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# Effect of Bud Load on Vegetative Growth, Cluster Quality and Yield of Early Sweet Grapevines

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**Abstract:** This investigation was conducted during 2016 and 2017 seasons to study the effects of bud load levels at 44, 50, 56, 62, 68 or 74 buds per vine of Early Sweet grapevines on the vegetative growth characters, bud behavior, cluster and berry quality. The chosen vines were trellised by Gable supporting system, grown in a clay loam soil, spaced at 2 x 3 meters apart and spur-pruned by fixed two eyes per spur in all treatments at the first week of December during two seasons. According to the results, the percentages of bud burst increased with decreasing the bud load levels/vine, while the coefficient bud fruitfulness and bud fertility have negatively effects by high bud load levels in two seasons. Also, the high bud load levels significantly decreased vegetative growth characters and fruit quality, while increased yield/vine to pruning weight ratio (expressed as the Ravaz index). Moreover, both high and low bud load levels had negatively effects on chemical composition of berry such as T.S.S., T.S.S/acid ratio and antioxidants activity. On the other hand, high bud load levels gave the highest values of both the total acidity in grape berries and number of clusters per vine. Generally, the bud load at 56 or 62 buds per vine is more suitable for Early Sweet grapevines to produced good yield with high fruit quality, thus economic return.

**Key words:** Grapevines · Early Sweet · Bud load

## INTRODUCTION

Grapevines are among the most important and common horticultural crops worldwide due to their economic importance and beneficial effects on human health. Their importantly can be related to their biochemical composition such as sugars, organic acids, phenolic compounds and vitamins. Also, grape has an important role in human health such as, anti-inflammatory effects, prevent cataracts, antioxidant, anti-cancer, anti-microbial and anti-allergic [1]. The table grapes industry plays an essential role in the Egyptian economy. Egypt possesses the natural recourses to produce early ripening table grapes. Recently, Early Sweet cultivar is one of the newly introduced grape cultivars to Egypt.

Early Sweet (*Vitis vinifera* L.) is the earliest commercial Seedless grapevines in Egypt. In this concern, Early Sweet grapevines are promises for the Egyptian local commercial producers and exporters due to its early maturity date. Also, its berries are round to oval in shape, excellent eating quality and attractive creamy color and the high sugar level. One of the attractive factors of Egyptian Early Sweet growers is maintain the perfect balance between high fruit quality and harvest timing at ideal sugar levels by horticultural practice such as, pruning and then adjusts optimum bud load of Early Sweet that achieve increasing the production with high fruit quality.

The optimum bud load in order to achieve grape quality is still the most important management issues in viticulture. Importantly, Di-Lorenzo and Pisciotta [2] mentioned that canopy, vigour and productivity of the vine can be balanced through pruning; the vine need to have moderate number of buds that reflect on the balance of vegetative growth and fruiting of vines, in order to maintain the uniform vigour for the best grape quality. Also, they reported that pruning is an obvious practical technique seems to be very important for achieving a good balance between vegetative growth and crop load of grapevines. Moreover, crop load, expressed as the ratio

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of fruit yield/vine to pruning weight/vine in the Ravaz index, relates vine photosynthetic sinks, the fruit to the photosynthetic capacity of the vine represented by the winter pruning weight [3]. Importantly, Monteiro *et al.* [4] reported that the importance of light in bud fruitfulness is essentially obvious by the influence of direct light on leaf photosynthetic activity and carbohydrate availability. On the other hand, low light intensity reduces the amount of photoassimilates, limiting the carbohydrates supplied to the developing buds [5].

Furthermore, the moderate bud load levels increase spread light into the canopy; so, the chlorophyll is mainly concentrated around Photosystem (PSII) and most abundant in light-harvesting complexes [6]. Also, Ceccarell *et al.* [7] stated that the released electrons through the water-splitting reaction on the Photosystem side as the light responsive photosynthetic process and this process followed by NADP reduction to NADPH and proton flow into the lumen in order to generate ATP, which generated NADPH and ATP serve as an energy source for the carbon fixation process and this may be positively reflect on increasing the content of carbohydrate in canes; which lead to enhancing berry quality.

In addition to find a good balance between vegetative growth and crop load, Kliewer and Dokoozlian [3] reported that Ravaz index is consider a good indicator for determined the balance between vegetative growth and crop load of grapevines. Moreover, Ravaz [8] mentioned that Ravaz index is a ratio between total yield per vine and pruning weight per vine, where, balanced vines should provide a Ravaz index in between 5 and 10 (<5 under cropped, >10 = over cropped vines). Thus, Almanza-Merchan *et al.* [9] who pointed that the pruning is used to limit the number of clusters, generating a suitable balance between plant vigor and production. Moreover, Somkuwar and Ramteke [10] reported that to produce the quality grapes, it requires careful control of crop size to balance the amount of fruit per vine to vegetative growth, fruit quality and adequate vine growth for consistent productivity. Thus, excess fruit production lead to poor fruit quality. Finally, a little attention has been paid on pruning severity and bud load of Early Sweet grapevines and its effect on vegetative growth density, yield and berry quality.

The objective of this investigation is carried out to determine the optimum bud load per vine to obtain reasonable yield with high fruit quality attributes of Early Sweet grapevines.

## MATERIALS AND METHODS

This investigation was carried out during 2016 and 2017 seasons in a private vineyard at Mati district, Minia governorate, Egypt on 6-year-old Early Sweet grapevines, grown in a clay loam soil, spaced at 2 x 3 meters apart and trellised by Gable system. The vines were pruned during the first week of December and trained to quadrilateral cordon with fixed number of buds per spur (2buds/spur). The chosen vines were received common horticultural practice.

This experiment included six treatments. Each treatment was replicated five times and each replication had three vines.

Six pruning treatments with different bud load levels: 44, 50, 56, 62, 68 or 74 buds per vine.

The following measurements were adopted to evaluate the tested treatments:

**Bud Behavior:** The percentages of bud burst, bud fertility and coefficient of bud fruitfulness were determined according El-Sharkawy [11] by using the following equations:

$$\text{Bud burst \%} = \frac{\text{no. of bursted buds/vine}}{\text{total number of buds/vine}} \text{x}100$$

$$\text{Bud fertility \%} = \frac{\text{no. of fruited buds/vine}}{\text{total buds per vine}} \text{x}100$$

$$\text{Coefficient of bud fruitfulness} = \frac{\text{no. of fruited buds/vine}}{\text{no. of bursted/vine}}$$

**Vegetative Growth Parameters:** At the first week of June, the following morphological studies were conducted on five fruitful shoots/the conducted vines:

- Average shoots length (cm).
- Average leaf area ($cm^2$): ten leaves were taken from the apical fruiting shoots for each vine to measured average leaf area ($cm^2$) (using leaf area meter, Model CI 203, U.S.A.).
- Cane thickness (cm): at last week of November, five basal internodes of five canes per vine were measured by using a vernier caliper.

**Chemical Constitutes of Leaves and Canes:** At the first week of June, ten leaves were collected from 5-7$^{th}$ apical leaves from shoot top to measure the following characters at the growing season:

- Total leaf chlorophyll was measured by using the nondestructive Minolta chlorophyll meter model SPAD 502 according to Wood [12].
- N, P and K in leaves were determined according to A.O.A.C. [13].
- Total carbohydrates: at winter pruning, five fruiting canes were selected and determined total carbohydrate in canes according the methods of A.O.A.C. [13].

**Yield and Physical Characteristics of Cluster and Berries:** At harvest date (1st week of June) in both seasons, five clusters per vine were harvested at the ripening stage when juice T.S.S% reached about 18-20% according to Tourky *et al.* [14] to estimate the following parameters:

- Yield: yield/vine (kg) was calculated by multiplying number of clusters/vine by cluster weight and expressed in weight (kg).
- Average cluster length and cluster width (cm).
- Average cluster weight (g).
- Average of number of clusters/ vine.

$$\text{Shot berries per cluster} = \frac{\text{number of shot berries / cluster}}{\text{total number of berries / cluster}} \text{X100}$$

- Average berry weight (g).
- Average berry length and diameter (cm) by using a vernier caliper.
- Average berry firmness (g/cm$^2$): was determined by using penetrometer, Model FT 011; Italy.

**Berry Chemical Analysis:**

- Total soluble solids (T.S.S %): was determined in juice using a hand refractometer.
- Acidity: titratable acidity was estimated by the method of A.O.A.C. [13].
- T.S.S. / acid ratio.
- Antioxidant activities in the grape juice (DPPH %): the antioxidant activities was evaluated by (2, 2-diphenyl-1-picrylhydrazyl (DPPH) radical scavenging method according to the procedure of Chen *et al.* [15].

**Wood Ripening and Pruning Weight:**

- Pruning weight: was measured at dormancy period (winter pruning) per vine.
- Wood ripening: was determined by using the following equation:

$$\text{Wood ripening} = \frac{\text{length of ripening part}}{\text{Total length of shoot}} \text{X100}$$

**Ravaz Index:** Ravaz index was calculated by rating total yield per vine and pruning weight per vine, where; balanced vines should provide a Ravaz index in between 5 and 10 (<5 under cropped, >10 = over cropped vines). Ravaz index was determined according to Ravaz [8] by using the following equation:

$$\text{Ravaz index} = \frac{\text{total yield / vine}}{\text{pruning weigth / vine}}$$

**Economic Study:** The economic study was performed to estimate the gross return, the net return and beneficial cost ratio for Early Sweet grapevines by determined cultivation cost as average of 2016 and 2017 seasons as mentioned in Table 1. The economic parameters (the gross return, the net return and beneficial cost ratio) were calculated as follow:

- Gross return (L.E/fed) = total vine yield (kg) x [total no. of vines per fed X price of grapes (L.E)].
- Net return (L.E/fed) = gross return – total cultivation cost.

$$\text{Beneficial cost ratio} = \frac{\text{gross return}}{\text{total cultivation cost}}$$

**Experimental Design and Statistical Analysis:** The experiment design was arranged in randomized complete block design (RCBD). The statistical analysis of the present data was carried out according to Snedecor and Cochran [16]. Averages were compared using New L.S.D. values at 5% level [17].

Table 1: Cultivation cost (L.E/fed)

| Cultivation cost | Average two seasons |
|---|---|
| Land rent | 11000 |
| Vineyard maintenance | 300 |
| Winter pruning | 3100 |
| Farmyard manure | 2210 |
| Hoeing | 430 |
| Irrigation | 1575 |
| Fertilizers | 4095 |
| Foliar application of dormex | 1140 |
| Insect control | 1385 |
| Fungal diseases control | 665 |
| Weed control | 620 |
| Foliar application of nutrients | 965 |
| Total common cost | 27485 |

## RESULTS AND DISCUSSIONS

**Bud Behavior:** Data presented in Table (2) showed that the percentage of bud burst, were decreased significantly by increasing the number of bud load per vine during 2016 and 2017 seasons. The highest bud load (74 buds/vine) gave the lowest percentage of bud burst whereas; the highest values of bud burst were observed in bud load at 44 buds per vine followed by bud load levels at 56 & 62 buds per vine during the two seasons. Generally, the highest percentages of bud burst in low bud load levels may be due to that the buds are dependent on vines for stored nutrients to burst out. Also, the increase of bud load levels decreased bud burst as a result of minimizing the amount of nutrients for each bud to bud to burst out. Moreover, Monteiro *et al.* [4] mentioned that the bud burst affected by many factors such as signals from the vine for stimulate the bud burst, where, the apoplast could be a considerable pathway for long range signals from the mother vine to buds, which trigger bud burst. Meanwhile, excessive bud load resulting in weak signals which may be insufficient to trigger all bud burst per vine. For this reason the high bud load reduced the percentage of bud burst.

On the other hand, the percentage of bud fertility and coefficient of bud fruitfulness affected negatively by decreasing or increasing the bud load levels per vine, while the moderate bud load levels had the highest values of mentioned characters during 2016 and 2017 seasons. In this connection, the best results of mentioned characters were obtained from bud load levels at 56 & 62 buds per vine during two seasons. These results go in line with Fawzi *et al.* [18] who mentioned that moderate vigor vine produced usually more fruitful bud, while the low fruitfulness may be due to the high vigor vine of Crimson Seedless cultivar. These results are in conformity with earlier studies given by Di-Lorenzo and Pisciotta [2], Khamis *et al.* [19] and Fawzi *et al.* [20].

**Vegetative Growth Characteristics:** Data in Table (3) found that different bud load levels had announced differences on the vegetative growth characteristics namely; shoot length, cane thickness and leaf area during both seasons. The increasing in vegetative characters values related with the decreasing bud load per vine in both seasons. In this concern, the best results for improving the vegetative growth characters were obtained from bud load levels at 44 buds per vine, followed by treatment of bud load levels at 50 & 56 buds per vine during 2016 and 2017 seasons. On the other hand, bud load levels at 74 buds per vine were found to have the lowest values of mentioned characters in this respect. Meanwhile, the low bud load resulting in vigorous shoots because all of the stored energy in the roots, arms and trunks is available to relatively few growing points [3]. On the contrary, they stated that the high bud load resulting in weakness shoots because the higher of bud load which all of the stored energy in the roots, arms and trunks is insufficient to getting the better shoots growth. Additionally, Khamis *et al.* [19] reported that the increasing of bud load levels per vine decreased the shoot length and this may be attributed to the competition among the shoots in the treatments of high bud load levels. Also, shoots developing on shaded canes are generally having less vegetative growth than shoots on lighted canes [3]. Meanwhile, the greater leaves densities as result of the high bud load levels, which may be decreased photosynthetic efficiency of Early Sweet grapevine and this, reflect negatively on the mentioned characters in this respect.

The same findings were obtained by Khamis *et al.* [19] and Fawzi *et al.* [20] as they stated that increasing bud load was accompanied with decreasing vegetative growth characters.

**Chemical Constitutes of Leaves and Canes:** With respect to the effect of number of buds per vine on N, P and K content in leaves petioles, data obtained in Table (4) showed that chemical constitute content in leaves petioles affected by different bud load levels during 2016 and 2017 seasons. The highest values of N, P and K in leaves petioles were noticed with the pruned vines at 62 buds per vine. On the other hand, the lowest values of the mentioned characters were noticed with the pruned vine at 74 buds per vine during both seasons. In general, there is a positive relationship among N and photosynthetic capacity in leaves petioles and this because of the canopy spread light improved incorporation of nitrogen into leaf cellular proteins such as ribulose bisphosphate carboxylase [21], for this reason moderate bud load levels may be enhanced N content in leaves petioles of Early Sweet grapevines during two seasons. Also, P and K content in leaves petioles of grapevines increasing in moderate bud load levels and this may be due to spread a good light into canopy and that increase photosynthesis in leaves, which positively reflect on the chemical content of leaves for Early Sweet grapevines.

Table 2: Effect of bud load on bud behavior of Early Sweet grapevines during 2016 and 2017 seasons

| | Bud burst (%) | | Bud fertility (%) | | Coefficient of bud fruitfulness | |
|---|---|---|---|---|---|---|
| Bud load/vine | 2016 | 2017 | 2016 | 2017 | 2016 | 2017 |
| 44 | 95.45 | 94.73 | 51.14 | 56.82 | 0.57 | 0.59 |
| 50 | 85.00 | 88.00 | 63.00 | 56.68 | 0.74 | 0.61 |
| 56 | 87.65 | 93.83 | 67.90 | 62.04 | 0.73 | 0.63 |
| 62 | 86.67 | 91.25 | 64.17 | 63.89 | 0.74 | 0.70 |
| 68 | 78.59 | 90.01 | 55.46 | 57.81 | 0.71 | 0.63 |
| 74 | 81.07 | 88.57 | 56.19 | 59.52 | 0.66 | 0.67 |
| New L.S.D at 5 % | 0.30 | 0.20 | 1.05 | 1.09 | 0.01 | 0.01 |

Table 3: Effect of vine bud load on some vegetative growth parameters of Early Sweet grapevines during 2016 and 2017 seasons

| | Shoot length (cm) | | Leaf area ($cm^2$) | | Cane thickness (cm) | |
|---|---|---|---|---|---|---|
| Bud load/vine | 2016 | 2017 | 2016 | 2017 | 2016 | 2017 |
| 44 | 173.4 | 174.2 | 164.6 | 169.5 | 1.37 | 1.20 |
| 50 | 167.0 | 169.5 | 159.2 | 165.4 | 1.05 | 1.07 |
| 56 | 166.0 | 168.6 | 161.3 | 166.1 | 1.00 | 1.05 |
| 62 | 163.6 | 165.8 | 163.9 | 167.4 | 1.00 | 1.03 |
| 68 | 142.4 | 142.3 | 149.1 | 147.0 | 0.83 | 0.83 |
| 74 | 137.2 | 137.6 | 135.9 | 132.2 | 0.73 | 0.70 |
| New L.S.D at 5 % | 2.3 | 2.4 | 0.5 | 0.7 | 0.01 | 0.01 |

Table 4: Effect of vine bud load on chemical constitutes of leaves and canes for Early Sweet grapevines during 2016 and 2017 seasons

| | N (%) | | P (%) | | K (%) | | Total chlorophyll (SPAD) | | Total carbohydrates (g/100g) | |
|---|---|---|---|---|---|---|---|---|---|---|
| Bud load/vine | 2016 | 2017 | 2016 | 2017 | 2016 | 2017 | 2016 | 2017 | 2016 | 2017 |
| 44 | 2.11 | 2.13 | 0.29 | 0.30 | 1.92 | 1.91 | 44.3 | 46.8 | 33.5 | 33.8 |
| 50 | 2.09 | 2.07 | 0.29 | 0.31 | 1.93 | 1.90 | 44.1 | 45.3 | 33.1 | 33.7 |
| 56 | 2.08 | 2.09 | 0.30 | 0.31 | 1.93 | 1.94 | 45.2 | 47.2 | 34.7 | 35.3 |
| 62 | 2.13 | 2.14 | 0.31 | 0.33 | 1.95 | 1.97 | 45.1 | 46.6 | 34.2 | 34.9 |
| 68 | 1.97 | 1.99 | 0.22 | 0.24 | 1.88 | 1.85 | 40.0 | 40.3 | 26.6 | 26.8 |
| 74 | 1.91 | 1.90 | 0.21 | 0.21 | 1.79 | 1.77 | 37.5 | 37.4 | 24.2 | 24.3 |
| New L.S.D at 5% | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 | 0.2 | 0.2 | 0.1 | 0.1 |

Concerning the effect of bud load levels per vine on the total chlorophyll in leaves and total carbohydrates in fruiting cane, data in Table (4) revealed that there are significant differences among different bud load levels during two seasons. In this concern, the highest values of mentioned characters were recorded in 56 buds per vine followed by 62 buds per vine during 2016 and 2017 seasons. The moderate bud load levels increased spread light into the canopy; so, the chlorophyll is mainly concentrated around Photosystem (PSII) and most abundant in light-harvesting complexes [6], for this reason the moderate bud load level may be increased chlorophyll in leave of Early sweet grapevines. Also, Ceccarell *et al.* [7] stated that the released electrons through the water-splitting reaction on the Photosystem side as the light responsive photosynthetic process and this process followed by NADP reduction to NADPH and proton flow into the lumen in order to generate ATP, which generated NADPH and ATP serve as an energy source for the carbon fixation process and this may be positively reflect on increasing the content of carbohydrate in canes of Early Sweet grapevines.

These results confirm those of Fawzi *et al.* [18] and Khamis *et al.* [19] for other grape cultivars.

### Yield and Physical Characteristics of Cluster and Berries

**Yield and Number of Clusters:** Data presented in Table (5) showed that the number of clusters and yield per vine increased by increasing of bud load levels during both seasons. The number of clusters per vines was increased by increasing bud load levels per vine. In this connection, the highest number of clusters per vine was obtained from bud load levels at 74 buds per vines during two seasons. Also, yield per vine had the lowest values in the low bud load levels (44buds/vine), while the best results found at 62 buds per vine in this respect during 2016 and 2017 seasons.

Table 5: Effect of vine bud load on yield/vine and physical characteristics of cluster for Early Sweet grapevines during 2016 and 2017 seasons

| | Yield/ vine (kg) | | Cluster length (cm) | | Cluster width (cm) | | Cluster weight (g) | | No. of clusters /vine | | Shot berries /cluster (%) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Bud load/vine | 2016 | 2017 | 2016 | 2017 | 2016 | 2017 | 2016 | 2017 | 2016 | 2017 | 2016 | 2017 |
| 44 | 13.87 | 15.30 | 20.20 | 20.80 | 12.86 | 14.00 | 483.3 | 493.7 | 28.7 | 31.0 | 2.95 | 2.73 |
| 50 | 14.45 | 16.86 | 20.05 | 20.90 | 12.77 | 13.70 | 479.7 | 490.0 | 30.2 | 34.4 | 3.17 | 3.01 |
| 56 | 16.96 | 19.73 | 20.13 | 21.00 | 12.94 | 13.83 | 498.8 | 500.7 | 34.0 | 39.4 | 2.41 | 2.20 |
| 62 | 23.55 | 23.20 | 21.00 | 21.40 | 13.30 | 15.50 | 530.4 | 544.5 | 44.4 | 42.6 | 2.82 | 2.61 |
| 68 | 21.78 | 22.32 | 19.75 | 19.80 | 11.73 | 12.80 | 461.5 | 465.0 | 47.2 | 48.0 | 5.63 | 5.59 |
| 74 | 22.60 | 22.60 | 19.70 | 19.78 | 11.10 | 11.20 | 429.6 | 433.0 | 52.6 | 52.2 | 7.82 | 7.90 |
| New L.S.D at 5 % | 0.04 | 0.05 | 0.02 | 0.02 | 0.01 | 0.02 | 3.5 | 3.6 | 0.8 | 0.9 | 0.21 | 0.23 |

Table 6: Effect of vine bud load on physical characteristics of berries for Early Sweet grapevines during 2016 and 2017 seasons

| | Berry weight (g) | | Berry length (cm) | | Berry diameter (cm) | | Berry firmness (g/cm$^2$) | |
|---|---|---|---|---|---|---|---|---|
| Bud load/vine | 2016 | 2017 | 2016 | 2017 | 2016 | 2017 | 2016 | 2017 |
| 44 | 5.56 | 5.58 | 2.10 | 2.26 | 1.93 | 2.09 | 556.7 | 565.3 |
| 50 | 5.37 | 5.45 | 2.13 | 2.19 | 1.93 | 2.03 | 545.3 | 550.3 |
| 56 | 5.63 | 5.64 | 2.16 | 2.00 | 1.94 | 1.96 | 567.6 | 571.0 |
| 62 | 5.64 | 5.66 | 2.24 | 2.20 | 2.11 | 2.07 | 574.0 | 584.0 |
| 68 | 5.24 | 5.27 | 2.12 | 1.94 | 1.90 | 1.91 | 537.3 | 543.3 |
| 74 | 5.01 | 5.03 | 1.98 | 1.92 | 1.88 | 1.89 | 534.3 | 538.7 |
| New L.S.D at 5 % | 0.01 | 0.01 | 0.04 | 0.05 | 0.01 | 0.01 | 4.2 | 5.1 |

Furthermore, the obtained data was in the same line with Fawzi *et al.* [18] and Khamis *et al.* [19] who found that increasing of bud load/vine increased number of clusters.

**Physical Characteristics of Cluster and Berries:** Based on data in Tables (5 & 6), it was clear that the cluster characteristics namely; cluster length, cluster width, cluster weight and shot berries as well as, berry parameters, such as; berry weight, berry length, berry diameter and berry firmness were affected by different bud load levels per vine during two seasons. Meanwhile, the vines which pruned to 62 buds per vine exhibited the highest values of mentioned characters, followed by 56 buds per vine. Whereas, high bud load levels (74buds/vine) gave the lowest values in this context during two seasons. The improving in mentioned characters may be due to the early development of larger, open canopies, which provide higher photosynthetic activity, because leaf gas exchange and this may be positively reflect on quality of Early Sweet grapevines [22]. Moreover, Di-Lorenzo and Pisciotta [2] reported that a better explanation can be found by looking at cluster weight behavior, which was negatively correlated with high bud load of Grillo grapevines.

Regarding shot berries data in Table (5) indicated that increasing the bud load levels per vine increased shot berries in the cluster of Early Sweet cultivar during 2016 and 2017 seasons. In this regard, vines which pruned at 74 buds per vine had the highest values of shot berries per cluster, while the best results were obtained from bud load levels at 56 buds per vines. Thus, the highest values of shot berries per cluster under higher vine bud loads might be attributed to the great depletion of various nutrients in forming more clusters which result in imbalance between various nutrients [23].

These results in this respect are harmony with the findings found of Abdle-Hamid *et al.* [24] who that found the percentage of shot berries/cluster of Autumn Royal Seedless grapes was increased by increasing buds per vine.

**Chemical Characteristics of Berries:** It is quite clear from data presented in Table (7) that the content of T.S.S %, total acidity, T.S.S/ acidity ratio and antioxidants activity of Early Sweet berries were affected by different bud load levels per vine during 2016 and 2017 seasons. It obvious that bud load levels of 56 or 62 buds per vine gave the highest values of T.S.S% and T.S.S/ acid ratio, antioxidants activity in Early Sweet berries, while total acidity had the lowest values in this respect compared with other treatments during both seasons. On the other hand, bud load of 74 buds per vine had the lowest values of T.S.S %, T.S.S/ acidity ratio and antioxidants activity of Early Sweet berries, while total acidity had the highest values in this context compared with other treatments during 2016 and 2017 seasons. High bud load levels decreased T.S.S % and T.S.S/ acidity ratio and this may be due to reductions in the available sugar per berry and water absorption [25]. Moreover, the increasing percentages of antioxidants activity were related with reduction bud load per vine and that coincides with results obtained by Baianoa and Terraconeb [26] who reported that, the reduction of bud load caused an increase in pulp antioxidant activity of Thompson Seedless grapes.

A similar response of bud load levels was referred by Abdle-Hamid *et al.* [24] who found that the of T.S.S %, total acidity and T.S.S/ acidity ratio was affected by different bud load levels; consequently, T.S.S % and T.S.S/acidity ratio were decreased by increasing the number of buds per vine of Autumn Royal Seedless grapes.

**Wood Ripening and Pruning Weight:** It is clear from the data in Table (8) show that different bud load levels had announced differences on the wood ripening and pruning weight during both seasons. The increasing in the percentage wood ripening and pruning weight values related with the decreasing bud load per vine in both seasons. In this concern, the best results for improving pruning weight were obtained from bud load level at 44 buds per vine, followed by treatment of bud load levels at 56 & 62 buds per vine during 2016 and 2017 seasons. While, the best results for the percentage of wood ripening were obtained from bud load at 56 buds per vines, followed by 62 buds per vines. On the other hand, bud load levels at 74 were found to have the lowest values of mentioned characters in this respect. Meanwhile, the low bud load resulting in vigorous shoots because all of the stored energy in the roots, arms and trunks is available to relatively few growing points [3]. For this season, the low bud load increased winter pruning weight during first season and second seasons. On the contrary, they stated that the high bud load resulting in weakness shoots because the higher bud load which all of the stored energy in the roots, arms and trunks is insufficient to getting the better shoots growth and this may be decreased wood ripening coefficient and winter pruning weight during 2016 and 2017 seasons.

The results obtained in the present investigation were in general agreement with those of Khamis *et al.* [19] and Fawzi *et al.* [20] as they indicated that increasing bud load was accompanied with decreasing wood ripening coefficient and winter pruning weight for other grape cultivars.

Table 7: Effect of vine bud load on chemical characteristics of berries for Early Sweet grapevines during 2016 and 2017 seasons

| | T.S.S (%) | | Acidity (%) | | T.S.S/ acid ratio | | Antioxidants (DPPH %) | |
|---|---|---|---|---|---|---|---|---|
| Bud load/vine | 2016 | 2017 | 2016 | 2017 | 2016 | 2017 | 2016 | 2017 |
| 44 | 19.42 | 19.58 | 0.488 | 0.481 | 39.80 | 40.71 | 56.1 | 56.0 |
| 50 | 19.89 | 20.00 | 0.472 | 0.467 | 42.14 | 42.83 | 55.2 | 55.6 |
| 56 | 20.72 | 20.83 | 0.461 | 0.451 | 44.95 | 46.19 | 57.1 | 57.7 |
| 62 | 20.91 | 21.00 | 0.453 | 0.447 | 46.16 | 46.98 | 58.2 | 58.9 |
| 68 | 19.40 | 19.53 | 0.502 | 0.500 | 38.65 | 39.06 | 54.8 | 54.1 |
| 74 | 19.23 | 18.83 | 0.510 | 0.513 | 37.71 | 36.71 | 53.9 | 53.5 |
| New L.S.D at 5 % | 0.40 | 0.50 | 0.011 | 0.014 | 1.22 | 1.25 | 0.4 | 0.5 |

Table 8: Effect of vine bud load on wood ripening, pruning weight and Ravaz index of Early Sweet grapevines during 2016 and 2017 seasons

| | Wood ripening (%) | | Pruning weight (kg) | | Ravaz index | |
|---|---|---|---|---|---|---|
| Bud load/vine | 2016 | 2017 | 2016 | 2017 | 2016 | 2017 |
| 44 | 93.86 | 93.62 | 3.33 | 3.15 | 4.17 | 4.86 |
| 50 | 93.92 | 94.10 | 3.11 | 3.40 | 4.65 | 4.96 |
| 56 | 94.65 | 95.81 | 2.37 | 2.92 | 7.16 | 6.76 |
| 62 | 93.95 | 95.19 | 2.75 | 3.21 | 8.56 | 7.23 |
| 68 | 75.64 | 75.25 | 2.13 | 2.18 | 10.23 | 10.24 |
| 74 | 69.20 | 68.80 | 2.04 | 2.09 | 11.08 | 10.81 |
| New L.S.D at 5 % | 0.01 | 0.1 | 0.02 | 0.04 | 0.12 | 0.10 |

Table 9: Effect of vine bud load on gross return, net return and beneficial cost ratio of Early Sweet grapevines during 2016 and 2017 seasons

| | Gross return (L.E./ fed) | | Net return (L.E./ fed) | | Beneficial cost ratio | |
|---|---|---|---|---|---|---|
| Bud load/vine | 2016 | 2017 | 2016 | 2017 | 2016 | 2017 |
| 44 | 38836 | 42840 | 11351 | 15355 | 1.41 | 1.56 |
| 50 | 40460 | 47208 | 12975 | 19723 | 1.47 | 1.72 |
| 56 | 47488 | 55244 | 20003 | 27759 | 1.73 | 2.01 |
| 62 | 65940 | 64960 | 38455 | 37475 | 2.40 | 2.36 |
| 68 | 60984 | 62496 | 33499 | 35011 | 2.22 | 2.27 |
| 74 | 63280 | 63280 | 35795 | 35795 | 2.30 | 2.30 |
| New L.S.D at 5 % | 980 | 781 | 842 | 713 | 0.02 | 0.01 |

**Ravaz Index:** The ratio between yield and winter pruning weight (expressed as the Ravaz index) changed basically because of yield variations Table (8). By comparing the values of the Ravaz index, the vines pruned at 44 & 50 buds per vine were under cropping (4.17 & 4.86) and (4.65 & 4.96) during two seasons respectively, while, the vines pruned at 68 & 74 buds per vine were over cropping (10.23 & 10.24) and (11.08 & 11.81) during two seasons respectively. Fortunately, the moderate bud load such as 56 & 62 buds per vine, by comparing the values of the Ravaz index (7.16 & 6.76) and (8.56 & 7.23), during 2016 and 2017 seasons respectively, where, these vines produced adequate vegetative growth (Table 3) to support the crop. The best results of Ravaz index were reached by the bud load levels at 56 & 62 buds per vine during 2016 and 2017 seasons.

Ravaz index is considering a good indicator for determined the balance between vegetative growth and crop load of Early Sweet grapevines. Ravaz index is a ratio between total yield per vine and pruning weight, where, balanced vines should provide a Ravaz index in between 5 and 10 (<5 under cropped, >10 = over cropped vines) [8]. Thus, Almanza-Merchan *et al.* [9] who pointed that the pruning is used to limit the number of clusters, generate a suitable balance between plant vigor and production. Moreover, Somkuwar and Ramteke [10] reported that to produce the quality grapes, it requires careful control of crop size to balance the amount of fruits per vine to vegetative growth, fruit quality and adequate vine growth for consistent productivity. Excess fruit production lead to poor fruit quality, but it reduced vegetative growth resulting in poor yield.

**Economic Study:** The economic study (Table 9) showed that the highest gross return of 65940 and 64960 (L.E/fed), net return of 38455 and 37475 (L.E/fed) and cost beneficial ratio of 2.40 and 2.36, respectively in two growing seasons were obtained at the treatment of bud load levels at 62 buds per vine. The increasing in mentioned characters may be due to the increasing total yield per vine.

## CONCLUSION

From the data in this study, it could be concluded that the moderate bud load levels at 56 or 62 buds per vine gave the best results on yield/vine to pruning weight/vine ratio (Ravaz index) to get a good balance between vegetative growth and crop load and this reflect on improving yield quantitatively and qualitatively, thus economic return of Early Sweet grapevines.

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