# Combining ability analysis of quality characters for parents of hybrid in *Brassica napus* L.

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**Abstract**

Twelve combinations have been done with incomplete diallel cross design, which were crossed by three male sterility lines and four restoring lines. The combining ability of $F_1$ ten characters (glucosinolate, protein, oil, palmitic, stearic, oleic, linoleic, linolenic, eicosenoic, erucic acid) is analyzed. Results showed: general combining ability effect of A-lines were different significantly at 0.05 or 0.01 level on glucosinolate, palmitic, stearic, oleic, linolenic, eicosenoic acid. General ability effect of C-lines are different significantly at 0.05 or 0.01 level on glucosinolate, protein, oil, stearic, oleic, linolenic, eicosenoic acid. Specific combining ability effect of A-line and C-line have marked influence to $F_1$ three characters only, they are content of protein, oil and stearic acid. General combining ability effect of A-lines and C-lines has great influence to $F_1$ most quality characters. The quality characters of parents must be improved in breeding. Tests showed that the combination with A9 and P27-1 has higher content of oil, oleic acid, protein and lower content of erucic acid, glucosinolate, linolenic acid.

**Key words:** hybridized combinations, quality characters, combining ability

## Introduction

As industrialization and urbanization goes on, the rapeseed varieties that is suitable for machine work are needed in Tai-lake region of Jiang Su province. We did researches on breeding of hybrid rapeseed (*Brassica napus* L.) suitable machine work since 2001. Some cytoplasm male sterility lines (A-line) and restoring lines (C-line) were gained. Hybrid vigor on yield characters has researched, at same time analysis on combining ability of quality characters of three A-lines and four C-lines researched, too.

## Material and Methods

Experiment has done in Jiang Su Tai-lake region agricultural science institute 2003~2005. three male sterility lines A4, A7, A9 and four restoring lines jian 1, Cj2-1, P27-1, jian 2 were used as parents, Twelve hybridized combinations has been done with incomplete diallel cross design 2003~2004. Hybrid strain seeds planted with compete randomized blocks, replicated 2-plot experiment. It is 8.4$m^2$ per plot. It is 15cm between tree distance and 35cm between row distance. 160 plants were grown in a plot. After harvesting 5 grams seeds were taken out per plot randomly. Erucic acid, glucosinolate, protein, oil and other fatty acids content of exponents were tested with Near Infrared ray Reflecting Spectrum (NIRS) method.

## Results

*1. Quality characters of hybridized combination*

Ten quality characters of twelve hybridized combinations are showed in table 1. Coefficient of variation (C.V.) of quality characters are 1.61%~5.89%, except glucosinolate, eicosenoic acid and erucic acid. It tells us that the hereditary capacity of A-lines and C-lines are stability, also phenotype are similar. Erucic acid content of hybridized combination are similar, it varies from0.927% to 1.699% and is up to the international standard. C.V. of glucosinolate is 41.85%. It means greatly difference among hybridized combinations, glucosinolate content varied from 12.997%~40.315%. Among them nine hybridized combinations are up to the standard, another three are not. Four hybridized combinations that crossed with A7 are higher glucosinolate content, only A7/jian 1 is up to standard in the main. It may be relate to the genotype of A7. Average of protein content of hybridized combinations is 35.484%, varied from 34.181%~36.863%; oil content is 41.979%, varied from 40.521% to 42.965%, both are stability. Content of oleic acid, linoleic acid, linolenic acid are 65.143%,21.084% and 9.576% respectively. The three fatty acids are followed with interest. We have much work to do for reducing saturated fatty acid and linolenic acid, raising oleic acid content, making linoleic acid in proportion to linolenic acid (2:1).

*2. Analysis of combining ability variance*

Results of variance analysis of ten quality characters are listed in table2. They are difference significantly at 0.01 level except linoleic acid and erucic acid. It means that the genotypic effect of combination has significant difference. It is necessary that general and specific combining ability (GCA and SCA) of A-lines (P1) and

**Table 1 Phenotypic value of quality characters of hybridized combinations**

| hybridized combination | quality characters % | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | glu. | prot. | oil | palmitic | stearic | oleic | linoleic | linolenic | eicosenoic | erucic |
| A4/jian1 | 12.977 | 34.995 | 41.536 | 4.804 | 1.154 | 62.992 | 21.119 | 9.662 | 1.141 | 1.472 |
| A4/cj2-1 | 17.917 | 34.181 | 40.521 | 4.866 | 1.038 | 63.882 | 22.341 | 9.824 | 0.823 | 1.220 |
| A4/jian2 | 14.183 | 35.779 | 42.353 | 4.748 | 1.021 | 65.208 | 21.029 | 9.760 | 0.996 | 1.023 |
| A4/p27-1 | 17.312 | 36.414 | 42.908 | 4.773 | 1.080 | 65.215 | 20.240 | 9.063 | 0.862 | 1.318 |
| A7/jian1 | 28.292 | 34.472 | 41.148 | 4.915 | 1.054 | 65.470 | 20.804 | 10.062 | 1.332 | 1.699 |
| A7/cj2-1 | 40.315 | 35.238 | 42.221 | 4.847 | 1.072 | 64.627 | 21.443 | 9.907 | 1.267 | 1.589 |
| A7/jian2 | 39.933 | 34.994 | 41.550 | 4.884 | 1.004 | 65.389 | 20.758 | 10.316 | 1.277 | 1.163 |
| A7/p27-1 | 37.994 | 36.427 | 42.622 | 4.885 | 1.059 | 66.791 | 20.528 | 9.306 | 1.050 | 1.277 |
| A9/jian1 | 15.488 | 35.551 | 42.045 | 4.693 | 1.164 | 64.792 | 20.726 | 9.127 | 1.229 | 1.189 |
| A9/cj2-1 | 23.163 | 36.863 | 43.352 | 4.701 | 1.176 | 64.546 | 21.648 | 9.659 | 1.161 | 1.509 |
| A9/jian2 | 22.249 | 34.273 | 40.528 | 4.828 | 1.021 | 65.332 | 21.988 | 9.759 | 1.092 | 1.083 |
| A9/p27-1 | 21.449 | 36.620 | 42.965 | 4.720 | 1.042 | 67.478 | 20.390 | 8.472 | 0.879 | 0.927 |
| **average** | **24.274** | **35.484** | **41.979** | **4.805** | **1.074** | **65.143** | **21.084** | **9.576** | **1.092** | **1.289** |
| **C.V.** | **41.85** | **2.66** | **2.22** | **1.61** | **5.89** | **1.81** | **3.09** | **5.26** | **15.86** | **18.36** |

C-lines (P2) must be analyzed. The results showed: General combining ability effect of A-lines are difference significantly at 0.05 or 0.01 level on glucosinolate, palmitic acid, stearic acid, oleic acid, linolenic acid, eicosenoic acid. It pointed that the three A-lines have a great influence upon the six characters. General combining ability effect of C-lines are difference significantly at 0.05 or 0.01 level on glucosinolate, protein, oil, stearic acid, oleic acid, linolenic acid, eicosenoic acid. We can find that the four C-lines have a great influence upon the seven characters.

**Table2 Variance analysis of quality characters**

| Source of var. | df | gluco. | Prot. | oil | palmitic | stearic | oleic | linoleic | linolenic | eicosenoic | erucic |
|---|---|---|---|---|---|---|---|---|---|---|---|
| blocks | 1 | 0.671 | 0.016 | 2.003 | 0 | 0.791 | 3.168 | 0.113 | 3.194 | 4.371 | 0.011 |
| Comb. | 11 | 60.998** | 5.155* | 4.711** | 4.851** | 5.526** | 5.962** | 1.831 | 6.333** | 13.593** | 2.608 |
| A($P_1$) | 2 | 290.642** | 2.070 | 0.973 | 17.662** | 4.505* | 8.611** | 0.526 | 10.323** | 34.569** | 3.167 |
| C($P_2$) | 3 | 23.993** | 8.463** | 6.149* | 0.249 | 10.415** | 12.850** | 4.687 | 14.522** | 21.391** | 4.781 |
| $P_1 \times P_2$ | 6 | 2.952 | 4.530* | 5.237* | 1.552 | 3.422* | 1.635 | 0.837 | 0.909 | 2.701 | 1.336 |

Effect of specific combining ability of A-lines and C-lines is not significant influence, besides content of protein, oil and stearic acid. Hybrid strains of A7 are higher glucosinolates in seed, we must be careful not to misuse A7. At same time we take attention to specific combining ability of A7 on glucosinolate. That A4 and A9 cross with suit restoring lines can get better $F_1$ generation. $F_1$ seed content of glucosinolate and erucic acid are up to the standard. Content of oil, protein and oleic acid can be raised, linolenic acid reduced.

*3. Relative effect of general combining ability of A-lines and C-lines*

**Table 3 Relative effect of general ability of A-lines and C-line**

| Parent | glucosinolate | protein | oil | palmitic | stearic | oleic | linolenic | eicosenoic |
|---|---|---|---|---|---|---|---|---|
| A4 | -35.73 | -0.40 | -0.35 | -0.17 | -0.09 | -1.26 | 0.01 | -12.55 |
| A7 | 50.91 | -0.57 | -0.22 | 1.60 | -2.42 | 0.65 | 3.35 | 12.73 |
| A9 | -15.19 | 0.97 | 0.58 | -1.46 | 2.51 | 0.60 | -3.36 | -0.18 |
| Jian | 1 | -22.03 | -1.35 | -0.96 | -0.02 | 4.66 | -1.11 | 0.43 |
| Cj2-1 | 11.77 | -0.16 | 0.12 | -0.02 | 2.05 | -1.22 | 2.30 | -0.82 |
| Jian | 2 | 4.87 | -1.32 | -1.20 | 0.31 | -5.40 | 0.25 | 3.84 |
| P27-1 | 3.39 | 0.03 | 0.67 | -0.27 | 0.28 | -0.23 | -2.20 | 4.02 |

Glucosinolate content of Hybrid strain crossed with A4 and A9, jian 1 are lower, opposite A7and Cj2-1. Relative effect of general combining ability of A-lines and C-lines are small on content of protein, oil, oleic acid, linolenic acid. It showed that gene action of A-lines and C-lines is similar. According to relative effect of general combining ability of A-lines and C-lines, $F_1$ content of glucosinolate and linolenic acid can be reduced, $F_1$ content of protein, oil, oleic acid can be raised, which crossed with A9 and P27-1.

*4. Analysis of genotypic variance of combining ability*

We can find that genotypic variance of combining ability differed among eight characters of parents from table 4. We did researches on content of five characters. They are content of glucosinolate, protein, oil, oleic acid and linolenic acid. The additive and non-additive variance of genes has three modes of action to the five characters. The first mode example is glucosinolate. The genotypic variance of A-lines(P1), C-lines(P2) and P1×P2 are all bigger than that of other four characters. To make further analysis, the value of genotypic variance of combining ability of A-lines is bigger than that of C-lines and

P1×P2. GCA of A-lines influenced the content of $F_1$ glucosinolate mainly. The second mode example is protein and oil. The genotypic variance of combining ability is little than that of glucosinolate. The value of genotypic variance of combining ability P1×P2 is bigger than that of A-lines and C-lines. SCA of A-lines and C-lines influenced the content of $F_1$ protein and oil mainly. The third mode example is oleic acid and linolenic acid. The genotypic variance of combining ability is little, too. The value of genotypic variance of combining ability of A-lines and C-lines is bigger than that of P1×P2. We think that the content of oleic acid and linolenic acid mainly controlled by GCA of A-lines and C-lines. Compare with three action modes, the three characters (glucosinolate, oleic acid and linolenic acid) among five characters researched mainly controlled by GCA of A-line and C-line. Another two characters (protein and oil) mainly controlled by SCA of A-line and C-line. Proceed from plant breeding, we wish A-lines and C-lines take effect on reducing the content of glucosinolate, linolenic acid, raising the content of protein, oil and oleic acid of hybrid strains.

According to heritability of eight characters, we can select in early stage of breeding. Additive effect of genes of glucosinolate is bigger, we must select parents correctly, especially the maternal plant used cross. Additive genetic effect of protein and oil is little. It is difficult that seed higher content of protein and oil is selected correctly. Identification of the living may be effect. Additive genetic effect of oleic acid and linolenic acid is bigger. We can detect objective in early phase of breeding with suitable A-line and C-line.

**Table 4 genotypic variance and heritability of combining ability**

| characters | genotypic variance of combining ability | | | environ. variance | variance of colony | | combining ability(%) | heritability(%) |
|---|---|---|---|---|---|---|---|---|
| | P1 | P2 | P1*P2 | | g.c.a | s.c.a | broad | narrow |
| Gluco. | 119.549 | 11.658 | 3.166 | 3.324 | 97.64 | 2.36 | 97.597 | 95.297 |
| Prot. | -0.106 | 0.226 | 0.871 | 0.344 | 12.09 | 87.91 | 74.21 | 8.98 |
| Oil | -0.198 | 0.057 | 1.204 | 0.372 | -13.34 | 113.34 | 79.68 | 13.93 |
| Palmiti. | 0.005 | -0.001 | 0.001 | 0.002 | 86.68 | 13.32 | 77.78 | 66.67 |
| stearic | 0.001 | 0.001 | 0.002 | 0.001 | 47.77 | 52.23 | 73.14 | 34.94 |
| oleic | 0.408 | 0.875 | -0.171 | 0.468 | 115.36 | -15.36 | 75.65 | 66.75 |
| linolenic | 0.094 | 0.182 | -0.087 | 0.080 | 146.33 | -46.33 | 81.94 | 62.30 |
| eicosenoic | 0.018 | 0.014 | 0.003 | 0.004 | 91.01 | 8.99 | 88.64 | 80.66 |

## Discussion

The combining abilities of A-lines and C-lines are different, the heritability of characters are different, too. The phenotypic values of same character of hybridized combinations are different. Ten characters are researched in this paper, in which eight characters have significant difference at level 0.01. It means that gene differ greatly from gene in acted mode. We must select parents correctly in breeding, make maximum hybrid vigor.

The content of erucic acid has non-significant difference among combinations. The combining ability of A-lines and C-lines are steady. Keeping genetic pure of parents can make hybridized combinations with lower content of erucic acid. $F_1$ higher content of glucosinolate related with A7.It is must be improved.

The trend of rapeseed quality breeding is raising content of unsaturated fatty acid, reducing content of saturated fatty acid, balancing component of fatty acid. The concrete breeding work is to increase content of oil, oleic acid, protein; to cut down content of erucic acid, glucosinolate, linolenic acid; to harmonize proportion between linoleic acid and linolenic acid. On the premise of maintain double lower, focal point of selecting A-line and C-line are to raise content of oil, oleic acid, to reduce content of linolenic acid in our breeding work.

## Conclusions

GCA effect of A-line has marked influence to $F_1$ six characters, GCA of C-line has marked influence to $F_1$ seven characters. SCA effect of A-line and C-line have marked influence to $F_1$ three characters only. Stearic acid is just affected by GCA and SCA. The results told us that the GCA of A-line and C-line have great influence to $F_1$ most quality characters. The quality characters of A-line and C-line must be improved.

A-line A4 and A9, C-line jian 1, Cj2-1, jian 2, and P27-1 have been tested for several years. The basic characters of them and their progeny accord with production demand. They can be used in production after making further test.

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