World Journal of Agricultural Sciences 9 (5): 377-382, 2013
ISSN 1817-3047

DOI: 10.5829/idosi.wjas.2013.9.5.1766

Application of Various Pruning Treatments for Improving Productivity and Fruit Quality of Crimson Seedless Grapevine

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Abstract: The present study was carried out to estimate the effect of cane length on Crimson Seedless grapevine variety productivity. To achieve this goal, experimental treatments were carried out during two successive seasons (2010 and 2011) on own rooted Crimson Seedless vines. The vines were 5 years old and grown in a sandy loam soil under drip irrigation system. They were subjected to six pruning treatments. The results cleared that, bud behavior was significantly affected by pruning treatments. Pruning at long canes (10 buds / cane) recorded the highest fruitful buds percentage as well as the lost bud burst percentage while the opposite was true with respect short pruning (2 buds / cane, spur pruning). As a general conclusion, the yield per vine as well as some physical properties of cluster progressively increased by increasing cane length. Generally, under the condition of this trial, it could be mention that pruning Crimson Seedless grapevines canes at 8 buds up to 10 buds / cane were considered the most optimum treatment to increase vine yield and fruit quality.

Key words: Grapevine · Crimson Seedless · Pruning · Cane length · Productivity · Yield · Fruit quality

INTRODUCTION

The grapevine (*Vitis vinifera L.*) is considered to be one of the most economically fruit crops in the world. 'Crimson Seedless' grape (*Vitis vinifera L.*) is a late-season, attractive, red seedless grape cultivar with firm berries. The cultivar, introduced in 1989, fills the need for a red seedless cultivar for the fresh market and provides a seedless alternative to 'Emperor', a late-ripening, red-seeded grape [1]. It is fast becoming the preferred red seedless grape in supermarkets worldwide because of its exceptional shelf life as well as it has a very distinctive, sweet, juicy flavor and elongated, pale pink berries. It has a crisp, firm skin with a juicy pulp. It has high sugar content, with half as glucose and half as fructose [2]. Crimson Seedless' vines are very vigorous on their own roots. Cane pruning is advisable because production on spurs was low in initial trials [1]. While, under the standard California "T" trellis is utilized, the quadrilateral cordon trained/spur pruned system offers several advantages over the head trained/cane pruned system. First, spur pruning is less complicated and generally less expensive than cane pruning. Second, because clusters are borne within a defined region of the canopy, fruit management practices (cluster thinning) and harvest are easier to perform. Basal leaf removal and other practices used to improve canopy microclimate are also easier to perform. The latter is particularly important since the fruit of Crimson Seedless requires significant sunlight exposure for optimum color development. Third, this system generally has lower humidity and in the fruiting region, an important consideration for a late ripening cultivar [3].

Pruning and training of the vine are two of the most important aspects for yield and quality of grape production. The aims of pruning are to establish/maintain the vine in the desired form, produce fruit of the target composition, select nodes that will produce fruitful shoots, regulate shoot number/crop load and regulate vegetative growth. Thus, pruning has a significant influence on the vine ability to grow and cropping [4]. The choice of pruning method is largely influenced by the fruitfulness characteristics of the vine variety [5]. Cane in some grape varieties may be fairly fruitful and differences in the degree of fruitfulness of buds along the length of the cane less marked than in other varieties whose buds are less fruitful near the base and show a sharp increase in fruitfulness towards the central part of

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the cane [6]. However, controlling yield via pruning is an important way for increase grapes quality [7]. Cane length/ number of buds per cane affected significantly the bud behavior, yield and fruit quality of grapevine cultivars [1, 5, 8, 9].

So, the scope of the present study is to select the optimum cane length which is improving the yield and fruit quality of 'Crimson Seedless' table grape under the Egyptian environmental condition.

MATERIALS AND METHODS

The present study was carried out during two successive seasons (2010 and 2011) on Crimson Seedless grapevines (*Vitis vinifera* L.) in a private vineyard located at El-Khatatba region, Giza governorate. The vines were 5 years old and spaced 1.5 m within vines and 3.5 m between rows and grown in a sandy loam soil under drip irrigation system (two lateral lines per row and four emitters per vine each at 8 L / h.). Throughout the growing season, the chosen vines received standard cultural practices performed by the grower that are common among all table grape varieties.

This investigation was initiated to evaluate the effects of pruning type in order to develop the optimal number of nods required to assure optimum growth and maximum productivity with high fruit quality.

Layout of the Experiment: Fifty four vines of normal growth, healthy and uniform in vigor were selected to complete this research. All vines were pruned to 70-72 nods by six pruning experimental treatments. Vine canes were punned from 2 nods up to 12 nods per cane to achieve pruning treatments (36 spur X 2-nods, 18 fruiting canes X 4-nods, 12 fruiting canes X 6-nods, 9 fruiting canes X 8-nods, 7 fruiting canes X 10-nods and 6 fruiting canes X 12-nods) during both seasons of study. Each treatment was replicated three times, with three vines per each.

The Following Parameters Were Assessed During the Study:

Bud Behavior Parameters: After one month of bud bursting of each season, the number of bursted buds and number of fruitful shoots were recorded then percentages of bud burst and fruitfulness were calculated according to Bessis [10] as follows:

Bud burst % = (No. of bursted buds / total No. of buds per vine) X 100

Fruitfulness % = (No. of fruitful buds/ No. of bursted buds) X 100

Yield: At harvest time, when color development accumulated in 80 % of berries / cluster, a randomly picked 3 clusters per vine used to determine average cluster weight (g) and then calculated average yield (kg) per vine (Yield = average cluster weight X number of clusters per vine).

Berry Parameters: Ten berries per cluster were randomly taken to determine the averages of berry weight (g) and volume (cm^3) then juice of pre-selected berries was pressed from the berries and filtered through two layers of cheese cloth to determine soluble solids concentration (SSC) by using hand refractometer and Titratable acidity percentage expressed as ml tartaric acid / 100 ml juice according to the official methods of analysis [11].

Total Carbohydrates and Nutrients Content: In order to follow the distribution of macro-nutrients as well as carbohydrates accumulation along the shoot length, sample of current year shoots of 3 untreated vine for each block (on the 2^{nd} season) were collected during bloom, period of flower initiation according to Winkler *et al.* [12] and Hellman [13], such shoots were divided into six sections (1-2, 3-4, 5-6, 7-8, 9-10 and 11-12 nods) then total carbohydrates and nutrients content were determined. Total carbohydrates content (g/ 100g dry weight) determined by using colorimetrically method according to Cherry [14]. Nitrogen percentage was estimated by micro-keldahl according to Pregel [15], phosphorus percentage was determined by colorimetric method, using commercial kit according to Temminghoff and Houba [16], potassium was estimated according to Brown and Lilleland [17].

Statistical Analysis: The experiment was one factor factorial that arranged in a randomized complete block design with three replicates in each treatment. The obtained data was tabulated and subjected to analysis of variance (ANOVA) according to Snedecor and Cochran [18], using MSTAT software package and means were compared using LSD range at 0.05 level. The percentages were transformed to arc sine to find the binomial data according to Steel and Torrie [19].

RESULTS AND DISCUSSION

Bud Behavior: Buds burst and fruitfulness percentages were significantly affected by pruning treatments (Table 1). Short pruning (2 nods) gave the highest bursted buds and the lowest fruitfulness percentages in the two seasons of study. The percentages of buds

Table 1: Effect of different pruning treatments on bud behavior of Crimson Seedless grapevine during 2010 and 2011 seasons.

	Bursted buds %		Fruitfulness %	
Pruning treatments (Cane length)	2010 season	2011 season	2010 season	2011 season
2- nods	84.51	83.1	27.55	33.41
4 -nods	68.80	65.26	34.98	41.79
6 -nods	62.91	70.89	36.53	45.38
8 -nods	61.06	65.26	45.61	51.94
10 -nods	54.47	61.97	48.29	69.11
12 -nods	56.52	62.91	35.28	62.46
LSD at 5%	9.824	18.04	14.32	16.22

Table 2: Effect of different pruning treatments on cluster parameters and yield of Crimson Seedless grapevine during 2010 and 2011 seasons.

	Cluster number/vine		Cluster weight (g)		Yield/vine (kg)	
Pruning treatments (Cane length)	2010 season	2011 season	2010 season	2011 season	2010 season	2011 season
2- nods	16.67	19.33	161.9	165.6	2.69	3.18
4 -nods	12.00	19.67	217.2	151.3	3.95	2.94
6 -nods	17.67	20.00	240.2	175.7	4.24	3.53
8 -nods	21.67	27.00	287.9	273.0	6.21	8.18
10 -nods	22.67	31.00	292.0	303.2	6.61	8.21
12 -nods	19.00	30.33	246.7	205.9	4.49	6.22
LSD at 5%	7.275	9.416	37.13	59.11	1.044	1.857

burst were decreased linearly by increasing the length of cane pruning; whereas the longest cane (10 and 12 nods) resulted in the lowest percentage of the bursted buds. In contrast, fruitfulness percentage was enhanced under longest pruning. Whereas the lowest fruitfulness percentage was produced when cane pruned at 2-nods while pruning cane at 10-nods produced the highest percentage in this respect during both seasonal study.

In this line, Fawzi [9] in a study on Superior grapevines found that, cluster index and compactness coefficient were increased by increasing cane length to 20 buds/cane, while the fruitfull buds and fertility coefficient was increased with cane length from 9 up to 12,14 buds/cane. Whereas, bud fertility along the cane was increased from the base to the middle and decreased again toward the tip [20]. Higher proportion of bunches come from more distal node positions of the canes; these contain larger inflorescence primordia than the basal two nodes present on spurs [21]. Thompson Seedless and Fiesta are cane pruned because of their low fruitfulness at the basal node positions, the basal three node positions on a 'Thompson Seedless' fruiting cane are shown to be of low fruitfulness. Instead, 12- to 15-node canes are retained because of the higher fruitfulness throughout the remaining node positions, particularly in the middle of the cane [5]. Furthermore, fruitful buds percentage and fertility coefficient of Early Superior grapevines were increased at cane length 12, 10 buds/cane [8].

Cluster Parameters and Yield: Data concerning the effect of cane length on number of cluster per vine, cluster weight (g) and average yield / vine (kg/ vine) are shown in Table (2). Statistically, pruning applied at 8 up to 12 nods per cane compared with shortage pruning at 2-nod gave the highest number of cluster per vine. While the heaviest cluster produced with pruning applied at 8 or 10 nods. So, the largest yield recorded at pruning type at 8 or 10 nods / cane while the lowest yield recorded at 2 nods pruning type. Generally, yield was positively correlated with cluster number [22]. Crimson Seedless vines are very vigorous on their own roots. Cane pruning is advisable because production on spurs was low in initial trials [1]. In addition, total yield / vine tended to increase either as average number of clusters/ vine or average weight of clusters/ vine [9]. Increasing the length of cane significantly increased the cluster number, fruiting shoots number and fertility coefficient. While it had no undesirable effects on dimension and weight of cluster. In other words, results show that there is more fruiting in apical buds of cane than first 1-4 buds which are mostly vegetative [23].

Berry Physical and Chemical Parameters: Berry weight and its size were significantly affected by different pruning treatments (Table 3). Pruning cane at 10 nods produced the largest berry weight (g) and size (cm^3) of Crimson Seedless grapevine with non-significant difference with berry produced at 8 or 12-nods treatments

Table 3: Effect of different pruning treatments on berry physical and chemical parameters of Crimson Seedless grapevine during 2010 and 2011 seasons.

Pruning treatments (Cane length)	Berry weight (g)		Berry size (cm^3)		SSC %		Acidity %	
	2010 season	2011 season	2010 season	2011 season	2010 season	2011 season	2010 season	2011 season
2- nods	3.83	3.09	29.29	28.33	17.31	18.87	0.55	0.56
4 -nods	4.21	3.35	31.06	30.00	17.36	19.11	0.55	0.57
6 -nods	4.60	3.50	34.51	32.33	17.80	19.10	0.53	0.55
8 -nods	4.79	3.57	34.81	31.67	17.87	19.12	0.54	0.54
10 -nods	4.88	3.87	35.66	33.67	17.88	19.17	0.54	0.52
12 -nods	4.64	3.65	35.40	32.67	17.83	19.00	0.55	0.53
LSD at 5%	0.237	0.372	2.335	3.038	n.s	n.s	n.s	n.s

Table 4: Effect of shoot sector on total carbohydrates content and shoot macro nutrients of Crimson Seedless grapevine during 2011 season.

Shoot sectors	Total carbohydrates (g/ 100g dry weight)	Nitrogen (%)	Potassium (%)	Phosphorus (%)
1-2 nods	38.24	1.25	2.58	1.05
3-4 nods	39.34	1.30	2.34	1.05
5-6 nods	30.55	1.30	2.70	1.05
7-8 nods	26.15	1.50	3.66	1.45
9-10 nods	25.85	1.50	4.79	1.12
11-12 nods	26.64	1.60	4.77	1.06
LSD at 5%	1.008	0.331	1.056	n.s

in both seasons. While, 2-nods pruning treatment produced the lowest weight and size of berry. Regarding to the effect of cane length on soluble solids concentration (SSC) and acidity, data indicated that SSC and total acidity appeared the same statistically values by different pruning treatments during both seasons.

Moreover, the highest values of berry weight were also obtained by 12, 14 buds / cane treatment with significant differences between them. Generally, pruning Superior grape cultivar by leaving 6 or 7 canes with 14 or 12 buds / cane resulted in a higher yield, better fruits quality and wood ripening [9]. Pruning levels did not appear clear effect on soluble solids concentrations (SSC) and titratable acidity of berry jucie of Crimson Seedless [1].

Total Carbohydrates Content: Data in table 4 clarify that the basal shoot sectors contain the highest significant total carbohydrates %. Whereas 3-4 node sector followed by 1-2 nod sector contained the highest amount of carbohydrates. Also, carbohydrates content was gradually decreased in the middle and terminal sectors of shoots.

Similar results were obtained by Salem *et al.* [24] and Ansam [25]. They reported that total carbohydrates in different parts of the canes were highest in basal and middle sectors of canes. However, the terminal sector had the lowest total carbohydrates content. Furthermore, storage C in the perennial tissues (roots, trunk, canes) was mainly made of starch, which accumulated in the ray parenchyma of the wood [26]. Also, grape shoots were matured gradually from basal internodes up to terminal ones.

Macro Nutrients Content: Different shoot sector affected significantly the shoot macro elements content (Table, 4). Data clearly indicated that all sectors of shoot from 3-4 up to 11-12 nod gave the highest N content, while the basal 1-2 bud sectors gave the lowest N content. Potassium shoot continent was significantly increased in the terminal shoot sectors (9- 10 or 11-12 nod) comparing with the basal ones (1-2 or 3-4 nod). There were no significant differences in phosphorus continent between different shoot parts. The highest P continent was recorded in 7-8 nod sectors followed by 9-10 nod sectors.

So, the fertility of terminal and middle bud (6-12 nods) of Crimson Seedless shoots may be due to the accumulation of nitrogen, potassium and phosphorus in these buds and the reaching of adequate light to them comparing to basal buds. Especially Crimson Seedless vines are very vigorous on their own roots [1] which basal buds were most shading. In this respect, nutrients have a significant effect on grapevine bud induction.

A depression in bud fertility of Muller-Thurgau grape associated with N deficiency as well as to N excess [27]. Also, the optimum phosphorus (P) nutrition promoted bud fruitfulness and phosphate deficiency is detrimental to the maintenance of initiated inflorescence primordia [28]. Studies with radioactive P indicated a preferential accumulation of P in actively growing shoot tips and in young buds that subsequently became fruitful [29]. Furthermore, there are several suggestions for the role for potassium (K) in inflorescence formation in the grapevine. Potassium is implicated in enzyme activation and carbohydrate mobilization in grapes [30]. Optimum levels of N, P and K are associated with maximum cytokinin production by grape roots [31]. Most studies seem to agree that to optimize bud fertility it is important that adequate light reaches the renewal zone [32, 8, 33]. Moreover, shading individual buds depresses fruitfulness [34, 33]. External buds are much more fruitful than buds inside the canopy because of excessive shading closer to vine head [35, 36, 33]. It appears that light availability in late spring is critical for flower induction; shading at this time has a greater effect on fruitfulness of latent buds than earlier or later in the season [31]. This coincides with the period when anlagen are being initiated and differentiated in the buds that will be retained at pruning of the following season.

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