YIELD AND FRUIT IMPROVEMENT OF TOMATO HYBRIDS USING MALE STERILE MUTANT LINE

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ABSTRACT

The present investigation conducted at the Institute of Plant and Agricultural Science of the Mongolian University Life Science in 2010-2012. The experimental material consisted of 10 tomato cross combinations and 10 check testers were included with male parents.

A search was conducted in commercial plantings in Mongolia for the first time in tomato for male-sterile technique, potentially useful in producing F1 hybrid seed and in cross-breeding. The extent of heterosis for yield components and fruit characters of tomato in cross combinations involving tolerant accessions and processing varieties/lines/ is reported in this paper.

We crossed the 7B-1 mutant a female parent with other tomato lines I-16398, MK-1846, I-23818, I-22936, MK-2926, MK-1881 as e,g and the hybrid seed produced was viable in terms of germination and plants showed normal growth and flowering. After the crossing the successful seed fertilization rate ranges between 41.7-88.9%, and the 7B-1 X MK-22872 crosses showed the highest performance of 88.9%.

Our study revealed that it is possible to use MK-1881, MK-2926 for increasing early harvest, and MK-5805, Mk-1846 are for increasing total yield. These two hybrids could be used commercially for high yield.

Keywords: heterosis, crossing, male parent, hybrid seed, early maturity

INTRODUCTION

Tomato is a major crop in nearly all parts of the world. In 2017, the worldwide production of tomatoes totaled 170.8 million tons. China, the leading producer of tomatoes, accounted for 31% of the total production. India and the United States followed with the second and third highest production of tomatoes in the world (WorldAtlas.com 2017).

Male sterility on crop plants, spontaneous or induced, is a choice material for plant breeders for several reasons including its use in backcrossing, interspecific hybridization, and in F1 hybrid seed production. There are several male-sterile (ms) mutants known in near crop, but their use in breeding programs has been limited for a variety of reasons (Kaul 1988; Rao et al.1990).

Numerous varieties of the tomato plant are widely grown in temperate climates across the world, with green houses allowing for the production of tomatoes throughout all seasons of the year.

Mongolia has an extreme cold and severe continental climate and it has only cold free months between June-September. The short growing season, low precipitation and high evaporation are the overriding constraints in Mongolian agriculture. Tomato is grown in many parts of the country in Mongolia possessing different agro-ecological conditions. It grows at an altitude between 700 and 1200 meters above sea level, which is characterized by warm and dry days and cooler nights which are favorable for optimum growth and development.

Based on the results of various test studies conducted at the Institute of Plant and Agricultural Sciences (IPAS) we selected tomato lines the Iyulskii, Evgeniya, Sibirskii skorospelii 1450, Nevskii -7, Vishnevidnii, Efimaya that have stable and high quality yield. Farmers are interested in planting these varieties; however, it is limited due to insufficient seed production and lack of new tomato variety release (D.Bolooj.1986; Ts. Narandelger , B.Odonchimeg.2010).

Tomato (Solanum lycopersicum L.) has the potential for improvement through the heterosis breeding which can further be utilized for the development of desirable recombinants.

Nowadays, farmers of Mongolia are more inclined to grow hybrid varieties having high yield potential and to get early harvest and good quality fruits. But there is a lack of good hybrids especially in the public sector. So, the development of hybrid varieties of tomato is needed to support the farmer. Therefore, the present experiment was carried out to identify best cross combinations for yield and quality components using male sterile technique.

MATERIALS AND METHODS

The 10 male parent lines and 7B-1 mutant as female parents which were crossed in 2010 planted in a completely randomized block design each on 3.2 m^2 plots. Seedlings were transplanted on 10 May with apart 70x40 cm or 20 plants per plot.

The 7B-1 mutant is a simple, natural and cost-effective system that has strong potential for use in commercial-scale production of tomato hybrid seed. The current practice of manual emasculation of tomato flowers for hybrid seed production is labor–intensive and contributes significantly to the high cost of seed. But, heterosis in the hybrid seed produced using 7B-1 mutant can be successfully used as female parent for F1 hybrid seed production (V.K.Sawhney 2004).

Observations were recorded from 10 selected plants from each parental line and hybrid on plant height (cm), number of branches per plant, days to 50% flowering, days to first harvesting, early fruit yield per plant (kg), fruit size (polar and equatorial diameter), total number of fruits per plant, total fruit yield per plant (kg), individual fruit weight (g), ascorbic acid (mg/%) and acidity (%) and replication wise mean value was used for statistical analysis.

The tomato seed setting success (seed fertilization rate) had been determined as per the methodology described by L.N. Golubinski (1974).

The analysis of hybrid vigour (heterosis advance) was carried out as per the methods described by F.Peter and K. Frey (1966) .

RESULTS AND DISCUSSIONS

Obtaining tomato hybrids began in 2010 using male sterile mutant 7B-1 which was received from the University of Saskatchewan, Canada.

We crossed the 7B-1 mutant with other tomato lines I-16398, MK-1846,I-23818,I-22936, MK-2926, MK-1881, I-23819,MK-1846,MK-5804,I-22872 and the hybrid seed produced was viable in terms of germination and plants showed normal growth and flowering.

The 4-6 plants from 7B-1 mutant and 10 plants from each male parent and 5-10 flowers from each plant used for crossing. Totally 80-120 plants used for 10 combinations and total 190 flowers are pollinated. The crossing carried out from 28 June to 9 July 2010.

Table 1. Results of crossing tomato mutant x lines /2010/

	Crosses	Number of pollinated flowers	Number of fruits	Successful seed fertilization, %
1	7B-1 x 16398	24	20	83.3
2	7B-1 x MK1846	16	13	81.3
3	7b-1 x 23818	14	10	71.4
4	7B-1 x 22936	16	14	87.5
5	7B-1 x MK2926	12	5	41.7
6	7B-1 x MK1881	24	14	58.3
7	7B-1 x 23819	18	14	77.8
8	7B-1 x MK1846	24	18	75.0
9	7B-1 x MK5804	24	20	83.3
10	7B-1 x 22872	18	16	88.9

After the crossing the successful seed fertilization rate ranges between 41.7-88.9% and the 7B-1 x 22872 showed (Table.1) the highest performance of 88.9%.

When producing tomato hybrid seeds, the hybridization success rate was decreased due to damage of flower organs and it's required higher skill, knowledge and labor demand. Scientists are established that hybridization success rate available between 90-95% efficiently in hybrid seed production and in the case emasculation is no needed (Yu.L.Avdeev, 1982). Seed yield decreased by 37 % when use emasculation (A.B.Alpatiev,1981). Therefore, using male sterile parent in hybridization is an easy and efficient method to produce hybrid seeds. There have some advantages to produce hybrid seeds without using emasculation and quarantine.

As an overall result we were able to harvest 144 fruits and 8513 hybrid seeds from 10 combinations. Approximately, each fruit holds about 34-110 seed.

Nevertheless, the data presented shows that the 7B-1 mutant can be successfully used as a female parent for F_1 hybrid seed production in tomato.

In 2011 the study was undertaken to estimate the heterosis in tomato and combining abilities of tomato varieties and find out high heterosis lines. Incomparable studies of 10 hybrid lines with their parents, the differed by leaf shape, color, fruit color and shape, inside color and morphology resulted in leaf shape modification similar to potato's and light green color, but all fertilized. Red fruit color dominated than yellow and long shape round one's.

Quantity of inheritance traits like yield, fruit numbers, size, plant heights are different depending on parent characters.

Table 2. Heredity of color and shape of fruits of the hybrid F_1

Combination	Color and shape of fruit		Type plant	
	Parent	Hybrid F1	Parent	Hybrid F_1
7B-1 x Mk-1846	red, ellipse	red, round	*sp*	*spp*
7B-1 x MK 1881	red, round	red, round	*sp*	*spp*
7B-1 x MK5805	red, flattened round	red, round	*½ sp*	*spp*
7B-1 x MK5804	red, flattened round	red, round	*½ sp*	*spp*
7B-1 x I-22936	orange, round	red, round	*½ sp*	*spp*

7B-1 x MK2926	yellow, round	red, round	*½ sp*	*spp*
7B-1 x I-23818	red , flattened round	red, round	*spp*	*spp*
7B-1 x I-23819	red, cylindrical	red, round	*spp*	*spp*
7B-1 x I-22872	red, slightly flattened	red, round	*spp*	*spp*

remarks: *sp – determinate type , ½ sp – semi determinate, spp – indeterminate type*

The significant changes have been observed in F1 hybrids. For example, the determinant type line MK-1846 and the indeterminant growth type line I-23819 which have cylindrical fruit shape had been changed into round fruit shape in F1 hybrid. Also, the color of the fruit skin and flesh of semi-determinant lines I-22936 and MK-2926 changed (Table.2) into red from yellow.

The hybrid Sakthi x TH 318 (180.34g) and Sakthi x fresh Market 9 (1155.47g) yielded more than the better parents but their heterobeltiosis effects were not significant. Significant relative heterosis was observed in these hybrids (9.20 and 13.24%). Alice Kurian et.al.,2001).

Our study revealed that it is possible to use MK-1881, MK-2926 for increasing early harvest, and MK-5805, Mk-1846 are for increasing total yield. These two hybrids could be used commercially for high yield.

Plant fruit number increase and distribution of balanced growth are the main factors of high yield performance in tomatoes.

There is a tendency to develop large fruit (101.3 -140.5g) hybrids in the combination of the 7B-1 x I-22936, 7B-1 x MK-1881,7B-1 x MK-2926 and 7B-1x MK-5805, however, by the seed number per fruit dominated female parent genotypes. This indicates that the hybrid lines (F_1) became with few seeds in fruits than male parents. This character could be useful for tomato fresh consumption market needs.

Results indicate that the early yield and fruit numbers are controlled by additive and dominance effects, fruit weight by dominance, and their interaction with environment effects.

In the selection of early maturity hybrid lines the detecting character of early maturing of fruit is important. Besides that recombination of yield formation ability is important. Therefore it is necessary to combine those two characters in hybrid line.

The yield of the combination 7B-1 x MK-1881 and 7B-1 x MK-5805 was 36.0-70.2% higher in comparison to the male parent also when combinations compared to the highest yielding male parent then the parameter was 17.8-19.3% high and the hybrid vigor (heterosis advance) was 1.6-5.5. It may conclude that the heterosis expression is dominant and relatively dominant.

The indicator of heredity desired traits to the hybrid offspring is the hybrid vigor (heterosis advance) (B.Griifing 1956, J.Brubeiker 1966).

The early yield amount in total yield ranges between 19.7-31.3% in male parents and 10.0-56.6% in hybrid combinations. In particular, the combinations 7B-1 x I-1881 (h_p = 51.6), 7B-1 x MK-2926 (h_p = 2.27) and 7B-1 x Ravid (h_p = 3.74) have got very high heterosis expression and early yield in comparison to other combinations.

The heritability study in wheat shows that among the yield components the number and weight of seed in single spike (H^2=0.60-0.72, h^2=0.57-0.66) have the highest heritability and it facilitates high opportunity to conduct breeding for plant productivity improvement productivity in Mongolia (N.Altansukh. 1989, Ya.Myagmarsuren 2000).

According to the heritage coefficient, the early yielding capacity or duration between germination to flowering and fruit maturity (h^2=0.69-0,67), and the number and weight of fruit in a per plant (h^2=0.60-0.66) in selected tomato combinations are heritable traits with medium value

and these traits can be improved through breeding. However, the traits like early and total fruit yield (h^2=0.45-0.58), and the number of leaves up to the first flower cluster (h^2=0.27) have re low heritable traits.

In tomato hybrid combinations not only yield increased also fruit quality, taste and other biochemical characters improved.

Ascorbic acid is a nutritional parameter. It is the substitute of anti-oxidants and Vitamin C. Ascorbic acid content of tomato fruits varied from 16.57 to 28.1 mg/100g fruit juice.

The taste quality indicator of tomato is the sugar and acidity ratio in the fruit and this indicator range (4.3:0.75) = 5.73% in the combination of 7B-1 x I-23818 and 7B-1 x Mk-2926 and (3.7:0.29) = 12.7% in 7B-1 x I-16398. Also, the sugar and acidity ratio in combinations 7B-1 x Mk-1846, 7B-1 x MK-5805 and 7B-1 x MK-5804 had been increased 0.68 - 1.73% than male parent.

CONCLUSION

Heterosis by cross-pollination between line and testers would help to develop better hybrids with high yield potential acceptable to the consumers.

In the case of crossing 7B-1 mutant the fertilization success was 41.7-88.9%, and plant height was increasing from 69.8% to 80.4% as changing the type from determimant to indeterminacy.

The combinations 7B-1 x MK-1881, 7B-1 x Mk-2926 F_1 have been selected as promising hybrids which mature in 118-136 days, have early yield index (38.6-56.6%), and high contents of C vitamin (24.4-24.7mg/%), and sugar and acid ratio (7.5-8.8).

Statistical analysis of tomato hybrid lines proved that their inheritance rate is an adequate (H^2=0.90).This fact confirmed, can be developed out hybrid lines with high yield performances and inheritance modification.

Plant fruit number increase and distribution of balanced growth are the main factors of high yield performance of tomatoes.

There is a tendency to develop large fruit size (101.3 -140.5g) hybrids by combining lines 7B-1 x I-22936, 7B-1 x MK-1881, 7B-1 x MK-2926 and 7B-1x MK-5805 but, by seed number in fruit the female parent genotypes dominated.This indicates that the hybrid lines (F_1) changed to have few seeds in fruit than male parents. This character could be useful for tomato fresh consumption market needs.

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