Study of quality characters of vegetable *Brassica campestris* L. and application to rapeseed breeding

WANG Xuefang, LI Dianrong, CHEN Wenjie, ZHANG Yanfeng, ZHANG Zhi

Hybrid Rapeseed Research Center of Shaanxi Province, Shaanxi Rapeseed Branch of National Oil Crops Genetic Improvement Center, Dali 715105, China Email: arsrc @public.xa.sn.cn; lidr@people.com.cn

Abstract

This paper reported 8 quality characters (saturated fatty acid, oleic acid, linoleic acid, linolenic acid, erucic acid, glucosinolates, oil content and protein) of 90 vegetable germplasm resources of *Brassica campestris*, such as Chinese-cabbage, no-heading Chinese-cabbage and purple Tsai-tai. Among the variation coefficient of 8 quality characters, glucosinolates and erucic acid took the first place and the last place, respectively. The result of correlation analysis showed that the correlation was more complex among these quality characters. So according to principal components analysis, 4 principal components with over 89.87% contribution were obtained. At the same time, 9 materials with good integrated quality characters were screened out. These materials supply good germplasm resources for rapeseed breeding.

Key words: Vegetable of *Brassica campestri*s, Quality character, Principal component analysis, Rapeseed breeding

Rapeseed is one of the important oil crops not only in China but also in the world. Breakthrough advances of rapeseed breeding are related to discovery and utilization of important gene resources. Spreading, exploring and utilizing multiplex gene is very important in rapeseed high yield breeding. At present, *B. napus* is over 80% in rapeseed planting area in China. Many of Chinese early *B. napus* were selected from ShengLi rapeseed directly or indirectly [1-2]. Guo gao et al [3] considered that the gene of many varieties came from Canada or western Europe according to analysis Chinese 63 single or double low varieties. It is difficult to break through in yield and resistance by using like genes or their derived progenies. So it is important to dig multiplex gene resources.

China is the original center of vegetable of *B. campestris* [4]. There are many variations and rich resources in long natural selection and evolution, whereas the resources were only utilized in vegetable breeding and ignored that their seeds can be used in rapeseed breeding. Our study indicated that there were resources of early mature, cold resistant, white flower, yellow seed, dwarf stem, more branches, more pods, big grain [5], high oil content [6] and low glucosinolates [7] in vegetable of *B. campestris*. This paper will study the seed quality characters of vegetable of *B. campestris* in order to provide usable resources for rapeseed quality and high yield breeding.

1 Materials and Methods

90 materials of vegetable of *B. campestris* (Chinese-cabbage, no-heading Chinese-cabbage and purple Tsai-tai was 30, respectively) were screened out from 505 self-line materials from over 10 provinces by the near infrared spectroscopy method (NIR). Planting patterns, planting date and field practice were the same with rapeseed. Every material was harvested respectively in seed mature period and determined their oil content using nuclear magnetic resonance (NMR) method, glucosinolates using high performance liquid chromatograph (HPLC) method [8], protein using Kjeldahl method and component of fatty acid (oleic acid, linoleic acid, linolenic acid, saturated fatty acid and erucic acid) using gas chromatography method. All data were analyzed by the programs of Yuan[9] or Excel.

2 Results and analysis

2.1 Variation of quality characters in different varieties

Variation of quality characters in different varieties was presented in table 1. In variation range, there were resources with low saturated fatty acid, low glucosinolates, high oil and protein content in vegetable of *B. campestris*. The coefficient of variation (CV) of 7 quality characters was over 9% except that of erucic acid. The maximum value of linoleic acid, oleic acid, linolenic acid, and saturated fatty acids was about one times greater than the minimum, and the glucosinolates range was the biggest with the maximum being 12.7 times greater than the minimum. So the vegetable of *B. campestris* was very special character, significant resources and rich types.

2.2 Correlation analysis of 8 quality characters

According to correlation analysis of 8 quality characters (table2), saturated fatty acids and linoleic acid, oleic acid and oil content, linoleic acid and linolenic acid, linolenic acid and protein, glucosinolates and protein were positive correlation and significant at the 0.01 level. Oil content and saturated fatty acids, linoleic acid, linolenic acid, glucosinolates, protein; oleic acid and linoleic acid, linolenic acid, erucic acid; as well as saturated fatty acids and erucic acid were negative correlated and significant at the 0.01 probability level. So it was needed to translate complex correlation characters to independent factors.

2.3 Principal component analysis of quality character in vegetable of B. campestris

Above all analysis showed that it was difficult to select materials with good integrated quality characters because of the complex and antagonistic relation among 8 quality characters. According to the requirements of rapeseed quality breeding, principal components analysis was carried through by 8 quality characters such as saturated fatty acids, oleic acid, linoleic acid, linolenic acid, erucic acid, glucosinolates, protein and oil content. Because of the antagonistic relation between protein and oil content, many breeders considered that combining them was better than isolating them. So this study combined protein and oil content for analyzation, ie oil+protein. The results (table3) indicated that 4 bigger eigenvectors (A1, A2, A3, A4) were screened out from 7 eigenvalues, and their cumulative percentage was 89.87%. At the same time, in order to improve analytical precision, the other eigenvector with smaller effect and bigger interference were eliminated. So the 4 principal components were able to value better the quality of vegetable of *B. campestris*.

Table 3 indicated: in the first principal component, oleic acid, oil+protein and linoleic acid had greater load, but two formers were positive load value and the latter was negative, so materials with bigger the first principal component would have higher oleic acid and oil+protein content and lower linoleic acid. In the second principal component, saturated fatty acid and erucic acid had greater load, in them the load value of saturated fatty acid was positive but that of erucic acid was negative, so materials with bigger the second principal component would have higher saturated fatty acid and lower erucic acid. In the third principal component, glucosinolates had positive bigger load value, so materials with bigger the third principal component would have higher glucosinolates. In the fourth principal component, linolenic acid had negative bigger load value, so materials with bigger the fourth principal component would have lower linolenic acid.

Combining the results of principal component analysis and the aim of rapeseed breeding, the first and the fourth principal component should be the bigger the better. Because of no low erucic acid materials, the second principal component should be the smaller the better, so as the third.

The principal component value of 90 materials was counted by eigenvalue and its corresponding eigenvector and the genetic value of every character. The average and the standard deviation of the first, second, third and fourth principal component were:

$\bar{Z}_1$=10.445, S_1=5.527, $\bar{Z}_2$=-10.202, S_2=18.495, $\bar{Z}_3$=105.786, S_3=60.555, $\bar{Z}_4$=-46.939, S_4=24.584

The regulation as follows:

The first:$Z_1>15.977$ good, $4.918\leqslant Z_1\leqslant 15.977$middle, $Z_1\leqslant 4.918$bad;

The second:$Z_2\leqslant -28.697$good, $-28.697\leqslant Z_2\leqslant 8.293$middle, $Z_2>8.293$bad;

The third:$Z_3\leqslant 45.231$good, $45.231\leqslant Z_3\leqslant 166.341$middle, $Z_3\geqslant 166.341$bad;

The fourth:$Z_4>-22.355$good, $-71.523\leqslant Z_4\leqslant -22.355$middle, $Z_4\leqslant -71.523$bad.

According to above standard, every material was valued (no present detailed data). The results showed that 9 materials (1 no-heading Chinese-cabbage 03V539 and 8 Chinese-cabbage 03V824, 03V833, 03V1081, 03V1153, 03V1193, 01V210, 01V224, 01V270) were all fine in 4 principal components, 7 materials (1 purple Tsai-tai,1 no-heading Chinese cabbage, 5 Chinese-cabbage) were fine in 3 principal components, 4 materials (1 purple Tsai-tai,1 No-heading Chinese, 2 Chinese-cabbage) were fine in 2 principal components, 7 materials (1 purple Tsai-tai, 3 No-heading Chinese cabbage, 3 Chinese-cabbage) were fine in 1 principal component, others were bad.

Table 1 Variation of quality characters in different varieties

Quality character	Range	Average	CV(%)
Saturated fatty acids	3.72~6.59	5.01	11.03
Oleic acid	9.92~26.19	14.04	18.40
Linoleic acid	7.51~15.54	11.68	18.87
Linolenic acid	5.53~10.94	8.46	11.02
Erucic acid	40.68~56.66	49.71	5.71
Glucosinolates	22.57~286.92	133.25	54.40
Oil content	33.8~50.15	42.57	9.26
Protein	18.94~29.6	23.36	9.29

Table2 Correlation matrix of quality characters

Quality character	X_1	X_2	X_3	X_4	X_5	X_6	X_7
Saturated fatty acid X_1	1						
Oleic acid X_2	-0.0804	1					
Linoleic acid X_3	0.4654**	-0.6092**	1				
Linolenic acid X_4	0.0248	-0.5917**	0.3600**	1			
Erucic acid X_5	-0.3521**	-0.6985**	0.0155	0.1220	1		
Glucosinolates X_6	0.1398	0.0304	-0.0050	-0.0317	-0.0915	1	
Oil content X_7	-0.3259**	0.3777**	-0.5562**	-0.2972**	-0.0814	-0.3389**	1
Protein X_8	-0.1378	-0.1753	0.1632	0.3387**	0.1148	0.2866**	-0.6647**

Note: ** means significant at 0.01 level

Table3 Principal components analysis of quality character in vegetable of *B. campestris*

Quality properties	Eigenvector			
	A1	A2	A3	A4
Saturated fatty acids	-0.288	0.538	-0.152	0.147
Oleic acid	0.518	0.369	-0.068	-0.040
Linoleic acid	-0.525	0.147	-0.207	0.069
Linolenic acid	-0.358	-0.229	-0.210	-0.777
Erucic acid	-0.192	-0.589	0.318	0.415
Glucosinolates	-0.061	0.257	0.869	-0.354
Oil+Protein	0.453	-0.304	-0.173	-0.264
Principal components	The first	The second	The third	The fourth
Cumulative percent (%)	37.76	64.13	78.37	89.87

3 Discussion

This paper analyzed 8 quality characters of vegetable *B. campestris* from the angle of rapeseed breeding. The result indicated that glucosinolates, oleic acid and linoleic acid had bigger CV, so they had broader variation range. Therefore, it is easy to succeed in selecting low glucosinolates, high oleic acid and linoleic acid in rapeseed breeding.

Now, the aim of rapeseed breeding is different due to final oil application. If for edible oil, new varieties should have low saturated fatty acids, low linolenic acid, low erucic acid, high oleic acid, high linoleic acid and high oil content. If for industry oil, they should have high erucic acid and so on. Correlation analysis of 8 quality characters indicated that high oil content would go with high oleic acid and low saturated fatty acids, linolenic acid and glucosinolates, this is favorable of breeding for edible oil. At the same time, it would cause linoleic acid reducing, this is unfavorable of breeding for edible oil. So we should consider fully and integratively according to the aim of rapeseed breeding.

One fine material is not only one good character but also integrative good characters. So this study analyzed the principal components of 8 qualities in vegetable *B. campestris.* For reducing selecting index, 4 principal components that could represent all characters were screened out. At the same time, every material was valued scientifically, and 9 materials with good integrated quality characters were screed out from 90 materails. According to the aim of breeding, selecting parents with complementary principal components can quicken polymerzation rate of good characters.

Above good materials can be applied directly in rapeseed breeding of *B. campestris.* At the same time, they also can be used in breeding of *B. napus* by *B. napus* × *B. campestris* or molecular assistant breeding. Some fine characters of *B. campestris* will be transferred into *B. napus* or their chromosomes will be exchanged each other so as to expend the genetic basis of *B. napus* and widen their gene pool.

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