Development of *Brassica* edible and forage interspecific hybrids using rapeseed male-sterile lines

Guohuai Wang [1]*, Chunyun Guan[1], Sheyuan Chen[1], Benkun Liu[1], Zhongsong Liu[1]
([1]Institute of Oil Crops, Hunan Agricutural University, Changsha, Hunan 410128,China)

ABSTRACT

Previous extensive studies from all over the world showed that the interspecific F_1 hybrids of brassicas had a poor seedset and therefore no heterosis in seed yield, which are of no use for oilseed production. However, they exhibited very high heterosis in vegetative growth with the vigorous growth before flowering. Overcoming the interspecific cross incompatibility of brassicas is the key to development of edible and forage interspecific hybrids of brassicas for exploitation of vegetative heterosis. The rapeseed male-sterile lines of different types have been bred since 1970s. These male-sterile lines and their maintainers were crossed with the varieties of *Brassica rapa* (ssp. *oleifera*, ssp. *chinesis*, ssp. *pekinensis*)for development of edible and forage interspecific hybrids of brassicas which could come into production. The results showed that cross compatibility indexes were 30~50% higher when the *Brassica rapa* varieties were crossed with the rapeseed male-sterile lines than with their maintainer lines, indicating a marked cytoplasmic effect. The resultant interspecific F_1 hybrids displayed the very high vegetative heterosis , with generally 30~126% higher vegetative yield over their parents. The interspecific hybrids also showed a positive heterosis in quality characters such as the contents of crude protein, crude fat and cellulose. Studies on physiological basis of heterosis indicated that the hybrids were superior to their male parents in photosynthetic rate, water use efficiency, root exuding and chlorophyll content. A new type of edible or forage interspecific hybrids could be developed through extensive evaluations and screening of combinations.

Key words: rapeseed heterosis incompatibility vegetable

INTRODUCTION

Poor seed set without heterosis in seed yield of interspecific F_1 hybrids of *Brassica* was confirmed by extensive previous studies. However, the F_1 hybrids showed vigorous vegetative heterosis. Up to now, no way has been found to exploit this vegetative heterosis due to the interspecific cross incompatibility in *Brassica*. The successful breeding of different types of male-sterile lines of *B. rapa* since 1970s brought very good opportunity to exploit this vegetative heterosis, for example, after extensive test cross and screening of the F_1 hybrids by crossing these male sterile lines and their maintainers with other *Brassica* species, different types of vigorous vegetative heterosis combinations can be realized, thus to exploit heterosis. By using different parents, different combinations can also be realized, hence a series of new types of edible and forage interspecific hybrid varieties with different flavors and growing durations can be selected, which was a new method in the exploiting of interspecific vegetative heterosis of *Brassica.* The interspecifie cross-compatibility of *B. rapa* male-sterile lines with other *Brassica* species, the performance of vegetative heterosis, physiological and quality characteristics were reported here.

MATERIALS AND METHODS

The experiment was carried out on the trial farm of Hunan Agricultural University from 1998 to 2002. The *Brassica rapa* cytoplasm male-sterile lines 681A, 714A, shichuan A, turnip cytoplasm A and their maintainers were crossed with Meihua purple cai-tai, Muyun Chinese cabbage, Changsha Guihuazhi respectively to get 12 hybrid combinations, then the performance of crossing compatibility of these combinations was studied. 681A and its maintainer was crossed with Meihua purple cai-tai, Muyun Chinese cabbage, Changsha Guihuazhi respectively to study the interspeifie hybrid male-sterile cytoplasm genetic effects. 681A and its maintainer was crossed with 5 varieties of *B.c.Var. parachinensis* respectively to get 5 hybrid combinations, and crossed with 5 varieties of *B. campestris ssp. Chinensis* (L.)Makino respectively to get 5 hybrid combinations, and crossed with 5 varieties of *B. compestris L. var. oleifera* to get 5 hybrid combinations, all these 15 combinations were used to compare the F1 vegetative heterosis of different types of combinations. 3 of the above 681A combinations were selected to study the physiology characteristics and quality components. The planting area of each of the combinations was 6.67m^2 with 2 replications. Seed setting percent, number of seeds per pod and weight of 1000 seeds were recorded at harvest. The compatibility index was calculated (compatibility index equals to the number of setting seeds divided by the number of pollinated flowers). Total leaves, green leaves, length and width of maximum leaf, size of stem base, branches and bolter yield were recorded on April 1. Hybrid heterosis was estimated according to the

following equations:

rate of heterosis compared with the parent material=F_1-MP;

rate of heterosis compared with relatively higher parent material =F_1-PH;

Fisher comparison method was adopted to analyze the difference significant level between F_1 and Mean value of two parent materials (F_1-MP), between F_1 and relatively higher parent material (F_1-PH), the percent of F_1 combination that is higher than the parent material was presented by (F_1-PH)%.

Physiological characteristics of different combinations. Photosynthetic rate, transpiration rate, water use efficiency and stoma resistance were measured by BAU photosynthesis measuring system, root exuding water was measured by weight, chlorophyll content was measured by colorimeter.

Quality analysis of different combinations. Cellulose content was measured by acid-alkaline treatment method, vitamin C content was measured by titration method, soluble sugars was measured by anthrone method.

RESULTS AND DIISCUSION

Interspecific crossing compatibility of different types of *Brassica rapa* male-sterile lines crossing with 3 types of varieties of *Brassica*.

As for the same male-sterile line, the crossing compatibility of those crossing with *B. compestris L. var. oleifera* was bigger than those crossing with *B. campestris ssp. Chinensis* (L.)Makino, and that of those crossing with *B. campestris ssp. Chinensis* (L.)Makino was bigger than those crossing with *B.c.Var. parachinensis*. The seed setting percent, number of seeds per pod, weight of 1000 seeds and compatibility index of the 4 male-sterile lines crossing with Meihua purple cai-tai, Muyun Chinese cabbage and Changsha Guihuazhi separately are in the range of 59.8%-95%, 10.65-24.65, 2.02-3.02and 7.7-20.14 respectively, hence relatively strong crossing compatibility of the 4 male sterile lines crossing with the 3 types of varieties, however, these compatibility varies with different male sterile lines, among them, shichuan A, 714A and turnip cytoplasm A were relatively higher, while that of 618A was the lowest. So in practical production, it is very important to extensively screen the strong crossing compatibility male sterile line and parent variety to get hybrid combination, thus increase the hybrid compatibility.

Male-sterile cytoplasm genetic effects of the interspecific crossing of *Brassica.*

As for 681A and its maintainer crossing with 3 types of varieties of *Brassica*, the mean seed setting percent of the combination of 681A was 67.8%, and mean compatibility was 8.74, while those of the 681A maintainers were 51.53% and 5.39 respectively, so the combination of male sterile line was 16.27% higher in seed setting percent and 3.35 more in compatibility index than the maintainer, This showed that *Brassca. rapa* male sterile lines has stronger interspecific heterosis compatibility than the normal crossing of normal *Brassica rapa* with other varieties of *Brassica*, which demonstrated the cytoplasm effect of *Brassica rapa* male sterile lines' interspecific heterosis compatibility.

Vegetative heterosis among different types of species.

There was evident vegetative heterosis of interspecific crossing of *Brassica rapa* male sterile lines with other species of *Brassica*. As for the 15 combinations, the 7 measured characteristics were superior to the parent material, especially the combination of *B.c.Var. parachinensis*, the bolter heterosis yield and heterosis branches were 35.63% and 72.41% respectively, and that of combination of *B. campestris ssp. Chinensis* (L.)Makino were 34.94% and 58.41% respectively, while that of the combination of *B. compestris L. var. oleifera* were 33.13% and 40.73% respectively. The differences to the mean value of the parent material and to the relatively higher parent material were at the obvious significant difference level. The hybrid bolters yield of the 3 types of varieties exceeded the relatively higher parent combinations by 100%. The difference of the hybrids' total leaves, green leaves, maximum leaf length and width, size of stem base to the two parent materials was also at significant or obvious significant level except relatively low heterosis to maximum leaf width of the hybrid compared with the parent material.

As for the F_1 heterosis of *Brassica* male sterile line crossing with 3 types of varieties, that with *B.c.Var. parachinensis* was stronger than that with *B. compestris L. var. oleifera*. The obvious significant F_1 heterosis predicted the potential future of exploiting the F1 interspecific vegetative heterosis of *Brassica rapa* male sterile lines.

Physiology base for the different interspecific vegetative heterosis.

Chlorophyll content, root exuding water and photosynthesis etc. were measured to determine the physiology difference among *Brassica rapa* male-sterile lines, parent materials and their combinations .

The photosynthetic rate, water use efficiency, root exuding water and chlorophyll content of the hybrids were higher than the parent materials, while transpiration rate was lower than the parent material, thus significant heterosis of the hybrids in solar energy and water use efficiency and root activity.

Quality difference among different interspecific combinations.

Cellulose content, vitamin C content and protein content of the parent materials and their related 3 types of combinations were measured to compare the qualities of these materials and combinations, the

results showed, the cellulose content of the 3 types of combinations were a bit higher than the 4 parent materials, so did the vitamin C content, while the protein content was relatively lower. Meanwhile, a lot of taste tests showed: hybrids were more delicious than the parent materials, somewhat insipid than the *B.c.Var. parachinensis* and stronger than the *B. campestris ssp. Chinensis* (L.)Makino, and also without the bitter taste of *Brassica Rapa*.

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