Breeding for the Heat Resistant Rhododendrons : II.Differences of Heat Resistance among Species and Hybrids

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II. Differences of Heat Resistance among Species and Hybrids

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Introduction

The distribution of elepidote rhododendrons is almost entirely confined to the wetter, high mountain regions. The centre of origin is said to be in the area where Tibet, Burma and Yunnan meet, and the areas ranging from the Himalayas through eastern Tibet, upper Burma to western and central China have been inhabited by a great majority of species.

From these areas they have extended their distribution, eastwards to Taiwan, north-eastwards through Japan and Siberia to north-eastern United States, westwards to the Caucasus and the Pyrenees, or southwards to Ceylon or Malaya and Sumatra. In the mountain regions of these areas blest with cool summer, the sporadic species are found.

Moreover, the hybridizations to create the garden forms have been mainly conducted in the areas with cool summer, *i.e.*, in the north-western Europe and the north-eastern or north-western United States.

Therefore, it has been very difficult to grow rhododendrons successfully in the lowlands of the south-western part of Japan; almost all of the natural species and their garden hybrids of foreign origin have never given good results in this region where the summer is exceedingly hot and the radical changes between the rainy and the sun scorching weathers are prevailing.

In the previous paper,[1)] the hybrid seedlings derived from the cross between cv. 'Ruby Hart' and *R. metternichii* were revealed to grow more vigorously, tolerating more heat than either parent and a major cause was attributed to heterosis.

The present investigation was conducted to get some clues to the breeding for heat resistant rhododendrons from the comparisons of the growth-differences in the seedlings of various species and hybrids.

Materials and Methods

Seeds used were chiefly obtained from the Seed Exchange System of Japanese Rhododendron Society and H. L. Larson Rhododendrons of U.S.A. Some seeds were also obtained from Yoshioka Nursery and the other seeds such as; *R. yakusimanum* × *R. simiarum* and *R. yakusimanum* × (*R. yakusimanum* × *R. wrayi*) were due to the courtesy of Dr. P. G. Valder of Sidney University; *R. metternichii* var. *hondoense* f. *brevifolium* and its hybrid with cv. 'Gill's Crimson' were from Mr. T. Nagami; *R. wrayi* was from our collection at Malaya.

Seeds were sown from late January to early February in 1980 and the seedlings obtained were

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transplanted into the 36×45×10 cm plastic boxes from April 20 to May 3, 1980. The media used were the mixtures of fine pumice, peat and shredded sphagnum moss, 6:3:1 by volumes. They were grown in a vinyl-house covered with black lawn, two layers in 1980 and one layer in 1981. Liquid fertilizer containing N, P and K, 50, 25 and 40 ppm, was given every 3-4 days in the growing season of 1980 and that containing 100, 50 and 80 ppm was given every 7 days in 1981. In the majority of cases the number of individuals in each seedling group at the start of the experiment was 150 plantlets, but ranging from some hundreds in the promising species or hybrids to some tens in which we could not obtain sufficient seeds.

The mean maximum and minimum temperatures in a growing vinyl-house in the summer half of 1981 were as follows; May, 34.4 and 13.4°C; June, 36.9 and 18.9°C; July, 40.1 and 24.8°C; August, 38.7 and 23.6°C; September, 34.0 and 20.6°C and October, 31.0 and 14.7°C, respectively.

The measurements of seedling growth were done every 45 days in both the growing seasons, but for plant survival only the final data of Nov. 20, 1981, and for vigour, plant height and leaf size those of Jan. 4–7, 1982, were summarized and presented in Figs. 1–3. In these figures each corner of square was survival ratio (left), vigour (top), plant height (right) and leaf size (bottom), respectively. The survival ratio was the percentage of individuals finally survived. The degree of vigour was based on the five grade estimation from ± through +, ++, +++ to ++++. The plant height was measured on the largest 30 individuals selected within each seedling group and the leaf size was based on the measurement of length and width of the largest leaf in each individual of these 30 plantlets selected. In Figs. 1–3, both measurements were presented on the percentage basis to the largest seedling group, *i.e.*, in the plant height the percentage to the value of 'Purple Splendour' × 'Scandinavia', and in the leaf size to the value of 'Blue Peter' × 'Scandinavia'.

Results and Discussion

1. Species of foreign origin

As seen in Fig. 1, there occurred a considerable difference in the heat resistance between series, subseries and species. A large number of species displayed poor behaviour to be used as the cross parent for future breeding. Especially in *R. auritum* of Boothii series, *R. haemaleum* of Neriiflorum series and *R. wardii* of Thomsonii series, all plantlets died. However, the species belonging to Fortunei series, subseries Fortunei gave fairly consistently good results as seen in *R. chlorops, R. decorum, R. diaprepes, R. discolor* and *R. fortunei*, although no good results were obtained in *R. houlstonii* belonging to the same subseries and in the following species belonging to the other subseries of the same series, *i.e.*, in *R. sutchuenense* of subseries Davidii, in *R. cardiobasis* and *R. orbiculare* of subseries Orbiculare and in *R. oreodoxa* of subseries Oreodoxa. The results of *R. praevernum* of subseries Davidii and *R. griffithianum* of subseries Griffithianum were intermediate.

In others, *R. elliottii* of Irroratum series and *R. ponticum* of Ponticum series gave satisfactory results. However, *R. wrayi* of Irroratum series inhabiting in the mountain regions of Malaya and, thus, being one of the most southern species among the elepidotes, displayed unexpectedly poor behaviour, probably because it could not readily prevail over the water-logged state of the growing medium.

Of particular interest was *R. formosanum*, which distributes in the mountain regions of middle altitude throughout Taiwan[5]. This species belongs to Arboreum series, subseries Argyrophyllum. From the distribution pattern of various species within this subseries, the centre of origin of Argyro-

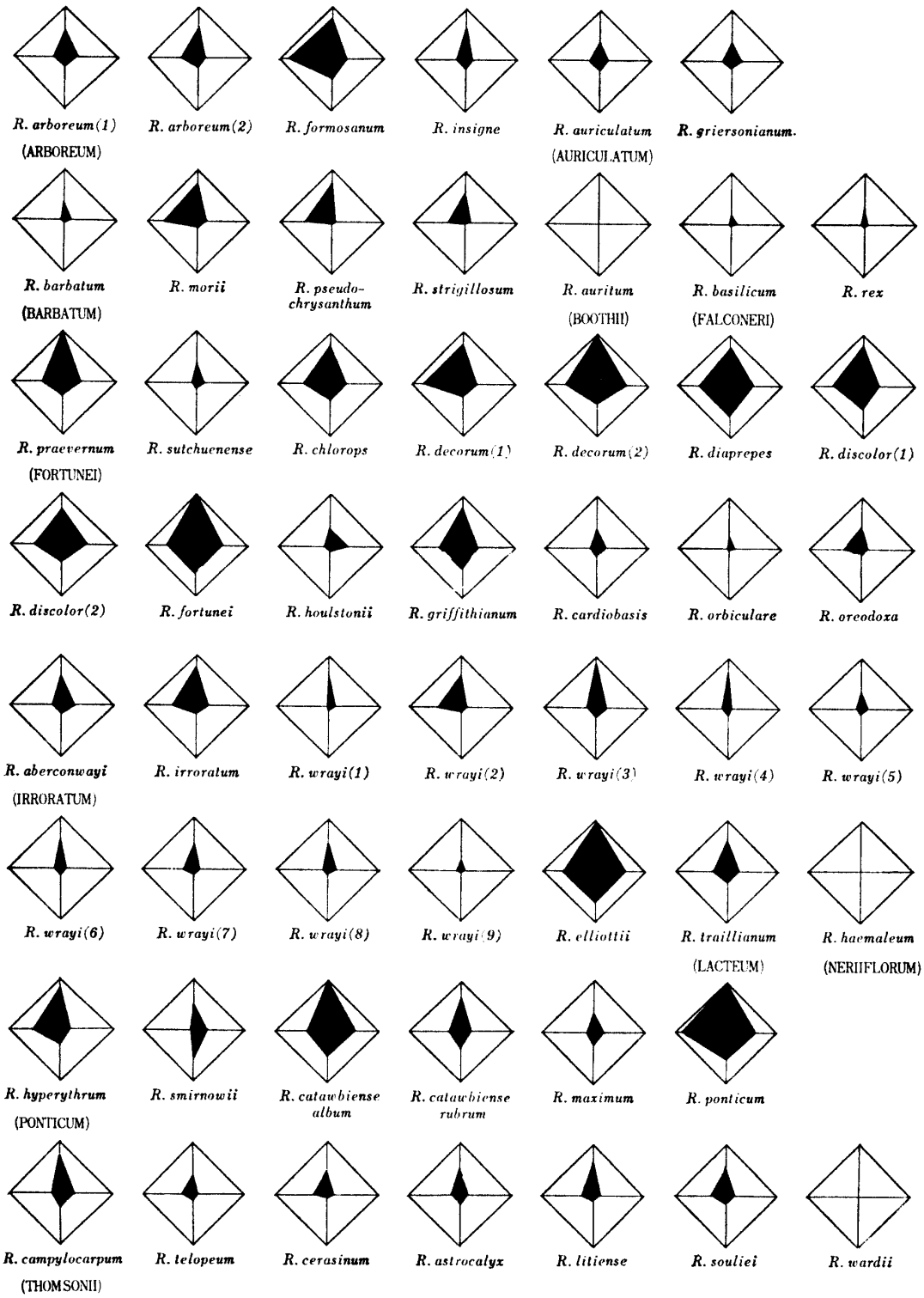

Fig. 1. The survival ratio, vigour and growth of the seedlings in the species of foreign origin. Each corner of square was survival ratio (left), vigour (top), plant height (right) and leaf size (bottom), respectively.

phyllum is assumed to be in the west Szechuan. Therefore, *R. formosanum* is one of the most remote, marginal species.

The struggle in the evolutionary processes during its species formation, in other words, the emulation in the dispersal processes from high mountain of Szechuan towards the east to Taiwan,

might afford to this species a sort of capacity tolerating the unfavourable circumstances. This would also be the reason why the distribution of this rhododendron could remain in broad-leaved forests at the middle altitude throughout the island and pass off without climbing up to the top of mountain.

The similar but somewhat inferior results were obtained in *R. morii* and *R. pseudochrysanthum* of Barbatum series of Taiwan origin. When compared with *R. formosanum*, it would be of interest that the species of higher altitude gave consistently more inferior results. However, the results of these two species were much more superior to those of *R. barbatum* and *R. strigillosum*. As in the case of *R. formosanum*, this would indicate the similar acquisition of tolerance by these two species during their geographical dispersal, although this phenomenon is not necessarily a general rule as seen in *R. wrayi, R. aureum, R. catawbiense* and *R. maximum.*

As compared with the results of its hybrids, mentioned later, *R. hyperythrum* didn't give so good a result as initially expected. The reason is not clear. The seed source of this species was from the United States, accordingly further investigations with the other seed sources will be needed.

Hoitink *et al.*[3,4] studied the resistance of various rhododendrons to the root rot caused by *Phytophthora cinnamomi*, the most serious disease of rhododendrons, and revealed that the majority of species and cultivars are highly susceptible and succomb to disease. The fungus is furious in the soil of high temperature with high water content. Thus, it will be practically impossible to exclude the resistance to this fungus from the breeding for heat resistant rhododendrons in the south-western part of Japan.

Although Hoitink *et al.*[3,4] did not study the resistance of *R. morii* and *R. formosanum* to this fungus, they evaluated *R. pseudochrysanthum* and *R. hyperythrum* to be highly and moderately resistant, respectively. It would be fairly reasonable to assume that the former two species might also be resistant, because Taiwan is known to be inside the centre of origin of *P. cinnamomi*[6] and they, especially *R. formosanum*, could tolerate high water content of growing medium. They would be worthy of particular attention as the cross parent for heat resistant rhododendrons.

2. Species of Japanese origin

The results are shown in Fig. 2. As compared with the foreign species, the characteristic of

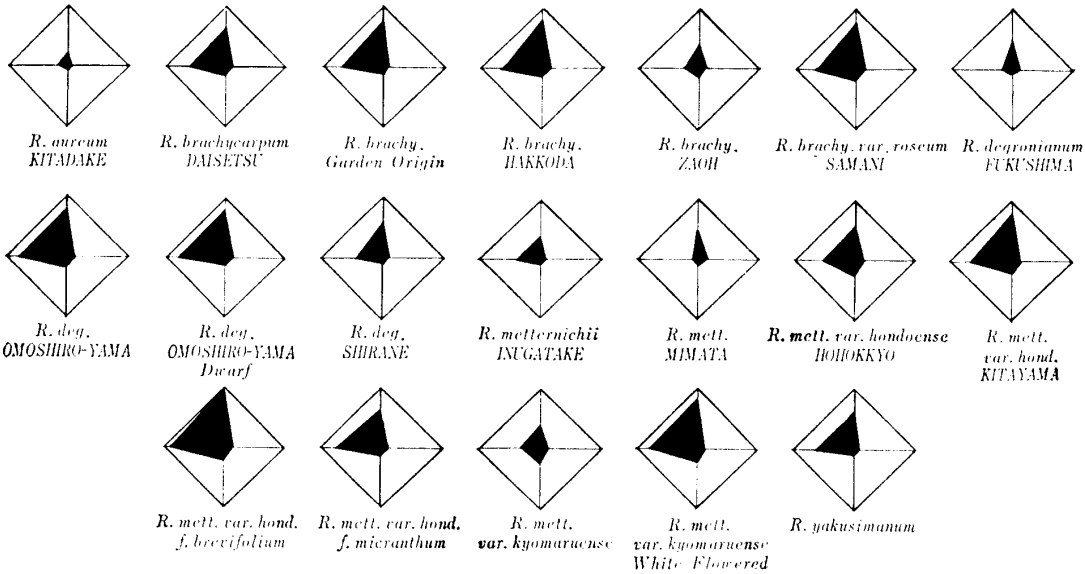

Fig. 2. The survival ratio, vigour and growth of the seedlings in the species of Japanese origin. For details see Fig. 1.

growth pattern of Japanese species was the projection in the direction to survival and vigour, indicating the rosette type-early growth of seedlings. This tendency was also seen in the species of Taiwan origin.

Concerning with the heat tolerance there occurred similar variations in the species of Japanese origin to those of foreign one. As for *R. aureum*, only one form from Kitadake of Yamanashi Prefecture could be tested, but the result was the worst as initially expected from its general lack of heat tolerance. In the other species, the great intraspecific variation was encountered with the difference of seed sources concerned. If this variation is based on the genetic difference within each species, the more detailed and systematic surveys throughout Japan will be needed, including the clarification of the following two issues, namely where the best seed source is and what individual is the most promising as the cross parent of future breeding.

As far as the present experiment is concerned, however, *R. metternichii* var. *hondoense* f. *brevifolium* was the most heat tolerant one in Japanese species. This form is an inhabitant of Oki-islands, the small island of Shimane Prefecture located at the southern part of the Sea of Japan, where it grows from almost at sea level to the mountain tops, the highest of which being only 608 m.

This geographical isolation without high mountain to climb up, might afford the heat tolerance to this form, as compared with the typical *R. metternichii* and *R. yakusimanum*, having high mountain to climb up 1700 m or over. Furthermore, some finest individuals of this form show compact growth with very shiny, shorter leaves that are elegantly curved down at the edges. One of the authors (K. A.) estimates this form rather higher than *R. yakusimanum* to combine the heat resistance with the excellent foliage and flowers.

3. Hybrids

As in the case of species rhododendrons, the hybrids also showed a great diversity in their heat tolerance in accordance with the difference of cross-combinations (Figs. 3–1 and 3–2). Dostălek *et al.*[2] had found the similar variation, especially in vigour and uniformity, in the hybrid seedlings obtained from the diallele cross and self-pollination of a few species and a cultivar ('Cunningham's White'), although the main purpose of their investigation was to disclose the combining ability to produce F_1 hybrid seed of rhododendron rootstocks.

It was difficult, however, to draw general conclusion from the present data obtained, mainly because, as expected from the seed sources, each cross combination was not so elaborately planned to compare each other systematically, and the individual used for the cross parent was not necessarily the same individual in such species as in *R. yakusimanum*, *R. degronianum* and *R. hyperythrum*.

In some cross combinations, however, the consistent results were obtained; the hybrids derived from *R. hyperythrum* and those from cv. 'Scandinavia' gave consistently good results, whereas all of those from cv. 'Crest' were rather poor. This might suggest that some specific species or cultivars have inherently the high heritability for heat tolerance and the others have not.

As in the other countries, the special emphasis on *R. yakusimanum* and its derivative hybrids to be used as the cross parent, is also prevailing in this country, chiefly because of their excellent ornamental values (Fig. 3–1). In this country, however, it is rather desirable that this emphasis should be turned to *R. hyperythrum*, as far as the heat tolerance is concerned.

In the other combinations the followings gave good results; *R. yakusimanum* × 'Elizabeth', *R. yakusimanum* × 'Ruby Hart', 'Mrs. Furnival' × *R. yakusimanum*, 'Scintillation' × *R. yakusimanum*, 'Venus' × *R. yakusimanum*, ('Britannia' × *R. yakusimanum*) × *R. yakusimanum*, (*R.*

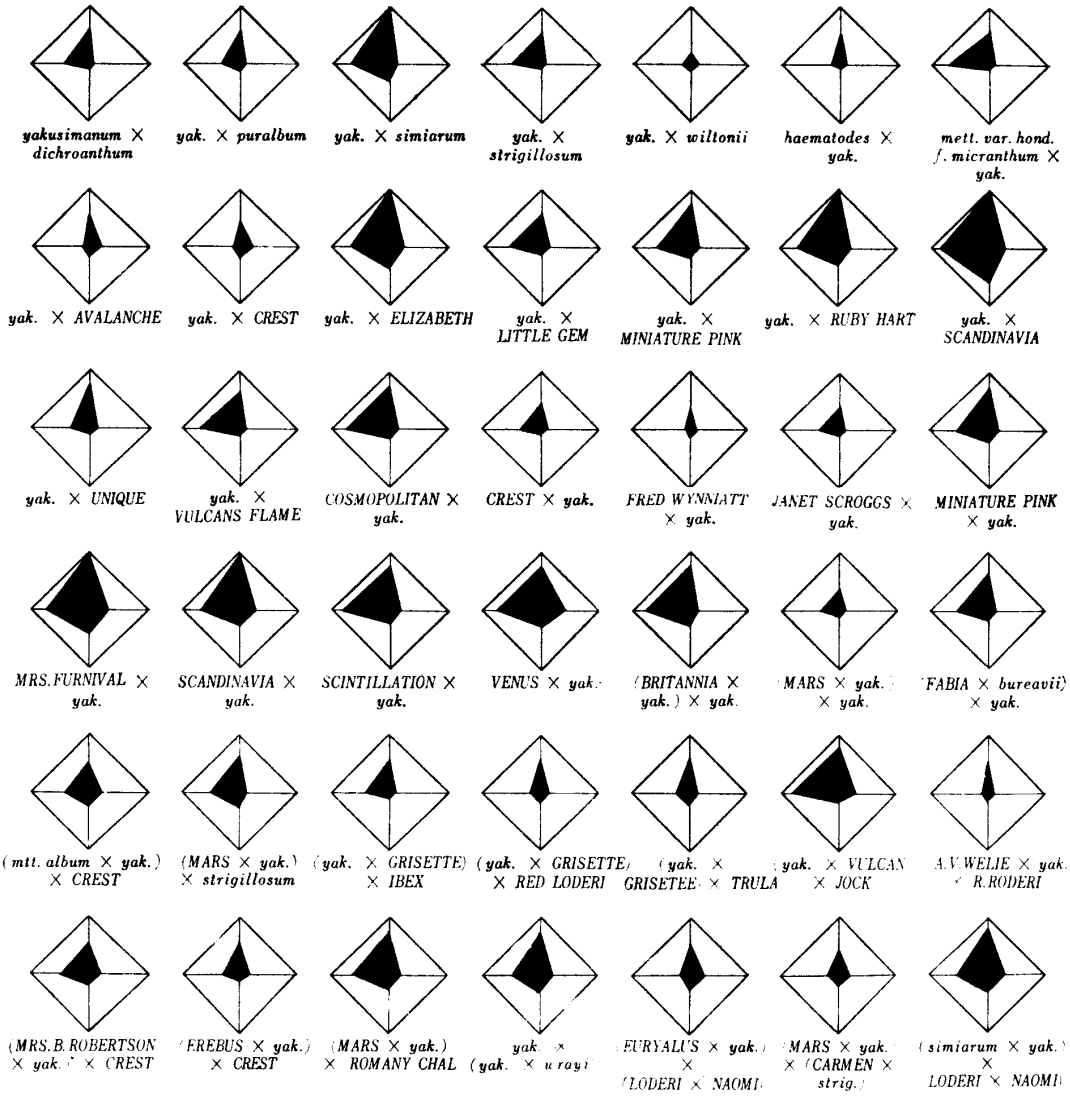

Fig. 3-1. The survival ratio, vigour and growth of the seedlings in the hybrids including *R. yakusimanum* within their pedigree. For details see Fig. 1.

yakusimanum × 'Vulcan') × 'Jock', *R. degronianum* × 'Bow Bells' and *R. metternichii* var. *hondoense* f. *brevifolium* × 'Gill's Crimson'. The definite reason why these combinations gave good results is not clear. As mentioned before, *R. metternichii* var. *hondoense* f. *brevifolium* showed good performance. The descendants of this form also gave consistently good results in several other combinations than that of 'Gill's Crimson', although the detailed data are not presented here. Therefore, this form appears to be another promising material for the heat resistant rhododendrons.

Summary

The present investigation was conducted to get some clues to the breeding for heat resistant rhododendrons from the comparisons of the growth-differences in the seedlings of various species and hybrids.

In both species and hybrids, the great diversity in the seedling growth was encountered with the difference of series, subseries, species, varieties, seed sources or cross-combinations.

A large number of species were revealed to be inappropriate to be used as the cross parent for

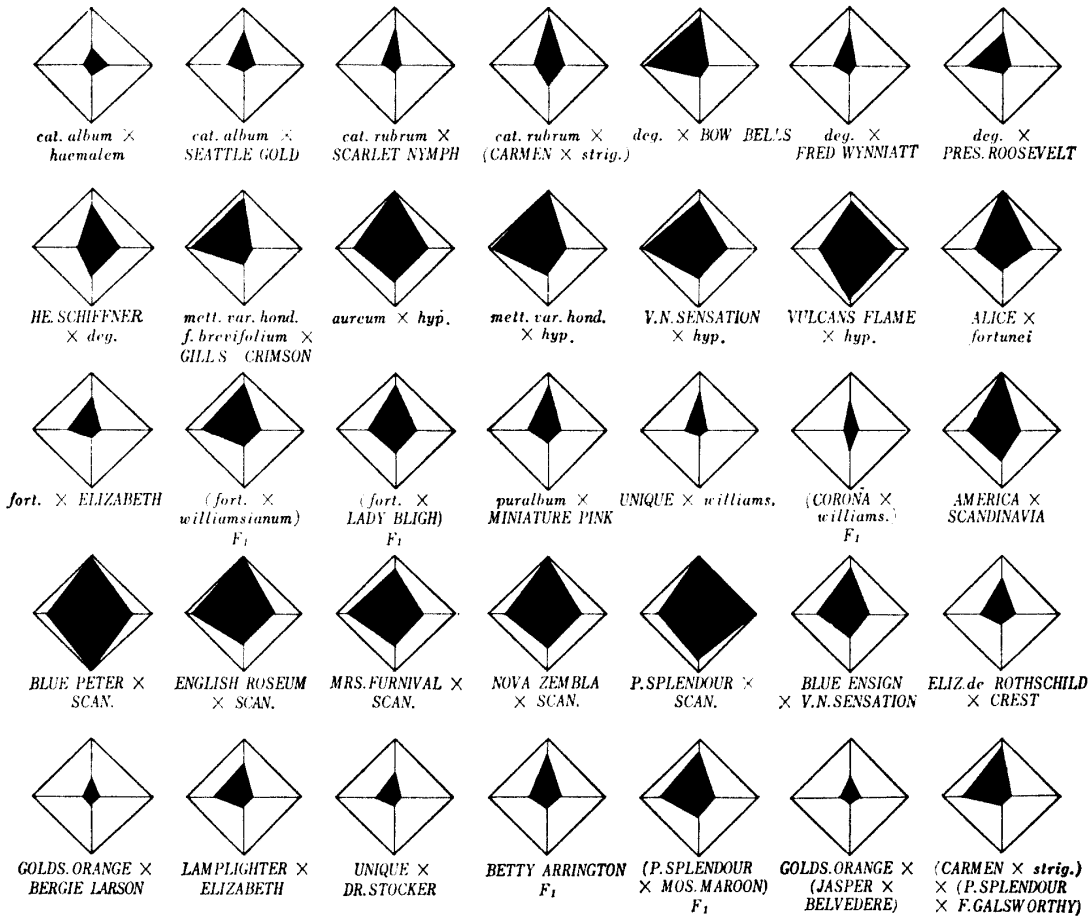

Fig. 3-2. The survival ratio, vigour and growth of the seedlings in the hybrids not including *R. yakusimanum* within their pedigree. For details see Fig. 1.

future breeding. Some species, however, seemed to be promising on the basis of the performance of their own and, in some cases, together with their descendants. They were *R. formosanum, R. hyperythrum, R. metternichii* var. *hondoense* f. *brevifolium* and *R. ponticum* and, to a lesser extent, *R. decorum, R. diaprepes, R. discolor, R. elliottii, R. fortunei* and *R. morii.*

In some species, the possibility was suggested that the heat tolerance had been secured by the geographical dispersal of long distance from the centre of origin and/or the isolation into small island without high mountain to climb up. It was also suggested that some specific species or cultivars have inherently the high heritability for heat tolerance and the others have not.

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