NOTES AND COMMENTS

GENETICS OF ANTHOCYANIN PRODUCTION IN THE RADISH

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In 1924, Uphof reported that pigmentation in the root of the garden radish, *Raphanus sativus*, was controlled by a single Mendelian factor. In four separate crosses of red and white varieties, he found the F_1 to be self-coloured violet and, in the F_2, observed, in all 588 red, 1326 violet and 583 white roots. He interpreted these results in terms of two alleles at one locus, the heterozygote being violet. His figures, however, give only a poor fit to this hypothesis ($P < 1$ per cent.).

In 1957, the pigments of red and violet roots were examined by standard procedures (Harborne, 1958*a*, *b*) and the aglycones were identified as pelargonidin and cyanidin respectively. Subsequent work (Harborne, 1962*a*) showed that the derived anthocyanins have the same glycosidic patterns, both anthocyanidins being present in radish as mixtures of the 3-*O*-(feruloylsophoroside)—5-*O*-glucoside and the 3-*O*-(*p*-coumaroylsophoroside)—5-*O*-glucoside. Thus the only chemical difference between the two colour types is that the anthocyanidin of violet roots has one more hydroxyl group than that of red roots. This observation, and the fact that the " white " varieties examined had some pigment on the root shoulder and were thus phenotypically violet, suggested that there is a gene in radish controlling hydroxylation of pelargonidin to cyanidin, which is independent of pigment distribution. Such a conclusion would bring the radish into line with other plants in which factors controlling anthocyanidin hydroxylation have been studied (Scott-Moncrieff, 1936; Harborne, 1962*b*). Since this does not agree with Uphof's hypothesis, the inheritance of anthocyanin in the radish was re-investigated and the results, which are presented below, support the re-interpretation.

The assumption was made, at the outset, that red forms (containing pelargonidin) are homozygous for a gene *h* and that the dominant allele *H* occurs in " white " varieties. Evidence was sought showing that pigment distribution in the root is determined by loci acting independently of *H*. The F_1 from crosses between the variety " Red Turnip " and two " white " varieties, " Carter's Icicle " and " White Turnip ", were violet, as expected, but the ratio of types in the F_2, raised from selfing F_1 plants, differed somewhat from that of Uphof (1924). The two parental combinations behaved similarly and the results are presented together in table 1. The contrast between coloured and white was not clear cut; in most families there were completely pigmented (*e.g.* self violet), mostly white (with variable amounts of pigment on the shoulder, *e.g.* white and violet) and completely white types. The last class was not completely acyanic, but contained some pigment in the shoot or flower.

The 1961 F_2 families yielded just over 20 per cent. of red plants, significantly less than the expected 25 per cent. A second batch was therefore grown in 1962, which agreed very closely with the 1961 batch in the segregation of violet and red, and representative plants of all five classes were crossed with " Red Turnip " and " White Turnip ". The results of

TABLE 1

The F_2 segregation in the radish

Year grown	Self Violet	White and Violet	Total Violet	Self Red	White and Red	Total Red	White
1961 . . .	312	203	515	57	76	133	112
1962 . . .	310	210	520	93	41	134	65
Total . . .			1035			267	

TABLE 2

Test cross of F_2 plants to parental types

Parents	× " Red Turnip "				× " White Turnip "			
	No. of families	Self Purple	Self Red	White	No. of families	Self Purple	White and Purple	White
Self Purple .	2	28	22	0	1	0	16	13
					1		continuous range	
White and Purple	2	34	0	0	1	1	14	12
	2	23	16	0	3	0	25	19
Self Red .	3	0	49	0	2	7	19	0
					1		continuous range	
White and Red	1	0	12	1	1	0	4	11
	1	0	14	0				
White .	2	0	34	9	2		continuous range	
	1	24	0	0	1	0	23	0

these test crosses (table 2) are consistent with the hypothesis of a single gene *H* controlling hydroxylation, but there is again a slight deficiency of the homozygous recessive, as in the F_2 (see above). Plants with white roots behaved as either white and violet or white and red types.

The mechanism controlling coloured versus white roots is certainly more complex than a single dominant gene. The observations differ in four respects from the situation expected on that hypothesis. First, the F_1 plants are coloured, but the incidence of mostly white roots in the F_2 was high (nearly 50 per cent.). Second, a few white roots segregated in test crosses of coloured F_2 plants to the true breeding pigmented variety. Third,

the two years results were not consistant, the proportion of self-coloured roots being higher in 1962, suggesting that the degree of pigmentation was liable to environmental modification. Fourth, in a few F_2 families and test crosses, the degree of pigmentation was so variable that discrete classes could no longer be recognised. Consideration of the genetic mechanisms of pigment distribution in the radish root is outside the scope of this report, but these results do establish, beyond doubt, that they are independent of the H locus.

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GENOTYPE FREQUENCIES IN A SECTION OF A CLINE

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1. INTRODUCTION

The study of the geographical diffusion of genes through a population is considerably simplified if the population is thought of as being distributed continuously in a one-dimensional habitat, such as a stretch of coast or the banks of a stream. For such a population, consider a pair of alleles a and A at a given locus, and let the relative fitnesses of the genotypes aa, aA and AA be $1+2m$, $1+m$ and 1, *i.e.* there is no dominance. Let x be the distance from an arbitrary origin, and $p(x, t)$ the frequency of the a gene in the population at position x and time t. If the breeding system is one of discrete generations and local panmixia, after which the offspring wander at random in such a way that the distances they move are normally distributed with standard deviation k, then it is known that in the limit, as the generation time tends to zero, the diffusion of a is represented by the differential equation

$$\frac{\partial p(x, t)}{\partial t} = k \frac{\partial^2 p(x, t)}{\partial x^2} + mp(x, t)\{1 - p(x, t)\}. \tag{1}$$

Fisher (1937) discussed the case where the solution is a wave of stationary form advancing with constant velocity. A different approach is to suppose