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SELECTION AND EVALUATION OF GENETIC DIVERSITY IN POMEGRANATE 6- PHENOTYPIC AND GENOTYPIC CHARACTERIZATION OF S_1 PROGENIES DERIVED FROM SELF-POLLINATION OF BADR POMEGRANATE CULTIVAR

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ABSTRACT

A breeding program to improve pomegranate for desired traits should be considered. Thus, this investigation was conducted during the 2019 and 2020 seasons to study the phenotypic and genotypic characters of S_1 progenies resulted from the self-pollinating Badr pomegranate cultivar. Thirteen S1 progenies were selected to evaluate their vegetative, floral and fruit characteristics. Results revealed that tree height ranged from 285 to 420 cm and trunk circumference from 31 to 56 cm. Tree no. 12 (T12) recorded the highest percentage of fruit set (24.86%) in the two seasons. The highest yield was achieved by T11 (38.00 kg) in the first season and by T7 (33.75 kg) in the second one. T12 and T7 recorded the highest fruit weight (424.27 and 348.03 g) and volume (409.00 and 427.50 cm^3) across the two seasons, respectively. Soluble solids content (SSC) ranged from 9.17 to 15.40 °Brix and SSC/Acidity ratio ranged from 7.25 to 32.31. T9 and T4 showed the highest value of vitamin C (24.40 and 23.08 mg/100 ml juice), whereas T5 gave the highest concentrations of anthocyanin content (0.77 and 0.76 mg/100 ml juice), respectively, across two seasons. Total sugars ranged from 10.98 to 13.51 mg/100 ml juice. DNA fingerprinting was conducted using the SCoT marker technique. A total of eighty bands were generated from eight SCoT primers, ranging in size from 230 to 1430 bp, 57 bands (70.37%) were polymorphic, and the number of polymorphic bands varied from 2 (SCoT-01) to 13 (SCoT-04) with an average of 7.12 bands per primer. None of the used polymorphic SCoT primers could discriminate all the tested genotypes independently. The genetic similarity among the tested Badr S_1 trees ranged from a maximum of 0.903 (between T4 and T6) to a minimum of 0.610 (between T2 and T5). In general, from the investigated thirteen Badr S_1 progenies, six trees (T1, T3, T5, T7, T9 and T10) are promising, which showed high weight and percentage of aril, high weight and volume of fruit, high red coloration of arils, attractive red color of peel, high content of soluble solid with low acidity, high content of vitamin C and anthocyanin and good yielding. This investigation is considered a preliminary study to select new Badr S_1 genotypes that could be used in further trials of breeding programs to develop new superior varieties.

Key words: ***Selection, Evaluation, Pomegranate* (*Punica granatum* L.), *Selfing, Fruit properties, Fingerprinting*.**

INTRODUCTION

Pomegranate is one of the oldest known edible fruits. The fruit is popular among consumers because of its appealing, juicy, sweet, acidic, and refreshing arils. Due to its drought resistance, it is considered an excellent

tree for growing in arid zones. It is now widely grown in the Mediterranean, as well as in tropical and subtropical regions.

Pomegranate is genetically heterozygous, and it is a self and cross-pollinated crop, so fruit traits are generated naturally as well as through crossing (Jalikop and Kumar 1990). According to the great demand for pomegranate fruits due to its superior pharmacological and therapeutic properties, a studied breeding program must be initiated and intensified to improve fruit characteristics such as juice content, arils color, seed mellowness, fruit size, besides high yielding to meet the desires of local and international consumers, processors, growers, and exporters. These new genotypes can be obtained through traditional methods such as seedling selection, hybridization followed by selection, or through inducing mutations (Jalikop 2010).

In Egypt, there are some common cultivars such as Araby, Manfalouty, Assuity, Nab El-Gamal, Banati, Hegazy and Wardy, as well as some selected varieties such as Badr (4/8), Tahrir (4/9) and Montakhab (Khalil *et al* 1985, Abou El-Khashab *et al* 2005 and Gowda *et al* 2009). Khalil *et al* (2014) studied some hybrids between El-Tahrir and Nab El-Gamal cultivars. The offspring revealed a dark color of grains and the best ratio of T.S.S./acidity. They stated that some of these progenies gave a good yield per tree. Rayan *et al* (2015) studied some progenies resulted from the combinations (Manfalouty self-pollinated, Manfalouty × Nab El-Gamal and Manfalouty open pollinated), and measured several morphological quantitative and qualitative characters. They concluded that six progenies were promising for fruit characters, anthocyanin content and good yielding.

The main objective of this investigation was to study the phenotypic and genotypic characteristics and fingerprinting of thirteen S_1 progenies resulted from self-pollinated of Badr pomegranate cultivar to develop new varieties that could be used later to improve pomegranate characteristics through breeding programs.

MATERIALS AND METHODS

A breeding program to develop new pomegranate genotypes was started in the spring of 2004 by the staff of the breeding research department, Horticulture Research Institute (HRI), Agricultural Research

Center (ARC), Giza, Egypt, using "Manfalouty", "Nab El-Gamal", "Badr" and "Tahrir" pomegranate local cultivars that were grown at Aly-Mubarak farm, South Tahrir Research Station, Beheira Governorate, Egypt. All cross combinations were implemented to produce F_1 hybrids. During the spring of 2008, all F_1 seedling trees were planted at Shandaweel Island Research Station farm, Sohag Governorate, Egypt. This study evaluated thirteen Badr S_1 progenies (12-year-old trees) resulted from Badr self-pollination. These thirteen S_1 trees were selected according to their performance and were evaluated during the two growing seasons of 2019 and 2020 as follows:

Vegetative growth and floral attributes

Randomly, twelve shoots were marked on each selected tree in four directions to measure vegetative growth parameters. The initial date of vegetative growth, shoot length (cm), shoot diameter (cm), internode length (cm), tree height (m), trunk circumference (cm) and no. of leaves/shoot were recorded. Regarding floral attributes, dates of the blooming, initial fruit set and end of fruit set were recorded. Afterwards, flowering duration and fruit set duration were calculated by days.

Fruit set and yield

The percentages of male and perfect flowers were calculated relative to the total no. of flowers/shoot during the two seasons. Moreover, the no. of fruits per tree and total yield per tree (kg) were recorded.

Fruit properties

Randomly, twelve full mature fruits per tree were harvested and fruit characteristics were classified as follows:

Fruit physical properties

The fruit weight (g), volume (cm^3), length (cm), diameter (cm), and circumference (cm), no. of fruit chambers, weights (g) and percentage of arils (edible part) and peel (non-edible part) and no. of arils in 100 g were recorded. Fruit aril and peel colors were estimated visually by color chart.

Fruit juice chemical properties

Soluble solid content (°Brix), acidity percentage, ratio of SSC/Acidity, juice volume (ml per 100 g of arils), vitamin C (mg per 100 ml of juice), anthocyanin (mg per 100 ml of juice), total sugars (mg per 100 ml of juice), reducing sugars (mg per 100 ml of juice), non-reducing sugars

(mg per 100 ml of juice) and tannins (mg per 100 ml of juice) were estimated as follows:

- Soluble solids content (SSC) was estimated on pomegranate juice samples per fruit with a digital refractometer.
- Acidity was estimated by titration using sodium hydroxide at 0.1 N and phenolphthalein as an indicator, then expressed as grams of citric acid/100 ml juice as described in A.O.A.C. (2005).
- Total sugars were determined according to the method described by Dubois *et al* (1956).
- Fruit juice content was determined by extracting the contents of replicate samples of 100 g of arils per fruit using a juice extractor.
- Vitamin C content in the juice was estimated by using 2,6 dichlorophenolindophenol dye for titration according to A.O.A.C. (2005).
- Anthocyanin content in the fruit juice was estimated as described by Hsia *et al* (1965).
- Tannins content is determined in the fruit juice by the method described by Winton and Winton (1945).

SCoT-PCR analysis

DNA extraction

Total genomic DNA was extracted from young and fresh leaves tissues of Badr cultivar (as a parent plant) and thirteen selected trees of Badr S_1 progenies using DNeasy Plant Mini Kit (QIAGEN), according to the manufacturer's protocol.

SCoT marker technique was used to screen genetic polymorphism among the tested thirteen S_1 seedlings. Polymerase chain reaction (PCR) was conducted using eight SCoT primers as shown in Table (1).

PCR amplification conditions

The PCR amplification reactions were performed within 25µl total volume containing 1µl of template DNA (40 ng/µl), 1µl of primer (10 pmol/µl), 12.5µl 2X PCR Master mix solution [Promega Corporation, (50 units/ml of *Taq*DNA polymerase supplied in a proprietary reaction buffer (pH 8.5), 400µM of each deoxyribonucleotide triphosphates and 3mM $MgCl_2$)], and 10.5µl ddH_2O according to the Promega-PCR Master mix

protocol. Amplification reactions were carried out in Techne TC-5000 thermal-cycler, programmed as an initial Pre-denaturation step at 94 ºC for 5 minutes, followed by 40 cycles of 1-minute at 94 ºC, 1-minute at an annealing temperature of 46-58 ºC (varied for each primer) and 2-minutes at 72 ºC, followed by final extension cycle for 5-minutes at 72 ºC; then the reaction was finally stored at 4°C.

Table 1. List of SCoT primers and their nucleotide sequences.

No.	Name	Sequence	T_m °C	GC %
1	SCoT 1	ACG ACA TGG CGA CCA CGC	63	67
2	SCoT 2	ACC ATG GCT ACC ACC GGC	63	67
3	SCoT 3	ACG ACA TGG CGA CCC ACA	61	61
4	SCoT 4	ACC ATG GCT ACC ACC GCA	61	61
5	SCoT 6	CAA TGG CTA CCA CTA CAG	51	50
6	SCoT 8	ACA ATG GCT ACC ACT GAG	53	50
7	SCoT 9	ACA ATG GCT ACC ACT GCC	57	56
8	SCoT 10	ACA ATG CTA CCA CCA AGC	54	50

All amplification products were separated on 1.5 % agarose gels containing ethidium bromide (0.5µg/ml). The electrophoresis was performed in1 X TBE buffer solution at 100 Volts for one hour. After that, DNA fragments were visualized and photographed under U.V. light. The molecular size of the amplified fragments was determined against100bp DNA Ladder H3 Ready-to-use (GeneDireX, Inc.).

Data analysis

The Quantity One 1-D analysis software (Bio-Rad) was employed for processing and analyzing SCoT gels. Identification of the obtained DNA pattern for each sample was classified as (0, 1) coding, where 0; stands for the absence of the DNA band, whereas 1; stands for the presence of the DNA band. After that, these data were devoted to the calculation of the similarity index based on the Dice similarity coefficient (Dice 1945).

The calculated similarity matrix was elucidated for constructing the phylogenetic tree reflecting the diversity (genetic distances) among the studied Badr S_1 trees using the method of unweighted pair group method with arithmetical averages (UPGMA), where "IBM SPSS Statistics" (Ver. 25) was utilized.

Statistical analysis

Experiments were arranged in a randomized complete blocks design with three replicates. Data were subjected to analysis of variance (ANOVA). The differences among means of data were compared by Duncan's Multiple Range Test. All statistical determinations were made at $P \leq 0.05$ according to Gomez and Gomez (1984). Furthermore, because each tree is considered a unique seedling, some attributes were determined without replications such as tree height, trunk circumference, number of fruits per tree, and total yield per tree.

RESULTS AND DISCUSSION

Vegetative and floral attributes

Vegetative attributes

Table 2 represents the attributes of initial date of vegetative growth, shoot length, shoot diameter, internode length, tree height, trunk circumference and numbers of leaves per shoot of thirteen Badr S_1 progenies during the two seasons. Figure 1 illustrates the differences of initial date of vegetative growth between both two seasons for all S_1 trees, which ranged between (3 and 22 days). This may be due to differences in climatic conditions.

In 2019 and 2020 seasons, the highest shoot length was recorded with tree no. 8 (T8); (49.33 cm), (61.00 cm) and tree no.10 (T10); (48.00 cm), (61.33), respectively, but without significant differences among them. T13 showed the lowest shoot length values (34.67 cm) and (41.33 cm) in both seasons, respectively.

Regarding shoot diameter, T10 scored the highest value (0.88 cm), while T1 showed the lowest (0.60 cm) in the first season. However, during the second season, the highest significant values were (0.93 and 0.90 cm) for progenies T9 and T10, respectively. By contrast, the lowest was (0.66 cm) for T1 and T5.

Table 2. Vegetative growth attributes of Badr S_1 progenies during 2019 and 2020 seasons.

Tree No.	Initial date of vegetative growth		Shoot length (cm)		Shoot diameter (cm)		Internode length (cm)	
	2019	2020	2019	2020	2019	2020	2019	2020
T1	Feb. 17	Feb. 6	44.00 c	52.67 e	0.60 d	0.66 c	2.20 e	1.87 cd
T2	27	20	35.00 fg	43.33 i	0.68 cd	0.68 cd	1.97 f	2.10 ab
T3	17	20	38.33 e	58.67 b	0.67 cd	0.69 cd	2.13 e	1.97 bc
T4	15	09	36.33 f	45.67 h	0.69 cd	0.67 cd	2.00 f	2.07 ab
T5	13	23	41.00 d	51.00 f	0.66 cd	0.66 c	2.17 e	2.07 ab
T6	17	23	46.33 b	54.67 d	0.66 cd	0.69 cd	2.57 c	2.00 bc
T7	17	23	44.00 c	56.33 c	0.77 bc	0.67 cd	2.50 c	2.20 a
T8	15	23	49.33 a	61.00 a	0.69 b-d	0.81 ab	2.57 c	2.03 b
T9	28	25	44.33 c	56.33 c	0.80 ab	0.93 a	3.13 a	1.83 d
T10	5	27	48.00 a	61.33 a	0.88 a	0.90 a	2.33 d	1.83 d
T11	12	09	42.00 d	47.67 g	0.68 cd	0.71 cd	2.77 b	1.67 e
T12	28	14	45.33 bc	57.00 c	0.73 bc	0.74 cd	2.13 e	1.87 cd
T13	17	20	34.67 g	41.33 j	0.76 bc	0.73 cd	2.83 b	1.97 bc

Table 2. Cont.

Tree No.	No. of leaves/shoot		Tree height (cm)		Trunk circumference (cm)	
	2019	2020	2019	2020	2019	2020
T1	164.67 e	190.00 g	320 bcde	365 bcd	34.00 cd	40.00 c
T2	142.67 g	165.00 h	330 bcde	355 bcd	41.00 abc	49.00 abc
T3	200.00 d	251.67 e	324 bcde	375 abcd	38.00 abcd	47.00 abc
T4	204.33 d	265.00 d	320 bcde	350 bcd	36.00 bcd	41.00 c
T5	275.67 b	311.67 c	355 abc	390 ab	37.00 bcd	44.00 bc
T6	131.00 h	144.67 j	345 abcd	380 abc	36.00 bcd	48.00 abc
T7	150.00 f	200.00 f	370 ab	390 ab	34.00 cd	42.00 c
T8	139.33 g	159.00 h	385 a	420 a	45.00 a	56.00 a
T9	132.33 h	158.33 hi	360 abc	400 ab	36.00 bcd	45.00 bc
T10	261.67 c	312.67 c	310 cde	350 bcd	31.00 d	39.00 c
T11	130.33 h	150.00 ij	300 de	330 cd	42.00 ab	54.00 ab
T12	298.67 a	386.67 a	300 de	350 bcd	35.00 bcd	42.00 c
T13	280.33 b	323.33 b	285 e	325 d	41.00 abc	53.00 ab

Means followed by the same letter(s) in each column are not significantly different at (P < 0.05) using Duncan's multiple range test.

In the first season, T9 recorded the highest internode length value (3.13 cm), and the lowest was (1.97 and 2.00 cm) for T2 and T4, respectively without significant differences among them. T7 recorded the highest internode length value (2.20 cm), and the lowest was (1.67 cm) for T11 in the second season.

Concerning the average number of leaves per shoot, T12 recorded the highest significant value (298.67 and 386.67 leaves) in the two seasons. On the other hand, T11, T6 and T9 recorded the lowest significant values (130.33, 131.00 and 132.33 leaves), respectively, in the first season. While T6 scored 144.67 leaves in the second season. Studies on the vegetative growth of six local Egyptian pomegranate cultivars were investigated by Abou El-Khashab *et al* (2005). They reported that Manfalouty cultivar

exhibited the superior shoot length and the highest number of internodes, while Montakhab cultivar has the lowest number of leaves per shoot.

Data presented in Table 2 and Figure 2 revealed the increment rate of all Badr S_1 tree height, which ranged from 20.0 to 50.0 cm. The highest values of tree height were 385 and 420 cm with T8, and the lowest values were 285 and 325 cm with T13 in both seasons. Trunk circumference increment rate ranged from 5.0 to 12.0 cm during the 2019 and 2020 seasons, as shown in Figure 3. The highest values were obtained with T8 (45.00 and 56.00 cm), while T10 recorded the lowest values (31.00 and 39.00 cm) in 2019 and 2020 seasons, respectively.

The previous results of tree height are in good agreement with previous findings of Wani *et al* (2012), who stated that under Kashmir conditions, the tree height of some selections of pomegranate ranged from 2.34 to 4.78 m. Whereas Sharma and Bist (2005) noted that the "Chawla" cultivar had the maximum tree height (3.33 m), whereas the "PS-75-K-5" cultivar had the minimum tree height (1.65 m). Gowda *et al* (2009) reported that cultivars of Badr, Tahrir and Manfalouty had the highest circumference values of the tree trunk, while the tree height values ranged from 3.34 and 3.55 for Manfalouty to 2.55 and 2.65 for Badr cultivar.

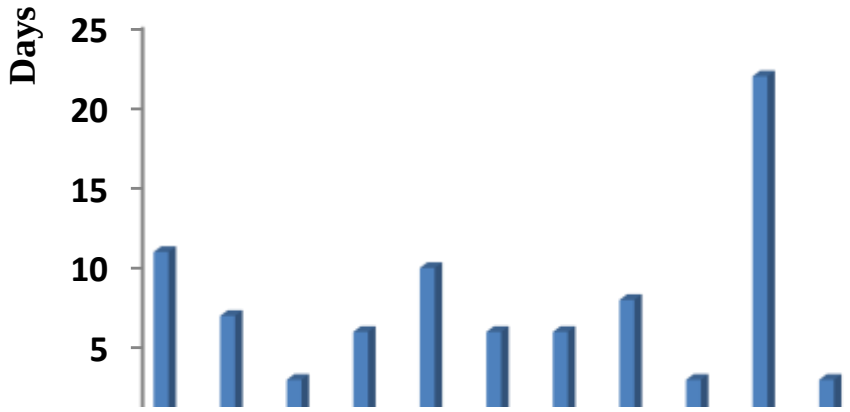

Fig. 1. Day differences in the beginning of vegetative growth of Badr S_1 progenies between the two seasons.

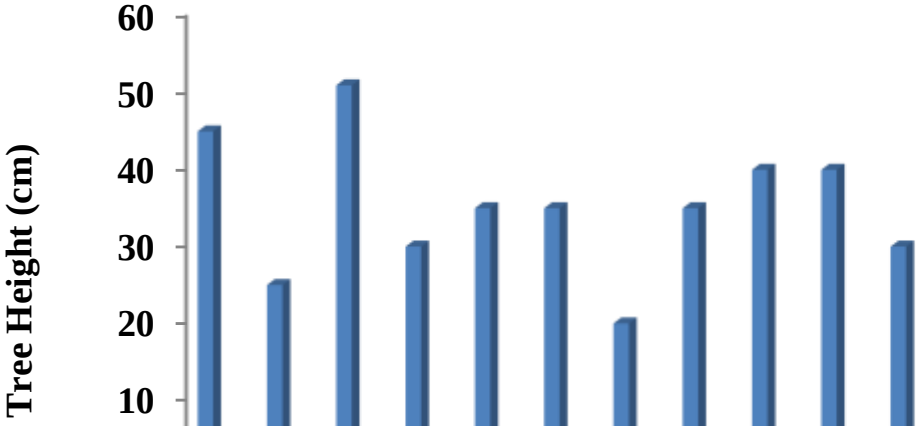

Fig. 2. Increment rate of tree height of Badr S_1 progenies during the two seasons.

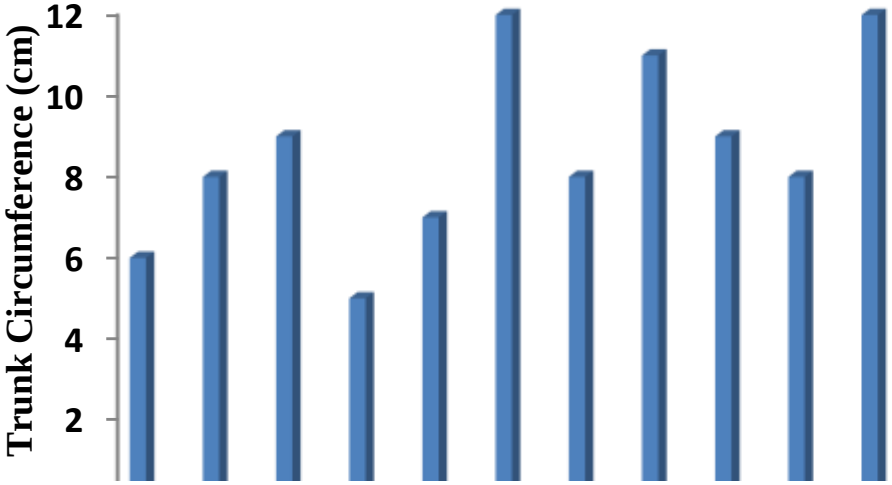

Fig. 3. Increment rate of trunk circumference of Badr S_1 progenies during the two seasons.

Floral attributes

Differences between blooming dates and fruit set of the thirteen Badr S_1 progenies in the two seasons (2019 and 2020) were presented in Table 3. Generally, data revealed that all progenies under study in the second season were the earliest for initial blooming dates, which ranged between 16th to 26th of March compared with the first season, except T9 was on the 3rd of April. T6 flower buds opening date was the first at opening where it occurred exactly on the 1st of March in the first season. All trees ended their blooming date in May in the two seasons. The longest flowering duration was 55 days with T6, while the shortest was 40 days with T9 in the first season.

Concerning the initial fruit set date, it is obvious that T8 and T13 were the earliest trees, where it occurred on the 28th of March during the second season, and it ranged from 1st to 10th of April for other S_1 trees. During the first season, all S_1 trees ranged between the 10th and 17th of April.

While for the end of fruit set date, all S_1 trees ranged between 20th and 29th of May during the first season and from 15th to 23rd of May in the second season. The longest fruit set duration was 49 days with T6, while the shortest was 35 days with T9 in the first season.

Under the environmental conditions of Bani-Suef governorate (representing the Middle Egypt region), Gowda *et al* (2009) found that Araby and Badr cultivars were earlier (1st week of April) during both seasons. They indicated that Badr cultivar produced the highest number of perfect flowers/tree (295.74), followed by Tahrir cultivar (258.20). As regards the number of male flowers/tree, Nab El-Gamal produced the highest number of male flowers/tree (1063.60). Whereas Badr came in the second order (820.46). As for fruit set (%) and no. of fruits/tree, Wardy showed the highest percentage of fruit set and no. of fruits/tree (34.30%) and (135.60 fruits/tree), while Badr gave the lowest percentage of fruit set and no. of fruits/tree (26.77 and 25.05%) and (84.04 and 108.69) in both seasons, respectively. The highest yield per tree was produced by Nab El-Gamal (38.85 and 42.04 kg), and the lowest yield was obtained with Badr (19.18 and 23.73 kg) in both seasons.

Table 3. Dates of blooming and fruit set, flowering and fruit set durations of Badr S_1 progenies during 2019 and 2020 seasons.

Tree No.	Blooming date Initial		End		Fruit set Initial		End		Flowering duration (days)		Fruit set duration (days)	
	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020
T1	Apr. 7	Mar. 18	May 23	May 02	Apr. 17	Apr. 05	May 29	May 15	46	45	42	40
T2	5	25	20	10	15	05	29	18	45	45	44	43
T3	5	24	20	10	15	09	29	18	45	46	44	39
T4	5	18	24	10	15	05	29	18	49	52	44	43
T5	6	16	25	5	16	01	29	15	49	49	43	44
T6	1	18	25	5	10	05	29	15	55	47	49	40
T7	2	18	25	5	12	02	29	15	54	47	47	43
T8	2	18	15	5	12	Mar. 28	20	15	44	47	38	48
T9	5	Apr. 03	15	18	15	Apr. 10	20	23	40	45	35	43
T10	5	Mar. 18	23	10	15	05	25	15	48	52	40	40
T11	5	24	23	10	15	06	29	15	48	46	44	39
T12	7	26	25	10	17	02	29	15	48	44	42	43
T13	12	18	25	10	15	Mar. 28	29	15	43	52	44	48

Percentages of male, perfect flowers and fruit set, yield and number of fruits per tree

It is clear from Table 4 that T13 gave the highest value of male flowers percentage (66.67 %) and the lowest value of perfect flowers percentage (33.33 %) in the first season, while T4 and T11 had the same previous values for the highest male flowers percentage and the lowest perfect flowers percentage in the second season and without significant differences between them.

Table 4. Percentages of male, perfect flowers, fruit set, yield and no. of fruits per tree Badr S_1 progenies during 2019 and 2020 seasons.

Tree No.	Male flowers percentage (%)		Perfect flowers percentage (%)		Fruit set (%)		No. of fruits/tree		Yield/tree (kg)	
	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020
T1	33.33 d	33.33 d	66.67 a	66.67 ab	20.50 abc	20.37 bcde	98 bc	90 de	17.00 e	19.25 ef
T2	33.33 d	33.33 d	66.67 a	66.67 ab	18.48 bc	22.87 abc	69 de	107 bcd	22.50 de	24.50 cdef
T3	57.14 ab	57.14 ab	42.86 cd	42.86 de	18.87 bc	19.33 e	74 cde	120 ab	24.80 cd	26.00 bcde
T4	33.33 d	66.67 a	66.67 a	33.33 e	16.46 c	19.40 e	52 e	87 e	17.25 e	23.00 cdef
T5	50.00 bc	40.00 cd	50.00 bc	60.00 bc	20.14 bc	23.00 ab	93 bcd	135 a	28.00 bcd	17.50 f
T6	33.33 d	50.00 bc	66.67 a	50.00 cd	18.25 c	21.55 abcde	79 cde	103 bcde	25.50 bcd	21.60 def
T7	33.33 d	25.00 d	66.67 a	75.00 a	19.33 bc	20.00 de	86 bcd	97 cde	32.50 ab	33.75 a
T8	40.00 cd	33.33 d	60.00 ab	66.67 ab	19.10 bc	22.36 abcd	78 cde	111 bc	21.80 de	19.25 ef
T9	50.00 bc	60.00 ab	50.00 bc	40.00 de	20.11 bc	20.21 cde	93 bcd	94 cde	30.40 bc	32..50 ab
T10	60.00 ab	50.00 bc	40.00 cd	50.00 cd	20.10 bc	20.22 cde	90 bcd	96 cde	25.25 cd	27.80 abcd
T11	60.00 ab	66.67 a	40.00 cd	33.33 e	22.64 ab	21.83 abcde	112 b	106 bcd	38.00 a	30.25 abc
T12	60.00 ab	50.00 bc	40.00 cd	50.00 cd	24.86 bc	22.52 abcd	78 cde	112 bc	32.50 ab	32.10 ab
T13	66.67 a	50.00 bc	33.33 d	50.00 cd	24.86 a	23.42 a	160 a	137 a	16.50 e	20.50 def

Means followed by the same letter(s) in each column are not significantly different at (P < 0.05) using Duncan's multiple range test.

The highest percentage of fruit set was (24.86%) for T13 in the two seasons, and the lowest percentage was recorded by T4 and T6 (16.46 and 18.25%) in the first season and T3 and T4 (19.33 and 19.40%) in the second season, respectively.

Regarding the number of fruits per tree, the highest number (160 fruits per tree) was achieved by T13 and the lowest number (52 fruits per

tree) by T4. For other trees, no. of fruits ranged between (69 and 112 fruits per tree) in the first season. During the second season, T13 and T5 achieved the highest number of fruits (137 and 135 fruits/tree), respectively, and the lowest number (87 fruits/tree) by T4, while other trees gave number of fruits ranging between (90 and 120 fruits/tree).

Concerning the yield per tree, the highest yield was achieved by T11 (38.00 kg) in the first season and by T7 (33.75 kg) in the second one. The other trees gave yields ranging from (16.50 to 32.50 kg) during the two seasons. Similar results were obtained by Khalil *et al* (2014), who studied thirteen F_1 hybrids of unknown parents. Some of these F_1 progenies showed the best yield (24.92 kg/tree and 72.50 fruits) across two seasons. Bist *et al* (1994) reported a great variation in fruit set and yield of some promising selections of wild pomegranate.

Fruit properties

Fruit physical properties

In respect to arils and peels of fruits of the thirteen Badr S_1 trees, data of weight, percentage and color of arils (edible part) and peels (non-edible part), as well as the number of arils per 100 g, were shown in Table 5 and Figure 4.

The highest weight value of arils was obtained with T12 (206.19 g), while the lowest was (50.28 g) with T13 in the first season. While in the second season, T9 gave the highest significant percentage (181.20 g). By contrast, T5 and T3 scored the lowest percentages (62.32 and 65.87 g, respectively) with no significant differences between them. Regarding the percentage of arils, T6 scored the highest value (54.60%), while T10 scored the lowest value (45.17%) in the first season. T13 gave the highest value (53.11%), and T3 gave the lowest value (30.26%) in the second season.

The highest weight value of peels was obtained with T12 (218.08 g), while the lowest was (83.24 g) with T13 in the first season. During the second season, T7 gave the highest significant percentage (223.31 g); moreover, T13 and T5 scored the lowest percentages (66.96 and 67.31 g), respectively with non-significant differences between them. Regarding the percentage of peels, T9 scored the highest value (53.70%), while T6 scored the lowest value (45.40%) in the first season.

Table 5. Fruit physical properties of Badr S_1 progenies during 2019 and 2020 seasons.

Tree No.	Aril (edible part)				Peel (Non-edible part)			
	Weight (g)		%		Weight (g)		%	
	2019	2020	2019	2020	2019	2020	2019	2020
T1	83.44 f	107.50 b-d	48.15 d-f	50.12 ab	89.66 d	106.80ef	51.85 b-d	49.88ef
T2	153.19 c-e	99.53 c-e	46.90 e-g	42.90 cd	172.71bc	132.32d	53.10 ab	57.10cd
T3	162.93 c-e	65.87 g	48.46 c-f	30.26 f	173.37bc	151.96cd	51.54 b-e	69.74a
T4	166.86 b-d	112.63 b-d	48.45 c-f	42.19 c-e	166.44bc	152.31cd	49.93 e-g	57.81b-d
T5	150.03c-e	62.32 g	49.84 b-d	48.06 a-c	150.87c	67.31g	50.16 d-g	51.94d-f
T6	177.86 a-c	82.00 e-g	54.60 a	39.17 de	147.47c	128.26de	45.40 h	60.83bc
T7	194.24 ab	124.50 b	50.58 bc	35.72ef	189.80ab	223.31 a	49.42 fg	64.28 ab
T8	139.36de	71.90fg	46.90e-g	41.42 c-e	144.00 c	101.65 f	50.36 c-g	58.58 b-d
T9	151.41ce	181.20 a	46.30fg	52.31 a	175.26bc	165.04 c	53.70 a	47.69 f
T10	131.68e	120.17bc	45.17 g	41.29 c-e	147.09 c	169.53 c	52.09 a-c	58.71 b-d
T11	176.07a-c	91.62 d-f	51.28 b	32.35 f	166.66bc	194.19 b	48.72 g	67.65 a
T12	206.19a	125.83b	48.58 c-e	43.80 b-d	218.08 a	161.46 c	51.42 b-e	56.20 c-e
T13	50.28 g	77.33 e-g	46.43 e-g	53.11 a	83.24 d	66.96 g	50.83 c-f	46.89 f

Table 5. Cont.

Tree No.	No. of arils in 100g		Aril color	Peel color
	2019	2020	Two seasons	Two seasons
T1	377.25 a	380.11 a	Jasper Red (018)	Fire Red (15/1)
T2	240.00 de	246.00 d	Chrome Yellow (605/2)	Mars Orange (013/2)
T3	315.00 b	339.94 b	Azalea Pink (618/1)	Vermillion (18/1)
T4	273.00 c	302.01 c	Chrome Yellow (605/3)	Mars Orange (013/1)
T5	219.94 ef	231.96 de	Currant Red (821/3)	Scarlet (19/1)
T6	203.02 fg	209.35 ef	Chrome Yellow (605/3)	Mars Orange (013/1)
T7	185.23 g	256.00 d	Jasper Red (018/1)	Burnt Orange (014/2)
T8	252.95 cd	231.00 de	Azalea Pink (618/1)	Mars Orange (013/1)
T9	207.00fg	195.00 f	Azalea Pink (618)	Fire Red (15/1)
T10	190.00 g	228.96 de	Jasper Red (018/1)	Scarlet (19/2)
T11	207.00fg	206.04ef	Azalea Pink (618/1)	Vermillion (18/2)
T12	190.00 g	240.34 d	Chrome Yellow (605/2)	Maize Yellow (607/1)
T13	225.00ef	205.12ef	Chrome Yellow (605/3)	Jasper Red (018/1)

Means followed by the same letter(s) in each column are not significantly different at ($P < 0.05$) using Duncan's multiple range test.

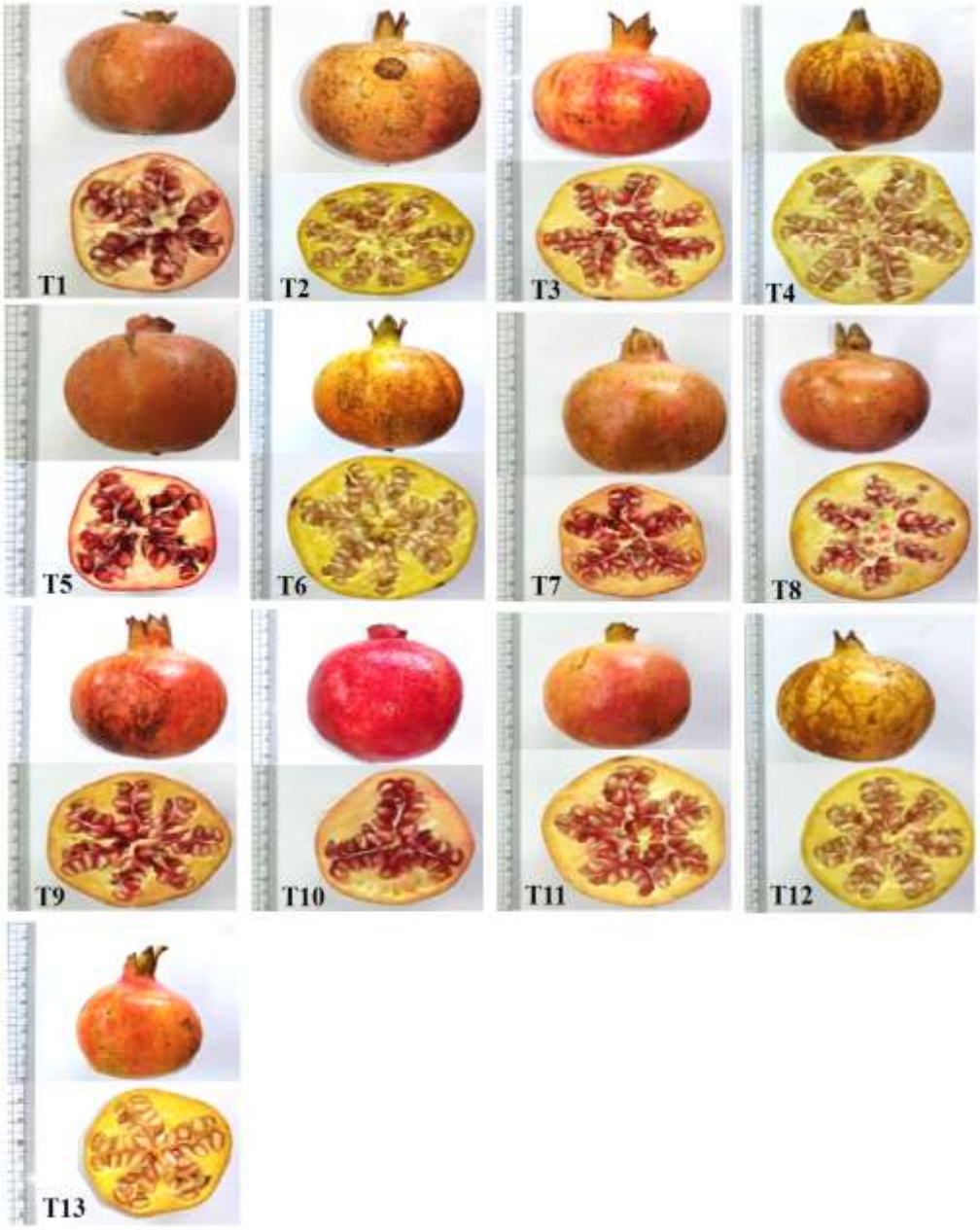

Fig. 4. Pomegranate fruits of thirteen S_1 Badr progenies.

During the second season, T3 and T11 gave the highest value (69.74 and 67.65%), and T13 and T9 gave the lowest value at 46.89 and 47.69%, respectively, without any significant differences between them.

Concerning the number of arils in 100 g, T1 showed the highest number of grains (377.25 and 380.11) in the two seasons, respectively, while T7, T10 and T12 had the lowest number (185.23, 190.00 and 190.00), respectively in the first season and T9 was (195.00) in the second season.

The color of the aril and peel of the fruit is an important quality attribute in pomegranate marketing. The red color is an important parameter for commercial quality classification, as it influences consumer behavior (Zaouay and Mars 2014). Under this investigation, T1, T3, T5, T7, T9 and T10 were recorded the best colors for peels and arils during both seasons as shown in (Table 5 and Figure 4).

In studies on four pomegranate cultivars; Edkawy, Manfaloty, Sahrawy and Wonderful by Abdel-Salam *et al* (2018). They indicated that percentages of arils and peels ranged between 48.88 to 52.87 and 37.26 to 39.79 of the fruit weight, respectively. Furthermore, Ismail *et al* (2014) showed that the arils weight value was the highest (275 g) for Nab El-Gamal cultivar followed by Manfalouty cultivar with 210 g, and the percentage of arils was 59.34% and 58.19% for Manfalouty and Nab El-Gamal cultivars, respectively.

Data in Table 6 include fruit physical characteristics: weight, volume, diameter, length, circumference and number of fruit chambers. It was noticed that there were highly significant differences among the thirteen trees. T12 recorded the highest value of fruit weight (424.27 g), while the lowest value was (101.67 g) for T13 in the first season. While in the second season, T7 and T9 revealed the highest values of fruit weight at 348.03 and 346.40 g, respectively, while the lowest values (129.63 and 144.43 g) were obtained with T5 and T13, respectively. Gadže *et al* (2012) classified pomegranate cultivars into four grades according to their fruit weight, small (150-200g), medium (201-300g), large (301-400) and extra-large (401-500g). According to this classification, the fruits of thirteen S_1 Badr progenies during the two seasons ranged from small to large except T12, being extra-large (424.27 g) in the first season.

Table 6. Fruit physical properties of Badr S_1 progenies during 2019 and 2020 seasons.

Tree No.	Fruit weight (g)		Fruit Volume (cm^3)		Fruit diameter (cm)	
	2019	2020	2019	2020	2019	2020
T1	173.07 h	214.30 de	163.10 j	212.00 g	7.40 f	7.71 c-f
T2	325.90 e	231.83 d	301.00 d	235.00 f	8.80 a	7.80 b-f
T3	336.30 cd	217.82 de	283.27 e	250.00 f	8.30bc	7.63 d-f
T4	333.30 de	264.90 c	243.60gh	287.50e	8.10 d	8.09 b-e
T5	300.90 f	129.63 g	222.77i	175.00 h	8.20 cd	6.27 h
T6	325.33 e	210.29 e	299.03 d	242.50 f	7.77 e	7.44 e-g
T7	384.03 b	348.03 a	336.07 b	427.50 a	8.47 b	7.39fg
T8	280.33 g	173.66 f	246.23 g	187.00 h	8.03 d	6.86gh
T9	326.67 e	346.40 a	312.93 c	387.50 b	8.07 d	8.93 a
T10	280.23 g	289.67 b	235.57 h	325.00 c	7.80 e	8.25 a-d
T11	342.73 c	285.80bc	256.13 f	305.00 d	8.37bc	8.47 ab
T12	424.27 a	287.40 b	409.00 a	292.50 de	8.87 a	8.34 a-c
T13	101.67i	144.43 g	100.00 k	150.00i	5.17 g	6.45 h
Tree No.	Fruit length (cm)		Fruit circumference (cm)		No. of fruit chambers	
	2019	2020	2019	2020	2019	2020
T1	6.00 g	6.67 f	24.77 e	24.50 f	6.67 ab	6.00 a
T2	7.77 c	7.00 e	27.30bc	24.90ef	6.17 c	4.67 cd
T3	7.70 c	6.70 d	27.27bc	24.40 f	7.00 a	5.33 b
T4	7.60 d	7.77 d	26.17 cd	25.67 de	4.67ef	5.33 b
T5	7.40 e	5.73 g	27.17bc	20.60 h	6.00 c	5.33 b
T6	7.53 d	6.67 f	27.20bc	24.47 f	5.33 d	4.33 de
T7	7.43 e	8.30 b	29.40 a	29.60 a	6.00 c	5.00bc
T8	6.97 f	6.70 f	25.63 de	22.07 g	6.67 ab	5.00bc
T9	7.53 d	8.13bc	26.47 b-d	28.40 b	6.67 ab	6.00 a
T10	7.00 f	8.70 a	26.10 cd	25.60 de	4.33 f	6.00 a
T11	8.20 b	7.93 cd	27.53 b	26.27 cd	6.33bc	4.00 e
T12	8.60 a	7.70 f	30.00 a	26.50 c	5.00 de	5.00bc
T13	4.63 h	6.47 f	17.33 f	21.00 h	4.67ef	4.67 cd

Means followed by the same letter(s) in each column are not significantly different at ($P < 0.05$) using Duncan's multiple range test.

Concerning fruit volume, the data revealed that T12 and T7 showed the maximum values (409.00 and 427.50 cm^3), respectively in the two seasons, while T13 showed the minimum values (100.00 and 150.00cm^3) in the two seasons.

The results showed that values of fruit diameter in both seasons ranged between (8.87 and 5.17 cm) for T12 and T13, respectively, in the first season, and between (8.93 and 6.27 cm) for T9 and T5, respectively in the second season.

In respect to fruit length, T12 gave the highest value (8.60 cm), while T13 gave the lowest value (4.63 cm) in the first season. The highest value of fruit length was achieved by T10 (8.70 cm), and the lowest value was (5.73 cm) with T5 in the second season. These results are in accordance with previous findings of Zaouay *et al* (2012).

As regard to fruit circumference, T12 and T7 gave the highest value of fruit circumference (30.00 and 29.40 cm), respectively with non-significant differences between them in the first season, and T7 had the highest value (29.60 cm) in the second season. Only T13 gave the lowest values of fruit circumference (17.33 and 21.00 cm) in the two seasons.

Concerning the number of fruit chambers, data showed that the values ranged from 4 to 7 in the two seasons. T3 revealed the highest significant value at 7 chambers in the first season, while T1, T9 and T10 recorded 6 chambers in the second season.

In a previous study, Peng *et al* (2020) analyzed thirty-seven pomegranate varieties in China for phenotypic traits and biochemical indicators. They stated that fruit weight ranged between (210.5 and 576.5 g) and fruit diameter (11.46 to17.50 mm). Different strains of Pomegranate were selected and evaluated in the Punjab by *Abbas* et al *(2018), who* indicated that pomegranate selection-6 gave the maximum values of fruit length (75.04 mm) and fruit weight (268.6 g).

Gowda *et al* (2009) in Egypt showed that Manfalouty cultivar produced the greatest weight of fruit (306.78 g) in the first season and Badr cultivar had the lowest fruit weight (227.67 and 218.20 g) in both seasons. Whereas Nab El-Gamal cultivar gave the highest fruit length, diameter and fruit volume followed by Manfalouty cultivar. In contrast, the least fruit

volume was recorded for Badr cultivar. As for the number of fruit chambers, Araby cultivar had the highest number of fruit chambers while Badr cultivar gave the lowest values. Ismail *et al* (2014) in Egypt showed that the fruit weight ranged between 479.4 and 185 g for Nab El-Gamal and Assuity cultivars and fruit volume was highest at 416.6 cm^3 and lowest (214.8 cm^3) for Nab El-Gamal and Wardi, respectively. In other experiments also in Egypt, Abdel-latif (2000) stated that the fruit volume of Manfalouty cultivar was 313 cm^3.

Fruit juice chemical properties

Tables 7 and 8 showed fruit chemical properties of thirteen S_1 Badr progenies during the two seasons. The maximum values of soluble solids content (SSC) were obtained by T9, T10 and T5 at 12.67, 12.33 and 12.10 °Brix. In that context, T6, T2 and T11 recorded the minimum values at 9.67, 9.50 and 9.17 °Brix, respectively, in the first season. While during the second season, T7 and T9 recorded the highest significant values of SSC (15.40 and 15.17 °Brix), respectively. Besides, T11 scored the lowest significant value (10.17 °Brix). These results are in harmony with those reported by Martinez *et al* (2006) on some Spanish cultivars, in which the SSC values ranged between 12.36 and 16.32 °Brix, while Fadavi *et al* (2005) and Akbarpour *et al* (2009) stated that the SSC ranged from 12.0 to 16.5 °Brix and from 15.17 to 22.03 °Brix on different Iranian cultivars, respectively. In other studies, Gowda *et al* (2009) in Egypt reported that Manfalouty cultivar gave the highest significant total soluble solids (15.80°Brix), while the lowest was obtained from fruits of Araby cultivar (14.63°Brix). In addition, Ismail *et al* (2014) in Egypt indicated that SSC content ranged between 16.01°Brix for Hegazy cultivar and 12.55 °Brix for Assuity cultivar.

Clear differences existed between the trees for percentages of acidity in the first season. In that respect, T123 gave the highest percentage (1.64 %) while T5 and T6 gave the lowest (0.52 and 0.53 %), respectively. In the second season, the highest acidity value was 1.58 % with T8, while the lowest values were for T6, T5 and T13 (0.42, 0.44 and 0.45 %), respectively.

Table 7. Chemical properties of fruit juice of Badr S_1 progenies during 2019 and 2020 seasons.

Tree No.	SSC (Brix)		Acidity (%)		SSC/acidity ratio		Vitamin C (mg/100 ml)		Anthocyanin (mg/100 ml)		Juice volume (ml/100 g)	
	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020
T1	11.33bc	12.17 de	1.56 a	1.46 b	7.25 f	8.36 d	16.00ef	15.67i	0.53 b	0.48 b	14.67 h	17.00 g
T2	9.50 d	12.00 e	0.72 f	0.84 e	13.43 d	14.33 c	16.97 e	17.00gh	0.40 de	0.40 d	13.67 h	16.00 g
T3	12.00 ab	13.33 c	1.64 a	1.47 b	7.36 f	9.10 d	16.12ef	15.97 hi	0.51bc	0.50 b	19.00ef	24.00 d
T4	11.33bc	13.83bc	1.39 b	1.21 d	8.29ef	11.47 cd	23.08 a	22.63bc	0.34 g	0.37 e	18.67 f	20.00 f
T5	12.10 a	12.67 d	0.52 h	0.44 g	23.21 a	29.90 ab	16.70 e	17.47 g	0.77 a	0.76 a	22.00 c	28.00 c
T6	9.67 d	13.50 c	0.53 h	0.42 g	18.28 c	32.31 a	15.27 f	15.27i	0.38ef	0.31 f	20.33 d	20.00 f
T7	11.33bc	15.40 a	0.58gh	0.53 f	19.55bc	30.20 ab	21.59bc	21.33 de	0.49 c	0.50 b	17.33 g	20.00 f
T8	11.00 c	13.50 c	1.36bc	1.58 a	8.23ef	8.57 d	22.85 ab	23.50 ab	0.49 c	0.50 b	20.00 de	22.33 e
T9	12.67 a	15.17 a	0.67fg	0.58 f	19.33bc	27.42 b	22.68 ab	24.40 a	0.31 h	0.31 f	21.67 c	25.00 d
T10	12.33 a	14.33 b	1.27 c	1.34 c	9.85 e	10.73 cd	24.86 d	19.73 f	0.51bc	0.50 b	21.00 cd	26.67 c
T11	9.17 d	10.17 f	1.04 d	1.13 d	8.81ef	8.96 d	19.38 d	20.23ef	0.42 d	0.43 c	30.00 b	37.00 b
T12	11.00 c	12.00 e	0.86 e	0.91 e	12.84 d	13.27 c	21.81 a-c	21.67 cd	0.37 f	0.37 e	31.33 a	36.67 b
T13	11.17 c	11.83 e	0.54 h	0.45 g	20.75 b	27.36 b	20.86 c	22.30 cd	0.29 h	0.28 f	32.00 a	43.33 a

Means followed by the same letter(s) in each column are not significantly different at (P < 0.05) using Duncan's multiple range test.

Table 8. Chemical properties of fruit juice of Badr S_1 progenies during 2019 and 2020 seasons.

Tree No.	Tannins (mg/100 ml)		Reducing sugars (mg/100 ml)		Non-reducing sugars (mg/100 ml)		Total sugars (mg/100 ml)	
	2019	2020	2019	2020	2019	2020	2019	2020
T1	3.99 d	4.07 d-g	11.39 a-e	12.49 a	1.04 a	1.02 a	12.42 a-d	13.51 a
T2	3.57 e	3.83 h	10.51 de	10.07 d	1.00 a	0.91 a	11.52 d	10.98 d
T3	4.08 b-d	4.18 de	12.43 a	12.47 a	0.94 a	0.91 a	13.36 a	13.38 a
T4	3.99 d	4.23 cd	11.00 b-e	11.33 a-c	1.01 a	0.92 a	12.01 b-d	12.25 ac
T5	4.10 b-d	4.00 f-h	11.78 a-d	11.53 ab	1.08 a	1.02 a	12.86 a-c	12.55 ab
T6	4.17 a-c	4.23 cd	10.50 e	10.44 b-d	1.08 a	1.02 a	11.58 cd	11.46 b-d
T7	4.09 b-d	4.73 a	10.81 c-e	11.83 a	0.92 a	1.00 a	11.73 b-d	12.84 a
T8	4.03 cd	3.99 f-h	12.24 ab	12.20 a	1.12 a	1.02 a	13.36 a	13.23 a
T9	4.23 ab	4.40 bc	11.47 a-e	11.94 a	1.00 a	0.96 a	12.47 a-d	12.89 a
T10	4.30 a	4.41 b	11.58 a-e	12.35 a	1.02 a	0.98 a	12.60 a-d	13.33 a
T11	3.96 d	3.89 gh	10.62 de	10.26 cd	0.99 a	0.95 a	11.61 cd	11.21 cd
T12	4.26 a	4.12 d-f	11.90 a-c	10.57 b-d	1.04 a	0.96 a	12.93 ab	11.53 b-d
T13	4.06 cd	4.03 e-g	11.92 a-c	10.25 cd	1.02 a	0.94 a	12.94 ab	11.19 cd

Means followed by the same letter(s) in each column are not significantly different at (P < 0.05) using Duncan's multiple range test.

As for SSC/Acidity ratio, the highest significant ratio was recorded by T5 (23.21), and the lowest significant ratios were (7.25 and 7.36) scored by T1 and T3 in the first season. During the second season, the highest significant ratio was (32.31) with T6, and the lowest ratios were (8.36, 8.57, 8.96 and 9.10) with T1, T8, T11 and T3, respectively. Akbarpour *et al* (2009) revealed that the maximum acidity was found in "Lamsari-e-Behshahr" (3.36%) and minimum in "Khazar-e-Bardeskan" (0.35 %), whereas SSC/Acidity ratio was the highest in "Khazar-e-Bardeskan" (50.24) and the lowest in "Lamsari-e-Behshahr" (5.57). Khalil *et al* (2014) in Egypt reported that the best SSC/Acidity ratio ranged from (31.96 to 29.86) for progenies of hybrid between (El-Tahrir × Nab El-Gamal) pomegranate cultivars. On the other hand, Rayan *et al* (2015) in Egypt gave values ranged from (70.00 to 59.70) for some progenies resulted from the combinations of Manfalouty cultivar.

Regarding vitamin C, T9 and T4 showed the highest values (24.40 and 23.08 mg/100 ml juice), respectively, in the two seasons. Only T6

showed the same lowest value (15.27 mg/100 ml juice) in the two seasons. Concerning total anthocyanin, T5 gave the highest concentrations of anthocyanin content (0.77 and 0.76 mg/100 ml juice) in the two seasons, respectively, while T13 and T9 gave the lowest concentrations (0.29 and 0.31), respectively, in the first season and for T13, T6 and T9 were (0.28, 0.31 and .031), respectively, in the second season. Similar results were reported by Gadže *et al* (2012), who stated that vitamin C values ranged between 18.8 mg/100 ml juice in "Ciparski" and 26.0 mg/100 ml juice in "Pastun". On the other hand, in different Iranian pomegranates, Tehranifar *et al* (2010) reported that ascorbic acid values ranged from 9.91 to 20.92 mg/100 g of juice. Moreover, the total anthocyanin ranged between 5.56 and 30.11 mg/100 g of juice. Varasteh *et al* (2009) evaluated five commercial cultivars in Iran and stated that the anthocyanin content varied from 1.04 to 1.92 mg/100 ml juice. In other studies, on the Egyptian local pomegranate cultivars, Manfalouty and Nab El-Gamal produced the highest content of vitamin C (23.40 and 23.20 mg /100 ml juice), respectively, in the first season. Moreover, Nab El-Gamal, Badr and Manfalouty gave the highest content of vitamin C (24.13, 23.80 and 23.73), respectively, in the second season. As regard to anthocyanin content, Manfalouty cultivar produced the highest content of anthocyanin (0.662 %), followed by Nab El-Gamal cv. and Tahrir (0.581 and 0.511%), respectively (Gowda *et al* 2009).

Regarding juice volume, in the first season, the highest significant values were recorded by T13 and T12 (76.00 and 75.33 ml/100 g), while the lowest values were 13.67 and 14.67 ml/100 g scored by T2 and T1, respectively. In the second season, the highest significant value was recorded by T13 (43.33 ml/100 g), and the lowest values were (16.00 and 17.00 ml/100 g) by T2 and T1, respectively. Different proportions of pomegranate juice to fruit have been reported for Spanish varieties, which ranged from (50.26 to 64.17 %) (Martinez *et al* 2006). Gowda *et al* (2009) reported that Nab El-Gamal cultivar produced the highest juice volume followed by Manfalouty and Araby, however, the lowest volume of juice was recorded for Badr cultivar. Also, Ismail *et al* (2014) indicated that Nab El-Gamal had the highest juice volume (71.81 ml/100 g).

As for tannins, T10 and T12 recorded the highest values (4.30 and 4.26 mg/100 ml), respectively, and T2 recorded the lowest value (3.57 mg/100 ml) in the first season. T7 recorded the highest value (4.73 mg/100 ml), and the lowest value was (3.83 mg/100 ml) with T2 in the second season. Elfalleh *et al* (2011) found that the tannins content of six Tunisian pomegranate varieties ranged from (1.97 to 3.38 mg/100 ml). Gowda *et al* (2009) reported that Manfalouty and Nab El-Gamal cultivars had the highest tannins content (3.23 and 3.10 mg/100 ml), while the lowest was obtained from Wardy cultivar (2.57 and 2.73 mg/100 ml), respectively in both seasons.

In respect to reducing sugars, in the first season, T3 gave the highest significant value at 12.43 mg/100 ml of juice; however, T6 gave the lowest value at 10.50 mg/100 ml. While in the second season, many trees showed the highest values of reducing sugars and ranged between (12.49 and 11.83 mg/100 ml) with non-significant differences between them. T2 recorded the lowest value of reducing sugars (10.07 mg/100 ml) in the second season. The opposite was observed for non-reducing sugars; all trees had the same values with non-significant differences between them during the two seasons. Regarding total sugars, T3 and T8 recorded the highest value (13.36 mg/100 ml), while T2 recorded the lowest value (11.52 mg/100 ml) in the first season. In the second season, many trees showed the highest values of reducing sugars and ranged between (13.51 and 12.84 mg/100 ml) with non-significant differences between them. T2 recorded the lowest value of reducing sugars (10.98 mg/100 ml) in the second season. Akbarpour *et al* (2009) studied twelve pomegranate cultivars for different physical and chemical characteristics. Results revealed that the reducing sugar ranged from 29.83 to 13.89 mg/100 ml for Naderi and Abdandan cultivars, respectively, which represent the highest and lowest values. Fadavi *et al* (2005) recorded that the total sugar content in juices of pomegranate cultivars grown in Iran ranges from 97.20 to 12.36%, while Ozgen *et al* (2008) in Turkey reported that the sugar content in juices of pomegranate cultivars grown in Turkey is 13.20% in average. In other studies, on some Egyptian pomegranate cultivars, Gowda *et al* (2009) stated that the highest percentages of total sugars were (15.46 and 15.03%) for Manfalouty

cultivar, while the lowest percentages were (13.24 and 13.78%) for Badr cultivar.

Polymorphism as detected by SCoT analysis

As shown in Table 9, all the tested SCoT primers generated amplification products. Moreover, primers SCoT-03 and SCoT 09 produced monomorphic bands (100% monomorphism).

Table 9. SCoT primers and their amplification results generated with Badr and the thirteen S_1 trees.

Primer	Size Range	TAB	NMB	NPB	PPB
SCoT 1	1100-230	11	9	2	18.18
SCoT 2	1430-316	14	3	11	78.57
SCoT 3	1300-260	10	2	8	80
SCoT 4	1270-350	13	0	13	100
SCoT 6	840-320	7	2	5	71.4
SCoT 8	1000-360	8	3	5	62.5
SCoT 9	1070-380	7	4	3	42.8
SCoT 10	1260-275	10	0	10	100
Total		80	23	57	--
Mean		10	2.87	7.12	69.18

TAB= total amplified bands; NMB = number of monomorphic bands; NPB = number of polymorphic bands; PPB = percentage of polymorphic bands.

Thus, a total of 80 bands were generated from eight SCoT primers and ranged in size from 230 to 1430 bp. The number of bands per primer ranged from 7 (SCoT-06 and SCoT-09) to 14 (SCoT-02), with an average of 10.12 bands per primer. Of these 80 bands, 57 bands (70.37 %) were polymorphic, and the number of polymorphic bands varied from 2 (SCoT-01) to 13 (SCoT-04) with an average of 7.12 bands per primer. The detected polymorphism per primer among the studied S_1 trees ranged from 18.18 % (SCoT-01) to 100% (SCoT-04 and SCoT-10).

None of the tested polymorphic SCoT primers had the ability to discriminate any of the investigated Badr S_1 trees independently; however, there were specific amplified fragments (bands) that are common with some Trees (appeared with some Trees and disappeared with the rest of the thirteen tested trees) as illustrated in Figure 5.

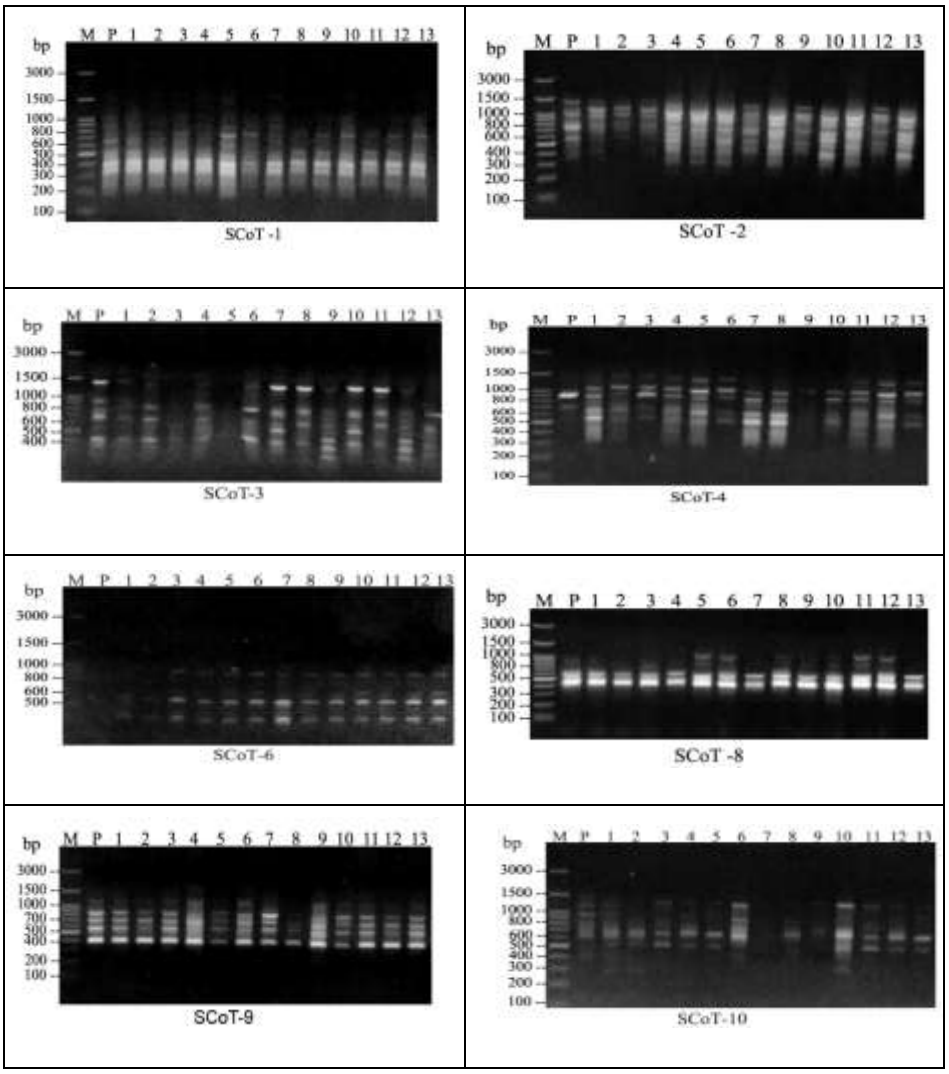

Fig. 5. SCoT patterns of Badr and its thirteen S_1 trees revealed by primers SCoT-1,
SCoT-2, SCoT-3, SCoT-4, SCoT-6, SCoT-8, SCoT-9 and SCoT-10. M: 100 bp DNA ladder marker, P: Badr, 1: T1, 2: T2, 3: T3, 4: T4, 5: T5, 6: T6, 7: T7, 8: T8, 9: T9, 10: T10, 11: T11, 12: T12, 13: T13.

These results agreed with those obtained by Ahmed (2018), which confirmed that SCoT polymorphism is advantageous over other dominant DNA markers because of its reproducibility, higher polymorphism, and better marker resolvability in addition to the linkage between SCoT markers and functional genes as described by Xiong *et al* (2011).

Genetic Similarity Analysis as Revealed by SCoT Data

Results of similarity index based on Dice similarity coefficient among the thirteen S_1 trees with Badr cultivar (parent) using UPGMA computer analysis are shown in Table 10. SCoT data revealed genetic similarity ranging from a maximum of 0.903 (between Tree 4 and Tree 6) to a minimum of 0.610 (between Tree 2 and Tree 5).

Dendrogram for the genetic relationships among Badr and the thirteen S_1 trees was divided into two main clusters, as illustrated in Figure 6.

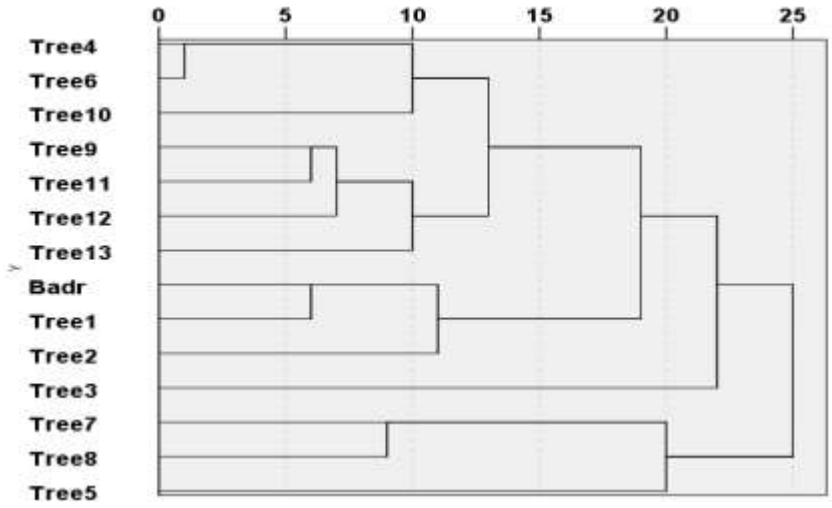

Fig. 6. Dendrogram for Badr and the thirteen S_1 trees constructed from the SCoT data using UPGMA and similarity matrix computed according to Dice coefficient.

Table 10. Similarity index based on SCoT analysis among Badr and the thirteen S_1 trees.

Genotypes (S_1 trees)	Badr	Tree1	Tree2	Tree3	Tree4	Tree5	Tree6	Tree7	Tree8	Tree9	Tree10	Tree11	Tree12	Tree13
Badr	1.000													
T1	0.869	1.000												
T2	0.852	0.832	1.000											
T3	0.779	0.811	0.769	1.000										
T4	0.855	0.836	0.800	0.814	1.000									
T5	0.719	0.786	0.610	0.757	0.825	1.000								
T6	0.855	0.820	0.800	0.796	0.903	0.789	1.000							
T7	0.718	0.713	0.648	0.679	0.769	0.804	0.752	1.000						
T8	0.721	0.733	0.708	0.685	0.787	0.768	0.787	0.852	1.000					
T9	0.752	0.748	0.759	0.755	0.803	0.710	0.838	0.764	0.730	1.000				
T10	0.826	0.773	0.786	0.727	0.810	0.739	0.876	0.789	0.756	0.825	1.000			
T11	0.787	0.783	0.796	0.775	0.852	0.768	0.852	0.817	0.850	0.870	0.857	1.000		
T12	0.772	0.800	0.746	0.759	0.835	0.786	0.819	0.833	0.832	0.867	0.790	0.864	1.000	
T13	0.783	0.743	0.755	0.769	0.800	0.743	0.835	0.778	0.708	.852	0.821	0.832	0.847	1.000

The first cluster includes Tree 5, Tree 7 and Tree 8. However, the second cluster was divided into two groups the first included tree 3 separately. While the second group was divided into three sub-groups, one of them included Badr, tree 1 and tree 2; meanwhile, the second clustered tree9, tree 11, tree 12 and tree 13; however, the third sub-group included tree 4, tree 6 and tree 10.

In conclusion, six trees out of the studied thirteen S_1 progenies are promising according to their characters (high weight and percentage of aril,

high weight and volume of fruit, high red coloration of arils, attractive red color of peel, and high content of soluble solid with low of acidity, high content of vitamin C and anthocyanin and good yielding). These trees are T1, T3, T5, T7, T9 and T10. This investigation is considered a preliminary study to select new Badr S_1 genotypes that could be used in further trials of breeding programs to develop new superior varieties. Moreover, advanced studies are needed through using more SCoT Primers, followed by elution and sequencing procedures to the resulted unique bands, then undergoing multiple alignments (BLAST; Basic Local Alignment Search Tool) using the NCBI database to get correlations between the resulted markers and functional genes or loci.

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الإنتخاب والتقييم للإختلافات الوراثية في الرمان

٦- التوصيف الظاهري والوراثي لنسل الجيل الأول الناتج من التلقيح الذاتي لصنف الرمان بدر

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قسم بحوث تربية الفاكهة ونباتات الزينة والأشجار الخشبية – معهد بحوث البساتين – مركز البحوث الزراعية – مصر

أجريت هذه الدراسة خلال موسمي (٢٠١٩-٢٠٢٠) بهدف دراسة الصفات الظاهرية والوراثية لنسل الجيل الأول الناتج من التلقيح الذاتي لصنف الرمان بدر, وتم إنتخاب ١٣ نسل (شجرة) ودراسة إختلافات النمو الخضري والزهري وتقديرالصفات الطبيعية والكيماوية للثمار وكمية المحصول. وقد أظهرت النتائج أن إرتفاع الأشجار تراوح من (٢٨٥ إلي ٤٢٠ سم) , ومحيط الجذع للأشجار تراوح من (٣١ إلي ٥٦ سم) في كل الأنسال تحت الدراسة لكلا الموسمين. وجد أن النسل رقم ١٢ أعطي النسبة الأعلي من عقد الثمار (٢٤,٨٦%) في كلا الموسمين, وأعلي كمية محصول كانت (٣٨,٠٠ كجم) في النسل رقم ١١ في الموسم الأول, (٣٣,٧٥ كجم) في النسل ٧ في الموسم الثاني. أعطي كلا من النسل ١٢ , ٧ أعلي وزن للثمار (٤٢٤,٢٧, ٣٤٨,٠٣ جم) وأيضا أعلي حجم للثمار (٤٠٩,٠, ٤٢٧,٥ سم^{٣}) عبر الموسمين علي التوالي. المحتوي من المواد الصلبة الذائبة الكلية تراوح من (٩,١٧ إلي ١٥,٤٠ °Brix) , ونسبة المواد الصلبة الكلية إلي الحموضة تراوحت من (٧,٢٥ إلي ٣٢,٣١) وذلك في كل الأنسال عبر الموسمين. أعلي تركيزات من فيتامين C في عصير الثمار كانت (٢٤,٤٠, ٢٣,٠٨ مجم/١٠٠ مل عصير) تم الحصول عليها في النسل ٩, ٤, بينما أعطي النسل ٥ أعلي تركيزات من صبغة الأنثوسيانين في العصير (٠,٧٧, ٠,٧٦ مجم/١٠٠ مل عصير), علي التوالي في عبر الموسمين. تراوحت السكريات الكلية في كل الأنسال من (١٠,٩٨ إلى ١٣,٥١ مجم/١٠٠ مل عصير). تم عمل البصمة الوراثية على مستوي الـ DNA بإستخدام عدد ٨ بادئات لتحليل SCoT، وقد أظهرت النتائج عدد ٨٠ حزمة كلية تتراوح أوزانها الجزيئية ما بين ٢٣٠ إلى ١٤٣٠ زوج من القواعد النيتروجينية، منها عدد ٥٧ حزمة مختلفة أي بنسبة إختلاف ٧٠,٣٧% وكان عدد الحزم المختلفة يتراوح ما بين عدد ٢ حزمة (مع البادئ SCoT-2) إلى عدد ١٣ حزمة (مع البادئ SCoT-4) أي بمتوسط 7.12 حزمة لكل بادئ. كانت درجة التشابه الوراثي بين أنسال الجيل الذاتي الأول لصنف بدر المدروسة كالتالي: أعلى درجة تشابه هي ٠,٩٠٣ وكانت بين شجرة ٤ وشجرة ٦، وأقل درجة تشابه هي ٠,٦١٠ وكانت بين شجرة ٢ و شجرة ٥. ويمكن أن نستنتج من هذه الدراسة أنه من إجمالي ١٣ نسل تحت الدراسة، فأن هناك ٦ أنسال واعده (١, ٣, ٥, ٧, ٩, ١٠) تتميز بنسبة عالية ووزن كبير من الحبوب، حجم ووزن كبير للثمار، تلوين أحمر عالي

للحبوب، لون أحمر جذاب لقشرة ا لثمرة، محتوي عالي من المواد الصلبة الكلية ومحتوي منخفض من الحموضة، محتوي عالي من فيتامين C والأنثوسيانين، بالإضافة إلى عائد جيد للمحصول. ويمكن القول بأن هذه الدراسة تعتبر الخطوة الأولي لتقييم تراكيب وراثية جديدة كمصدر لتحسين وتطوير سلالات جديدة تلبي معايير الإنتاجية والجودة في الرمان.