Successful transferring of male sterility from globe artichoke into cultivated cardoon

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Abstract

In the cultivated forms of the genus *Cynara*, genetic male sterility was recorded only in globe artichoke (var. *scolymus*). Depending on the plant material used, its inheritance is controlled by up to three independent loci (ms1ms1ms2ms2ms3ms3), where the male sterile (MS) plants are recessive for all loci involved. In order to access the effect of these loci in a var. *altilis* background, a backcross scheme was conducted along two generations. The donor plant of the MS was a segregant selfed from the genetic composite (MS×'Reri') × ('Cada'×'Riga'). The var. *altilis* used as recurrent parent was the 'Blanc Ameliore' Semence seeds population. In segregating population, plants were field established and prior anthesis, at least three capitula per plant were covered with pollination bags in order to avoid pollen removal by pollinators. Screenings for pollen production were conducted daily along flowering, except in rainy days. Plants were recorded as male fertile (MF) or MS, when absolutely no pollen shed was observed. F_1 plants (12) were all MF. The F_2 generation presented 81 MF and 4 MS plants, fitting a 15:1 ratio of two loci segregation (χ^2=0.3; p=0.6-0.55). Two backcrossed were advanced, and in the selfed BC_2 population 87 MF and 6 MS plants were counted, matching the expected 15:1 ratio (χ^2=0.006; p=0.95-0.9). We concluded that the male sterile attribute can be successfully transferred into the cultivated cardoon. This will pave the way for the production of hybrids, not only between var. *altilis* counterparts, but also among different botanical varieties as well, in order to exploit the vigorous heterotic biomass growth for industrial purposes.

Keywords: genetic male sterile, hybrids, backcrosses, *Cynara cardunculus* var. *altilis*, var. *scolymus*

INTRODUCTION

The hybrid vigor is one of the primary reasons for the success of plant breeding endeavors in many crops and horticultural plants (Stuber, 1994). In globe artichoke (var. *scolymus*) the interest in hybrid F_1 has been demonstrated by the heterosis found in yield and its components, and by the presence of male sterility and the possibility of vegetative multiplication (Pécaut and Foury, 1992). Also, in an evaluation of the three forms of *Cynara cardunculus* (*altilis*, *scolymus* and *silvestris*) and its crossess, Mauromicale and Ierna (2004) found that the greatest biomass yield was produced in the progenies of globe artichoke × wild cardoon, globe artichoke × cultivated cardoon, and in the cultivated cardoon itself.

In the genus *Cynara*, genic male sterility was found only in globe artichoke. The first record was of Principe (1984), who found in a half-sib family of a selected parent of unknown origin, three male sterile (MS) plants. Along backcrosess of these MS plants towards its maternal parent, he studied the inheritance which fitted a single recessive model, being MS the *ms1ms1* genotype. Later, Basnizki and Zohary (1994), reported two additional, non-alelic recessive genes which were designated *ms2* and *ms3*. The *ms2* gene was found in a progeny of 'Cavo' origin and produced largely shriveled, almost fully aborted pollen grains, same as *ms1*, whereas the *ms3* was from a 'Tudela' progeny, rendering totally

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sterile (pollen-less) anthers (Basnizki and Zohary, 1998). Stamigna et al. (2004) found MS plants in a F_2 populations among French MS clones, 'Romanesco' and 'Violetto di Provenza' cultivars. They studied its inheritance and found to be controlled by a digenic model of two recessive genes, segegating 15:1 male fertile (MF) to MS in F_2 population.

Since, among the three forms of the genus *Cynara*, the cultivated cardoon is the one that pruduces the highest seed yield (Mauromicale and Ierna, 2004), the utilization of hybrids would be of interest in crosses within cultivated cardoon and between cultivated cardoon and the two other forms.

In the present contribution we studied the possibility to transfer the male sterility found in globe artichoke into cultivated cardoon. This will pave the way for the production of hybrids, not only between var. *altilis* counterparts, but between different botanical varieties as well, in order to exploid the vigorous heterotic biomass growth for industrial purposes.

MATERIALS AND METHODS

The donor plant of the MS was a segregant selfed from the genetic composite (MS×'Reri') × ('Cada'×'Riga'). The var. *altilis* used as recurrent parent was the 'Blanc Ameliore' Semence seeds population. The F_1, BC_1, BC_2 and selfed BC_2 generations were advanced and field planted in the Experimental Field of the Rosario's National University, Zavalla, Argentina. In segregating population, prior anthesis, plants heads were covered with pollination bags in order to avoid pollen removal by pollinators; at least three capitula per plant were secured. Screenings for pollen production were conducted daily along flowering, except in rainy days. Plants were recorded as male fertile (MF) or MS, when absolutely no pollen shed was observed (pollen-less type).

The proportion of observed MF and MS plants in each segregating generation was fitted to known proportions of mendelian inheritance along a goodness of fit test.

RESULTS AND DISCUSSION

The F_1 plants (12) were all MF. The F_2 generation produced 81 MF and 4 MS plants; which fitted a 15:1 ratio of two loci segregation (χ^2=0.3; p=0.6-0.55). The selfed BC_2 population segregated 87 MF and 6 MS plants, (Figure 1), adjusting again the 15:1 ratio (χ^2=0.006; p=0.95-0.9). When the selfed BC_2 data were more accurately screened, in the MF class two different groups were observed: normal MF with abundant pollen and few polen type. This rendered a three class segregation of 74 normal MF, 13 few pollen MF and 6 MS plants. This adjusted a 12:3:1 single dominat epistatic segregation (χ^2=1.39; p=0.25-0.5). The MS1 and MS2 loci when dominat are espistatic over the MS3, rendering MF. The few pollen phenotype is the result of having at least one dominant allele in the MS3 locus and recessiviness in the ms1 and ms2 loci.

Figure 1. Left, male sterile BC_2 selfed plant, right male fertile BC_2 selfed plant.

It was possible to introduce male sterility into a cultivated cardoon background. The segregation 15:1 of the male fertile to sterile was in concordance to that presented by

Stamigna et al. (2004).

We tried to undestand our results and those of Principe (1984) and Basnizki and Zohary (1998), who reported single inheritance in three non-allelic loci. First of all, as Basnizki and Zohary (1998) pointed, the so called "MS" found by Principe (ms1ms1) and by them in the ms2ms2 locus was of the few-pollen type, since some normal pollen grains were produced. The ms3ms3 genotype of Basnizki and Zohary (1998) was the real MS pollen-less type. So the putative MF genotype of Basnizki and Zohary (1998) which rendered 3:1 when selfed was MS2ms2MS3MS3; and the putative MF genotype, non-alellic to the first one, which also rendered 3:1 when selfed was MS2ms2ms3ms3.

So MF plants will be the result of having at least one dominant allele in each of the loci MS1 or MS2, the few-pollen plants will appear with the genotype ms1ms1ms2ms2MS3_; and finally, the MS plants will be ms1ms1ms2ms2ms3ms3.

CONCLUSIONS

We concluded that the male sterile attribute can be successfully transferred into the cultivated cardoon. This will pave the way for the production of hybrids, not only between var. *altilis* counterparts, but also among different botanical varieties as well, in order to exploid the vigorous heterotic biomass growth for industrial purposes.

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