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Full Length Research Paper

Inheritance of fresh seed dormancy in groundnut

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Pre-harvest sprouting in groundnut (*Arachis hypogaea* L) seeds belonging to sub species *fastigiata* is undesirable since it leads to substantial loss of seeds, both in quantity and quality. A short period of dormancy is therefore desirable in this sub-species to reduce such losses. This study was conducted to determine the heritability of fresh seed dormancy in groundnut and to transfer this trait from exotic lines (ICGV 86158 and ICGV 87378) known to posses dormancy, into the genetic background of two groundnut varieties (Shitaochi and Aprewa) widely grown in Ghana but lack dormancy. Freshly harvested seeds of mature pods from parents, F_1, F_2 and the backcross populations were assessed for their dormancy by incubating in petri dishes in the laboratory. The F_1 progenies from crosses between dormant and non-dormant parents were dormant. The F_2 progenies fitted the expected 3 dormant to 1 non-dormant ratio. The study showed that seed dormancy is controlled by monogenic inheritance with dormancy dominant over non-dormant.

Key words: Groundnut, *Arachis hypogaea*, dormant, non-dormant seeds.

INTRODUCTION

Groundnut belongs to the family *Fabaceae* and a member of the genus *Arachis*. Groundnut is classified into two subspecies based on morphological characteristics (Kaprovickas and Gregory, 1994). The pods of the subspecies *hypogaea,* are typically two-seeded and these seeds show marked dormancy, ranging from 30 to 360 days (Gregory et al., 1951; Zade et al., 1986). Their seeds also do not suffer from vivipary when harvesting is delayed.

Subspecies *fastigiata* which includes the Spanish and Valencia market types are the most preferred groundnut in the semi-arid tropics, which accounts for about 60% of the world's groundnut production area. Sprouting in this sub-species, which occurs before harvest and sometimes beyond, contributes significantly to yield losses. Yield losses due to *in situ* germination in bunch varieties have been estimated to range between 20 and 40% (Reddy et al., 1985; Nagajun and Radder, 1983). Thus, a short period of seed dormancy is necessary to reduce these losses.

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Seed dormancy has been defined as the failure of an intact, viable seed to complete germination under favourable conditions (Bewley, 1997). In groundnut, seed dormancy has been reported to be controlled by two hormones: abscisic acid which inhibits sprouting and ethylene which is accumulated in storage to break dormancy to allow germination (Ketring and Morgan, 1971, 1972). In another study, Nautiyal et al. (1994) found different parts of groundnut seed being involved in imposing dormancy, which included the seed coat, cotyledons and embryo.

Despite the importance of dormancy in groundnut production, there has been few studies conducted on the inheritance of its fresh seed dormancy, In this vein, Lin and Lin (1971) observed monogenic control with complete dominance of dormant over non-dormant seed, whereas John et al. (1948) and Nautiyal et al. (1994) indicated that the character may be quantitatively inherited. Khalfaoui (1991) concluded that dormancy is a quantitatively inherited trait and additive, dominance and digenic epistasis effects were involved in its genetic control. Ramachandran et al. (1967) observed partial dominance. The objectives of this study was to determine the genetic inheritance of fresh seed dormancy and to transfer the trait of fresh seed dormancy from exotic lines

Table 1. The chi-square values and probabilities of goodness of fit for expected ratio of 3 dormant : 1 non-dormant seeds in F_2 generations of crosses of ICGV 87378 and ICGV 86158 with Shitaochi and Aprewa.

Cross	Dormant	Non-dormant	Total	χ^2	P
Shitaochi x ICGV 87378	129	34	163	0.153	0.695
ICGV 87378 X Shitaochi	107	32	149	0.060	0.806
Shitaochi x ICGV 86158	140	40	180	0.022	0.881
ICGV 86158 x Shitaochi	90	37	127	0.071	0.790
ICGV 87378 x ICGV 86158	163	0	163	-	-
ICGV 86158 x ICGV 87378	133	4	137	-	-
Aprewa x ICGV 87378	126	35	161	0.752	0.385
ICGV 87378 x Aprewa	116	33	149	0.329	0.566
Aprewa x ICGV 86158	103	29	132	0.273	0.602
ICGV 86158 x Aprewa	124	38	162	0.395	0.530

known to posses this trait, into the genetic background of two popular Spanish varieties grown widely in Ghana but suffer from vivipary, particularly when harvesting is delayed .

MATERIALS AND METHODS

Four Spanish groundnut genotypes: Shitaochi and Aprewa (local varieties which suffer from vivipary), were collected from the (Council for Scientific and Industrial Research (CSIR)-Crops Research Institute, Kumasi, Ghana and ICGV 86158 and ICGV 87378 (lines with fresh seed dormancy) collected from the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru, India. Seeds of the four groundnut genotypes were planted in plastic pots, 35 cm diameter containing 6 kg of sterilized soil in a lath house at the Crop Science Department of Kwame Nkrumah University of Science and Technology, Kumasi, Ghana. The plants were thinned to one plant/pot one week after emergence.

At flowering, each of the two local genotypes (Shitaochi and Aprewa) was reciprocally crossed to the two exotic lines (ICGV 86156 and ICGV 87378). There were also reciprocal crosses of ICGV 86158 and ICGV 87378 to generate F_1 (hybrid) seeds. Ten F_1 (hybrid populations) were generated from the crosses.

The seeds were harvested on June 15, 2004. Seeds of the hybrids and the four parental lines were harvested and shelled immediately after harvest maturity. The presence of black layer in the shell was the criterion used to identify mature seed. Care was taken during shelling to avoid damage to the testa. Seeds were plated on Petri dishes lined with 9 cm filter paper after sterilization with Bavistin (at the rate of 0.25 g carbendezin/kg seed). Watering was done on daily basis to prevent drying of the seeds with distilled water.

Daily counts of emerged seeds were taken. Seeds that germinated before 14 days were classified as non-dormant and those that germinated after 14 days as dormant. Seeds that did not germinate after 35 days were treated with 0.05% ethrel to induce germination (Upadhyaya and Nigam, 1999).

Seeds that emerged after 14 days (dormant seeds) were planted in small plastic pots containing 1 kg of sterilized soil in a plant house at the (CSIR)-Crops Research Institute at Fumesua, Kumasi. Seedlings were transferred to the field and planted; the soil type was Kumasi series (Haplic Ferralsol, FAO classification).

The seedlings and the 4 parental lines were planted on ridges 30 cm high, spaced 1.0 m apart, 10 m long and within row spacing of 20 cm. Both parents were backcrossed to the F_1 plants to generate 20 backcross F_1 populations and some of the F_1 plants were selfed to produce F_2 populations. The parents were again crossed as in the first season to produce fresh F_1 hybrid seeds. Supplementary irrigation was given when necessary. The crop was protected against aphids by spraying an insecticide, *Karate* (ai 15 g lambda-cyhalothrin per hectare) three weeks after transplanting.

Dormancy of parents, F_1, F_2, and backcrossed generations were assessed in the laboratory by planting freshly harvested seeds on 9 cm filter paper lined in Petri dishes and kept moist with distilled water at 37°C. The number of seeds that germinated was recorded daily for 35 days. To test for the viability of seeds that did not germinate the seeds were treated with 0.05% ethrel solution to stimulate germination. Chi-square test was applied to test the goodness of fit of the observed to the expected ratios in all populations.

RESULTS

The results indicated that out of 50 freshly harvested seeds of the 4 parents, five seeds of Aprewa and four seeds of Shitaochi germinated 14 days after incubating in Petri dishes; the remaining seeds germinated before or on 14 days. On the other hand out of 50 seeds, 45 and 47 seeds of ICGV 86158 and ICGV 87378 germinated 14 days after incubation, respectively.

The crosses between the dormant and non-dormant parents produced F_1 seeds which were dormant in terms of the number of days to germination. Less than 10% of the F_1 seeds were non-dormant and germinated before 14 days. Crosses between the two dormant parents resulted in more than 90% of the progenies which were dormant

In the F_2 generation, one quarter of the progenies were non-dormant and therefore germinated on or before 14 days and three quarters germinated after 14 days. Four seeds out of 200 seeds from the crosses between 2 dormant parents germinated before 14 days in the F_2 generation (Table 1). The backcross generations with the non-dormant (Shitaochi and Aprewa) parents fitted the expected ratio of 1 dormant: 1 non-dormant (Table 2). Backcrosses to the dormant parents produced seeds that

Table 2. The chi-square values and probabilities of goodness of fit for expected ratio of 1 dormant : 1 non-dormant seeds in backcross F_1 generations of crosses of ICGV 87378 and ICGV 86158 with Shitaochi and Aprewa.

Cross	Dormant	Non-dormant	Total	χ^2	P
Shitaochi x (Shitaochi x ICGV 87378)	17	22	39	0.641	0.423
Shitaochi x (ICGV 87378 x Shitaochi)	19	24	43	0.581	0.446
Shitaochi x (Shitaochi x ICGV 86158)	25	17	42	1.523	0.217
Shitaochi x (ICGV 86158 x Shitaochi)	20	17	37	0.243	0.622
Aprewa x (Aprewa x ICGV 87378)	19	18	37	0.027	0.869
Aprewa x (ICGV 87378 x Aprewa)	22	16	38	0.947	0.330
Aprewa x (Aprewa x ICGV 86158)	24	20	44	0.364	0.546
Aprewa x (ICGV 86158 x Aprewa)	18	21	39	0.231	0.631

Table 3. The chi-square values and probabilities of goodness of fit for expected ratio of 1 dormant : 1 non-dormant seeds in backcross F_1 generations of crosses of ICGV 87378 and ICGV 86158 with Shitaochi and Aprewa.

Cross	Dormant	Non-dormant	Total	χ^2	P
ICGV 87378 x (Shitaochi x ICGV 87378)	34	0	34	-	-
ICGV 87378 x (ICGV 87378 x Shitaochi)	27	2	29	-	-
ICGV 86158 x (Shitaochi x ICGV 86158)	44	3	47	-	-
ICGV 86158 x (ICGV 86158 x Shitaochi)	46	1	47	-	-
ICGV 87378 x (ICGV 87378 x ICGV 86158)	38	0	38	-	-
ICGV 87378 x (ICGV 86158 x ICGV 87378)	41	0	41	-	-
ICGV 86158 x (ICGV 86158 x ICGV 87378)	32	0	32	-	-
ICGV 86158 x (ICGV 87378 x ICGV 86158)	25	0	25	-	-
ICGV 87378 x (Aprewa x ICGV 87378)	36	4	40	-	-
ICGV 87378 x (ICGV 87378 x Aprewa)	29	2	31	-	-
ICGV 86158 x (Aprewa x ICGV 86158)	38	2	40	-	-
ICGV 86158 x (ICGV 86158 x Aprewa)	35	0	35	-	-

were dormant (Table 3).

DISCUSSION

The results showed that more than 90% of the freshly harvested seeds of the non-dormant parents (shitaochi and Aprewa) germinated before 14 days whereas less than 10% of seeds of the dormant parents germinated during the same period. These observations corroborated that Aprewa and shitaochi are non-dormant and ICGV 87378 and ICGV 86158 are dormant. The F_1 progenies generated from crosses between the dormant and non-dormant parents showed dormancy with more than 90% germinating after 14 days. This shows that at least one dominant allele of the dormant gene must be present to impart dormancy in groundnut seed and therefore dormant trait is dominant over non-dormant. Regardless of whether the dormant parent was a male or female, the F_1 progenies were dormant. This observation proves that dormancy in groundnut is not maternally controlled.

In the F_2 generations, the ratio of dormant to non-dormant seeds fitted the ratio, 3:1 in crosses between dormant and non-dormant parents, which confirms that dormancy is controlled by a single allele of the dominant gene. These results differ from that of Khalfaoui (1991), who found that seed dormancy is controlled by several genes. The results, however, agree with those of Lin and Lin (1971) and Upadhyaya and Nigam (1999), who observed complete dominance in controlling dormancy in groundnut seeds.

The F_2 progenies of crosses between 2 dormant parents resulted in only 4 out of the 200 seeds germinating before 14 days, indicating dormancy in the progenies. This is an indication of no segregation in dormancy. These observations further suggest that the dormant gene controlling seed dormancy in both parents is in the same locus. If the gene for dormancy were in different loci on the chromosome of the dormant parents, there would have been segregation at F_2. Backcross progenies with non-dormant parents fitted to an expected 1 dormant: 1 non-dormant. However, data from the backcross to the dormant parents produced progenies which were dormant.

Conclusion

The F_1 progenies from crosses between dormant and non-dormant parents were dormant. The F_2 progenies fitted the expected 3 dormant to 1 non-dormant ratio The study showed that fresh seed dormancy is controlled by monogenic inheritance with dormancy dominant over non-dormant. The 2 dormant parents would be used as parents to transfer fresh seed dormancy trait into the background of adapted lines in Ghana to reduce losses associated with *in situ* sprouting which would lead to higher productivity and adoption by farmers.

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