INHERITANCE OF PUBESCENCE IN SOY BEANS AND ITS RELATION TO POD COLOR¹

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INTRODUCTION

NAGAI and SAITO (1923) described a glabrous soy bean plant that appeared in the F₂ generation of a cross between two pubescent parent plants. The data presented showed the glabrous character to be a simple mendelian dominant to pubescence, and the factor pair was designated as P_1p_1 . STEWART and WENTZ (1926) reported the discovery of a glabrous soybean outwardly resembling the type found by NAGAI and SAITO (1923), also arising from a cross between two pubescent parents, but behaving as a recessive to the pubescent type instead of as a dominant. This factor pair was designated P_2p_2 .

The F₂ results reported by STEWART and WENTZ (1926) deviated quite widely from a 3:1 ratio, an actual ratio of 6.76:1 being obtained. Results of the F₃ and later generations, however, fitted a 3:1 ratio much better. On the basis of this and other considerations, the authors interpreted the inheritance as being due to a single pair of mendelian factors, and concluded that the character they studied was not the same as that described by NAGAI and SAITO (1923).

As pointed out by OWEN (1927) critical evidence on the genetic relationship of these two glabrous types should be furnished by a study of a cross between them. We propose to present in this paper the results obtained

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in a study of such a cross, a genetic interpretation of them, and the relation between pod color and the presence or absence of pubescence.

SOURCE OF PARENT MATERIAL

Several years ago, through the courtesy of Mr. W. J. MORSE of the United States Department of Agriculture, we obtained a glabrous soybean, which in crosses with pubescent types, has proved itself to be dominant. This likely carried the same factor for glabrousness that was carried by the type discovered by NAGAI and SAITO (1923). This is indicated by the fact that OWEN (1927) made use of glabrous types from both sources in crosses with pubescent types and obtained similar results, so far as the inheritance of glabrousness was concerned. Seed of the recessive glabrous type was obtained through the kindness of Professor WENTZ.

In our crossing experiments, we were successful in making a cross between the recessive glabrous type used as the female parent, and the dominant type used as the male. One pod was produced containing two seeds. The particular dominant glabrous plant used as a parent in this cross was a homozygous segregate from a cross between Medium Green and the original dominant glabrous type secured from Mr. MORSE. In addition to dominant glabrousness from one parent, it had black pods and green cotyledons from the Medium Green parent. Since the green color of the cotyledons is, in this case, maternally inherited, it does not enter into consideration.

F₁ RESULTS

The two F₁ plants were grown in the greenhouse and were glabrous.

F₂ RESULTS

Plants of the F₂ generation were grown in the field in the summer of 1928. Both glabrous and pubescent plants were produced. Of a total of 232 plants grown, 183 were glabrous and 49 were pubescent. The data seem to fit a 13:3 ratio better than a 3:1, as evidenced by the fact that the deviation divided by the probable error on a 3:1 basis was 2.02, whereas on a 13:3 basis it was only 1.37.

The 13:3 ratio would be produced in F₂ if the dominant glabrous parent is assumed to carry a factor for pubescence (P_2), but is inhibited from expressing the pubescent character by an inhibiting factor (P_1), and if the recessive glabrous parent is assumed to carry the recessive factor for pubescence (p_2) as well as the recessive inhibiting factor (p_1). The genetic constitutions of the parental, F₁, and F₂ generations, and the breeding behavior in F₃ are as follows:

Parents	F_1	F_2	Breeding behavior in F_3
$P_1P_1P_2P_2$		$1P_1P_1P_2P_2$ Glabrous	All glabrous
Glabrous		$2P_1P_1P_2p_2$ Glabrous	All glabrous
×	$P_1p_1P_2p_2$	$2P_1p_1P_2P_2$ Glabrous	3 glabrous: 1 pubescent
	Glabrous	$4P_1p_1P_2p_2$ Glabrous	13 glabrous: 3 pubescent
$p_1p_1p_2p_2$		$2P_1p_1p_2p_2$ Glabrous	All glabrous
Glabrous		$1P_1P_1p_2p_2$ Glabrous	All glabrous
		$1p_1p_1p_2p_2$ Glabrous	All glabrous
		$2p_1p_1P_2$ Pubescent	3 pubescent: 1 glabrous
		$1p_1p_1P_2P_2$ Pubescent	All pubescent

We should expect, therefore, that of 16 plants in the F_2 generation, there would be the following types in the following ratio based upon their breeding behavior in the F_3 generation.

F_2 ratio	F_3 ratio
16 { 13 glabrous	{ 7 would breed true for glabrousness 2 would segregate, 3 glabrous: 1 pubescent 4 would segregate, 13 glabrous: 3 pubescent
3 pubescent	{ 2 would segregate, 3 pubescent: 1 glabrous 1 would breed true for pubescence

F_3 RESULTS

To test this factorial hypothesis, seeds of 158 F_2 plants were planted in sand benches in the greenhouse, as pubescent and glabrous plants can easily be distinguished in the seedling stage. Of these F_2 plants, 109 were glabrous and 49 were pubescent. The data are summarized³ in table 1. On account of the low seed yield of the glabrous plants, the num-

TABLE 1

Classification of F_3 progeny on basis of breeding behavior with reference to the glabrous-pubescent character pair in soy beans.

TYPE OF F_2 PARENT	F_2 BREEDING BEHAVIOR	OBSERVED RESULTS	CORRECTED RESULTS	EXPECTED RATIO
Glabrous	Bred true	52	61	7
	Segregate 3:1	22	26	2
	Segregate 13:3	35	41	4
Pubescent	Segregate 3:1	36	22	2
	Bred true	13	8	1
Totals		158	158	16

$$\chi^2 = 3.145$$

$$P = .5358$$

³ Due to lack of space, detailed data cannot be given. The authors would be glad to furnish a typewritten copy of the tables for the inspection of anyone particularly interested in seeing them.

ber in the progeny was smaller than desirable, especially for differentiation between 3:1 and 13:3 ratios. However, deviations and probable errors were calculated for each progeny for each ratio, and each segregating progeny from a glabrous parent was classed as a 3:1 or a 13:3 according to which ratio had the smaller quotient (deviation $\div$ probable error), and therefore the better fit.

Some difficulty was experienced in classifying the progeny of pubescent F_2 parents. Thirteen progenies were classed as breeding true for pubescence, and 36 as segregating in a 3:1 ratio. Of those classed as breeding true, four produced a few glabrous plants. Thus one plant produced 29 pubescent: 2 glabrous, two plants each, 49 pubescent: 1 glabrous, and the fourth, 47 pubescent: 3 glabrous. It is not certain just how these anomalous results may be accounted for. The pods were picked off the plants and shelled by hand. For this reason, it is very unlikely that the glabrous plants are the result of seed mixture. As the F_2 plants were grown close together in the row so that the branches of adjacent plants were in contact, a certain amount of natural crossing may have occurred. It is known that natural crosses take place in soybeans more or less frequently, depending upon the variety, locality, season, and probably other factors. If a pollen grain from a dominant glabrous plant fertilizes an ovule on a pubescent plant, the seed thus produced will develop into a glabrous plant. Such mixtures, due to natural crossing, can not be identified in progenies of heterozygous or homozygous dominant parents, though they probably occur with equal frequency. We believe we are justified in classing these four progenies with those breeding true for pubescence (1) because such wide deviations from a 3:1 ratio, due to chance alone, are improbable, and (2) because natural crosses are known in soybeans, and are known to have produced anomalous results in other genetic studies (WOODWORTH (1921); STEWART and WENTZ (1926)).

Since the F_2 glabrous and pubescent plants tested in F_3 were not in the ratio of 13:3, it was necessary to correct the results before determining the deviation from the expected ratio. This procedure has been followed by LINDSTROM (1917) in studies on aleurone and chlorophyll factors in corn, and by WOODWORTH (1921) in determining the genetic relation between cotyledon and seed-coat colors in soybeans. The correction is justifiable and necessary in the present instance, since the wide deviation from a 13:3 ratio in the numbers of F_2 plants tested is not due to segregation and recombination.

The low value of χ^2 , and the consequent high value of P , (table 1) indicate that the above genetic hypothesis is the correct one. Hence, it appears

that the dominant type of glabrousness carried a pubescence factor (P_2) and an inhibiting factor (P_1), and the recessive type, the recessive allelomorphs of both (p_1, p_2). It should be possible to isolate, by appropriate crosses, still a third glabrous type in homozygous condition; namely, that which is recessive for the pubescence factor (p_2), but dominant for the inhibiting factor (P_1). The genetic constitutions of the three homozygous glabrous types are $P_1P_1P_2P_2$, $P_1P_1p_2p_2$, and $p_1p_1p_2p_2$.

Factor symbols P_1p_1 and P_2p_2 have been used in this case, in order to avoid revisions in symbolism respecting other character pairs in soybeans. It appears that NAGAI and SAITO (1923) in their experiments with the glabrous type, were really studying the effect of an inhibiting factor which prevented the production of hairs on the plant. Hence, P_1 is retained but thought of as an inhibitor of pubescence rather than as a factor for glabrousness. Also, STEWART and WENTZ (1926) were concerned with a single factor pair designated by them P_2p_2 , the dominant member producing pubescence, the recessive member, glabrousness. The inhibiting factor was recessive and therefore not involved in their experiments. The symbol I has usually been used to designate inhibition, but in soybeans this symbol is already in use to designate inhibition of black and brown pigments in the seed-coat. Hence, it appears simplest to retain P_1p_1 and P_2p_2 to express genetically the glabrous-pubescence relationship in soybeans.

POD COLOR

The dominant glabrous type used in the cross had dark or black pods (L) and the recessive type light brown pods (l). The F_1 plants bore dark pods, and in F_2 there was segregation for pod color in approximately a 3:1 ratio. Of a total of 232 plants, 183 were dark-podded, and 50 were light-podded. This represents a deviation of 8 from expectation, with a probable error of 4.908. The quotient (deviation $\div$ probable error) is 1.63. Thus, one factor pair (Ll) is involved, and the results confirm those reported elsewhere (WOODWORTH (1923)).

RELATION BETWEEN POD COLOR AND PRESENCE OR ABSENCE OF PUBESCENCE

The cross between the dominant and recessive glabrous types affords an opportunity for determining whether there is any linkage between the factor pairs Ll and P_1p_1 or Ll and P_2p_2 . The data are summarized in table 2.

The actual results obtained corresponded quite closely with those expected on the basis of independence between the factor pairs concerned.

TABLE 2

Classification of F₂ plants showing independent relation between presence and absence of pubescence and pod color.

TYPES		ACTUAL NUMBERS	EXPECTED NUMBERS	EXPECTED RATIO
Pubescence	Pod Color			
Glabrous	Dark	146	141	39
	Light	37	47	13
Pubescent	Dark	36	33	9
	Light	13	11	3
Totals		232	232	64

$$\chi^2 = 2.9416 \quad P = .40218$$

It is, therefore, concluded that the factor pair *Ll* is independent of the factor pairs *P₁p₁* and *P₂p₂* for the presence and absence of pubescence.

SUMMARY

1. In a cross between a dominant glabrous and a recessive glabrous soybean, the F₁ was glabrous and there was segregation in the F₂ in the ratio of 13 glabrous to 3 pubescent plants. The F₂ ratio was substantiated by the F₃ results.

2. The data were interpreted as being the result of the interaction of two factor pairs *P₁p₁* and *P₂p₂*. *P₂* is responsible for pubescence; *p₂* for glabrousness; *P₁* inhibits *P₂* from producing pubescence, thus causing glabrousness; *p₁* has no effect on *P₂*. Thus three different pure types of glabrous plants are possible, namely, *P₁P₁P₂P₂*, *P₁P₁p₂p₂*, and *p₁p₁p₂p₂*. The pure pubescent type is *p₁p₁P₂P₂*.

3. In F₂ two color types of pods were found, dark (*L*) and light (*l*). Segregation occurred in the ratio of 3 dark to 1 light.

4. The presence or absence of pubescence was found to be inherited independently of pod color.

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