

EFFECT OF WAYS OF HAND THINNING ON ANNA APPLE FRUIT QUALITY AND VEGETATIVE GROWTH UNDER EGYPTIAN DESERT CONDITIONS

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Abstract

Thinning is essential for producing 'Anna' apple fruits of high quality. Various ways of hand thinning were practical on fruitlets at the age of two weeks from full bloom by either leaving two or three fruitlets per cluster all over the tree or removing all fruitlets from the upper two limbs of each tree and leaving three only per cluster on the lower two limbs. The results reveal production of bigger fruits by all treatments, however best results concerning fruit weight, size and dimensions were obtained when all fruitlets were thinned from the upper two limbs and 3/ cluster left on the other two. Both firmness and T.S.S. were not changed significantly by any of the conducted treatments. Concerning effect of thinning on vegetative growth (number of shoots, average length of new shoots and total shoot length) produced during the current year were evidently increased by thinning. However, the results were insignificant except the average length of a single shoot which increased significantly.

INTRODUCTION

Production of apples, in Egypt, had rather been limited because of the high chilling requirements of the world famous cultivars which are not fulfilled under local conditions (Brooks and Olmo, 1972). However, apples of rather good quality have been successfully grown during the last decade after the introduction of low and moderate chilling cultivars on semi-dwarf stocks (A.D.S., 1982). The effect of rootstocks on vegetative growth of 'Anna' and 'Ein-Shemer' cultivars was studied by Abdel-Aziz, *et al.* (1990). Nevertheless, fruit size is of a prime importance in ensuring marketability of fruits especially apples (Westwood, 1992).

Usually, with proper pollination, Anna apple trees set a high number of fruits thus producing a high crop with inferior fruit quality. The removal of excess fruits from apple trees is an essential orchard practice (Williams, 1979). It has been recognized that proper thinning is of most importance to produce fruits of high quality and suitable size in cultivars that set a high amount of fruits and do not give enough vegetative growth as those grafted on semidwarf stocks (Westwood, 1992 and Fukuda, *et al.*, 1991). Hand fruit thinning has been practiced since early times to improve fruit size and quality. Attempts had been made to control cropping by hand thinning in an early time (Williams, 1979). Thinning at blossom stage produces much larger fruits than later thinning (Jones *et al.*, 1992).

MATERIALS AND METHODS

This investigation has been carried during the two successive seasons 1995 and 1996 on Anna, 4-6 years old, apple trees buded on M.M. 106 rootstock and planted 2.5 x 4 meters apart in fine sandy soil at El-Nubaria, Egypt. A drip system is used for irrigation and all trees received the same usual cultural practices. Dorsett Golden trees are used as pollinizers at a rate of 1-8. Trees are trained according to the modified spindle bush system with four limbs. The orchard is sprayed with H₂ CN₂ (1.5%) yearly at 15 Jan. (Petri and Stuker, 1995).

Experimental work

Four treatments, each comprised three replicate trees, were conducted in this investigation. The same replicate trees of each treatment were used throughout the years of the investigation. They were chosen to be healthy and of the same vigour at the beginning of the experiment.

The treatments were as follows:

- A. Control (without thinning).
- B. Thinning by leaving 2 fruitlets/cluster.
- C. Thinning by leaving 3 fruitlets/cluster.
- D. Fruits on the two upper limbs were completely thinned while those on the lower were thinned to 3 fruitlets/cluster.

Thinning was carried out at the following dates and fruit age from blooming in the two successive seasons (Table 1):

Table 1. Full bloom and thinning dates in the two seasons.

Seasons	Full bloom		Thinning		Age at thinning
	Date of full bloom	Julian Dates*	Date of thinning	Julian dates	
1995	15/2	46	17/3	76	30 days
1996	1/2	32	4/3	64	32 days

* The Julian day is the day of the year in succession considering first of January as one and the end of December as 365 or 366 days.

Fruit characteristics

Samples of 15 fruits were taken at specified intervals starting from the age of 56 days from full bloom (21/4/1995) in the first season and 32 days (4/3/1996) in the second season till maturity at the age of 102 days and 107 days, in the two seasons, respectively (ABd-El-Aziz *et al.*, 1985).

The following data were recorded for each sample :

- Average fruit weight and size.
 - Average fruit length and diameter by using a vernier caliper.
 - The average of flesh thickness was determined at the two sides of the fruit (widest side and narrowest) by using a vernier caliper.
 - Firmness of fruits was determined using Penetrometer (pressure tester) Trade Mark Effect with plunger of 5/16 inch and recorded in lb/Inch².
 - Total soluble solids of fruit juice (T.S.S.):
- Percentage of total soluble solids (T.S.S.) was measured by using ATAGO (ATC-1) refractometer (A.O.A.C., 1960).
- Total anthocyanin content: was determined according to the method of Husia, *et al.* (1965).

Vegetative growth

The following data were taken at the end of the two seasons 1995 and 1996.

1. Number of new shoots:

Total number of new shoots developed on each individual tree was determined.

2. Average shoot length:

Average length of individual developed shoots was measured at the end of each growing season.

3. Total length of developed vegetative growth during the season.

Total vegetative growth per plant (excluding that of spurs) was determined by the equation:

Number of shoots/plant x Average of shoot length.

Statistical analysis

All data obtained were statistically analysed using the completely randomized design according to Snedecor and Cochran (1967). Mean separation was carried out by L.S.D. (0.05).

RESULTS

Effect of thinning on fruit characteristics

Effect on fruit characters were studied on samples taken at successive periods till maturity. Samples were taken in the first season at the ages of 56,86, and 102 days and in the second season at the ages of 32, 47, 62, 77, 92, and 107 days from full bloom.

Fruit weight

It is evident from both Tables 2 and 3 that treatment D, in which all the fruitlets were thinned from the upper two limbs while those on the lower two limbs were thinned to three fruitlets resulted in the heaviest fruits. The control fruits were the lightest. However, those of the other two treatments were intermediate in weight

and did not significantly differ from each other.

Fruits were increasing in weight significantly from the first till the last date of sampling, however, in the second season the change in weight was not evident between the first and second samples, afterwards it increased continuously. Fruits at maturity (3rd sample) in the first season, averaged 116.1g. However, it averaged 114.7g in the second season at the last date of sampling (age of 117 days). Nevertheless, the control fruits reached only 78.9 g in the former and around 64 g in the second at the same date. Differences between various treatments at that date coincided with the general average in the two seasons.

Table 2. Effect of thinning treatments on fruit weight in grams. (season 1995).

Treatment	Age in days from full bloom			Average
	56	86	102	
A	12.147	29.347	78.933	40.142
B	13.673	36.607	87.267	45.849
C	15.753	33.530	90.100	46.461
D	15.500	37.867	116.117	56.494
Average	14.268	34.338	93.104	47.337

Mean separation by L.S.D. 0.05.

Dates = 4.254

Treatments = 4.912

L.S.D. for interaction (Dates x Treatments) = 8.508

Table 3. Effect of thinning treatments on fruit weight in grams. (season 1996).

Treatment	Age in days from full bloom						Average
	32	47	62	77	92	107	
A	2.567	6.790	9.957	22.383	36.443	63.967	23.684
B	2.533	7.430	14.767	23.527	55.453	76.367	30.013
C	2.880	7.087	14.790	26.900	42.673	93.300	31.272
D	3.507	8.847	14.427	28.227	71.853	114.667	40.254
Average	2.872	7.538	13.485	25.259	51.606	87.075	31.306

Mean separation by L.S.D. 0.05.

Dates = 5.410

Treatments = 4.417

L.S.D. for interaction (Dates x Treatments) = 10.820

Fruit size

Results presented in Tables 4 and 5 show that fruits were increasing significantly in size till the last date of sampling. Average results indicate that treatment D was superior to the three other treatments, however, control A and treatment B in the first season and A and C in the second one resulted in the smallest fruits. Interaction between treatments and dates showed that in the last sampling dates the results coincided with the general average.

Table 4. Effect of thinning treatments on fruit size in ml. (season 1995).

Treatments	Age in days from full bloom			Average
	56	87	102	
A	14.133	33.333	96.567	48.011
B	15.467	42.657	103.467	53.867
C	18.533	42.667	105.333	55.511
D	18.333	50.667	136.333	68.444
Average	16.617	42.333	110.425	561.458

Mean separation by L.S.D. 0.05.

Dates = 5.937

Treatments = 6.856

L.S.D. for interaction (Dates x Treatments) = 11.875

Table 5. Effect of thinning treatments on fruit size in ml. (season 1996).

Treatments	Age in days from full bloom						Average
	32	42	59	76	94	107	
A	2.933	6.667	10.0000	23.667	48.613	79.667	28.591
B	3.200	8.000	16.667	25.667	64.390	88.667	34.432
C	3.533	7.333	16.667	29.667	47.220	85.667	31.681
D	3.800	9.667	16.667	30.333	76.50	122.333	43.258
Average	3.367	7.917	15.00	27.333	59.243	94.083	34.491

Mean separation by L.S.D. 0.05.

Dates = 4.853

Treatments = 3.962

L.S.D. for interaction (Dates x Treatments) = 9.705

Dimensions

Fruit length

Fruits of the highest length (Tables 6 and 7) were obtained from treatment D, followed by those from B and C. However, the shortest was that of the control A in the first season. No differences could be attributed to treatments D, C or B in the second season. Fruits increased in length significantly till the last sampling date in the two seasons. Results in that date of sampling were similar to the average, however, treatment B resulted in lower length than both C and D treatments.

Table 6. Effect of thinning treatments on fruit length in cm. (season 1995).

Treatment	Age in days from full bloom			Average
	56	87	102	
A	2.933	3.667	5.433	4.011
B	3.243	3.967	5.967	4.392
C	3.200	4.100	6.133	4.478
D	3.633	4.117	6.633	4.794
Average	3.252	3.962	6.042	4.419

Dates = 0.191

Treatments = 0.221

Table 7. Effect of thinning treatments on fruit length in cm. (season 1996).

Treatment	Age in days from full bloom						Average
	32	42	59	76	94	107	
A	2.100	2.857	3.200	3.967	4.193	5.133	3.575
B	2.283	2.800	3.733	4.223	5.863	6.000	4.151
C	2.317	3.000	3.700	4.500	5.033	6.333	4.147
D	2.447	3.087	3.867	4.267	5.500	6.400	4.261
Average	2.287	2.936	3.625	4.239	5.148	5.867	4.033

Mean separation by L.S.D. 0.05.

Dates = 0.169

Treatments = 0.138

L.S.D. for {interaction (Dates x Treatments)} = 0.338

Fruit width :

Results in Tables 8 and 9 of both 1995 and 1996 seasons showed that treatment D gave the widest fruit diameter followed by B and C treatments. Control fruits A, however, had the smallest width. Fruits increased significantly in diameter till the last date of sampling in both seasons.

Table 8. Effect of thinning treatments on fruit width in cm. (season 1995).

Treatment	Age in days from full bloom			Average
	56	87	102	
A	2.700	3.233	5.100	3.678
B	3.200	3.300	5.833	4.111
C	3.033	3.500	5.933	4.156
D	3.400	3.433	6.500	4.444
Average	3.08	3.367	5.842	4.097

Mean separation by L.S.D. 0.05.

Dates = 0.158

Treatments = 0.182

L.S.D. for interaction (Dates x Treatments) = 0.317

Table 9. Effect of thinning treatments on fruit width in cm. (season 1996).

Treatment	Age in days from full bloom						Average
	32	42	59	76	94	107	
A	1.167	1.900	2.167	3.200	3.833	4.933	2.867
B	1.333	2.100	2.833	3.633	4.767	5.500	3.361
C	1.400	2.267	2.933	3.833	4.667	5.700	3.467
D	1.400	2.433	3.000	3.967	4.967	6.133	3.650
Average	1.325	2.175	2.733	3.658	4.558	5.567	3.336

Mean separation by L.S.D. 0.05.

Dates = 0.154

Treatments = 0.126

L.S.D. for interaction (Dates x Treatments) = 0.309

Flesh thickness

Results in Tables 10 and 11 of both seasons indicate that the three treatments resulted in thicker flesh than the control fruits in both seasons.

Table 10. Effect of thinning treatments on flesh thickness (cm) of the fruit (season 1995).

Treatment	Age in days from full bloom			Average
	56	87	102	
A	0.400	0.833	1.267	0.833
B	0.567	1.067	1.467	1.033
C	0.650	1.167	1.567	1.128
D	0.600	1.067	1.667	1.111
Average	0.554	1.033	1.492	1.026

Dates = 0.092

Treatments = 0.106

Table 11. Effect of thinning treatments on flesh thickness (cm) of the fruit (season 1996).

Treatment	Age in days from full bloom						Average
	32	42	59	76	94	107	
A	0.150	0.250	0.300	0.500	0.633	0.867	0.450
B	0.233	0.317	0.569	0.900	1.033	1.267	0.779
C	0.233	0.317	0.500	0.967	1.100	1.267	0.731
D	0.200	0.300	0.517	0.900	1.067	1.500	0.747
Average	0.204	0.296	0.471	0.817	0.958	1.225	0.662

Mean separation by L.S.D. 0.05.

Dates = 0.077

Treatments = 0.063

L.S.D. for interaction (Dates x Treatments) = 0.155

Total soluble solids of fruit juice

Percentage of total soluble solids (T.S.S.) indicates a gradual increase till last sampling age (Table 12). Although various treatments resulted in an obvious increase, yet the differences from the control were insignificant. Results of fruits

picked at the last sampling age nearly coincided with those of the average.

Table 12. Effect of thinning treatments on fruit (T.S.S. %) (season 1996).

Treatment	Age in days from full bloom			Average
	76	94	107	
A	9.00	9.767	10.667	9.811
B	9.833	10.300	11.167	10.433
C	9.667	9.933	11.167	10.256
D	9.500	10.167	11.833	10.500
Average	9.500	10.042	11.208	

Dates = 0.411

Treatments = 0.368

Effect of thinning on anthocyanin of the peel

Anthocyanin content increased gradually during the two seasons (Tables 13 and 14), however average results were different in the two seasons. Control fruits contained always the lowest anthocyanin peel content, however, the highest content was obtained from treatment C in the first season and treatment D in the second. It is worth mentioning that the content was the higher in the second than in the first season. Results of the last date of sampling coincided with the average trend, however, in the second season it is evident that the highest content at the time of maturity was found in fruits of treatment B followed by those of treatment D.

Table 13. Effect of thinning treatments on anthocyanin (mg/g) of the fruit peel (season 1995).

Treatment	Age in days from full bloom			Average
	56	87	102	
A	11.880	19.803	74.110	53.264
B	15.383	19.973	76.087	37.148
C	16.513	25.290	144.317	62.040
D	23.930	24.383	89.270	45.861
Average	16.927	22.363	95.946	45.078

Mean separation by L.S.D. 0.05.

Dates = 0.557

Treatments = 0.643

(L.S.D. for interaction (Dates x Treatments) = 1.114)

Table 14. Effect of thinning treatments on anthocyanin content (mg/g) of fruit peel (season 1996).

Treatment	Age in days from full bloom						Average
	32	42	59	76	94	107	
A	14.710	23.703	37.050	52.950	75.637	76.147	46.699
B	34.110	42.537	61.780	69.807	87.350	134.870	71.742
C	22.060	46.840	50.750	85.027	99.460	99.853	67.332
D	24.213	40.957	93.407	100.470	101.773	103.133	77.326
Average	23.773	38.509	60.747	77.063	91.055	103.501	65.775

Mean separation by L.S.D. 0.05.
 Dates = 0.608
 Treatments = 0.497
 L.S.D. for interaction (Dates x Treatments) = 1.216)

Firmness

Flesh firmness decreased significantly with the increase of sampling age (Table 15). Flesh firmness decreased insignificantly than in the control in treatments C and D in the average results. However, results of the last date of sampling showed an insignificant increase in flesh firmness as in treatment B.

Table 15. Effect of thinning treatments on fruit firmness (lb/in²) (season 1996).

Treatment	Age in days from full bloom			Average
	76	94	107	
A	23.000	20.167	17.833	20.333
B	22.333	20.000	18.000	20.111
C	20.000	18.000	17.667	18.556
D	20.667	19.500	17.667	19.278
Average	21.500	19.417	17.792	19.57

Dates = 1.712
 Treatments = 1.531

Vegetative growth

The development of new shoots was followed during the two seasons of the study, and measured when the leaves started to shed at the end of each season. Number of developed shoots during every season and their average length were measured in all concerned trees.

Referring to Tables 16 and 17, it is evident that although all the treatments resulted in an increase in growth by trees subjected to various thinning treatments than that of the control trees, yet the differences were insignificant. The only significant effect from that of the control was noticed between the average length of its new shoots and those of both treatments C (3 fruitlets/cluster) and D (upper two limbs completely thinned and two lower thinned to 3 fruitlets/cluster) in the first season.

Table 16. Effect of various treatments on the seasons's vegetative growth (season 1995).

Treatment	No. of new shoots per tree	Average length of new shoots	Total vegetative growth
A	23.333	10.877	246.547
B	29.667	26.000	804.887
C	31.667	37.223	1201.490
D	30.333	45.777	1388.183

L.S.D. 0.05

23.76

Table 17. Effect of various treatments on the seasons's vegetative growth (season 1996).

Treatment	No. of new shoots per tree	Average length of new shoots	Total vegetative growth
A	33.000	34.557	1106.303
B	41.333	45.667	2001.333
C	43.333	54.890	2357.720
D	39.667	71.113	2617.313

General discussion and conclusion

The present study reveals that hand thinning gave promising results in improving the quality of Anna fruits produced under the Egyptian desert condition. Thinning all fruits in the upper two limbs and leaving only 3/cluster in the lower two gave fruits of highest weight, size and diameter in the two seasons. Concerning fruit length, the same treatment gave superior results in the first season, however in the second season, all treatments gave nearly the same results. It has been reported that the average fruit size of Golden Delicious fruits thinned at full bloom was improved as compared with later thinning (Bergh, 1992).

Thinning of Fuji apple increased fruit weight and size (Bound, *et al.*, 1993). Fruit weight of Fuji apple was higher when one fruit/cluster was left than 2 fruits/cluster and better than the control (Chen, *et al.*, 1992). Fruit diameter was increased by thinning of Golden Delicious apple (Stan, *et al.*, 1983). Fruit weight was greatly affected by thinning and was heavier than those of the control (ADS, 1982 and Abd-El-Aziz, *et al.*, 1985).

Fruit firmness and T.S.S. were not changed by any of the thinning treatments. Same result had been reported by Bound *et al.* (1993) who mentioned that there was no effect on fruit firmness and soluble solids by thinning. concerning anthocyanin content, thinning 2 fruitlets/cluster in the first season and thinning all fruits in the upper two limbs and leaving 3 fruitlets/cluster on other limbs gave the highest content in the second season. Various treatments resulted in insignificant increase in vegetative growth although some parameters reached more than double the values in some cases. This might be due to the variability of response of individual replicate trees. However, it has been reported that the fruiting which reduces shoot numbers, has little effect on shoot length, and reduces total shoot growth (Burlow, 1964; Quinlan and Perston, 1968 ; Avery, 1970).

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تأثير طرق الخف اليدوي لثمار التفاح صنف الأنا على صفات الثمار ونمو الأفرع تحت ظروف الصحراء المصرية

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يعتبر الخف ضروريا لإنتاج ثمار تفاح ذات صفات جيدة وقد استخدمت عدة طرق للخف اليدوي على ثمار صغيرة عمر اسبوعين من التزهير الكامل بترك اثنين او ثلاثة ثمار فى العنقود الواحد لكل شجرة او بازالة كل الثمار من الذراعين العلويين لكل شجرة مع ترك ثلاث ثمرات فقط لكل عنقود على الذراعين السفليين.

تشير النتائج الى انتاج ثمار اكبر فى كل المعاملات الا أن أفضل النتائج حصل عليها فيما يتعلق بوزن الثمار وحجمها وأبعادها حينما أجرى خف كل الثمار الصغيرة من الذراعين العلويين وترك ثلاث على العنقود على الذراعين السفليين. لم تتغير صلابة الثمار والمواد الصلبة الذائبة الكلية بصفة معنوية بأى من المعاملات التى أجريت. وفيما يتعلق بتأثير الخف على النمو الخضري فان عدد النموات ومتوسط أطوال النموات الجديدة وجملة طول الأفرع فقد كانت الفروق غير معنوية باستثناء متوسط الطول للنموات الجديدة والذي زاد معنويا عند ترك اثنين او ثلاث ثمرات بالعنقود على الشجرة فى السنة الأولى .