Inheritance of Fresh Seed Dormancy in Peanut

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ABSTRACT

Incorporation of seed dormancy of limited duration in Spanish peanut (*Arachis hypogaea* L.) genotypes is required to avoid loss in pod yield and seed quality because of in situ germination in unpredictable rainfall environments. Knowledge of inheritance of fresh seed dormancy is important to peanut breeders for developing fresh seed dormant early-maturing Spanish cultivars. This study was conducted to determine the inheritance of fresh seed dormancy using three Spanish peanut genotypes. Two dormant (ICGV 86158 and ICGV 87378) and one non-dormant (JL 24) genotypes were crossed in all possible combinations, including reciprocals. The fresh seeds from mature pods from parents, F_1, F_2, F_3, and backcross populations were evaluated for their dormancy by germination tests in the laboratory at 35 ± 2°C in the dark. Results showed that the fresh seed dormancy in these genotypes is controlled by a dominant allele of a single gene. The two dormant parents, ICGV 86158 and ICGV 87378, possess the same allele for fresh seed dormancy.

PEANUT GENOTYPES belonging to Spanish (subsp. *fastigiata* var. *vulgaris*) and Valencia (subsp. *fastigiata* var. *fastigiata*) types have short life cycles and non dormant seeds, while those of Virginia (subsp. *hypogaea* var. *hypogaea*) type have long life cycles and dormant seeds. Spanish types are predominantly grown in the semi arid regions of Asia and Africa where the growing season is short or peanut is grown in multiple cropping systems. Rains immediately prior to harvest can cause the seeds of Spanish and Valencia genotypes to sprout in the ground. In the semi arid tropics, which account for about 60% of global peanut production area, such situations are frequent and losses in yield and quality can be substantial. To avoid these losses it is essential to have fresh seed dormancy of 2 to 3 wk duration in Spanish cultivars. Breeding such cultivars is an important objective in most peanut improvement programs.

The physiological basis for dormancy in peanut has been investigated and shown to result from the hormonal balance between abscisic acid, which acts as a germination inhibitor, and ethylene, which acts as a germination activator and is produced by the embryo through the action of cytokinin during seed imbibition (Ketring and Morgan, 1971, 1972). Depending on their genetic constitution, different seed parts—seed coat, cotyledons, and embryo—have been reported to have a role in imparting dormancy (Nautiyal et al., 1994). However, seed dormancy is an inherent property of peanut seed and it does not depend on an impervious or protective seed coat (Hammons, 1973).

There have been a few studies on the inheritance of seed dormancy in peanut. These studies have drawn contradictory conclusions. Lin and Lin (1971) reported monogenic control, whereas Hull (1937) and John et al. (1948) reported polygenic control. Lin and Lin (1971) used the seeds 2 wk after harvest from reciprocal crosses between a Spanish cultivar and three Virginia cultivars of different dormancy duration. Hull (1937) used the seeds 10 d after harvest in eight crosses involving Spanish or Valencia and the Virginia type parents. Nautiyal et al. (1994) indicated that the character may be quantitatively inherited. Lin and Lin (1971) reported complete dominance of dormant over non-dormant seed, whereas Stokes and Hull (1930) and Ramchandran et al. (1967), using Spanish × Virginia crosses, observed partial dominance. Khalfaoui (1991) used fresh seeds of a cross between two Spanish types and concluded that dormancy is a quantitatively inherited trait and that additive, dominance, and digenic epistatic effects were involved in its genetic control.

The objective of this investigation was to determine the inheritance of fresh seed dormancy in crosses involving three Spanish genotypes, JL 24, ICGV 86158, and ICGV 87378.

MATERIALS AND METHODS

Three Spanish peanut genotypes—JL 24 (released name 'Phule Pragati'), ICGV 86158, and ICGV 87378—were selected for this study which was conducted at the ICRISAT Center, Patancheru, India. JL 24, a short-duration Indian cultivar, is non-dormant (Patil et al., 1980) and ICGV 86158 (PI 594971) and ICGV 87378 (PI 594972) are dormant germplasm developed at ICRISAT (Upadhyaya et al., 1997). ICGV 86158 is an elite germplasm derived from a cross involving a Spanish line ICGS 30 and an F_6 breeding line from a cross between the Virginia line TMV 10, and the early-maturing Spanish line, Chico (Bailey and Hammons, 1975). ICGV 87378 is a bulk selection from Kanto No. 40, a Spanish germplasm line from Japan, also known as ICG 7261 or EC 123074.

JL 24, ICGV 86158, and ICGV 87378 were crossed in all possible combinations including reciprocals in the glasshouse. Each of the resultant six F_1 hybrids was crossed to both parents to generate 12 backcrosses and selfed to produce six F_2 populations in the 1992-1993 postrainy season. The parents were crossed once again to produce fresh F_1 seeds for evaluating with the parents, backcrosses, and F_2 populations. The filial generations in this study were designated on the basis of the embryonic genotype, thus the F_1 seeds were those obtained immediately after crossing of female and male parents, and the F_2 seeds were those obtained by selfing the F_1 plants.

The dormancy of parents, F_1, F_2, and backcross F_1 generations was assessed in the laboratory by incubating noncured seeds from freshly harvested mature pods from the 1992-1993 postrainy season. The maturity of pods was ascertained by the development of black coloration inside the shell (Miller and Burns, 1971). Care was taken not to damage the testa while removing seed from the pods. Seeds were treated with Captan, *n*-[(trichloromethyl) thio]-4-cyclohexene-1,2-dicarboxymide, at 2 g kg^{-1} seed, placed on filter paper in a petri dish which was kept moist with distilled water during the

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Table 1. The chi-square values and probabilities of goodness of fit for a ratio of 3 dormant:1 non-dormant in the F_2, and F_3 generations of crosses of ICGV 86158 and ICGV 87378 with JL 24 in the 1993 rainy (R) and 1992–1993 and 1994–1995 postrainy (PR) seasons.

Cross	Season	Generation	Number of seeds			χ^2	P
			Total	Dormant	Nondormant		
ICGV 86158 × JL 24	1992–1993 PR	F_2	85	70	15	2.451	0.117
	1993 R	F_2	262	195	67	0.046	0.830
	1994–1995 PR	F_2	408	305	103	0.013	0.909
Pooled over segregating progenies	1994–1995 PR	F_3	898	668	230	0.180	0.671
Total			1653	1238	415	0.010	0.923
Heterogeneity						2.680	0.444
JL 24 × ICGV 86158	1992–1993 PR	F_2	75	53	22	0.751	0.386
	1993 R	F_2	225	180	45	3.000	0.083
	1994–1995 PR	F_2	466	339	127	1.262	0.261
Pooled over segregating progenies	1994–1995 PR	F_3	783	567	216	2.793	0.095
Total			1549	1139	410	1.782	0.182
Heterogeneity						6.024	0.110
ICGV 87378 × JL 24	1992–1993 PR	F_2	80	64	16	1.067	0.302
	1993 R	F_2	78	63	15	1.385	0.239
	1995–1996 PR	F_2	311	226	85	0.901	0.343
Pooled over segregating progenies	1995–1996 PR	F_3	415	298	117	2.256	0.133
Total			884	651	233	0.869	0.351
Heterogeneity						4.740	0.192
JL 24 × ICGV 87378	1992–1993 PR	F_2	51	31	20	5.497	0.019
	1993 R	F_2	131	98	33	0.003	0.956
	1995–1996 PR	F_2	282	201	81	2.085	0.149
Pooled over segregating progenies	1995–1996 PR	F_3	616	445	171	2.502	0.114
Total			1080	775	305	6.049	0.014
Heterogeneity						4.038	0.257

course of the study, and incubated at 35 ± 2°C in the dark in an incubator. The number of germinating seeds was recorded daily for 35 d after incubation. On the 36th day, to test the viability of the seeds which did not germinate, 0.05% ethrel (2-chloroethyl-phosponic acid) solution was sprayed on them to stimulate germination. To confirm the behavior and separate selfs from crossed seeds, the germinating F_1 seeds of all crosses were transplanted to 10-cm plastic pots in the glasshouse. The parents were also grown to obtain fresh seeds for evaluation with the seeds from the F_2 generation. The 15 d old seedlings were transplanted to the field, alfisols-Patancheru Soil Series (Udic Rhodustolf) and grown on 60-cm ridges. Parents and F_1 plants were harvested individually and seeds of each plant tested for fresh seed dormancy in the 1993 rainy season.

The crosses involving ICGV 86158 and JL 24 were studied in detail in the 1994-1995 postrainy season and those involving ICGV 87378 and JL 24 in the 1995-1996 postrainy season by incubating fresh seeds of each plant progenies separately in a test that included the parents, F_1, F_2, F_3, and backcross generations (ICGV 86158 × (ICGV 86158 × JL 24 F_1), ICGV 86158 × (JL 24 × ICGV 86158 F_1), JL 24 × (ICGV 86158 × JL 24 F_1), JL 24 × (JL 24 × ICGV 86158 F_1), ICGV 87378 × (ICGV 87378 × JL 24 F_1), ICGV 87378 × (JL 24 × ICGV 87378 F_1), JL 24 × (ICGV 87378 × JL 24 F_1), JL 24 × (JL 24 × ICGV 87378 F_1). Plant progenies which had cumulative germination similar to the dormant parents after 2 wk of incubation were classified as dormant. Progenies with a germination pattern similar to the non-dormant parent were classified as non-segregating, non-dormant. The remaining progenies in the F_3 and backcross F_2 generations were classified as segregating. Chi-square tests were applied to test the goodness of fit of the observed to the expected ratios in all populations.

RESULTS AND DISCUSSION

In the 1992-1993 postrainy season, all 100 seeds of JL 24 and only three of 100 seeds each of ICGV 86158 and ICGV 87378 had germinated after 2 wk of incubation. The progenies of the six seeds which germinated were found to be dormant. This confirmed the non-dormant nature of JL 24 and dormant nature of ICGV 86158 and ICGV 87378.

In the F_1 generation of dormant × non-dormant crosses, the percentage of seeds which germinated was similar to the dormant parent (<10%). The dormancy of the F_1 seeds indicated that fresh seed dormancy in

Table 2. The chi-square values and probabilities of goodness of fit for expected ratio of 1 dormant:1 non-dormant seeds in the backcross F_1 generations of crosses of ICGV 86158 and ICGV 87378 with JL 24.

Cross	Total seeds	Dormant	Non-dormant	χ^2	P
ICGV 86158 × (ICGV 86158 × JL 24 F_1)	36	36	0	–	–
ICGV 86158 × (JL 24 × ICGV 86158 F_1)	43	43	0	–	–
JL 24 × (JL 24 × ICGV 86158 F_1)	30	16	14	0.133	0.715
JL 24 × (ICGV 86158 × JL 24 F_1)	41	26	15	2.951	0.086
Total	71	42	29	2.380	0.123
Heterogeneity				0.704	0.401
ICGV 87378 × (ICGV 87378 × JL 24 F_1)	48	48	0	–	–
ICGV 87378 × (JL 24 × ICGV 87378 F_1)	40	37	3	–	–
JL 24 × (JL 24 × ICGV 87378 F_1)	60	28	32	0.267	0.605
JL 24 × (ICGV 87378 × JL 24 F_1)	48	25	23	0.083	0.773
Total	108	53	55	0.037	0.848
Heterogeneity				0.313	0.576

Table 3. The chi-square values and probabilities of goodness of fit for a ratio of 1 non-segregating dormant:2 segregating:1 non-segregating non-dormant progenies in the F_3 generations of crosses of ICGV 86158 and ICGV 87378 with JL 24.

Cross	Non-segregating dormant	Segregating	Non-segregating non-dormant	χ^2	*P*
ICGV 86158 × JL 24	15	40	13	2.235	0.327
JL 24 × ICGV 86158	17	32	11	1.467	0.486
Total	32	72	24	3.000	0.223
Heterogeneity				0.702	0.704
ICGV 87378 × JL 24	16	32	21	1.087	0.581
JL 24 × ICGV 87378	17	33	24	2.189	0.335
Total	33	65	45	3.195	0.202
Heterogeneity				0.081	0.960

ICGV 86158 and ICGV 87378 is dominant over non-dormancy in JL 24.

In the F_2 generation, the numbers of dormant and non-dormant seeds from all crosses between dormant and non-dormant parents fit a 3:1 ratio (Table 1) suggesting that fresh seed dormancy is controlled by a dominant allele of a single gene. In the backcross generations with the ICGV 86158 and ICGV 87378 parents all seeds except for the three in the backcross with later parent were dormant. In the backcross generations with JL 24 parent the number of dormant and non-dormant seeds fit a 1:1 ratio (Table 2), supporting the conclusion of single gene inheritance.

Data from the F_3 progenies fit an expected 1:2:1 ratio of dormant, non-segregating: segregating: non-dormant, non-segregating progenies (Table 3). The segregating F_3 progenies showed an excellent fit to a 3 dormant:1 non-dormant ratio individually as well as on a pooled basis (Table 1). This further indicated that dormancy is controlled by a dominant allele of a single gene.

Backcross progenies with the dormant parent fit to an expected 1 dormant non-segregating:1 segregating ratio. Similarly, progenies from backcross with the non-dormant parent fit to an expected 1 segregating:1 non-dormant, non-segregating ratio. The segregating progenies in these backcross F_2 generations showed a good fit to a 3 dormant:1 non-dormant ratio on individual as well as pooled basis (Table 4). This confirmed the earlier conclusion that fresh seed dormancy in crosses involving JL 24, ICGV 86158, and ICGV 87378 is controlled by a dominant allele of a single gene.

In the cross involving the two dormant parents, ICGV 86158 and ICGV 87378, only 1 out of 50 F_1 seeds in the ICGV 86158 × ICGV 87378 cross and none out of 50 F_1 seeds in the ICGV 87378 × ICGV 86158 cross germinated after 2 wk of incubation, indicating the dormancy of the F_1 hybrid. In the F_2 generation only 1 out of 66 seeds in the ICGV 86158 × ICGV 87378 cross and 1 out of 60 seeds in the ICGV 87378 × ICGV 86158 cross germinated in the 1992-1993 postrainy season, indicating no segregation for dormancy. In another test with the F_2 generation in the 1993 rainy season, only 3 seeds out of 226 in the ICGV 86158 × ICGV 87378 cross and only 1 seed out of 454 in the ICGV 87378 × ICGV 86158 cross germinated. In the backcross generations, the number of seeds germinated was 2 out of 45 in ICGV 86158 × (ICGV 86158 × ICGV 87378 F_1), 2 out of 57 in ICGV 86158 × (ICGV 87378 × ICGV 86158 F_1), none out of 42 in ICGV 87378 × (ICGV 87378 × ICGV 86158 F_1), and 1 out of 36 in ICGV 87378 × (ICGV 86158 × ICGV 87378 F_1). The possible reason for these putative dormant seeds to germinate could be their relative over maturity vis-a-vis other seeds included in the study. All these germinating seeds were progeny tested for germination and were subsequently found to be dormant. This would indicate that the dominant allele of the gene for dormancy in the two dormant parents, ICGV 86158 and ICGV 87378 is at the same

Table 4. The chi-square values and probabilities of goodness of fit for a ratio of 3 dormant:1 non-dormant in the segregating progenies in backcross F_2 generations of crosses involving ICGV 86158 and ICGV 87378 with JL 24 in the 1994–1995 and 1995–1996 postrainy (PR) seasons.

Cross	Season	Number of seeds			χ^2	*P*
		Total	Dormant	Non-dormant		
ICGV 86158 × (ICGV 86158 × JL 24 F_1)	1994–1995 PR	212	176	36	7.270	0.007
ICGV 86158 × (JL 24 × ICGV 86158 F_1)	1994–1995 PR	298	224	74	0.004	0.950
Total		510	400	110	3.203	0.074
Heterogeneity					4.071	0.044
JL 24 × (ICGV 86158 × JL 24 F_1)	1994–1995 PR	329	239	90	0.974	0.324
Jl 24 × (JL 24 × ICGV 86158 F_1)	1994–1995 PR	188	135	53	1.021	0.312
Total		517	374	143	1.950	0.163
Heterogeneity					0.045	0.832
ICGV 87378 × (ICGV 87378 × JL 24 F_1)	1995–1996 PR	24	18	6	0.000	0.999
ICGV 87378 × (JL 24 × ICGV 87378 F_1)	1995–1996 PR	245	187	58	0.229	0.632
Total		269	205	64	0.209	0.648
Heterogeneity					0.020	0.888
JL 24 × (ICGV 87378 × JL 24 F_1)	1995–1996 PR	196	136	60	3.293	0.069
Jl 24 × (JL 24 × ICGV 87378 F_1)	1995–1996 PR	275	189	86	5.771	0.016
Total		471	325	146	9.036	0.003
Heterogeneity					0.028	0.867

locus. This is interesting because these two parents do not have any commonality in their origin. The gene for dormancy in ICGV 86158 might have come from Virginia TMV 10, whereas in ICGV 87378 it might have existed in the Spanish background.

The inheritance of fresh seed dormancy in Spanish parents as observed in the present study is simple. This is contrary to the observations of Stokes and Hull (1930) who found complex inheritance, and Hull (1937) and Nautiyal et al. (1994) who suggested polygenic-quantitative inheritance in different sets of genotypes. However, in these studies seeds were cured for varying duration before germination testing, and the crosses studied were between non-dormant Spanish or Valencia and dormant Virginia types. Seed curing reduces seed dormancy, and the degree of reduction depends on method of curing (Bear and Bailey, 1974). Further, intervarietal crosses between different subspecies give more complex ratios for various traits than those within the same subspecies of peanut (Coffelt and Hammons, 1972).

The monogenic nature of fresh seed dormancy in genotypes ICGV 86158 and ICGV 87378 makes them a preferred choice as sources of fresh seed dormancy in a Spanish-Valencia breeding program.

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