Inheritance of Seed Dormancy in Rice"

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Introduction.

Dormancy or rest period required for the seed to attain a satisfactory germination is a phenomenon met with in many groups of of plants and assumes much importance in practical problem of crop production. The problem of dormancy in paddy has attracted the attention of breeders from the point of view of eliminating the undesirable characteristic of immediate germination in cases where a ripe crop is subject to the hazards of inclement weather or such other environmental conditions which will result in the sprouting of the seed on the ear itself. It is common in rice growing areas where short duration crops are raised that the prevailing weather at the time of harvest is apt to be highly humid and continuously wet due to seasonal rains. Nondormant varieties commonly sprout on the ear when such weather prevails even when the culms are upright.

Previous investigators have come to different conclusions regarding the ultimate causes of dormancy. However, facts gathered from investigators on different materials indicate to some extent that the causal mechanism is heritable (Mangelsdorf[s], 1930). There seems to be an agreement that the characteristic is not simple and easily analysable. In most of the cases a multi factorial system has been suggested. The investigations reported herein were undertaken to elucidate further the nature of dormancy in Rice by a study of selected material expressing, the contrasting characters to the maximum degree and expression ofthis phenomenon in segregating population.

Review of Literature.

A few workers have attempted the study of inheritance of seed dormancy in cereals other than rice. Mangelsdorf (1926)4 has presented evidence to show that atleast 15 genetic factors are involved in the inheritance of premature germination in maize. Those factors operated at various stages in the development of the seed and differed in some of their effects. However, ail were alike in forcing the seed to germinate before the development was completed. Johnson[2] (1935) has reported the inheritance of delayed germination in reciprocal crosses between dormant wildcats. *AvenafetuaL.* & nondormant cultivated ones, *Avenasativa.* He concluded that germinability was genetically dominant over nongerminability. Freistedt[1] (1935)

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conducted extensive studies over a number of years on the dormancy of both spring and winter barleys. In a genetic analysis conducted on the F_2 of 4 crosses of spring barley, dormancy proved recessive. In one cross one factor seemed to be involved while in other crosses two factors were recognisable, Harrington and Knowles[2] (1939) effected crosses between dormant and nondormant types of *wheat* and found that several progenies of hybrid lines displayed more resistance sprouting than the resistant parental variety itself. They were of opinion that the inheritance of sprouting resistance was not governed by a single gene and further stated that lines of higher sprouting resistance might be expected from crosses having at least one sprouting resistanct parent. They believed that a cross between two susceptible parents might result in certain lines more resistance than either parents, a case of transgressive segregation. Shanmugasundaram6 (1953) has reported that dormancy in rice is inherited as a dominant character which is controlled by more than one gene. He has attributed the wide variation in the degree of resistance to sprouting among parents to the action of modifiers.

Materials and Methods

Choice oi material :-

Based on the information available in the records of the Paddy Breeding Station, Coimbatore, a total number of 13 short duration exotic types and 8 short duration departmental strains were selected out for the study. All the 21 cultures selected were in the "Breeding Plots" at the station nearing maturity. Panicles from 21 selected cultures were separately harvested when completely mature, the maturity being judged on the basis of standard ripening colour of the flowering glumes. Those ripe ears collected on the day of harvest from each of the 21 types were immersed on the same day in half an inch of well water (Paddy Breeding Station Well) kept in a shallow zinc tray. This method was adopted since it approximates the prevailing natural conditions at the time of harvest in rice fields.

Daily counts of sprouting were taken for 10 days from the next day of commencement of test. Based on the data obtained the percentage of germination for each culture was calculated. If no grain had germinated within the 10 days limit that culture was classified as "dormant." The iesi was repeated at 10 days intervals for such periods as necessary to obtain a satisfactory percentage of germination for each culture with a view to find out the period of dormancy of the types selected.

Based on the results of the above experiment, two exotic types-T. 2105 and T. 1926 were selected as dormant parents and two departmental strains PTB. 10 and CO. 13 as nondormant parent for hybridisation work. The 4 parental types were raised in separate breeding plots of 20' x 3' at a spacing of 1' between lines and 6" between plants. Crosses were made in 4 reciprocal combinations between dormant and nondormant types adopting the 'Wet cloth method' as practised in Paddy Breeding Station, Coimbatore. Details of crosses effected are given below :-

Cross No.	0 Parent. T	O Parent.		No. of spikelets crossed.	No. of Seeds obtained.
I.	T. 2105	PTB. 10	)	(*) 48	8
II.	T. 1926	CO. 13	∫	50	27
m.	PTB. 10	T. 2105	)	54	17
IV.	CO. 13	T. 1926	f	50	17

(*) NONDORMANT.
(%) DORMANT.

The hybrid seeds were collected 35 days after pollination and half the total number of seeds in each of the 4 cross combinations were put to germination tests on the same day. A random sample of 25 seeds from each of the respective parents were also kept for germination trials as checks along with the hybrid seeds.

The first filial generation plants were raised with the remaining half of the hybrid seeds, after keeping them for one month to overcome their dormancy period, in nonreplicated plots in the field. Respective parents were also grown in adjacent rows along with the F_1S.

The I "seeds" borne on F, plants as well as the parents were harvested when completely mature, the maturity being judged by ripening colour of glumes. At the time of harvest ripe panicles were collected from each of the F plants and the parents separately, and tested for germination of seeds at the rate of one panicle per plant. Daily counts of sprouting were taken for 10 days and the percentage of germination for each of the F plants as well as the parents was calculated. The remaining F_2 seeds were kept for one month to overcome the dormancy period.

The second filial generation plants were grown and studied in crosses 1 and III (2 families in each) in long strips of 55′×3′ with a spacing of 1′×6*. The respective parents were also grown for comparison in adjacent strips.

When mature, ripe ears were collected, one from each of the individual plant of the different families and tested for germination as in the first case. The parents were also subjected to similar test for comparison. The seeds germinated were counted daily for 10 days and percentage of germination of seeds of individual plants was calculated. Based on the data, the F_2 frequency distribution of the different phenotypic classes was worked out for all the four families.

Experimental and Results

In the study of inheritance of seed dormancy we are concerned mainly with the generations of the embryos rather than that of the mature plant since the assessment of this character is based on the reaction of the embryo to the environment. Hence observations on the behaviour of hybrids and the successive progenies in these studies are to be placed on a different level from that usually employed in genetic methods with reference to mature plant characteristics in as much as there are three different entities constituting the seed which is involved in the test. A clear distinction is to be drawn between the maternal tissue constituting the flowering glumes (husk), the endosperm and the embryo. In hybrids the genetic constitutions of these three constituents are different either in genotype or in dosage. Depending on the relative influence of these three entities in ihe expression of dormancy there can be expected to result variations in the characteristic 01 the seed produced by hybridisation and that resulting from selfingin the F, plants and that formed on the F, plants. Therefore, in this particular study, the seed produced on the parental type plant by artificial hybridisation is termed as F1 "seed" and the seed produced on the mature plants derived from the F[seeds are designated as F2, "seeds" and those seeds whicl1 are to give rise the third filial generation of plants as I•', "seeds".

Nature of dormancy in parents

Results of germination trials conducted at an interval of 10 days, the test being commenced from the day of harvest, for 13 exotic types and 8 departmental strains are presented in table I. It may be seen from the table that the percentage of germination varies in different types from 0 to 76, Of the 21 types examined 10 have recorded 0% germination in the initial test and the rest, values above 0 varying from 3 to *76*. The results of successive tests reveal that the rest periods required for dormant types vary in individual cases.

Inheritance of dormancy

(i) F1 "seed":-A total number of 21 hybrid seeds, 4 in cross I, 9 in cross I I , 5 in cross III and 3 in cross IV were tested for its germinability on the day of collection along with the parents as checks and the results are presented in Table II. In these tests it is significant to note that none of the hybrid seeds in any of the 4 combinations germinated while the seeds of the respective nondormant parent gave above 55% germination.

(ii) *F2, "seeds":-* Seeds of 35 F1 plants belonging to 4 different combinations of crosses were tested for its germinability soon after harvest and the results of these observations are summarised in table III. A wide variation ranging from 0 to 76 in the percentage of germination among the different F2 families studied is observed. But in all the groups there is a high percentage of dormant seeds as judged by initial germination. The segregation of dormant and nondormant classes does not appear to conform to any single mode of inheritance.

(iii) *F3 "seeds"* :- Two families in each of the two crosses I & III were carried forward to !-, plant generation. The seeds of individual F2 plants of all the 4 families were harvested when mature and tested for their germinability, the test being commenced on the same day of harvest. Thus a total of 1165F. families were tested and the results of these tests are summarised and presented in Table IV. The results show that there is a wide variation in the percentages of germination ranging from 0 to 100 in F_3,

Discussion and Conclusions

From the data presented in Table I it can be observed that the 21 different types show wide variations in their sprouting values. Those types which showed high initial sprouting values continued to have the same behaviour in the successive tests. In the case of those which showed no sprouting immediately after harvest, the test after different rest periods indicated variations in the percentage of sprouting, determined by the length of time for which the seeds were kept. Similar observations have been made by Harrington and Knowles (1939) in wheat. The variation in the rest period required in the different types tested is high. The initial test immediately after harvest can only indicate those which are absolutely nondormant. The requirement of rest period of dormant types is apt to necessitate successive tests.

The observations on the nature of F_1 "seech" of the 4 sets of reciprocal crosses are highly interesting. No germination is noted in any of the seeds of these groups tested immediately after harvest. The absence of reciprocal difference is indicative of the fact that the husk or the maternal tissue of the seed has very little part to play in the expression of dormancy. It might, therefore, be said that the characteristic in question is intimately associated with the other tissues of the seed which are hybrid in origin. It is apparent that dormacy is expressed as dominant at least with reference to the capacity for immediate germination of the seed after harvest. The possibility, however, exists that the rest periods required by the seeds might be of a different nature from that of the dormant parent. The paucity of seeds available did not enable a test of the actual rest period required for the F, embryo. The sprouting in the nondormant parental types kept as a check was markedly contrasting (PTB. 10 -56% CO. 13-64%).

A study of the F_1 "seed" indicates that the variation in immediate germination after harvest is high in different families. There is a predominance of dormant classes in majority of the cases which are apt to include those individuals which require varying rest periods. The lack of a clear cut segregation into distinct classes which fit a particular proportion resulting from the action of a single gene or two is observed. The aberrant segregation observed in most cases 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 the rest periods required in individual cases by further tests. An indication of such a nature is provided by the variability observed in the types themselves which are initially studied.

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 in individual families is high and continuous. (Plates I & II and figures 1 & 2). No definite grouping of the the phenotypes into distinct classes is possible. Again dormant class is predominant. Some of the families are similar to the nondormant parental class showing 60-70% germination. The recovery of parental types confirms the interaction of a number of factors.

The fact that this trait shows continuous variation supports the view that it is probably controlled by either multiple genes or a few major genes having major effect whose action is suitably modified by a few minor genes called modifiers.

Thus the nature of inheritance of this trait may be considered as essentially quantitative. But in quantitative inheritance dorminance in the strict sense is absent, F_1 appearing intermediate. However, the complete dormancy of F_1 noticed can be accounted for by taking into consideration the fact that they may be intermediate between the parents with respect to the rest period which has to be strengthened by further trials.

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. This can be shown to be so in the analysis of F_2 seeds only by a study of the rest periods of individual seeds of different families which could not be undertaken. However, the analysis in F_3 in the present case gives a positive evidence. As may be observed from Table IV, the F_3 distribution may be assumed as one having two different phases. Based on the sprouting values of the seeds in the test immediately after harvest the I" progenies can be broadly grouped into dormant and non-dormant ones. In the present non-dormant group the different segregants can be scored off and their frequencies can be worked out based on the results of the same test, as has been done in the present case. But the dormant group has to be analysed into different classes by taking into consideration the dormancy period of individuals in the F, progenies of each of the groups since the difference between two dormant types can be expressed only through the rest period. Since there is segregation of individuals into different classes on the nondormant groups, as is proved in the present case, it might be reasonable to assume that the individuals on the dormant side will also show similar segregation. This is to foe strengthened by further trials. Based on this assumption we get a smooth curve characteristic of normal distribution (Fig, 3). This assumption seems to be reasonable, since it is supported by the following facts. In the present distribution as in the case of a normal curve (i) approximately equal number of frequencies fall on either side of the modal class (ii) mean, mode and median coincide and (iii) F_2 and F_3 means lie between F_1 mean and parental means.

Further a small fraction of the F_3 population is observed to have exceeded the parental limit in the expression of dormancy, in the nondormant group. This is a case of transgressive segregation which gives additional proof for the variability present in the parental type with regard to 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 the predominant dormant class observed in the initial tests.

Summary

The inheritance of seed dormancy in Rice in two sets of crosses with reference to the embryonic generation is discussed. The behaviour of F_1 "Seed" when put to germination trials immediately after harvest apparently indicates that dormancy is inherited as a dominant character. The significant differences observed between individual F_2 families in their initial sprouting values may be attributed to the action of a system of modifiers. A further study of F_3 which shows continuous variation indicates that dormancy is not a simply inherited trait but,

one controlled by either multiple genes or by one or two major genes and a few minor genes. Transgressive segregation is observed in F_3 which again strengthens the view that this phenomenon is the resultant of complex interactions.

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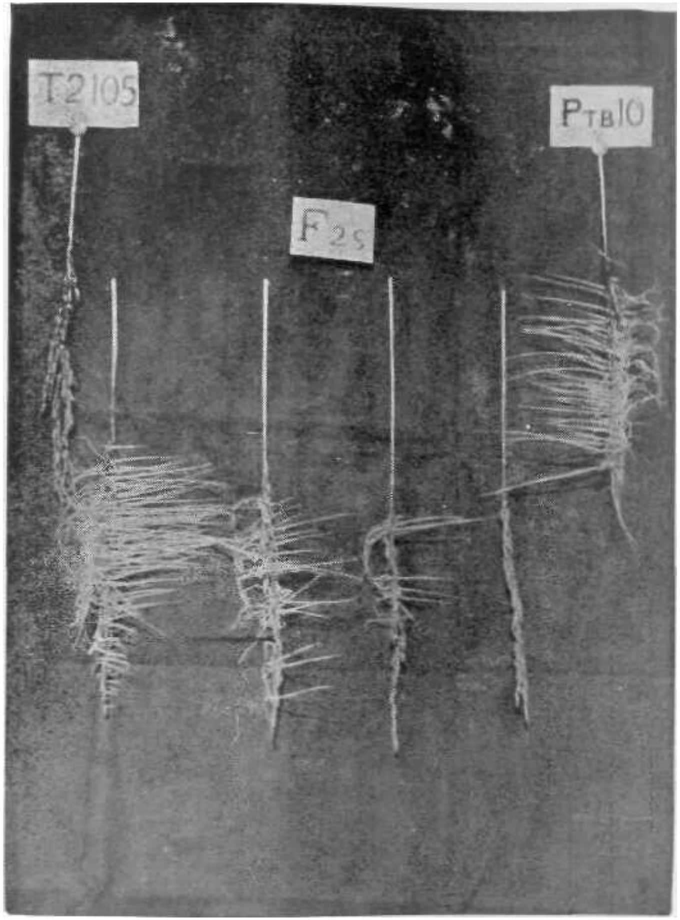

PLATE- I. F_3 segregation of Cross + T. 2I05X PTB. 10
A obtained fromseeds borne on F_2 plants.
O

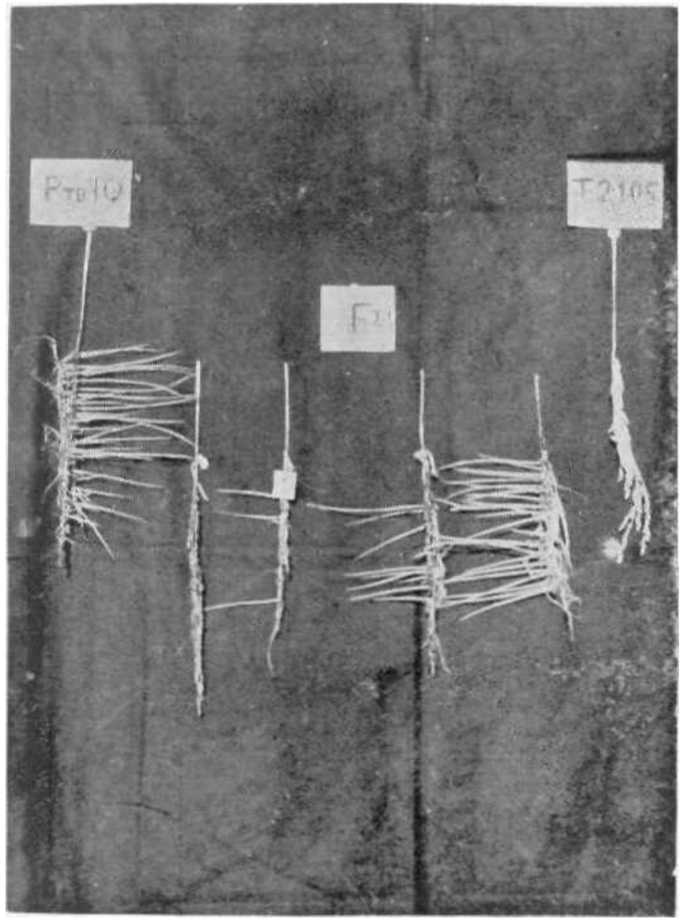

PLATE II F3 segregation of Cross O PTB. IOxT. 2105
+ O
obtained from seeds borne on F., plants.

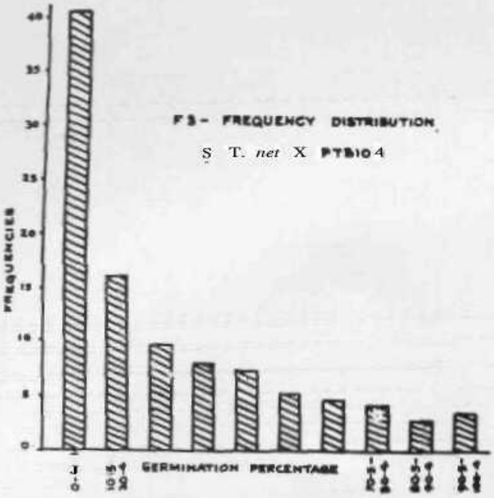

FIG. 1. Histogram representing the F_3 frequency distribution of Cross ♀ T. 2105 × PTB.10 ♂.

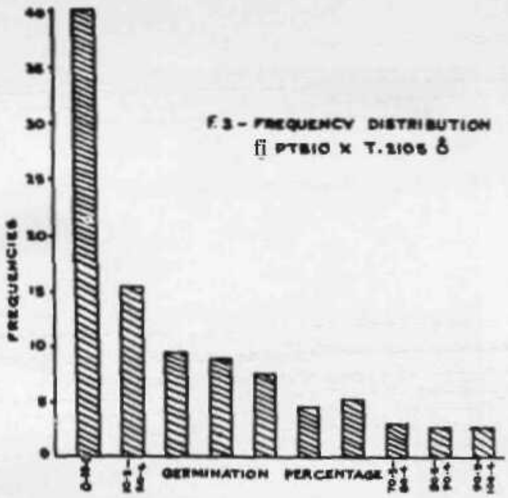

FIG. 2. Histogram representing the F_3 frequency distribution of Cross ♀ PTB 10 X T. 2105 ♂.

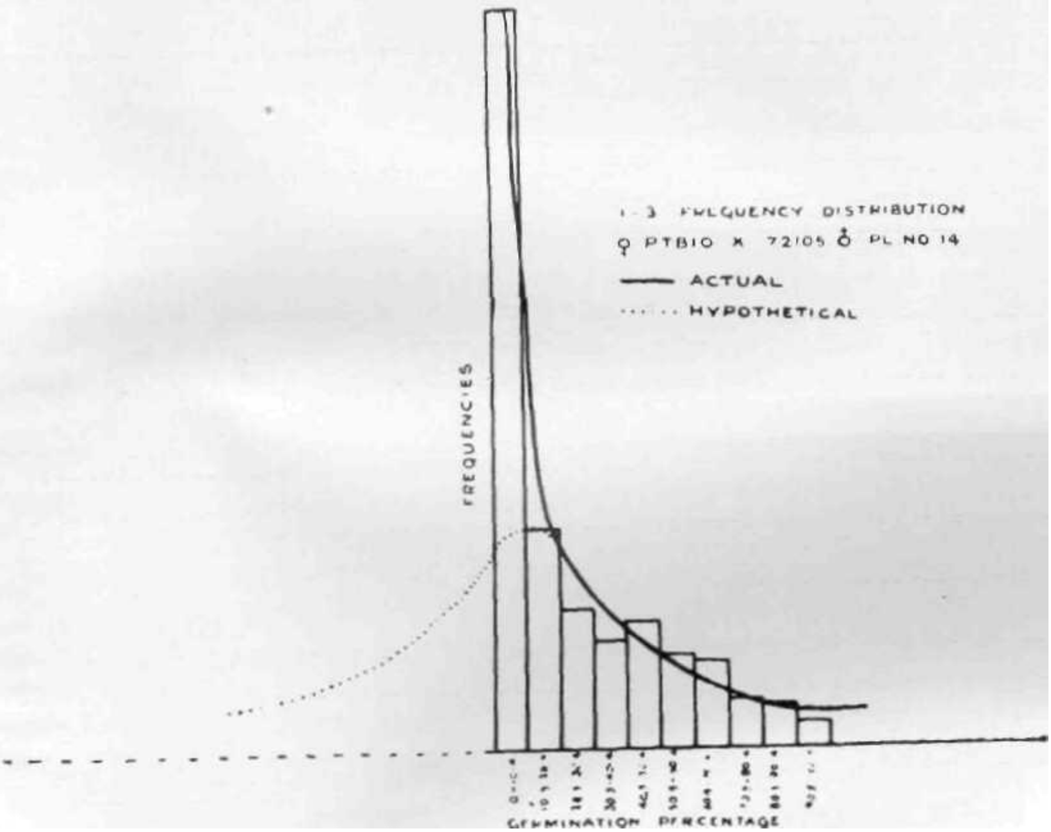

FIG. 3. F_3 frequency distribution of Cross ♀ PTB. 10XT. 2105 ♂ plant No. 14 represented graphically ——— Actual, ... Hypothetical.

TABLE I

Percentage of germination of types.

			Duration in days (seed to seed)	At harvest	Percentage or germination after harvest								Remarks
					10 days	20 days	30 days	40 days	50 days	60 days	70 days	80 days.	
I.	T.	962	95	76	60	100	68	68	94	100	—		Nondormant
2.	MTU.	15	125		32	72	88	84	90	98			*j
3.	T.	1653	112	—		20	28	72	80	86			Dormant
4.	T.	1926	88	—	—	—	3.6	40	61	92			H
5.	ADT.	3	95	4	26	60	60	60	90	100			Nondormant
6.	ADT.	4	100	12	6S	80	84	81	96	100			
7.	T.	1815	112	4		—		8	8	47	65	96	Dormant
8.	PTB,	10	100	40	68	72	80	0f,	100				Nondormant
9.	T.	2024	102	16		—		4	48	89	98	–	Dormant
10.	PTB.	7	125		--	19	49	72	89	96			11
11.	Co.	13	115	36	61	72	88	100	100	..—	—	. _ ,	Nondormant
12.	T.	2105	94	—		—		0.4	29	48	67	90	Dormant
13.	Co.	10	120	64	80	72	8T	90		"—			Nondormant
14.	T.	568	106			—	4	31	58	87	93	—	Dormant
15.	Co.	18	125	35	"80	92	96						Nondormant
16.	T.	1666	105	—		7	29	58	73	80	—	_	Dormant
17.	T.	1824	97	—		0.5	19	41	69	87			
18.	T.	367	86		29	43	60	80					
19.	T.	1443	100	3	30	61	87	97	100	—	—	—	Nondormant
20.	T.	967	98	—	11	51	59	73	87	9~7			Dormant
21.	T.	2021	107	5	—	11	51	59	73	87	97		Nondormant

TABLE II

Percentage of germination of seeds of F_1 embryo generation and parents

Sl. No.		Pedigree.	No. of seeds kept for germination.	No. of seeds germinated within 10 days,	Percentage of germination
1.	Cross	I O T2105 x PTB 10 o	4	—	
2.		II OT 1926 X CO 13 o	9	—	— "
3.		III 0 PTB 10 x T 2105 ^O	5		
4.		IV 0 CO 13 x T 1926 ^O	3	—	
5.	Parent	T 2105)	25		
6.		T 1926J >*	25	—	—
7		PTB 10]	25	14	56
8.	,,	cotfr	25	16	64

* Dormant
© Nondormant

TABLE *III*

Sprouting values of Fz seeds borne on F_1 plants.

Sl No	Details of crosses	Plant No.	No. of seeds kept.	No. of seeds not germinated	No. of seeds germinated.	X' Calculated on the basis of 3 : 1 ratio.
1.	9 T 2105 x PTB 10 £	1 a	100	48	52	38.88
		Ib	100	24	76	138.93
2.	0 PTB 10 x T 2105 £	1	100	80	20	1.33
		3	100	44	56	51.25
		4	100	56	44	19.25
		5	100	92	8	15.41
		6	100	68	32	2.61
		11	300	72	28	0.48
		12	100	52	48	28.21
		13	100	68	32	2.61
		14	100	4S	52	38.86
3.	0 T 1926 x Co, 13 * i- w	1	100	96	4	23.52
		3	100	92	8	15.41
		5	100	100	0	33.27
		6	100	60	40	12.00

Sl. No.	Details of crosses	Plant No.	No. of seeds kept.	No. of seeds not germinated	No. of seeds germinated.	X^5 Calculated on the basis of 3 : 1 ratio.
		7	100	84	16	4.32
		8	100	64	36	6.45
		9	100	92	8	15.41
		10	100	84	16	4.32
3.	0 T 1926 X Co. 13 ^	{*	100	100	0	33.27
			100	75	25	
		13	100	80	20	1.33
		14	100	75	25	
		15	100	68	32	2^1
		17	100	32	68	98.61
		1	100	96	4	23.52
		7	100	76	24	0.05
		8	100	92	8	15.41
		9	100	96	4	23.52
		11	100	92	8	15.41
4.	^Co. 13 X_T 1926 o^A	12	100	72	28	0.48
		14	100	44	56	51,25
		15	100	92	8	15.41
		16	100	96	4	23.52
		18	100	100	0	33.27

TABLE IV

Frequency distribution of percentage of germination of seeds of individual 12 plants of crosses I and III

Crosses	Families.	Percentage of germination of seeds from individual F_a plants										Total No.
		0-10.4	10.5-20.4	20,5-30.4	30.5-40.4	40.5-50.4	50.5-60.4	60.5-70.4	70.5-80.4	80.5-90.4	90.5-100.4	
0 T2105 X PTB 10 £	la	154	48	31	27	29	15	17	13	5	9	348
	Ib	96	47	26	20	15	14	10	10	8	9	255
0 PTB 10 X T2W5 £j	14	154	47	29	22	27	19	18	11	10	5	342
	17	81	38	23	25	16	7	11	6	5	8	220