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EFFECTS OF ENVIRONMENTAL CONDITIONS ON SOME QUANTITATIVE AND QUALITATIVE CHARACTERISTICS OF POMEGRANATE FRUITS CV. SALIMI GROWN IN THREE DIFFERENT REGIONS AT DIYALA GOVERNORATE, IRAQ

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ABSTRACT

This study aims to reveal the effect of environmental conditions in three main areas of pomegranate cultivation at Diyala governorate, Republic of Iraq. The experiment was carried out for two growing seasons on 5yrs old Pomegranate cv. Salimi grown in three orchards at three different locations at Diyala governorate (Otomaniyah, Gedidat al Shatt, and Muqdadiyah). Fruits cracking percentage was compared between the three locations, mineral and hormonal contents of fruit peel have been examined in cracked and uncracked fruits. The highest fruit cracking percentage were found in Muqdadiyah in both growing seasons, whereas the lowest was in Gedidat al Shatt in 2018. Cracked fruit peel contained lower levels of calcium, IAA and GA3 while ABA content of the peel was generally higher in cracked fruit than in the peel of healthy (non-cracked) fruit.

***Keywords*:** Environmental condition, Pomegranate Fruit cracking

Introduction

Pomegranate is a member of *Punicacea* family originated in Iran and later on was brought to the Arabian Peninsula, Spain, and America by the Arabs. The importance of pomegranate returns to its nutritional value, chemical constituents and anti-oxidant compounds which gave this fruit a large role in the Pharmaceutical and food industry (Naser, 1996). The cultivation of this crop suffered from many physiological disorders (sunburn, fruit cracking), and moth infestation are among the main constraints for pomegranate production, which greatly reduce quality and marketability of this fruit (Gharesheikhbayat, 2006; Bakeer, 2016). Fruit cracking or splitting is one of the main disorders that affects pomegranate quality and quantity,as well as it also provides ports of entry for insects and fungi and renders fruits more susceptible to the environmental stresses, hence causing a serious commercial loss to farmers (El-Rhman, 2010; Abubakar *et al*., 2013).Cracked fruits are susceptible to storage diseases and shelf life became shorter (Khadivi-Khub ,2009). The damage can sometimes affect most of the yield (Blumenfeld et. al., 2000). Fruit split is the rupturing of the rind and is the physiological disorder responsible for the greatest losses of pomegranate fresh market yields (Blumenfeld *et al*., 2000). Fruit split typically occurs during the final stages of fruit development (El-Rhman, 2010), although some pomegranate cultivars have a tendency to split before fruit maturity (Holland *et al*., 2009). However, the causes of fruit split of pomegranate are not well understood. Factors affecting the incidence of fruit split include timing of flower development (Glozer and Ferguson, 2008), cultivar (Hepaksoy *et al*., 2000; Lefeng *et al*., 2010; Levin, 2006), soil water content (Holland *et al*., 2009), water use efficiency (Hepaksoy *et al*., 2000), and fruit size and shape (Saei *et al*., 2014). Though flower removal (Singh and Kingsly, 2007), plant growth regulator applications (El-Khawaga, 2007; Yilmaz and Özgüven, 2009), antitranspirant application (Ghanber Pour *et al*.,2019), and controlled irrigation (El-Rhman, 2010) have been tested as possible strategies to prevent fruit split of pomegranate, a commercially acceptable treatment has not yet been identified.

Materials and Methods

Three orchards located at three different sites represents the most important regions for pomegranate production at Diyala Governorate (Otomaniyah, Gedidat al Shatt, and Muqdadiyah) were chosen to study the effect of environmental conditions on fruit cracking of pomegranate fruits. This experiment lasted two growing seasons (2018 & 2019. The growth and development of fruits for both seasons in each site was monitored on a weekly intervals since the beginning of July until the date of harvesting to determine the time of cracking incidence at each location and to compare moisture, nutritional and hormonal content of the peel in cracked and healthy (non-cracked) fruits located at the same trees in order to reveal the cause for this phynomena.

Table 1: Physical and chemical properties of the soil used in the experiment:

Region	Soil texture	B $mgKg^{-1}$	K $mgKg^{-1}$	P $mgKg^{-1}$	N $mgKg^{-1}$	Ca meq/L	pH	EC ds/m
Otomaniyah	Clay loam	0.543	114	8.09	33	22	7.13	2.9
Gedidat al Shatt	Clay loam	0.254	121	7.98	36	19	7.22	3.6
Shahrbban	Clay loam	0.325	111	8.13	43	23	7.17	3.2

The following traits were recorded in this study:

1. Average fruit weight
2. peel thickness
3. Peel mineral contents: Dried peel samples were grounded and digested with H_2SO_4, and N, P, K were determined as follows: nitrogen was determined by spectrophotometer (Novozamsky *et al.*, 1974), P by spectrophotometer (Van Schouwenberg and Walinga, 1967), K by flame photometer (Tendon, 2005), Ca and Mg (Chengand Bray, 1952).

After data collection, the results were analyzed using the T-test and the least significant difference (LSD).

Results and Discussion

1. Fruits cracking (%)

Figure (1) showed that the highest cracking percent obtained for both seasons obtained from trees grown at Muqdadiyah site, whereas the least one obtained from that grown at Jididat-Alshat for the first season and Otomaniyah site at the second one.

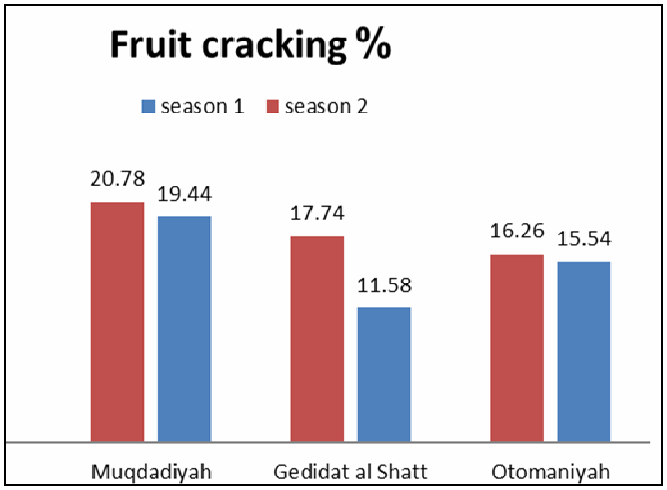

Fig. 1 : Fruits Cracking (%) at the experimental sites

2. Fruits weight (g)

Results in the table-2, below revealed that fruits weights didn't differ significantly between both fruits type (healthy and Cracked) during both seasons the first season, on the other hand orchards location have no significant effect on healthy fruits weight during the first season ,whereas fruits obtained from Otomaniyah site gave the highest weight followed by Jididat-Alshat and Muqdadiyah site at the second growing season.

3. Peel thickness (mm)

Results in table (3) showed that peel thickness at Otomaniyah, and Jididat-Alshat locations didn't differ in both fruits type (healthy, and cracked)in both seasons ,whereas healthy fruits at Muqdadiyah location exceeded cracked one in peel thickness at the same location during the first season.

4. Peel moisture content (%)

Healthy fruits at the three locations gave the highest peel moisture content compared with cracked one in these locations at both seasons, but didn't differ from each other significantly. whereas cracked fruits at Otomaniyah location gave the highest moisture content compared with cracked one at the rest two locations (Table-4).

5. Peels N content (%)

Peels N content of healthy fruits obtained from Muqdadiyah orchard have the highest, compared with fruits from Otomaniyah location which gave the lowest content in both growing seasons (Table -5).

6. P content (%)

No significant differences were observed in peel phosphorus content for both fruits type, and between studied locations (Table 6).

7. K content (%)

Fruits type (healthy and cracked) had no significant effect on K content in fruits peel for both growing seasons, whereas cracked fruits peel at Muqdadiyah orchard revealed the highest content compared with cracked fruits in the rest orchards during both seasons, on the other hand healthy fruits at the first season didn't differ significantly from each other for the three location, on contrast with the second season where healthy fruits at Muqdadiyah orchard gave the highest potassium content in fruits peel, whereas fruits grown at Otomaniyah orchard gave the lowest content (Table-7).

8. Ca content (%)

Results in table (8) showed that healthy fruits peel gave the highest Ca content compared with cracked one at Otomaniyah orchard during the first season, on the other hand no significant differences in Ca content between fruits type at the rest two locations was observed. Healthy and cracked fruits at Otomaniyah orchard. As for the effect of the region, the peel of the healthy and cracked fruits gave the highest content at Otomaniyah orchard, followed by the content of the Muqdadiya fruits and then Jididat- Alshat. In the second season, the content of the healthy fruits peel did not differ significantly from the cracked fruits in calcium content at Otomaniyah orchard, while the content of the healthy fruits peel was superior to that of the cracked fruit in Jididat- Alshat and Muqdadiyah.

9. Mg content (%)

From the results in table (9) we can observe that there was no significant difference between the types of fruits and regions in the content of the fruit peel of magnesium in the first season, whereas the content of the healthy fruit peel in Muqdadiyah region exceeded its cracked one in the same

region, but as for the effect of the region on magnesium content of the two types of fruit, the two types of fruits (healthy and cracked) in Jididat- Alshat and Otomaniyah regions were superior to the content of the two types of fruits in Muqdadiyah.

10. Effect of fruit type on peel Auxin content (mcg kg^{-1}) at the studied orchards

Results in table (10) show the significant superiority of the healthy fruit peel content of auxin in the studied locations over counterparts cracked one. As for the effect of the region on the fruit content of auxin, the healthy fruit peel of Jididat-Alshat surpassed the highest auxin content in both seasons followed by the Otomaniyah fruit peel content, whereas fruits from Muqdadiyah gave the lowest auxin content in the first season, while in the second season Otomaniyah region gave the lowest content.

11. Effect of fruit type on peel GA content (mcg kg^{-1}) at the studied orchards

The results presented in the table-11, show the superiority of the healthy fruit in it's content of gibberelin over cracked one in the studied locations. As for the effect of the region on the fruit content of hormones, the healthy fruits Jididat-Alshat were outperformed with the highest peel content of the gibberelin followed by the healthy fruit of the Otomaniyah region and then Muqdadiyah at the first season, whilst in the second season the content of the healthy fruit peel for the Muqdadiya region was in the second rank after the content of the Jididat- Alshat region, and the lowest content was for the Otomaniyah, on the contrast cracked fruits didn't differ significantly at the three locations during both seasons.

12. Effect of fruit type on peel ABA content (mcg kg^{-1}) at the studied orchards:

It is noted from the results presented in Table (12) that the cracked fruits peel in the studied areas had the significant superiority in its highest content of abcisic acid compared with the healthy fruits in both seasons, and it is noted from the data in the same table that there is no significant difference between healthy fruits in it's peels ABA content in the studied areas for both seasons, whereas in cracked fruits we can notice that ABA content in cracked fruits from the content of cracked fruits from Jididat-Alshat gave the highest ABA content followed by followed by Otomaniyah region ,whereas cracked fruits grown in Muqdadiyah region had the lowest content in the first season, but they didn't differ significantly from each other in the second season.

Table 2 : Fruit weight of Pomegranate in different growing seasons.

Growing season 2018				
Orchard site				**Fruit type**
LSD at 0.05	**Muqdadiyah**	**Jididat- Alshat**	**Otomaniyah**	
36.423	247.83	250.35	285.30	Healthy
72.55	266.53	250.35	271.72	Cracked
	64.923	49.736	64.134	LSD at 0.05
2019 growing season				
Orchard site				**Fruit type**
LSD AT 0.05	**Muqdadiyah**	**Jididat- Alshat**	**Otomaniyah**	
21.44	intact	273.91	266.08	Healthy
30.79	cracked	276.51	262.85	Cracked
	LSD at 0.05	22.22	34.20	LSD at 0.05

Table 3: Peel Thickness of Pomegranate in different growing seasons.

Growing season 2018				
Orchard site				**Fruit type**
LSD AT 0.05	**Muqdadiyah**	**Jididat- Alshat**	**Otomaniyah**	
0.231	3.35	3.30	3.39	healthy
0.237	3.18	3.24	3.26	cracked
	0.1654	0.3251	0.2151	LSD AT 0.05
2019 growing season				
Orchard site				**Fruit type**
LSD AT 0.05	**Muqdadiyah**	**Jididat- Alshat**	**Otomaniyah**	
0.2192	3.34	3.56	3.46	healthy
0.2643	3.38	3.47	3.40	cracked
	0.3048	0.1643	0.2711	LSD AT 0.05

Table 4: Peel moisture content (%) of Pomegranate in different growing seasons

Growing season 2018				
Orchard site				**Fruit type**
LSD AT 0.05	**Muqdadiyah**	**Jididat- Alshat**	**Otomaniyah**	
2.687	66.81	67.20	68.13	healthy
2.161	61.40	61.05	60.29	Cracked
	3.493	1.795	2.017	LSD AT 0.05
2019 growing season				

Orchard site				Fruit type
LSD AT 0.05	**Muqdadiyah**	**Jididat- Alshat**	**Otomaniyah**	
1.608	69.91	70.48	68.98	healthy
1.967	61.49	62.56	64.30	Cracked
	1.410	2.521	1.495	LSD AT 0.05

Table 5 : Peel N content(%) of Pomegranate in different growing seasons.

Growing season 2018				
Orchard site				**Fruit type**
LSD AT 0.05	**Muqdadiyah**	**Jididat- Alshat**	**Otomaniyah**	
0.0099	0.836	0.830	0.826	healthy
0.011	0.833	0.828	0.825	Cracked
	N.S	N.S	N.S	LSD AT 0.05
2019 growing season				
Orchard site				**Fruit type**
LSD AT 0.05	**Muqdadiyah**	**Jididat- Alshat**	**Otomaniyah**	
0.0055	0.844	0.838	0.838	healthy
0.0083	0.841	0.833	0.832	Cracked
	N.S	N.S	N.S	LSD AT 0.05

Table 6: P content (%) of Pomegranate in different growing seasons.

Growing season 2018				
Orchard site				**Fruit type**
LSD AT 0.05	**Muqdadiyah**	**Jididat- Alshat**	**Otomaniyah**	
0.0046	0.156	0.156	0.153	healthy
0.0059	0.154	0.155	0.151	Cracked
	N.S	N.S	N.S	LSD AT 0.05
2019 growing season				
Orchard site				**Fruit type**
LSD AT 0.05	**Muqdadiyah**	**Jididat- Alshat**	**Otomaniyah**	
0.0044	0.155	0.158	0.158	healthy
0.0052	0.153	0.157	0.155	Cracked
	N.S	N.S	N.S	LSD AT 0.05

Table 7: K content(%) of Pomegranate in different growing seasons.

Growing season 2018				
Orchard site				**Fruit type**
LSD AT 0.05	**Muqdadiyah**	**Jididat- Alshat**	**Otomaniyah**	
0.0074	1.130	1.117	1.120	healthy
0.0069	1.128	1.115	1.118	Cracked
	0.0084	0.0038	0.0091	LSD AT 0.05
2019 growing season				
Orchard site				**Fruit type**
LSD AT 0.05	**Muqdadiyah**	**Jididat- Alshat**	**Otomaniyah**	
0.0075	1.136	1.131	1.128	healthy
0.0076	1.134	1.128	1.125	Cracked
	0.0049	0.0082	0.009	LSD AT 0.05

Table 8 : Ca content(%) of Pomegranate in different growing seasons.

Growing season 2018				
Orchard site				**Fruit type**
LSD AT 0.05	**Muqdadiyah**	**Jididat- Alshat**	**Otomaniyah**	
0.0049	0.729	0.728	0.739	healthy
0.0059	0.727	0.724	0.731	cracked
	0.0064	0.0064	0.0041	LSD AT 0.05
2019 growing season				
Orchard site				**Fruit type**
LSD AT 0.05	**Muqdadiyah**	**Jididat- Alshat**	**Otomaniyah**	
0.0045	0.738	0.742	0.734	healthy
0.0059	0.725	0.733	0.730	cracked
	0.005	0.004	0.0071	LSD AT 0.05

Table 9 : Mg content(%) of Pomegranate in different growing seasons.

Growing season 2018				
Orchard site				**Fruit type**
LSD AT 0.05	**Muqdadiyah**	**Jididat- Alshat**	**Otomaniyah**	
0.023	0.374	0.376	0.376	healthy
0.0239	0.373	3710.	0.371	cracked
	0.0043	0.0076	0.041	LSD AT 0.05
2019 growing season				
Orchard site				**Fruit type**
LSD AT 0.05	**Muqdadiyah**	**Jididat- Alshat**	**Otomaniyah**	
0.0041	0.377	0.385	0.383	healthy
0.0044	0.374	0.383	0.379	cracked
	0.0034	0.0036	0.006	LSD AT 0.05

Table 10: Effect of fruit type on peel Auxin content (mcg kg $^{-1}$) at the studied orchards

Growing season 2018				
Orchard site				**Fruit type**
LSD AT 0.05	**Muqdadiyah**	**Jididat- Alshat**	**Otomaniyah**	
10.70	40.01	49.65	36.10	healthy
5.56	23.71	23.28	24.95	Cracked
	8.970	12.060	7.413	LSD AT 0.05
2019 growing season				
Orchard site				**Fruit type**
LSD AT 0.05	**Muqdadiyah**	**Jididat- Alshat**	**Otomaniyah**	
6.00	38.93	43.64	34.61	healthy
6.09	24.95	26.09	28.43	Cracked
	7.269	8.706	3.566	LSD AT 0.05

Table 11 : Effect of fruit type on peel GA content (mcg kg $^{-1}$) at the studied orchards:

Growing season 2018				
Orchard site				**Fruit type**
LSD AT 0.05	**Muqdadiyah**	**Jididat- Alshat**	**Otomaniyah**	
36.73	429.88	490.77	437.49	healthy
29.29	391.40	418.17	416.18	Cracked
	37.18	21.25	8.270	LSD AT 0.05
2019 growing season				
Orchard site				**Fruit type**
LSD AT 0.05	**Muqdadiyah**	**Jididat- Alshat**	**Otomaniyah**	
13.82	476.99	493.37	461.54	healthy
27.217	417.34	412.55	420.70	Cracked
	39.85	7.67	12.33	LSD AT 0.05

Table 12 : Effect of fruit type on peel ABA content (mcg kg^{-1}) at the studied orchards

Growing season 2018				
Orchard site				**Fruit type**
LSD AT 0.05	**Muqdadiyah**	**Jididat- Alshat**	**Otomaniyah**	
18.72	87.15	94.67	100.14	healthy
15.67	122.03	140.65	136.14	Cracked
	26.18	7.94	20.07	LSD AT 0.05
2019 growing season				
Orchard site				**Fruit type**
LSD AT 0.05	**Muqdadiyah**	**Jididat- Alshat**	**Otomaniyah**	
5.28	84.99	85.16	89.69	healthy
13.78	124.10	132.18	130.49	Cracked
	9.35	12.18	13.6	LSD AT 0.05

It is noted from the results that the healthy fruits content of calcium, auxin and gibberelin exceeds the content of cracked one, and this explains the role of calcium in the elongation of cells as well as its association with the pectate forming the calcium pectate that forms the Middle lamella of the cell walls. Calcium pectate acts as adhesive between cell walls (Jundia, 2003), and it is possible that auxin has a role in increasing the movement of calcium ions (Sorce *et al*., 2011), as well as its acidic effect as it creates a pump for hydrogen ions in the regions of the cell wall , so the reaction between

the cell wall is acidic, that is, low pH and led to Softness and elasticity of the walls (Arsuffi and Braybrook, 2018), or it may be due to the role of auxin in the nutriment transformation is to supply energy to the H ions pump, and this results in a decrease in pH, which work in directly on the ductility and expansion of the cell wall (Saqr, 2006). Furthermore, gibberellic acid plays a role in changing the nature of cell walls by increasing its expansion through it's effect on the arrangement and distribution of hemicellulose fibers and making them more rubbery so that their permeability increases and then the largest amount of water and nutrients enter the succulent gap to increase their osmotic pressure (Abu Zaid, 2000 and Hartmann *et al*., 2002), In addition to its role in stimulating enzymes responsible for cell division and elongation and reducing the effectiveness of the enzyme pectinase responsible for the breakdown of pectin in cell walls (Venkatesan and Mohiden, 1994), it also increases the proportion of cells performing the division process (Yassin, 2001 and Harberd and Fu, 2003).

Increasing the content of the fruit peel of the Abscisic acid led to preventing or reducing the flexibility and elasticity of cell wall, and reducing its permeability, which reduces the entry of water and mineral salts necessary for growth, as it reduces or improves the production of auxins and gibberellin and thus reduces or prevents cell division and elongation (Jendia, 2003) Cracking occurs. This results was in agreement with that founded by Sharma and Dhillon (1998)who noted that there were higher ABA contents in the aril and peel of cracked litchi fruit than that of healthy fruits.And with the founding of Josan, et. al. (1998) whom reported that ABA content was higher in fruits which had higher fruit cracking ratio.

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