# GENETIC CONSIDERATIONS FOR BREEDING *POTENTILLA FRUTICOSA*

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The shrubby potentilla or cinquefoil is a common dwarf shrub that is widely planted in the Northern Hemisphere. There are in excess of 60 cultivars that have been named and released; however, few have remained popular (11).

The basis of any breeding program requires sound knowledge of the taxonomy of the particular plant. When we established the breeding program in *Potentilla* I found that the taxonomy of the species was very confused. It was, therefore, necessary to become involved in a taxonomic study of the plant to help define the complex and identify problem areas. There are up to 10 different species reported in the shrubby group (1, 3, 4, 6, 7, 9). However, there is no overall concensus on which is the best taxonomic approach.

One of the approaches utilized to study the taxonomic status was to establish breeding relationships among the groups. This was accomplished by crossing between the major types reported in the literature. The concept of gene exchange and limits to gene exchange are important in species definition and critical in a breeding program (8). The exercise is also valuable in that one is forced to become familiar with a broad range of plants and the diversity of characteristics present. Eight different plants were selected to represent the major types. These included North American, European, and Asian representatives. Each of these were intercrossed in all possible combinations. The resulting seed set, germination percentages, and subsequent seedling production were recorded. All plants were successfully crossed and viable and fertile seedlings produced. Breeding barriers were relatively minor (Figure 1). It appears that all members of this complex are the same species since gene exchange is possible in all combinations. On the basis of this research and other studies we completed it appears that *Potentilla fruticosa* is the most appropriate name for the complex.

The next phase of the study investigated the inheritance of flower colour and extra petals. These two characteristics are of considerable interest in relation to cultivar development. Knowledge of the inheritance of these should be of importance and help speed the release of new introductions.

To initiate this study, four principal parents were selected to represent important phenotypic classes. These were:

1) UM 8102 ('Snowbird') white ± 15 petals
2) UM 7901 ('Yellowbird') bright yellow ± 10 petals

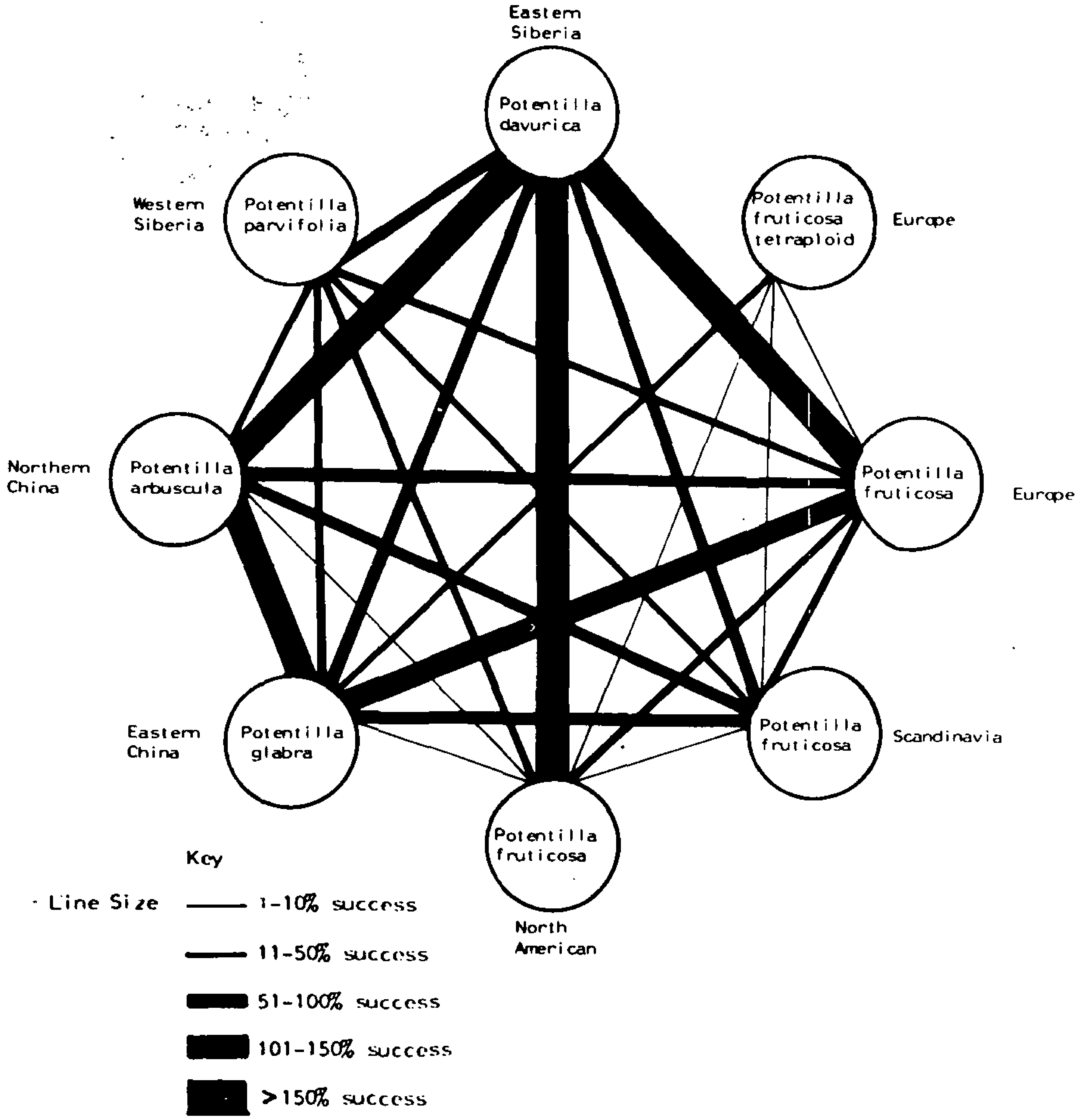

**Figure 1.** Breeding relationships based on success of seedling production. Success was based on average seedling yield for the cross and reciprocal, divided by the appropriate outcrossed maternal parent value.

3) UM 7911 ('Pin Whisper') creamy white with pink 5(6) petals
4) UM 7904 ('Orange Whisper') creamy yellow with orange 5 petals

These plants were crossed in all combinations to develop populations to study inheritance. Information was also obtained from other controlled crosses. The resulting seedlings were field-planted in a randomized block design. Data were collected from the onset of flowering through to mid-September. Robertson (10) found that flower colour and extra petals were influenced by the environment. Both characteristics are more predominate under cool moist conditions. Cyanic pigments, those responsible for orange, pink and red, are reduced during periods of high temperatures while droughty conditions often reduce expression of extra petals.

To develop a hypothesis for the inheritance of yellow and white flower colour several assumptions were made (2). There were:

1) Dark yellow, bright yellow, and light bright yellow were treated as one phenotypic class. These colours are quite similar and could possibly be due to environmental variability or the effect of a diluting or bleaching gene(s). Similarly, creamy yellow, light creamy yellow, and creamy white were treated as a second phenotypic class.
2) Bright and creamy yellow colours may be associated with cyanic pigments but the quantities were low and the background colour was visible. These were easily classified in either the bright or creamy yellow colour classes.
3) Any strongly cyanic plants, orange, pink, or salmon colours were removed from the analysis since their background colour was not easily visible. This resulted in the removal of only 6 plants from over 600 seedlings assessed.

On the basis of data collected there appear to be at least four genes involved: two whitening genes and two yellowing ones. In crosses between white and bright yellow there were two groups of bright yellows. In one case, creamy yellow progeny predominated while in the other bright yellow flowers were more prevalent. In both situations 3:1 ratios were observed. The cause of the differences was not due to the white parent since the same white-flowered plant was used as a parent in all crosses.

In crosses between UM 7901 ('Yellowbird') and 7904 ('Orange Whisper') bright colours outnumbered creamy types 3:1. In crosses between UM 7901 ('Yellowbird') and UM 7904 ('Pink Whisper') bright colours again outnumbered creamy types by 3:1. On the basis of the data analysis tentative genotypes for the parents have been developed. These are:

UM 8102 ('Snowbird') $W_1W_1W_2w_2Y_1y_1$— —
UM 7901 ('Yellowbird') $w_1w_1W_2w_2Y_1Y_1Y_2y_2$
UM 7904 ('Orange Whisper') $w_1w_1W_2w_2Y_1Y_1y_2y_2$
UM 7911 ('Pink Whisper') $w_1w_1W_2w_2Y_1Y_1y_2y_2$+ bleacher

Models of cyanic flower colour inheritance were more difficult since seedling populations were very small. From the data collected however, a preliminary hypothesis was prepared that should be useful in future studies. The background petal colour must be taken into account since the anthocyanins may interact with the base pigments. For example, the colour orange appears to be a combination of a reddish anthocyanin and the yellow background pigment. Secondly, there appear to be at least two anthocyanin controlling genes involved. Colours observed include pink, orange and salmon. Different pigments or pigment combinations are responsible for these colours. The location of the pigment must also be considered. Flowers may be uniformly cyanic, or have a central blotch or feather. Positional genes must therefore be involved. Finally, the anthocyanin pigments observed were temperature-sensitive. There was variability in the sensitivity of these, thus selection for more stability may be possible. Selection for good stable and uniformly coloured flowers should be an obtainable goal.

The second character investigated was extra petals or double flowered plants. Potentillas normally have 5 petals. Selection programs at the University of Manitoba had previously identified plants with petal counts of up to 10 extra petals.

Progeny from the crossing program were analyzed to establish a model of inheritance for this particular character. Comparisons were first made between single and double flowered plants. Any plants with more than the basic compliment of 5 petals were considered double. Double flowered plants were placed into one of two phenotypic classes: those with 6–10 petals and those with 11–15 petals. Ranges within the class sizes were necessary since environmental influences are common (10).

The model developed proposes three genes. The first two act as a trigger or switch. If either gene is fully recessive then up to 5 extra petals are produced. The third gene is a modifier which, if recessive, enables production of up to 5 more petals.

All of the families studied fit with one exception. There were reciprocal differences in the cross between the 10 and 15 petaled plants. Further studies suggest that the genetics of this is quite complicated (Innes 1988). The genotypes of the parents involved are proposed as follows:

UM 8102 ('Snowbird') $D_1d_1d_2d_2d_md_m$?
UM 7901 ('Yellowbird') $d_1d_1D_2d_2D_md_m$
UM 7904 ('Orange Whisper') $D_1D_1D_2d_2D_md_m$
UM 7911 ('Pink Whisper') $D_1D_1D_2d_2D_md_m$

where $D_1$ and $D_2$ are the initial switch and $D_m$ is the modifier (double modifier).

Innes (5) has confirmed this model and has suggested that at least one other modifying gene is present. In his population petal counts of up to 25 were recorded. In addition to this he found that the double modifier gene was genetically linked to the self-incompatibility locus. The close proximity of these two genes means that segregation ratios are altered from expectations.

Nearly all shrubby potentillas are self-incompatible. This means that flowers must be cross-pollinated before any seed can be set. The only exception to this was in a tetraploid ($2N = 4x = 28$).

This plant would set seed when it was selfed; however, resulting seedling vigour was very low. In relation to breeding, self-incompatibility has at least two important implications. Firstly flowers do not have to be emasculated. Pollen from the same plant cannot fertilize another flower on the same plant. This speeds up the field work considerably since less time is required to cross-pollinate. Secondly, it is more difficult to obtain plants that are fully recessive. Many of the floral characters studied are only expressed if fully recessive. Frequency of occurrences are lower which often means more generations of intermating are necessary to obtain the desired combinations.

In conclusion:

1) White and yellow colours are determined by two white ($W_1W_2$) and two yellow ($Y_1Y_2$) genes. The role of a bleaching gene to slightly modify these colours is also suspected.
2) Cyanic flower colour inheritance is complex. Future studies should consider genes for cyanic pigments, temperature sensitivity, pigment location and the background colour of the petal.
3) Three or possibly four genes are implicated in the inheritance of extra petals. If one of the first two genes ($D_1$ or $D_2$) is fully recessive then up to 5 extra petals develop and if the third ($D_m$) gene is also recessive an additional 5 petals may be produced. A tentative fourth gene ($D_{m2}$) also has to be in a recessive condition before any more extra petals are produced.

These genetic models will be very useful in the further development of *Potentilla fruticosa* cultivars. However, the floral characters must be in combination with other characteristics. The plant must be strong, vigourous, and healthy before it can be released to the landscape industry. Too often, we have seen plants promoted for a single characteristic with little attention paid to the plant as a whole. There remains within the *Potentilla* complex a great deal of variability that can and should be exploited. As we gain more and more information about this plant, more and more doors open.

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# BREEDING NEW PIERIS CULTIVARS

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Plant breeding was one of the projects to be conducted at the newly established North Willamette Experiment Station of Oregon State University when I was hired in 1959. *Pieris* was chosen as there were several species and a number of named cultivars of *P. japonica*, none of which were known to be the result of hybridization. Among the objectives were development of plants with growth habits different than the narrow, upright habit of *P. japonica*, fade resistant pink flowers, and bright red growth.

Thirty different plants were acquired in 1959 and 1960 from local and eastern nurseries including one or more of the following species: *Pieris floribunda*, *P. formosa* and its variety *forrestii*, *P. japonica*, *P. nana*, *P. phillyreifolia*, and *P. taiwanensis*. Also obtained was a plant of *P.* 'Forest Flame', which is reported to be a natural hybrid between *P. formosa* var. *forrestii* and *P. japonica*. Results of attempts at interspecific hybridization in *Pieris* by Dr. Richard Jaynes and I have been reported (1).

Seven of the *P. japonica* forms were supposed to be pink but all resembled the one honestly named 'Pink Bud'. The pink bud types crossed together did not result in any darker pinks. The real break for breeding dark pink *Pieris* came in March, 1961, when I was called to Lambert Gardens, a display garden and landscape firm in