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Male Sterility in the Egyptian Onion (*Allium cepa* L. cultivar Behairy)[1]

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ABSTRACT

The frequencies of factors controlling male sterility in the Egyptian cultivar, Behairy, were determined. Male sterile plants were found with a frequency of 0.00159. The frequency of the chromosomal factor ms was found to be 0.73, and that of the cytoplasmic factor S to be 0.003. The expected frequencies of the six possible genotypes were calculated under the assumption that the population is at equilibrium under random mating and ignoring the very low frequency of male sterile plants that do not form viable pollen grains.

The results indicated that the situation in the Egyptian onion cultivar Behairy is favourable for hybrid onion breeding. A hybrid programme in Behairy should concentrate on developing inbred lines and making test crosses to identify the genotype N ms ms. Therefore, the production and maintenance of lines essential for the hybrid production will be simplified. In such a breeding programme, attention should be given to eliminate through selection the undesirable characters in Behairy bulbs, such as thick neck and shades of redness. Inbred lines of Giza 6 Mohassan cultivar could be used in such a programme.

INTRODUCTION

Various papers were published on the occurrence of male sterility in onions and on the frequencies of factors controlling this character, e.g. Meer and Van Bennekom (3), Banga and Petiet (1), Pienaar (5), Peterson and Foskett (4). This published data indicated that the factors ms and S may occur in highly different frequencies. El-Shafie and Ahmed (2) determined the frequencies of factors controlling male sterility in the Egyptian cultivar Giza 6 Mohassan. They reported that the frequency of the chromosomal factor ms was found to be 0.013, whereas the cytoplasmic factor S was present in a frequency of 1.00. The implications of such information for hybrid onion breeding were discussed.

The purpose of the present investigation is to determine the frequencies of factors controlling male sterility in another cultivar of the Egyptian onion, i.e. Behairy culti-

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var, to see whether a situation similar to that of Giza 6 Mohassan is present or not. Such information will be of assistance in developing a breeding programme for the production of hybrid onions in Egypt.

MATERIAL AND METHODS

The present study involved only the cultivar Behairy that is grown on a large scale in the Delta area. In the season, 1972–1973 a farm at Kafr El-Ziaat was planted for commercial production of onion seed. From that field, that represents a natural population of Behairy cultivar, a sample of 3,137 plants were scored for male sterility or fertility. The frequency of male sterile plants was determined.

Twenty male sterile plants from the breeding stocks of the Agricultural Research Centre were transferred into the field. They were distributed among plants of the natural population of Behairy cultivar at as regular intervals as possible. These male sterile plants were left for open pollination and seeds were collected from them. In the season 1973–1974, seeds of the male sterile plants were planted separately to obtain bulbs. Bulbs of each progeny were grown in the season 1974–1975 for the production of flowers and subsequently seeds. At that season, the frequencies of male sterile and fertile plants in the progeny of each male sterile plant were determined. These frequencies would in turn reflect the frequency of ms and Ms in the natural population of Behairy.

The method of calculations was that used by Pienaar (5), and Meer and Van Bennekom (3). If (a) represents the frequency of male sterile plants in the natural population, and (q) represents the frequency of male sterile plants in the progeny of the male sterile plants transferred into the field, then the frequency of ms was (q) and that of S —that representing the frequency of plants with S cytoplasm — was a/q^2. The frequency of Ms and that of plants with N cytoplasm can be easily calculated by subtraction from one.

RESULTS

Table 1 shows the frequency of male sterile plants in a natural population of Behairy cultivar. The frequency of male sterile plants was found to be 0.00159. Table 2 shows the frequencies of male sterile and male fertile plants in the progeny of each male sterile plant left to be pollinated by the natural population of Behairy pollen grains. From the data, the frequencies of ms and Ms were calculated, i.e. 0.73 and 0.27, respectively. It is clear that ms and Ms are present in a ratio of 3:1.

Calculations of the frequency of plants with S cytoplasm and those with N cytoplasm are shown in Table 3. The calculations depend upon the frequency of male sterile plants and that of ms (q). The frequency of plants with S cytoplasm and those with N cytoplasm was found to be 0.003 and 0.997, respectively.

Table 1 Frequency of male sterile plants in natural population of Behairy cultivar.

Plants scored	Male sterile plants	Frequency of male sterile plants
3137	5	0.00159

Table 2 Frequencies of male sterile and male fertile plants in the progeny of male sterile plants left for open pollination. The table shows also the calculation of the frequencies p and q that represent the frequency of Ms and ms, respectively.

Plant No.	Number of plants in the progeny of male sterile plants: Sterile	Fertile	Fitness to[a] 3:1 ratio	Calculations
			P	
1	28	9	.98–.95	
2	14	4	.99	
3	16	5	.98–.95	frequency of ms (q) $= \frac{510}{699} = 0.73$
4	29	3	0.2–0.1	
5	14	3	.8–.7	
6	32	15	.7–.5	Since $p + q = 1$
7	62	12	.3–.2	$\therefore$ frequency of Ms (p) = 0.27
8	39	19	.5–.3	
9	28	6	.7–.4	
10	16	3	.7–.5	
11	21	29	.001	
12	20	9	.8–.7	
13	5	1	.99	
14	33	12	.98–.90	
15	35	8	.7–.5	
16	25	16	.2–.1	
17	35	14	.8–.7	
18	19	12	.3–.2	
19	29	4	.3–.2	
20	10	5	.8–.7	
Total:	510	189	.5–.3	
	699			

[a] By adjusted chi-square.

Table 4 shows the frequencies of the six possible genotypes regarding male sterility, assuming that the population is at equilibrium under random mating and ignoring the very low frequency of male sterile plants that do not form viable pollen grains. From Table 4, it can be seen that 53.13% of the plants in Behairy cultivar are expected to be of the genotype N ms ms. The expected proportions of the genotypes N Ms Ms and

Table 3 Calculations of the frequency of plants with S and N type of cytoplasm

Frequency of male sterile plants = freq. of S cytoplasm × freq. of q^2

$.00159 = S \times q^2$

$.00159 = S\,(.73)^2$

$.00159 = S \times 0.5329$

$\therefore$ freq. of plants with S cytoplasm $= \frac{.00159}{.53290} = 0.0029$

$\approx .003$

Since $S + N = 1$

$\therefore$ freq. of plants with N cytoplasm = 0.997

Table 4 Frequencies of the six possible genotypes, assuming that the population is at equilibrium under random mating and ignoring the very low frequency of male sterile plants that do not form viable pollen grains.

Genotype	Frequency	Calculated frequency
N Ms Ms	N p^2	.0726813
N Ms ms	N 2pq	.3930174
N ms ms	N q^2	.5313013
S Ms Ms	S p^2	.0002187
S Ms ms	S 2 pq	.0011826
S ms ms	S q^2	.0015987
Total:		1.0000000

N Ms ms are 7.26% and 39.30%, respectively. Only 0.02% and 0.11% are of the genotypes S Ms Ms and S Ms ms, respectively. It can be noted that the expected frequency of the male sterile genotype S ms ms is exactly the same as the observed frequency.

DISCUSSION AND CONSEQUENCES FOR BREEDING

The results of the present investigation show that the frequency of ms in Behairy cultivar of the Egyptian onion is relatively high, i.e. 0.73. The frequency of plants with S cytoplasm is very low, i.e. 0.003, and those with N cytoplasm appears to be very high, i.e. 0.997. Such information is important in drawing up a hybrid programme.

The situation here in Behairy cultivar is somewhat similar to that found in the Dutch variety Rijnsburger as reported by Meer and Van Bennekom (3). They found that the frequency of ms was over 0.95 and the cytoplasmic factor S was in a frequency of less than 0.01. Therefore, the situation regarding the Egyptian Behairy cultivar is favourable for hybrid onion breeding. A and B lines can be developed easily since male sterile plants can be found while nearly 53.13% of the plants are expected to be of the B line genotype N ms ms. The latter line is used as a maintainer for the male sterile line A (S ms ms). A hybrid programme in Behairy cultivar should concentrate on developing inbred lines and making test crosses to identify the genotype N ms ms. Therefore, the production and maintenance of lines needed for the hybrid production will be simplified. Attention should be given in such breeding programme to eliminating the undesirable characters in the Behairy type of the Egyptian onion. Selection should be directed against thick neck and the shades of red colour in the bulbs. The hybrid programme can take benefits from those Behairy lines with good characteristics that are under development by the onion breeding section of the Field Crops Institute of Egypt.

According to El-Shafie and Ahmed (2), survey for the N ms ms genotype in the Egyptian Giza 6 Mohassan cultivar has failed. That cultivar is grown commercially in Upper Egypt. They recommend the incorporation of N cytoplasm from a foreign source into Giza 6 Mohassan. However, the results of the present investigation indicated that the situation in Behairy cultivar is more favourable for hybrid production. Such information will facilitate developing F_1 hybrids in Egypt. Good inbred lines of Giza 6 Mohassan cultivar could be used in such a programme.

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