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Single-plant Similarity-difference Selection in Wheat Breeding

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Abstract: A new method of single-plant selection was proposed using the principle of similarity-difference analysis to overcome the limitation of traditional breeding by means of experiences. The method is considered as the method of single-plant similarity-difference selection. Its principle and steps were introduced. By means of the breeding data of Yumai 35, Anmai No.1 and Anmai No.7, the analysis of single-plant similarity-difference selection was made in the process of single-plant selection. The results show that the method is feasible and efficient in the practice of breeding. Based on this, the superiorities of the method were discussed. It is pointed that combining the method with the technique of molecule marker assisted selection will is a very meaning study direction.

Keywords: Breeding, similarity-difference selection, single-plant, wheat

INTRODUCTION

Single-plant selection is a key link during the course of crop breeding. Therefore, the breeding workers extreme emphasize its technique and method for years. Early in 1936, Smith (1936) advanced the method of selection index on the basis of the conception of discrimination function proposed by Fisher (1936) to raise the selection effect of single-plant. Afterwards, Kempthome and Nordskog (1959) and Tallis (1962) put forward the method of restrictive selection index. Lin improved the method of selection index given by Smith (1936) to bring it to completion in Lin (1978). Nevertheless, the methods require the particular test design and more repetitions in test and it is very difficult to put them into practice in the breeding course, its application range has a certain restriction. For this reason, Wang and Guo (1991) advanced the improved contingency table method with the merits of being easy to compute and convenient for application. To set up the contingency table requires a lot of breeding information and data; it can not apply to breeding practice for the unit of shorter breeding history. Consequently, the principle and method of single-plant grey selection was born at the right moment (Guo *et al*., 1992; Guo, 1992; Xue *et al*., 1994), thus causing the single-plant selection to make considerable headway. On the basis of this, this study put forward a new method of single-plant selection using the principle of similarity-difference analysis (Zhao, 2000; Guo, 2004) to expect to supply an effective method for breeding workers.

MATERIALS AND METHODS

Observations of traits of new wheat (*Triticum aestivum* L.) cultivar yumai 35 each generation were from the test data of Neixiang County Institute of Agricultural Sciences, Henan province from1988 to 1990; observations of traits of new wheat (*Triticum aestivum* L.) cultivars wheat (*Triticum aestivum* L.) Anmai 1 and Anmai 7 from the test data of Anyang Institute of Agricultural Sciences, Henan province from 1990 to 1992 (Table 1). Anmai 1 and Anmai 7 came from the same cross combination (Yumai 13/Zhou 8826), which are sibling lines with different traits. Each singleplant in Table 1 was obtained by breeding worker visually selected in accordance with the breeding objectives, using pedigree method in the test field.

In the background of single-plant selection (suppose it is W), given 2 sets A and B. Among them, A stands for a certain single-plant and B ideal single-plant. They constitute the set pair H = (A, B). Define the connection degree of A, B 2 sets as:

$$\mu\,(W) = a+bi \tag{1}$$

where, i is an uncertain value among interval [-1, 1] in accordance with concrete conditions, a means the identical degree between the single-plant A and ideal single-plant B, namely, similarity degree and b, difference degree. a, b satisfy the normalization conditions:

$$a+b = 1 \tag{2}$$

The difference between a and b reflects the similarity-difference connection trend of 2 sets in the background of single-plant selection. Generally, the bigger a is, the higher the degree that some single-plant A is close to the ideal single-plant B, the better A is.
Thus, draw some definitions as follows:

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Table 1: The trend and single-plant grades under the identical-difference relationship

Trend	Connection trend	a, b and its relation	Single-plant grade
Identical trend	Quasi identical trend	a = 1 or b = 0	The first grade
	Strong identical trend	a>b, 0.809≤a<1	
	Weak identical trend	a>b, 0.691≤a<0.809	
	Mini-identical trend	a>b, 0.5<a <0.691	
Mean trend	Mean trend	a = b = 0.5	The second grade
Different trend	Mini-different trend	a<b,0.309≤a<0.5	The third grade
	Weak different trend	a<b,0.191≤a<0.309	
	Strong different trend	a<b,0<a≤0.191	
	Quasi different trend	a = 0 or b=1	

Definition 1: In the connection degree μ (W) = a+bi, when b≠0, a/b is the connection trend in the set pair H which can be expressed as:

$$S(H) = a/b, \text{ or } b \neq 0 \tag{3}$$

Definition 2: In the connection degree μ(W) = a+bi, if a/b = 1, or a = b = 0.5, the connection trend right now is known as the connection mean trend in the set pair H under the similarity-difference relationship which can be showed as:

$$S(H)_M = a/b = 1, (a = b = 0.5) \tag{4}$$

where, $S(H)_M$ means that the identical and different trend between 2 sets are in equilibrium. The degree of the single-plant A closed to the ideal single-plant is 1/2.

Definition 3: In the connection degree μ (W) =a+bi, if a/b>1, the connection trend at present is known as the connection similarity trend in the set pair H under the similarity-difference relationship which can be indicated as:

$$S(H)_I = a/b, a/b>1 \tag{5}$$

where, $S(H)_I$ shows that the identical trend between 2 sets has an advantage.

Definition 4: In the connection degree μ(W) = a+bi, if a/b<1, the connection trend now is known as the connection difference trend in the set pair H under the similarity-difference relationship which can be expressed as:

$$S(H)_D = a/b, a/b<1 \tag{6}$$

where, $S(H)_D$ indicates that the difference trend between 2 sets has an advantage.

On the grounds of the principle of golden section, the connection identical trend can be divided into 4 grades: a quasi-similarity trend, a strong identical trend, a weaker identical trend and a mini-identical trend and the connection difference trend can be divided into 4 grades: a mini-different trend, a weak different trend, a strong different trend and a quasi-different trend (Table 1).

According to Table 1, the rules of test of significance of connection trend can be gained: if the single-plants to be evaluated are in the same trend grade, there are no significant difference among them; if they are in the different trend grade of the same tendency, there are significant difference among them; if they are in the different tendency, there are remarkable significance among them.

By the analysis of similarity-difference, if the single-plant A and the ideal single-plant B are in the same trend, the single-plant A belongs to the first grade single-plant; if they are in the mean trend grade, the single-plant A second grade one; if they are in the difference trend grade, the single-plant A the third grade one. Generally, the first and second grade single-plant should be retained to be planted continuously; the third grade single-plant should be eliminated.

Thus it can be seen that the principles mentioned above is essentially to ascertain good or bad of the single-plant by the analysis of the identical or different degree. Hence, we call the method the similarity-difference selection method.

Let x_{gk} (g = 1, 2, …, n; k = 1, 2,…, m) be the observation value of the gth single-plant, the kth character. Thus, steps of the method of single-plant similarity-difference selection as follows:

Set the ideal value of various characters which is the best value in a certain character, the ideal single-plant character set B can be gained. The ideal value of the kth characters can be expressed as x_{0k}.

Find out the identical degree between the character value and ideal character value for single-plants which constitute the matrix P of similarity-difference degree:

$$P = \begin{vmatrix} a_{11} & a_{12} & \cdots & a_{1m} \\ a_{21} & a_{22} & \cdots & a_{2m} \\ \vdots & \vdots & \cdots & \vdots \\ a_{n1} & a_{n2} & \cdots & a_{nm} \end{vmatrix} \tag{7}$$

The element a_{gk} of the matrix is known as the identical degree between the single-plant character value x_{gk} and the ideal single-plant character value x0k. By further spreading the Eq. (1), there are:

$$a_{gk} = \frac{x_{ok}}{x_{gk}}, \text{ When } x_{gk} \geq x_{0k} \tag{8}$$

$$a_{gk} = \frac{x_{gk}}{x_{ok}}, \text{ When } x_{gk} < x_{0k} \tag{9}$$

$$a_{gk} = \frac{x_{ok}}{x_{ok} + |x_{ok} - x_{gk}|}, \text{ When } x_{0k} \text{ is moderate} \tag{10}$$

Ascertain the weight matrix vector $W = (w_1, w_2, \ldots, w_m)$ of various characters using the method of grey relational degree (Guo, 1995).

Construct the comprehensive identical degree matrix U between the evaluated single-plant and the ideal single-plant:

$$U = P \times W^T \tag{11}$$

The element Ag in U is a comprehensive identical degree between the gth single-plant character and the ideal single-plant character set:

$$A_g = \sum_1^m a_{gk} w_k, \ (g = 1,2,\ldots,n; k = 1, 2,\ldots, m) \tag{12}$$

According to the Eq. (1) and (2), write out the connection formulas among the various single-plant characters and the ideal single-plant character set. From this, we can make out the ratio relationship of the identical degree to difference degree.

On the grounds of Eq. (4), (5) and (6), calculate the mean connection trend of various single-plants.

In the right of the relation between the identical degree a and the difference degree b in Table 1, fix the connection trend and single-plant grades of various single-plants.

The single-plant evaluated as the first or the second grade should be planted continuously and the single-plant evaluated the third grade should be eliminated.

RESULTS AND DISCUSSION

The breeding observation data (Table 2) of wheat variety Yumai 35, Anmai 1 and Anmai 7 were analyzed during the course of single-plant selection by adopting the principle and method above mentioned. Among them, Anmai 1 and Anmai 2 came from the same cross combination, which are sibling lines with different characters.

The ideal single-plant is the best single-plant for various characters which consist of the best values in single-plants evaluated. The breeding experiences for years show that the height of single-plant belongs to the moderate character, its suitable range is among 65-80 cm in conditions of breeding test field and other characters are upper limit characters, their ideal values are all the maximum value (Table 2).

In accordance with the Eq. (8)-(10), the identical degree of single-plant gained in various characters in generations as shown in Table 3. For instance, the identical degree between the observation value (Table 2) and the ideal value of pedigree No. 87C29-66 is $a_{12} = x_{12}/x_{02} = 7.5/13 = 0.5769$ in the ears per plant. The calculation of other characters is similar to this.

To evaluate the good or bad of the single-plant comprehensively, each character's importance is clearly not alike. With a progressive increase in cross generations, the heritability for various characters has a certain change (Borojevic, 1990; Pan, 1994; Zhang, 2006). Consequently, the weight for various characters is inconsistent in generations. For this reason, the weights for various characters are determined by breeding expert's experience or by adopting the method of grey relational degree (Guo, 1995), according to the observation values of various characters for single-plant in generations. Using breeding expert's experience, the weights for various characters have been determined in this example, which is as shown in Table 4.

In accordance with the Eq. (12), the comprehensive identical degree of single-plant in generations can be obtained which is listed in 3th column in Table 5. For example, the synthetic identical degree of 87C29-66 is $A_1 = 1\times0.1201+0.5769\times0.1930+0.5283\times 0.1545 +1\times 0.1267+0.9458\times0.2305+0.5\times0.1752 = 0.7454$. The calculation of other single-plants is similar to this.

Generally, the bigger the comprehensive identical degree of the single-plant is, the nearer the single-plant is to the ideal single-plant, the better the single-plant shows.

Table 2: Observation values of characters in different generations

Variety	Pedigree No.	Plant height (cm)	Ears per plant	Grains per ear	1000-grain weight (g)	Yield per plant (g)	Plumpness
Yumai35	87C29-66	77	7.5	42.9	49.7	46.0	0.5
	87C29-66-1	70	10	49.9	49.2	21.4	1
	87C29-66-1-25	80	13	81.2	46.1	48.5	1
Anmai1,	8909-16-2	72	13	45.2	39.2	23	0.5
Anmai7	8909-16-2-1	65	12	46.0	40.9	17.6	0.5
	8909-16-2-1-1	65.5	11	46.2	40.9	18.8	0.5
Ideal value		65-80	13	81.2	49.7	48.5	1

Table 3: Identical degree of characters in different generations

Variety	Pedigree No.	Plant height (cm)	Ears per plant	Grains per ear	1000-grain weight (g)	Yield per plant (g)	Plumpness
Yumai35	87C29-66	1	0.5769	0.5283	1.0000	0.9458	0.5
	87C29-66-1	1	0.7692	0.6145	0.8893	0.4412	1
	87C29-66-1-25	1	1.0000	1.0000	0.9276	1.0000	1.0000
Anmai1,	8909-16-2	1	1.0000	0.5567	0.7887	0.4742	0.5
Anmai7	8909-16-2-1	1	0.9231	0..5665	0.8229	0.3629	0.5
	8909-16-2-1-1	1	0.5462	0.5690	0.8229	0.3876	0.5
Ideal value		1	1	1	1	1	1

Table 4: Weighted coefficients of characters in different generations

Generation	Plant height (cm)	Ears per plant	Grains per ear	1000-grain weight (g)	Yield per plant (g)	Plumpness
F_2	0.1201	0.1930	0.1545	0.1267	0.2305	0.1752
F_3	0.1162	0.1935	0.1460	0.1245	0.2428	0.1770
F_4	0.1252	0.2065	0.1652	0.1321	0.2322	0.1388

Table 5: Identical-difference analysis of single-plant in different generations

Variety	Pedigree No.	Synthetic identical degree	Connection formula	Connection trend value	Connection trend	Single-plant grade
Yumai35	87C29-66	0.7454	0.7454+0.2546*i*	2.9277	Strong identical trend	1
	87C296-66-1	0.7496	0.7496+0.2504*i*	2.9936	Mini-identical trend	1
	87C29-66-1-25	0.9904	0.9904+0.0096*i*	103.5583	Strong identical trend	1
Anmai 1,	8909-16-2	0.6959	0.6959+0.3041*i*	2.2888	Mini-identical trend	1
Anmai 7	8909-16-2-1	0.6566	0.6566+0.3434*i*	1.9120	Mini-identical trend	1
	8909-16-2-1-1	0.6001	0.6001+0.3999*i*	1.5006	Mini-identical trend	1

Table 6: The regional test yield and their registration states of Yumai 35, Anmai 1 and Anmai 7

Variety	Test type	Year	Mean yield (kg/hm^2)	Increasing yield than CK (%)	Yield order	Registration department
Yumai35	Regional test in Henan	1991-1992	6738.0	5.95*	1	Variety approval council
	Regional test in Henan	1992-1993	6670.5	17.19**	1	in Henan in 1995
	Production test in Henan	1993-1994	4863.0	7.78*	1	
	Production test in Henan	1994-1995	4525.5	3.11	2	
Anmai No.1	Regional test in Henan	1998-1999	7294.5	8.27**	1	Variety approval council
	Regional test in Henan	1999-2000	9900.0	8.36**	2	in Henan in 2001
	Production test in Henan	2000-2001	7250.4	2.19	2	
Anmai No.7	Super high yield test in Henan	1998-1999	8110.5	6.15	3	Variety approval council
	Super high yield test in Henan	1999-2000	8433.3	0.07	5	in Henan in 2004
	Arid regional test in Henan	2001-2002	4250.1	5.6**	2	
	Arid regional test in Henan	2002-2003	4996.5	1.75	5	
	Arid production test in Henan	2003-2004	4392.0	1.1	3	

*: Significance at 0.05 levels; **: Significance at 0.01 levels

According to the Eq. (1) and (2), write out the connection formula for various single-plants (Table 5). From the expression formulas of connection degree, we can see that the bigger the identical degree of single-plant or the smaller the difference degree of single-plant is, the bigger the connection degree of single-plant is. For example, the identical degree of single-plant 87C29-66-1-25 for Yumai 35 is 0.9904; its difference degree is 1-0.9904 = 0.0096, this show that the coincidence degree of breeding target character of the single-plant with the ideal single-plant character is 99.04% which is the definite part. Other 0.96% is difference to the ideal single-plant and is indefinite, its indefinite degree depends on i value. That is to say that identical degree and difference degree are two aspects of a contradiction, they are coexistence in a unitary body of single-plant which takes i as a link. If i is positive value, the part can be transformed into the identical degree; if i is negative value, the part can be transformed into the difference degree. Generally speaking, because the relationship between the identical degree and the difference degree is relatively complemented, i is -1 in the analysis of similarity-difference of single-plant. Thus, the connection degree between the single-plant and the ideal single-plant is 0.9904-0.0096 = 0.9808, which shows that the single-plant has a higher connection degree; its comprehensive characters have attained the ideal status on the whole. The analysis of other single-plants is the same as this.

Calculate the connection trends of various single-plants by the Eq. (4), (5) and (6). In accordance with the relation between the identical degree and the difference degree in Table 1, determine the grades and connection trends of various single-plants. For instance, the connection trend value of 87C29-66 is a/b = 0.7454/0.2546 = 0.9277. The calculation of other single-plants is similar to this.

From Table 5, we can see that the connection trend values of various single-plants are all bigger than 1. The connection trends among the various single-plants and the ideal single-plant are in the status of identical trend from the definition 3 above mentioned. Hence, the single-plants for Yumai 35, Anmai 1 and Anma 7 having been selected are all the first grade single-plant. After that, those good single-plants all climbed into the good strains and manifested excellent in the wheat region test in Henan province which were examined and approved by the Henan Province Agricultural Crop Variety Examination and Approval Committee (Table 6).

In recent years, varieties mentioned above show some prominent traits with high yield, stable yield and disease resistance in the promotion course, their cumulative promotion area have reached 1.35 million ha, having a tremendous economic and social benefits and by the farmer welcome.

Thus, using the principle and method of single plant similarity-difference selection to direct the wheat breeding is practical and effective.

The method of single-plant similarity-difference selection applying in the course of wheat single-plant selection has overcame the limitations of traditional breeding by subjective experiences making one's choice and has made a valuable try and exploration in the quantization of single-plant selection, making the single-plant selection more objective and science, being an important significance to speeding up the selection progress, to raising the selection efficiency and to realizing the intellectuality of crop breeding.

The method of single-plant similarity-difference selection can consider many characters simultaneously and can make the multiple breeding goals being an unity harmoniously each other, avoiding the phenomenon of caring for this and losing that in tradition breeding, being an unique decision-making method of multi-target single-plant selection.

The method of single-plant similarity-difference selection is simple in computing, mastered easily, disseminated conveniently. If it is programmed the computer system, the method shall be faster and more handy. Consequently, the method has a vast application prospect.

Application the method to the breeding course of Yumai 35, Anmai 1 and Anmai 7 has proved the feasibility of the method from the angle of breeding practice. Because the process of crop breeding has a similarity, the method can apply to the process of single-plant of other crop breeding simultaneously. Therefore, we have reason to think the method being an effective tool and means of breeding workers.

Owing to the method of the single-plant similarity-difference selection based on the phenotype of single-plant which observed characters are the results of interaction of genotype and environment, it could not describe and solve the problems from the angle of molecules. For this reason, Combining the method with the molecule marker assisted selection technique will be a meaning research direction in crop breeding.

CONCLUSION

It was concluded that similarity-difference selection method could be used as an effective tool and means for crop breeders.

Owing to the method of the single-plant similarity-difference selection based on the phenotype of single-plant, it could not solve the problems from the angle of molecules. For this reason, Combining the method with the molecule marker assisted selection technique will be a meaning research direction in crop breeding.

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REFERENCES

Borojevic, S., 1990. Principles and Methods of Plant Breeding. Elsevier Science Publisher, Amsterdam, pp: 94-99.

Guo, R.L., 1992. The application of grey system to wheat genetic breeding-grey selection. J. Grey Syst., 4: 269-280.

Guo, R.L., 1995. Crop Grey Breeding Science. China Agricultural Science and Technology Press, Beijing, pp: 166-188. (In Chinese)

Guo, R.L., 2004. The test of connection trend for the similarity-difference analysis and its application in regional test of wheat variety. J. Triticeae. Crops, 24: 63-65. (In Chinese)

Guo, R.L., C.J. Song, C.L. Yang and L. Guan, 1992. Study ongreysingle-selectionmethodof wheat. Acta Agric. Univ., Henanensis, 26: 410-416. (In Chinese)

Kempthome, O. and A.W. Nordskog, 1959. Restricted selection indicies. Boimetrics, 15: 10-19.

Lin, C.J., 1978. Index selection for genetic improvement of quantitative character. Theor. Appl. Genet., 52: 49-56.

Pan, J.J., 1994. General Discussion of Crops Breeding. China Agricultural Press, Beijing, pp: 59-60. (In Chinese)

Smith, H.F., 1936. A discriminant function for plant selection. Ann. Eugenic., 7: 240-250.

Tallis, G.M., 1962. A selection index for optimum genotype. Boimetrics, 18(1962): 120-122.

Wang, F.T. and R.L. Guo, 1991. Application the improved contingency method to wheat breeding. Acta Ggron. Sinica, 17: 11-17. (In Chinese)

Xue, G.D., R.L. Guo and C.J. Song, 1994. The application of single plant grey selection theory in wheat breeding. Proceedings of 3rd National Youth Symposium on Crop Genetics and Breeding, pp: 281-288 (In Chinese)

Zhang, T.Z., 2006. General Discussion of Crops Breeding. China Agricultural Press, Beijing, pp: 59-60. (In Chinese)

Zhao, K.Q., 2000. Set Pair Analysis and Its Preliminary Applications. Zhejiang Science and Technology Press, Hangzhou, pp: 9-12. (In Chinese)