

Analysis of tetraploid-diploid hybrids in cultivated potatoes

H. DE JONG and G. C. C. TAI

Agriculture Canada Research Station, Fredericton, New Brunswick, Canada

Accepted for publication: 8 December 1976

Zusammenfassung, Résumé p. 120

Keywords: Phureja; Stenotomum; heterosis; Combining ability; gametes; haploid.

Summary

Progeny families of 4x-2x hybrids between Group Tuberosum and Group Phureja-haploid Group Tuberosum hybrids were evaluated under simulated commercial agricultural practices in 1974 and 1975. The range of the observed values for the 4x-2x hybrids exceeded the range of the 4x parents for nearly all measured traits. The mean for total yield of the 4x-2x hybrids was equal to (1974 experiment) or significantly higher (1975 experiment) than the mean of the 4x parents. In the 1975 experiment 17.8% of the 4x-2x hybrids produced a higher total yield than the highest yielding 4x parents. The 4x-2x hybrids exhibited a significantly lower mean than the 4x parents for marketable yield and tuber weight but transgressive segregants were found for these traits in both experiments. The heterosis and variability of the hybrids indicates that this breeding method is a potentially powerful tool in potato improvement.

Introduction

The cultivated diploid ($2n = 2x = 24$) Groups Phureja and Stenotomum represent a valuable reservoir of genetic diversity which can be used to broaden the genetic base of tetraploid ($2n = 4x = 48$) Group Tuberosum cultivars and breeding stocks. This germ plasm can now readily be transferred to 4x Tuberosum by means of 2n gametes from 2x parents (Hanneman & Peloquin, 1969; Mendiburu, 1971).

Several workers have reported heterotic effects when tetraploid Group Tuberosum cultivars are crossed with Group Phureja - haploid Group Tuberosum hybrids (Hanneman & Peloquin, 1969; Mendiburu, 1971; Mok & Peloquin, 1975a; Quinn & Peloquin, 1973). Progenies from 4x - 2x matings are especially high yielding if the diploid parents produce 2n gametes by a mechanism which is equivalent to first division restitution (Mendiburu, 1971; Mok & Peloquin, 1975a). A breeding scheme similar to the approach proposed by Mendiburu et al. (1974) is currently being evaluated in the Canadian National Potato Breeding Project, with headquarters at Fredericton, N.B. The purpose of this research was to assess the 4x - 2x breeding method, utilizing well-adapted Tuberosum cultivars and breeding stocks and evaluating the progenies under simulated commercial agricultural practices in Canada.

Materials and methods

Two 2x Group Phureja – haploid Group Tuberosum hybrids, W5295.7 and W5337.3, both of which are known to form diplandrous gametes by the parallel spindle mechanism (Mok & Peloquin, 1975b) were used as male parents with several 4x Group Tuberosum female parents. In the 1974 experiment 14 4x – 2x hybrid families were investigated. This experiment included 12 4x parents of which ten were crossed to one of the 2x parents and two were crossed to both 2x parents. In the 1975 experiment progenies from each of eight 4x parents and both 2x parents were studied (Table 1).

Seedlings were raised in the greenhouse. One tuber was saved from each genotype and planted in the field the following season in a single hill planting. At harvest time ten genotypes were randomly selected from each family for the field experiment in the following season.

In both experiments the clones under observation were planted in two replicates of five hills. The 4x parents were treated in the same manner as their progeny. In

Table 1. Families of 4x–2x hybrids.

1974 experiment ¹			1975 experiment ¹		
family ²		number of genotypes analysed ³	family ²		number of genotypes analysed ³
Bake King	· W 5337.3	8	Belleisle	· W 5295.7	10
Green Mountain	· W 5337.3	9	Belleisle	· W 5337.3	9
Hunter	· W 5337.3	8	Dorita	· W 5295.7	8
Katahdin	· W 5337.3	7	Dorita	· W 5337.3	9
Kennebec	· W 5295.7	10	RU-18	· W 5295.7	10
Raritan	· W 5295.7	9	RU-18	· W 5337.3	9
Raritan	· W 5337.3	9	F61008	· W 5295.7	10
Red Pontiac	· W 5295.7	10	F61008	· W 5337.3	10
Superior	· W 5337.3	10	F61019	· W 5295.7	10
F56047	· W 5295.7	8	F61019	· W 5337.3	10
F58050	· W 5295.7	8	F61025	· W 5295.7	9
F62008	· W 5295.7	9	F61025	· W 5337.3	10
F62008	· W 5337.3	9	F66076	· W 5295.7	10
F64068	· W 5337.3	10	F66076	· W 5337.3	10
			F67114	· W 5295.7	10
			F67114	· W 5337.3	10
Total ⁴		124	Total ⁴		154

¹ Versuch – Expérimentation; ² Familie – Famille; ³ Zahl der untersuchten Genotypen – Nombre de génotypes étudiés; ⁴ Insgesamt – Total.

Tabelle 1. Familien von 4x–2x Hybriden.

Tableau 1. Familles d'hybrides 4x–2x.

both experiments one plot of each 4x parent was planted along with its respective progeny family in each replicate. In the 1974 experiment each replicate was planted with 140 progeny plots (14 families; 10 genotypes per family) and 14 4x parent plots (12 parents, two of which had duplicate plots). In the 1975 experiment 160 progeny plots (16 families; 10 genotypes per family) and 16 parent plots (8 parents, each of which had duplicate plots) were planted in each replicate.

Seed pieces were cut to approximately 35 g and spaced 25.4 cm within rows and 91.4 cm between rows. The 1974 experiment was planted at the Potato Breeding Substation at Alma, N.B. on 28 May and harvested on 2 October (127 days). The 1975 experiment was planted at the Potato Breeding Substation at Benton Ridge, N.B. on 22 May and harvested on 2 October (133 days). Due to the necessity of maintaining a high standard of plant hygiene, certain plots were rogued out during the growing season because they showed some symptoms of virus infection. In 1974 and 1975, respectively, 7.8% and 0.9% of the plots had to be discarded as a result of this procedure. The number of genotypes per family which could be analysed ranged from 7 to 10 in the 1974 experiment and from 8 to 10 in the 1975 experiment (Table 1). Data of 13 and 14 4x parent plots per replicate in the 1974 and 1975 experiments, respectively, were used in the analysis.

The following traits were measured:

1. *Early vigour* – measured when approximately 90% of the plants had emerged. Clones were rated on a scale from 0 (no emergence) to 5 (very vigorous).
2. *Top vigour* – based on total amount of foliage – measured approximately two weeks before harvest on a scale from 1 (very weak) to 5 (very vigorous).
3. *Maturity* – measured approximately two weeks before harvest on a scale from 1 (very mature) to 5 (very immature).
4. *Number of main stems* – number of separable main stems per 5-hill plot counted at harvest.
5. *Marketable yield* – weight of all tubers ≥ 5.7 cm in kg per plot.
6. *Total yield* – weight of all tubers in kg per plot.
7. *Number of tubers per plot*.
8. *Tuber weight* – total yield per plot in g/number of tubers per plot.
9. *Specific gravity* – weight in air/(weight in air – weight in water).

The analysis of variance was computed according to the mixed design by Myers (1966). The test of significance was determined by treating families as fixed effects and hybrids within families as random effects. Data of 4x parents were first analysed independently and then jointly with the progeny data to compare the overall difference between 4x - 2x hybrids and their 4x parents. The factorial type of crossing plan of the 1975 experiment (Table 1) enabled us to investigate the family effects due to 4x parents, 2x parents as well as the interaction between 4x and 2x parents. These variations were treated as fixed effects.

Results

The range of the observed values for the 4x – 2x hybrids exceeded the range of the 4x parents for nearly all measured traits in both experiments (Table 2). The 4x – 2x hybrids exhibited a significantly higher mean than the 4x parents for top vigour, maturity, number of main stems and number of tubers in both experiments. The hybrids were found to have a significantly lower mean than the 4x parents for marketable yield and tuber weight in both experiments. No significant differences could

Table 2. Means and ranges of 4x–2x hybrids and 4x parents.

	4x–2x hybrids ¹		4x parents ²		Significant difference ⁵ †
	mean ³	range ⁴	mean ³	range ⁴	
<i>1974 experiment⁶</i>					
Early vigour ⁷ (0–5)	3.75	0.5–5	3.46	2–5	n.s.
Top vigour ⁸ (0–5)	4.66	2–5	4.27	3–5	**
Maturity ⁹ (1–5)	4.19	2.5–5	4.01	2.7–5	*
Main stems per plot ¹⁰	17.99	9–38	14.08	7–21	**
Marketable yield (kg/plot) ¹¹	2.66	0–7.28	4.16	2.32–6.47	**
Total yield (kg/plot) ¹²	5.42	2.75–8.18	5.46	3.90–6.92	n.s.
Number of tubers per plot ¹³	68.54	24–136	40.96	25–64	**
Tuber weight (g/tuber) ¹⁴	86.04	30.40–310.90	140.55	89.4–216.3	**
Specific gravity ¹⁵	1.085	1.059–1.139	1.082	1.069–1.104	n.s.
<i>1975 experiment</i>					
Early vigour	2.04	0–5	2.14	1–4	n.s.
Top vigour	4.66	3–5	4.28	3.5–5	**
Maturity	4.43	2–5	4.02	3–5	**
Main stems per plot	20.74	5–50	13.43	7–24	**
Marketable yield	2.64	0–6.35	3.63	0.54–5.31	**
Total yield	4.99	1.99–10.57	4.56	2.63–5.80	**
Number of tubers per plot	69.45	26–173	35.11	17–69	**
Tuber weight	78.32	22.53–340.90	148.92	47.80–277.47	**
Specific gravity	1.083	1.060–1.104	1.090	1.077–1.103	**

† n.s. = non-significant – Nicht signifikant – Non-significative; * $P < 0.05$; ** $P < 0.01$.

¹ Hybrid – Hybride; ² Eltern – Géniteurs; ³ Durchschnitt – Moyennes; ⁴ Schwankungsbereich – Classement; ⁵ Signifikante Unterschiede – Différence significative; ⁶ Versuch – Expérimentation; ⁷ Auflaufbonitur – Vigueur à la levée; ⁸ Bonitur zum optimalen Wachstumszeitpunkt – Vigueur en végétation; ⁹ Reife – Maturité; ¹⁰ Zahl der Hauptstengel pro Parzelle – Nombre de tiges principales par parcelle; ¹¹ Marktfähiger Ertrag (kg/Parzelle) – Rendement commercialisable (kg/parcelle); ¹² Gesamtertrag (kg/Parzelle) – Rendement total (kg/parcelle); ¹³ Zahl der Knollen pro Parzelle – Nombre de tubercules par parcelle; ¹⁴ Knollengewicht (g/Knolle) – Poids du tubercule (g/tubercule); ¹⁵ Spezifisches Gewicht – Poids spécifique.

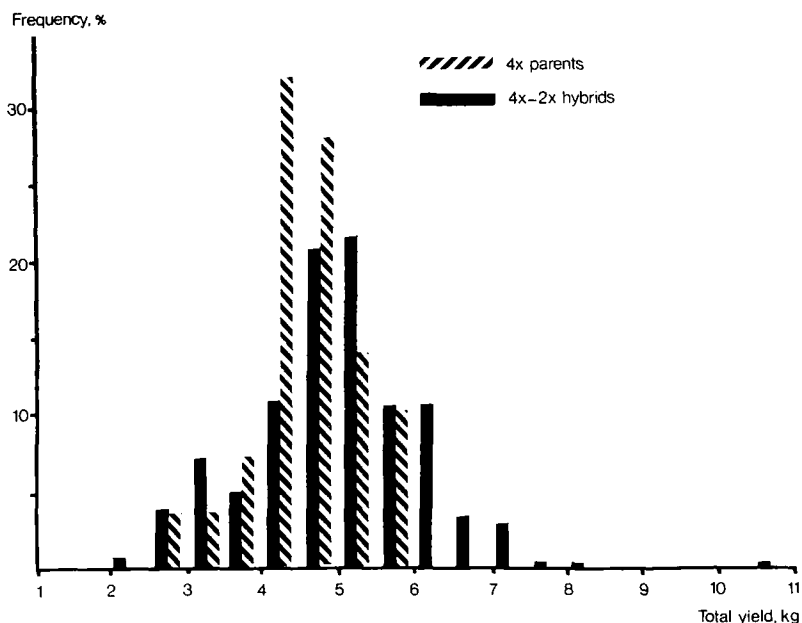
Tabelle 2. Durchschnitt und Schwankungsbereich der 4x–2x Hybriden und 4x Eltern.
Tableau 2. Moyennes et classements des hybrides 4x–2x et des géniteurs 4x.

be detected between the means of the 4x – 2x hybrids and the 4x parents for early vigour in both experiments and for total yield and specific gravity in the 1974 study. In the 1975 trial the mean for total yield of the 4x – 2x hybrids was significantly higher at $P < 0.01$ than the mean of the parental 4x clones (Table 2). In this experiment 17.8% of the 4x – 2x hybrids produced a higher total yield than the best 4x parents (Fig. 1).

Families of 4x – 2x hybrids were significantly different in both experiments for number of main stems, number of tubers, tuber weight and specific gravity. In the 1975 experiment families also differed significantly in early vigour and both marketable and total yield. Significant differences at $P < 0.01$ were observed between 4x – 2x hybrids within families for all traits in both experiments (Table 3; the analysis of variance of the 1974 experiment is omitted to save space).

Highly significant differences were observed in 1975 between families from different 4x parents for all measured traits except top vigour and maturity (Table 3). A comparison of the families derived from the two 2x parents in the 1975 experiment showed significant differences between these two parents for all traits except number of main stems and total yield (Tables 3 and 4). Families obtained from W5295.7 were more

Fig. 1. Frequency distribution for total yield in the 1975 experiment.



Frequency – Häufigkeit – Fréquence; Total yield – Gesamtertrag – Rendement total; Parents – Eltern – Géniteurs; Hybrids – Hybriden – Hybrides

Abb. 1. Häufigkeitsverteilung für den Gesamtertrag des Versuches von 1975.

Fig. 1. Distribution des fréquences pour le rendement total de l'expérimentation de 1975.

Table 3. Analysis of variance of the 1975 experiment.

Source of variance ¹⁶		D.f. ¹⁷	Mean squares ¹⁸ †		market- able yield ¹¹	total yield ¹²	number of tubers ¹³	tuber weight ¹⁴	specific gravity ¹⁵ ($\times 10^{-6}$)
Replicates ¹⁹	1	9.67**	3.28*	0.54	381.44**	4.89**	0.30	348.50	125.50**
4x-2x hybrids ¹ & 4x parents ²	167	1.33**	0.27**	0.55**	68.02**	2.86**	1.85**	2468.17**	144.81**
4x-2x hybrids	153	1.34**	0.25**	0.53**	62.06**	2.77**	1.93**	1343.33**	142.85**
Families ²⁰	15	3.58*	0.47	0.83	144.70**	11.06**	5.09**	5318.48**	503.83**
4x parents	7	4.55**	0.35	0.73	217.15**	20.89**	7.68**	9609.68**	427.71**
2x parents	1	7.17*	2.11**	2.19*	70.16	8.49*	0.19	5142.00*	4541.50**
4x parents & 2x parents	7	2.10	0.36	0.75	82.91	1.61	3.21	1052.50	3.14
4x-2x hybrids within families	138	1.10**	0.23**	0.49**	53.08**	1.87**	1.59**	911.25**	103.62**
4x-2x hybrids & replicates	153	0.46	0.08	0.16	19.60	0.50	0.68	339.23	19.16
Families & replicates	15	0.86*	0.10	0.29*	22.48	0.51	0.65	424.35	28.67
4x-2x hybrids w.f. & replicates	138	0.42	0.07	0.15	19.29	0.49	0.68	329.98	18.12
4x parents	13	1.26*	0.17	0.59**	24.30	2.21**	0.68	5282.98**	83.68*
4x parents & replicates	13	0.34	0.07	0.07	26.22	0.43	0.33	1059.70	27.24
4x-2x hybrids vs. 4x parents	1	0.26	3.61**	4.40**	1372.14**	25.30**	4.89**	126101.00**	1238.72**
(4x-2x h. & 4x p.) & replicates	167	0.45	0.07	0.15	20.78	0.49	0.65	455.36	19.57

* $P < 0.05$; ** $P < 0.01$.

† Units as in Table 2 – Einheiten wie in Tabelle 2 – Unités comme tableau 2

1, 2, 7, 15 Siehe Tabelle 2 – Voir tableau 2; 16 Varianzquelle – Source de la variation; 17 Freiheitsgrade – Degrés de liberté; 18 Quadrat der Mittelwerte – Variance; 19 Wiederholungen – Répétitions; 20 Familien – Familles

Tabelle 3. Varianzanalyse des Versuchs von 1975.

Tableau 3. Analyse de la variance pour l'expérimentation de 1975.

Table 4. Means of 4x-2x hybrid families derived from diploid parents in 1975 experiment.

	Diploid parent ¹		Significant difference ²
	W 5295.7	W 5337.3	
Early vigour ⁷ (0-5)	1.89	2.19	*
Top vigour ⁸ (1-5)	4.58	4.74	**
Maturity ⁹ (1-5)	4.34	4.51	*
Main stems per plot ¹⁰	20.30	21.25	n.s.
Marketable yield (kg/plot) ¹¹	2.81	2.48	*
Total yield (kg/plot) ¹²	5.00	4.99	n.s.
Number of tubers per plot ¹³	65.11	73.79	**
Tuber weight (g/tuber) ¹⁴	82.38	74.24	*
Specific gravity ¹⁵	1.086	1.079	**

* $P < 0.05$; ** $P < 0.01$.

¹ *Diploide Eltern – Géniteurs diploïdes*; ² *Signifikante Unterschiede – Différence significative*;

⁷⁻¹⁵ *Siehe Tabelle 2 – Voir tableau 2.*

Tabelle 4. Mittelwerte des Versuches von 1975 der 4x-2x Hybridfamilien, die von diploiden Eltern abstammen.

Tableau 4. Moyennes des familles d'hybrides 4x-2x issues des géniteurs diploïdes dans l'expérimentation de 1975.

mature, produced a higher yield of marketable tubers, a higher tuber weight and a higher specific gravity than families derived from W5337.3 (Table 4). No significant interactions could be detected between the 4x and 2x parents (Table 3).

Discussion

The experiments reported here were designed to measure the potential usefulness of the 4x – 2x breeding method, by testing the hybrids under presently accepted commercial agricultural practices in Canada. This applies particularly to plant spacing which in these experiments were 91.4 cm between rows and 25.4 cm within rows. The reports by previous authors (Mendiburu, 1971; Mok & Peloquin, 1975a) of heterosis for yield in 4x – 2x hybrids were based on plant spacings of 91.4 cm between rows and, depending on location, 45.7 cm or 81.3 cm within rows. We have found that the performance of individual clones at such wide spacings is not necessarily indicative of their performance under the closer spacings which are at present standard commercial practice. The 4x parents used in these experiments were originally selected for their performance under the same commercially practiced spacings. A comparison between these breeding stocks and other genetic material under a considerably different spacing could penalize the 4x parents. Since the mean number of tubers per plot from the 4x hybrids is nearly twice as high as the mean number from the 4x parents (Table 2), a wider spacing will favour the hybrids more than the

4x parents. The experiments reported here have, therefore, exposed the 4x – 2x hybrids to greater stresses than the previously reported studies with similar genetic material (Mendiburu, 1971; Mok & Peloquin, 1975a).

The mean for total yield of the 4x – 2x hybrids was equal to (1974) or 9% higher (1975) than the mean of the 4x parents (Table 2). This represents an improvement over yields of families from 4x – 4x (intra *Tuberosum*) crosses. Mok & Peloquin (1975a) and Tai (1974) indicated that the family mean for total yield of such matings is frequently below the yield of the parents. Mok & Peloquin (1975a) reported a 35% yield increase in their 4x – 2x hybrids (derived from diploids which produce 2n gametes via first division restitution) above the yield of their 4x parents over two locations. The above-mentioned stresses to which the material was exposed in our experiments is probably the principal cause of the reduction in heterosis when our means for total yield are compared with those of Mok & Peloquin (1975a).

In an asexually propagated crop such as the potato, where a single superior genotype can immediately be multiplied, the range is also a very meaningful measure. A genetic advance can be made with a mating if the upper end of the range of the progeny exceeds the best parent, regardless of the mean. In both experiments the 4x – 2x hybrids produced a mean marketable yield which was considerably below the mean of the 4x parents. However, the best hybrids exceeded the best parents in marketable yield in both experiments (Table 2). The fact that certain hybrids produced no marketable yield at all is no serious disadvantage since such genotypes can quickly be eliminated from a breeding program. The range of the hybrids also exceeded the range of the 4x parents in nearly all other measured traits (Table 2).

The highly significant differences for nearly all measured traits between families derived from different 4x parents (Table 3) suggest considerable differences in general combining ability for these traits among the 4x parents when they are mated with the two 2x parents. No significant differences could be detected among the 4x parents themselves for total yield. This indicates that the value of these clones as parents for total yield cannot be determined from their own performance but must be assessed by progeny analysis.

Differences in general combining ability also exist between the two 2x parents (Tables 3 and 4). The absence of significant differences among the 4x parents $\times$ 2x parents interaction shows that specific combining ability did not play a significant role in these experiments. This contradicts the results of Mok & Peloquin (1975a) who found that general combining abilities of both 4x and 2x parents were not significant and that only specific combining ability contributed to the differences between families of 4x – 2x hybrids. If a broader spectrum of 2x parents had been available, we might also have been able to detect a significant specific combining ability.

Mendiburu (1971) and Mok & Peloquin (1975b) have shown that the two diploid parents used in this study produce 2n gametes by the parallel spindle mechanism, which is genetically equivalent to first division restitution. Thus a large amount of heterozygosity can be transferred from the diploid parent to the 4x progeny. There

is now considerable evidence for the hypothesis that the heterosis exhibited by the $4x - 2x$ hybrids is related to the amount of heterozygosity which is transferred to the progeny via the $2n$ gamete from the (heterozygous) diploid parent (Kidane-Mariam & Peloquin, 1974; Mendiburu, 1971; Mok & Peloquin, 1975a). In their discussion on heterosis for yield in *Tuberosum*-*Andigena* and reciprocal hybrids, Tarn and Tai (in press) suggested that a judicious combination of yield components in the parents can also result in hybrid vigour for yield. If total yield is considered as the multiplicative interaction of tuber number and tuber weight then a proper combination of these factors can result in heterosis. The combination of the relatively high tuber weight of the $4x$ parents with the relatively high tuber number of the x parents could then lead to a high total yield in the progeny. The heterozygosity and yield component hypotheses are not necessarily mutually exclusive but can be considered as complementing one another. Both hypotheses require a careful choice of parents for the exploitation of heterosis.

Since the genetic variability of the Group *Tuberosum* material appears to be more limited than that of the cultivated diploid Groups *Phureja* and *Stenotomum* or of hybrids derived from them and haploids of Group *Tuberosum*, it is quite likely that intensive breeding and selection on the diploid level can produce $2x$ parents with a considerably greater combining ability in $4x - 2x$ hybridization than the $2x$ parents which were used in these experiments. This expectation is reinforced by the facts that (1) significant differences in general combining ability for all but two of the measured traits were found between the two diploid parents (Table 4), (2) the mechanisms for $2n$ pollen formation which have been discovered thus far are all controlled by simple recessive mutations (Mok & Peloquin, 1975c) and (3) diplandroid forming clones occur relatively frequently in Groups *Phureja* and *Stenotomum* (Quinn et al., 1974).

Both diploid parents are hybrids between relatively unselected *Phureja* clones and *Tuberosum* haploids. Their progenies in these $4x - 2x$ matings have a considerably higher maturity reading than the $4x$ parents although earlier maturing transgressive segregants do occur (see Table 2). This late maturity can, no doubt, be traced back to the original *Phureja* clones. It, therefore, becomes imperative that selection for daylength response precedes the breeding utilization of primitive cultivated material such as *Phureja* or *Stenotomum*. In this 'pre-breeding' period, selection should also be made for other horticultural traits such as tuber type and eye depth. Our general observations about tuber appearance agree with those of Quinn & Peloquin (1973) where they suggest a fairly high narrow sense heritability for tuber appearance. Many of the $4x - 2x$ hybrids resembled the $2x$ parents in appearance - they had deep eyes and a tuber type which was considerably less attractive than that of the $4x$ parents.

The overall response of the $4x - 2x$ hybrids has been very encouraging under the simulated commercial agricultural practices in Canada. A broader utilization of this breeding method must await the development of more adapted diploid parents. Since several potato breeding programs around the world are now including cultivated diploids in their breeding efforts, such clones will probably be developed in

the near future. Potato breeders will then have an even more powerful tool to produce superior high-yielding breeding stocks and cultivars.

Acknowledgments

The technical assistance of Mr R. H. Brown and Miss V. J. Burns and the consultation of other members of the National Potato Breeding Project are gratefully acknowledged. The authors thank Dr S. J. Peloquin, University of Wisconsin, for supplying the diploid parents.

Zusammenfassung

Analyse tetraploid-diploider Hybriden in Kulturkartoffeln

Zwei Gruppen von Phureja-haploiden Tuberosumhybriden, von denen bekannt ist, dass sie diplandroide Gameten durch den Parallelspindelmechanismus bilden, wurden als männliche Elternteile für verschiedene weibliche Eltern der Gruppe Tuberosum benutzt (Tabelle 1). Nachkommenschaften aus 4x-2x-Kreuzungen wurden 1974 und 1975 unter ähnlichen landwirtschaftlichen Bedingungen geprüft. Der Schwankungsbereich der gemessenen Werte für die 4x-2x Hybriden überstieg den der 4x Eltern in nahezu allen gemessenen Merkmalen in beiden Versuchen. Die 4x-2x Hybriden hatten einen signifikant niedrigeren Durchschnittswert für marktfähigen Ertrag und Knollengewicht, aber in beiden Versuchen wurden transgressive Abweichungen für diese Merkmale gefunden (Tabelle 2). 1975 ergaben 17,8% der 4x-2x Hybriden einen höheren Gesamtertrag als die besten 4x Eltern (Abb. 1).

1975 wurden hoch signifikante Unterschiede bei fast allen gemessenen Merkmalen zwischen

Familien gefunden, die von verschiedenen 4x Eltern abstammen (Tabelle 3). Das deutet auf beträchtliche Unterschiede dieser Merkmale in der allgemeinen Kombinationsfähigkeit in den 4x Eltern hin. Unterschiede in der allgemeinen Kombinationsfähigkeit bestehen auch zwischen den zwei 2x Eltern (Tabellen 3 und 4). Zwischen den 4x und 2x Eltern konnten keine signifikanten Wechselwirkungen beobachtet werden (Tabelle 3).

Das Gesamtergebnis der 4x-2x Hybriden war sehr ermutigend. Ein breiterer Gebrauch dieser Züchtungsmethode hängt von der Entwicklung kultivierter diploider Eltern ab, in denen das Merkmal diplandroider Bildung mit relativ früher Reife und anderen Eigenschaften wie Knollenform und Augentiefe kombiniert ist. Wenn solche Klone verfügbar werden, werden die Kartoffelzüchter ein noch mächtigeres Werkzeug haben, um Zuchtstämme und Sorten mit hohen Erträgen zu züchten.

Résumé

Etude d'hybrides de pommes de terre tétraploïdes-diploïdes

Deux hybrides issus du groupe Phureja haploïde-groupe Tuberosum, connus pour leurs gamètes diplandres obtenus par le mécanisme du fuseau parallèle, ont été utilisés comme géniteurs mâles, avec plusieurs géniteurs femelles du groupe Tuberosum (tableau 1).

La descendance d'hybrides 4x-2x a été étudiée dans des conditions similaires à celles

de la pratique en 1974 et 1975. Le classement des valeurs observées pour les hybrides 4x-2x est supérieur à celui des géniteurs 4x pour presque tous les critères évalués dans les deux essais. Les hybrides 4x-2x ont en moyenne un rendement commercialisable et un poids par tubercule significativement inférieurs aux géniteurs 4x, mais une transgression est observée pour

ces caractères dans les deux essais (tableau 2).

Dans l'essai de 1975, 17,8% des hybrides 4x-2x ont donné un rendement total supérieur aux meilleurs géniteurs 4x (fig. 1).

Des différences hautement significatives ont été mises en évidence en 1974 pour presque tous les critères mesurés, entre des familles issues de différents géniteurs 4x (tableau 3). Ceci suggère qu'il existe en général de grandes différences dans l'aptitude à la recombinaison de ces critères parmi les géniteurs l'aptitude à la recombinaison de ces critères parmi les géniteurs 4x. Des différences se retrouvent également entre les parents 2x (tableaux 3 et 4). Aucune interac-

tion significative n'a pu être détectée entre les géniteurs 4x et 2x (tableau 3).

Les résultats obtenus avec les hybrides 4x-2x sont très encourageants. Une plus large utilisation de cette méthode suppose l'obtention de géniteurs diploïdes dans lesquels la formation du caractère diplandre est associée à une maturité relativement plus précoce et à d'autres caractéristiques agronomiques telles que le type de tubercule et la profondeur des yeux. Quand de tels clones seront disponibles, les obteneurs auront un outil encore plus puissant pour produire du matériel génétique de haut rendement et des variétés.

References

- Hanneman, R. E. Jr. & S. J. Peloquin, 1969. Use of Phureja and haploids to enhance the yield of cultivated tetraploid potatoes. *Am. Potato J.* 46: 436.
- Kidane-Mariam, H.-M. & S. J. Peloquin, 1974. The effect of direction of hybridization (4x × 2x vs. 2x × 4x) on yield of cultivated potatoes. *Am. Potato J.* 51: 330-336.
- Mendiburu, A. O., 1971. The significance of 2n gametes in potato breeding and genetics. Ph.D. Thesis, University of Wisconsin, 89 pp. University Microfilms, Ann Arbor, Mich. (Diss. Abstr. 32: 1387B.)
- Mendiburu, A. O., S. J. Peloquin & D. W. S. Mok, 1974. Potato breeding with haploids and 2n gametes. In: K. J. Kasha (Ed.), Haploids in higher plants. Advances and potential, p. 249-258. University of Guelph, Guelph.
- Mok, D. W. S. & S. J. Peloquin, 1975a. Breeding value of 2n pollen (diplandroids) in tetraploid × diploid crosses in potatoes. *Theor. appl. Genet.* 46: 307-314.
- Mok, D. W. S. & S. J. Peloquin, 1975b. Three mechanisms of 2n pollen formation in diploid potatoes. *Canad. J. Genet. Cytol.* 17: 217-225.
- Mok, D. W. S. & S. J. Peloquin, 1975c. The inheritance of three mechanisms of diplandroid (2n pollen) formation in diploid potatoes. *Heredity* 35: 295-302.
- Myers, J. L., 1966. Fundamentals of experimental design. Allyn and Bacon, Boston, 407 pp.
- Quinn, A. A., D. W. S. Mok & S. J. Peloquin, 1974. Distribution and significance of diplandroids among the diploid *Solanums*. *Am. Potato J.* 51: 16-21.
- Quinn, A. A. & S. J. Peloquin, 1973. Use of experimental tetraploids in potato breeding. *Am. Potato J.* 50: 415-420.
- Tai, G. C. C., 1974. A method for quantitative genetic analysis of early clonal generation seedlings of an asexual crop with special application to a breeding population of the potato (*Solanum tuberosum* L.). *Theor. appl. Genet.* 45: 150-156.
- Tarn, T. R. & G. C. C. Tai, 1977. Heterosis and variation of yield components in F₁ hybrids between Group Tuberosum and Group Andigena potatoes. *Crop Sci.* (in press).