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POTENTIAL FOR INTERSPECIFIC HYBRIDIZATION IN THE GENUS ACTINIDIA

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ABSTRACT

Inter- and intraspecific variation has been evaluated among a range of *Actinidia* species and appropriate selections have been made. Interspecific hybridization has been attempted and a range of interfertility exists. The cause of incompatibility in some crosses is being investigated in the hope that some limitations may be overcome. The features and reproductive biology of one fertile hybrid are described.

KEYWORDS

Kiwifruit, hybrid characteristics.

INTRODUCTION

The kiwifruit of commerce (*Actinidia deliciosa* (A. Chev.) C.-F. Liang et A.R. Ferguson var. *deliciosa*) is a deciduous, dioecious liane endemic to eastern Asia (Liang, 1983). World production of this fruit crop is dominated by one cultivar (Hayward) selected by a New Zealand nurseryman in 1930 (Ferguson, 1983). This monocultural situation causes concern about susceptibility to disease epidemics, unseasonal weather, the concentration of on- and off-orchard activities, finite marketing opportunities and limited regional development of the crop.

The Division of Horticulture and Processing of DSIR has a broad-based kiwifruit breeding programme aimed at improving the qualities of Hayward and producing new and varied fruiting types. In working towards this latter objective, a range of *Actinidia* species have been collected and are being evaluated for their agronomic, morphological and physiological traits. This will allow the identification of desirable characters of each species, as well as those of individuals within species. Such qualities are monitored over successive growing seasons, and the interfertility of all species (once flowering) is assessed by fruit set, seed set and pollen tube growth using fluorescence microscopy.

SPECIES CHARACTERISTICS

The taxonomic classification and ploidy levels of the *Actinidia* species studied are shown in Table 1. Ten of the 52 known species, representing all 4 sections of the genus and all known ploidy levels were included, although in some cases only one sex was represented. Accessions of all the collected species originate from a large and climatically diverse area of eastern Asia.

Table 1. Classification and ploidy of the *Actinidia* species studied. *Chromosome numbers:* 2x = 58, 4x = ca. 116, 6x = ca. 170 (Li 1952, Liang 1984, Liang and Ferguson 1984, M. McNeilage pers. comm.).

Species	Section	Ploidy
A. arguta (Sieb. et Zucc.) Planch. ex Miq. var. *arguta*	Leiocarpae	4x
A. arguta var. *purpurea* (Rehd.) C.F. Liang[2]	Leiocarpae	4x
A. arguta var. *rufa* (Sieb. et Zucc.) Maxim.	Leiocarpae	2x
A. melanandra Franch. var. *melanandra*[2]	Leiocarpae	2x
A. polygama (Sieb. et Zucc.) Maxim	Leiocarpae	2x
A. callosa Lindl. var. *henryi* Maxim.[2]	Maculatae	2x
A. hemsleyana Dunn. var. *hemsleyana*	Strigosae	2x
A. eriantha Benth. form *eriantha*	Stellatae	2x
A. chinensis Planch. var. *chinensis*	Stellatae	2x
A. deliciosa (A. Chev.) C.-F. Liang et A.R. Ferguson var. *deliciosa*	Stellatae	6x

[2] Only one sex represented

The range of variation among the species in characters of interest in the breeding programme, is shown in Table 2. Each of the main yield components showed extensive variation (Table 3). Fruit size was particularly variable but the largest fruits were all from *A. deliciosa*. Mid-flowering (50% buds open) was reached in mid-October in *A. chinensis* but not until late December in *A. eriantha* and *A. polygama* (Table 4). The timing of fruit maturity also varied between species but did not necessarily correlate with flowering times, ie. *A. arguta* flowered in mid-November and the fruit matured late in February, while *A. chinensis*

Table 2. Variation in characters among ten *Actinidia* species.

Yield components	
- precocity	2 to 5$^+$ years
- bud break	10% to 60%
- flowering axils per shoot	1 to 9
- flowers per axil	1 to 9
- fruit size	4 to 127 g
Flowering season	early October to late January
Fruit maturity	late February to mid June
Fruit characters	
- storage life	1 week to 6 mths
- flavours	wide range
- flesh colour	greens and yellows
- vitamin C content	up to 720 mg/100 g fresh weight
- hairiness	glabrous to densely tomentose
- skin type	edible/inedible
- skin colour	green/brown/yellow/white

flowered in October and the fruit matured in April. There was also considerable interspecific variation in other vine characters such as cold hardiness and vigour.

Fruit storage life at or near 0°C was very variable. In some species, such as *A. arguta*, the fruit softens rapidly on the viine before abscising, while in others the fruit ripens slowing without abscission. Flavour components have been assessed organoleptically and analytically (H. Young, pers. comm.). While fruit of most species tends to be edible but unpalatable, a few show a new and rich fruitiness reminiscent of an exotic fruit. Various shades and intensities of green and yellow flesh colour were found among the species. Yellow coloured flesh has not been found in *A. deliciosa* accessions. Vitamin C content, considered to be high in *A. deliciosa* (126 mg/100g fresh weight) (Huang *et al.*, 1983), was found to reach values nearly 6 times higher in *A. eriantha* (720 mg/1]] gfresh weight) (Bank, 1985). Skin types ranged from the hairless, edible types of *A. arguta* to the coarsely tomentose, chewy types typical of *A. deliciosa.*

Table 3. Major yield components of some *Actinidia* species. Different letters denote differences significant at the 5% level, except for fruit size where differences are significant at the 1% level.

Species	Flowers per bud						Fruit size (g)		
	male			female			female		
	mean	range	n	mean	range	n	mean	range	n
A. arguta arguta	4.80 b	0.69-10.0	12	0.65 a	0-3.49	7	5.94 a	3.4-8.2	11
A. arguta purpurea	15.0 c	-	1	n.a.			n.a.		
A. callosa	1.21 a	1.1-1.3	2	n.a.			n.a.		
A. chinensis	4.15 b	0.38-11.6	15	0.98 a	0.05-3.19	15	41.4 d	21-60	16
A. deliciosa				2.51 b	1.13-5.69	9	64.2 e	19-127	158
A. eriantha	19.1 c	11.5-28.3	9	4.81 b	1.49-9.02	15	14.2 c	8.1-23	66
A. hemsleyana	7.96 bc	-	1	1.94 ab	-	1			
A. melanandra	5.99 b	-	1	n.a.			n.a.		
A. polygama	13.1 c	5.14-18.4	5	4.07 b	1.52-12.7	6	8.78 b	6.4-11	18
A. rufa	15.3 c	2.14-31.6	6	1.25 a	0.28-2.06	4	14.5 c	8.6-24	29

Table 4. Seasonal data for some *Actinidia* species.

Species	50% Flowering dates (1985)						Onset of fruit maturity
	male			female			female
	mean	range	n	mean	range	n	
A. arguta arguta	22.11	18-28.11	11	10.11	14-24.11	5	late February
A. arguta purpurea	25.12	-	1	n.a.			n.a.
A. callosa	1.12	-	2	n.a.			n.a.
A. chinensis	25.10	13.10-3.11	15	25.10	19.10-3.11	12	early - mid April
A. deliciosa		10-30.11			9-30.11		mid April
A. eriantha	14.12	10-17.12	9	15.10	9-20.12	17	late April
A. hemsleyana	10.12	-	1	3.12	-	1	
A. melanandra	10.11	-	2	n.a.			n.a.
A. polygama	6.12	21.11-12.12	9	6.12	21.11-21.12	17	mid - late March
A. rufa	9.12	6-11.12	6	4.12	2-7.12	4	mid June?

AN INTERSPECIFIC HYBRID: *A. ARGUTA X A. DELICIOSA*

This cross if of particular interest since *A. arguta* has some qualities of commercial interest, such as hairless, green, edible skins, early fruit maturity, new flavour components and more cold hardiness than *A. deliciosa.* However, it also has some less desirable traits including short storge life, small fruit, and on-vine softening and abscission of the fruit. In addition, individual berries ripen at significantly different times, even on the same inflorescence. This makes harvesting particularly difficult as there is little if any visible change in the appearance of the fruit as it matures and ripens.

When the tetraploid *A. arguta* was used as the pistillate parent, and the hexaploid A. deliciosa as the staminate parent, as many as 50% of the flowers pollinated set fruit. The number of seed set per fruit was as good as from an intraspecific control cross. Seed size and embryo development were also comparable to that in controls, and fertilisation occurred within two days of pollination.

In the reciprocal cross, however, no fruit was set. While pollen tube growth occurred, fertilisation did not take place within three days of pollination. The styles of *A. deliciosa* were much longer than those of *A arguta* and pollen vitality may be lost before the sperm nuclei reach the ovules. Pollen tubes did not show striking abnormalities, but their growth was retarded.

The F1 hybrid had a chromosome number of about 140 which was intermediate between that of its parents, indicating pentaploidy. Most vegetative and floral characters were intermediate between the two parents, but the fruit largely resembled that of the pistillate *A. arguta* parent (Table 5).

All of the hybrids showed a marked decrease in vigour compared to the parents. Some had leaves which tended to curl upwards at the margins, but this feature showed variable expression both within and between vines. New season's shoots of *A. arguta* and the hybrid did not have the long red hairs typical of *A. deliciosa.*

Pollen quality in the hybrid was very poor, probably because of chromosome imbalance resulting from pentaploidy. Staining with 2% acetocarmine showed at most only 5% of the grains from staminate vines had stainable contents. *In vitro* germination confirmed this lack of quality. Total pollen production also seemed to be low. As a result, the hybrid plants were poor staminate parents in full sib and backcrosses; seed production was very low but seed quality was high (as determined by morphological development). More successful seed production was achieved when the hybrid was used as a pistillate parent.

Table 5. Flower and fruit comparisons of populations of one interspecific hybrid and its parents. Flowering dates are for the 1985 season; dates for the parental species are for the particular lines used in the cross.

	A. arguta	*A. deliciosa*	*Fl hybrid*
50% flowering	20 Nov	29 Nov	24 Nov
Flower size	small	large	intermediate
Anther colour	black	yellow	yellow/brown
Fruit maturity	early	late	intermediate
Fruit size	small	large	small
Skin colour	green	brown	green
Hairs	absent	present	absent
Hayward marks	absent	present	present

OTHER SPECIES CROSSES

A large range of reciprocal interspecific crosses have been made over the last two flowering seasons. The large number attempted has meant that relatively few flowers (10 to 50) were pollinated for each cross combination.

A continuum of interfertility was found. Some crosses set no fruit, some set fruit which abort before maturity, others produced mature fruit where seed quality was extremely poor, and in several crosses good fruit and seed set were obtained. Failure of some combinations due to embryo abortion could be overcome by the use of embryo culture techniques to rescue hybrids deemed to be of value.

Crosses between ploidy levels tended to be more successful if the pistillate parent had the lower chromosome number. Exceptions to this occurred but the seed quality was very poor and such combinations were usually between closely related species. Crosses within major taxonomic groups tended to be more successful than those between groups. Some results suggested that there may be genotypic differences in compatibility in species crosses. Pollen fertility, as judged by *in vitro* germination, was also highly variable. Some genotypes had poor fertility in the medium used. However, one cannot discount the possibility of other media being more suited to some genotypes or species.

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