Flax Genetics and Gene Symbolism

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THE mode of inheritance of traits of flax (Linum usitatissimum L.), including petal, anther, and seed colors, disease resistance, and other characteristics has been studied extensively during the last 50 years. Some studies have led to complex but apparently valid genetic interpretations. Unfortunately, the same symbols were used for radically different characteristics or stocks. Many of the original seed stocks have been lost; thus adequate complementation tests are impossible.

This is a review of literature in three research areas: (I) genetic and inheritance studies; (II) irradiation studies; (III) cytology and cytogenetics. A system of gene symbolism is suggested, and previously described genes given new symbols if former designations were confusing.

GENETICS AND CYTOLOGY OF FLAX

1. Genetic and Inheritance Studies

An excellent review of genetics and inheritance studies in flax was published by Dillman (15) in 1936; Culbertson et al. (10) reviewed certain aspects of flax genetics in 1954. More recent reviews by Hoffman (25) and Richarda (44), contain large bibliographies of flax literature. Dillman (16) describes many characteristics of flax plants that are useful in classification and some of these variations have been studied genetically.

A. Flower Parts

1. Petal color and shape. Tammes (47 through 53) developed 14 lines of flax with combinations of eight genes which determine petal color and other characteristics. Genes B1, B2, and C are all needed in the dominant condition for production of petal color. Gene D causes blue color, while with dd the petal color is pink. A- and E- intensify color, while F- dilutes it, and ff changes blue to lilac. Generally, veins in the petal are darker than the intervenal area, but the heterozygote, Cc, gives a flower without apparent venation. With K- the entire petal is colored, but with kk, the color is concentrated on the outer edge. Petal shape depends on the 3 basic color factors, B1, B2, and C. With B1 and B2 and any combination of C alleles, the petal is flat. With either b1b1, or b2b2, and C-, the petal is narrow and crimped. Thus, all colored petals are flat, but white petals may be flat or crimped.

Shaw et al. (46), studying Indian type flaxes, found that petal color was influenced by 7 genes. The genes, B and C, interact to produce pink, but with either homozygous recessive, the color was white. Genes D and F modified the color. With D, the pink color of B and C was changed to lilac, and with bb and D, the color caused a faint tinge of blue. Gene E intensified petal color, while N diluted it. Gene K distributed the color over the whole petal, and with E or F, intensified color. With kk, the color is deeper in the upper half of the petals. With ee or ff there was no intensification with kk.

The system described by Tammes (53), and the one proposed by Shaw et al. (46) are similar, but Dillman (15) points out that a difference in petal color existed in the two studies. Shaw et al. (46) classified petals with pink or blue edges as white, whereas Tammes insisted that white petals have no trace of color. Dillman (15) stated that the seed stocks from these studies were exchanged, and a cross of the white types produced flat, colored petals.

In the United States and Canada, where Indian type flaxes are not extensively grown, the system proposed by Tammes has been used. Dillman (15) states that Tammes' system was valid for many studies at the Northern Great Plains Field Station and her system was adequate for the date of Barnes et al. (2).

2. Anther color. Anther color can be either yellow or blue. Tammes (53) showed that with b1b1, d1, or h, the anther color is yellow. With all of these genes dominant, the color is blue. Thus pink petals are always associated with yellow anthers, but white flowers with a cc genotype can have blue anthers.

Shaw et al. (46) stated that, in addition to the petal color genes, four additional factors determined anther color. Genes Z1, and Z2 produced color in the filaments if B, C, and K plus either E, or F were present. Gene T restricts the blue color of the filament to the region immediately below the pollen sac. Gene H produced blue in the anthers if B and D were dominant.

3. Style and stigma color. Shaw et al. (46) postulated 3 genes for color in the style and stigma, R produced blue color in the style with B, C, K, and either E, or F. P produced pink color in the stigma with B and C, but the stigma was purple with R and B, C, and D. Gene I inhibited color in the stigma.

B. Seed Color

Tammes (53) explained seed color as due to absence or presence of pigment in the seed coat. If G was present the seed coat was colored, but with gg the seed coat was colorless. Gene d changed yellow to brown and b1 produced a greenish tone. With B, D, and G, the color was reddish, but with either dd or dd, b1b1, yellow changed to brown without the reddish tone. This system was corroborated by Barnes et al. (2) and is used in the United States and Canada.

Shaw et al. (46) stated that 3 genes in combination with D (of the flower color genes) determined seed coat color. Gene G produced gray color in the seed coat; M with D produced fawn color; with M, D, G, the fawn color was changed to brown. With gg, or either mm or dd, the color of the seed coat was yellow. Another gene, X, intensified the color, changing fawn to dark fawn, and yellow to dark yellow.

C. Disease Resistance

1. Susceptibility and resistance to Melampsori lini. (Ehrenb.) Lev. Flor (17, 18, 19, 20) has shown that rust resistance or susceptibility is conditioned by an inter-