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MULTIVARIATE ANALYSIS AS A TOOL IN THE ASSESSMENT OF THINNING OF SEGAE DATE PALM CULTIVAR (*PHOENIX DACTYLIFERA* L.)

SOLIMAN S.S[1,2*], R.S. AL-OBEED[1] AND A.M. Al-SAIF[1]

[1]*Plant production Dept., College of food & Agic. Sciences, King Saud University, Saudi Arabia*
[2]*Department of Horticultural Crops Technology, National Research Centre, Cairo-, Dokki, Egypt*
**Corresponding author e-mail: said_soliman@hotmail.com*

Abstract

Different hand thinning treatments were conducted on Segae date palm cultivar to study their effect on bunch yield and fruit quality. Five thinning treatments; control (no thinning (A)), removing 10 cm of strands length per bunch (B), removing 20 cm of strands length per bunch (C), removing the middle of the bunch (D), removing the middle of the bunch and removing 10 cm of strands length per bunch (E) were investigated at Deirab, Riyadh, Saudi Arabia. Fruit thinning substantially decreased bunch yield and increased fruit weight, flesh weight, flesh weight, fruit size, fruit dimensions in both seasons as compared with the control (no thinning) treatment. Fruit thinning had significant effect on the fruit acidity, total soluble solids and total sugars in both seasons. Thinning treatments had no effect on seed weight, reducing sugars, non-reducing sugars and moisture content in two seasons. It could be recommended that removing the middle of the bunch and removing 10 cm of strands length per bunch (treatment E) is the most appropriate practice for thinning as it gave the highest bunch yield with best fruit quality as compared with other applied treatments. Principle component analysis determined into three components which explained 82.92% and 82.11% of the total variance in the first and second seasons, respectively. First component (50.98% and 43.20%) strongly influenced by fruit length, fruit diameter, fruit weight, fruit volume, seed weight and flesh weight at first and second seasons, respectively. second component (19.69% and 24.95) was affected strongly by total sugars, non-reducing sugars & bunch weight and total sugars, non-reducing sugars at first and second seasons, respectively. Third component (12.24% and 13.97) was affected strongly by total soluble solids and moisture content at first and second seasons, respectively. This information can be used for future studies and can be used in identifying the best method to hand thinning in Segae date palm cultivar, which can be applied to get the higher the productivity with the high quality of the physical and chemical characteristics of the fruits.

Key words: Date palm, Thinning, Fruit quality, Bunch yield, PCA, HCA.

Introduction

Date palm (*phoenix dactylifera* L.) is one of the important fruit crops have been grown in Kingdom of Saudi Arabia. Segae is one of the best soft type date palm cultivars found be acceptable for Saudi consumer. Successful orchard management practices include appropriate fruit thinning which gives the remaining fruits a better chance to develop larger size and better quality.

Fruit thinning is one of major practices that often help to overcome this problem. In addition, it gives better quality and reduced compactness among fruits within bunch. It also helps to have good flowering in the flowering year (Hussein, 1970; Moustafa, 1993 and Marzouk *et al.*, 2007).Such results could be attained either by reducing the number or fruits per bunch or by reducing the number of bunches per palm. Hasan *et al.* (1998) found that there was an inverse relation between the numbers of bunches and each of volume and weight of both fruit and seed. However, the total yield of the palm showed a non linear relationship with the number of bunches. Thinning treatments improved of most physical and chemical properties of fruits (Moustafa, 1998 and El-Shazly, 1999). Osman & Soliman (2001) found that the removing 25 percent to strands number per bunch gave the highest yield and best fruit quality. Al-Obeed *et al.* (2005) found that the 15% shortening of strands at pollination time led to obtain a reasonable yield with fruit quality. Removing 15% of total number of Haiany and Halawy bunch strands by either thinning out or cutting back before pollination was benefice to regulate the yield with enhancing the maturity and quality of dates, Amen *et al*. (2007). Behseresht *et al.* (2007) reported that the thinning in chimiri stage had no significant effects on fruit quality and quantity when compared with that at pollination stage. Although removal of one third (control and strand-tip) of strands reduced yield, this treatment increased fruits in top grads. Al-Darwish (2010) found that the fruit thinning reducing fruit shrivel. Soliman *et al*., 2011 (2011) found that the thinning treatments improved fruit characteristics where they increased significantly fruit physical and chemical properties of dates (at Tamer stage). Soliman & Harhash (2012) found that the thinning treatments have improved fruit characteristics, where they increased significantly fruit physical and chemical properties of dates (Beser and Tamur stage) than the control. Meanwhile, the most beneficial treatment in such concern was thinning 30% of total number of strands from the center of bunches. Mohammad (2009) found that the bunch thinning of Omraheem date palm cultivar increased bunch weight, fruit flesh weight, reducing and non-reducing sugars.

Materials and Methods

The present investigation was carried out at the Research and Agriculture Experimental Station at Dirab, College of Food and Agricultural Sciences, King Saud University, Riyadh. The experiment was repeated for two successive years (2013 and 2014). Five date palms trees (15-years-old) grown on sandy soil were selected for each treatment. The experimental palms were healthy, uniform in growth, vigor and height. Pollination was achieved by using pollen grains from the same parent in both seasons.

All cultural practices were carried out according to the normal schedule for experimental palms. Only 10 bunches were left on each experimental tree. Thinning treatments were applied 30 days after hand pollination in both seasons as follows: control (no thinning (A)), removing 10 cm of strands length per bunch (B), removing 20 cm of strands length per bunch (C), removing the middle of the bunch (D), removing the middle of the bunch and removing 10 cm of strands length per bunch (E). Experimental treatments were arranged in randomized complete block statistical design with five replications (one palm tree for each replication). The total numbers of trees used in the experiment were 15 trees. The yield of experimental trees was harvested through the first half of September. Average bunch weight was recorded as kg/palm. Samples of 20 date fruits were picked at random for the determination of fruit size and dimensions (length and diameter), fruit weight, fruit flesh weight, seed weight and fruit compositions. Average bunch yield was estimated as kg/bunch.

Fruit physical characters: Samples of five replicates, 20 fruits each were taken randomly from each bunch to determine fruit weight, fruit flesh weight and seed weight (g), fruit size and dimensions (length and diameter, in cm).

Fruit chemical properties: Chemical properties of fruits (fruit acidity percentage and the titrable acidity was calculated as citric acid (Mawloud, 1980), (moisture content and total soluble solid "TSS"), and sugar content (reducing, non-reducing and total sugar) were determined according to Association of Official Agricultural Chemists (Anon., 1995a).

Data calculation and analysis: The multivariate analysis including the principle component analysis (PCA) and hierarchical cluster analysis (HCA) perfomed to indentify the relationship among investigated thinning in study. The PCA, HCA, and correlation coeffiicient analysis were performed by using Statistica for Windowes statistical software (Anon., 1995b). In the PCA, varimax raw was used as the rotation method in the analysis to determine total variance and loading of investigated thinning in Segae date palm cultivar. The HCA was obtained by Ward's method (Pearson's r).

Results

Bunch weight (Kg): Concerning the average bunch weight, date in Table 1 indicate that the fruit thinning of Segae palm significantly decreased bunch yield than the control treatment in second season. Removing the middle of the bunch and removing 10 cm of strands length per bunch (E treatment) gave the highest values of bunch yield compared with either the other treatments. The obtained results are similar to those of El-Shazly, 1999; Osman & Soliman, 2001, Amen *et al*., 2007, Soliman *et al*., 2011 and Soliman & Harhash (2012) on different date palm cultivars.

Fruit characteristics

Physical properties: Fruit thinning significantly increased the average the fruit weight, flesh weight, fruit volume and fruit dimensions as compared to the control in both seasons. Removing the middle of the bunch and removing 10 cm of strands length per bunch (E treatment) followed by removing the middle of the bunch (D treatment), gave the highest physical properties than those control and other treatments in both seasons. Regarding the seed weight, the data obtained indicated that, ther were significant differences between all treatments during two seasons. Removing the middle of the bunch and removing 10 cm of strands length per bunch (E treatment) and Removing the middle of the bunch (D treatment) gave the highest values seed weight as compared to other treatments in the first and second seasons, respectively (Table 1).

Table 1. Effect of fruit thinning treatments on physical properties and bunch weight.

Treatments	Fruit weight (g)	Flesh weight (g)	Seed weight (g)	Fruit volume (cm)	Fruit length (cm)	Fruit diameter (cm)	Bunch weight (kg)
	2012-2013 seasons						
1	7.1	6.3	0.76	7.5	3.6	2.1	17.3
2	9.8	8.9	0.86	9.7	4.0	2.3	10.6
3	10.2	9.3	0.85	10.0	4. 4	2.3	11.1
4	10.4	9.6	0.85	10.1	4.1	2.4	12.3
5	12.8	11.9	0.93	12.7	4.1	2.5	14.4
LSD at 0.05	**0.75**	**0.74**	**0.11**	**0.97**	**0.2**	**0.1**	**ns**
	2013-2014 seasons						
1	11.2	10.3	0.89	11.0	4.1	2.3	13.9
2	11.7	11.2	0.46	11.8	4.0	2.3	5.2
3	14.5	13.5	0.97	15.3	4.5	2.5	8.6
4	14.7	13.7	1.00	15.0	4.5	2.6	8.5
5	15.0	14.0	0.99	14.7	4.5	2.6	9.0
LSD at 0.05	**2.9**	**2.7**	**0.09**	**3.8**	**0.4**	**0.2**	**6.1**

Chemical properties: Data clearly indicated that different thinning treatments had increasing acidity percent in fruit in both seasons. Significant differences in total acidity percent between treatments were obtained in removing 20 cm of strands length per bunch (C treatment) followed by control (no thinning (A)) and removing 10 cm of strands length per bunch (B treatment) followed by control in the first and second seasons, respectively. Total soluble solids and total sugars percent of fruit was significantly affected by thinning treatments. Removing the middle of the bunch and removing 10 cm of strands length per bunch (E treatment) followed by removing the middle of the bunch (D treatment) increased TSS and total sugars in fruit compared with either the control and other applied treatments in both seasons. Removing 20 cm of strands length per bunch (C treatment) followed by control and removing the middle of the bunch and removing 10 cm of strands length per bunch (E treatment) gave the highest reducing sugars in the first and second seasons, respectively. Data show also those significant differences in non-reducing sugars between thinning treatments in both seasons. Removing the middle of the bunch and removing 10 cm of strands length per bunch (E treatment) followed by removing the middle of the bunch (D treatment) and removing the middle of the bunch (D treatment) followed by removing the middle of the bunch and removing 10 cm of strands length per bunch (E treatment) gave the highest values of non-reducing sugars than those control and other treatments in the first and second seasons, respectively. Noticeable is that moisture content was not significantly affected by thinning treatments for Segae cultivar in both seasons (Table 2).

Multivarite statistical analysis and correlation study: The correlation study showed that significant positive correlation among various physical and chemical properties of Segae date palm cultivar study (Table 3). According to correlation coefficient physical properties of fruit length, fruit diameter, fruit weight, fruit volume, seed weight or flesh weight are significantly correlated with each other in both seasons with r^2 0.75-0.98 and 0.77-1 in the first and second seasons, respectively. Fruit flesh weight is significantly negative correlated with total and non-reducing sugars in first season. Also, reducing sugars showed significant negative correlation with the non-reducing sugars in the first season. Total sugars are significantly correlated with non-reducing sugars in both seasons. Moreover, total soluble solid showed significant positive correlation with total and non-reducing sugars in second season. Total acidity is significantly correlated with moisture content in second season. Removing the middle of the bunch and removing 10 cm of strands length per bunch (E treatment) gave the highest values of bunch yield, physical properties and some chemical properties as compared to other treatments.

Principal components analysis is a way of identifying patterns in data, and expressing the data in such a way as to highlight their similarities and differences. The results of PCA showed that three factors are extracted, which account for 82.92% and 82.11% of the total variance in the first and second seasons, respectively (Table 4). Factor 1 is dominated by fruit length, fruit diameter, fruit weight, fruit volume, seed weight and flesh weight which amounted to 50.98% and 43.20% the total variance at first and second seasons, respectively. Factor 2 is dominated by total sugars, non-reducing sugars & bunch weight and total sugars, non-reducing sugars accounts for 19.69% and 24.95 of the total variance at first and second seasons, respectively. Factor 3 is dominated by total soluble solids and moisture content accounts 12.24% and 13.97% the total variance at first and second seasons, respectively (Table 5).

Table 2. Effect of fruit thinning treatments on chemical properties.

Treatments	Acidity %	TSS %	Reducing sugars	Non-R. sugars	Total sugars	Moisture content %
	2013-2014 seasons					
1	0.256	56.7	35.2	17.6	52.8	13.4
2	0.250	58.8	33.4	20.2	53.6	14.0
3	0.333	58.8	36.1	17.6	53.7	14.0
4	0.224	59.6	33.2	23.1	56.3	13.5
5	0.240	62.5	32.5	26.5	59.0	11.7
LSD at 0.05	**0.06**	**3.9**	**ns**	**9.1**	**4.0**	**ns**
	2013-2014 seasons					
1	0.257	52.5	34.5	13.9	48.4	14.2
2	0.321	56.0	34.5	18.0	52.5	13.3
3	0.254	59.5	36.1	20.1	56.2	14.2
4	0.222	60.2	32.3	24.2	56.5	14.7
5	0.245	60.5	35.2	22.1	57.3	13.5
LSD at 0.05	**0.25**	**5.3**	**ns**	**10.5**	**5.5**	**ns**

Table 3. The correlation coefficients (r) among various physical properties in the first and second seasons.

Physical properties	Factor 1	Factor 2	Factor 3	Factor 1	Factor 2	Factor 3
	First season			Second season		
Fruit length (cm)	0.97*	0.14	0.09	0.97*	0.08	-0.08
Fruit diameter (cm)	0.93*	0.20	0.04	0.87*	-0.05	0.06
Fruit weight (g)	0.96*	0.23	0.03	0.98*	-0.01	-0.08
Fruit volume (cm)	0.95*	0.25	0.00	0.88*	0.22	0.17
Seed weight (g)	0.89*	-0.20	-0.20	0.98*	-0.02	-0.06
Flesh weight (g)	0.96*	0.25	0.04	0.96*	-0.05	0.00
TSS %	0.09	0.10	-0.92*	0.03	0.95	0.17
Acidity %	0.23	-0.54	0.52	0.25	-0.28	-0.63
Reducing sugars %	0.30	0.64	-0.36	0.20	-0.28	0.59
Total sugars %	-0.37	-0.81*	-0.26	0.08	0.96*	0.16
Non-R. sugars %	-0.40	-0.86*	0.04	0.00	0.99*	-0.08
Moisture content %	0.24	0.43	0.56	-0.13	0.20	0.90*
Bunch weight (kg)	0.00	0.74*	-0.34	-0.42	-0.06	-0.57
Eigenval	6.63	2.56	1.59	5.62	3.24	1.82
% total variance	50.98	19.69	12.24	43.20	24.95	13.97
Cumul eigenval	6.63	9.19	10.78	5.62	8.86	10.67
Cumul %	50.98	70.67	82.92	43.20	68.15	82.11

Table 4. The correlation coefficients among various physical and chemical properties in first season.

Physical and chemical properties	FL	FD	FW	FV	SW	FFW	TSS	Acid	Red	Tsug	Non	Mo
Fruit length (cm)	1											
Fruit diameter (cm)	0.94*	1.00										
Fruit weight (g)	0.97*	0.93*	1.00									
Fruit volume (cm)	0.97*	0.93*	0.98*	1.00								
Seed weight (g)	0.78*	0.75*	0.79*	0.76*	1.00							
Flesh weight (g)	0.97*	0.93*	1.00*	0.98*	0.78*	1.00						
TSS %	0.01	0.02	0.09	0.11	0.21	0.08	1.00					
Acidity %	0.19	0.06	0.11	0.07	0.15	0.11	-0.48	1.00				
Reducing sugars %	0.34	0.32	0.39	0.43	0.12	0.40	0.46	-0.19	1.00			
Total sugars %	-0.47	-0.51	-0.55*	-0.55*	-0.20	-0.56*	0.21	0.31	-0.42	1.00		
Non-R. sugars %	-0.48	-0.50	-0.56*	-0.58*	-0.19	-0.57*	-0.14	0.30	-0.83*	0.85*	1.00	
Moisture content%	0.35	0.29	0.36	0.33	-0.01	0.37	-0.23	0.06	0.16	-0.44	-0.36	1.00
Bunch weight (kg)	0.08	0.18	0.19	0.17	-0.09	0.20	0.33	-0.51	0.43	-0.50	-0.56*	0.06

Concerning the HCA, the investigated physical and chemical properties are grouped into different clusters (Fig. 1). It was observed that the cluster 1 containing fruit length, fruit diameter, fruit weight, fruit volume, flesh weight, seed weight and moisture content, which are associated with bunch weight, reducing sugars and total soluble solids in cluster 2 for the first season. The third group of the first season contains acidity, total sugar and non-reducing sugars and associated with cluster 1 and 2. Similarly, for the second season, the first group included the physical properties of fruit length, fruit diameter, fruit weight, fruit volume, flesh weight, and seed weight. The second, third and fourth groups was made up of three properties (non-reducing sugars, total soluble solids and total sugars), two properties (moisture content and reducing sugars) and two properties (bunch weight and acidity), respectively. These results were clear with the correlation coefficients between these parameters in both seasons. The PCA used in our work showed that Factor 1 is dominated by physical properties of fruit length, fruit diameter, fruit weight, fruit volume, seed weight and flesh. Both PCA and HCA indicated that the thinning is very importance practice affecting the physical properties of date palm. Data clearly indicate also that the correlation between physical properties and some chemical properties including total soluble solid and sugars as well as bunch weight.

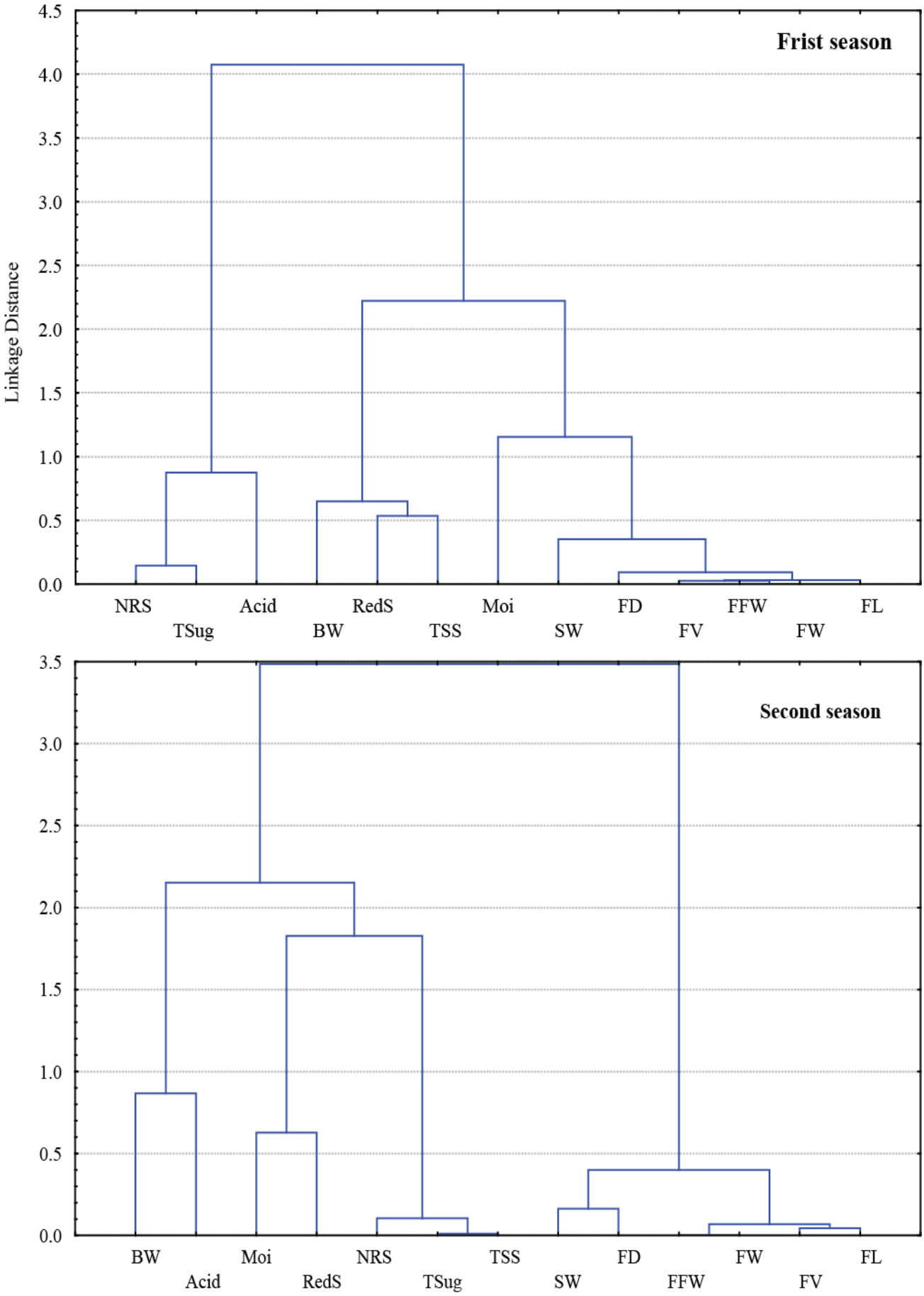

Fig. 1. Cluster dendogram for physical and chemical properties by Ward's method (Pearson's *r*) at physical and chemical properties in first and second seasons.

Table 5. The correlation coefficients among various physical and chemical properties in second season.

Physical and chemical properties	FL	FD	FW	FV	SW	FFW	TSS	Acid	Red	Tsug	Non	Mo
Fruit length (cm)	1.00											
Fruit diameter (cm)	0.78*	1.00										
Fruit weight (g)	0.95*	0.78*	1.00									
Fruit volume (cm)	0.96*	0.77*	0.96*	1.00								
Seed weight (g)	0.85*	0.84*	0.80*	0.81*	1.00							
Flesh weight (g)	0.95*	0.78*	1.00*	0.96*	0.79*	1.00						
TSS %	0.09	0.01	0.00	-0.03	0.22	0.01	1.00					
Acidity %	0.25	0.16	0.31	0.16	-0.07	0.31	-0.28	1.00				
Reducing sugars %	0.15	0.23	0.15	0.21	0.08	0.20	0.00	-0.09	1.00			
Total sugars %	0.14	0.01	0.06	0.02	0.25	0.07	0.99*	-0.27	0.00	1.00		
Non-R. sugars %	0.07	-0.07	0.00	-0.06	0.20	-0.01	0.91*	-0.21	-0.38	0.92*	1.00	
Moisture content%	-0.18	-0.09	-0.20	-0.15	0.08	-0.18	0.32	-0.53*	0.37	0.30	0.14	1.00
Bunch weight (kg)	-0.31	-0.31	-0.40	-0.34	-0.45	-0.40	-0.09	0.13	-0.10	-0.11	-0.07	-0.50

Discussion

These obtained results from this study cleared that physical properties were affected significantly by different applying thinning treatments. Removing the middle of the bunch and removing 10 cm of strands length per bunch (E treatment) followed by removing the middle of the bunch (D treatment), gave the highest physical properties than those control and other treatments in both seasons. Soliman *et al*. (2011), Micro-elements such as iron, zinc, manganese, boron that affect the elongation of the cell division and cell enlargement as well as the biosynthesis of carbohydrates and proteins. This could be responsible for increasing fruit in weight, fruit flesh weigh, fruit saiz and fruit dimensions (Siminis *et al*., 1998). These results are in agreement with those obtained by Khalifa *et al*. (1987), Hasan *et al*. (1998), Osman & Soliman (2001), Al-Obeed *et al.* (2005), Amen *et al*. (2007), Soliman *et al*. (2011) and Soliman & Harhash (2012), Mostafa and El-Akkad (2011) and Bashir *et al*. (2014) they found that the fruit physical properties was increased in both years by applying thinning treatments. Hussein *et al*. (1977) recorded that the thinning is one of the most important horticultural processes that lead to regular bearing. Moreover, production of great ideal number of inflorescence in female and reduced compactness among fruits within bunch. This leads to provide inflorescence for next season. Unthinning lead to accumulation strands top of each other and become compactness fruit inside bunches which negatively affects the physical qualities of the fruit and chemical. Where blocking light and air, and competition for nutrients significantly.Also, the total soluble solids, total sugars, reducing sugars and non-reducing sugars were affected significantly by different applying thinning treatments used in this study. It was clearly noticed that removing the middle of the bunch and removing 10 cm of strands length per bunch (E treatment) increased TSS and total sugars in fruit compared with the control and other applied treatments in both seasons. Also, the treatment same increased reducing sugars fruit compared with the control and other treatments in the second and first seasons, respectively. Removing 20 cm of strands length per bunch (C treatment) and removing the middle of the bunch (D treatment) and removing the middle of the bunch (D treatment) gave the heights non-reducing sugars in the first seasons, respectively. These results are in agreement with those by El-Kassas (1983), El-Shazly (1999), Osman & Soliman (2001), Al-Obeed *et al.* (2005), Amen *et al.* (2007), Soliman *et al*. (2011), Soliman & Harhash (2012), Mostafa and El-Akkad (2011) and Bashir *et al.* (2014). They reported that fruit quality varied according to thinning method used in strands of bunch of date palm. The multivarite statistical analysis and correlation study showed that significant positive correlation among various physical and chemical properties of Segae date palm cultivar. Analysis showed that the thinning significantly affect the physical properties such as fruit weight, fruit flesh weight and seed weight, fruit size and dimensions (length and diameter) and some chemical characteristics such as fruit acidity percentage, total soluble solid and total sugar. These results are in agreement with those reported by El-Kassas (1983), Khalifa *et al*. (1987), Amen *et al*. (2007), Soliman *et al*. (2011) and Soliman & Harhash (2012).This results suggests that fruit thinning can give better quality and reduced compactness among fruits within bunch. It also helps to have good flowering in the flowering year (Moustafa, 1993 and Marzouk *et al*., 2007).

In conclusion and recommendation: Thinning which gives the left fruits a better chance to develop larger size and better quality. Alternate bearing with high and low yields is common in date palms. Removing the middle of the bunch and removing 10 cm of strands length per bunch (E treatment) was the best to improve the productivity and fruit quality of Segae date palm cultivar.

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