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Application of Genetic Rules of Quality Traits in the Selection of Watermelon Inbred Lines

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Abstract On the basis of ascertaining the dominant and recessive relationship and separation ratio of quality traits such as leaf type and peel stripes, the separation of dominant and recessive traits was studied to infer whether the genes of the previous generation were homozygous. Individuals with homozygous recessive traits can be confirmed in F_2 generation, and homozygous single lines with dominant traits can be confirmed in F_3 generation, which speeds up the breeding process of watermelon inbred lines.

Key words Watermelon, Inbred line, Quality trait, Selection

1 Introduction

Traditionally, watermelon inbred lines are selected by more than five generations of genetic isolation and selection. To breed inbred lines with highly homozygous traits, more than five generations of watermelon having some target traits with high heritability are inbred continuously until both of the traits and the genes are homozygous.

In order to accelerate the homozygous process of watermelon inbred lines, a rapid selection technology study on the quality characters of watermelon inbred lines was carried out. According to the number of pairs of genes controlling a certain trait and the relationship between dominant and recessive genes, the separation ratio of its progeny was inferred[1], and the proportion and phenotypic expression of the homozygote and heterozygote of this quality trait in the offspring were determined to determine the gene homozygosity. After 1 - 2 generations of screening, strains with homozygous quality traits could be selected[2].

1 Materials and Methods

1.1 Test materials The test materials are homozygous inbred lines selected by Kaifeng Academy of Agriculture and Forestry for many years. For material H406, the leaves are incised; the fruit is highly round, and the peel is white and green covered with fine mesh stripes; the central sugar content is 10.7%. For material H431, the leaves are entire; the fruit is highly round, and the peel is white and green covered with green racks; the central sugar content is 10.3% (Table 1). In August 2017, H406 and H431 were combined to obtain hybrid seeds.

The field experiments were conducted in the experimental fields of Kaifeng Academy of Agriculture and Forestry. The spring experiment used double-film low-gross cultivation, and the sowing date was March 25. The autumn experiment adopted greenhouse cultivation, and the sowing date was July 25. The row spacing was 0.5 m × 2.0 m, and there were two vines on one branch. Conventional filed management method was adopted in production.

1.2 Test methods

1.2.1 Planting experiment of F_1 generation. In March 2018, 20 hybrid seeds were planted. The growth potential and leaf type of each plant were observed throughout the growth period. The shape, peel color and covering stripe of fruit were observed during the fruit setting period. The dominant and recessive relationships of quality traits were judged from leaf type, fruit appearance and covering stripe performance. During the opening period of female flower, the individual plants were strictly inbred. During the mature period, 10 melons with neat appearance were selected to measure the weight of a single melon and the sugar content of fruit center and edge, from which two heavy melons that met the target quality traits and had a high sugar content were planted, and each of the melons was a single line.

1.2.2 Planting experiment of F_2 generation. 60 plants of each material were planted. Beside the observation and examination items of F_1 generation, the leaf type, peel color and covering stripe, and separation ratio were counted, and the number of pairs of genes controlling the traits was judged. Ten fruits were selected from plants with dominant and recessive traits, respectively, and tested for planting. According to the results of the test, two heavy melons rich in sugar were selected from recessed traits (entire leaves, green peel covered with fine stripes); four heavy melons rich in sugar were selected from dominant traits (incised leaves, green peel covered with racks), and the next generation was promoted to six single lines.

1.2.3 Planting experiment of F_3 generation. For F_3 generation, 30 plants of each material were planted. The homozygosity of the material in terms of leaf type, peel color and stripes was mainly observed. If the target quality traits of a line were separated, the last generation of plants were heterozygotes. If that of a line were not separated, the last generation of plants were homozygotes. The single lines with separated quality traits were eliminated, while in the lines without separation, individual plants were strictly inbred. During seed selection, the one with the best quantitative traits can be used as a homozygous material.

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Table 1 Traits of parent materials

No.	Leaf shape	Fruit shape	Peel color and stripe	Sugar content//%	
				Center	Edge
H406	Incised	Highly round	White and green peel covered with fine mesh stripes	10.7	9.7
H431	Entire	Highly round	White and green peel covered with green racks	10.3	9.1

2 Results and Analysis

2.1 Dominant and recessive relationship in F_1 generation It can be seen from Table 2 that in the inheritance of leaf type, the leaves of all plants in F_1 generation were slightly incised, and there was no entire leaf. It shows that entire leaves were recessive to incised leaves. In the inheritance of peel color and covering stripes, all peel was covered with green racks, and no green mesh stripes appeared. It shows that mesh stripes were recessive to racks.

Table 2 Traits of F_1 generation in the autumn of 2017

No.	Source	Leaf shape	Separation of leaf shape	Peel color and stripe	Separation of peel	Sugar content//%	
						Center	Edge
F1101	H406 × H431	Slightly incised	No	Green peel covered with racks	No	10.6	9.4

2.2 Planting experiment of F_2 generation From Table 3, it can be seen that in the 60 plants, the leaf type and peel stripes were separated. The separation of leaf type is as follows: in F1201, there were 15 plants with entire leaves, 30 plants with slightly incised leaves, and 15 plants with incised leaves, so the separation ratio was 1∶2∶1; in F1202, there were 14 plants with entire leaves, 32 plants with slightly incised leaves, and 14 plants with incised leaves, so the separation ratio was 1∶2.3∶1. Both of them agree with the genetic segregation rule of quality traits proposed by Mendel, indicating that the entire leaf type and the incised leaf type are controlled by a pair of genes. The separation of peel stripes is as follows: in F1201, there were 16 plants with green peel covered with fine mesh stripes and 44 plants with green peel covered with racks, so the separation ratio was 1∶2.7, close to 1∶3; in F1202, there were 15 plants with green peel covered with fine mesh stripes and 45 plants with green peel covered with racks, so the separation ratio was 1∶3. Both of them also showed the characteristics of single-gene hereditary traits.

Table 3 Traits of F_2 generation

No.	Source	Leaf shape	Separation of leaf shape	Peel color and stripe	Separation of peel	Sugar content//%	
						Center	Edge
F1201	F1101-1	Entire leaves + slightly incised leaves + incised leaves	15 + 30 + 15	Green peel covered with mesh stripes + green peel covered with racks	16 + 44	10.6	9.4
F1202	F1101-2	Entire leaves + slightly incised leaves + incised leaves	14 + 30 + 14	Green peel covered with mesh stripes + green peel covered with racks	15 + 45	10.7	9.3

2.3 Planting experiment of F_3 generation It can be seen from Table 4 that among the 6 single lines planted, the target quality traits (leaf type and peel stripes) of single lines F1301 and F1302 obtained by recessive individuals were not separated. There were all entire leaves and green peel covered with fine mesh stripes. It was further verified that the leaf type and peel stripes were controlled by recessive genes, and the single plants of F_2 generation were already homozygous. The leaf type of F1303 was not separated, and all leaves were incised, indicating that the line was homozygous for the dominant trait leaf type. However, separation appeared in the peel color and stripes, that is, there were two types of peel (green peel covered with mesh stripes and green peel covered with racks). It indicates that the line was not heterozygous for this trait, that is, the single plants of F_2 generation were heterozygous. The leaves of F1304 and F1306 were incised or entire, and there was green peel covered with mesh stripes or racks. It shows that the homozygosity of this line was poor, and the single plants of F_2 generation was heterozygous. The leaves of F1305 were all incised, and there was no separation, indicating that its leaf type was homozygous; green peel was covered with racks, and there was no separation, indicating that its peel color and stripes were also homozygous. It can be judged that the single plant of F_2 generation were already homozygous.

Table 4 Traits of F_3 generation

No.	Source	Leaf shape	Separation of leaf shape	Peel color and stripe	Separation of peel	Sugar content//%		Homozygosis of quality traits
						Center	Edge	
F1301	F1201-1	Entire leaves	No	Green peel covered with mesh stripes	No	10.7	9.4	Homozygous
F1302	F1202-1	Entire leaves	No	Green peel covered with mesh stripes	No	10.2	8.7	Homozygous
F1303	F1202-2	Incised leaves	No	Green peel covered with mesh stripes + green peel covered with racks	Yes	10.8	9.4	Heterozygous

(To be continued)

(Continued)

No.	Source	Leaf shape	Separation of leaf shape	Peel color and stripe	Separation of peel	Sugar content//%		Homozygosis of quality traits
						Center	Edge	
F1304	F1201-2	Incised leaves + entire leaves	Yes	Green peel covered with mesh stripes + green peel covered with racks	Yes	11.0	9.6	Heterozygous
F1305	F1202-3	Incised leaves	No	Green peel covered with racks	No	10.6	9.5	Homozygous
F1306	F1202-4	Incised leaves + entire leaves	Yes	Green peel covered with mesh stripes + green peel covered with racks	Yes	10.3	9.2	Heterozygous

3 Conclusion and Discussion

(i) According to the dominant and recessive relationships and separation ratio of quality traits, the generation and proportion of homozygous individuals were inferred. Homozygous individuals controlled by recessive genes could be obtained in F_2 generation, and homozygous individuals controlled by dominant traits could be obtained in F_3 generation. This process was shortened by 2 – 3 generations compared with the homozygous process of traditional pedigree method (5 – 6 generations), thereby accelerating the selection process of watermelon inbred lines[3]. (ii) For a quality trait controlled by a pair of genes, the separation ratio of dominant trait and recessive trait is 3∶1 in F_2 generation. In order to obtain one individual with a homozygous recessive trait in F_2 generation, F_2 generation should have 4 plants theoretically at least. Considering the genetic neutrality of quantitative traits such as weight of a single melon and sugar content, more than 10 fruits with recessive traits should be obtained. Therefore, the number of plants in F_2 generation should be more than 40. In this study, 60 plants were planted in F_2 generation. (iii) In this study, the homozygosity of a line was observed in F_3 generation. The individuals with recessive traits obtained in F_2 generation were promoted to single lines in F_3 generation, and was mainly used for the selection of quantitative traits and the verification of the homozygosity of the target quality traits. It was appropriate to plant 25 plants in a single line. The individuals with dominant traits obtained in F_2 generation were promoted to a single line in F_3 generation. If the quality target selection separation occurred in the line, the individuals of F_2 generation were heterozygous, and the whole line could be eliminated. If there was no selective separation of quality targets in the line, the individuals of F_2 generation were homozygous, that is, the target quality traits had been homozygous. In such a single line, the quantitative properties were selected. The quality traits of individuals with dominant traits obtained in F_2 generation will be separated in F_3 generation, so the number of planted plants should be 30.

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