Euphytica 30 (1981) 9–14

DIVERSITY OF FLOWER COLOURS IN *RHODODENDRON SIMSII* PLANCH. AND PROSPECTS FOR BREEDING

J. HEURSEL

Institute of Ornamental Plant Growing, Caritasstraat 21, B-9230-Melle, Belgium

Received 14 April 1980

INDEX WORDS

Rhododendron simsii, evergreen azalea, flower colours, anthocyanins, flavonols.

SUMMARY

A survey of the flower colours present in evergreen azaleas, *Rhododendron simsii* PLANCH is given. The following colours occur: white, red, carmine red, pink, purple and lilac. Crosses can lead to greater diversity although no really new shades have resulted. Quantitative anthocyanin and flavonol determinations for the cultivars enable us to gain an insight into the possibilities of increasing these contents and thus obtaining new colours. The prospects of breeding for intensely red, yellow and blue cultivars are also reviewed.

INTRODUCTION

The evergreen azalea, *Rhododendron simsii* PLANCH., is one of the most important pot plants in Western Europe and the USA. The breeding history of this vegetatively propagated plant is a relatively short one, and breeding has been focused on flower characters because the public is continually asking for new flower colours and flower types.

Research concerning the heredity of the flower colours, the doubleness of flowers and of the hose-in-hose character (coloured calyx) started in 1963 (HEURSEL, 1972, 1975, 1976; HEURSEL & HORN, 1977; HORN & BACHTALER, 1964). DE LOOSE (1970, 1978, 1979) has investigated the flavonoids in *Rhododendron simsii* and *R. obtusum* PLANCH. Development of new colours requires genetic diversity. We intend to review this diversity of the cultivars and to examine the degree to which it can be extended by means of crosses.

MATERIAL AND METHOD

It can be assumed that some 250 azalea cultivars exist in Western Europe, fifty of which are of economic importance. The basis for their study was the collection of the Institute of Ornamental Plant Growing at Melle, Belgium, containing 198 cultivars. A detailed description of the cultivars is to be found in HEURSEL (1977).

Also, 22757 seedlings, the result of 143 cross combinations carried out between 1963 and 1976, were examined. The colour of each cultivar or seedling was determined on the basis of the Royal Horticultural Society Colour Chart (RHSCC) (1966). The determination of colour shades by means of a colour chart remains subjective and cannot be relied on if the aim of the selection is to increase the anthocyanin and flavonol contents. The increase may then produce more intensely red or carmine red flowers. This is why quantitative anthocyanin and flavonol determinations were performed on the cultivars. The total anthocyanin content was determined starting from 3 g of fresh flowers by measuring the extinction in a 250 ml extract 1 % HCl in water at 513 nm (De Loose 1970). The flavonols were also determined by way of the De Loose (1970) method starting from 3 g of fresh flowers by measuring the extinction at 400 nm. The extinctions were recalculated afterwards on the basis of 1 g, and multiplied by 1000.

RESULTS

RHSCC determinations of cultivars. Determinations by means of the colour chart make it possible to subdivide azaleas into six colour groups (see Fig. 1): white, red, carmine red, pink, purple and lilac. By red is meant that the colour contains no bluing elements, while carmine red (the colour of red wine) is a shade of red showing a distinctly bluish

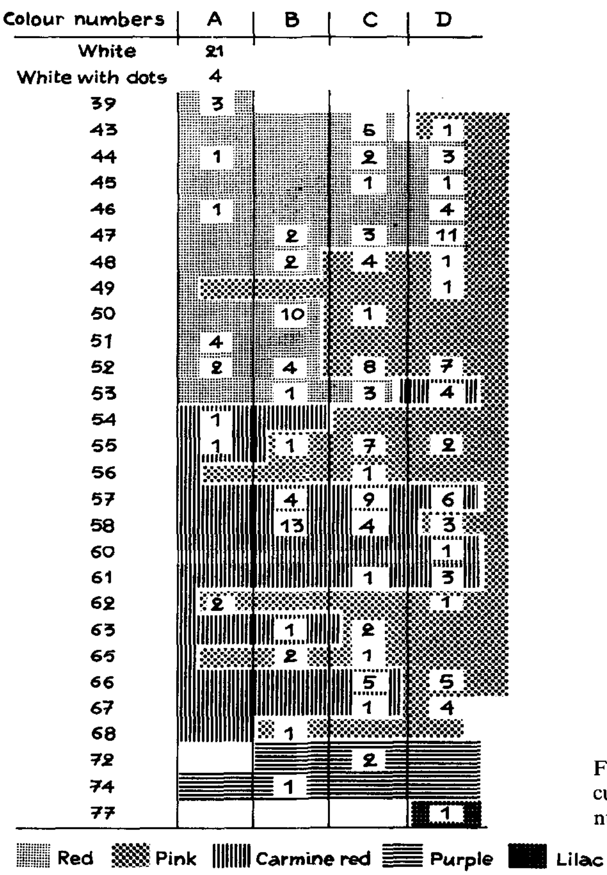

Fig. 1. Number of *Rhododendron simsii* cultivars with their RHSCC colour numbers.

component, an effect due to the presence of flavonols. When red and carmine red are less saturated, i.e. are less intense, they both change into pink. It is not desirable to distinguish between the various shades of pink. The bluing element nearly always present in pink is not always due to flavonols. Purple is caused by malvidin and, as a copigment, methylmyricetin or myricetin. Lilac is light purple. The red, carmine red and pink colours also occur as sports with more or less clearly marked white edges (see BROERTJES & VAN HARTEN, 1978; DE LOOSE, 1979; HEURSEL, 1980).

In Fig. 1 we also see that carmine red is very strongly represented. Two reasons for this can be distinguished. In the first place, carmine red is dominant to red, which means carmine red very often reappears in the progenies of crosses. The more carmine red seedlings are found, the better the chance a good one can be selected from them.

The second reason is that carmine red and some pink cultivars contain flavonols. These fluoresce when subjected to ultraviolet radiation. Since artifical light of the daylight type also emits some ultraviolet radiation carmine red and pink cultivars luminesce in the living-room whereas red cultivars do not.

Colour numbers	A	B	C	D
White	● *			
White with dots	● *			
34	*			
39	●			
41	*	*	*	*
42	*	*	*	*
43	*	*	●	●
44	●	*	●	●
45	*		●	●
46	●	*	*	●
47	*	●	●	●
48	*	●	●	●
49			*	●
50	*	●	●	*
51	●	*	*	*
52	●	●	●	●
53	*	●	●	●
54	●	*	*	*
55	●	●	●	●
56		*	●	*
57	*	●	●	●
58		●	●	●
59		*	*	*
60	*		*	●
61		*	●	●
62	●	*	*	●
63	*	●	●	*
64		*	*	*
65	*	●	●	*
66		*	●	●
67	*	*	●	●
68	*	●	*	*
69		*		
70		*		*
71		*	*	*
72		*	●	*
73	*	*	*	*
74	*	●	*	*
75	*	*	*	*
76		*	●	*
77		*	*	●
78	*	*	*	*
80	*			
84		*		
87		*		

● Seedlings and cultivars * seedlings
22.757 observations

Fig. 2. Synopsis of RHSCC colour numbers of *Rhododendron simsii*.

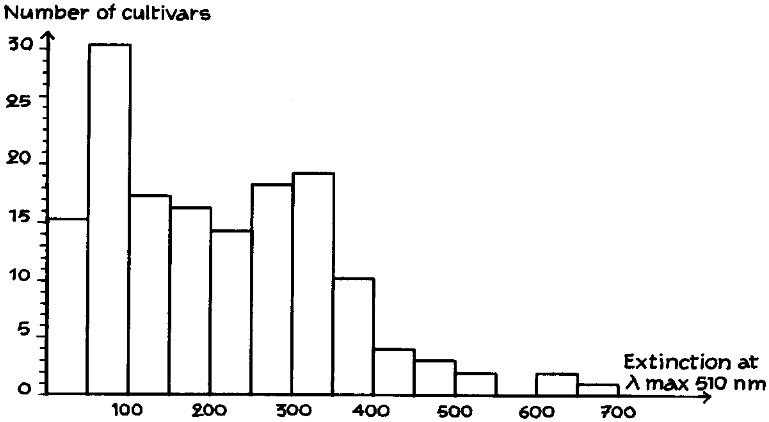

Fig. 3. Anthocyanin content of *Rhododendron simsii* cultivars.

It strikes that for several colour numbers there are many cultivars. For instance, colour number 58 B contains no less than 13 cultivars and, clearly, this assortment could easily be reduced. Still, there is cause for some caution in this respect since cultivars with a given colour number may differ for flower size and type, and flowering period. The colour of the flower edge may also differ from that of the other parts of the flower.

It is obvious too that several colour numbers are absent. The opportunities for further breeding may be found here.

RHSCC determinations of seedlings. Fig. 2 shows how crosses may contribute considerably to diversification. In the red group the numbers 41 and 42 were added, and the numbers 78, 80, 84 and 87 in the purple group. The intense red shades 58 A, 59 A, 61 A and 64 A, however, did not occur. Mending this would require an increase of the anthocyanin and flavonol contents of the flowers.

Anthocyanin and flavonol content of the cultivars. Fig. 3 is a representation of the anthocyanin content distribution. Pink cultivars have an extinction value of up to circa 100. We also see that the number of cultivars with values of over 400 is small. The highest values are reached by 'Hermann's superba' 650 followed by 'Friedhelm Scherrer' 603 and 'Doctor Sven Hedin' 600. It is hardly accidental that red cultivars rank above for anthocyanin content.

Results from crossings to increase the anthocyanin content prove that a high anthocyanin content is associated with the absence of flavonols. Probably there is competition for a common precursor. The success of 'Friedhelm Scherrer' can be partly explained by the fact that it attains the fine colour 53 C with a high anthocyanin content coupled with sufficient flavonol. The mean extinction value for anthocyanins is 208 $\pm$ 11.

In studying the flavonol content of the cultivars, the red group was not taken into account. Its members contain no more than traces of flavonol with an extinction value

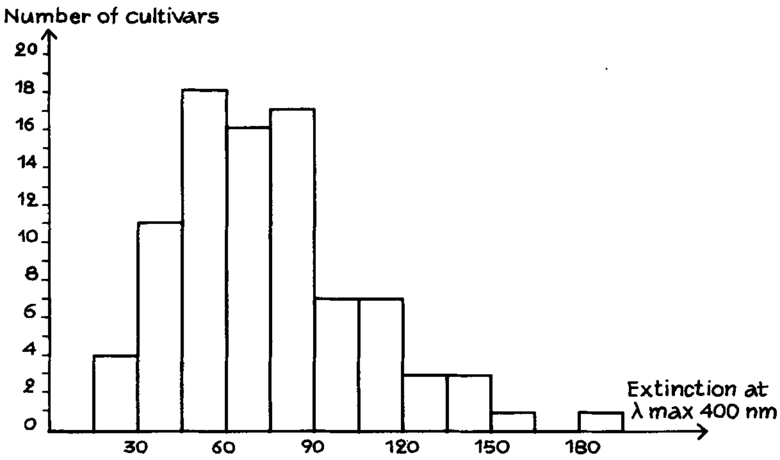

Fig. 4. Flavonol content of *Rhododendron simsii* cultivars.

of less than 15. Including some red cultivars would have distorted the histogram of Fig. 4.

White cultivars may contain flavonols or not. Their appearance does not prove this. Fig. 4 is a representation of the flavonol content distribution. 'Ernst Thiers' shows the highest extinction value: 182. 'Dicky', a sport of 'Ambrosiana', attains 153. The colour of flowers with a high flavonol content depends on their anthocyanin content. If the latter is low, the flower is faintly bluish.

Amongst the white cultivars, 'Paloma' syn. 'Mw. Edmond Troch' reaches the highest extinction value, viz. 85. It is a sport of 'Hellmut Vogel'. This carmine red cultivar also attains a fairly high extinction value of 104. The mean value for flavonols is 73 $\pm$ 3.

DISCUSSION

Although the colour range of *R. simsii* cultivars, not counting white, extends over 56 colour numbers, it remains very limited. We see no perspective of extension by further crosses within the group. The great number of seedlings examined support this view. The following prospects exist for breeding for new flower colours.

Intense red shades 33 A and 40 A might perhaps be obtained with pelargonidin. Since pelargonidin is substituted at a lower level than cyanidin, one cannot exclude the possibility that pelargonidin variations could be found in the center of origin, Southern China. In the center of origin of *R. kiusianum*, Makino, Japan, these variations do not occur.

For the dark red colours 53A and B to be obtained, selection will have to be for high anthocyanin and flavonol contents. This is hampered, however, by the fact that the flavonol content falls as the anthocyanin content rises. One possible approach is to determine the common precursor(s) by biochemical means, and then select for types having a high precursor content.

As to yellow, theoretically there are two ways. In the first place, one can turn to carotinoids present in *R. molle* (BLUME, G. DON) hybrids. Crosses with *R. simsii* as a mother plant often produce seed. However, the cotyledons are yellow and the seedlings wither away. Somatic hybridisation and haploids may offer a solution. The same approaches hold for orange starting from carotinoids. A second possibility is to start from flavonols to obtain yellow flowers. Indeed, if the flavonol content is 3.5 times higher than the highest content found in *R. simsii*, lemoncoloured flowers are the result, as is the case, for instance, in *R. lutescens* FRANCH. and *R. keiskei* MIQ. Although, these species are chemically related they are morphologically very remote. There is a long way to go.

According to ASEN (1979) the following conditions must be met to produce blue flowers. The flowers should contain the pigments delphinidin, and apigenin or vitexin, with a pH of the vacuole equal to 5.0. Azaleas containing delphinidin have been produced through breeding. The pH of the expressed cell sap in the vacuoles is too low, however, to initiate a shift of colour towards blue (DE LOOSE, 1978). Moreover, we do not know which varieties can be used as a source of apigenin or vitexin when crossing.

It seems desirable first to test in vitro various possibilities of obtaining blue on the basis of existing pigments.

ACKNOWLEDGMENTS

The author wishes to express his gratitude to Dr R. De Loose (IWONL, Belgian Institute for the Encouragement of Scientific Research in Industry and Agriculture) for the interest he has taken in his work and the readiness with which he has made his methods of analysis available.

REFERENCES

ASEN, S., 1979. Personal communication.

BROERTJES, C. & A. VAN HARTEN, 1978. Application of mutation breeding methods in the improvement of vegetatively propagated crops. Elsevier, Amsterdam.

DE LOOSE, R., 1970. Flower pigment composition of natural bud-variants among hybrid Chinese azaleas, *Rhododendron simsii* PLANCH. J. Hort. Sci. 45: 265–274.

DE LOOSE, R., 1978. *Azalea indica* flower colour as related to the parameters: pH, anthocyanins and flavonol copigments. Scientia Horticulturae 9: 285–290.

DE LOOSE, R., 1979. Radiation induced chimaeric rearrangement in the flower structure of *Rhododendron simsii* PLANCH. (*Azalea indica* L.). Use of recurrent irradiation. Euphytica 28: 105–113.

HEURSEL, J., 1972. Studie van de overerving en de genotypische variabiliteit van kleur, grootte en vorm van de bloemen bij *Rhododendron simsii* PLANCH. (*Azalea indica* L.). Meded. Rijksstat. Sierplantenteelt, B-9230-Melle (Belgium), Meded. nr. 28.

HEURSEL, J., 1975. Inheritance of the flavonols azaleatin and quercetin in *Rhododendron simsii* PLANCH. Z.Pflanzenzüchtg. 74: 62–70.

HEURSEL, J., 1976. Die Vererbung des Merkmals 'hose in hose' (Doppelkronigkeit) bei Azaleen. Gartenwelt 76: 111–113.

HEURSEL, J., 1977. Beschrijvende lijst van *Rhododendron simsii* PLANCH. (*Azalea indica* L.) cultivars. Mededelingen Rijksstation voor Sierplantenteelt, B-9230-Melle, nr. 39, pp. 60.

HEURSEL, J., 1980. Sportvorming bij *Rhododendron simsii* PLANCH. (*Azalea indica* L.): Een synthese. Landbouwtijdschrift 33: 985–994.

HEURSEL, J. & W. HORN, 1977. A hypothesis on the inheritance of flower colours and flavonoids in *Rhododendron simsii* PLANCH. Z.Pflanzenzüchtg. 79: 238–249.

HORN, W., & E. BACHTALER, 1964. Züchterisches über Azaleen. Gartenwelt 64: 381–382.

ROYAL HORTICULTURAL SOCIETY, 1966. Royal Horticultural Society Colour Chart. Roy. Hortic. Soc., London.