INHERITANCE OF X-RAY INDUCED MUTANTS IN THE NAVY BEAN

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INHERITANCE OF X-RAY INDUCED MUTANTS IN THE NAVY BEAN

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INTRODUCTION

In the spring of 1938 Genter irradiated several lots of Michelite bean (Phaseolus vulgaris) seed, both dormant and germinated, with varying dosages of X-rays (2). Of the rather large number of mutants resulting from this experiment, only a few produced seed in sufficient quantities to permit continuation of the individual lines. Abnormal plants (mutants) selected from the second generation of X-rayed material in 1939 bred true in 1940. Several lines of mutants were thus obtained. These could be grouped into four types, according to vegetative appearance.

The present study was undertaken to determine whether the similar appearing progenies in each type were genetically alike; whether the different types were alike genetically; and how many factors were responsible for the expression of the mutant character in each case.

Prior to the work of Genter in 1939, no study had been made on the genetic effects of X-rays on beans.

METHODS OF EXPERIMENTATION

Description of the Mutant Types

The four types of mutants studied were designated as A, B, C, and D. Their descriptions follow:

Type A: The plants were about three-fourths as large as the normal (Michelite), the leaves proportionately smaller; the branches were smaller in diameter and considerably more numerous than those of the normal; fewer runners were produced (Fig. 1A).

Fig. 1. Typical plants from the normal and the four mutant types.

Type B: The plants were irregularly shaped and about one-third as large as normal, the leaves proportionately smaller; similar to type A in that it had numerous slender, viny branches; no runners were produced (Fig. 1B).

Type C: The plants were about one-fourth to one-half as tall normal, cylindrical in shape with thick, leathery leaves and only a few short, stubby branches produced on a rather thick, stiff central stem (Fig. 1C).

Type D: These were quite similar to type B, except that the plants were more regular in shape and that more of the slender, viny branches were produced (Fig. 1D).

Types A, B, and C were obtained from dormant seed X-rayed 30 minutes. Types A, B, and C were obtained from dormant seed X-rayed 30 minutes. Type D resulted from dormant seed X-rayed 60 minutes.

Experimental Plan

The mutant parental lines consisted of two progenies each of types A, B, and C, and of three progenies of type D. These were designated as A1 and A2, B1 and B2, and so on. All the seed in a progeny came from a single plant grown in 1940. Seed for the normal type was taken from a lot of certified Michelite bean seed.

In order to determine whether or not the mutants were genetically alike, crosses were made between the individual lines in each type—that is, lines A1 and A2 were crossed together, and so on. For a similar purpose crosses were made between the different types. All possible combinations were attempted. To determine the number of factors responsible for the inheritance of each mutant type, crosses were made between all the

mutant types and the normal type. In addition, backcrosses between the F_1 and the corresponding mutant parent were made in the spring of 1941.

For a detailed description of the hybridizing technique, see Down and Thayer (1).

The parent types and F_1 plants were grown in the greenhouse in the winter and spring of 1940-1941. The F_2 generation and a row of each parent type were grown in the field in 1941.

When the F_1 plants were grown it became evident that all the mutants were recessive to the normal type, as all the F_1 plants in crosses between the mutants and normal were normal in appearance. In cases where mutants were the female parents this information was used to decide whether the F_1 plants were really hybrids or were self-pollinated. When it was not possible to discard selfs on this basis, segregation in the F_2 was used as a criterion.

The F_1 plants used in the backcrosses were all results of normal pollen and mutant female parents, so the use of true hybrids was assured.

All counts were made after the plants had nearly reached full size. The ratios obtained were tested by PQN formulae.

RESULTS

Crosses Within Types

Only a limited number of F_2 progenies were obtained from crosses made within types (Table 1).

Table 1. Crosses Within Types

Cross	No. progenies	F_1 appearance	F_2 appearance
A1/A2	4	Mutant	All mutant
A2/A1	7	"	" "
B1/B2	2	"	" "
D1/D2	2	"	" "
D2/D1	2	"	" "
Total	17		

It seems safe to conclude that the similar appearing progenies in each type are genetically alike, since in 17 crosses all F_1 plants were similar to the mutants and no segregation took place in the F_2. If we can expect about five per cent selfing (of 136 crosses made between the mutant types and between the mutants and the normal, seven were selfs), it still is not probable that all 11 of the seeds obtained from crosses between the two type A lines were selfs. Only two progenies were obtained from pollinations between the two type B lines, but these too indicated that similar appearing lines were identical genetically. Similar conclusions could be drawn from the reaction of the four progenies obtained from crosses between the three lines of type D, none of which segregated. No data were obtained that would indicate whether or not the two type C lines were identical.

Crosses Between Types

In all crosses involving different types of mutants, the F_1 plants were normal in appearance. This proves that the four types were genetically different from each other.

It was not possible in the field to distinguish between mutant types A, B, and D. Hence all mutants expected in a 9:3:3:1 ratio were grouped together. In all instances ratios were obtained that correspond very closely to a 9 normal to 7 mutant type ratio (Table 2).

It was not possible in the first series of pollinations to obtain hybrids between type C and any of the other mutant types. Later, however, three hybrids between C2 and D1 were gotten. These F_1 plants were grown in the field in 1941 and the F_2 in the greenhouse in the fall of 1941. The F_2 ratio was 63 normal: 5 type D: 9 type C: 2 of a new type, probably the double recessive (Fig. 2). This is not a good fit to a 9:3:3:1 ratio, there being too few recessives, but with larger numbers better results might be expected. These results do show, however, that both types that went into the hybrids were recovered, and, in addition, a new type resulted which was intermediate between the two parent types.

Crosses Between the Mutant and the Normal Types

As a result of pollinations between the normal and the mutant types, a total of 88 F_2 progenies were obtained. The F_1 plants were all normal in appearance, and in the F_2 the segregation of normal to mutant more or less closely approximated a 3:1 ratio (Table 3). Crosses between types A and D and the normal gave almost exactly 3:1 ratios. The results of crosses between types B and C and the normal were not so satisfactory, there being a somewhat large deficiency of mutant types in each case. Observations of types B and C in the greenhouse indicated that neither was as viable nor as vigorous in growth as the normal or types A and D. The main difficulty with B was its low viability, and with C its lack of vigor (slow growth). This behavior may be used as an explanation for the short-

Table 2. Crosses Between Types

Cross	No. of Progenies	F_1 Type	F_2 Segregation Normal	Mutant	Total	Dev. From 9:7	Dev. S.E.	Odds*
A1/B1	2	Normal	53	40	93			
A2/B1	2	"	22	29	51			
A2/B2	2	"	27	15	42			
B1/A1	1	"	11	12	23			
B1/A2	9	"	86	71	157			
B2/A2	6	"	70	66	136			
Sub-total	22		269	233	502	13	1.17	3.4:1
A1/D2	1	"	6	6	12			
A2/D1	3	"	14	12	26			
A2/D3	3	"	25	20	45			
D1/A1	3	"	62	44	106			
D3/A1	2	"	48	33	81			
Sub-total	12		155	115	270	3	0.39	0.4:1
B1/D1	1	"	9	9	18			
B2/D1	2	"	40	38	78			
D1/B1	2	"	29	16	45			
D1/B2	1	"	28	23	51			
D2/B1	1	"	24	20	44			
Sub-total	7		130	106	236	3	0.39	0.4:1
Total	41		554	454	1008	13	0.83	1.4:1

*The odds given are against the occurrence of this deviation being due to chance alone. Odds of 19:1 are at the 5% level.

Fig. 2. The double recessive from a cross between types C and D.

Table 3. Crosses Between Mutants and Normal Types

Cross	No. of Progenies	F_1 Type	F_2 Segregation Normal	Mutant	Total	Dev. From 3:1	Dev. / S.E.	Odds
A1/N	9	Normal	140	52	192			
A2/N	3	"	64	14	78			
N/A2	4	"	44	19	63			
Sub-total	16		248	85	333	2	0.22	0.2:1
B1/N	2	"	65	13	78			
N/B1	5	"	77	24	101			
B2/N	5	"	117	31	148			
N/B2	3	"	42	10	52			
Sub-total	15		301	78	379	17	1.99	21:1
C1/N	21	"	415	110	525			
N/C1	1	"	9	2	11			
C2/N	5	"	53	14	67			
Sub-total	27		477	126	603	25	2.12	27:1
D1/N	6	"	120	34	154			
D2/N	5	"	112	44	156			
N/D2	10	"	242	84	326			
D3/N	5	"	83	21	104			
N/D3	4	"	52	20	72			
Sub-total	30		609	203	812	0	0.0	0:1
Total	88		1635	492	2127	40	2.0	21:1

age of mutants in these two crosses, because during the week following the planting of these progenies heavy rains fell, causing rather severe crusting of the surface soil. Although various methods were used to break up this crust over the sprouting beans, some of the less vigorous seedlings may have perished.

Backcrosses to the Mutant Parents

The results from backcrossing are summarized in Table 4. Excluding the backcrosses involving the mutant type D, these counts tend to confirm the results obtained from crosses between the mutants and the normal; that is, the mutant types were caused by single recessive factors. The preponderance of non-normal types in the backcrosses to the recessive parent D is rather difficult to explain. It may be that the pollen of this type matured earlier than was expected, with the result that a high percentage of selfing of the recessive female parent occurred.

Table 4. Backcrosses.

Cross	Backcross progeny Normal	Mutant	Total	Dev. from 1:1	Dev. S.E.	Odds
A1 x N/A1	13	13	26			
A2 x N/A2	1	5	6			
B2 x N/B2	8	11	19			
C1 x N/C1	5	2	7			
Sub-total	27	31	58	2	0.53	0.6:1
D2 x N/D2	15	27	42			
D3 x N/D3	8	30	38			
Sub-total	23	57	80	17	3.8	6915:1
Total	50	88	138	19	3.4	727:1

SUMMARY

The object of the present experiment was to test genetically four mutant types appearing in irradiated Michelite beans (Phaseolus vulgaris).

It was concluded that the similar appearing progenies of the same type were genetically alike, and that the different types were genetically unlike. All types were governed by single recessive factors. Linkage between the four recessives seems improbable.

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