THE EFFECT OF CYTOPLASMIC SUBSTITUTION ON AGRONOMIC PERFORMANCE AND PRODUCTIVITY IN BRASSICA SPECIES

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INTRODUCTION

Cross compatibility studies within the genus Brassica have demonstrated the possibility of interspecific transfer of economically important traits (Harberd, 1976; Takahata and Hinata, 1983). The Brassicas have been extensively studied through interspecific hybridization (Catchside, 1934; U, 1935; Roebbelen, 1960), but little is known about the effect of the cytoplasm. Although nuclear genetic material is considered of primary importance in breeding, it is the interaction of the nuclear and cytoplasmic materials which affect the phenotypic characteristics of an individual. The objective of this study is to examine the effect of cytoplasms from the three diploid Brassica species on the agronomic performance and productivity of the three amphidiploid species.

MATERIALS AND METHODS

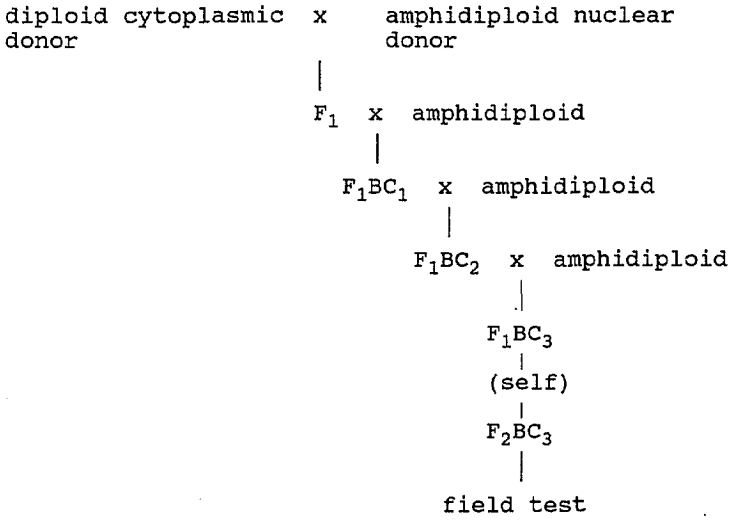
One cultivar each of the amphidiploid species (B. napus L. cv. Westar, B. juncea Czern & Coss cv. Domo and B. carinata A. Braun cv. S67) were used as recurrent male parents in crosses with cultivars or lines of at least two of the three diploid species (B. campestris L. cv. Tobin, B. campestris spp. yellow sarson cv. R500, B. nigra L. line R2591, and B. oleracea L.)(Figure 1). Un-opened immature buds from the cytoplasmic donor species were emasculated and immediately pollinated with fresh pollen from the nuclear donors. Interspecific hybrids were backcrossed two or three times with their respective amphidiploid parent in an attempt to place the nucleus of the amphidiploid parent into the foreign cytoplasm.

First or second generation self pollinated seed from BC_2 and/or BC_3 generations were field tested in 1986 at Saskatoon, Saskatchewan and in 1987 at Homewood, Manitoba. Field tests were arranged in a three replicate split-plot design with recurrent parents as main plots and cytoplasmic donors as sub-plots. Three and six row plots were used at Saskatoon and Homewood, respectively. Spacing between rows was 30.5cm with a seeding rate of 125 seeds per 3m row.

Fifty gram sub-samples were taken from each plot and further dried to less than five percent moisture. Seed oil

contents were estimated for each plot using a Newport Nuclear Magnetic Resonance (NMR) spectrometer. Total nitrogen contents were determined on the oil free meal of each sub-sample using the method of C.G. Youngs as described by Stringam et al. (1974). Hydrolysis of 100mg meal samples was carried out in 100ml micro Kjeldahl tubes. Nitrogen contents were converted to percent protein using the factor 6.25.

Figure 1 Crossing and backcrossing procedures for the production of cytoplasmic substitution lines.



RESULTS

Cytoplasmically substituted amphidiploids were completely fertile in the BC_1 generation; no further change in fertility or plant morphology, relative to the recurrent parent, was observed in subsequent back-cross generations. It was therefore assumed that by the BC_3 generation, used for most comparisons in this study, the substituted amphidiploids were fully reconstituted. Crosses with B. oleracea were unsuccessful and therefore the amphihaploid of B. napus (B. oleracea spp. alboglabra x B. campestris spp. pekinensis) was used as a bridge to transfer the cytoplasm.

Substituted amphidiploids matured earlier or at the same time as their respective recurrent parents (Table 1). The

B. juncea substitutions did not show any adverse effects in performance or quality, relative to the recurrent parent, Domo.

Table 1 Days to flower (DTF), days to mature (DTM), seed yield, seed oil and meal protein content of cytoplasmically substituted lines and recurrent parents, 1986-87.

Nuclear/ cytoplasmic donor	Cultivar or line	DTF	DTM	Yield (g/plot)	Oil (%)	Protein (%)
B. napus cv. Westar[1]						
B. napus	Westar	45	96	896	43.3	43.8
B. campestris	Tobin	44	96	615	42.0	45.9
B. campestris spp. sarson	R500	43	96	759	41.5	43.0
B. nigra	R2591	45	96	815	42.2	42.6
B. oleracea	L16	44	94	828	42.6	43.8
B. juncea cv. Domo[1]						
B. juncea	Domo	37	92	496	36.9	44.1
B. campestris	Tobin	36	88	558	37.3	44.3
B. nigra	R2591[3]	39	87	515	36.2	44.5
B. oleracea	L16	38	87	574	36.8	43.4
B. carinata cv. S67[2]						
B. carinata	S67	52	129	817	34.6	44.2
B. campestris	Tobin	53	128	252	33.5	44.8
B. campestris spp. sarson	R500[4]	52	128	297	31.6	45.7
B. nigra	R2591	51	128	687	31.9	42.2
[1]$LSD_{.05} \geq$				141	0.9	3.1
[2]$LSD_{.05} \geq$				173	1.2	3.1

[3]BC_2, [4]F_2BC_3

The B. oleracea cytoplasm (L16) appeared to have an overall positive effect on the traits measured while the B. campestris and B. nigra cytoplasms from Tobin and R2591 had positive effects on oil content and seed yield, respectively. The B. campestris spp. yellow sarson cytoplasm (R500) had a negative effect on seed yield and oil content. None of the cytoplasms had adverse effects on meal protein content.

DISCUSSION

It was expected that most cultivars, particularly those which have undergone intensive breeding efforts, would be most adversely affected by the substitution of a foreign cytoplasm. The B. napus recurrent parent Westar, for example, has undergone extensive selection for both agronomic performance and quality. Since its release in 1982, Westar has consistently outperformed other B. napus varieties in Western Canada, in most environments. Most modifications to this superior cultivar would probably be deleterious while similar modifications to the other two amphidiploid species, whose cultivars have not been as intensively bred, would be more readily accommodated.

Although this theory is supported by the B. juncea, and in part by the B. napus substitutions, the results of the B. carinata substitutions do not support this assumption.

Cultivar Westar was the subject of extensive selection for not only yield but also seed oil content. It was therefore expected that the seed oil content would behave in a similar manner. Only one B. napus substitution, L16/4*Westar, had a seed oil content equal to that of Westar. Although Westar's maternal parent was B. campestris (Rakow, personal communication), B. oleracea is thought to be the diploid maternal parent of most B. napus cultivars. The high oil content observed in this combination is probably due to a favourable interaction between the Westar nucleus and the L16 cytoplasm. Since none of the substituted lines underwent selection for oil, or any other character, it should be possible to improve seed oil content in this particular line through selection.

The B. juncea substitutions did not differ markedly in seed oil content. Domo, as with other mustard cultivars, has undergone selection for low seed oil content. Any cytonuclear interaction, resulting in a significant change in oil content, would not necessarily be negative if oil contents were lowered.

Since neither BC_1 nor BC_2 generations were included in this study, it is not possible to discern whether the observed differences were due to an interaction of the cytoplasm and the nucleus of the recurrent parent, or an interaction of the cytoplasm and the mixed genomes from the two parental species.

CONCLUSION

The results of this study suggest that certain cytoplasms could be useful for plant breeding not only for the agronomic improvement of existing cultivars but also for increasing genetic and cytoplasmic diversity.

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