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EFFECT OF SELF, OPEN AND CROSS POLLINATION ON FRUIT SET OF THREE APPLE CULTIVARS IN SOUTH JORDAN

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ABSTRACT

Pollination and fruit set were investigated in the three apple cultivars Ice, Adena and Red Top, at south Jordan during two successive seasons (2007 and 2008). The results indicated that the cultivars are self-incompatible. Open pollination was very effective in improving fruit set in the three cultivars. Cross-pollination with apple 'Golden delicious' pollen grains improved fruit set compared to self- pollination. These results suggest that many apple cultivars should be planted together in any orchard in order to obtain acceptable commercial productivity. Bloom time overlapping between these cultivars is required to ensure effective cross pollination. In general, there is a relationship between pollination type and some physical and chemical fruit characteristics.

Key words: *apple, cross pollination, open pollination, self pollination.*

1. INTRODUCTION

The increase of plantation areas for any fruit kind or cultivar depends on environmental factors and its ability to fruit set. In most fruit cultivars, pollination is the first step for fruit set and development. Failures of pollination is resulted from many different reasons such as self-incompatibility, the lack of suitable pollinizer (s) and the differences in blooming period between cultivars (Warmund, 2009). Most apple cultivars are either self-incompatible or partially self-fruitful, and accordingly the productivity will be decreased according to that characteristics (Broothaerts *et al.,* 1996; Broothaerts and Van Nerum, 2003). In order to obtain the best fruit set on apple, all cultivars should be cross pollinated (Jana and Parmer, 2001 and Warmund, 2009). The shape and the size of apple fruit are economically important. These characteristics are affected by seed number formation and their development during fruit growth period (De Witte *et al.,* 1996 and Keulemans *et al.,* 1996).

Because of the lack of information about the nature of pollination of some apple cultivars under environmental conditions in south Jordan, the objectives of this investigation were to (I) test the pollination type of the three apple cultivars Ice, Adena and Red Top and (II) study the effect of open and cross pollination on fruit set, seed number, fruit shape and weight and some other fruit chemical properties.

2. MATERIALS AND METHODS

Five single productive trees of three apple cultivars Ice, Adena and Red Top were selected at the Agricultural Research Station, which belongs to the Mu'tah University during two successive growing seasons (2007 and 2008). All cultivars were budded trees on seedling rootstock, and received the same agricultural practices. The experiment in the first season was consisting of two treatments, self and open pollination. In the second season, cross pollination with apple 'Golden delicious' pollen grains was added as a third treatment. Five different spurs for each tree were selected in different directions on the periphery of the tree. All spurs were bagged at ballon stage. The pollen grains for each cultivar were collected only in the second season where cross pollination was carried out. The anthers were separated from other flower parts and then dried at room temperature. For pollen grains collection, flowers for each cultivar were collected in 2008 by bagging several spurs at full pink stage. Pollens were separated from flower parts and then dried at room temperature.

Self pollination was done by bagging the flowering spurs at balloon stage, while the cross pollination with Golden delicious pollen grains for the cultivars was done at full bloom stage and spurs then re-bagged after pollination. Bags for the above two treatments were removed after two weeks from the full bloom. Open pollination treatment was represented by leaving twenty five spurs without bagging.

Pollen grain germination test was done using a germination medium consisted of 15% sucrose and two grams of agar which were placed in Petri-dishes, then pollen grains were spread over them, and thereafter incubated at 20 ºC for two days (Pinney and Polito, 1990). For each cultivar, three fields from each of the three Petri dishes were chosen in order to determine the number of germinated pollen grains under light microscope and were presented as percentage.

Fruit set percentage for open and cross pollination was recorded three weeks after full bloom according to the following formula (Westwood, 1997):

$$Fruit\ set\% = \frac{Number\ of\ \ fruit\ set}{Number\ of\ \ flower\ clusters} \times 100\%$$

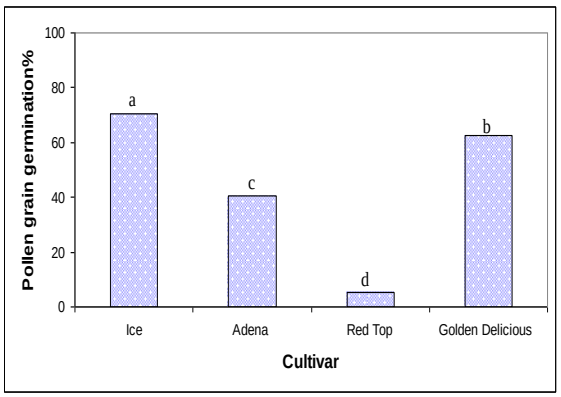

Fig. (1): Germination percentage of different apple cultivars Ice, Adena, Red Top and Golden delicious. Columns followed by different letters are significantly different at P<0.05.

Five fruits from each replicate for each cultivar were selected to record some physical and chemical characteristics of the fruits, such as fruit weight (g), fruit length and diameter (cm), shape, seed number, firmness, total soluble solids and acidity. The mean of fruit weight (g) was recorded by using electrical balance, mean fruit weight length and diameter (cm) were measured with a digital caliper to determine the fruit shape. Fruit firmness was measured by using fruit pressure tester model FT327 5/15" diameter plunger, while total soluble solids (TSS) was recorded by using hand refractometer and total acidity was calculated by titrating 5 ml of the fruit juice sample with 0.1 N NaOH.

The experimental design was a Randomized Complete Block Design (RCBD) with factorial arrangements (cultivars and treatments). The experiment was replicated five times. Data were analyzed by one way analysis of variance using the statistical package MSAT-C, and the differences between the means were compared using Fisher's least significant difference (LSD) at P≤ 0.05 (Steel and Torrie, 1980).

3. RESULTS AND DISCUSSION

3.1. Pollen grain germination

The results indicated that the germinability of pollen grains for the four cultivars was significantly different (P<0.01) (Figure 1). The highest value was 70.33% for 'Ice' and the lowest one for Red Top 5.33%. The pollen grain germination test showed that 'Adena' and 'Golden delicious' had intermediate level of pollen viability (40.33 and 62.66, respectively). These findings indicate that pollen grain germinability varied with cultivar.

3.2. Fruit set

The results indicated that open pollination was more efficient in improving fruit set than self-pollination during the two seasons and the cross pollination with Golden delicious in second season. Self pollination failed to set fruit through the two seasons of this investigation. With 'Adena' open pollination treatment produced the highest fruit set (88.4%) in first season. This value was significantly higher compared to fruit set of both 'Ice' (66.4%) and 'Red Top' (79.4%). Open pollination for "Ice" recorded the highest fruit set 78.2% in the second year. This value was significantly higher than the values obtained in 'Adena' and 'Red Top' (values= 50.9% and 59.4% respectively). Fruit set percentage was lower for "Ice" (39.7%) and Red Top (54.12%) when they were cross pollinated with "Golden delicious". Data indicated that open pollination for "Ice" was significantly higher than cross pollination for the same cultivar and for the two other cultivars.

The current study indicated a complete self incompatibility for the three cultivars. The results are in agreement with De Witte *et al.* (1996), Broothaerts *et al.* (1996) and Jana and Parmer (2001), who reported that the low productivity of most apple cultivars is due to self incompatibility, and suitable pollinizer cultivar must be chosen to increase fruit set. Broothaerts *et al.* (1996) and Broothaerts and,van Nerum (2003) proved that the cause of self incompatibility for apple was due to prevention of pollen tube to grow and reach the ovary for fertilization. Broothaerts *et al.* (1996) reported that many alleles of the S-gene control the female receptivity to self-pollination. Self pollination failed to set fruit due to some inhibitor (s) presented in the stigma that prevents pollen grain to germinate.

The present study also showed that open pollination improved fruit set compared to self pollination. These findings are in agreement with the results obtained by several researchers

(Szklanowska and Dabska, 1991; De Witte *et al.*, 1996 and Soltész, 1997) who mentioned that open pollination was satisfactory to give high productivity for different apple cultivars.

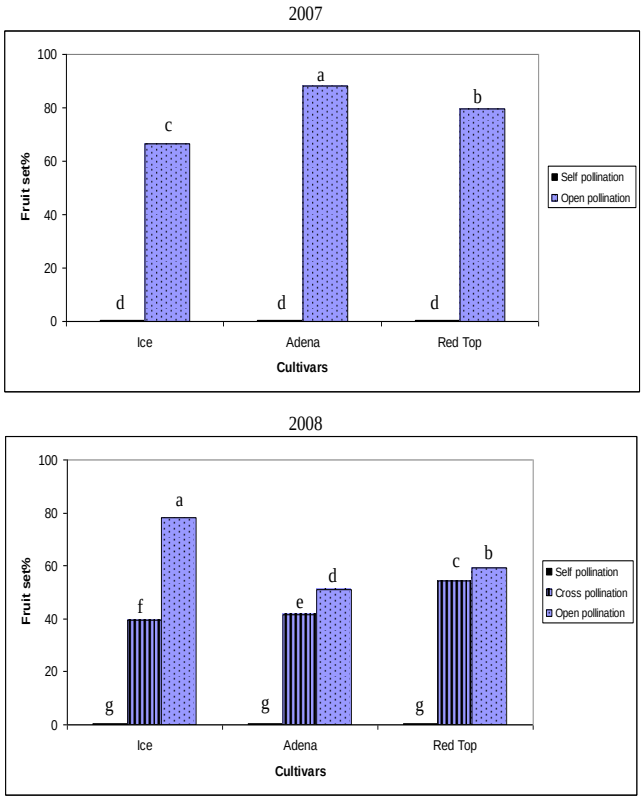

Fig. (2): Fruit set percentage using self, cross and open pollination for the three tested apple cultivars in 2007 and 2008 seasons. Columns followed by different letters are significantly different at P<0.05.

With respect to cross pollination with 'Golden delicious', the results indicate that the former treatments had lower fruit set percentage for the three cultivars compared to open pollination. This result could be explained by that pollen grains for 'Golden delicious' were not fully compatible with the flowers of these three cultivars, since pollen viability for 'Golden delicious' was 62.67%. These results are similar to the ones of De Witte *et al.* (1996) and Jana and Parmar (2001), who noted that the different pollinizers gave different fruit sets. Alburaki and Abutrabi (2004) confirmed that honeybees have very important role under open pollination to increase the fruit set for four cultivars. Schneider *et al.* (2005) concluded that the low productivity caused by insufficient pollination was due to semi-compatible pollinizer and can be avoided by using honeybees to increase pollination.

3.3. Seed number per fruit and fruit physical and chemical characteristics

In the first season, open pollination had neither effect on seed number per fruit nor on the fruit chemical and physical properties except the fruit weight. For 'Ice' fruit weight was 209.60 g was significantly higher than the fruit weight of 'Red Top' (Table 1). Table (2) shows that the cultivars significantly differed in physical and chemical characteristics in 2008 growing season indicating high level of genetic variability among the studied cultivars. Fruit weight and fruit diameter for 'Red Top' (values= 170.09 g and 5.52 cm respectively) were significantly higher than the fruit weight of the other two cultivars. 'Ice' showed the highest fruit length (4.60), fruit firmness (9.27), fruit shape (0.88) and acidity (0.27) compared to the other two cultivars. No significant differences among the three tested cultivars in TSS were obtained among the three tested cultivars. Open pollination significantly improved fruit length, fruit diameter, and fruit weight, while the three cultivars were not significantly differed in fruit shape, TSS and acidity.

The effect of open and cross pollination on some chemical and physical characteristics and their interactions with cultivars are presented in Table (3). Cross pollination with 'Golden delicious' for 'Ice' in the second season resulted in the highest seed number per fruit (9.64) significantly compared to open pollination for the same cultivar (5.2), and to other treatments for the other two cultivars (range= 5.2-5.3). Fruit firmness for 'Ice' resulted from open pollination and cross pollination with 'Golden delicious' (values= 9.15 and 9.39 respectively) was significantly compared to other two cultivars with different treatments (range= 5.57-7.03). In the second season, cross pollination of 'Red Top' with 'Golden delicious' resulted in the highest fruit diameter, significantly, and the highest fruit weight was significantly obtained from open pollination compared to other treatments for other two cultivars. These results are in line with Keulemans *et al.* (1996) and Solltesz *et al.* (1997) who pointed that cross and open pollination led to considerable increase in productivity and fruit weight of apples.

It is recommended to plant a combination of different apple cultivars in the same orchard with blooming period overlapping to improve fruit set. The results revealed that the type of pollination had an effect on seed number per fruit and on some fruit physical characteristics.

Table (1): Differences among cultivars in fruit length, diameter, shape and weight, seed number, firmness, TSS and acidity in 2007 growing season under open pollination system.

Cultivar	Fruit length (cm)	Fruit diameter (cm)	Fruit shape	Fruit weight (g)	Seed No.	Firmness (kg)	TSS (%)	Acidity (%)
Ice	4.78a	5.61a	0.85a	209.60a	6.44a	7.09a	14.38a	0.33a
Adena	5.19a	5.90a	0.88a	153.89ab	6.48a	7.07a	13.80a	0.29a
Red Top	5.07a	5.73a	0.88a	103.36b	6.72a	6.73a	13.66a	0.30a
Level of significance	NS	NS	NS	*	NS	NS	NS	NS
LSD (0.05)	-	-	-	66.06	-	-	-	-

*, ** Significant at 5% and 1% probability levels. respectively; NS= non-significant at P<0.05

Table (2): Effect of different pollination methods on fruit length, diameter, shape and weight, seed number, firmness, TSS and acidity of the three studied cultivars in 2008 growing season

Factor	Fruit length (cm)	Fruit diameter (cm)	Fruit shape	Fruit weight (g)	Seed No.	Firmness (kg)	TSS (%)	Acidity(%)
Cultivar								
Ice	4.60a	5.19b	0.88a	132.14b	7.42a	9.27a	13.85a	0.27a
Adena	4.26b	5.11b	0.83b	142.77b	5.28b	6.30b	13.74a	0.16b
Red Top	4.43ab	5.52a	0.80b	170.09a	5.35b	3.46b	13.70a	0.18b
LSD (0.05)	0.257	0.229	0.042	17.96	0.542	0.455	-	0.059
Pollination								
Cross	4.05a	4.89b	0.82a	143.46a	5.30b	7.68a	13.71a	0.19a
Open	4.82b	5.67a	0.85a	153.21a	6.72a	7.00b	13.81a	0.22a
LSD (0.05)								
Source of variation								
Cultivar	*	**	**	**	**	**	NS	**
Pollination	**	**	NS	NS	**	**	NS	NS
Cultivar ×Pollination	NS	*	NS	*	**	**	NS	NS
CV%	6.24	4.64	5.68	12.98	9.66	6.64	3.71	30.97

*, ** Significant at 5% and 1% probability levels. respectively; NS= non-significant at P<0.05

Table (3): Interactive effect of cultivars and different pollination methods on fruit length, fruit diameter, fruit shape, fruit weight, seed number, firmness, TSS and acidity in 2008 growing season

Cultivar	Pollination method	Fruit length (cm)	Fruit diameter (cm)	Fruit shape	Fruit weight (g)	Seed No.	Firmness (kg)	TSS (%)	Acidity (%)
Ice	Open	4.35a	5.00c	0.87a	113.83d	5.20b	9.15a	13.78a	0.22a
Ice	Cross	4.84a	5.38b	0.90a	150.46abc	9.64a	9.39a	13.92a	0.32a
Adena	Open	3.86a	4.65d	0.83a	143.78bc	5.36b	7.03b	13.70a	0.16a
Adena	Cross	4.65a	5.58b	0.83a	141.76c	5.20b	5.57c	18.78a	0.16a
Red Top	Open	3.92a	4.99c	0.78a	172.77a	5.36b	6.86b	13.66a	0.19a
Red Top	Cross	4.94a	6.04a	0.81a	167.41ab	5.34b	6.06c	13.74a	0.18a
LSD (0.05)		NS	0.323	NS	25.40	0.767	0.643	NS	NS

*, ** Significant at 5% and 1% probability levels. respectively; NS= non-significant at P<0.05

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تأثير التلقيح الذاتي و المفتوح والخلطي على عقد ثلاثة أصناف من التفاح في جنوب الأردن

علاء الجميلي - سائد جوزيف عويس - عادل حسن عبدالغني

قسم الانتاج النباتي - كلية الزراعة - جامعة مؤتة - ص. ب. 7 - الكرك - الأردن

ملخص

تم دراسة صفة التلقيح وعقد الثمار لثلاثة أصناف من التفاح (Apple cvs. Ice, Adena and Red Top) تحت ظروف المنطقة الجنوبية من الأردن خلال الموسمين 2007 و 2008. أوضحت النتائج بأن أصناف التفاح الثلاثة عقيمة ذاتيا، وكان التلقيح المفتوح فعال جدا في تحسين عقد الثمار ، وكذلك تبين ان التلقيح الخلطي بحبوب اللقاح لصنف التفاح 'Golden delicious' كان له أثر ايجابي في عقد الثمار مقارنة بمعاملة التلقيح الذاتي. ولذا يوصى بزراعة عدة أصناف من التفاح في بستان واحد لضمان الإنتاجية المقبولة تجاريا مع مراعاة تداخل فترات الإزهار بين الأصناف. أوضحت هذه الدراسة بأن هناك علاقة بين نوع التلقيح وبعض الصفات الطبيعية والكيميائية للثمار.

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