV-2. This study using dormant TMV-1 seeds 20 days after harvest, revealed that difference in concentration of the extract did not bring about significant difference in germination percentage between treatments other than control. The optimum concentration ranged from 250 ml to 4000 ml. For practical purposes, it was sufficient to use lower concentration to economise the treating material.

Sreeramulu and Rao (1968b) and 1969) observed that germination could be improved by leaching dormant seeds after removal of seed coat.

Rao et al. (1972) observed the possibility of breaking dormancy of groundnut seeds by subjecting the decoated seeds to running water for six hours.

Sengupta et al. (1977) based on a study of soaking seeds with seed leachates in nine groundnut genotypes showed that, dormant varieties did not germinate in the leachates obtained from nondormant

seeds. On the other hand, leachates of dormant seeds had little effect on nondormant seeds.

Nagarjun and Radder (1983b) suggested that a practical method of inducing germination in dormant varieties was leaching of seeds in running water. Seed leaching increased the rate of germination in Karad 4-11 but not in S_{230}.

2.6.3 Effect of chemicals

Shibuya (1938) reported that indole-3 acetic acid in lanolin (0.1 g of IAA/g of lanolin) applied to exposed radical end of dormant peanut seeds stimulated germination. However, it was necessary to wound the tissue to allow penetration of the hormone, since wounding or IAA lanoline alone, did not stimulate germination. Also 90 per cent germination was achieved only after drying the pods under natural conditions for one week and determining germination at the end of two weeks.

Toole et al. (1964) after a study with seeds of Virginia bunch type groundnut seeds reported that dormancy could be broken by ethylene.

Ketring and Morgan (1969) based on a germination study of peanut varieties having dormant and nondormant seeds found that ethylene was associated with germination process of nondormant seeds and participated in breaking dormancy of dormant seeds.

Ketring and Morgan (1970) observed that IAA did not stimulate ethylene production by or germination of dormant NC-13 Virginia type peanut seeds to any extent. GA at 5×10^{-4}M stimulated ethylene production by apical seeds and germination to only 40 per cent above the control. The more dormant basal seeds were affected even less by GA than the apical seeds. Ethylene gas stimulated germination to 85 per cent above the control in apical and basal seeds. 2-chloroethyl phosphonic acid (CEPA) at 10^{-3} and 5×10^{-4}M provided results similar to ethylene gas.

Bear and Bailey (1971) found that seed treatment with tetramethyl thiuram disulphide and germination environment had a substantial effect on dormancy of seeds of Spanish and Valencia peanuts. They suggested that thiram altered the balance of promoters and inhibitors which was responsible for initiation of germination process.

Ketring and Morgan (1971) determined germination, ethylene production and Co_2 production by dormant Virginia peanuts under treatment with plant growth regulators. Kinetin, benzylaminopurine and 2-chloroethylphosphonic acid induced extensive germination above water controls. Coumarin induced slight germination stimulation while 2,4-D, ABA and succinic acid did not stimulate germination above controls. Benzylaminopurine and 2-chloroethylphosphonic acid increased the germination of the more dormant basal seeds to a larger extent than less dormant apical seeds. However, the opposite was true for kinetin.

Thandavarayan et al. (1972) reported that ethrel could remove the dormancy of TMV-10 groundnut variety.

In a trial with groundnut cultivar NC-13, Florunner, Virginia Bunch 67 and early runner, Bailey and Bear (1973b) found that ethephon used as a water solution at 10^{-3}M or as a slurry in conjunction with thiram dust as a pre-sowing treatment showed promise as a practical means for breaking dormancy. The treatment was fully effective when applied immediately before or as much as 60 days before sowing.

Nur and Gasim (1974) reported that seed dressing with Aldrex-T (Adlrin + Thiram) and seed shelling had significant effect on breaking dormancy and increasing germination in nine varieties as compared with seed treatment using mercuric chloride. Dipping the seed in mercuric chloride and then washing it with water or leaving the seeds without washing had the same effect on inducing germination as the treatment having no seed dressing.

Narasimhareddy and Swamy (1976) studied the effect of various growth hormones on germination in dormant groundnut seeds. Kinetin and BA were found to be highly effective in breaking dormancy even in the presence of seed coat. GA was found to be ineffective in breaking dormancy of seeds with and without seed coat. ABA inhibited seed germination. They found that kinetin and BA could reverse the inhibitory effect of seed coat.

Ketring (1977) found that a dust formulation of ethrel diluted with fungicide Orthocide/Botran and applied to dry dormant seeds of Virginia type cultivar, NC-13 at 1, 3 and 5 per cent ethrel in the mixture broke the seed dormancy of groundnut cultivar.

Sengupta et al. (1977) observed that application of 0.1 mg GA_3 increased germination per cent but was effective only when one week seed dormancy had elapsed. Application of CCC caused partial inhibition of germination in nondormant seeds which could be reversed by GA.

Rehim et al. (1981) reported that germination rate in Florunner seeds was increased by soaking seeds in water or aqueous solution of calcium hydroxide at 50°C for 20 minutes. Seeds which were dried at 40°C for 48 hours after soaking or were soaked, dried and then stored upto 35 days had higher germination rate than untreated seeds. Soaking also decreased mould growth.

Nagarjun and Radder (1983b) found that out of the 11 seed treatments tried, ethrel was found to be very effective in inducing early germination and breaking the seed dormancy. However, from the economical point of view of seed treatment, leaching of seeds with running water was better. As an alternative thiram slurry seed treatment could be suggested. Varieties differed in their response to different treatments.

Huang and Fu (1983) reported that ethylene release was enhanced by treatment with 0.5 or 1.0 mM GA_3, 0.1 mM ACC and 0.05 or 0.5 mM BA. The ethylene release was inhibited when 10^{-3}, 0.5×10^{-3} M. IAA and 250, 500 or 2000 ppm Bg (daminozide) were used for seed soaking.

Fu et al. (1984) observed that treatment of groundnut seeds with 20 per cent polyethylene glycol at 17°C for two days followed by drying at 30°C for two hours gave germination more rapidly than untreated seeds. The treatment also increased phosphate uptake and RNA synthesis.

Fu et al. (1985) noticed that sowing seeds in 50-500 ppm ethephon increased germination and vigour. Chilling at 3-5°C before sowing increased vigour and improved the performance.

2.7 Inheritance of dormancy in groundnut

Dormancy of seed appears to be more common in certain group of plants than in others. Certain varieties or species of cultivated crops show dormancy whereas others do not. The degree of dormancy appears to be dependent on climatic conditions during maturation and also on storage.

Stokes and Hull (1930) in their study of progenies of crosses between Spanish and Runner types of groundnut, found that the dormancy of Runner type was incompletely dominant over nondormant nature of Spanish type.

Hull (1937) measured the rest period of seeds in terms of average time required for emergence when planted at harvest. In Spanish and Valencia rest period ranged from 9-50 days, while in Runners the range was from 110 to 210 days. He assumed a multigenic control of dormancy with normal frequency distribution.

The inheritance of seed dormancy in groundnut was observed in a few varieties and their hybrids by John et al. (1948). The seeds of F_1 were found intermediate in behaviour between the two parents while the F_2 segregation showed great variability and indicated that multiple factors were responsible.

Ramachandran et al. (1967) based on a study in direct and reciprocal crosses involving four nondormant female parents and six dormant pollen parents, showed that dormancy was partially dominant over nondormancy and the dormant nature was associated with dark green leaves.

Lin and Lin (1971) indicated that dormancy was controlled by a single dominant gene D. The F_2 of Java-2 (Nondormant) x NC-1 (short dormancy) deviated from 3:1 ratio, because the two varieties were not widely different in dormancy.

Materials and Methods

3. MATERIALS AND METHODS

The investigations reported herein were undertaken in the Department of Agricultural Botany, College of Horticulture, Vellanikkara during the years 1987 to 1990.

3.1 MATERIALS

The materials used in the study consisted of 419 genotypes representing different botanical groups and belonging to different countries. Out of these 242 belonged to hypogaea group (Virginia), 137 to vulgaris (Spanish) and 38 to fastigiata (Valencia).

The materials were obtained from the Germplasm Resources Unit of ICRISAT, Hyderabad. The details of the genotypes are furnished in Table 1 and illustrated in Plates 1a and 1b.

3.2 METHODS

3.2.1 Dormancy rating of the genotypes under study

The 419 genotypes mentioned above were grown in nonreplicated breeding plots of 2 m x 2 m during May 1987 to September 1987 adopting a spacing of 25 cm

Table 1. Details of groundnut germplasm used for dormancy study

Sl. No.	Catalog No.	Identity	Botanical group	Country of origin
(1)	(2)	(3)	(4)	(5)
1	ICG 1	RS 1	hypogaea	India
2	" 33	RS 114	vulgaris	Unknown
3	" 45	RS 132	"	"
4	" 46	RS 135	"	"
5	" 68	66-94	hypogaea	"
6	" 74	RB 4	"	India
7	" 128	AH 7398	fastigiata	Unknown
8	" 179	IARI 731	vulgaris	India
9	" 185	69-9	hypogaea	Unknown
10	" 187	Big Japan	"	India
11	" 198	68-B	"	Unknown
12	" 237	IARI 687	vulgaris	India
13	" 382	A 18	"	USA
14	" 429	44-187	fastigiata	Argentina
15	" 459	Barberton	vulgaris	S. Africa
16	" 479	Cochin Red	hypogaea	India
17	" 490	Kopergaon 1	"	"
18	" 530	AH 6835	"	Tanzania
19	" 572	S 7-12-1	"	Sudan
20	" 573	S 7-2-2	"	"

Table 1.(contd....)

(1)	(2)	(3)	(4)	(5)
21	ICG 596	HG 11	hypogaea	India
22	" 599	KR 50	"	"
23	" 721	6842	"	USA
24	" 741	Castle Cary(PC)	"	Nigeria
25	" 759	K 7-4-11	"	India
26	" 760	K 4-11-2(R)	"	"
27	" 801	Samrala-3 Seeded	"	"
28	" 805	SP. Peanut	"	Unknown
29	" 807	Talod 32-3	"	India
30	" 813	B 3	"	"
31	" 819	C 15	"	Unknown
32	" 821	C 22	"	"
33	" 829	C 38	"	India
34	" 844	C 87	"	Unknown
35	" 845	C 99	"	India
36	" 857	C 114	"	Unknown
37	" 860	C 117	"	"
38	" 861	C 118	"	"
39	" 862	C 121	"	"
40	" 866	C 125	"	"
41	" 867	C 129	"	"
42	" 883	C 145-12-P-14	"	India

Table 1.(contd.....)

(1)	(2)	(3)	(4)	(5)
43	ICG 889	C 145-12-P-34	hypogaea	India
44	" 890	C 147	"	Unknown
45	" 894	C 151	"	"
46	" 898	C 158	"	"
47	" 899	C 159	"	"
48	" 900	C 160	"	"
49	" 905	C 175	"	"
50	" 907	C 177	"	"
51	" 908	C 178	"	India
52	" 909	C 179	"	"
53	" 911	C 284	"	Unknown
54	" 912	C 1025	"	"
55	" 914	Dixie Runner	"	USA
56	" 920	Teso Bunch	"	Kenya
57	" 924	Kanyoma Bunch	"	Tanzania
58	" 939	U 4-4-26	"	Unknown
59	" 941	U 2-1-6	"	Senegal
60	" 943	F 7	"	Unknown
61	" 944	F 11	"	"
62	" 950	G 37	"	India
63	" 966	RS 7	"	Unknown
64	" 976	T 11-11	"	India

Table 1.(contd....)

(1)	(2)	(3)	(4)	(5)
65	ICG 1002	AH 84	hypogaea	India
66	" 1006	AH 262	"	USA
67	" 1018	AH 731	"	Unknown
68	" 1028	AH 6990	"	"
69	" 1037	AH 7224	"	Nigeria
70	" 1039	AH 8045	"	Unknown
71	" 1040	AH 8048	"	"
72	" 1054	145-12-12	"	India
73	" 1056	#438-8	"	Unknown
74	" 1063	#648-4 (GWALIOR)	"	India
75	" 1070	#3095	"	Unknown
76	" 1079	AH 6950	"	India
77	" 1081	AH 7010	"	"
78	" 1086	Batani-9	vulgaris	"
79	" 1092	Chandodi	"	"
80	" 1094	Changja	hypogaea	Unknown
81	" 1118	Kalamdi	vulgaris	Kenya
82	" 1180	AH 73	"	Tanzania
83	" 1207	AH 2615-1	"	India
84	" 1231	AH 4218	"	"
85	" 1258	AH 7154	"	Unknown
86	" 1278	AH 7320	"	China

Table 1.(contd....)

(1)	(2)	(3)	(4)	(5)
87	ICG 1281	AH 7336	vulgaris	China
88	" 1308	U 4-4-27	"	Zaire
89	" 1334	NG 268	"	India
90	" 1335	NG 337	"	"
91	" 1355	SS 50	"	"
92	" 1399	U 2-4-1	fastigiata	Malawi
93	" 1435	U 4-4-23	vulgaris	Uganda
94	" 1440	U 4-4-29	"	Zaire
95	" 1452	U 4-12-3	"	Argentina
96	" 1459	1-3	"	India
97	" 1460	2-2	"	"
98	" 1512	#2196	"	Unknown
99	" 1552	AH 7834	"	"
100	" 1564	X 7-2-4-3-1-B	hypogaea	India
101	" 1568	X 7-2-4-3-22-B	"	"
102	" 1574	AH 3583	vulgaris	USA
103	" 1581	Erecta	"	Unknown
104	" 1584	AH 6678	"	"
105	" 1597	AH 7117	hypogaea	"
106	" 1752	EC 259627	fastigiata	Uruguay
107	" 1767	AH 259	hypogaea	Unknown
108	" 1796	U 2-4-7	fastigiata	Senegal

Table 1. (contd....)

(1)	(2)	(3)	(4)	(5)
109	ICG 1808	U 4-7-24	vulgaris	Sudan
110	" 1836	U 4-47-10	"	USA
111	" 1848	NG 387	"	India
112	" 1859	EC 6902	"	Unknown
113	" 1869	NG 423	"	India
114	" 1882	658	"	Unknown
115	" 1883	EC 289622	fastigiata	"
116	" 1895	Spantex	vulgaris	USA
117	" 1896	Short 1	"	India
118	" 1902	1736	"	Unknown
119	" 1905	Short 3	"	India
120	" 1920	AH 3490	hypogaea	Unknown
121	" 1927	NG 243	vulgaris	India
122	" 1928	EC 6189	"	Unknown
123	" 1931	Occile	"	"
124	" 1938	Maghigood 1-1	"	India
125	" 1947	XVI 1-3-4-3	"	"
126	" 1964	NG 53	"	"
127	" 1983	TG 4	"	Tanzania
128	" 1985	U 2-12-1	"	Zaire
129	" 2021	AH 2789	"	Unknown
130	" 2038	AH 6451	"	India

Table 1.(contd....)

(1)	(2)	(3)	(4)	(5)
131	ICG 2070	# 420	vulgaris	Unknown
132	" 2073	# 639	"	"
133	" 2076	# 1025	"	"
134	" 2093	RS 60	"	"
135	" 2118	1-2	hypogaea	India
136	" 2144	U 2-24-5	fastigiata	Senegal
137	" 2145	U 2-24-7	"	Unknown
138	" 2149	U 2-1-24	vulgaris	Zaire
139	" 2166	U 4-4-16	"	India
140	" 2170	U 4-4-26	"	Tanzania
141	" 2189	AH 6481-1	"	India
142	" 2236	Jhobad No.6	"	"
143	" 2322	Normal SEG DMC	hypogaea	USA
144	" 2327	Normal SED DMC	"	"
145	" 2362	Virginia Bunch	"	Brazil
146	" 2456	AH 62	"	India
147	" 2471	AH 4354	"	"
148	" 2488	AH 7620	"	Unknown
149	" 2503	C 3	"	"
150	" 2511	C 21	"	India
151	" 2515	C 29	"	Unknown
152	" 2518	C 37	"	"
153	" 2519	C 38	"	India

Table 1.(contd....)

(1)	(2)	(3)	(4)	(5)
154	ICG 2521	C 41	hypogaea	Unknown
155	" 2523	C 46	"	India
156	" 2530	C 75	"	"
157	" 2539	C 100	"	"
158	" 2545	C 107	"	Unknown
159	" 2553	C 121	"	"
160	" 2566	C 140	"	"
161	" 2571	C 145-12	"	India
162	" 2572	C 146	"	Unknown
163	" 2578	C 152	"	India
164	" 2587	C 162	"	Unknown
165	" 2591	C 171	"	"
166	" 2595	C 175	"	"
167	" 2599	C 179	"	India
168	" 2604	Castle Chery	"	Nigeria
169	" 2641	EC 16622	"	Unknown
170	" 2767	JH 352	"	India
171	" 2769	JH 354	"	"
172	" 2770	K 8-8-1	"	"
173	" 2789	Madagascar	"	Malagasay
174	" 2832	Samrala	"	India
175	" 2866	US 73	"	USA

Table 1.(contd....)

(1)	(2)	(3)	(4)	(5)
176	ICG 2868	USA 20	hypogaea	USA
177	" 2872	USA 69	"	"
178	" 2875	28-206-1	"	"
179	" 2876	VAR 28-2	"	Senegal
180	" 2887	# 1-2	"	India
181	" 2894	# 6-11-6	"	"
182	" 2901	# 40-4	"	"
183	" 2902	# 42-9	"	"
184	" 2921	C 145-12-P-7	"	"
185	" 2931	575-2	"	"
186	" 2973	DH 3-30	vulgaris	"
187	" 3100	AH 4218	"	Unknown
188	" 3136	AH 7890	"	"
189	" 3165	Chinese	"	China
190	" 3173	C 941	"	India
191	" 3179	Dharwar 1	"	"
192	" 3189	EC 1717	"	Unknown
193	" 3192	EC 1939	"	"
194	" 3196	Kalamdi	"	Kenya
195	" 3204	EC 16697	fastigiata	Unknown
196	" 3207	R 7-47-11	vulgaris	Sudan
197	" 3376	JH 223	"	India

Table 1.(contd....)

(1)	(2)	(3)	(4)	(5)
198	ICG 3482	Surin	vulgaris	India
199	" 3611	Starr	"	USA
200	" 3655	Azozorozo	"	Zaire
201	" 3777	Robut 33	fastigiata	Israel
202	" 3782	R 7-47-10	vulgaris	Sudan
203	" 3810	AH 33-4-1	hypogaea	India
204	" 3878	E 6919	"	Unknown
205	" 3882	C 830	"	India
206	" 3915	AH 3849	"	Sri Lanka
207	" 4002	Punjab Bold	"	India
208	" 4322	K/160	"	Tanzania
209	" 4324	IC 22966	"	India
210	" 4326	Kaulikoro	"	Tanzania
211	" 4329	Kongwa Runner	"	"
212	" 4331	IC 22939	"	India
213	" 4332	M 145	"	"
214	" 4333	M 755	"	"
215	" 4335	MD 351	"	Nigeria
216	" 4339	Mixture	"	Unknown
217	" 4343	NG 268	"	India
218	" 4350	No.4354	"	Unknown
219	" 4351	P 331	"	India
220	" 4353	IC 22956	"	"

Table 1.(contd....)

(1)	(2)	(3)	(4)	(5)
221	ICG 4354	PB 71-17	hypogaea	India
222	" 4357	IC 22945	"	"
223	" 4358	PB 649	"	"
224	" 4365	R 7-4-5	"	Sudan
225	" 4368	R 7-4-9	"	Tanzania
226	" 4369	R 7-4-10	"	Sudan
227	" 4373	R 7-24-4	"	"
228	" 4376	R 7-24-7	"	Tanzania
229	" 4377	R 7-24-8	"	Sudan
230	" 4379	R 7-47-2	"	Senegal
231	" 4380	R 7-47-3	"	Tanzania
232	" 4407	Spanette	vulgaris	USA
233	" 4603	Jatuti	"	Unknown
234	" 4637	S 227	"	India
235	" 4643	Southern Cross	"	USA
236	" 4735	U 4-47-4	"	Senegal
237	" 4750	Rosado	"	Paraguay
238	" 4861	AH 7652	hypogaea	"
239	" 4862	AH 7684	vulgaris	Argentina
240	" 4869	AH 7221	fastigiata	Nigeria
241	" 4870	AH 6958	vulgaris	India
242	" 5086	RCM 492	fastigiata	Paraguay

Table 1.(contd....)

(1)	(2)	(3)	(4)	(5)
243	ICG 5087	RCM 525	vulgaris	Paraguay
244	" 5090	RCM 541	"	Brazil
245	" 5094	RCM 585	fastigiat:	"
246	" 5112	Avoca 110	hypogaea	"
247	" 5115	SAN 92	"	"
248	" 5116	RCM 436	"	Bolivia
249	" 5118	NCAC 17732	"	USA
250	" 5123	NCAC 17840	"	"
251	" 5127	NCAC 17287	"	"
252	" 5128	4518	"	"
253	" 5131	GA 205	fastigiata	"
254	" 5133	4080	hypogaea	"
255	" 5135	MF 47	vulgaris	Argentina
256	" 5219	Florigiant	hypogaea	USA
257	" 5293	Mwitunde	"	Uganda
258	" 5294	Early Runner	vulgaris	USA
259	" 5297	Spanhoma	"	"
260	" 5325	MH 383	hypogaea	Nigeria
261	" 5329	A 5-46	fastigiata	Liberia
262	" 5357	C 12-P-17	hypogaea	India
263	" 5358	C 12-P-28	"	"
264	" 5373	No.1022	"	"

Table 1. (contd....)

(1)	(2)	(3)	(4)	(5)
265	ICG 5374	No.2402-1	hypogaea	India
266	" 5389	AH 7787	"	Unknown
267	" 5393	Florispan	"	USA
268	" 5428	F 1-5-1	vulgaris	India
269	" 5433	Go 133	"	"
270	" 5453	US 29	fastigiata	USA
271	" 5457	20-1-2	vulgaris	India
272	" 5461	AH 816	fastigiata	Unknown
273	" 5585	AH 7846	vulgaris	USA
274	" 5601	AH 8318	"	Unknown
275	" 5617	AH 62	hypogaea	India
276	" 5709	HL 234	fastigiata	Argentina
277	" 5729	NCAC 10477-B	hypogaea	USA
278	" 5825	NC 17 S	"	"
279	" 5981	Spancross	vulgaris	"
280	" 6021	NCAC 434	"	Argentina
281	" 6109	B 27	hypogaea	USA
282	" 6181	Local Spreading	"	Zimbabwe
283	" 6193	43 G 44	"	S. Africa
284	" 6242	Rabat No.3	vulgaris	Mauritius
285	" 6277	WCG 166 B	fastigiata	Brazil
286	" 6297	NCAC 17615	hypogaea	USA
287	" 6301	NCAC 17649	"	"

Table 1.(contd....)

(1)	(2)	(3)	(4)	(5)
288	ICG 6341	2280	fastigiata	USA
289	" 6381	Kabota White	vulgaris	S. Africa
290	" 6405	RG 398	hypogaea	USA
291	" 6441	Sam Col.303	"	Unknown
292	" 6477	Bambey 487	"	Senegal
293	" 6525	Mwitunde Nahcigaea	"	Tanzania
294	" 6557	489	fastigiata	Malawi
295	" 6561	Kaputo	hypogaea	"
296	" 6565	Sam Col.72	fastigiata	Unknown
297	" 6566	Sam Col.86	"	"
298	" 6581	Virginia Bunch Large	hypogaea	USA
299	" 6678	K 472	vulgaris	China
300	" 6679	Japanese	"	Zimbabwe
301	" 6689	Mbwa Runner	hypogaea	Tanzania
302	" 6746	M 20	"	Malawi
303	" 6761	Sam Col.217	"	Unknown
304	" 6773	RCM 518	fastigiata	Paraguay
305	" 6774	RCM 549	"	Brazil
306	" 6778	SB 110	vulgaris	Zimbabwe
307	" 6789	SAN 89	hypogaea	Brazil
308	" 6809	Sam Col.232	"	Unknown
309	" 6865	TMV 1	"	India

Table 1.(contd....)

(1)	(2)	(3)	(4)	(5)
310	ICG 6881	BMP 6	vulgaris	Zimbabwe
311	" 6894	NCAC 17659	hypogaea	USA
312	" 6950	NCAC 17562	"	"
313	" 6982	NCAC 17705	"	"
314	" 6997	Chiba Shoryu	vulgaris	Japan
315	" 7005	RCM 592	fastigiata	Brazil
316	" 7174	Sam Col.284	vulgaris	Unknown
317	" 7177	Malimba 3	"	Malawi
318	" 7178	2/1	hypogaea	Unknown
319	" 7180	US 34	vulgaris	"
320	" 7198	MS 24	"	Zimbabwe
321	" 7269	BMP 16/52	"	"
322	" 7282	65/4	"	"
323	" 7287	RCM 539	fastigiata	Brazil
324	" 7317	NCAC 17606	hypogaea	USA
325	" 7318	NCAC 17610	"	"
326	" 7381	295/63	fastigiata	Nigeria
327	" 7386	308/75	hypogaea	Malawi
328	" 7388	311/63	fastigiata	Zimbabwe
329	" 7393	404/64	"	"
330	" 7398	LV 5	"	"
331	" 7400	RV 6	"	"
332	" 7401	RV 8	"	"

Table 1.(contd....)

(1)	(2)	(3)	(4)	(5)
333	ICG 7402	RV 9	fastigiata	Zimbabwe
334	" 7409	RCM 582	"	Brazil
335	" 7422	TMV 3	hypogaea	India
336	" 7423	NRN 2	"	Zimbabwe
337	" 7425	Perdeniya	vulgaris	"
338	" 7426	Spanish 228	"	USSR
339	" 7434	NCAC 17902	hypogaea	USA
340	" 7438	M 1075-74(2)S	"	Nigeria
341	" 7446	M 6-76 M	"	"
342	" 7451	M 25-68(I) K	"	"
343	" 7474	Marabba Runner	"	Sudan
344	" 7475	Variety 68	"	Zimbabwe
345	" 7477	NCAC 17644	"	USA
346	" 7478	NCAC 17684	"	"
347	" 7479	NCAC 17690	"	"
348	" 7481	NCAC 17754	"	"
349	" 7485	M 145-75 S	"	Nigeria
350	" 7512	Hung Mein Chao	vulgaris	China
351	" 7537	VRR 348	"	India
352	" 7541	VRR 353	"	"
353	" 7553	VRR 365	"	"
354	" 7613	VRR 426	hypogaea	"
355	" 7614	NCAC 981	vulgaris	Argentina

Table 1.(contd....)

(1)	(2)	(3)	(4)	(5)
356	ICG 7615	Cord Willow	hypogaea	USA
357	" 7621	NCAC 17718	"	"
358	" 7626	PI 344839	fastigiata	Unknown
359	" 7633	UF 71513	"	USA
360	" 8009	F 1-17	hypogaea	Zimbabwe
361	" 8013	BMP 29	vulgaris	"
362	" 8025	NCAC 17780	hypogaea	USA
363	" 8029	NCAC 17864	"	"
364	" 8086	Magale 1	vulgaris	Tanzania
365	" 8105	RCM 449-3	"	Argentina
366	" 8110	NCAC 17591	hypogaea	USA
367	" 8121	Sam Col.93	vulgaris	Unknown
368	" 8217	AM 2	hypogaea	Zimbabwe
369	" 8218	Luwingu	"	"
370	" 8220	NCAC 17706	"	USA
371	" 8225	NCAC 403	fastigiata	"
372	" 8281	NC 10468	hypogaea	"
373	" 8289	NC 10452	"	"
374	" 8313	NC 90854	"	"
375	" 8321	NC 7497	"	"
376	" 8329	NC 9085 S	"	"
377	" 8345	NC 6720	"	"
378	" 8429	SAD 148	"	Malawi
379	" 8541	RG 363	"	Bolivia

Table 1.(contd....)

(1)	(2)	(3)	(4)	(5)
380	ICG 8669	ACC # 737	vulgaris	Indonesia
381	" 8673	ACC # 805	"	"
382	" 8685	MJH 004	"	Malayasia
383	" 8689	MJH 008	"	"
384	" 8690	MJH 009	"	"
385	" 8793	ZM 560	hypogaea	Zambia
386	" 8809	ZM 837	"	"
387	" 8829	JM 4205	vulgaris	Burma
388	" 8861	MS 30	"	Zimbabwe
389	" 8865	Argentine # 8-1	"	"
390	" 8981	CBRR 5	"	USA
391	" 8985	GA 61-36	hypogaea	"
392	" 9002	Spanish 139	vulgaris	Zambia
393	" 9006	NCAC 17571	hypogaea	USA
394	" 9009	NCAC 17593	"	"
395	" 9014	NCAC 17713	"	"
396	" 9045	58-1	"	Niger
397	" 9049	58-18	"	Mali
398	" 9062	58-41	"	Togo
399	" 9117	75-74	vulgaris	Nigeria
400	" 9121	75-78	hypogaea	"
401	" 9342	59-348	vulgaris	Senegal

Table 1.(contd....)

(1)	(2)	(3)	(4)	(5)
402	ICG 9425	63-108	hypogaea	Senegal
403	" 9445	75-51	vulgaris	Argentina
404	" 9497	63-106	"	Senegal
405	" 9501	PR 5290	"	Philippines
406	" 9541	RPM 074	hypogaea	Mozambique
407	" 9542	RPM 076	"	"
408	" 9609	VRR 535	vulgaris	India
409	" 9613	VRR 546	"	"
410	" 9681	VRR 683	hypogaea	"
411	" 9725	VRR 766	"	"
412	" 9729	VRR 775	"	"
413	" 9769	DSA 181	"	Ghana
414	" 9773	DSA 200	vulgaris	"
415	" 9833	Ashford	hypogaea	Sudan
416	" 9909	ZM 2907	"	Zambia
417	" 10328	G 397-1	others	India
418	" 10339	Indonesia 2	vulgaris	Indonesia
419	" 11403	SC 2251	others	India

Plate 1a Variability in seed size and colour in the material included in the study

1. ICG 1281
2. ICG 3777
3. ICG 1180
4. ICG 1308
5. ICG 198
6. ICG 8281
7. ICG 1037

Plate 1b Variability in seed size and colour in the material included in the study

8. ICG 2523
9. ICG 2144
10. ICG 2471
11. ICG 1002
12. ICG 8218
13. ICG 976
14. ICG 3882

Plate 1a Variability in seed size and colour in the material included in the study

1. ICG 1281
2. ICG 3777
3. ICG 1180
4. ICG 1308
5. ICG 198
6. ICG 8281
7. ICG 1037

Plate 1b Variability in seed size and colour in the material included in the study

8. ICG 2523
9. ICG 2144
10. ICG 2471
11. ICG 1002
12. ICG 8218
13. ICG 976
14. ICG 3882


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between rows and 25 cm between plants in a row. The cultural operations, manurial requirements and plant protection measures were followed as per the Package of Practices Recommendations, KAU, 1986.

The crop was harvested 80 days after the appearance of first flower and seeds extracted. The seeds were then tested for germinability on the day of harvest, the test being conducted in accordance with the provisions and procedures of ISTA (Anon, 1976). Each test consisted of 100 fully developed seeds per genotype. Care was taken to keep the blotting paper towel moist throughout the experiment.

Seed was considered to have germinated if the radicle had pierced the seed coat. A sound seed that had not germinated was considered to be dormant. Based on the results of the germination test, germination percentage and dormancy percentage were worked out. Following the dormancy scale employed by Lin and Chen (1970), the genotypes were classified into different dormancy groups as detailed below:

Dormancy rating or scale	0	1	2	3	4	5	6	7	8
Dormant seed %	0	1-10	11-20	21-40	41-60	61-70	71-80	81-99	100

Thus the percentage of germination immediately after harvest was taken as the basis for classifying the genotypes into groups having different dormancy rating.

3.2.2 Period of dormancy of genotypes

The pods, shade dried for seven days, were stored at room temperature and were used to determine the period of dormancy. Genotypes coming under the dormancy rating '8' alone were used for this study. The germination test was repeated at intervals of ten days for such periods as necessary to obtain a germination percentage of 90 or above. Based on the results of this study, the period of dormancy required for individual genotypes was ascertained.

3.2.3 Role of different parts of the seed in delaying germination

With a view to finding out the role of different entities of the seed in delaying germination, the following experiment was conducted from April 1988 to August 1988.

Seven dormant genotypes having maximum dormancy period viz. ICG-198, ICG-1002, ICG-2471, ICG-2523, ICG-4326, ICG-8218 and ICG-8281 were selected for the study.

Germination test was conducted with intact pod (T_1), intact seed (T_2), seed with pinholes on the testa (T_3), seed with testa removed (T_4) and excised embryonic axis (T_5). Each treatment was replicated four times with 25 seeds in each replication. The test was repeated at ten days interval until the type completed the period of dormancy. Seeds without testa and excised embryonic axis were considered to have germinated when radicle elongated in them.

3.2.4 Effect of aqueous extracts of dormant and nondormant types on their germination

Aqueous extracts of two dormant types, ICG-198 and ICG-2523 and two nondormant types, ICG-1281 and ICG-3777 were prepared. To prepare the extract, hundred seeds were mixed with 100 ml of distilled water and ground in a blender. This was filtered through Whatman No.1 filter paper and the volume was made upto 500 ml. Hundred freshly harvested seeds of the seven dormant types viz. ICG-198, ICG-1002, ICG-2471, ICG-2523, ICG-4326, ICG-8218 and ICG-8281 were soaked in the extract of nondormant types for varying periods viz., six hours, 12 hours, 18 hours and 24 hours. Similarly the, freshly harvested seeds of seven nondormant types, ICG-128, ICG-459, ICG-1231,

ICG-1281, ICG-1308, ICG-2144 and ICG-3777 were soaked in the extract of dormant types for 6 hours, 12 hours, 18 hours and 24 hours. After treatment for specified periods, the seeds were throughly washed with distilled water and kept for germination.

3.2.5 Effect of washing the seeds in running water

Hundred freshly harvested seeds in each of seven dormant types, ICG-198, ICG-1002, ICG-2471, ICG-2523, ICG-4326, ICG-8218 and ICG-8281 were used in this study. Seeds were taken in muslin cloth bag and kept in running water under a tap for 12 hours and 24 hours. Two sets of seeds were used in this study; one set with seed coat intact and the other set with seed coat removed. They were then tested for their germinability, the test being conducted as described earlier.

3.2.6 Effect of presowing treatments on the germination of dormant types

Four dormant groundnut genotypes ICG-198, ICG-1002, ICG-2471 and ICG-2523 were used for the study. A batch of hundred seeds was used for each treatment under each genotype. The different presowing treatments employed are given in Table 2.

Table 2. Different presowing treatments given to break the dormancy

Sl. No.	Chemical	Concentration	Time of treatment
1	$CuSO_4$	1.5%	24 hours
2	"	3%	"
3	$ZnSO_4$	1.5%	"
4	"	3%	"
5	$HgCl_2$	1 : 1000	5 minutes
6	"	"	10 minutes
7	Boric acid	1.5%	24 hours
8	"	3%	"
9	Glutathion	0.03%	"
10	"	0.3%	"
11	Ethyl alcohol	96%	5 minutes
12	"	"	10 minutes
13	IAA	0.001%	24 hours
14	"	0.01%	"
15	2,4-D	0.003%	"
16	"	0.03%	"
17	H_2O_2	1%	3 hours
18	"	5%	"
19	Boiling water	--	10 seconds
20	Steam	--	60 seconds
21	Untreated control	--	--

For seed treatment, the solution of each chemical was prepared according to the concentration by dissolving the requisite quantity of chemical in distilled water. For each treatment, hundred seeds were selected at random and soaked in the solution for specified periods. After treatment of the seeds, they were thoroughly washed in distilled water and subjected to germination test.

3.2.7 Inheritance of seed dormancy

Two dormant and two nondormant genotypes selected based on their germinability at harvest were grown in separate nonreplicated plots of 2 m x 2 m at a spacing of 50 cm between lines and 25 cm between plants in a line in May-December 1989. They were crossed in all possible combinations excluding reciprocals adopting the method described by Reddy and Kaul (1986). This method essentially consisted of the following steps.

A flower bud that was to open the next day, was selected and retained removing all other smaller buds and opened flowers at a particular node with the help of a pair of forceps. Holding the flower bud so chosen in position between the thumb and index finger, the single calyx lobe located above the keel was lifted upwards

and held back with the thumb. The fused lobes of calyx at the back of the standard petal, were pushed downwards and held back with the index finger. The standard petal also was pulled downwards and held back with the same index finger to expose the wing petals which were pulled side ways and inter locked with the base of the standard petal to expose the keel petals which were in their turn pulled upwards to expose anthers and stigma. Anthers (4 oblong and 4 globose) were removed and petals were pushed back to their original position. A coloured thread was tied just above the node where emasculation was performed. Next day morning, anthers which were to burst on that day, were collected from the male parent and rubbed against the stigmatic surface of the emasculated flower bud in the female parent.

Spanish and Valencia types flowered 20-24 days after sowing and Virginia types flowered 2-5 days later. Hence maximum crosses could be attempted during 30-40 days in Spanish and Valencia types and 35-45 days in Virginia types, after sowing. Emasculation was done after 4 PM (Kale and Mouli, 1984). Pollination was done during 6 AM to 9 AM (Kale and Mouli, 1984).

The nondormant varieties ICG-3777 and ICG-1281 were used as female parents as they possessed the recessive marker trait of the erect nature. This helped in easy and clear cut identification of hybrid. Details of crosses effected are furnished in Table 3.

Table 3 Particulars of crosses effected

Sl. No.	♀ parent	♂ parent	No. of flower buds crossed	No. of pods obtained	% of success
1	ICG-1281 (nondormant)	ICG-198 (dormant)	98	20	20.41
2	ICG-1281 (nondormant)	ICG-2523 (dormant)	94	19	20.21
3	ICG-3777 (nondormant)	ICG-198 (dormant)	104	24	23.08
4	ICG-3777 (nondormant)	ICG-2523 (dormant)	110	28	25.45

3.2.7.1 Study of F_1

The hybrid seeds were collected when fully mature. Half of the total number of seeds so obtained was put to germination test on the day of harvest. A random sample of 50 seeds of parents was also kept for germination test

as checks along with hybrid seeds on the day of harvest. Percentage of germination was worked out for hybrids and parents.

3.2.7.2 Study of F_2

The other half of seeds obtained above, was kept for two months at room temperature to overcome the after ripening period. F_1 was raised in plots of 4 m x 2 m at a spacing of 50 cm between rows and 50 cm between plants in a row during April-July 1990. The parents were also grown along with F_1 for comparison. The F_2 seeds borne on F_1 plants as well as parental lines were harvested 80 days after first flower opening. The pods were collected separately from each F_1 plant and parents. The percentages of germination for each of the F_1 plant seeds and parental lines were calculated.

3.2.7.3 Study of F_3

The seeds borne on two F_1 plants in each of the four crosses were used to raise F_2 plant generation during September-December 1990 in strips of 4 m x 3 m at a spacing of 50 cm betweens rows and 50 cm between plants, each family consisting of a strip. The parents were also grown for comparison in adjacent strips of

similar size. The pods of each plant were harvested separately to find out germination percentage. Thus the germinability of F_3 was also worked out. The interpretations on the inheritance of dormancy were made based on the data in the F_1, F_2 and F_3 germinations of the embryo.

Results

4. RESULTS

Results of observations on different aspects of seed dormancy in groundnut, collected from various experiments carried out in selected materials are presented in Tables 4 to 38.

The different aspects included in the study are survey and classification of groundnut genotypes into different dormancy groups, role of different parts of seed in delaying germination, presence of inhibitors or promoters causing dormancy or otherwise, effect of presowing treatments in breaking dormancy and nature of transmission of seed dormancy from parents to progeny. Results are presented hereunder.

4.1.1 Survey and classification of genotypes into different dormancy groups

For classifying groundnut genotypes into different dormancy groups, freshly harvested seeds of 419 genotypes belonging to various botanical groups and countries of origin, were subjected to germination test at harvest and the results are furnished in Table 4.

Table 4. Germination percentage and dormancy of groundnut genotypes at harvest

Sl. No.	Cagalog No.	Country of origin	Botanical group	Germination (%)	Dormant seed (%)	Dormancy rating
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1	ICG 1	India	hypogaea	0	100	8
2	" 33	Unknown	vulgaris	52	48	4
3	" 45	"	"	40	60	4
4	" 46	"	"	36	64	5
5	" 68	"	hypogaea	0	100	8
6	" 74	India	"	0	100	8
7	" 128	Unknown	fastigiata	90	10	1
8	" 179	India	vulgaris	10	90	7
9	" 185	Unknown	hypogaea	26	74	6
10	" 187	India	"	0	100	8
11	" 198	Unknown	"	0	100	8
12	" 237	India	vulgaris	60	40	3
13	" 382	USA	"	20	80	6
14	" 429	Argentina	fastigiata	16	84	7
15	" 459	S. Africa	vulgaris	90	10	1
16	" 479	India	hypogaea	0	100	8
17	" 490	"	"	0	100	8
18	" 530	Tanzania	"	0	100	8

Table 4.(contd....)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
19	ICG 572	Sudan	hypogaea	0	100	8
20	" 573	"	"	0	100	8
21	" 596	India	"	0	100	8
22	" 599	"	"	0	100	8
23	" 721	USA	"	0	100	8
24	" 741	Nigeria	"	0	100	8
25	" 759	India	"	0	100	8
26	" 760	"	"	0	100	8
27	" 801	"	"	0	100	8
28	" 805	Unknown	"	0	100	8
29	" 807	India	"	0	100	8
30	" 813	"	"	0	100	8
31	" 819	Unknown	"	0	100	8
32	" 821	"	"	0	100	8
33	" 829	India	"	0	100	8
34	" 844	Unknown	"	0	100	8
35	" 845	India	"	0	100	8
36	" 857	Unknown	"	0	100	8
37	" 860	"	"	0	100	8
38	" 861	"	"	0	100	8
39	" 862	"	"	0	100	8
40	" 866	"	"	0	100	8

Table 4.(contd....)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
41	ICG 867	Unknown	hypogaea	0	100	8
42	" 883	India	"	0	100	8
43	" 889	"	"	0	100	8
44	" 890	Unknown	"	20	80	6
45	" 894	"	"	0	100	8
46	" 898	"	"	10	90	7
47	" 899	"	"	0	100	8
48	" 900	"	"	0	100	8
49	" 905	"	"	0	100	8
50	" 907	"	"	0	100	8
51	" 908	India	"	0	100	8
52	" 909	"	"	0	100	8
53	" 911	Unknown	"	0	100	8
54	" 912	"	"	40	60	4
55	" 914	USA	"	0	100	8
56	" 920	Kenya	"	0	100	8
57	" 924	Tanzania	"	0	100	8
58	" 939	Unknown	"	0	100	8
59	" 941	Senegal	"	10	90	7
60	" 943	Unknown	"	0	100	8
61	" 944	"	"	0	100	8
62	" 950	India	"	0	100	8

Table 4.(contd.....)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
63	ICG 966	Unknown	hypogaea	0	100	8
64	" 976	India	"	0	100	8
65	" 1002	"	"	0	100	8
66	" 1006	USA	"	0	100	8
67	" 1018	Unknown	"	0	100	8
68	" 1028	"	"	0	100	8
69	" 1037	Nigeria	"	0	100	8
70	" 1039	Unknown	"	0	100	8
71	" 1040	"	"	0	100	8
72	" 1054	India	"	0	100	8
73	" 1056	Unknown	"	0	100	8
74	" 1063	India	"	0	100	8
75	" 1070	Unknown	"	0	100	8
76	" 1079	India	"	0	100	8
77	" 1081	"	"	20	80	6
78	" 1086	"	vulgaris	50	50	4
79	" 1092	"	"	40	60	4
80	" 1094	Unknown	hypogaea	0	100	8
81	" 1118	Kenya	vulgaris	40	60	4
82	" 1180	Tanzania	"	42	58	4
83	" 1207	India	"	30	70	5
84	" 1231	"	"	88	12	2

Table 4.(contd....)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
85	ICG 1258	Unknown	vulgaris	42	58	4
86	" 1278	China	"	22	78	6
87	" 1281	"	"	96	4	1
88	" 1308	Zaire	"	88	12	2
89	" 1334	India	"	40	60	4
90	" 1335	"	"	36	64	5
91	" 1355	"	"	36	64	5
92	" 1399	Malawi	fastigiata	36	64	5
93	" 1435	Uganda	vulgaris	46	54	4
94	" 1440	Zaire	"	40	60	4
95	" 1452	Argentina	"	60	40	3
96	" 1459	India	"	40	60	4
97	" 1460	"	"	26	74	6
98	" 1512	Unknown	"	28	72	6
99	" 1552	"	"	76	24	3
100	" 1564	India	hypogaea	20	80	6
101	" 1568	"	"	40	60	4
102	" 1574	USA	vulgaris	40	60	4
103	" 1581	Unknown	"	20	80	6
104	" 1584	"	"	28	72	6
105	" 1597	"	hypogaea	20	80	6
106	" 1752	Uruguay	fastigiata	30	70	5

Table 4.(contd....)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
107	ICG 1767	Unknown	hypogaea	0	100	8
108	" 1796	Senegal	fastigiata	50	50	4
109	" 1808	Sudan	vulgaris	80	20	2
110	" 1836	USA	"	66	34	3
111	" 1848	India	"	60	40	3
112	" 1859	Unknown	"	50	50	4
113	" 1869	India	"	60	40	3
114	" 1882	Unknown	"	48	52	4
115	" 1883	"	fastigiata	18	82	7
116	" 1895	USA	vulgaris	0	100	8
117	" 1896	India	"	30	70	5
118	" 1902	Unknown	"	40	60	4
119	" 1905	India	"	22	78	6
120	" 1920	Unknown	hypogaea	16	84	7
121	" 1927	India	vulgaris	70	30	3
122	" 1928	Unknown	"	40	60	4
123	" 1931	"	"	70	30	3
124	" 1938	India	"	48	52	4
125	" 1947	"	"	42	58	4
126	" 1964	"	"	20	80	6
127	" 1983	Tanzania	"	0	100	8
128	" 1985	Zaire	"	46	54	4

Table 4.(contd....)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
129	ICG 2021	Unknown	vulgaris	16	84	7
130	" 2038	India	"	60	40	3
131	" 2070	Unknown	"	80	20	2
132	" 2073	"	"	32	68	5
133	" 2076	"	"	12	88	7
134	" 2093	"	"	22	78	6
135	" 2118	India	hypogaea	0	100	8
136	" 2144	Senegal	fastigiata	94	6	1
137	" 2145	Unknown	"	80	20	2
138	" 2149	Zaire	vulgaris	30	70	5
139	" 2166	India	"	64	36	3
140	" 2170	Tanzania	"	60	40	3
141	" 2189	India	"	20	80	6
142	" 2236	"	"	44	56	4
143	" 2322	USA	hypogaea	0	100	8
144	" 2327	"	"	0	100	8
145	" 2362	Brazil	"	34	66	5
146	" 2456	India	"	0	100	8
147	" 2471	"	"	0	100	8
148	" 2488	Unknown	"	0	100	8
149	" 2503	"	"	0	100	8

Table 4.(contd....)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
150	ICG 2511	India	hypogaea	0	100	8
151	" 2515	Unknown	"	0	100	8
152	" 2518	"	"	0	100	8
153	" 2519	India	"	0	100	8
154	" 2521	Unknown	"	0	100	8
155	" 2523	India	"	0	100	8
156	" 2530	"	"	2	98	7
157	" 2539	"	"	0	100	8
158	" 2545	Unknown	"	6	94	7
159	" 2553	"	"	0	100	8
160	" 2566	"	"	0	100	8
161	" 2571	India	"	20	80	6
162	" 2572	Unknown	"	2	98	7
163	" 2578	India	"	0	100	8
164	" 2587	Unknown	"	0	100	8
165	" 2591	"	"	20	80	6
166	" 2595	"	"	4	96	7
167	" 2599	India	"	0	100	8
168	" 2604	Nigeria	"	8	92	7
169	" 2641	Unknown	"	0	100	8
170	" 2767	India	"	0	100	8
171	" 2769	"	"	0	100	8

Table 4.(contd....)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
172	ICG 2770	India	hypogaea	0	100	8
173	" 2789	Malagasay	"	0	100	8
174	" 2832	India	"	14	86	7
175	" 2866	USA	"	0	100	8
176	" 2868	"	"	0	100	8
177	" 2872	"	"	10	90	7
178	" 2875	"	"	0	100	8
179	" 2876	Senegal	"	0	100	8
180	" 2887	India	"	0	100	8
181	" 2894	"	"	8	92	7
182	" 2901	"	"	0	100	8
183	" 2902	"	"	40	60	4
184	" 2921	"	"	0	100	8
185	" 2931	"	"	0	100	8
186	" 2973	"	vulgaris	60	40	3
187	" 3100	Unknown	"	0	100	8
188	" 3136	"	"	36	64	5
189	" 3165	China	"	20	80	6
190	" 3173	India	"	24	76	6
191	" 3179	"	"	16	84	7
192	" 3189	Unknown	"	10	90	7
193	" 3192	"	"	40	60	4

Table 4. (contd....)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
194	ICG	3196	Kenya	vulgaris	66	34	3
195	"	3204	Unknown	fastigiata	20	80	6
196	"	3207	Sudan	vulgaris	52	48	4
197	"	3376	India	"	60	40	3
198	"	3482	"	"	76	24	3
199	"	3611	USA	"	20	80	6
200	"	3655	Zaire	"	24	76	6
201	"	3777	Israel	fastigiata	96	4	1
202	"	3782	Sudan	vulgaris	40	60	4
203	"	3810	India	hypogaea	0	100	8
204	"	3878	Unknown	"	0	100	8
205	"	3882	India	"	0	100	8
206	"	3915	Sri Lanka	hypogaea	0	100	8
207	"	4002	India	"	0	100	8
208	"	4322	Tanzania	"	0	100	8
209	"	4323	India	"	0	100	8
210	"	4326	Tanzania	"	0	100	8
211	"	4329	"	"	0	100	8
212	"	4331	India	"	0	100	8
213	"	4332	"	"	0	100	8
214	"	4333	"	"	0	100	8
215	"	4335	Nigeria	"	0	100	8

Table 4.(contd....)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
216	ICG 4339	Unknown	hypogaea	0	100	8
217	" 4343	India	"	20	80	6
218	" 4350	Unknown	"	0	100	8
219	" 4351	India	"	0	100	8
220	" 4353	"	"	0	100	8
221	" 4354	"	"	0	100	8
222	" 4357	"	"	0	100	8
223	" 4358	"	"	0	100	8
224	" 4365	Sudan	"	4	96	7
225	" 4368	Tanzania	"	0	100	8
226	" 4369	Sudan	"	0	100	8
227	" 4373	"	"	0	100	8
228	" 4376	Tanzania	"	0	100	8
229	" 4377	Sudan	"	0	100	8
230	" 4379	Senegal	"	0	100	8
231	" 4380	Tanzania	"	0	100	8
232	" 4407	USA	vulgaris	70	30	3
233	" 4603	Unknown	"	80	20	2
234	" 4637	India	"	40	60	4
235	" 4643	USA	"	60	40	3
236	" 4705	Senegal	"	44	56	4
237	" 4750	Paraguay	"	30	70	5

Table 4.(contd....)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
238	ICG 4861	Paraguay	hypogaea	0	100	8
239	" 4862	Argentina	vulgaris	36	64	5
240	" 4869	Nigeria	fastigiata	60	40	3
241	" 4870	India	vulgaris	40	60	4
242	" 5086	Paraguay	fastigiata	10	90	7
243	" 5087	"	vulgaris	56	44	4
244	" 5090	Brazil	"	80	20	2
245	" 5094	"	fastigiata	60	40	3
246	" 5112	"	hypogaea	0	100	8
247	" 5115	"	"	0	100	8
248	" 5116	Bolivia	"	10	90	7
249	" 5118	USA	"	0	100	8
250	" 5123	"	"	0	100	8
251	" 5127	"	"	0	100	8
252	" 5128	"	"	2	98	7
253	" 5131	"	fastigiata	60	40	3
254	" 5133	"	hypogaea	0	100	8
255	" 5135	Argentina	vulgaris	20	80	6
256	" 5210	USA	hypogaea	40	60	4
257	" 5293	Uganda	"	0	100	8
258	" 5294	USA	vulgaris	42	58	4
259	" 5297	"	"	36	64	5

Table 4.(contd....)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
260	ICG 5325	Nigeria	hypogaea	0	100	8
261	" 5329	Liberia	fastigiata	42	58	4
262	" 5357	India	hypogaea	0	100	8
263	" 5358	"	"	0	100	8
264	" 5373	"	"	0	100	8
265	" 5374	"	"	0	100	8
266	" 5389	Unknown	"	0	100	8
267	" 5393	USA	"	0	100	8
268	" 5429	India	vulgaris	16	84	7
269	" 5433	"	"	40	60	4
270	" 5453	USA	fastigiata	40	60	4
271	" 5457	India	vulgaris	10	90	7
272	" 5461	Unknown	fastigiata	80	20	2
273	" 5585	USA	vulgaris	40	60	4
274	" 5601	Unknown	"	52	48	4
275	" 5617	India	hypogaea	0	100	8
276	" 5709	Argentina	fastigiata	22	78	6
277	" 5729	USA	hypogaea	0	100	8
278	" 5825	"	"	20	80	6
279	" 5981	"	vulgaris	66	34	3
280	" 6021	Argentina	"	40	60	4
281	" 6109	USA	hypogaea	0	100	8

Table 4.(contd....)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
282	ICG 6181	Zimbabwe	hypogaea	0	100	8
283	" 6193	S. Africa	"	0	100	8
284	" 6242	Mauritius	vulgaris	76	24	3
285	" 6277	Brazil	fastigiata	60	40	3
286	" 6297	USA	hypogaea	60	40	3
287	" 6301	"	"	78	22	3
288	" 6341	"	fastigiata	36	64	5
289	" 6381	S. Africa	vulgaris	50	50	4
290	" 6405	USA	hypogaea	40	60	4
291	" 6441	Unknown	"	0	100	8
292	" 6477	Senegal	"	0	100	8
293	" 6525	Tanzania	"	26	74	6
294	" 6557	Malawi	fastigiata	20	80	6
295	" 6561	"	hypogaea	0	100	8
296	" 6565	Unknown	fastigiata	20	80	6
297	" 6566	"	"	20	80	6
298	" 6581	USA	hypogaea	0	100	8
299	" 6678	China	vulgaris	0	100	8
300	" 6679	Zimbabwe	"	0	100	8
301	" 6689	Tanzania	hypogaea	0	100	8
302	" 6746	Malawi	"	0	100	8
303	" 6761	Unknown	"	0	100	8

Table 4.(contd....)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
304	ICG 6773	Paraguay	fastigiata	60	40	3
305	" 6774	Brazil	"	60	40	3
306	" 6778	Zimbabwe	vulgaris	70	30	3
307	" 6789	Brazil	hypogaea	0	100	8
308	" 6809	Unknown	"	0	100	8
309	" 6865	India	"	0	100	8
310	" 6881	Zimbabwe	vulgaris	20	80	6
311	" 6894	USA	hypogaea	60	40	3
312	" 6950	"	"	0	100	8
313	" 6982	"	"	50	50	4
314	" 6997	Japan	vulgaris	60	40	3
315	" 7005	Brazil	fastigiata	40	60	4
316	" 7174	Unknown	vulgaris	30	70	5
317	" 7177	Malawi	"	20	80	6
318	" 7178	Unknown	hypogaea	0	100	8
319	" 7180	"	vulgaris	78	22	3
320	" 7198	Zimbabwe	"	76	24	3
321	" 7269	"	"	0	100	8
322	" 7282	"	"	40	60	4
323	" 7287	Brazil	fastigiata	20	80	6
324	" 7317	USA	hypogaea	20	80	6
325	" 7318	"	"	0	100	8

Table 4.(contd....)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
326	ICG 7381	Nigeria	fastigiata	74	26	3
327	" 7386	Malawi	hypogaea	0	100	8
328	" 7388	Zimbabwe	fastigiata	60	40	3
329	" 7393	"	"	20	80	6
330	" 7398	"	"	50	50	4
331	" 7400	"	"	80	20	2
332	" 7401	"	"	66	34	3
333	" 7402	"	"	74	26	3
334	" 7409	Brazil	"	36	64	5
335	" 7422	India	hypogaea	0	100	8
336	" 7423	Zimbabwe	"	0	100	8
337	" 7425	"	vulgaris	36	64	5
338	" 7426	USSR	"	46	54	4
339	" 7434	USA	hypogaea	0	100	8
340	" 7438	Nigeria	"	30	70	5
341	" 7446	"	"	0	100	8
342	" 7451	"	"	0	100	8
343	" 7474	Sudan	"	0	100	8
344	" 7475	Zimbabwe	"	0	100	8
345	" 7477	USA	"	0	100	8
346	" 7478	"	"	60	40	3
347	" 7479	"	"	40	60	4

Table 4.(contd.....)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
348	ICG 7481	USA	hypogaea	0	100	8
349	" 7485	Nigeria	"	0	100	8
350	" 7512	China	vulgaris	72	28	3
351	" 7537	India	"	20	80	6
352	" 7541	"	"	40	60	4
353	" 7553	"	"	44	56	4
354	" 7613	"	hypogaea	0	100	8
355	" 7614	Argentina	vulgaris	38	62	5
356	" 7615	USA	hypogaea	0	100	8
357	" 7621	"	"	40	60	4
358	" 7626	Unknown	fastigiata	70	30	3
359	" 7633	USA	"	40	60	4
360	" 8009	Zimbabwe	hypogaea	40	60	4
361	" 8013	"	vulgaris	44	56	4
362	" 8025	USA	hypogaea	0	100	8
363	" 8029	"	"	0	100	8
364	" 8086	Tanzania	vulgaris	36	64	5
365	" 8105	Argentina	"	60	40	3
366	" 8110	USA	hypogaea	40	60	4
367	" 8121	Unknown	vulgaris	10	90	7
368	" 8217	Zimbabwe	hypogaea	0	100	8
369	" 8218	"	"	0	100	8

Table 4. (contd....)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
370	ICG 8220	USA	hypogaea	40	60	4
371	" 8225	"	fastigiata	48	52	4
372	" 8281	"	hypogaea	0	100	8
373	" 8289	"	"	0	100	8
374	" 8313	"	"	0	100	8
375	" 8321	"	"	0	100	8
376	" 8329	"	"	0	100	8
377	" 8345	"	"	0	100	8
378	" 8429	Malawi	"	0	100	8
379	" 8541	Bolivia	"	0	100	8
380	" 8669	Indonesia	vulgaris	40	60	4
381	" 8673	"	"	60	40	3
382	" 8685	Malayasia	"	66	34	3
383	" 8689	"	"	70	30	3
384	" 8690	"	"	48	52	4
385	" 8793	Zambia	hypogaea	0	100	8
386	" 8809	"	"	0	100	8
387	" 8829	Burma	vulgaris	72	28	3
388	" 8861	Zimbabwe	"	48	52	4
389	" 8865	"	"	58	42	4
390	" 8981	USA	"	20	80	6
391	" 8985	"	hypogaea	0	100	8

Table 4. (contd....)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
392	ICG 9002	Zambia	vulgaris	26	74	6
393	" 9006	USA	hypogaea	0	100	8
394	" 9009	"	"	0	100	8
395	" 9014	"	"	0	100	8
396	" 9045	Niger	"	0	100	8
397	" 9049	Mali	"	0	100	8
398	" 9062	Togo	"	0	100	8
399	" 9117	Nigeria	vulgaris	54	46	4
400	" 9121	"	hypogaea	0	100	8
401	" 9342	Senegal	vulgaris	30	70	5
402	" 9425	"	hypogaea	0	100	8
403	" 9445	Argentina	vulgaris	46	54	4
404	" 9497	Senegal	"	16	84	7
405	" 9501	Philippines	"	30	70	5
406	" 9541	Mozambique	hypogaea	0	100	8
407	" 9542	"	"	0	100	8
408	" 9609	India	vulgaris	40	60	4
409	" 9613	"	"	0	100	8
410	" 9681	"	hypogaea	0	100	8
411	" 9725	"	"	0	100	8
412	" 9729	"	"	0	100	8

Table 4. (contd....)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
413	ICG 9769	Ghana	hypogaea	0	100	8
414	" 9773	"	vulgaris	10	90	7
415	" 9833	Sudan	hypogaea	0	100	8
416	" 9909	Zambia	"	0	100	8
417	" 10328	India	others	36	64	5
418	" 10339	Indonesia	vulgaris	76	24	3
419	" 11403	India	others	40	60	4

As seen from the data presented in the above Table, the germination per cent among the 419 genotypes varied from zero to 96. The lowest germination per cent of zero was registered by 207 genotypes. The highest germination per cent of 96 was recorded by two different genotypes viz., ICG-1281 and ICG-3777.

From the Table it is also clear that the dormancy levels of 419 genotypes ranged from 4 to 100 per cent. The lowest dormancy level of four per cent was for ICG-1281 and ICG-3777 (Plate 2). None of the genotypes under present study registered zero per cent dormancy at harvest.

From Table 4, it is also evident that the 419 genotypes under study fell into eight different groups, having dormancy ratings of 1 to 8. The lowest dormancy rating of one in the present study was recorded by five different genotypes viz., ICG-128, ICG-459, ICG-1281, ICG-2144 and ICG-3777. The highest dormancy rating of 8, was recorded by 207 genotypes. The genotypes tested also belonged to different countries of origin and botanical groups.

The frequency of genotypes in different botanical groups possessing different dormancy ratings is presented in Table 5 and illustrated in Fig.1.

Plate 2 Sprouting before harvest in ICG 3777

Table 5 Frequency of genotypes possessing varying degrees of dormancy, in different botanical groups

Dormant seed		Botanical group				Total
(%)	scale	hypogaea	vulgaris	fastigiata	others	
0	0	0	0	0	0	0
1-10	1	0	2	3	0	5
11-20	2	0	6	3	0	9
21-40	3	4	30	11	0	45
41-60	4	11	45	7	1	64
61-80	5	2	17	4	1	24
81-90	6	11	20	7	0	38
91-99	7	14	10	3	0	27
100	8	200	7	0	0	207
Total		242	137	38	2	419

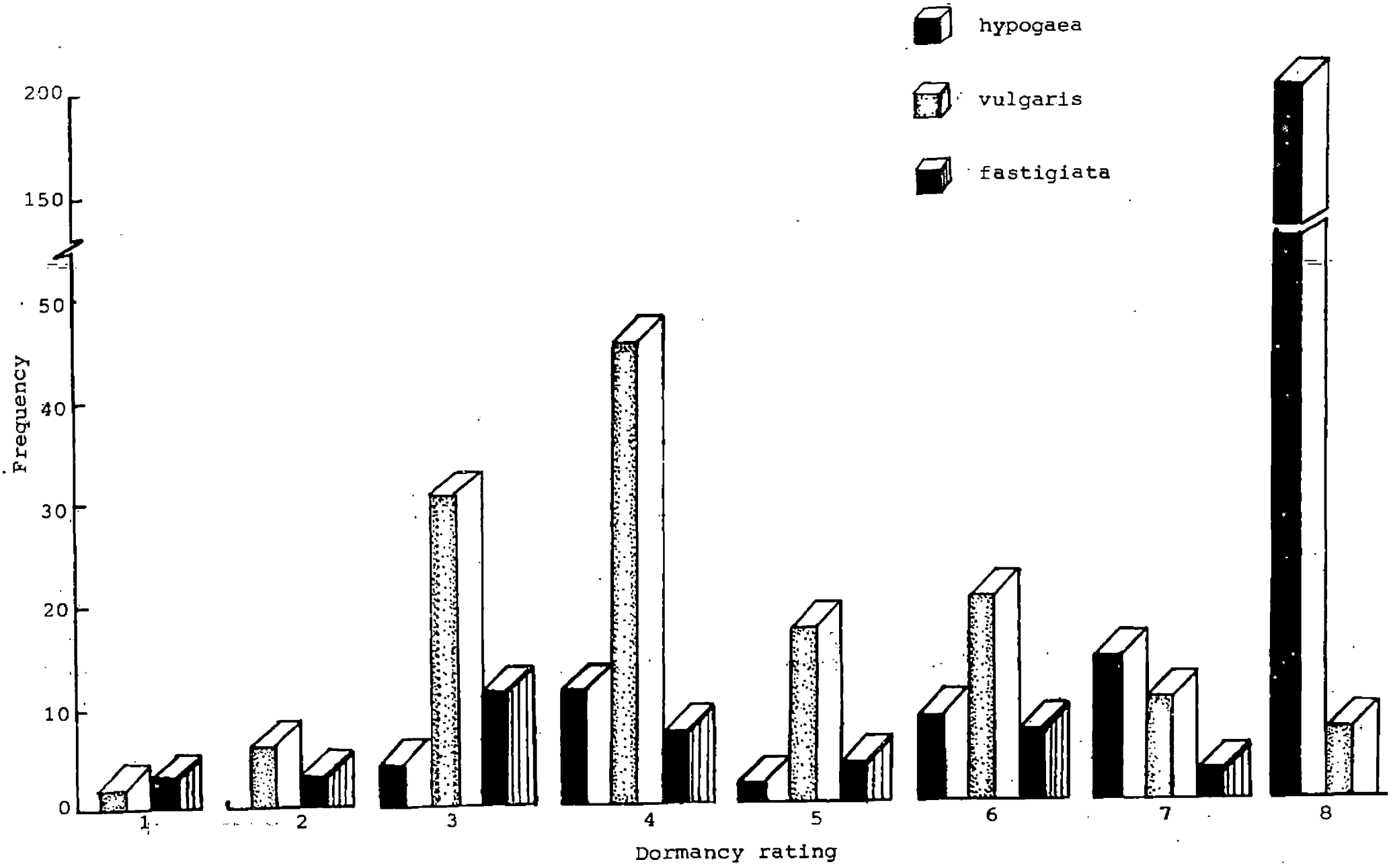


Fig. 1. Frequency of groundnut genotypes with varying degrees of dormancy at harvest

A survey of the Table shows that the lower dormancy ratings of 1 and 2 in the present study were registered by vulgaris and fastigiata types. There were only five genotypes in the lowest dormancy rating of 1 in this experiment, out of which two belonged to vulgaris and three to fastigiata. Of the 207 genotypes which belonged to the highest dormancy rating 8, 200 were hypogaea types and seven vulgaris types. None of the fastigiata genotypes used in the present investigation fell in this catagory. The lowest dormancy rating in the case of hypogaea genotypes was 3 and was recorded by four genotypes.

The frequency of genotypes belonging to different countries and possessing different dormancy ratings is presented in Table 6.

As seen from the data in Table 6, in the case of 92 genotypes, the origin of which is unknown, there were types belonging to all dormancy ratings. Out of 419 genotypes tested, 112 belonged to India. Among the genotypes indigenous to India, there were 64 having cent per cent dormancy at harvest. Most of the genotypes tested belonged to Semi-Arid Tropical countries.

Table 6. Distribution of dormant and nondormant genotypes having different countries of origin

Sl. No.	Country	Dormancy rating									Total	% of type with dormancy rating 8
		0	1	2	3	4	5	6	7	8		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
1	India	-	-	1	9	16	5	10	7	4	2	57
2	Argentina	-	-	-	2	2	2	2	1	0	9	0
3	Sudan	-	-	1	-	2	-	-	1	7	1	64
4	Senegal	-	1	-	-	2	1	-	2	4	0	40
5	Malawi	-	-	-	-	-	1	2	-	4	7	57
6	Brazil	-	-	1	3	1	2	1	-	3	1	27
7	Sri Lanka	-	-	-	-	-	-	-	-	1	1	100
8	Paraguay	-	-	-	1	1	1	-	1	1	5	20
9	Zimbabwe	-	-	1	5	6	1	2	-	7	2	32
10	Japan	-	-	-	1	-	-	-	-	-	1	0
11	Zambia	-	-	-	-	-	-	1	-	3	4	75

Table 6. (contd....)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
12	Mali	-	-	-	-	-	-	-	-	1	1	100
13	Mozambique	-	-	-	-	-	-	-	-	2	2	100
14	S. Africa	-	1	-	-	1	-	-	-	1	3	33
15	Nigeria	-	-	-	2	1	1	-	1	8	13	62
16	China	-	1	-	1	-	-	2	-	1	5	20
17	Uganda	-	-	-	-	1	-	-	-	1	2	50
18	Malagasay	-	-	-	-	-	-	-	-	1	1	100
19	Indonesia	-	-	-	2	1	-	-	-	-	3	0
20	Bolivia	-	-	-	-	-	-	-	1	1	2	50
21	Mauritious	-	-	-	1	-	-	-	-	-	1	0
22	USSR	-	-	-	-	1	-	-	-	-	1	0
23	Burma	-	-	-	1	-	-	-	-	-	1	0
24	Togo	-	-	-	-	-	-	-	-	1	1	100
25	USA	-	-	-	9	13	2	5	2	35	66	53

Table 6. (contd....)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
26	Tanzania	-	-	-	1	1	1	1	-	10	14	71
27	Kenya	-	-	-	1	1	-	-	-	1	3	33
28	Zaire	-	-	1	-	2	1	1	-	-	5	0
29	Uruguay	-	-	-	-	-	1	-	-	-	1	0
30	Israel	-	1	-	-	-	-	-	-	-	1	0
31	Liberia	-	-	-	-	1	-	-	-	-	1	0
32	Malayasia	-	-	-	2	1	-	-	-	-	3	0
33	Niger	-	-	-	-	-	-	-	-	1	1	100
34	Philippines	-	-	-	-	-	1	-	-	-	1	0
35	Ghana	-	-	-	-	-	-	-	1	1	2	50
36	Unknown	-	1	4	4	10	4	11	10	48	92	52
	Total	-	5	9	45	64	24	38	27	207	419	-

4.1.2 Period of rest required for the dormant types

A total of 207 genotypes with dormancy rating of 8, was tested for their germinability at 10 day intervals after harvest until the germination percentage surpassed 90. The data pertaining to this are presented in Table 7.

From the data it can be seen that there was no uniformity in the breaking of dormancy and it was achieved by different genotypes in different periods. The dormancy period ranged from 20 days in some genotypes (ICG-5393, ICG-6678 and ICG-7269) to a maximum of 110 days in some other genotypes (ICG-198, ICG-1002, ICG-2471, ICG-2523, ICG-4326, ICG-8218 and ICG-8281). The others came in between them.

Based on the dormancy period, the genotypes used in the experiment could be classified into three categories viz., those having short dormancy period (upto 30 days), prolonged dormancy period (70 days or more) and intermediate types. Out of the 207 types, 12 genotypes were having short dormancy period, 65 were having prolonged dormancy period and 130 genotypes fell in the intermediate group.

Table 7. Period of dormancy of groundnut genotypes with cent per cent dormancy at harvest

Sl. No.	Catalog No.	Country of origin	Percentage of germination after harvest												Period of dormancy in days
			At harvest	10 days	20 days	30 days	40 days	50 days	60 days	70 days	80 days	90 days	100 days	110 days	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
1	CG 1	India	0	0	22	60	82	100	-	-	-	-	-	-	50
2	" 68	Unknown	0	0	62	84	100	-	-	-	-	-	-	-	40
3	" 74	India	0	0	0	20	24	40	64	82	88	96	-	-	90
4	" 187	"	0	0	16	48	74	88	100	-	-	-	-	-	60
5	" 198	Unknown	0	0	0	0	0	10	18	32	56	70	84	92	110
6	" 479	India	0	0	0	0	26	50	62	86	94	-	-	-	80
7	" 490	"	0	0	8	40	56	72	98	-	-	-	-	-	60
8	" 530	Tanzania	0	0	0	16	48	80	92	-	-	-	-	-	60
9	" 572	Sudan	0	0	40	66	82	100	-	-	-	-	-	-	50
10	" 573	"	0	0	0	0	24	36	64	78	86	94	-	-	90
11	" 596	India	0	12	36	52	84	96	-	-	-	-	-	-	50

Table 7.(contd....)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
12	ICG 599	India	0	0	0	0	60	88	100	-	-	-	-	-	60
13	" 721	USA	0	0	0	0	34	60	78	92	-	-	-	-	70
14	" 741	Nigeria	0	0	14	20	40	78	100	-	-	-	-	-	60
15	" 759	India	0	0	18	46	76	86	100	-	-	-	-	-	60
16	" 760	"	0	0	12	40	86	94	-	-	-	-	-	-	50
17	" 801	"	0	0	40	58	100	-	-	-	-	-	-	-	40
18	" 805	Unknown	0	0	12	34	74	98	-	-	-	-	-	-	50
19	" 807	India	0	0	0	0	28	46	80	92	-	-	-	-	70
20	" 813	"	0	0	0	0	30	56	84	100	-	-	-	-	70
21	" 819	Unknown	0	0	16	80	98	-	-	-	-	-	-	-	40
22	" 821	"	0	0	26	40	68	80	100	-	-	-	-	-	60
23	" 829	India	0	18	48	64	88	100	-	-	-	-	-	-	50
24	" 844	Unknown	0	0	28	62	100	-	-	-	-	-	-	-	40
25	" 845	India	0	8	20	52	74	100	-	-	-	-	-	-	50

Table 7.(contd....)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
26	ICG 857	Unknown	0	22	28	70	92	-	-	-	-	-	-	-	40
27	" 860	"	0	10	26	52	84	98	-	-	-	-	-	-	50
28	" 861	"	0	0	72	100	-	-	-	-	-	-	-	-	30
29	" 862	"	0	0	66	80	92	-	-	-	-	-	-	-	40
30	" 866	"	0	0	32	58	76	92	-	-	-	-	-	-	50
31	" 867	"	0	20	46	54	66	82	100	-	-	-	-	-	60
32	" 883	India	0	16	34	52	78	96	-	-	-	-	-	-	50
33	" 889	"	0	0	24	64	86	100	-	-	-	-	-	-	50
34	" 894	Unknown	0	16	28	66	88	100	-	-	-	-	-	-	50
35	" 899	"	0	0	30	52	86	100	-	-	-	-	-	-	50
36	" 900	"	0	8	36	70	84	100	-	-	-	-	-	-	50
37	" 905	"	0	12	68	92	-	-	-	-	-	-	-	-	30
38	" 907	"	0	18	26	64	88	100	-	-	-	-	-	-	50

Table 7.(contd....)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
39	ICG 908	India	0	30	54	88	96	-	-	-	-	-	-	-	40
40	" 909	"	0	0	32	68	82	100	-	-	-	-	-	-	50
41	" 911	Unknown	0	0	0	20	44	78	100	-	-	-	-	-	60
42	" 914	USA	0	0	0	10	24	38	60	78	90	-	-	-	80
43	" 920	Kenya	0	0	16	30	38	52	92	-	-	-	-	-	60
44	" 924	Tanzania	0	0	18	40	74	82	100	-	-	-	-	-	60
45	" 939	Unknown	0	0	2	12	24	36	50	64	82	96	-	-	90
46	" 943	"	0	0	0	20	48	66	84	100	-	-	-	-	70
47	" 944	"	0	0	12	68	86	100	-	-	-	-	-	-	50
48	" 950	India	0	0	2	30	62	80	96	-	-	-	-	-	60
49	" 966	Unknown	0	16	42	80	100	-	-	-	-	-	-	-	40
50	" 976	India	0	20	44	58	70	78	86	100	-	-	-	-	70
51	" 1002	"	0	0	0	10	18	30	56	74	78	80	88	94	110
52	" 1006	USA	0	0	0	28	32	44	60	72	84	92	-	-	90

Table 7.(contd....)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
53	ICG 1018	Unknown	0	14	32	46	68	92	-	-	-	-	-	-	50
54	" 1028	"	0	0	0	0	16	40	72	100	-	-	-	-	70
55	" 1037	Nigeria	0	0	0	8	32	50	62	72	88	100	-	-	90
56	" 1039	Unknown	0	0	0	0	32	70	88	94	-	-	-	-	70
57	" 1040	"	0	28	64	72	100	-	-	-	-	-	-	-	40
58	" 1054	India	0	0	0	0	16	68	80	100	-	-	-	-	70
59	" 1056	Unknown	0	0	0	0	16	50	68	96	-	-	-	-	70
60	" 1063	India	0	24	52	68	78	100	-	-	-	-	-	-	50
61	" 1070	Unknown	0	6	20	36	48	80	100	-	-	-	-	-	60
62	" 1079	India	0	0	0	2	18	30	44	60	80	100	-	-	90
63	" 1094	Unknown	0	0	0	0	0	32	76	88	100	-	-	-	80
64	" 1767	"	0	2	28	54	78	94	-	-	-	-	-	-	50
65	" 1895	USA	0	60	88	100	-	-	-	-	-	-	-	-	30
66	" 1983	Tanzania	0	0	0	36	100	-	-	-	-	-	-	-	40
67	" 2118	India	0	0	6	14	26	48	66	84	100	-	-	-	80

Table 7.(contd....)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
68	ICG 2322	USA	0	0	0	2	10	36	50	72	84	92	-	-	90
69	" 2327	"	0	12	32	54	66	82	98	-	-	-	-	-	60
70	" 2456	India	0	0	0	0	40	62	96	-	-	-	-	-	60
71	" 2471	"	0	0	0	4	18	34	48	56	74	82	88	100	110
72	" 2488	Unknown	0	0	0	16	48	66	80	92	-	-	-	-	70
73	" 2503	"	0	0	54	78	100	-	-	-	-	-	-	-	40
74	" 2511	India	0	0	0	10	40	84	92	-	-	-	-	-	60
75	" 2515	Unknown	0	0	0	0	8	36	66	80	82	100	-	-	90
76	" 2518	"	0	20	48	64	82	100	-	-	-	-	-	-	50
77	" 2519	India	0	6	20	46	62	80	98	-	-	-	-	-	60
78	" 2521	Unknown	0	20	46	60	84	100	-	-	-	-	-	-	50
79	" 2523	India	0	0	0	0	0	26	38	54	66	80	88	92	110
80	" 2539	"	0	26	48	68	92	-	-	-	-	-	-	-	40
81	" 2553	Unknown	0	16	50	60	88	96	-	-	-	-	-	-	50

Table 7.(contd....)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
82	ICG 2566	Unknown	0	14	48	52	84	100	-	-	-	-	-	-	50
83	" 2578	India	0	16	50	82	100	-	-	-	-	-	-	-	40
84	" 2587	Unknown	0	18	42	76	88	94	-	-	-	-	-	-	50
85	" 2599	India	0	12	48	64	80	86	100	-	-	-	-	-	60
86	" 2641	Unknown	0	8	28	62	86	92	-	-	-	-	-	-	50
87	" 2767	India	0	42	78	84	100	-	-	-	-	-	-	-	40
88	" 2769	"	0	30	42	58	86	92	-	-	-	-	-	-	50
89	" 2770	"	0	40	62	88	94	-	-	-	-	-	-	-	40
90	" 2789	Malagasay	0	10	62	80	96	-	-	-	-	-	-	-	40
91	" 2866	USA	0	18	40	58	84	96	-	-	-	-	-	-	50
92	" 2868	"	0	12	68	80	92	-	-	-	-	-	-	-	40
93	" 2875	"	0	6	40	78	90	-	-	-	-	-	-	-	40
94	" 2876	Senegal	0	34	40	60	78	92	-	-	-	-	-	-	50
95	" 2887	India	0	8	46	52	86	100	-	-	-	-	-	-	50

Table 7.(contd....)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
96	ICG 2901	India	0	20	34	52	80	94	-	-	-	-	-	-	50
97	" 2921	"	0	40	68	82	100	-	-	-	-	-	-	-	40
98	" 2931	"	0	30	64	82	96	-	-	-	-	-	-	-	40
99	" 3100	Unknown	0	56	68	92	-	-	-	-	-	-	-	-	30
100	" 3810	India	0	22	36	58	82	100	-	-	-	-	-	-	50
101	" 3878	Unknown	0	0	0	0	16	40	56	80	88	100	-	-	90
102	" 3882	India	0	0	10	38	50	66	84	100	-	-	-	-	70
103	" 3915	Sri Lanka	0	22	50	74	98	-	-	-	-	-	-	-	40
104	" 4002	India	0	18	34	54	66	78	100	-	-	-	-	-	60
105	" 4322	Tanzania	0	0	0	0	28	66	82	100	-	-	-	-	70
106	" 4324	India	0	0	18	40	64	78	92	-	-	-	-	-	60
107	" 4326	Tanzania	0	0	0	8	18	22	26	50	70	82	86	94	110
108	" 4329	"	0	0	0	10	28	50	66	78	94	-	-	-	80
109	" 4331	India	0	0	22	48	66	72	84	88	94	-	-	-	80

Table 7.(contd....)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
110	ICG 4332	India	0	52	70	98	-	-	-	-	-	-	-	-	30
111	" 4333	"	0	16	34	66	92	-	-	-	-	-	-	-	40
112	" 4335	Nigeria	0	0	0	0	12	46	72	100	-	-	-	-	70
113	" 4339	Unknown	0	0	16	48	72	100	-	-	-	-	-	-	50
114	" 4350	"	0	20	32	60	82	100	-	-	-	-	-	-	50
115	" 4351	India	0	16	48	70	88	96	-	-	-	-	-	-	50
116	" 4353	"	0	8	30	42	66	80	88	100	-	-	-	-	70
117	" 4354	"	0	36	48	56	80	92	-	-	-	-	-	-	50
118	" 4357	"	0	32	62	84	100	-	-	-	-	-	-	-	40
119	" 4358	"	0	0	32	76	80	100	-	-	-	-	-	-	50
120	" 4368	Tanzania	0	0	0	0	62	70	84	100	-	-	-	-	70
121	" 4369	Sudan	0	26	42	68	92	-	-	-	-	-	-	-	40
122	" 4373	"	0	0	0	0	34	66	100	-	-	-	-	-	60
123	" 4376	Tanzania	0	12	30	56	84	100	-	-	-	-	-	-	50

Table 7.(contd....)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
124	ICG 4377	Sudan	0	0	20	50	68	100	-	-	-	-	-	-	50
125	" 4379	Senegal	0	18	32	56	72	100	-	-	-	-	-	-	50
126	" 4380	Tanzania	0	8	20	46	72	80	96	-	-	-	-	-	60
127	" 4861	Paraguay	0	20	44	62	70	84	98	-	-	-	-	-	60
128	" 5112	Brazil	0	0	70	100	-	-	-	-	-	-	-	-	30
129	" 5115	"	0	0	0	56	80	100	-	-	-	-	-	-	50
130	" 5118	USA	0	0	20	56	68	94	-	-	-	-	-	-	50
131	" 5123	"	0	0	26	50	68	100	-	-	-	-	-	-	50
132	" 5127	"	0	0	0	0	16	42	78	92	-	-	-	-	70
133	" 5133	"	0	16	58	78	82	96	-	-	-	-	-	-	50
134	" 5293	Uganda	0	0	0	0	10	38	56	80	88	100	-	-	90
135	" 5325	Nigeria	0	14	42	64	76	98	-	-	-	-	-	-	50
136	" 5357	India	0	0	78	100	-	-	-	-	-	-	-	-	30
137	" 5358	"	0	22	36	60	78	92	-	-	-	-	-	-	50
138	" 5373	"	0	32	64	80	98	-	-	-	-	-	-	-	40

Table 7.(contd....)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
139	ICG 5374	India	0	22	46	70	86	100	-	-	-	-	-	-	50
140	" 5389	Unknown	0	24	46	62	78	90	-	-	-	-	-	-	50
141	" 5393	USA	0	80	100	-	-	-	-	-	-	-	-	-	20
142	" 5617	India	0	12	38	58	72	88	100	-	-	-	-	-	60
143	" 5729	USA	0	0	0	16	30	46	100	-	-	-	-	-	60
144	" 6109	"	0	0	0	10	28	40	78	100	-	-	-	-	70
145	" 6181	Zimbabwe	0	12	30	44	58	100	-	-	-	-	-	-	50
146	" 6193	S. Africa	0	18	40	56	68	82	100	-	-	-	-	-	60
147	" 6441	Unknown	0	0	0	32	50	76	90	-	-	-	-	-	60
148	" 6477	Senegal	0	0	0	20	60	78	92	-	-	-	-	-	60
149	" 6561	Malawi	0	0	8	26	40	68	72	94	-	-	-	-	70
150	" 6581	USA	0	24	62	88	100	-	-	-	-	-	-	-	40
151	" 6678	China	0	40	94	-	-	-	-	-	-	-	-	-	20
152	" 6679	Zimbabwe	0	36	68	100	-	-	-	-	-	-	-	-	30
153	" 6689	Tanzania	0	0	0	18	40	66	88	94	-	-	-	-	70

Table 7.(contd....)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
154	ICG 6746	Malawi	0	0	0	10	28	42	60	84	100	-	-	-	80
155	" 6761	Unknown	0	22	48	60	88	96	-	-	-	-	-	-	50
156	" 6789	Brazil	0	0	0	32	46	78	100	-	-	-	-	-	60
157	" 6809	Unknown	0	20	42	78	100	-	-	-	-	-	-	-	40
158	" 6865	India	0	0	0	28	56	70	94	-	-	-	-	-	60
159	" 6950	USA	0	12	38	66	100	-	-	-	-	-	-	-	40
160	" 7178	Unknown	0	0	12	46	70	80	100	--	-	-	-	-	60
161	" 7269	Zimbabwe	0	42	96	-	-	-	-	-	-	-	-	-	20
162	" 7318	USA	0	0	0	12	44	70	84	92	-	-	-	-	70
163	" 7386	Malawi	0	0	10	26	42	70	86	100	-	-	-	-	70
164	" 7422	India	0	0	0	10	18	32	98	-	-	-	-	-	60
165	" 7423	Zimbabwe	0	0	0	10	22	38	56	72	88	100	-	-	90
166	" 7434	USA	0	0	0	0	58	76	84	98	--	-	-	-	70
167	" 7446	Nigeria	0	32	66	78	100	-	-	-	-	--	-	-	40

Table 7.(contd....)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
168	ICG 7451	Nigeria	0	0	0	12	38	40	68	92	-	-	-	-	70
169	" 7474	Sudan	0	0	0	0	16	44	78	86	100	-	-	-	80
170	" 7475	Zimbabwe	0	60	88	100	-	-	-	-	-	-	-	-	30
171	" 7477	USA	0	22	46	68	72	90	-	-	-	-	-	-	50
172	" 7481	"	0	0	0	12	34	58	82	98	-	-	-	-	70
173	" 7485	Nigeria	0	0	0	10	28	52	76	88	100	-	-	-	80
174	" 7613	India	0	0	0	12	26	42	58	62	88	100	-	-	90
175	" 7615	USA	0	0	8	20	36	64	76	84	92	-	-	-	80
176	" 8025	"	0	0	0	30	66	82	100	-	-	-	-	-	60
177	" 8029	"	0	10	32	56	76	100	-	-	-	-	-	-	50
178	" 8217	Zimbabwe	0	0	0	20	32	68	82	94	-	-	-	-	70
179	" 8218	"	0	0	0	10	26	38	52	60	78	84	88	96	110
180	" 8281	USA	0	0	0	6	8	28	42	56	70	82	88	100	110
181	" 8289	"	0	0	10	66	92	-	-	-	-	-	-	-	40
182	" 8313	"	0	0	0	16	34	68	84	90	-	-	-	-	70

Table 7.(contd....)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
183	ICG 8321	USA	0	0	0	0	0	14	32	60	88	100	-	-	90
184	" 8329	"	0	10	36	60	78	100	-	-	-	-	-	-	50
185	" 8345	"	0	0	4	16	22	40	50	74	100	-	-	-	80
186	" 8429	Malawi	0	0	0	0	12	40	60	78	86	100	-	-	90
187	" 8541	Bolivia	0	0	0	16	22	34	78	86	92	-	-	-	80
188	" 8793	Zambia	0	0	0	14	42	70	88	96	-	-	-	-	70
189	" 8809	"	0	16	38	56	72	88	100	-	-	-	-	-	60
190	" 8985	USA	0	22	64	88	100	-	-	-	-	-	-	-	40
191	" 9006	"	0	0	28	40	68	88	92	-	-	-	-	-	60
192	" 9009	"	0	0	30	38	42	60	86	100	-	-	-	-	70
193	" 9014	"	0	0	28	30	54	62	78	96	-	-	-	-	70
194	" 9045	Niger	0	0	0	0	28	64	84	100	-	-	-	-	70
195	" 9049	Mali	0	0	24	30	68	70	82	94	-	-	-	-	70
196	" 9062	Togo	0	0	42	86	92	-	-	-	-	-	-	-	40

Table 7.(contd....)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
197	ICG 9121	Nigeria	0	0	36	48	70	76	88	100	-	-	-	-	70
198	" 9425	Senegal	0	0	40	44	72	80	92	-	-	-	-	-	60
199	" 9541	Mozambique	0	0	40	56	88	96	-	-	-	-	-	-	50
200	" 9542	"	0	0	20	64	72	86	100	-	-	-	-	-	60
201	" 9613	India	0	26	40	70	86	92	-	-	-	-	-	-	50
202	" 9681	"	0	0	10	38	74	88	100	-	-	-	-	-	60
203	" 9725	"	0	0	56	82	90	-	-	-	-	-	-	-	40
204	" 9729	"	0	0	22	48	60	92	-	-	-	-	-	-	50
205	" 9769	Ghana	0	0	10	78	96	-	-	-	-	-	-	-	40
206	" 9833	Sudan	0	0	40	64	80	86	98	-	-	-	-	-	60
207	" 9909	Zambia	0	0	34	60	68	76	92	-	-	-	-	-	60

The frequency distribution of genotypes belonging to different botanical groups and possessing varying periods of dormancy is presented in Table 8 and illustrated in Fig.2.

As is evident from Table 8, of the three genotypes with shortest dormancy period of 20 days in the present study, two were vulgaris types and one hypogaea type. Among the vulgaris types studied, the highest period of dormancy exhibited was 50 days. The hypogaea types studied were having long dormancy period lasting upto 110 days.

The frequency of types in different botanical groups based on the nature of breakage of dormancy is presented in Table 9.

The breaking of dormancy was gradual in some varieties and sudden in other varieties as has been evident from the above Table. Wherever the breaking of dormancy was sudden, the increase in the per cent of germination was 50 or more as compared with the preceeding germination test. Of the 29 genotypes with sudden breakage in dormancy, 24 belonged to hypogaea and 5 to vulgaris types. In slow or gradual breakage of dormancy

Table 8. Distribution of groundnut genotypes possessing varying periods of dormancy in different botanical groups

Botanical group	Period of dormancy (days after harvest)											
	0	10	20	30	40	50	60	70	80	90	100	110
hypogaea	0	0	1	6	33	55	40	32	12	14	0	7
vulgaris	0	0	2	3	1	1	0	0	0	0	0	0
fastigiata	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	3	9	34	56	40	32	12	14	0	7

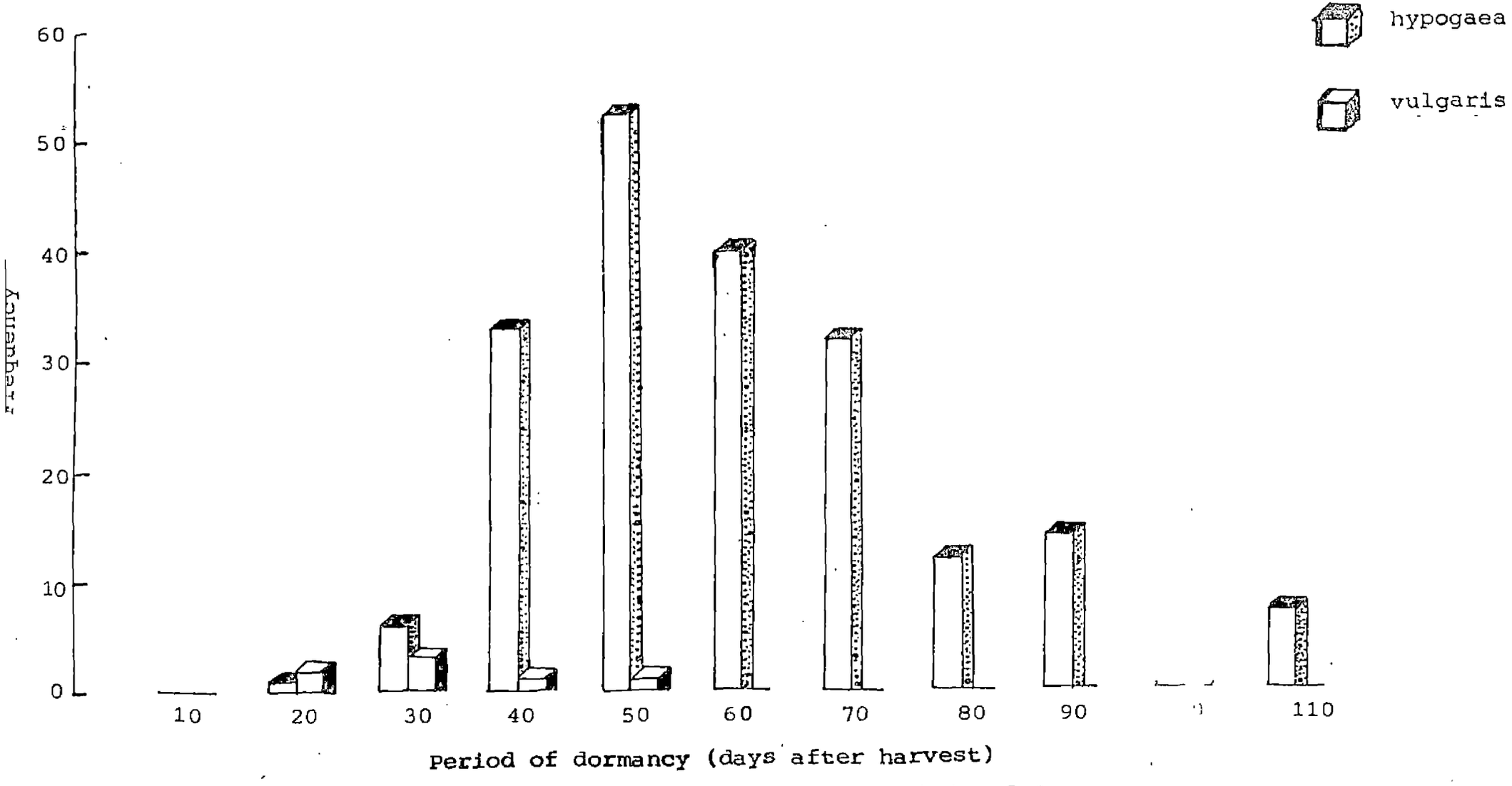


Fig. 2. Frequency of groundnut genotypes with varying periods of dormancy

Table 9. Distribution of groundnut genotypes of different botanical groups, based on the nature of breakage of dormancy

Nature of dormancy breakage	*hypogaea*	*vulgaris*	*fastigiata*	Total
Sudden	24	5	0	29
Slow	176	2	0	178

*A difference of >50% between two successive germination tests

there was lesser percentage increase in germination from test to test. Out of the 178 types in this category, 176 were hypogaea types and two vulgaris types.

4.2 Role of different parts of seed in delaying the germination

To find out the role of different entities of seed in dormancy mechanism of groundnut, germination test was conducted at ten day intervals from the day of harvest until the type completed the period of dormancy. The results are presented in Tables 10-20.

Seven dormant types, ICG-198, ICG-1002, ICG-2471, ICG-2523, ICG-4326, ICG-8218, ICG-8281 with maximum dormancy period in the previous experiment were used for the study. Germination test was conducted with intact pod (T_1), intact seed (T_2), seed with pin holes on the testa (T_3), seed with testa removed (T_4) and excised embryonic axis (T_5).

Results of germination test conducted on the day of harvest are presented in Table 10.

Table 10. Role of different entities of groundnut seed in its germination at harvest

Sl. No.	Genotype	Percentage of germination of					Mean
		Intact pod (T_1)	Intact seed (T_2)	Seed with pin holes on the testa (T_3)	Seed with testa removed (T_4)	Excised embryonic axis (T_5)	
1	ICG 198	0.57 (0.00)	0.57 (0.00)	0.57 (0.00)	14.00 (5.85)	66.50 (84.10)	40.24 (41.73)
2	ICG 1002	0.57 (0.00)	0.57 (0.00)	0.57 (0.00)	18.35 (9.91)	66.50 (84.10)	42.43 (45.52)
3	ICG 2471	0.57 (0.00)	0.57 (0.00)	0.57 (0.00)	16.43 (8.00)	64.93 (82.05)	40.68 (42.49)
4	ICG 2523	0.57 (0.00)	0.57 (0.00)	0.57 (0.00)	20.14 (11.85)	68.08 (86.06)	44.11 (48.45)
5	ICG 4326	0.57 (0.00)	0.57 (0.00)	0.57 (0.00)	20.14 (11.85)	68.08 (86.06)	44.11 (48.45)
6	ICG 8218	0.57 (0.00)	0.57 (0.00)	0.57 (0.00)	26.51 (19.92)	71.65 (90.09)	49.08 (57.10)
7	ICG 8281	0.57 (0.00)	0.57 (0.00)	0.57 (0.00)	16.43 (8.00)	66.50 (84.10)	41.47 (43.85)
	Mean	0.57 (0.00)	0.57 (0.00)	0.57 (0.00)	18.55 (10.44)	67.46 (85.31)	

CD(0.05) for variety means : 2.40

CD(0.05) for treatment means : 1.29

CD(0.05) for interaction : N.S.

Note 1. Arc sine transformation was done before analysis. Figures in parenthesis indicate values in the original scale

2. Intact pod, seed and seed with pin holes on the testa did not give any germination and hence were not included in the analysis

T_5 had the highest germination percentage among the different treatments (Plates 3a, b, c, d, e, f and g) and here the germination percentage ranged from 82.05 in ICG-2471 to 90.09 in ICG-8218. T_4 showed slight germination percentage ranging from 5.85 in ICG-198 to 19.92 in ICG-8218. No germination was observed in T_1, T_2 and T_3 in any of the genotypes tested. Analysis of variance showed significant differences between treatments and varieties. But here the variety x treatment interaction was nonsignificant.

Results of germination test conducted ten days after harvest are presented in Table 11.

Here also T_5 had the highest germination in all the types and germination per cent ranged from 86.05 in ICG-198 to 95.12 in ICG-8218. In T_4 slight increase in germination per cent from previous one was noticed. In this treatment the highest germination was recorded by ICG-8218 (58.01 per cent) and the lowest by ICG-198 (17.95 per cent). As in the previous case, none of the tested genotypes showed germinability in T_1, T_2 and T_3. Analysis of variance showed significant difference between T_4 and T_5. Interaction and varietal differences were also significant.

Plate 3a Role of different entities of the seed in delaying germination in ICG 198

Plate 3b Role of different entities of the seed in delaying germination in ICG 1002

Table 11. Role of different entities of groundnut seed in its germination ten days after harvest

Sl. No.	Genotype	Percentage of germination of					Mean
		Intact pod (T_1)	Intact seed (T_2)	Seed with pin holes on the testa (T_3)	Seed with testa removed (T_4)	Excised embryonic axis (T_5)	
1	ICG 198	0.57 (0.00)	0.57 (0.00)	0.57 (0.00)	25.07 (17.95)	68.07 (86.05)	46.57 (52.74)
2	ICG 1002	0.57 (0.00)	0.57 (0.00)	0.57 (0.00)	37.46 (36.99)	71.65 (90.09)	54.56 (66.38)
3	ICG 2477	0.57 (0.00)	0.57 (0.00)	0.57 (0.00)	27.25 (20.96)	70.69 (89.07)	48.97 (56.91)
4	ICG 2523	0.57 (0.00)	0.57 (0.00)	0.57 (0.00)	30.64 (25.97)	76.02 (94.16)	53.33 (64.33)
5	ICG 4326	0.57 (0.00)	0.57 (0.00)	0.57 (0.00)	44.43 (49.01)	69.86 (88.14)	57.15 (70.58)
6	ICG 8218	0.57 (0.00)	0.57 (0.00)	0.57 (0.00)	49.61 (58.01)	77.24 (95.12)	63.42 (79.98)
7	ICG 8281	0.57 (0.00)	0.57 (0.00)	0.57 (0.00)	28.64 (22.97)	71.65 (90.09)	50.14 (58.92)
	Mean	0.57 (0.00)	0.57 (0.00)	0.57 (0.00)	34.73 (32.46)	72.17 (90.62)	

CD(0.05) for variety means : 11.82

CD(0.05) for treatment means : 6.32

CD(0.05) for interaction : 2.78

Note 1. Arc sine transformation was done before analysis. Figures in parenthesis indicate values in the original scale

2. Intact pod, seed and seed with pin holes on the testa did not give any germination and hence were not included in the analysis

Table 12 shows the results of germination test conducted 20 days after harvest.

As in the previous cases highest germinability was observed in T_5 with ICG-2523 and ICG-8218 having the highest germination per cent of 98.99. The lowest was observed in ICG-2471 (86.06 per cent). Germination in T_4 further improved. ICG-8218 had the highest germination in T_4 also (85.05 per cent). In T_4 the lowest germination was recorded by ICG-198 (48.99 per cent). Types ICG-8218 and 8281 showed slight germination in T_2 and T_3 also. In the case of T_2, ICG-8218 recorded a germination of 11.86 per cent and ICG-8281, 8.93 per cent. In T_3, 16.97 per cent germination was observed in the type ICG-8218 and 11.86 per cent in ICG-8281. No germination was observed in any of the tested genotypes in T_1. Analysis of variance showed that T_2 and T_3 were on par. There were significant treatment and varietal differences. Interaction was also significant.

The results of germination test conducted 30 days after harvest are presented in Table 13.

Table 12. Role of different entities of groundnut seed in its germination 20 days after harvest

Sl. No.	Genotype	Percentage of germination of					Mean
		Intact pod (T_1)	Intact seed (T_2)	Seed with pin holes on the testa (T_3)	Seed with testa removed (T_4)	Excised embryonic axis (T_5)	
1	ICG 198	0.57 (0.00)	0.57 (0.00)	0.57 (0.00)	44.42 (48.99)	71.65 (90.09)	29.30 (23.95)
2	ICG 1002	0.57 (0.00)	0.57 (0.00)	0.57 (0.00)	62.05 (78.03)	76.02 (94.16)	34.80 (32.57)
3	ICG 2471	0.57 (0.00)	0.57 (0.00)	0.57 (0.00)	47.30 (54.01)	68.08 (86.06)	29.13 (23.70)
4	ICG 2523	0.57 (0.00)	0.57 (0.00)	0.57 (0.00)	54.95 (67.02)	84.23 (98.99)	35.08 (33.03)
5	ICG 4326	0.57 (0.00)	0.57 (0.00)	0.57 (0.00)	54.34 (66.01)	71.65 (90.09)	31.78 (27.74)
6	ICG 8218	0.57 (0.00)	20.14 (11.86)	24.33 (16.97)	67.25 (85.05)	84.23 (98.99)	48.99 (56.94)
7	ICG 8281	0.57 (0.00)	17.39 (8.93)	20.14 (11.86)	51.95 (62.01)	70.69 (89.07)	40.04 (41.39)
	Mean	0.57 (0.00)	5.77 (1.01)	6.76 (1.39)	54.61 (66.46)	75.22 (93.49)	

CD(0.05) for variety means : 8.20

CD(0.05) for treatment means : 6.20

CD(0.05) for interaction : 3.26

Note 1. Arc sine transformation was done before analysis. Figures in parenthesis indicate values in the original scale

2. Intact pod, seed and seed with pin holes on the testa did not give any germination and hence were not included in the analysis

Table 13. Role of different entities of groundnut seed in its germination 30 days after harvest

Sl. No.	Genotype	Percentage of germination of					Mean
		Intact pod (T_1)	Intact seed (T_2)	Seed with pin holes on the testa (T_3)	Seed with testa removed (T_4)	Excised embryonic axis (T_5)	
1	ICG 198	0.57 (0.00)	0.57 (0.00)	0.57 (0.00)	62.06 (78.05)	84.23 (98.99)	36.86 (35.98)
2	ICG 1002	0.57 (0.00)	25.07 (17.95)	27.95 (21.97)	68.08 (86.06)	76.02 (94.16)	49.28 (57.44)
3	ICG 2471	0.57 (0.00)	22.75 (14.95)	26.51 (19.92)	68.08 (86.06)	69.86 (88.14)	46.80 (53.14)
4	ICG 2523	0.57 (0.00)	19.31 (10.93)	25.76 (18.89)	64.19 (81.04)	78.46 (96.00)	46.93 (53.37)
5	ICG 4326	0.57 (0.00)	25.07 (17.95)	25.82 (18.97)	76.02 (94.16)	76.02 (94.16)	50.73 (59.93)
6	ICG 8218	0.57 (0.00)	38.05 (37.99)	39.81 (40.99)	66.42 (84.00)	84.23 (98.99)	57.13 (70.54)
7	ICG 8281	0.57 (0.00)	25.07 (17.95)	27.25 (20.96)	64.93 (82.05)	73.83 (92.24)	47.77 (54.83)
	Mean	0.57 (0.00)	22.27 (14.36)	24.81 (17.61)	67.11 (84.87)	77.52 (95.33)	

CD(0.05) for variety means : 10.46

CD(0.05) for treatment means : 7.91

CD(0.05) for interaction : 3.64

Note 1. Arc sine transformation was done before analysis. Figures in parenthesis indicate values in the original scale

2. Intact pod did not give any germination and hence was not included in the analysis

As evident from the Table, ICG-198 did not show any germination in T_2 and T_3. In all the other types tested, slight germination was noticed in both the treatments. In T_2 germination per cent ranged from 10.93 in ICG-2523 to 37.99 in ICG-8218. In T_3, germination percentage ranged from 18.89 in ICG-2523 to 40.99 in ICG-8218. ICG-8218 had the highest germination in treatments T_2 and T_3. In T_4, the germination per cent ranged from 78.05 in ICG-198 to 94.16 in ICG-4326.

In the case of excised embryonic axis (T_5), germination percentage ranged from 88.14 in ICG-2471 to 98.99 in ICG-198 and ICG-8218. Analysis of variance showed that T_2 and T_3 were on par. There were significant treatment and varietal differences. Interaction was also significant.

Table 14 shows the results of germination test conducted 40 days after harvest.

ICG-198 did not show any germination in T_1, T_2 and T_3. ICG-2523 had no germination in T_1. The highest germination percentage in the case of T_2 and T_3 was exhibited by ICG-4326 (54.01 per cent and 50.00 per cent

Table 14. Role of different entities of groundnut seed in its germination 40 days after harvest

Sl. No.	Genotype	Percentage of germination of					Mean
		Intact pod (T_1)	Intact seed (T_2)	Seed with pin holes on the testa (T_3)	Seed with testa removed (T_4)	Excised embryonic axis (T_5)	
1	ICG 198	0.57 (0.00)	0.57 (0.00)	0.57 (0.00)	64.93 (82.05)	80.12 (97.06)	29.35 (24.02)
2	ICG 1002	6.06 (1.11)	40.39 (41.99)	42.13 (45.00)	78.90 (96.29)	87.12 (99.75)	50.92 (60.26)
3	ICG 2471	13.99 (5.84)	43.28 (47.00)	40.97 (42.99)	84.23 (98.99)	74.10 (92.49)	51.31 (60.92)
4	ICG 2523	0.57 (0.00)	24.33 (16.97)	25.68 (18.78)	84.23 (98.99)	84.23 (98.99)	43.81 (47.92)
5	ICG 4326	24.24 (16.86)	47.30 (54.01)	45.00 (50.00)	76.02 (94.16)	73.83 (92.24)	53.28 (64.25)
6	ICG 8218	22.67 (14.86)	42.70 (45.99)	42.70 (45.99)	87.12 (99.75)	83.01 (98.52)	55.64 (68.15)
7	ICG 8281	16.16 (7.74)	38.05 (37.99)	40.97 (42.99)	81.35 (97.74)	76.02 (94.16)	50.51 (59.56)
	Mean	12.04 (4.35)	33.80 (30.95)	34.00 (31.27)	79.54 (96.70)	79.77 (96.85)	

CD(0.05) for variety means : 11.00

CD(0.05) for treatment means : 9.29

CD(0.05) for interaction : 5.74

Note 1. Arc sine transformation was done before analysis. Figures in parenthesis indicate values in the original scale

respectively). In the case of T_4, germination ranged from 99.75 per cent in ICG-8218 to 82.05 per cent in ICG-198. T_5 exhibited germination ranging from 99.75 per cent in ICG-1002 to 92.24 per cent in ICG-4326. Analysis of variance showed significant treatment and varietal differences. Interaction was also significant. T_2 and T_3 were on par. Similarly T_4 and T_5 were also on par.

Table 15 shows the results of germination study conducted 50 days after harvest.

Germination percentage of ICG-198 improved further in the case of T_1, T_2 and T_3. In ICG-198, T_4 and T_5 had very good germination of 99.75 per cent and 98.99 per cent respectively. In T_4 and T_5, all the varieties had more than 90 per cent germination. In T_1, highest germination percentage was recorded by ICG-4326 and ICG-8218 (19.92 per cent in both). In the case of T_2 and T_3 also, ICG-4326 had the highest germination values of 70.02 per cent and 71.07 per cent respectively. There were significant treatment and varietal differences. Interaction of variety and treatment was also significant. T_4 and T_5 were on par. Similarly T_2 and T_3 were also on par.

Table 15. Role of different entities of groundnut seed in its germination 50 days after harvest

Sl. No.	Genotype	Percentage of germination of					Mean
		Intact pod (T_1)	Intact seed (T_2)	Seed with pin holes on the testa (T_3)	Seed with testa removed (T_4)	Excised embryonic axis (T_5)	
1	ICG 198	6.06 (1.11)	24.33 (16.97)	26.50 (19.91)	87.12 (99.75)	84.23 (98.99)	45.65 (51.13)
2	ICG 1002	19.18 (10.79)	53.15 (64.03)	55.57 (68.03)	80.12 (97.06)	87.12 (99.75)	59.03 (73.52)
3	ICG 2471	18.35 (9.91)	48.46 (56.02)	49.04 (57.03)	87.12 (99.75)	87.12 (99.75)	58.01 (71.93)
4	ICG 2523	10.02 (3.02)	39.81 (40.99)	41.55 (43.99)	74.79 (93.12)	84.23 (98.99)	50.08 (58.82)
5	ICG 4326	26.51 (19.92)	56.80 (70.02)	57.46 (71.07)	84.23 (98.99)	84.23 (98.99)	61.85 (77.74)
6	ICG 8218	26.51 (19.92)	54.34 (62.01)	53.75 (65.04)	90.00 (100.0)	87.12 (99.75)	62.34 (78.45)
7	ICG 8281	23.50 (15.90)	49.04 (57.03)	49.61 (58.01)	84.23 (98.99)	84.23 (98.99)	58.12 (72.11)
	Mean	18.59 (10.16)	46.56 (52.72)	47.64 (54.60)	83.94 (98.89)	85.47 (99.38)	

CD(0.05) for variety means : 7.37

CD(0.05) for treatment means : 6.23

CD(0.05) for interaction : 6.07

Note 1. Arc sine transformation was done before analysis. Figures in parenthesis indicate values in the original scale

Table 16 presents the results of germination test conducted 60 days after harvest.

More than 90 per cent germination was obtained in all the types studied in T_4 and T_5. ICG-4326 and ICG-8218 exhibited highest value for germination in T_1 (23.93 per cent). In the case of T_2 and T_3, ICG-4326 showed the highest germination values (79.04 per cent and 79.11 per cent respectively). The treatment and varietal differences were significant. Interaction was also significant. T_2 and T_3 were on par. Similarly T_4 and T_5 were also on par.

Results of germination study conducted 70 days after harvest are furnished in Table 17.

ICG-8218 had the highest germination per cent in T_1 (27.96 per cent). In T_2 and T_3, ICG-8218 had the maximum germination values (84.10 per cent and 86.06 per cent respectively). T_4 and T_5 exhibited very high germination values in all the genotypes tested. In T_4, 100 per cent germination was obtained for ICG-2523 and ICG-4326. In T_5, 100 per cent germination was observed for ICG-8281. ICG-198 showed the lowest germination per cent in the treatments T_1, T_2 and T_3.

Table 16 Role of different entities of groundnut seed in its germination 60 days after harvest

Sl. No.	Genotype	Percentage of germination of					Mean
		Intact pod (T_1)	Intact seed (T_2)	Seed with pin holes on the testa (T_3)	Seed with testa removed (T_4)	Excised embryonic axis (T_5)	
1	ICG 198	20.13 (11.84)	39.81 (40.99)	39.81 (40.99)	87.12 (99.75)	90.00 (100.00)	55.37 (67.71)
2	ICG 1002	23.50 (15.90)	56.80 (70.02)	58.71 (73.03)	84.23 (98.99)	84.23 (98.99)	61.49 (77.22)
3	ICG 2471	20.14 (11.86)	51.95 (62.01)	54.34 (66.01)	90.00 (100.00)	87.12 (99.75)	60.71 (76.07)
4	ICG 2523	21.93 (13.95)	55.57 (68.03)	56.80 (70.02)	83.00 (98.51)	87.12 (99.75)	60.88 (76.32)
5	ICG 4326	29.29 (23.93)	62.75 (79.04)	62.80 (79.11)	85.89 (99.49)	90.00 (100.00)	66.15 (83.65)
6	ICG 8218	29.29 (23.93)	57.46 (71.07)	56.80 (70.02)	87.12 (99.75)	90.00 (100.00)	64.13 (80.96)
7	ICG 8281	28.64 (22.97)	50.19 (59.01)	51.95 (62.01)	87.12 (99.75)	90.00 (100.00)	61.58 (77.35)
	Mean	24.70 (17.46)	53.50 (64.62)	54.46 (66.21)	86.35 (99.59)	88.35 (99.92)	

CD(0.05) for variety means : 5.56
CD(0.05) for treatment means : 4.70
CD(0.05) for interaction : 5.14

Note 1. Arc sine transformation was done before analysis. Figures in parenthesis indicate values in the original scale

Table 17. Role of different entities of groundnut seed in its germination 70 days after harvest

Sl. No.	Genotype	Percentage of germination of					Mean
		Intact pod (T_1)	Intact seed (T_2)	Seed with pin holes on the testa (T_3)	Seed with testa removed (T_4)	Excised embryonic axis (T_5)	
1	ICG 198	25.07 (17.95)	51.37 (61.03)	52.57 (63.06)	84.23 (98.99)	87.12 (99.75)	60.07 (75.11)
2	ICG 1002	26.51 (19.92)	65.76 (83.14)	64.19 (81.04)	87.12 (99.75)	87.12 (99.75)	66.14 (83.64)
3	ICG 2471	26.51 (19.92)	62.06 (78.05)	63.49 (80.08)	81.35 (97.74)	87.12 (99.75)	64.10 (80.92)
4	ICG 2523	25.76 (18.89)	58.08 (72.04)	60.02 (75.03)	90.00 (100.00)	87.12 (99.75)	64.20 (81.06)
5	ICG 4326	29.29 (23.93)	64.19 (81.04)	66.64 (84.28)	90.00 (100.00)	84.23 (98.99)	66.87 (84.57)
6	ICG 8218	31.92 (27.96)	66.50 (84.10)	68.08 (86.06)	87.12 (99.75)	87.12 (99.75)	68.15 (86.15)
7	ICG 8281	31.89 (27.91)	61.36 (77.03)	62.05 (78.03)	84.23 (98.99)	90.00 (100.00)	65.91 (83.34)
	Mean	28.14 (22.24)	61.33 (76.98)	62.43 (78.58)	86.29 (99.58)	87.12 (99.75)	

CD(0.05) for variety means : 3.99

CD(0.05) for treatment means : 3.38

CD(0.05) for interaction : 5.37

Note 1. Arc sine transformation was done before analysis. Figures in parenthesis indicate values in the original scale

ANOVA showed that interaction, treatment and varietal differences were significant. T_2 and T_3 were on par. T_4 and T_5 were also on par.

Results of germination test conducted 80 days after harvest are presented in Table 18.

Germination percentage in T_1 increased and the highest was observed in ICG-8218 (29.98 per cent). The highest germination percentage in T_2 was also shown by ICG-8218 (89.21 per cent). In the case of T_3, ICG-4326 and ICG-2471 showed the highest germination per cent (90.09). Very high germination values exceeding 90 per cent were observed in all the genotypes in T_4 and T_5. Treatment and varietal differences and interaction were significant. T_2 and T_3 were on par. T_4 and T_5 were also on par.

Results of germination test conducted 90 days after harvest are presented in Table 19.

In treatments T_4 and T_5, there was more than 90 per cent germination in all the genotypes. In T_1, the germination percentage ranged from 27.96 in ICG-198 to 33 in ICG-8218. In T_2 and T_3, there was more than 90 per cent germination in all varieties studied except

Table 18. Role of different entities of groundnut seed its germination 80 days after harvest

Sl. No.	Genotype	Percentage of germination of					Mean
		Intact pod (T_1)	Intact seed (T_2)	Seed with pin holes on the testa (T_3)	Seed with testa removed (T_4)	Excised embryonic axis (T_5)	
1	ICG 198	29.29 (23.93)	61.36 (77.03)	64.19 (81.04)	90.00 (100.00)	90.00 (100.00)	66.97 (84.70)
2	ICG 1002	31.30 (26.99)	64.19 (81.04)	64.93 (82.05)	90.00 (100.00)	84.23 (98.99)	66.93 (84.64)
3	ICG 2471	26.51 (19.92)	70.69 (89.07)	71.65 (90.09)	90.00 (100.00)	90.00 (100.00)	69.77 (88.04)
4	ICG 2523	29.99 (24.98)	63.49 (80.08)	65.07 (82.23)	90.00 (100.00)	90.00 (100.00)	67.71 (85.61)
5	ICG 4326	31.92 (27.96)	68.08 (86.06)	71.65 (90.09)	87.12 (99.75)	90.00 (100.00)	69.75 (88.02)
6	ICG 8218	33.20 (29.98)	70.82 (89.21)	70.69 (89.07)	90.00 (100.00)	90.00 (100.00)	70.94 (89.34)
7	ICG 8281	30.64 (25.97)	65.76 (83.14)	66.50 (84.10)	90.00 (100.00)	90.00 (100.00)	68.58 (86.66)
	Mean	30.41 (25.62)	66.34 (83.90)	67.81 (85.14)	89.59 (99.99)	89.18 (99.98)	

CD(0.05) for variety means : 3.02
CD(0.05) for treatment means : 2.56
CD(0.05) for interaction : 3.17

Note 1. Arc sine transformation was done before analysis. Figures in parenthesis indicate values in the original scale

Table 19. Role of different entities of groundnut seed in its germination 90 days after harvest

Sl. No.	Genotype	Percentage of germination of					Mean
		Intact pod (T_1)	Intact seed (T_2)	Seed with pin holes on the testa (T_3)	Seed with testa removed (T_4)	Excised embryonic axis (T_5)	
1	ICG 198	31.92 (27.96)	67.25 (85.05)	68.08 (86.06)	87.12 (99.75)	90.00 (100.00)	68.87 (87.01)
2	ICG 1002	33.20 (29.98)	72.61 (91.07)	72.61 (91.07)	90.00 (100.00)	90.00 (100.00)	71.68 (90.12)
3	ICG 2471	34.43 (31.97)	71.65 (90.09)	76.02 (94.16)	87.12 (99.75)	90.00 (100.00)	71.84 (90.29)
4	ICG 2523	32.58 (29.00)	70.69 (89.07)	69.86 (88.14)	90.00 (100.00)	87.12 (99.75)	70.05 (88.36)
5	ICG 4326	33.20 (29.98)	76.02 (94.16)	80.12 (97.06)	87.12 (99.75)	90.00 (100.00)	73.29 (91.73)
6	ICG 8218	35.06 (33.00)	74.79 (93.12)	76.02 (94.16)	90.00 (100.00)	90.00 (100.00)	73.17 (91.62)
7	ICG 8281	33.20 (29.98)	73.83 (92.24)	72.87 (91.32)	90.00 (100.00)	90.00 (100.00)	71.98 (90.43)
	Mean	33.37 (30.25)	72.41 (90.87)	73.65 (92.08)	88.76 (99.95)	89.59 (99.99)	

CD(0.05) for variety mean : 2.59
CD(0.05) for treatment means : 2.19
CD(0.05) for interaction : 4.04

Note 1. Arc sine transformation was done before analysis. Figures in parenthesis indicate values in the original scale

in ICG-198 and ICG-2523. Treatment and varietal differences were significant. Interaction of variety and treatment was also found to be significant. T_4 and T_5 were on par. Similarly T_2 and T_3 were also on par.

Results of germination study conducted 100 days after harvest are furnished in Table 20.

More than 90 per cent germination was noticed in T_2, T_3, T_4 and T_5 in all the genotypes tested. In the case of T_1, the germination ranged from 29 per cent in ICG-198 to 30.99 per cent in ICG-1002, ICG-2471, ICG-2523 and ICG-8281.

There was increase in germination with increase in storage period in treatments T_2 and T_3 in all the genotypes.

4.3 Presence of water soluble promoters or inhibitors in the seed

With a view to finding out the presence of water soluble promoters and inhibitors in the seed, the following experiments were conducted and results are furnished in Tables 21 to 23.

Table 20. Role of different entities of groundnut seed in its germination 100 days after harvest

Sl. No.	Genotype	Percentage of germination of					Mean
		Intact pod (T_1)	Intact seed (T_2)	Seed with pin holes on the testa (T_3)	Seed with testa removed (T_4)	Excised embryonic axis (T_5)	
1	ICG 198	32.58 (29.00)	73.83 (92.24)	75.06 (93.35)	87.12 (99.75)	87.12 (99.75)	71.14 (89.55)
2	ICG 1002	33.83 (30.99)	78.90 (96.29)	83.01 (98.52)	90.00 (100.00)	90.00 (100.00)	75.15 (93.43)
3	ICG 2471	33.83 (30.99)	76.02 (94.16)	77.24 (95.12)	84.23 (98.99)	87.12 (99.75)	71.68 (90.12)
4	ICG 2523	33.83 (30.99)	74.79 (93.12)	76.02 (94.16)	87.12 (99.75)	90.00 (100.00)	72.35 (90.81)
5	ICG 4326	33.20 (29.98)	87.12 (99.75)	90.00 (100.00)	90.00 (100.00)	90.00 (100.00)	78.06 (95.72)
6	ICG 8218	33.20 (29.98)	87.12 (99.75)	84.23 (98.99)	90.00 (100.00)	87.12 (99.75)	76.33 (94.41)
7	ICG 8281	33.83 (30.99)	84.23 (98.99)	87.12 (99.75)	84.23 (98.99)	84.23 (98.99)	74.73 (93.06)
	Mean	33.47 (30.42)	80.29 (97.16)	81.81 (97.97)	87.53 (99.81)	87.94 (99.87)	

CD(0.05) for variety means : 4.24

CD(0.05) for treatment means : 8.59

CD(0.05) for interaction : 6.24

Note 1. Arc sine transformation was done before analysis. Figures in parenthesis indicate values in the original scale

The aqueous extracts of two nondormant types ICG-3777 and ICG-1281, were prepared to find out whether any stimulatory substance was present in them which could elicit germination in dormant types. Seeds of seven dormant types, ICG-198, ICG-1002, ICG-2471, ICG-2523, ICG-4326, ICG-8218 and ICG-8281 were treated with these extracts for varying periods viz., 6, 12, 18 and 24 hours and their germination tested and the results are summarised in Table 21.

No germination was noticed in the treated materials as well as in the untreated control indicating that there was no significant difference between treatments and control.

With a view to finding out the presence of inhibitory substances in dormant groundnut seeds, the aqueous extracts of ICG-198 and ICG-2523, two dormant types with dormancy rating 8, were prepared. Aqueous extracts were used for treating seven nondormant types ICG-128, ICG-459, ICG-1231, ICG-1281, ICG-1308, ICG-2144 and ICG-3777 for varying periods (6, 12, 18 and 24 hours) and germination determined afterwards. Results are presented in Table 22.

Table 21. Effect of aqueous extract of nondormant types on the germination of dormant ones at harvest

Sl. No.	Dormant genotype	Percentage of germination of seeds treated with extract of								Control
		ICG 3777 (nondormant)				ICG 1281 (nondormant)				
		6 hours	12 hours	18 hours	24 hours	6 hours	12 hours	18 hours	24 hours	
1	ICG 198	0	0	0	0	0	0	0	0	0
2	ICG 1002	0	0	0	0	0	0	0	0	0
3	ICG 2471	0	0	0	0	0	0	0	0	0
4	ICG 2523	0	0	0	0	0	0	0	0	0
5	ICG 4326	0	0	0	0	0	0	0	0	0
6	ICG 8218	0	0	0	0	0	0	0	0	0
7	ICG 8281	0	0	0	0	0	0	0	0	0

Table 22. Effect of aqueous extract of dormant types on the germination of nondormant ones at harvest

Nondormant genotype	Percentage of germination of seeds treated with extract of								Untreated control	Mean
	ICG 198 (dormant)				ICG 2523 (dormant)					
	6 hours	12 hours	18 hours	24 hours	6 hours	12 hours	18 hours	24 hours		
ICG 128	81.87 (98.00)	80.17 (97.09)	85.94 (99.50)	84.23 (98.99)	84.23 (98.99)	80.17 (97.09)	80.17 (97.09)	84.23 (98.99)	81.87 (98.00)	82.54 (98.31)
ICG 459	84.23 (98.98)	81.87 (98.00)	85.94 (99.50)	81.87 (98.00)	84.23 (98.98)	85.94 (99.50)	80.17 (97.09)	77.14 (95.04)	84.23 (98.99)	82.85 (98.45)
ICG 1231	76.02 (94.16)	77.14 (95.04)	78.46 (96.00)	75.82 (94.00)	77.14 (95.04)	75.82 (94.00)	77.14 (95.04)	76.02 (94.16)	75.82 (94.00)	76.60 (94.63)
ICG 1281	90.00 (100.00)	81.87 (98.00)	85.94 (99.50)	90.00 (100.00)	81.87 (98.00)	84.23 (98.99)	90.00 (100.00)	90.00 .00.00)	90.00 (100.00)	87.10 (99.74)
ICG 1308	73.57 (92.00)	73.69 (92.11)	72.57 (91.03)	74.70 (93.04)	75.82 (94.00)	76.02 (94.16)	74.70 (93.04)	73.57 (92.00)	74.70 (93.04)	74.37 (92.74)
ICG 2144	84.23 (98.98)	81.87 (98.00)	85.94 (98.50)	80.17 (97.09)	85.94 (99.50)	81.87 (98.00)	80.17 (97.09)	81.87 (98.00)	85.94 (99.50)	83.11 (98.56)
ICG 3777	81.87 (98.00)	90.00 (100.00)	90.00 (100.00)	90.00 (100.00)	81.87 (98.00)	85.94 (99.50)	90.00 (100.00)	90.00 (100.00)	90.00 (100.00)	87.74 (99.84)
Mean	81.68 (97.91)	80.94 (97.52)	83.54 (98.73)	82.40 (98.25)	81.59 (97.86)	81.42 (97.77)	81.76 (97.95)	81.83 (97.98)	83.22 (98.61)	

CD(0.05) for variety means : 2.51
CD(0.05) for treatment means : N.S.
CD(0.05) for interaction : N.S.

Note 1. Arc sine transformation was done before analysis. Figures in parenthesis indicate values in the original scale

There was no significant difference between treated ones and the untreated control. Results of treatment replicates were highly consistent and more than 90 per cent germination was observed in treated and untreated materials.

To confirm the presence of water soluble inhibitors in dormant seeds, a leaching treatment was also given to the seeds of seven dormant groundnut genotypes viz., ICG-198, ICG-1002, ICG-2471, ICG-2523, ICG-4326, ICG-8218 and ICG-8281. Results of the experiment to find out the effect of washing with running water on the germination of intact seed and seed without testa are presented in Table 23.

Washing the intact seed in running water for 12 hours and 24 hours did not give any germination as in the case of untreated control. Washing the seed in running water, after removing the testa, for 12 hours and 24 hours did give some positive results in all the seven genotypes tested. In the case of leaching treatment of decoated seeds for 12 hours, the highest germination per cent was recorded by the genotypes ICG-1002 and ICG-4326 (76 per cent). ICG-198 had the least response with 62.01 per cent germination. By increasing the treatment time to 24 hours, the germination per cent

Table 23. Effect of washing with water on the germination of dormant groundnut genotypes at harvest

Sl. No.	Genotype	Percentage of germination of				Untreated control	Mean
		Intact seed		Seed without testa			
		12 hours	24 hours	12 hours	24 hours		
1	ICG 198	0.29 (0.00)	0.29 (0.00)	51.95 (62.01)	71.56 (89.99)	0.29 (0.00)	61.76 (77.61)
2	ICG 1002	0.29 (0.00)	0.29 (0.00)	60.69 (76.04)	78.85 (96.26)	0.29 (0.00)	69.77 (88.04)
3	ICG 2471	0.29 (0.00)	0.29 (0.00)	53.13 (64.00)	73.57 (92.00)	0.29 (0.00)	63.35 (79.88)
4	ICG 2523	0.29 (0.00)	0.29 (0.00)	56.80 (70.00)	73.69 (92.11)	0.29 (0.00)	65.25 (82.47)
5	ICG 4326	0.29 (0.00)	0.29 (0.00)	60.69 (76.04)	81.87 (98.00)	0.29 (0.00)	71.28 (89.70)
6	ICG 8218	0.29 (0.00)	0.29 (0.00)	56.79 (70.00)	78.84 (96.25)	0.29 (0.00)	67.82 (85.75)
7	ICG 8281	0.29 (0.00)	0.29 (0.00)	55.56 (68.02)	73.57 (91.99)	0.29 (0.00)	64.57 (81.56)
	Mean	0.29 (0.00)	0.29 (0.00)	56.51 (69.55)	75.99 (94.14)	0.29 (0.00)	

CD(0.05) for variety means : 3.14
CD(0.05) for treatment means : 1.68
CD (0.05) for interaction : N.S.

Note 1. Arc sine transformation was done before analysis. Figures in parenthesis indicate values in the original scale
2. Intact seed and untreated control did not give any germination and hence were not included in the analysis

also increased. The highest germination was obtained in ICG-4326 (98 per cent) and the lowest germination was recorded by ICG-198 (89.99 per cent).

The treatment and varietal differences were significant. But interaction was not significant.

4.4 Effect of presowing treatments in breaking dormancy

Effect of different presowing treatments on the germination of four dormant groundnut genotypes is presented in Table 24 and illustrated in Fig.3.

Treatments with $CuSO_4$, $ZnSO_4$ and boric acid for varying concentrations, boiling water (10 sec.) and steam (60 sec.) did not give any germination as in the case of untreated control. Varying percentages of germination were obtained in the other treatments. In the case of ICG-198, the highest germination was obtained for treatment with $HgCl_2$ for 5 minutes (44.99 per cent). For ICG-1002, the best treatment was the one with glutathion 0.3 per cent for 24 hours where 68.02 per cent germination was obtained. In the case of ICG-2471 also, treatment with glutathion 0.3 per cent for 24 hours gave the highest germination of 67 per cent. In the case of ICG-2523, treatment with ethyl alcohol for 10 minutes

Table 24. Effect of different presowing treatments on the germination of four dormant groundnut genotypes at harvest

Sl. No.	Treatments: Item	Treatments: Concentration	Time	Germination percentage of: ICG 198	ICG 1002	ICG 2523	ICG 2471	Mean
1	Untreated control	-	-	0.29 (0.00)	0.29 (0.00)	0.29 (0.00)	0.29 (0.00)	0.29 (0.00)
2	$CuSO_4$	1.5%	24 hours	0.29 (0.00)	0.29 (0.00)	0.29 (0.00)	0.29 (0.00)	0.29 (0.00)
3	$CuSO_4$	3%	24 hours	0.29 (0.00)	0.29 (0.00)	0.29 (0.00)	0.29 (0.00)	0.29 (0.00)
4	$ZnSO_4$	1.5%	24 hours	0.29 (0.00)	0.29 (0.00)	0.29 (0.00)	0.29 (0.00)	0.29 (0.00)
5	$ZnSO_4$	3%	24 hours	0.29 (0.00)	0.29 (0.00)	0.29 (0.00)	0.29 (0.00)	0.29 (0.00)
6	Boric acid	1.5%	24 hours	0.29 (0.00)	0.29 (0.00)	0.29 (0.00)	0.29 (0.00)	0.29 (0.00)
7	Boric acid	3%	24 hours	0.29 (0.00)	0.29 (0.00)	0.29 (0.00)	0.29 (0.00)	0.29 (0.00)

Table 24. (contd....)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
8	Boiling water	-	10 sec.	0.29 (0.00)	0.29 (0.00)	0.29 (0.00)	0.29 (0.00)	0.29 (0.00)
9	Steam	-	60 sec.	0.29 (0.00)	0.29 (0.00)	0.29 (0.00)	0.29 (0.00)	0.29 (0.00)
10	$Hgcl_2$	1 : 1000	5 mnts.	42.13 (44.99)	45.00 (50.00)	40.40 (42.00)	46.15 (52.01)	43.42 (47.24)
11	$Hgcl_2$	1 : 1000	10 mnts.	34.45 (32.00)	38.05 (37.99)	36.86 (35.98)	45.00 (50.00)	38.59 (38.91)
12	Glutathion	0.03%	24 hours	8.13 (1.99)	39.23 (40.00)	15.30 (6.96)	45.00 (50.00)	26.92 (20.50)
13	Glutathion	0.3%	24 hours	26.56 (19.99)	55.56 (68.02)	30.64 (25.97)	54.94 (67.00)	41.93 (44.65)
14	Ethyl alcohol	96%	5 mnts.	16.31 (7.88)	33.20 (29.98)	20.27 (12.00)	35.06 (33.00)	26.21 (19.51)
15	Ethyl alcohol	96%	10 mnts.	26.53 (19.95)	45.00 (50.00)	42.70 (45.99)	52.54 (63.00)	41.69 (44.24)
16	IAA	0.001%	24 hours	18.44 (10.00)	26.53 (19.95)	21.92 (13.94)	27.26 (20.97)	23.54 (15.95)

Table 24. (contd....)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
17	IAA	0.01%	24 hours	36.84 (35.95)	50.77 (60.00)	38.06 (38.01)	42.71 (46.00)	42.09 (44.92)
18	2,4-D	0.003%	24 hours	0.29 (0.00)	8.13 (1.99)	0.29 (0.00)	11.54 (4.00)	5.06 (0.77)
19	2,4-D	0.03%	24 hours	20.01 (11.71)	19.35 (10.98)	21.97 (14.00)	21.12 (12.98)	20.61 (12.39)
20	H_2O_2	1%	3 hours	31.94 (27.99)	45.00 (50.00)	34.44 (31.98)	50.77 (60.00)	40.54 (42.25)
21	H_2O_2	5%	3 hours	25.07 (17.95)	23.54 (15.95)	23.58 (16.00)	26.54 (19.97)	24.68 (17.43)
	Mean	-	-	23.89 (16.40)	35.78 (34.18)	27.20 (20.89)	38.22 (38.28)	

CD(0.05) for variety means : 5.00

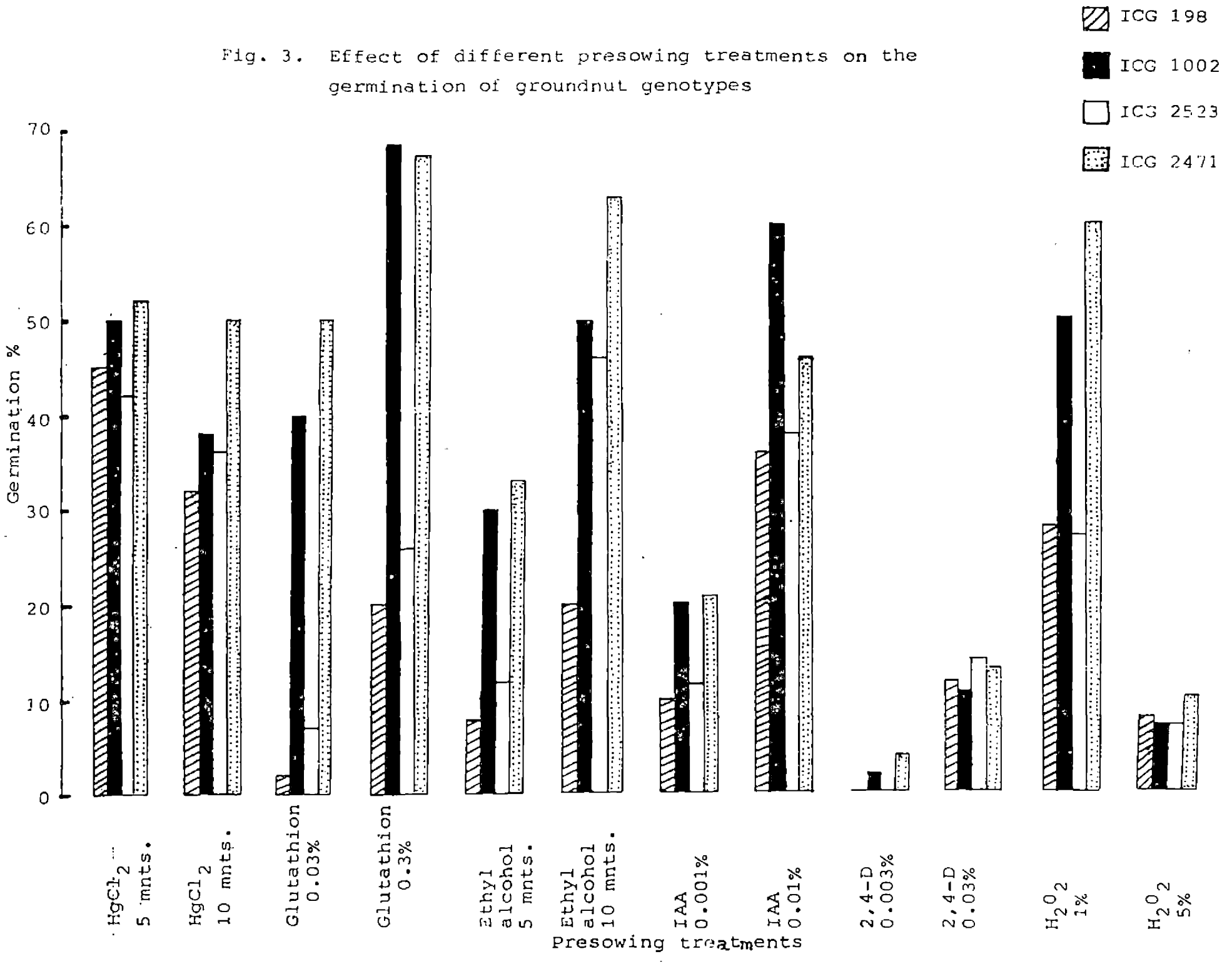
CD(0.05) for treatment means : 8.67

CD(0.05) for interaction : 3.29

Note 1. Arc sine transformation was done before analysis. Figures in parenthesis indicate values in the original scale

2. Treatments 1 to 9 did not give any germination and hence were not included in the analysis

Fig. 3. Effect of different presowing treatments on the germination of groundnut genotypes



gave the highest germination per cent (45.99 per cent). Glutathion, 0.3 per cent, though effective in ICG-1002 and ICG-2471 did not increase germination in ICG-198 and ICG-2523 substantially. Analysis of variance showed significant treatment and varietal differences. Interaction effect of varieties and treatments was also significant.

4.5 Inheritance of seed dormancy

In the study of inheritance of dormancy, we are concerned with the generation of embryo rather than that of mature plant, since the assessment of this character is based on the reaction of the embryo to the environment. It might be well to discuss the matter of designation of generation before presenting the actual results of the experiment.

The original hybrid seeds obtained by hybridisation possess F_1 embryo, seeds of F_1 plants have F_2 embryos, seeds of F_2 plants have F_3 embryos and so on. Thus in germination tests, the hybrid seeds express the embryonic germinability of F_1, the seeds of F_1 plants express F_2 segregation for embryonic germinability, seeds of F_2 plants express F_3 segregation for embryonic germinability and so on (Johnson, 1935). The embryo

and the plant developed from it can be looked upon as same individual in different stages of development. Thus the seeds produced by initial hybridisation are F_1 seeds, seeds borne on F_1 mature plants are F_2 seeds which will show variation in germinability in F_2. For the present investigation it was considered worthwhile to choose genotypes with maximum expression of contrasting traits both with respect to the initial germination per cent as well as period of rest required. Thus two types ICG-1281 and ICG-3777 (Plates 4a and b) which showed maximum germination per cent and requiring no rest periods were chosen to represent the nondormant class. Similarly two types ICG-198 and ICG-2523 (Plates 4c and d) which showed minimum germination per cent in the first test and requiring longest periods of dormancy were chosen to represent the dormant class.

4.5.1 Study of F_1

From four crosses without reciprocals, which were effected, inheritance was studied. The first filial generation (F_1) is represented by the embryo developed after fertilisation brought about by hybridisation. Twenty hybrid seeds in each cross were


ICG-1281


ICG-3777

Plate 4c Dormant parent ICG 198

Plate 4d Dormant parent ICG 2523


ICG-198


ICG-2523

tested for germinability on the day of collection along with parents as checks and results are furnished in Table 25.

Results have revealed that none of the hybrid seeds in any of the four combinations germinated while the nondormant parents ICG-1281 and ICG-3777 gave 96 per cent and 98 per cent germination respectively. Due to the paucity of seeds available, germination test could not be repeated at 10 day intervals to find out the rest period of F_1 embryos. F_1 embryos apparently resembled the dormant parents with regard to their germinability on the day of harvest.

4.5.2 F_2 generation

Seeds of F_1 plants (Plates 5a, b, c and d) belonging to four crosses were tested for germinability soon after harvest and the results are presented in Table 26 to 29.

Germination percentage ranged from zero to 77.42 In all groups there was a high percentage of dormant seeds as judged by initial germination. The individual

Plate 5a F_1 plant of cross ICG 1281 x ICG 198

Plate 5b F_1 plant of cross ICG 1281 x ICG 2523

Table 25. Germination of seeds of parents and F_1's at harvest (F_1 embryo generation)

Sl. No.	Parent/F_1		Number of seeds kept for germination	Number of seeds germinated	Germination (%)
1	ICG 1281	Nondormant	50	48	96
2	ICG 3777		50	49	98
3	ICG 198	Dormant	50	0	0
4	ICG 2523		50	0	0
5	ICG 1281 x ICG 198		20	0	0
6	ICG 1281 x ICG 2523		20	0	0
7	ICG 3777 x ICG 198		20	0	0
8	ICG 3777 x ICG 2523		20	0	0


A x C


A x D

Plate 5c F_1 plant of cross ICG 3777 x ICG 198

Plate 5d F_1 plant of cross ICG 3777 x ICG 2523


B X C


B x D

Table 26. Sprouting values of F_2 seeds at harvest borne on F_1 plants of cross ICG 1281 x ICG 198

Plant No.	Number of seeds			Germination per cent	X^2 calculated on the basis of 3:1 ratio
	Kept for germination	Germinated	Not germinated		
1	37	17	20	46.50	8.658*
2	31	0	31	0.00	10.333*
3	15	2	13	13.30	1.089
4	19	1	18	5.30	3.947*
5	24	2	22	8.30	3.556
6	24	1	23	4.20	5.556*
7	27	2	25	7.40	4.457*
8	36	15	21	41.70	5.333*
9	41	18	23	43.90	7.813*
10	30	0	30	0.00	10.000*
11	12	2	10	16.70	0.444
12	13	1	12	7.70	2.077
13	20	0	20	0.00	6.667*
14	14	1	13	7.10	2.381
15	19	2	17	10.50	2.123
Total chi-square (X^2_{15})					74.434*
Deviation chi-square (X^2_1)					10.346*
Heterogeneity chi-square (X^2_{14})					64.088*

* Significant at 5% level

Table 27. Sprouting values of F_2 seeds at harvest borne on F_1 plants of cross ICG 1281 x ICG 2523

Plant No.	Number of seeds			Germination per cent	X^2 calculated on the basis of 3:1 ratio
	Kept for germination	Germinated	Not germinated		
1	42	19	23	45.20	9.174*
2	39	5	34	12.80	3.085
3	21	2	19	9.50	2.683
4	18	2	16	11.10	1.852
5	39	1	38	2.60	10.470*
6	47	23	24	48.90	14.362*
7	18	0	18	0.00	6.000*
8	23	4	19	17.40	0.710
9	39	7	32	18.00	1.034
10	33	5	28	15.20	1.707
11	12	2	10	16.70	0.444
12	13	2	11	15.40	0.641
13	28	1	27	3.60	6.857*
14	40	10	30	25.00	0.000
15	13	0	13	0.00	4.333*
16	29	3	26	10.30	3.332
Total chi-square (X^2_{16})					66.674*
Deviation chi-square (X^2_1)					8.883*
Heterogeneity chi-square (X^2_{15})					57.791*

*Significant at 5% level

Table 28. Sprouting values of F_2 seeds at harvest borne on F_1 plants of cross ICG 3777 x ICG 198

Plant No.	Number of seeds			Germination per cent	X^2 calculated on the basis of 3:1 ratio
	Kept for germination	Germinated	Not germinated		
1	8	3	5	37.50	0.667
2	15	3	12	20.00	0.200
3	31	5	26	16.10	1.301
4	24	7	17	29.20	0.222
5	19	1	18	5.30	3.947*
6	11	3	8	27.30	0.030
7	13	3	10	23.10	0.026
8	37	4	33	10.80	3.973*
9	21	4	17	19.10	0.397
10	39	6	33	15.40	1.923
11	15	3	12	20.00	0.200
12	24	1	23	4.20	5.556*
13	14	3	11	21.40	0.095
14	24	18	6	75.00	32.000*
15	12	9	3	75.00	16.000*
16	51	6	45	11.80	4.765*
17	38	4	34	10.50	4.246*
18	18	3	15	16.70	0.667
19	25	6	19	24.00	0.013
20	41	6	35	14.60	2.350
21	35	6	29	17.10	1.152
22	14	4	10	28.60	0.095
23	9	4	5	44.40	1.815
Total chi-square (X^2_{23})					81.640*
Deviation chi-square (X^2_1)					5.018*
Heterogeneity chi-square (X^2_{22})					76.622*

*Significant at 5% level

Table 29. Sprouting values of F_2 seeds at harvest borne on F_1 plants of cross ICG 3777 x ICG 2523

Plant No.	Number of seeds			Germination per cent	X^2 calculated on the basis of 3:1 ratio
	Kept for germination	Germinated	Not germinated		
1	31	8	23	25.80	0.011
2	10	0	10	0.00	3.333
3	14	6	8	42.90	2.381
4	20	2	18	10.00	2.400
5	39	27	12	62.20	40.692*
6	17	3	14	17.70	0.490
7	38	6	32	15.80	1.719
8	31	24	7	77.40	45.430*
9	12	2	10	16.70	0.444
10	14	3	11	21.40	0.095
11	25	4	21	16.00	1.080
12	8	1	7	12.50	0.667
13	8	0	8	0.00	2.667
14	20	4	16	20.00	0.267
15	19	14	5	73.70	24.017*
Total chi-square (X^2_{15})					125.693*
Deviation chi-square (X^2_1)					13.181*
Heterogeneity chi-square (X^2_{14})					112.512*

*Significant at 5% level

chi-square values showed an approximation to 3:1 ratio in several cases. But the total, deviation and heterogeneity chi-square values calculated on the basis of 3:1 ratio were significant in all the cases. From this, it appeared that the segregation of different dormant and nondormant classes did not confirm to any simple mode of inheritance. It has to be mentioned here that many of the seeds which required varying rest periods would have been included under the class dormant which as stated was predominant in most of the F_2 families.

4.5.3 F_3 generation

Two families in each of the four crosses were carried forward to the F_2 plant generation. The total number of 245 F_2 plants representing the eight families belonging to the four crosses were harvested when mature and tested for their germinability, the test being commenced on the same day of harvest. The results are summarised and presented in Table 30-37.

Wide variation in germination from zero to 100 per cent was observed in F_3 families. No definite grouping

Table 30. Germination percentage of F_3 seeds borne on F_2 plants derived from F_1 plant number one of cross ICG 1281 x ICG 198

F_2 plant No.	Number of seeds			Germination percentage
	Kept for germination	Germinated	Not germinated	
1	19	0	19	00.00
2	18	2	16	11.10
3	33	5	28	15.20
4	43	8	35	18.60
5	13	3	10	23.10
6	29	7	22	24.10
7	37	9	28	24.30
8	38	11	27	29.00
9	24	8	16	33.30
10	43	15	28	34.90
11	17	6	11	35.30
12	39	14	25	35.90
13	47	18	29	38.30
14	29	12	17	41.40
15	21	9	12	42.90
16	51	22	29	43.10
17	43	19	24	44.20
18	39	18	21	46.20
19	39	19	20	48.70
20	52	27	25	51.90
21	19	10	9	52.60
22	28	15	13	53.60
23	26	15	11	57.70
24	41	26	15	63.40
25	32	21	11	65.60
26	26	18	8	69.20
27	29	22	7	75.90
28	18	14	4	77.80
29	12	10	2	83.30
30	29	28	1	96.60

Table 31. Germination percentage of F_3 seeds borne on F_2 plants derived from F_1 plant number nine of cross ICG 1281 x ICG 198

F_2 plant No.	Number of seeds			Germination percentage
	Kept for germination	Germinated	Not germinated	
1	31	0	31	00.00
2	54	0	54	00.00
3	36	4	32	11.10
4	47	9	38	19.20
5	43	10	33	23.30
6	39	11	28	28.20
7	42	12	30	28.60
8	35	11	24	31.40
9	36	13	23	36.10
10	19	7	12	36.80
11	23	9	14	39.10
12	28	11	17	39.30
13	38	16	22	42.10
14	21	9	12	42.90
15	18	8	10	44.40
16	47	21	26	44.70
17	51	23	28	45.10
18	25	12	13	48.00
19	39	19	20	48.70
20	25	13	12	52.00
21	49	26	23	53.10
22	23	13	10	56.50
23	37	23	14	62.20
24	43	27	16	62.80
25	27	18	9	66.70
26	18	14	4	77.80
27	33	26	7	78.80
28	28	24	4	85.70
29	32	31	1	96.90

Table 32. Germination percentage of F_3 seeds borne on F_2 plants derived from F_1 plant number one of cross ICG 1281 x ICG 2523

F_2 plant No.	Number of seeds			Germination percentage
	Kept for germination	Germinated	Not germinated	
1	11	0	11	00.00
2	28	1	27	03.60
3	47	8	39	17.00
4	39	9	30	23.10
5	54	13	41	24.10
6	23	7	16	30.40
7	37	12	25	32.40
8	39	14	25	35.90
9	45	17	28	37.80
10	21	8	13	38.10
11	24	10	14	41.70
12	22	10	12	45.50
13	28	13	15	46.40
14	21	10	11	47.60
15	18	9	9	50.00
16	19	10	9	52.60
17	20	11	9	55.00
18	19	11	8	57.90
19	40	24	16	60.00
20	23	15	8	65.20
21	29	20	9	69.00
22	33	26	7	78.80
23	24	21	3	87.50
24	26	25	1	96.20

Table 33. Germination percentage of F_3 seeds borne on F_2 plants derived from F_1 plant number five of cross ICG 1281 x ICG 2523

F_2 plant No.	Number of seeds			Germination percentage
	Kept for germination	Germinated	Not germinated	
1	51	0	51	00.00
2	21	3	18	14.30
3	19	3	16	15.80
4	47	11	36	23.40
5	28	7	21	25.00
6	33	9	24	27.30
7	23	7	16	30.40
8	29	9	20	31.00
9	46	15	31	32.60
10	23	8	15	34.80
11	37	13	24	35.10
12	34	12	22	35.30
13	28	11	17	39.30
14	48	20	28	41.70
15	14	6	8	42.90
16	35	16	19	45.70
17	39	18	21	46.20
18	41	19	22	46.30
19	19	9	10	47.40
20	27	13	14	48.20
21	17	9	8	52.90
22	11	6	5	54.60
23	31	17	14	54.80
24	19	11	8	57.90
25	30	18	12	60.00
26	13	8	5	61.50
27	13	9	4	69.20
28	27	19	8	70.40
29	20	16	4	80.00
30	47	42	5	89.40
31	42	41	1	97.60

Table 34. Germination percentage of F_3 seeds of borne on F_2 plants derived from F_1 plant number ten of cross ICG 3777 x ICG 198

F_2 plant No.	Number of seeds			Germination percentage
	Kept for germination	Germinated	Not germinated	
1	48	0	48	00.00
2	41	1	40	02.40
3	23	3	20	13.00
4	37	7	30	18.90
5	18	4	14	22.20
6	27	7	20	25.90
7	19	5	14	26.30
8	29	8	21	27.60
9	37	12	25	32.40
10	24	9	15	37.50
11	29	11	18	37.90
12	39	15	24	38.50
13	28	11	17	39.30
14	33	13	20	39.40
15	41	17	24	41.50
16	19	8	11	42.10
17	28	12	16	42.90
18	24	11	13	45.80
19	34	16	18	47.10
20	36	17	19	47.20
21	25	12	13	48.00
22	35	17	18	48.60
23	37	19	18	51.40
24	29	16	13	55.20
25	16	9	7	56.30
26	21	12	9	57.10
27	19	12	7	63.20
28	23	15	8	65.20
29	27	19	8	70.40
30	21	16	5	76.20
31	29	23	6	79.30
32	33	29	4	87.90
33	34	30	4	88.20
34	28	28	0	100.00

Table 35. Germination percentage of F_3 seeds borne on F_2 plants derived from F_1 plant number twenty of cross ICG 3777 x ICG 198

F_2 plant No.	Number of seeds			Germination percentage
	Kept for germination	Germinated	Not germinated	
1	29	0	29	00.00
2	32	0	32	00.00
3	41	6	35	14.60
4	18	3	15	16.70
5	15	3	12	20.00
6	35	8	27	22.90
7	43	11	32	25.60
8	42	11	31	26.20
9	29	8	21	27.60
10	28	8	20	28.60
11	35	11	24	31.40
12	12	4	8	33.30
13	42	16	26	38.10
14	13	5	8	38.50
15	31	12	19	38.70
16	38	15	23	39.50
17	45	18	27	40.00
18	24	10	14	41.70
19	36	16	20	44.40
20	29	13	16	44.80
21	17	8	9	47.10
22	34	16	18	47.10
23	21	10	11	47.60
24	33	16	17	48.50
25	18	9	9	50.00
26	31	16	15	51.60
27	23	12	11	52.20
28	33	18	15	54.60
29	31	17	14	54.80
30	18	10	8	55.60
31	42	24	18	57.10
32	33	21	12	63.60
33	29	19	10	65.50
34	39	27	12	69.20
35	36	25	11	69.40
36	41	29	12	70.70
37	42	33	9	78.60
38	46	41	5	89.10
39	44	43	1	97.70

Table 36. Germination percentage of F_3 seeds borne on F_2 plants derived from F_1 plant number one of cross ICG 3777 x ICG 2523

F_2 plant No.	Number of seeds			Germination percentage
	Kept for germination	Germinated	Not germinated	
1	30	0	30	00.00
2	27	3	24	11.10
3	16	4	12	25.00
4	35	10	25	28.60
5	24	7	17	29.20
6	19	6	13	31.60
7	34	12	22	35.30
8	35	13	22	37.10
9	38	15	23	39.50
10	32	13	19	40.60
11	31	13	18	41.90
12	33	14	19	42.40
13	24	11	13	45.80
14	21	10	11	47.60
15	27	13	14	48.20
16	29	15	14	51.70
17	42	23	19	54.80
18	23	13	10	56.50
19	35	21	14	60.00
20	27	18	9	66.70
21	36	25	11	69.40
22	21	16	5	76.20
23	41	33	8	80.50
24	20	18	2	90.00
25	12	12	0	100.00

Table 37. Germination percentage of F_3 seeds borne on F_2 plants derived from F_1 plant number six of cross ICG 3777 x ICG 2523

F_2 plant No.	Number of seeds			Germination percentage
	Kept for germination	Germinated	Not germinated	
1	18	0	18	00.00
2	11	0	11	00.00
3	39	5	34	12.80
4	35	9	26	25.70
5	27	7	20	25.90
6	37	10	27	27.00
7	46	13	33	28.30
8	31	9	22	29.00
9	28	9	19	32.10
10	18	6	12	33.30
11	32	11	21	34.40
12	36	13	23	36.10
13	36	14	22	38.90
14	47	19	28	40.40
15	32	14	18	43.80
16	36	17	19	47.20
17	21	10	11	47.60
18	23	11	12	47.80
19	35	17	18	48.60
20	12	6	6	50.00
21	28	14	14	50.00
22	28	15	13	53.60
23	18	10	8	55.60
24	21	12	9	57.10
25	27	16	11	59.30
26	21	13	8	61.90
27	32	21	11	65.60
28	27	18	9	66.70
29	28	20	8	71.40
30	39	31	8	79.50
31	37	31	6	83.80
32	30	27	3	90.00
33	21	21	0	100.00

of individuals was possible in this. Here it was significant to note that there were families giving 100 per cent germination in initial test after harvest.

The pooled frequency distribution of the F_3 progenies by germination percentage on the day of harvest along with expected frequencies under normal distribution are given in Table 38 and illustrated in Fig.4.

Table 38. Frequency distribution in F_3

Class number	Class interval	Middle value of class	Observed number	Expected number
1	0 - 10	5	13	13.80
2	10 - 20	15	14	17.20
3	20 - 30	25	30	28.30
4	30 - 40	35	43	38.50
5	40 - 50	45	52	43.00
6	50 - 60	55	35	39.60
7	60 - 70	65	24	30.10
8	70 - 80	75	14	18.80
9	80 - 90	85	10	9.70
10	90 - 100	95	10	6.10

Chi-square value (χ^2_9) : N.S.

Mean : 45.76

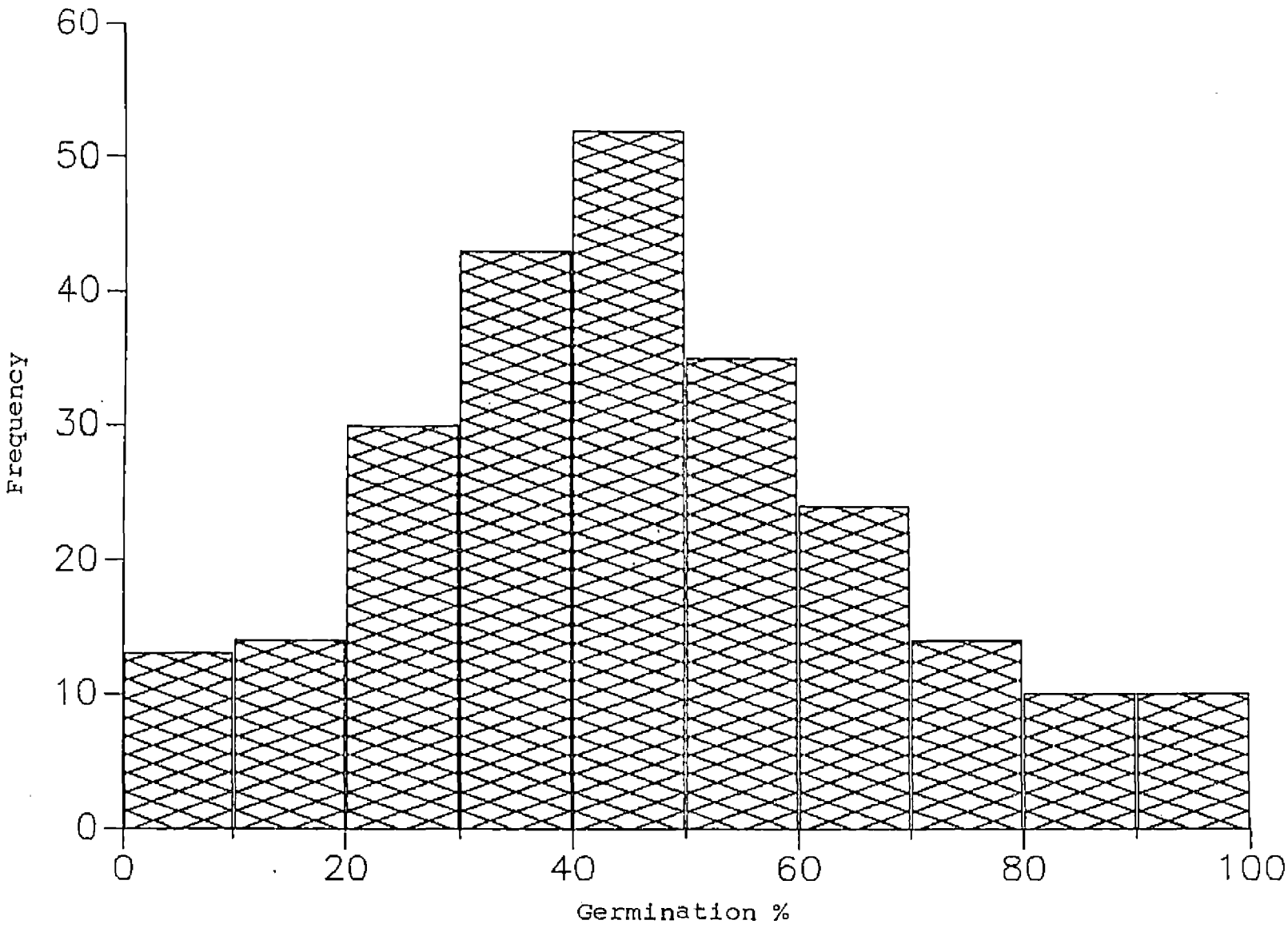


Fig. 4. Frequency distribution in F_3

Discussion

5. DISCUSSION

Dormancy or rest period required for the seed to attain a satisfactory germination is a phenomenon met with in a variety of plants and assumes much importance in practical problem of crop production when concerned with crop plants.

In groundnut, the problem of seed dormancy has many folded effects in our state where two pure crops of groundnut, one during April-May to August-September and another during September-October to December-January are normally taken. The first crop comes to harvest during August-September when monsoon showers are likely to occur. Groundnut by its very nature of fruiting under the ground, needs sufficient moisture in the soil for successful and easy harvest. As such the monsoon showers at maturity stage of the crop are helpful for harvest. However, high soil moisture and high atmospheric temperature which are likely to coincide with the harvest of the first crop, force most of the cultivated types now available in the state to germinate in the field itself, resulting in the loss of a sizeable proportion of the produce to the farmer. In such situations, dormant varieties are

a boon to the farmer. However, there are instances where a portion of the first crop harvest is utilised for raising a second crop. In such situations a prolonged dormancy period becomes a handicap. Under the conditions prevalent in our state, it will be ideal to have high yielding short duration groundnut variety with a dormancy period ranging from 20-30 days. It is in this background that the present investigation was taken up.

An attack on the nature of seed dormancy and its inheritance has been in the purview of both Physiologists and Plant breeders from different angles. Though investigators have come to different conclusions regarding the ultimate cause of seed dormancy in physiological terms like inability of dormant seeds to absorb sufficient quantity of water for germination, impermeability of seed coat to oxygen, presence of germination inhibitors in the seed etc., it appears that there is a general inhibiting mechanism which may not be merely mechanical but some more complex chemical phenomenon. However, facts gathered from investigations on different materials indicate, to some extent, that the casual mechanism is heritable (Mangelsdorf, 1930). There seems to be an agreement in the opinion of most

of these workers that the characteristic is not simple and easily analysable. In most cases a multifactorial system has been suggested.

The investigations reported herein, were undertaken to elucidate further the mechanism of seed dormancy in groundnut and the nature of its inheritance by a study of selected materials expressing the contrasting characters to the maximum degree.

5.1.1 Survey and classification of genotypes into different dormancy groups

A survey of dormancy levels as expressed by the initial sprouting values at harvest, in the 419 genotypes including in the present study has shown wide variation ranging from four to 100 per cent. None among the tested genotypes has exhibited 100 per cent germination at harvest leading to zero per cent dormancy. However, 207 out of 419 have registered an initial sprouting value of zero per cent at harvest showing cent per cent dormancy. The rest of the genotypes have exhibited sprouting values from zero to 96 per cent at harvest. These results have thus indicated that the tested material possesses a wide spectrum of variability with reference to dormancy.

The 419 genotypes included in the present investigation belonged to the three botanical groups hypogaea (242 genotypes), vulgaris (137 genotypes) and fastigiata (38 genotypes) excluding two entries which did not belong to any of the above mentioned botanical groups. It is interesting to observe that in all the botanical groups, genotypes possessing varying degrees of dormancy in the zero to eight scale as per the ratings of Lin and Chen (1970) are occuring. In other words, dormancy is not seen confined to one or the other botanical group. However, there seems to be a difference among the botanical groups with reference to the number of dormant types in them. As for example in the hypogaea group, 200 out of 242 are seen to have cent per cent dormancy while in the vulgaris and fastigiata groups, the corresponding values are seven out of 137 and zero out of 38. These results are in agreement with those of Lin and Chen (1970) and Bailey and Bear (1973a).

A comparison of the distribution of dormant and nondormant genotypes in different countries of the world have shown interesting results. The genotypes included in the present investigation have come from over 35 countries of the world with a sizeable number

from unknown place of origin. The results have indicated that both dormant and nondormant genotypes have originated from one and the same country. In otherwords, distribution of a particular group of genotypes is not confined to any particular country, as for example among the genotypes from India we have types of different dormancy ratings. Same is the case with reference to genotypes from Argentina or Zimbabwe or USA or Tanzania. This points to the fact that the distribution of dormant or nondormant types does not have any relationship with the country of origin.

5.1.2. Period of rest required for dormant types

Such of those types which registered zero per cent germination at harvest or cent per cent dormancy were tested further for their germinability at intervals of ten days, the test being continued for such periods as to give sprouting values over 90 per cent.

The results have indicated that the rest period required for the tested genotypes has ranged from 20 to 110 days. Among the types of vulgaris group this range was been from 20 to 50 days while the same for the types of hypogaea group is seen to be from 20 to 110 days. In the fastigiata group there has been no genotype having

the maximum dormancy and as such no type from this group could be included in this study. That the types belonging to hypogaea group require longer period of rest as compared to those of the vulgaris group have already been reported by Stokes and Hull (1930); John et al. (1948); Gregory et al. (1951); Gelmond and Nakmura (1963); Patil (1967); Varisai Muhammad and Dorairaj (1968); Krapovickas (1969); Lin and Chen (1970); Bailey and Bear (1973a); Sengupta et al. (1977) and Zade et al. (1986).

The results have further shown that there is a progressive increase in the percentage of germination in successive tests after ten days. However, the pattern of increase is not the same in all the genotypes. In genotypes like ICG-1895, ICG-2539, ICG-2921 etc. the increase in the percentage of germination is seen to be quick while in genotypes like ICG-1002, ICG-2471, ICG-2523 etc. the increase is seen to be rather slow. In other words the tested genotypes are found to differ with respect to the nature of breakage of dormancy in them. In some dormancy is broken suddenly while in others it is seen to be rather slow. Again genotypes with sudden or gradual breakage of dormancy are seen in all the botanical groups. It is also seen that breakage

of dormancy does not seem to have any relationship with the period of dormancy. This indicates that period of dormancy and nature of its breakage are two independent events. This finding is in agreement with the report of Zade et al. (1986).

5.2 Role of different entities of seed in delaying the germination

A seed botanically is the mature ovule of a flowering plant. This seed essentially concists of three main entities, the embryo, the endosperm and the coat structures, each of which may directly or indirectly affect its germination which is nothing but the visible activity of the embryo to the environment.

Results of germination test conducted at ten day intervals, commencing from the day of harvest with seven dormant genotypes having a dormancy period of 110 days, for explaining the role of different entities of seed in delaying germination, have shown that groundnut embryonic axis does not require any rest period. This goes to show that the causes for seed dormancy in groundnut have to be sought elsewhere other than the

embryonic axis. The intact pods, intact seeds, and seed with pinholes on the testa have registered identical sprouting values for the tests conducted at harvest and ten days later. However, seeds with testa removed have registered sprouting values ranging from five to 19 per cent in the test at harvest and 17 to 58 per cent in the test ten days after harvest. In the test conducted from twenty days after harvest, the percentages of germination among the different genotypes are found to increase progressively. These results indicate that the dormancy inducing factor in groundnut is not residing in the embryonic axis. This is in support of the results of Patil (1967). However, it is in contrast to the results obtained by Sreeramulu and Rao (1969) and Vaithialingam and Rao (1973a) in groundnut.

The data further indicate that there is sudden improvement in the sprouting value from T_4 (seed with testa removed) to T_5 (excised embryonic axis). This vast difference in the sprouting values even in the initial test at harvest points the major role the cotyledons might be playing in causing dormancy in groundnut.

Results of statistical analysis have further confirmed the above inference (Fig. 5). In the first

1. At harvest	T_5	T_4	T_3	T_2	T_1
2. Ten days after	T_5	T_4	T_3	T_2	T_1
3. Twenty days after	T_5	T_4	T_3	T_2	T_1
4. Thirty days after	T_5	T_4	T_3	T_2	T_1
5. Fourty days after	T_5	T_4	T_3	T_2	T_1
6. Fifty days after	T_5	T_4	T_3	T_2	T_1
7. Sixty days after	T_5	T_4	T_3	T_2	T_1
8. Seventy days after	T_5	T_4	T_3	T_2	T_1
9. Eighty days after	T_4	T_5	T_3	T_2	T_1
10. Ninety days after	T_5	T_4	T_3	T_2	T_1
11. Hundred days after	T_5	T_4	T_3	T_2	T_1

Fig. 5. Homogeneous groups of treatments in delaying germination of groundnut seed

three tests, ie. at harvest, ten and twenty days after harvest, T_1, T_2 and T_3 have been found to be on par, and T_4 and T_5 significantly differed from each other and also from T_1, T_2 and T_3. In the fourth test conducted 30 days after harvest T_1, T_4 and T_5 are seen to be significantly different, T_2 and T_3 being on par. In the fifth test conducted on the 40th day after harvest onwards till the 10th test conducted on the 90th day after harvest, the same trend is seen, ie. T_1 is significantly different from T_2 and T_3 which are on par and from T_4 and T_5 which also are on par. These results point to the fact that by providing pinholes on the testa, no substantial increase in sprouting values is obtained and hence the mechanical resistance of the coat is not the cause of dormancy. Piercing the seed coat has no effect in the present investigation on groundnut seeds in breaking deep dormancy as was reported by Sharir (1978).

On the contrary till the fifth test, conducted on the 40th day, after harvest, T_4 and T_5 were significantly different. The fundamental difference between T_4 and T_5 lies in the fact that T_4 is embryonic axis with cotyledons and T_5 embryonic axis alone. This indicates the importance of cotyledons in causing seed

dormancy in groundnut. However, this requires further supporting experimental evidence for confirmation. In the last test conducted on the 100th day of harvest the results have shown that T_1 is significantly different from the rest, T_2 and T_3 on par, T_3 and T_4 on par and T_4 and T_5 on par. This is indicative of the fact that the role of cotyledons as a factor of causing seed dormancy in groundnut ceases to exist by the 40th day of harvest. However, the role of testa contributing to seed dormancy still prevails till the 11th test conducted on the 100th day after harvest by which time T_3 and T_4 are on par.

This points to the fact that dormancy in groundnut is primarly caused by cotyledons with the support of the testa. Many germination inhibitors may be present in the cotyledons which are responsible for the imposition of dormancy and the seed coat impairs the escape of inhibitors. This has to be further supported by experimental evidence.

5.3 Presence of water soluble promoters or inhibitors in the seed

Effect of aqueous extracts of nondormant and dormant seeds on the germination of freshly harvested

dormant and nondormant seeds respectively has given interesting results. Aqueous extract of nondormant types did not induce germination of freshly harvested dormant seeds. This indicates that nondormant seeds of groundnut genotypes included in the present study did not contain any stimulatory substance capable of inducing freshly harvested dormant intact seeds to germinate. Even if had it contained any stimulatory substance it failed to make the embryo of dormant seeds germinate. The failure of the dormant seeds to germinate with the application of the aqueous extract might also have been due to the impermeability of the seed coat of the dormant types to the aqueous extract. This result agreed with those of Sengupta et al. (1977) but disagreed with those of Pillai (1966). Further the results of the present study have indicated that the aqueous extracts of dormant types failed to inhibit germination of freshly harvested nondormant seeds there by indicating the absence of any germination inhibitors in the seeds of freshly harvested dormant groundnut genotypes. However, the results of the present investigation did not agree with those of Vaithialingam and Rao (1973a) in the case of excised embryonic axis of TMV-2 treated with the extract of TMV-1. All these evidences suggest the fact that the

hypothetical inhibitor, even if present is a substance which is thermolabile and labile to grinding process.

But the effects of washing in running water on the germination of seeds of freshly harvested dormant groundnut genotypes have given further evidence in support of the presence of something in the cotyledons and the testa being impervious to the same. Washing in a flow of running water for 12 hours or 24 hours did not improve, the germinability of intact seeds of dormant groundnut genotypes at harvest from untreated control. However, washing the seed without testa for 12 hours and also for 24 hours has considerably, improved the sprouting value of freshly harvested dormant groundnut genotypes.

In the case of washing for 12 hours the improvement is over 62 per cent while the same in the case of 24 hours washing is over 90 per cent. Statistical analysis revealed significant difference between these two treatments. This points to the fact that water soluble inhibitors may be present in the cotyledons and the testa plays a vital role in the delayed germination of freshly harvested seeds of dormant groundnut genotypes. This may be mere mechanical obstructions or may be due to

impermeability of testa to various substances. However, the fact that continuous leaching proved to be ineffective in the case of intact seeds points to some sort of obstruction caused by the testa for free movement of water soluble substances through the seed coat. Hence rather than mechanical, testa must be considered to cause some sort of physiological obstruction. These findings are in agreement with those of Toole et al. (1964), Sreeramulu and Rao (1969) and Rao and Rao (1972). However, these results did not agree with those of Nagarjun and Radder (1983b).

5.4 Effect of presowing treatments in breaking dormancy

Various presowing treatments tried for breaking seed dormancy have given differential responses. Treatments with different concentrations/durations with $CuSO_4$, $ZnSO_4$, boric acid, boiling water and steam have proved to be ineffective in breaking the dormancy of freshly harvested seeds of groundnut genotypes. However, treatments with different concentrations/durations of $HgCl_2$, glutathion, ethyl alcohol, IAA, 2,4-D and H_2O_2 have broken dormancy to varying levels in different genotypes. In general the higher the concentration of the chemical or duration of treatment, the greater is the effect seen, except in the case of $HgCl_2$ and H_2O_2

where the order is seen to have been reversed. Varietal variation is also seen on the effect of chemical in breaking dormancy as reported by Nagarjun and Radder (1983b). This may perhaps be due to difference in the mechanism, causing seed dormancy in the different genotypes tested. However, this requires further confirmation.

5.5 Inheritance of seed dormancy

Observations on the behaviour of hybrids and successive progenies in such studies are to be placed on a different level from that usually employed in genetic studies with reference to mature plant characteristics in as much as there are different entities constituting the seed which is involved in the test. A clear distinction is to be made between maternal tissue constituting the seed coat, the cotyledons and the embryonic axis. In hybrids the genetic constitutions of these constituents are different. Depending upon the relative influence of these entities in the expression of dormancy there can be expected to result variations in the characteristic of the seed produced by hybridisation and that resulting from selfing in the F_1 plants and that formed on the F_2 plants. A clarification with regard to the terminology will be highly desirable in this respect.

For purpose of these discussions the seeds produced on the parental type plant by artificial hybridisation is termed as 'F_1' seed in as much as their embryos represent the first filial generation. The seeds produced in the mature plants derived from these embryos are designated as 'F_2' seeds and those seeds which are to give rise to the third filial generation of plants as 'F_3' seeds.

5.5.1 Study of F_1

The observations on the nature of F_1 seeds of the four crosses ICG-1281 x ICG-198, ICG-1281 x ICG-2523, ICG-3777 x ICG-198 and ICG-3777 x ICG-2523 are highly interesting. No germination is noted in any of the seeds of the four crosses tested immediately after harvest. The dormant parents ICG-198 and ICG-2523 gave zero per cent germination, while the nondormant parents ICG-1281 and ICG-3777 gave over 96 per cent germination at harvest. The behaviour of the F_1 is indicative of the fact that the characteristic in question is intimately associated with those parts of the seed which are hybrid in origin. It is apparent that dormancy is expressed as dominant, at least with reference to the capacity for immediate germination of the seed at harvest.

However, there exists a possibility that the rest periods required by the F_1 seeds might be of a different nature from that of the seeds of the dormant parent. The paucity of the F_1 seeds available did not make possible a complete and repeated test of the exact requirements of the rest periods in the different cases.

5.5.2 Study of F_2

The F_2 generation is represented by the embryos from the seeds borne on F_1 plants. Seeds of 69 F_1 plants belonging to 4 different combinations of crosses were tested for their germinability immediately after harvest. As indicated by the results, a wide variation in immediate germination after harvest is seen in different families. There is a predominance of dormant classes in majority of the cases. Among these which showed immediate sprouting, the values of germination of seeds observed in different families are again found to vary highly. It may be mentioned here that predominant class of dormant ones is likely to include those individuals which require varying rest periods. Lack of a clear cut segregation into two classes which fit a particular proportion resulting from the action of a single gene or two is observed. The individual chisquare

values showed an approximation to 3:1 ratio in several cases. This may be due to the limited size of the progeny in individual cases. The total deviation and heterogeneity chi-square calculated on the basis of 3:1 ratio were significant in all the cases. The aberrant segregation observed in the four crosses can be attributed to a system of modifiers at work. A clear idea of such an action can be determined only by a study of rest periods required in individual cases. It may, however, be stated that such an indication is provided by the variability observed in the genotypes themselves which were initially evaluated. Since each of the F_2 families studied in the present context consists of very limited number of individuals, distribution of them into different classes based on their germinability at harvest might not give a true picture of their frequency distribution. Besides, pooling all the four F_2 families and distributing them into various classes and plotting their frequencies against their percentages of germination in a graph has shown that the F_2 generation in the present case does not follow a normal distribution. It gives a skewed distribution which may perhaps be due to limited size of the population. This could again be due to the fact that parents belong to extreme classes with respect to duration of dormancy. The progeny, in such case, must

belong to an intermediary group with respect to period of dormancy resulting in low intensity of germination on the day of harvest. But the duration of dormancy the progeny could not be ascertained due to the paucity of seeds. However, the distribution pattern in the next generation has further supported the polygenic nature of inheritance of seed dormancy.

5.5.3 Study of F_3

An analysis of the F_3 is further indicative of the fact that a complex interaction of more than one factor is involved. The variation in sprouting of individual families is high. Again the dormant class is seen to be predominant. It is significant to note that some of the families are essentially similar to the nondormant parental class showing 96-98 per cent germination. In addition, types which show higher percentage of germination reaching hundred are also observed. This recovery of parental types confirm the action of a number of factors. The transgressive segregation giving super nondormant types gives additional proof for the variability present in the parental types with regard to the modifiers. The fact that such a transgressive segregation may also be

present when the rest periods are also considered, can be made explicit by only a thorough analysis of predominant dormant class observed in the initial test. The results obtained in the present investigation agrees with the findings of Stoke and Hull (1930), Hull (1937), John et al. (1948) and Ramachandran et al. (1967) in groundnut. However, it disagrees with those of Lin and Lin (1971).

The nature of inheritance of this trait may be considered as essentially quantitative. But in quantitative inheritance dominance in the strict sense is absent, the F_1 appearing intermediate (Sinnott et al. 1958).

However, the complete dormancy of F_1 noticed, which is apparently dominant as judged by the initial tests, can be accounted for, by taking into consideration of the fact that they may be intermediate between the parents with respect to the rest period. This, as stated earlier, has to be confirmed by further experiments.

In quantitative inheritance, the F_2 and F_3 frequencies will observe the general principles of normal distribution forming a normal curve if plotted

to suitable scales. If the present trait is considered to be a quantitative one, this can be shown to be so in the analysis of F_2 seeds, only by a study of rest periods of individual seeds of different families. This could not be undertaken in the present case. However, the analysis of F_3 population in the present case gives a positive evidence, based on the sprouting values of seeds in the test immediately after harvest.

The F_2 generation in the present case does not follow the normal distribution. It gives a skewed distribution with concentrations towards lower per cent of germination. In F_3, the distribution obtained in the present case can be considered to be typical of polygenic inheritance since a typical normal distribution is obtained.

In the present F_3 frequency distribution under discussion, it is observed that approximately two per cent of the total individuals examined in the nondormant group have exceeded the nondormant parents in their sprouting values. Since this is the case in one side of the curve, it appears to be reasonable to assume that a similar case might happen on the other side of the curve, ie. in the dormant group also. However,

this needs further confirmation by studying the rest period required by different segregants in the dormant group. This indicates that a certain fraction of F_3 individuals transgresses the parental limits in the expression of the character. The possibilities of fixing this transgressive variation will have to be studied in detail for incorporating the characteristic of dormancy in any breeding programme. It is true that such a transgressive segregation could not be observed in the F_2 which might perhaps be due to the limited size of F_2 population subjected to study in the present case.

Summary

SUMMARY

The present investigation on 'Seed dormancy in groundnut' was undertaken in the Department of Agricultural Botany, College of Horticulture, Vellanikkara during 1987-1990.

A total of 419 genotypes with wide spectrum of variability received from ICRISAT, Hyderabad was screened for their initial sprouting values based on which they were classified into different dormancy groups. Various aspects of seed dormancy like period of dormancy, part of the seed responsible for inducing dormancy, effect of different presowing treatments in breaking dormancy and nature of inheritance of dormancy were studied and the conclusions drawn are presented below:

1. There is wide variability in the expression of seed dormancy in the 419 genotypes studied.

2. Genotypes possessing varying degrees of dormancy are present in all the three botanical groups.

3. Distribution of dormant or nondormant types is not related to the country of origin.

4. The rest period required to give germination per cent over 90 varied from 20 to 110 days among the different types.

5. Genotypes belonging to hypogaea group required a longer period of rest.

6. In certain genotypes the increase in percentage of germination or breakage of dormancy is seen to be quick while in others the same is seen to be slow.

7. The nature of breakage of dormancy is not related to the length of dormancy or the botanical grouping.

8. The groundnut embryonic axis does not require any rest period for commencement of growth.

9. The dormancy in groundnut is primarily caused by the cotyledons with the support of testa.

10. There is no clear indication of the presence of any water soluble inhibitor in the freshly harvested dormant groundnut genotypes tested. Same is the case with reference to the presence of water soluble promoters in the freshly harvested seeds of non-dormant groundnut genotypes tested.

11. Leaching improved the germinability of freshly harvested seeds of groundnut genotypes only when testa has been removed.

12. Genotypes differed with respect to their response to different presowing treatments.

13. $HgCl_2$ 1 : 1000 for 5 minutes is the most effective treatment for breaking seed dormancy in groundnut.

14. Seeds of F_1 embryo generation behaved like the dormant parents in their sprouting values immediately after harvest, indicating the dominant nature of dormancy.

15. A study of F_2 revealed significant differences between individual families in their initial sprouting values.

16. The F_3 showed a continuous variation, there by indicating that dormancy was not a simply inherited trait.

17. In the F_3, a small fraction of individuals transgressed the parental values in their sprouting behaviour at harvest there by suggesting the involvement of complex interactions in the inheritance of seed dormancy. It also pointed to the great scope for judicious selection for better types possessing the maximum expression of the character under consideration in combination with other desirable plant attributes.

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* Original not seen

SEED DORMANCY IN GROUNDNUT

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ABSTRACT OF A THESIS

Submitted in partial fulfilment of the
requirement for the degree of

Doctor of Philosophy in Agriculture

Faculty of Agriculture
Kerala Agricultural University

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Vellanikkara, Thrissur

1992

ABSTRACT

The present investigation entitled "Seed dormancy in groundnut" was undertaken in the Department of Agricultural Botany, College of Horticulture, Vellanikkara during 1987-1990 using the 419 genotypes received from ICRISAT, Hyderabad.

The 419 genotypes possessed varying levels of dormancy at the time of harvest. Genotypes with varying degrees of dormancy were present in all the three botanical groups, viz., hypogaea, fastigiata and vulgaris.

The dormancy period of genotypes ranged from 20 to 110 days. The hypogaea genotypes required longer period of rest. The nature of breakage of dormancy and the period of dormancy were found to be two independent phenomena.

The factors for dormancy in groundnut were found to be residing in two distinct sites, the cotyledons and the seed coat (testa). Leaching improved the germinability of decoated seeds where as it failed to elicite germination in intact seeds. This indicates that germination inhibitors may be present in the cotyledons and testa retarded the removal of the same.

Different genotypes responded differently to various presowing treatments. $HgCl_2$ 1 : 1000 for five minutes was found to be the best treatment for breaking dormancy.

The study of germinability of F_1, F_2 and F_3 (embryonic generation) seeds on the day of harvest indicated that dormancy was controlled by polygenes.