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CANOPY DENSITY AND LEAF AREA OF THOMPSON SEEDLESS GRAPEVINES AS BIOLOGIC INDICES FOR YIELD AND CLUSTER QUALITY

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ABSTRACT

This work was carried out for two seasons : 2004 and 2005 on twelve years old Thompson Seedless grapevines. Vines were differently trellised, three systems of trellising were applied at three locations in the vineyard; the first was the simple traditional telephone cane training system (in which vines had a high canopy density), the second was T trellis system (moderate density) and the third was double T trellis system (Low density). For measuring the canopy density a point quior thin long metal was used. This was inserted 50 times in the canopy, then its going through gaps, leaves or clusters after which the data was recorded. Scores sheet was used for measuring the canopy density through different steps then data were calculated. The results showed that number of clusters/vine, cluster dimensions, cluster weight and TSS in berry juice were increased at the low canopy density (double T system). Chlorophyll content was found to increase in this treatment whereas leaf area was decreased. In the traditional cane system (high density), cluster weight, cluster dimensions and total soluble solids in berry juice were decreased whereas acidity of the juice was increased, this was attributed to the high density canopy which did not allow light and aeration to penetrate within the canopy as to reach the interior parts of the foliage. This high density canopy needs special management with the aim of modifying microclimate of the vines.

INTRODUCTION

Canopy management has become an active area of research especially in the new vineyards with modified trellis system.

A Canopy, is defined as the leaf and shoot system of the vine (Shaulis and Smart, 1974). It is described by dimensions of the boundaries in space (i.e., width, height, length etc), and also by the amount of shoot system within this volume (typically leaf area). Canopies are continuous where the foliage from adjacent vines down the row intermingle, and where there are no large gaps. If canopies are separated from vine to vine they are discontinuous. Where canopies of one vine (or adjacent vines) are divided into discrete foliage walls the canopy is termed divided. Canopies are crowded or dense where there is much leaf area within the volume bounded by canopy surfaces for example a high value of the ratio leaf area: canopy surface area (Smart, 1985), or of leaf layer number (Smart, 1988).

The term canopy management includes a range of techniques which can be applied to a vineyard to alter the position or achieve a certain amount of leaves, shoots and fruit in space and so as to achieve some desired arrangements (i.e., canopy microclimate). These techniques include winter and summer pruning, shoot positioning, leaf removal, shoot vigour control and use of improved training systems. Canopy management techniques can be used to improve production and cluster quality, reduce disease incidence,

and facilitiate mechanization. Open canopies also lead to more efficient distribution of applied agricultural chemicals (Travis, 1987).

Grapevine leaves as for other plants are strong absorbers of solar radiation, especially in the waveband 400-700 nm of photosynthetically active radiation (Smart, 1987). Since only about 6% of light in this waveband is transmitted by a leaf (Smart, 1987), light levels at the center of dense canopies are very low, less often than 1% of abovementioned canopy values (Smart, 1985).

Recent reviews (Smart 1984, 1985) have emphasized three means of canopy microclimate management, these being training system design, shoot number control and vigour manipulation. Since excessive canopy shading is the common fault of modern canopy management, the use of these techniques to reduce shading are emphasized.

At present, vine canopy size is commonly described using qualitative terms related to vine canopy and vigor. The term capacity is generally used to describe the total vegetative and reproductive biomass produced during the growing season, while the term vigor is used to describe the rate of vegetative biomass accumulation. (Winkler *et al.*, 1974).

Vines with large growth capacity and high vigor, such as those grown in fertile soils with large water-holding capacities, often produce canopies of high leaf area density and less favourable interior light exposure (Kliewer, 1982).

In contrast, vines cultivated under less favorable growth conditions normally produce canopies of lower leaf area density and more favorable interior light exposure.

Research on canopy characteristics can seek understanding in both the relation of such characteristics to the canopy microclimates, and to the size of the canopy per unit area of land. Advances in that understanding, and its relations to climate, variety, and the desired composition of grapes, can lead to canopy specifications and, then, to viticultural practices to attain those specifications (Shaulis, 1982).

This research will throw the light on the improper canopy management made by some growers, how problem canopies can be identified, and give some practical techniques of canopy management.

Management includes concepts of problem identification and then their solution.

MATERIALS AND METHODS

Owing to the fact that no research work dealing with this subject was available in the literature in Egypt at least in the field of viticulture, this part of the paper will be discussed in details. This investigation was carried out during two successive seasons, 2004 and 2005 on 12-years-old Thompson Seedless grapevines, grown in Sanhelra Kaliobeya governorate in a clay soil, irrigated by the furrow system and trellised to the double T (telephone trellis system), single T trellis system and the traditional cane training system. The three trellis systems were found in three separate sites of the vineyard. Cultural practices were performed in accordance with the standard

commercial production practices already applied for this variety. Vines in each system were similar in vigour and in canopy density. However, the systems were different in their canopy density. According to their canopy density, vines were classified into three categories : (high, low and moderate). Forty vines were chosen for each site according to their replicated four times, ten vines per each replicate to determine the density of canopy by different means of measurements. All vines were pruned according to the mixed pruning system (canes + spurs) to 6 cane with 12 buds per cane for each vine in both season.

Diagnosis of canopy problems :

This research includes two parts: the first presents in detail field methods for evaluating grapevine canopy density and the second, the yield/vine and some physical and chemical properties of clusters and berries.

Canopy assessment :

This was carried out through the period between veraison and harvest using eight characters as previously proposed by Smart and Smith, (1988); Smart and Sharp, (1989). Three of these characters describe the microclimate (canopy gaps, canopy density and fruit exposure) to light and aeration and the other five with prior growth/physiological status (leaf size, leaf colour, shoot length, lateral growth and growing tip presence. Each character is assessed out of 10 points thus giving a total of 80. It is to be noted that the scorecard should not be used for diseased, unhealthy or excessively stressed vines.

The techniques developed for diagnosing canopy problems are designed for practical field use by researchers and growers. The techniques are easy to learn and interprete, quick to use and also inexpensive.

This technique was first applied to vineyard canopy studies in 1980 (Smart *et al.*, 1982). This simple method describes the distribution of leaves and fruit in space, and provides quantitative canopy description as follows :

Point Quadrat Measurement :

A sharpened thin metal rod is passed at a fixed inclination into the canopy (normally in the fruit zone) where it contacts with leaves. Clusters and canopy gaps are noted.

The passage of the fine rod through the simulates of a beam of light is observed. Therefore the contact of the rod with parts of the canopy can be related to the exposure of that part to light. Contacts are recorded only with leaves and clusters but acknowledge that contact with stems may sometimes be significant (Smart, 1988).

Recommend the rod be inserted in the fruit zone, which is normally 20-40 cm wide for vertical canopies, the needle can be inserted horizontally. The needle is inserted perpendicular to the canopy face. Where the canopy is very dense, it is only necessary to insert to the center of the canopy.

We generally use 50 to 100 insertions per canopy to be described, this normally is a sample of 5-10 vines. The needle is inserted at random, we don't look at the canopy before insertion and for the sake of preciseness we rest a board against the canopy and make an insertion for each of the premarked intervals; i.e. each 10 seconds.

Using this fine rigid welding rod (2 mm diameter and sharpened at one end), it is easy to hold the needle in a tube of a slightly larger diameter, 20-30 cm long. This will stop the needle moving about in the canopy. It is also easy to have one person on the needle and another acting as recorder. One insertion can be made about each 10 seconds or about 360 times per hour.

Calculation of data :

The following score sheet gives the results of 50 determinations at the three sites of the vineyard. The first represents the higher canopy density (the traditional cane system), the second represents the low density as in the double T and the third, moderate density as in the T system.

These canopies were assessed from side to side. The following parameters could be readily calculated :

a) Percent gaps : The total number of "G" is divided by number of passes (50 here), multiplied by 100 to obtain the percentage.
b) LLN : total number of leaf contacts divided by number of passes (50 here).
c) Percentage interior leaves : The number of interior leaves, i.e., not at either surface, divided by total number of leaves multiplied by 100 to obtain the percentage.
d) Percent interior clusters : The number of interior clusters, i.e. not at either surface, divided by the total number of clusters, multiplied by 100, to obtain the percentage.

This scorecard Indicates Potential for Producing Quality of Grapes

Note : If majority of shoots are less than 30 cm long, or if these vines are clearly diseased or chlorotic or necrotic, or excessively stressed, do Not Score Vineyard

A. Standing away from canopy

1. CANOPY GAPS (from side to side of canopy, within area contained by 90% of canopy boundary)
   - about 40% 10
   - about 50% or more 8
   - about 30% 6
   - about 20% 4
   - about 10% or less 0

2. LEAF SIZE (basal-mid leaves on shoot, exterior).
   For this variety are the leaves relatively:
   - Slightly small 10
   - average 8
   - slightly large 6
   - very large 2
   - very small 2

3. LEAF COLOUR (basal leaves in fruit zone).
   - leaves green, healthy, slightly dull and pale 10
   - leaves dark green, shiny, healthy 6
   - leaves yellowish green, healthy 6
   - leaves with mild nutrient deficiency symptoms 6
   - unhealthy leaves, with marked necrosis or chlorosis 2

B. Standing at Canopy

4. CANOPY DENSITY (from side to side in fruit zone), mean leaf layer number
   - about 1 or less 10
   - about 1.5 8
   - about 2 4
   - more than 2 2

5. FRUIT EXPOSURE (remember that the canopy has two sides normally-that fruit which is not exposed on your side may be exposed to the other side)
   - about 60% or more exposed 10
   - about 50% 8
   - about 40% 6
   - about 30% 4
   - about 20% or less 2

6. SHOOT LENGTH
   - about 10-20 nodes 10
   - about 8-10 nodes 6
   - about 20-25 nodes 6
   - less than about 8 nodes 2
   - more than about 30 nodes 2

7. LATERAL GROWTH (normally from about point where shoots are trimmed. If laterals have been trimmed, look at diameter of stubs).
   - limited or zero lateral growth 10
   - moderate vigour lateral growth 6
   - very vigorous growth 2

8. GROWING TIPS (of all shoots, the proportion with actively growing tips - make due allowance for trimming).
   - about 5% or less 10
   - about 10% 8
   - about 20% 6
   - about 30% 4
   - about 40% 4
   - about 50% or more 0

Total pint score __ /80 = ___ %

OTHER COMMENTS

Some hints

First, stand away from the canopy with your back against the adjacent row to score the first three characters (canopy gaps, leaf size, and leaf colour).

Canopy gaps : Estimate the proportion of gaps in the canopy. Do not count as gaps the 'holes' which occur between spiky shoots at the edges of the canopy.

Leaf size and leaf colour : These scores require experience with the variety to know what are relatively large or small leaves and healthy, normal coloured leaves. Observe only exterior leaves in a basal to mid shoot position. Be careful not to include lateral leaves in your size assessment as these are generally smaller.

Canopy density : Assess this by putting your face near the canopy fruit zone, and fix your gaze straight ahead. Use your finger to move leaves aside in your line of sight, counting the number of leaves until you reach the other side of the canopy. Count zero for a canopy gap. Record the leaf layer number. Repeat to get a representative number.

Fruit exposure : Develop a mental image of the fruit you can see at the canopy exterior. Then, brush away the leaves, and assess how much fruit is in the canopy and not visible from the outside. Percent fruit exposure is the ratio of the two values. Repeat to get a representative number.

Shoot length : Count the nodes on some representative shoots and average them. Be careful not to unconsciously select the longest shoots. It is a good practice to close your eyes to select shoots so they will be chosen at random.

Lateral growth : Again select some shoots at random and look for lateral growth up and down the shoot. If the shoot has been trimmed, most lateral growth will be near the cut end. Again experience will help you in your assessment. The following guide will also help :

- Very vigorous lateral growth : Laterals are growing at most nodes, and the majority of them are longer than five nodes.
- Moderate vigorous: Laterals are developed at about one third of the nodes on the shoot and most laterals are less than four nodes long.
- Limited or zero vigorous: Laterals occur infrequently, and normally do not develop more than two nodes long.

Growing tips : Assess all the tips on main shoots and laterals. Tips that are actively growing will always have the blunt apex extending beyond any young leaves on the shoot. Tips which have stopped growing have young leaves which can be folded in front of the growing tip.

Optimum values

The scorecard will give high total points to a canopy which is very open, where vigour is moderate and where the vines are under slight water and nutrient stress.

Vineyard Scoring :

There are two primary groups of factors affecting grape quality; the canopy microclimate and the vine physiological status. As it turns out, both these factors can be visually assessed, leading to the concept of a vineyard scorecard, an idea first published in 1985 *(Smart et al., 1985)*. Eight characters are to be assessed, three of them deal especially with

microclimate (canopy gaps, canopy density and fruit exposure) and the other five with prior growth/physiological status (leaf size, leaf colour, shoot length, lateral growth and growing tip presence). Each character is assessed out of 10 points, leading to a total of 80. "Ideal" canopies have more than 40% canopy gaps, slightly small and dull green healthy leaves, LLN of 1.0 or less, about 60% fruit exposure, 10-20 node length, shoots with limited or zero lateral growth and 5% or less growing tips.

The scorecard should not be used for diseased, unhealthy or excessively stressed vines.

Vegetative measurements

Leaf area (cm^2).

At veraison, mature leaves at 5-7th position from shoot tip were collected to measure the individual leaf area using CI-203 laser area meter made by CID, Inc, Vancouver, USA.

Chlorophyll was measured using nondestructive Minolta chlorophyll meter SPAD 502 (SPAD as an acronym for soil plant analysis development, Wood *et al.*, (1992). It measures the relative amount of chlorophyll present by measuring the transmittance of the leaf in two wave bands 600-700 and 400-500 nm. The reading is proportional to the amount of chlorophyll.

At harvest, sixteen grape clusters were picked when total soluble solids of berry juice attained 17-18% (Kader *et al.*, 1985) and brought to the laboratory for the determination of cluster weight, length and width and number of clusters /vine was also recorded.

TSS (by a hand refractometer), acidity was determined in the juice according to A.O.A.C (1985).

Weight of Prunings : Immediately after pruning weight of one year old wood was determined as kg per vine at each location,(high density canopy, moderate density canopy and low density canopy). The values were considered as an indicator for the canopy density and vigour.

The data were subjected to analysis of variance according to Snedecor and Cochran (1980) and the new L.S.D test (5%) was used to compare between means.

RESULTS AND DISCUSSION

Cluster characteristics :

Cluster weight, length, width and yield : data in table (2) showed that the lowest values of these parameters were evident at the high canopy density at the two seasons of the study. The effect of crowded shoots and high canopy density had its negative effect on shading, thus giving poor fruit quality (Jackson and Coombe 1988). Cluster weight and yield recorded the highest values for the low canopy density in both seasons.

Data in Table (2) show that number of clusters per vine decreased at the vines with high canopy density, while it increased at the vines with low canopy density and those with moderate density. These results indicate that the double T trellis system and T trellis system gave an open canopies and

which are not close together, leaves and fruit had a uniform microclimate as possible. The obtained results are in agreement with those obtained by Shaulis and Smart (1974); Shaulis (1982) and Smart *et al.,* (1982) who found that shading of the new shoots of the center zone reduced cluster initiation and fruit quality.

TSS and acidity

As shown in Table (2) the highest values of TSS were evident at vines having low density canopy and followed by the moderate density canopy at the two seasons of the investigation. These results are in harmony with those obtained by Smart (1985) who found that shading reduced fruit sugar and increased malic acid and there existed a relationship between canopy microclimate and cluster quality. It is to be noticed that in the traditional cane trellising system, the leaves and shoots were shaded by the overhanging foliage. The new introduced trellis designs T and double T were found to have horizontal vertical canopies without crowded shoots. These systems had the highest percentages of TSS in both seasons of the study.

The results in this respect are in the same trend with Kliewer (1989) who found that the decrease in TSS induced by the high canopy density was due to fruits from interior shoots which had lower sugar and higher acidity.

Table (2) : Cluster characteristics and weight of prunings for different trellis systems (at season 2004 and 2005).

Cluster character	No. of clusters per vine		Cluster wt. (g)		Yield kg/vine		Cluster length (cm)		Cluster width (cm)		TSS (%)		Acidity mg/L	
Canopy density	2004	2005	2004	2005	2004	2005	2004	2005	2004	2005	2004	2005	2004	2005
(Double T) Low density canopies	31	34	290	330	8.99	11.22	28.0	26.0	14.0	12.0	18.4	18.8	0.74	0.41
(One T) Moderate density canopies	24	27	220	230	5.28	6.21	22.0	24.0	12.0	10.0	16.0	16.8	0.64	0.59
(Traditional cane training) High density canopies	18	21	175	190	3.15	3.99	18.0	19.0	9.0	8.0	14.4	16.0	0.72	0.67
L.S.D 5%	4.50	3.33	16.0	22.8	1.46	1.81	2.34	3.60	2.50	1.4	1.00	0.63	0.11	0.09

Data presented in table (3) show that leaf area varied significantly among the three trellising systems ranging between 198 to 186 in vines with low canopy density to 143, 133 for those having high canopy density. Leaf area decreased significantly at vines with high density canopy, while it increased significantly at the low and moderate canopy densities at the two seasons of the investigation.

Data in table (3) clear out that leaf chlorophyll content was higher in vines of low density canopy. This can ascribed to the presence of a high number of the gaps which allowed light to penetrate the foliage to the center of the vine canopy.

Table (3): Leaf area, chlorophyll content of leaves and weight of prunings per vine as affected by canopy density in Thompson seedless grapevines at 2004 and 2005 seasons.

Cluster character / Canopy density	Leaf area (cm^2)		Chlorophyll mg/g d.w		Weight of prunings/vine kg	
	2004	2005	2004	2005	2004	2005
(Double T) Low density canopies	198.0	186.0	4.4	4.6	0.90	0.75
(One T) Moderate density canopies	163.0	154.0	4.0	3.9	1.95	1.70
(Traditional cane training) High density canopies	143.0	133.0	3.5	3.0	2.35	7.80
L.S.D 5%	14.4	12.6	0.21	0.32	0.56	0.64

Weight of prunings :

It is evident from data in Table (3) that vines with high canopy density recorded the highest weight of prunings in comparison with the other canopy densities (low and moderate canopy densities). The results in this connection agree with those obtained by Shaulis and Smart, (1974), who found that high density of canopy was retained at winter pruning as one year old shoots. Weight of prunings was found to increase with leaf area density increased.

Point Quadrat analysis :

The following canopy descriptors can be generated from the data-percent gaps, LLN (leaf layer number) percent interior leaves and percent interior clusters. Table (1) showed typical data for high, low and moderate density canopies and demonstrated the method to calculate canopy density indices (Kliewer, 1989). Data showed that the low density canopies had the highest number of Gaps followed by the moderate whereas no gaps were found at the high canopy density.

It is worthy to note that the high number of gaps causes an adequate fruit exposure to sunlight, promotes and improves cluster quality while the lower number of gaps causes the shaded canopy to produce clusters with increased malic acid in berry juice and reduced sugar content and colour. It is apparent from data of Table (4) that the low canopy density had the least number of interior leaves and interior clusters as compared with other levels of two canopy densities (low and moderate). It is clear that the high density canopy system needs canopy management to improve the microclimate for the vines.

The scorecard as presented is based on observation and measurement of high quality vineyard. To solve the problem of the low cluster quality different ways of agricultural practices should be applied such as summer pruning, winter pruning, proper irrigation, fertilization, ...etc..

Ideal canopies have more than 40% canopy gaps, slightly small and slightly dull green healthy leaves, LLN of 1.0 or leaves about 60%, fruit exposure, 10-20 node length, shoot with limited or zero lateral growth and 5% or less growing tips.

The results in this respect are in the same trend since vines having low canopy density were considered as ideal, followed in a descending order by those with moderate canopy density. It was concluded that the double T trellis system is ideal for growing grape vines with open foliage and canopy management. A useful tool was found to diagnose canopy problems and to assess management procedures to improve canopies ie. Leaf plucking.

Sample point Quadrat Analysis Sheet

Each site has 50 value (average of 2004 and 2005) seasons

Low density canopy				Moderate density canopy				High density canopy			
1	G	26	LIL	1	LLL	26	LL	1	LCC	26	LLCLCL
2	G	27	LI	2	LCL	27	LCL	2	CLL	27	LLLCLLLL
3	LI	28	G	3	G	28	LC	3	LLL	28	LLLCL
4	LG	29	G	4	LL	29	LCCL	4	LLL	29	LLCCL
5	LL	30	LC	5	LLC	30	LLL	5	LCLLLL	30	LLCCL
6	L	31	C	6	CL	31	LCLL	6	LLLL	31	LLCLL
7	LL	32	CC	7	LLL	32	LCL	7	LCL	32	LLCLL
8	LL	33	G	8	LCL	33	LC	8	LL	33	LLL
9	CL	34	CLCC	9	LC	34	LC	9	LLL	34	CCLL
10	LL	35	CC	10	LCL	35	LL	10	LLL	35	LCL
11	L	36	G	11	LL	36	LL	11	LLLL	36	CLL
12	CLC	37	C	12	LLC	37	CL	12	LCLCL	37	LCCCCLL
13	LC	38	G	13	LL	38	LC	13	LLL	38	LCLL
14	LL	39	LL	14	CL	39	LCL	14	LLL	39	LLLLLLC
15	G	40	LLL	15	G	40	LCCL	15	LLL	40	LL
16	LCC	41	LCL	16	LL	41	LLL	16	LL	41	LCCLL
17	G	42	G	17	G	42	LL	17	LCLL	42	LLL
18	G	43	G	18	LCL	43	CL	18	LLCL	43	LCLL
19	LCL	44	LLL	19	LL	44	L	19	CLLL	44	LLCCLL
20	G	45	C	20	LCG	45	CL	20	LLCL	45	LL
21	LC	46	G	21	LC	46	LCC	21	LL	46	LLLL
22	LC	47	G	22	LCL	47	LCC	22	LLL	47	LLLLL
23	LLC	48	G	23	G	48	G	23	LL	48	LLLLLCLL
24	LLC	49	LCL	24		49	LC	24	LLL	49	LLLLLL
25	G	50	LCC	25		50	LCL	25	LLCCL	50	LLLLL
Percent gaps:				**17/50 = 0.34**				**6/50 = 0.12**			**0/50 = 0**
LLN:				**46/50 = 0.92**				**73/50 = 1.46**			**170/50 = 3.4**
Percent interior leaves:				**7/46 = 0.152**				**7/73 = 0.096**			**74/170 = 0.435**
Percent Interior clusters:				**6/26 = 0.23**				**15/33 = 0.45**			**37/39 0.948**

The results of this investigation indicated that the double T trellis system gave a wide surface of horizontal vegetative growth and light levels enter through the center of the canopies. Studies indicated that Shade at the center of the vine growth causes a reduction in the yield and cluster quality and number of clusters per vine.

Shade should be avoided by reducing leaf area, number of crowded shoots and increasing canopy gaps. Canopy management techniques should be considered according to vine vigour. More or high density of canopy increases the shade. For low to moderate vigour vineyards, summer pruning practices or fruit zone removal may be sufficient to improve the microclimate. High density of canopy needs to change the wires of the trellis system to be horizontal for the vegetative growth.

Table (4) : Calculation of data : The sample scorecard overleat has been used to describe Thompson Seedless vines trellised to double Telephone trellis, one Telephone trellis and the traditional cane training systems. The results are set out below.

Results of Scoring Canopy density (average of 2004 and 2005) seasons

Character	Double T trellis system Low density	One T trellis system moderate density	Old cane training system High density canopy
Canopy gaps	10	6	0
Leaf size	10	6	2
Leaf colour	10	6	6
Canopy density	10	2	2
Fruit exposure	10	2	2
Shoot length	8	6	10
Lateral growth	8	4	2
Growing tips	10	8	6
Total/80	78	42	30

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كثافة النمو والمسطح الورقي لأشجار العنب البناتي كدلالات بيولوجية علي كميـــة المحصول وجودة العناقيد

إيزيس عبد الشهيد رزق ، مرفت عبد الكريم علي و رأفت سيد سعيد الجندي

قسم بحوث العنب ، معهد بحوث البساتين ، مركز البحوث الزراعية ، الجيزة.

أجرى هذا البحث بمزرعة خاصة منزرعة بالعنب صنف طومسون سيدلس لمدة عامين هما ٢٠٠٤، ٢٠٠٥ علي كرمات عمر ١٢ عام ومدعمة بثلاث طرق هي : الطريقة القصيبة العادية وطريقة التليفون المزدوج وطريقة التليفون المفرد وكان الهدف من البحث دراسة العلاقة بين كثافة النمو الخضرى في طرق التدعيم الثلاثة مع محاولة لإيجاد الحلول المناسبة لعيوب كل طريقة ، وقد إشتملت الدراسة علي ثلاث معاملات : الأولي كثافة نمو عالية وتمثلها طريقة التدعيم ذات الثلاث أسلاك الرأسية (القصيبة القديمة) والثانية كثافة نمو متوسطة وتمثلها طرقة التليفون المفرد والثالثة كثافة نمو أقل من المتوسط وتمثلها طريقة التليفون المزدوج.

أجريت تقديرات كثافة النمو الخضرى للأشجار بإستخدام إبرة طويلة تخترق النمو الخضرى ثم يتم تحديد مدى كثافة وعدد طبقات الأوراق عن طريق ملامسة الإبرة للأوراق والعناقيد كذلك عدد الفتحات التي توجد في النمو الخضرى ويقصد بالفتحات الفراغات التي قد توجد بين الأوراق أو العناقيد.

كما إستخدمت طريقة أخرى للتقدير وذلك باستخدام نموذج التقديرات والذي يعتمد بدرجة كبيرة علي تسجيل الملاحظات بالمزرعة.

وقد أوضحت الدراسة أن إنخفاض كثافة النمو الخضرى أدي إلي زيادة متوسط عدد العناقيد ووزن العنقود لكل شجرة والمحصول كما إزدادت أيضاً أبعاد العناقيد والنسبة المئوية للمواد الصلبة الذائبة الكلية بعصير الحبات كما إزدادت درجة تركيز الكلوروفيل وهذا لسهولة دخول الضوء والشمس إلى قلب الكرمات.

وتشير النتائج إلي أن طريقة التليفون المزدوج كانت أفضل طرق التدعيم لذا فإنه يوصي بالتحول من الطريقة القصيبة القديمة والتليفون المفرد إلي هذه الطريقة والتحكم في تنظيم المسطح الورقي للأشجار بحيث يسمح بدخول الضوء والهواء إلى قلب الأشجار حيث يمكن أيضاً تعديل المناخ الداخلي للكرمات.