Effect of foliar spraying with GA_3 and/or sitofex on bud behaviour, vegetative growth, yield and cluster quality of Thompson Seedless grapevines

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Abstract: This investigation was conducted during three consecutive years (2009, 2010 and 2011). The aim of the study was to investigate the effect of foliar application of GA_3 and sitofex either in the single or combined form with regard to the concentration and time of application on bud behaviour, vegetative growth, cluster weight and fruit quality in Thompson Seedless grape. Sitofex at 3 or 5 ppm and GA_3 at 10 or 20 ppm were assessed individually or combined at three stages: the beginning of vegetative growth, at 75% bloom and at berry set. Remarkable effects on percentages of bud burst and fruitful buds were observed when CPPU at 3 ppm and / or GA_3 at 10 ppm were sprayed at the beginning of vegetative growth. Sprays including the high concentration of each growth regulator (CPPU or GA_3) resulted in appreciable increases in vegetative growth parameters, cluster weight, berry weight and size, berry length and diameter particularly when CPPU and / or GA_3 were sprayed at the beginning of vegetative growth. Application of both CPPU and GA_3 was found to increase TSS and decrease acidity in the berry juice. Generally, it can be said that the spraying sitofex and / or GA_3 at the beginning of vegetative growth at low concentrations (CPPU at 3 ppm or GA_3 at 10 ppm) gave the highest percentages of bud burst and fruitful buds; using a combination of sitofex and GA_3: CPPU at 3 ppm plus GA_3 at 40 ppm resulted in improving vegetative growth, cluster weight and berry quality of Thompson Seedless grapevine. Therefore it can be recommended not to spray Thompson Seedless grapevines with high concentrations of sitofex or GA_3 to avoid the possible reduction of bud fertility especially where vines are sprayed at bloom or berry set stages.

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Key words: Gibberellic acid, Sitofex, Thompson Seedless grape

1. Introduction

The grape is one of the most important fruits all over the world. This is due to its high production which gives a high net income to the growers. Thompson Seedless grape is the most profitable fruit in Egypt. Many factors of grape growing enter into the production of quality; some of these affect the vine and its fruit more directly, such as the use of plant growth regulators. Recently, growth regulators are widely used in the field of grape production. In spite of that, very little information are available concerning the effect of some of these growth regulators on bud fertility of grapevines.

The available literature concerning the after effect of some plant growth regulators such as gibberellic acid (GA_3) mentioned that foliar spraying of GA_3 may cause some problems such as inducing a decrease in bud fruitfulness (Jawanda *et al*., 1974) and Gloack and Guven (1994) stated that GA_3 played a certain role in bud burst occurring on the shoots in the following year of GA_3 application.

GA_3 is widely used in vineyards, all over the world to increase cluster weight, berry weight and size of Seedless cultivars which in turn increase the vine yield (Miele *et al*., 2000) and Reynolds and Savigny., (2004) found that GA_3 spray after blooming at 15 and 40 ppm increased cluster weight of the grapevines.

Moreover, Ezzahauani *et al*., (1985) and Shaaban *et al*., (1992) reported that GA_3 increased TSS% in grape juice of Thompson Seedless. With regard to the effect of GA_3 on total acidity percentage, Reynolds and Savigny (2004) treated the vine cultivar ̀Sovereign Coronation ́ and found that all GA_3 treatments decreased the titratable acidity of berry juice.

Sitofex (Forchlorfenuron) is a plant growth regulator of Cytokinin type (Nickell, 1985 a and b). its physiological effects were cited by Arie et al., (2008) who recorded that CPPU increased the number and density of cells causing an appreciable increase in berry size of Seedless grapes. Application of Sitofex (CPPU) showed promising results, such as increasing berry set and berry size in Thompson Seedless grape.

Retamales et al., (1995) also, Abdul et al., (1998) found that CPPU applied as a post-flowering cluster dip increased the number of clusters in Fujiminon grapevines.

Sitofex has been tried successfully, either alone or combined with other growth substances to improve grape quality (Mervet et al 2001).

The purpose of this investigation is to throw some light on the effect of foliar spraying of GA3 and / or Sitofex either in the single or combined form on bud behaviour, vegetative growth, cluster weight and fruit quality of Thompson Seedless grape.

2. Material and Methods

This investigation was carried out during three consecutive years (2009, 2010 and 2011) in a private vineyard located at the 84th kilometer of Cairo Alexandria Desert Road.

Eight years old Thompson Seedless grapevines were grown in sandy soil and spaced 1.75 x 2.75 m. The vines were supported by the Gable system. In the last week of December, the vines were pruned to 8 canes of 12 buds each. The vineyard was drip irrigated. All vines received the common cultural practices already applied in the vineyard. The experiment was designed according to the randomized block system with three replicates per treatment, five vines each. The work in the first year was considered as a preliminary trial, then the experiment proceeded with the same manner during the second and third seasons, respectively.

The applied treatments were as follows:

1. Sitofex CPPU at 3 ppm.
2. Sitofex CPPU at 5 ppm.
3. GA_3 at 10 ppm .
4. GA_3 at 20 ppm .
5. GA_3 at 40 ppm .
6. Sitofex CPPU at 3 ppm in addition GA_3 at 10 ppm .
7. Sitofex CPPU at 3 ppm in addition GA_3 at 20 ppm .
8. Sitofex CPPU at 3 ppm in addition GA_3 at 40 ppm .
9. Sitofex CPPU at 5 ppm in addition GA_3 at 10 ppm .
10. Sitofex CPPU at 5 ppm in addition GA_3 at 20 ppm .
11. Sitofex CPPU at 5 ppm in addition GA_3 at 40 ppm .
12. Control (untreated vines).

Vines were sprayed at three times as follows:

1- Spraying at the beginning of vegetative growth.
2- Spraying at 75% bloom.
3- Spraying immediately after berry set.

Grape clusters were picked when the total soluble solids of the control reached 16 – 17% (Tourky *et al.*, 1995).

Measurements:

The following parameters were recorded for both seasons:

1- Bud behavior:
  1) Bud burst (%): calculated by dividing number of bursted buds / total No. of buds left per vine at pruning time multiplied by 100.
  2) Vegetative buds (%): Number of vegetative buds / No. of bursted buds multiplied by 100.
  3) Fruitful buds (%): Number of fruitful buds per vine / No. of bursted buds multiplied by 100.

2- Growth aspects ultimate shoot length (cm), shoot diameter. Internode length prior to the first cluster (at the 3rd or the 4th node) was measured at the cluster ripening stage. The total leaf area of the mature basal 7th and 8th leaves were measured at bi-weekly intervals covering the period from time of spraying till harvesting time, the total surface area of the leaves per vines (m^2 / vine) was determined as follows: the mean leaf area multiplied by the number of leaves per shoot by number of shoots per vine using leaf area meter, Model Cl 203, U.S.A.

Coefficient of wood ripening: This was calculated by dividing length of the ripened part of the cane by the total length of the cane (Bourad, 1966).

3- Yield and fruit quality:

Clusters were harvested in each season when T.S.S. of the untreated vines reached 16-17%. At harvest time yield per vine and cluster weight were recorded. From each treatment three samples each containing 100 berries were used for physical and chemical determinations such as berry weight (g), size (cm^3) and dimension (cm), percentage of total soluble solids (T.S.S.) (by using hand refractometer), total acidity percentage according to A.O.A.C. (1985) and T.S.S. acid ratio (TSS / acid).

4- Histological studies:

For assessing bud fertility, buds were collected from shoots of the current season representing the control and the best promising treatment to be examined at the end of October in each season. The samples were transferred directly to the laboratory and preserved as soon as possible in F.A.A. solution and kept for 48 hours. The tissues were dehydrated in nbutanol. After embedding in paraffin wax, buds were sectioned longitudinally 12µ thick using a rotary microtome and stained with safran and fast green according to the method of Johansen (1940).

The means representing the effect of the tested treatments were compared by the New L.S.D. method at 0.05 significance according to Snedecor and Cochran (1980).

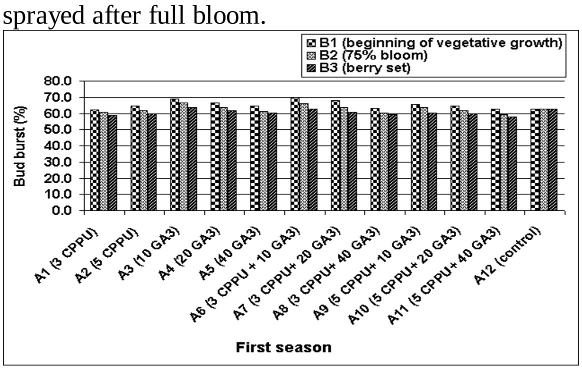
3. Results and Discussion

1- Effect of foliar application with sitofex and GA_3 on bud behavior of Thompson Seedless grape:

1-1 Bud burst:

Concerning the effect of spraying with sitofex and / or GA_3 on bud burst percentage, of

Thompson Seedless grapevines during 2010 and 2011 seasons, it can be noticed from Fig (1) that, slight differences occurred among the treatments under study. However, the single application of GA_3 was shown to increase the percentage of bud burst as compared with the control. Slight differences could be detected among GA_3 concentrations. Spraying GA_3 at 10 ppm gave the highest bud burst percentage whereas GA_3 at 40 ppm gave the lowest one. However, GA_3 at 20 ppm ranked in between in this respect. Similar results were reported by (Thomas, 1979 and Gloack, and Guven 1994) they found that GA_3 at 50 ppm caused a reduction in bud burst percentage. On the other hand, sitofex alone at 3 ppm and 5 ppm slightly increased bud burst percentage over the control in the first and second seasons respectively, the highest values of bud burst percentage were observed with spraying sitofex at 5 ppm. These results agree with those obtained by Famiani *et al* (2001) who reported that, the percentages of bud burst of grapevines were not affected by CPPU at 20 ppm sprayed after full bloom.



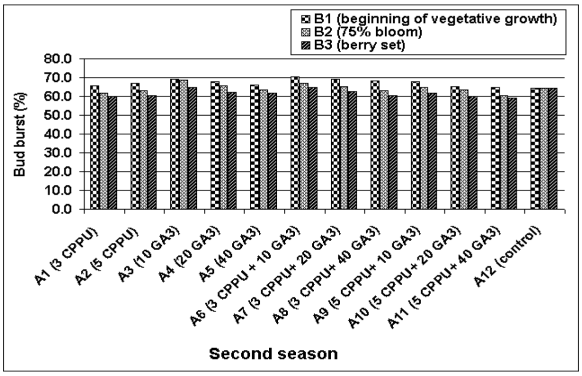
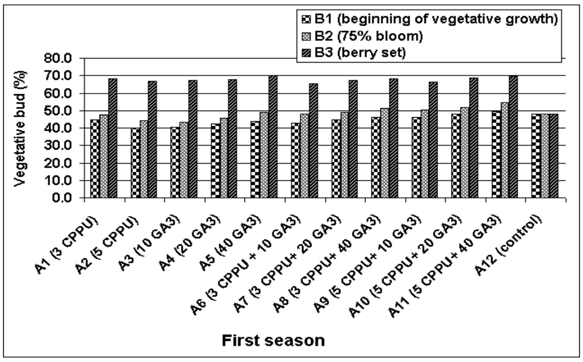


Fig (1): Foliar spraying of Sitofex and GA_3 and their effect on bud burst

More remarkable effects were obtained by the combined treatments of CPPU and GA_3 which achieved higher increase in bud burst percentage. The data revealed that, CPPU at 3 ppm plus GA_3 at 10 ppm and CPPU at 3 ppm plus GA_3 at 20 ppm treatment achieved the highest bud burst percentage when applied at the beginning of vegetative growth. Followed by the application at 75% bloom, while, spraying at berry set caused the lowest values of this parameter. The same trend was observed in both seasons. The increment may be mainly due to the benefit of spraying sitofex.

1-2- Vegetative buds:

Fig (2) shows the effect of the tested treatments on percentage of vegetative buds in both seasons. Spraying of sitofex alone at 3 ppm to 5 ppm or GA_3 at 10 ppm to 40 ppm gave a slight decrease of percentage of vegetative buds in Thompson Seedless grapevines as compared to the control. Increasing the concentration of either sitofex or gibberellin was followed by a gradual increase in the values of this parameter. Yet, slight increases were noticed by CPPU at 3 ppm plus GA_3 at 20 ppm and CPPU at 3 ppm plus GA_3 at 40 ppm when applied at the beginning of vegetative growth. CPPU at 5 ppm plus GA_3 at 20 ppm and CPPU at 5 ppm plus GA_3 at 40 ppm were found to be superior to control since they increased percentage of vegetative buds in the two successive seasons. Also, CPPU and / or GA_3 application at the beginning of vegetative growth resulted in higher values of this estimate as compared to spraying at bloom and berry set stages. The lowest vegetative bud percentages were recorded at berry set stage.



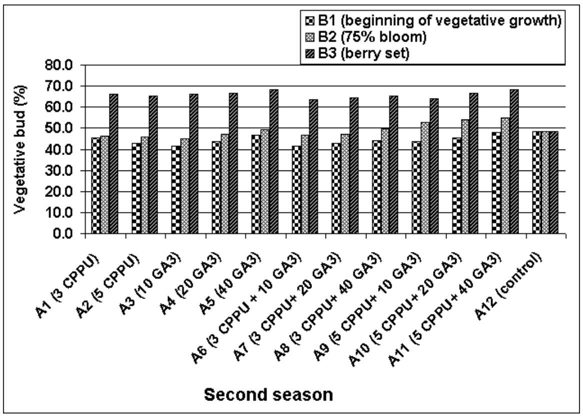


Fig (2): Foliar spraying of Sitofex and GA_3 and their effect on percentage of vegetative buds

1-3- fruitful buds:

Data in Fig. (3) and photo (1) show the percentage of fruitful buds as affected by spraying GA_3 and / or sitofex. It was observed that percentage of fruitful buds take a trend reverse to that of vegetative buds.

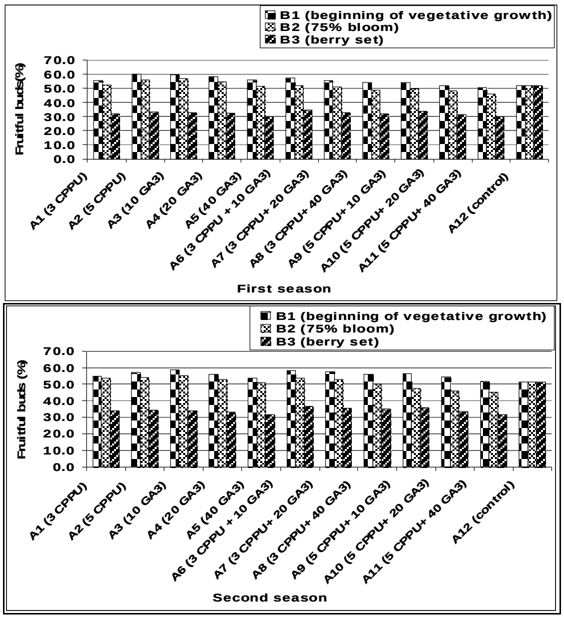
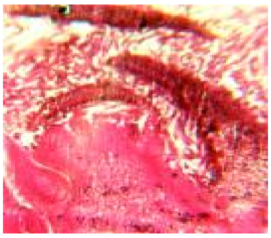
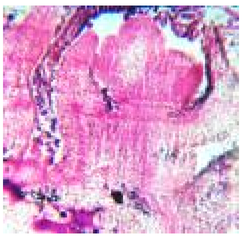


Fig (3): Foliar spraying of Sitofex and GA3 and their effect on bud fertility



Control

CPPU at 3ppm



GA_3 at 10ppm GA_3 at 10ppm + CPPU at 3ppm

Photo (1): Effect of spraying CPPU and GA_3; the branching cluster primordium appears more pronounced as compared with the control

Data revealed that, spraying grapevines with sitofex or GA3 increased percentage of fruitful buds as compared to the untreated vines, especially when higher concentrations of sitofex were applied. This result appears fact at spraying was carried out at the beginig of vegetative growth but at berry set stage it low values were obtained at spraying with CPPU at 5 ppm followed by CPPU at 3 ppm. On the other hand, GA3 was found to increase this parameter as compared with the control. The highest values were obtained when GA3 was sprayed at the low concentration (10 ppm) at the beginning of vegetative growth followed by those of 75% bloom while at berry set stage GA3 spraying resulted in the highest reduction in this estimate.

The role of gibberellins in adventitious bud development may be via an inhibitition of cell division leading to the organization of the new meristem which leads to the initiation of a primordium (Heide 1969).

As for the interaction among different sitofex and gibberellin treatments, the data clearly disclose that distinguished increments took place in both seasons of the study. In other words, the interaction between CPPU and GA_3 CPPU at 3 ppm plus GA_3 at 10 ppm achieved higher increases in percentage of fruitful buds in Thompson Seedless grape when applied at the beginning of vegetative growth, while, spraying at berry set stage caused the lowest values of this estimate in both seasons. Bigot and Nitsch, (1968) found that timing of GA_3 application was extremely important. Furthermore Ali and Fletcher, (1970) reported that, the efficiency of GA_3 for relasing buds depends on the physiological age of the buds. Spraying at 75% bloom stage ranked in between in this connection. Contrary to the above mentioned results, CPPU application at 5 ppm plus GA_3 at 20 or 40 ppm at any date caused a marked decrease in this parameter compared with other treatments for both seasons of this study.

Anyhow, it was found that all treatments at the berry set stage recorded the lowest values percentage of fruitful buds in both seasons. Concerning the effect of GA_3 when accompanied with sitofex, it was found that GA_3 at 20 or 40 ppm lessened the effect of sitofex especially, when spraying took place at berry set stage as compared with other stages. Of course, improving bud fertility seems to depend on package of factors among with viticultural practices such as fertilization, pruning, irrigation …..etc, as to be more effective in improving bud fertility when cluster induction and differentiation occurs through certain phonological stages (flowering, veraison and harvest). Time of cluster induction and initiation of grapevine inflorescence primordia in the buds begins around bloom time and continues almost until it is completed between veraison and harvest (Williams 2000). Therefore, the number of flower primorda per vine is determined during the previous year. In this respect, the discussion of bud behavior seems to be somewhat difficult since no available information could be obtained from the review concerning the effect of sitofex and / or GA_3.

However, the possible interpretation of the remarkable decrease in percentage of fruitful buds and hence in number of clusters in the bud was previous by Hassan (1984) in this study on the effect of spraying some seeded grapevine cultivars with GA_3 at different concentrations and at different stages of the growing season. It is known that spraying GA_3 especially at high concentration and through the stages in which clusters of the following year are being to be formed in the winter buds caused an inhibition of this proton.

2- Effect of different foliar applications of sitofex (CPPU) and / or GA_3 on vegetative growth:

2-1- Total shoot length, shoot diameter and internode length:

Data concerning the effect of spraying CPPU and / or GA_3 on total shoot length, shoot diameter and internode length of Thompson Seedless grapevines are shown in Table (1 and 2). It is evident from the obtained data that single or combined spraying of both CPPU and GA_3 significantly increased plant growth measurements as compared with control. Increasing concentration of sitofex from 3ppm to 5ppm and GA_3 from 10 ppm to 40ppm resulted in significant increases in shoot length, shoot diameter and internode length. Combined application of both growth regulators was necessary for attaining better vegetative growth.

The data also revealed that CPPU and GA_3 application had a positive effect on vegetative growth especially when applied at the beginning of growth (when the main shoots reached an average of 25 cm length) compared to the other stages in both seasons of this study. A similar trend was noticed as a result of the interaction between CPPU and GA_3. CPPU at 3 ppm plus GA3 at 40 ppm gave the highest values when applied at the beginning of growth, while CPPU at 3 ppm plus GA_3 at 40 ppm came next. These results obtained under the conditions of this study could be attributed to the enhancing effect of endogenous GA_3 on shoot growth as reported by Nickell,(1984). The positive action of GA_3 on vegetative growth was also supported by the results of Grzesik (1992) and El – Mogy et al (1999). The benefit of spraying CPPU on vegetative growth was cited by Arie *et al* (2008) who recorded that CPPU increased the number and density of cells. Moreover Cruz Castillo *et al* (2002) observed the stimulation of both cell division and cell expansion

2-2 Leaf area development:

It can be observed from Fig (4 and 5) that leaf area development was extremely high through the first period of growth from April 19^{th} up to July 16^{th} (at beginning of vegetative growth) during the two studied seasons, followed by a sharp decrease during the second period (75% bloom) Fig. (6 and 7) from May 16^{th} up to July 16^{th}, this decrease continued till it reached its minimal value at the berry set stage from May 31^{th} up to July 16^{th} Fig. (8 and 9).

The sharp decrease in leaf area development observed during the second period (75% bloom) from may 16^{th} up to July 16^{th} concided with the approach of blooming time the period in which temperature always record high degrees. Whereas the minimal values attained at the last period coincided with the beginning of physiological ripening of clusters.

Data also revealed that, leaf area development, in general, was increased on the average as noticed in (3 ppm CPPU plus 40 ppm GA_3) treatment in both seasons. Meanwhile, 5 ppm CPPU plus 40 ppm GA_3 came next in this respect. Data indicated also that, GA_3 treatments increased leaf area development at the beginning of vegetative growth more than that in the other stages.

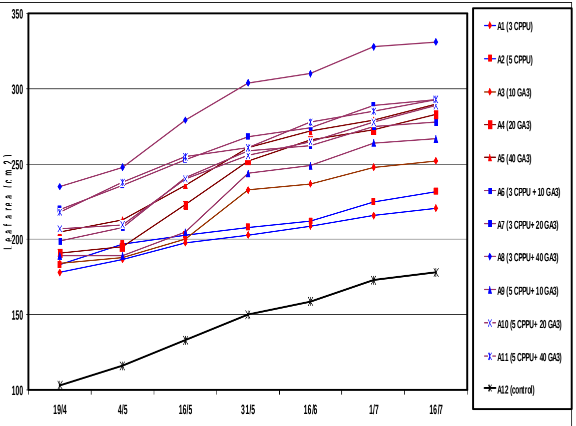


Fig. (4): Foliar spraying of Sitofex and GA_3 and their effect on leaf area development at beginning of vegetative growth in the first season

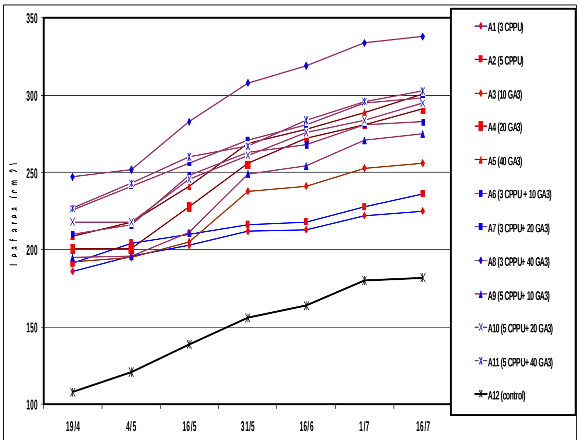


Fig. (5): Foliar spraying of Sitofex and GA_3 and their effect on leaf area development at beginning of vegetative growth in the second season

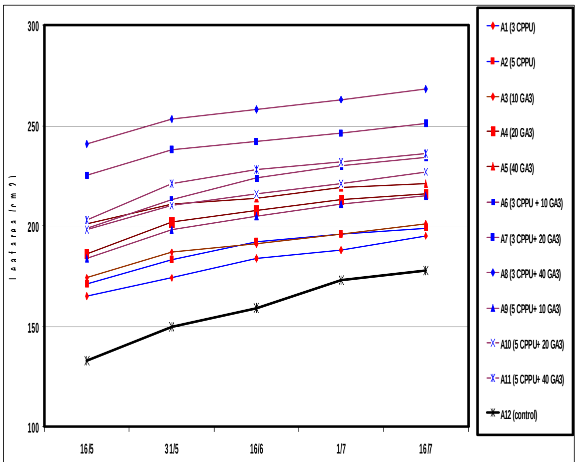


Fig. (6): Foliar spraying of Sitofex and GA_3 and their effect on leaf area development at 75% bloom in the first season

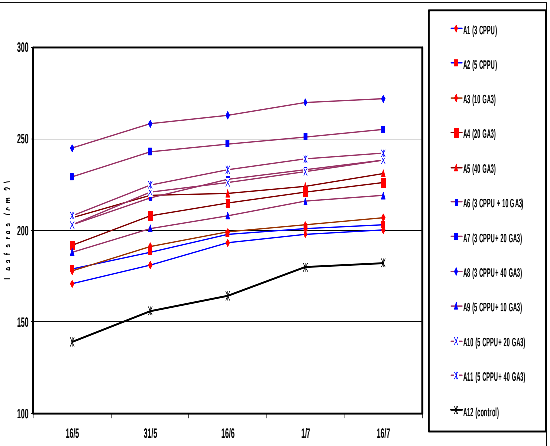


Fig. (7): Foliar spraying of Sitofex and GA_3 and their effect on leaf area development at 75% bloom in the second season

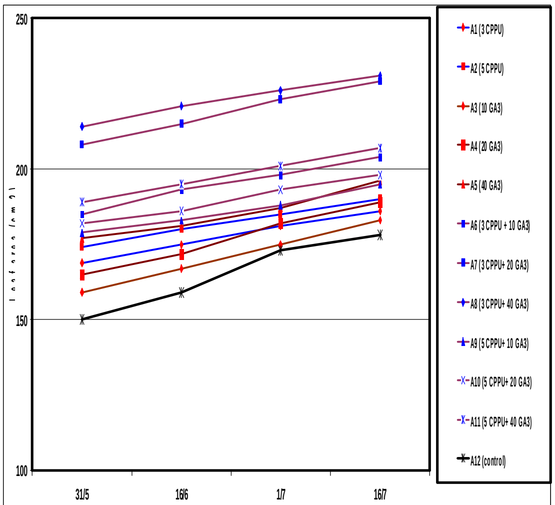


Fig. (8): Foliar spraying of Sitofex and GA_3 and their effect on leaf area development at berry set in the first season

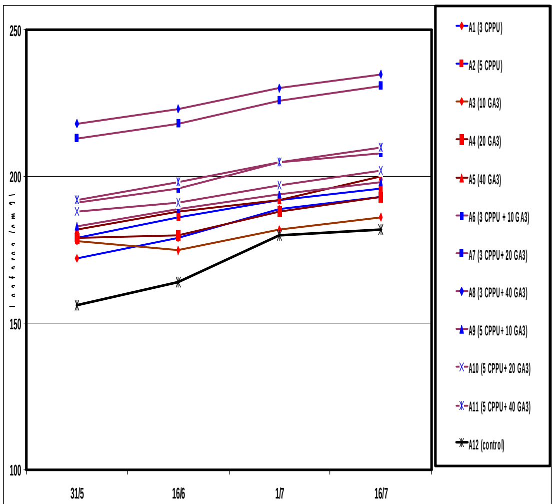


Fig. (9): Foliar spraying of Sitofex and GA_3 and their effect on leaf area development at berry set in the second season

While CPPU came next as compared to the control. Increasing the concentration of either GA_3 or CPPU was followed by a gradual increase in the leaf surface area development.

As for the interaction among different GA_3 and CPPU treatments, the data showed that distinguished increments took place in both seasons of the study at the beginning of vegetative growth stage which is considered as the best for improving this parameter more than that in the other stages. This trend holds true with all treatments, especially with the sole treatments of GA_3 or combined with CPPU.

Many investigations supported the theory that gibberellic acid plays a significant rol in regulating invertase level Tymowska and Kreis, (1998) and El-Gendy et al., (2006) which is regulated by various phytohormones that in most cases could be related to the increased carbohydrates demand of growth stimulated tissues.

The increase in leaf area development due to the application of sitofex may be ascribed to its positive role in activating the biosynthesis of proteins, RNA and DNA (Nickell, 1985a).

3- Wood ripening:-

Data dealing with dynamics of wood ripening are presented in Table (1 and 2). It is clear that sitofex alone and sitofex plus GA_3 showed the highest coefficient of wood ripening in both seasons. On the other hand control resulted in a remarkable reduction in wood ripening for both seasons of the study. However, it can be observed that sitofex was more effective in this respect followed by sitofex plus GA_3. GA_3 sprayed alone came next in this connection. This result reflects the importance of these treatments as one of the factors affecting the development of wood ripening since these treatments induce early growth and consequently, an earlier wood ripening. Sitofex application was found to increase wood ripening in Thompson Seedless grape when applied at the beginning of growth stage. The highest values were recorded at this stage in comparison with the treatments applied at bloom and fruit set stages. The results obtained in this respect indicated that GA_3 gave the same trend, applying GA_3 at 40 ppm was superior in both seasons to compared with GA_3 at 20 ppm or 10 ppm GA_3. Moreover, spraying at the beginning of growth stage gave the best results, followed by spraying at bloom stage. While, spraying at the berry set stage caused the lowest values of wood ripening. A similar trend was noticed as a result of the interaction between CPPU and GA_3. CPPU at 5 ppm plus GA_3 at 40 ppm and CPPU at 5 ppm plus GA_3 at 20 ppm which increased of wood ripening in Thompson Seedless grape when applied at the beginning of vegetative growth in comparison with the other stages.

Effect of different foliar application of sitofex and / or GA_3 on average cluster weight:

It is clear from the data shown in Table (3 and 4) that spraying sitofex at 3 and 5 ppm and GA_3 at 10, 20 and 40 ppm increased significantly the cluster weight of Thompson Seedless grapevines as compared to the control treatment.

Table (1): Foliar spraying of Sitofex and / or GA_3 and their effect on vegetative growth at the first season

Treatments	Internode length				Average shoot diameter				Average shoot length				Average leaf area				coefficient of wood ripening			
	D1	D2	D3	Means(A)	D1	D2	D3	Means(A)	D1	D2	D3	Means(A)	D1	D2	D3	Means(A)	D1	D2	D3	Means(A)
A1 (3 CPPU)	6	7	6	6	0.8	0.7	0.6	0.7	208	189	179	192	221.00	195.00	183.00	199.67	0.88	0.81	0.75	0.81
A2 (5 CPPU)	7	7	7	7	0.9	0.8	0.7	0.8	279	218	188	228	252.00	201.00	186.00	213.00	0.92	0.83	0.78	0.84
A3 (10 GA3)	6	7	6	6	0.6	0.6	0.6	0.6	224	203	181	203	232.00	199.00	189.00	206.67	0.82	0.76	0.68	0.75
A4 (20 GA3)	7	7	6	7	0.7	0.6	0.6	0.6	298	229	219	249	283.00	216.00	190.00	229.67	0.84	0.79	0.73	0.79
A5 (40 GA3)	8	8	6	7	1.0	0.9	0.6	0.8	315	236	228	260	290.00	221.00	196.00	235.67	0.86	0.81	0.73	0.80
A6 (3 CPPU + 10 GA3)	10	9	8	9	1.1	0.9	0.8	0.9	243	209	191	214	278.00	234.00	204.00	238.67	0.69	0.65	0.61	0.65
A7 (3 CPPU+ 20 GA3)	11	10	9	10	1.2	1.0	0.9	1.0	278	213	202	231	293.00	251.00	229.00	257.67	0.72	0.68	0.62	0.67
A8 (3 CPPU+ 40 GA3)	12	11	9	11	1.4	1.1	1.1	1.2	378	275	253	280	331.00	268.00	231.00	276.67	0.76	0.70	0.65	0.70
A9 (5 CPPU+ 10 GA3)	8	8	5	7	0.9	0.8	0.6	0.8	321	226	208	252	267.00	215.00	195.00	225.67	0.79	0.71	0.65	0.72
A10 (5 CPPU+ 20 GA3)	10	9	5	8	1.0	0.9	0.6	0.8	348	239	225	271	289.00	227.00	198.00	238.00	0.81	0.74	0.68	0.74
A11 (5 CPPU+ 40 GA3)	11	10	6	9	1.2	0.9	0.7	0.9	312	255	239	291	293.00	236.00	207.00	245.33	0.83	0.77	0.71	0.77
A12 (control)	4	4	4	4	0.5	0.5	0.5	0.5	149	149	149	149	178.00	178.00	178.00	178.00	0.59	0.59	0.59	0.59
Means(B)	8	8	6		0.9	0.8	0.7		279	220	205		267.25	220.08	198.83		0.79	0.74	0.68	
new L.S.D. (0.05) :																				
new L.S.D. (A) =	2				0.3				29				37.00				0.11			
new L.S.D. (B) =	1				0.1				12				14.80				0.04			
new L.S.D. (AXB) =	3				0.5				49				62.90				0.19			

B1 (beginning of vegetative growth)
B2 (75% bloom)
B3 (berry set)

Table (2): Foliar spraying of Sitofex and / or GA_3 and their effect on vegetative growth at the second season

Treatments	Internode length				Average shoot diameter				Average shoot length				Average leaf area				coefficient of wood ripening			
	D1	D2	D3	Means(A)	D1	D2	D3	Means(A)	D1	D2	D3	Means(A)	D1	D2	D3	Means(A)	D1	D2	D3	Means(A)
A1 (3 CPPU)	7	7	6	7	1.0	0.8	0.7	0.8	225	196	185	202	225.00	200.00	193.00	206.00	0.89	0.84	0.78	0.84
A2 (5 CPPU)	8	9	8	8	1.0	0.9	0.8	0.9	283	210	193	229	283.00	219.00	198.00	230.67	0.93	0.86	0.79	0.86
A3 (10 GA3)	7	8	7	7	0.8	0.7	0.7	0.7	235	208	186	210	235.00	203.00	196.00	230.67	0.85	0.80	0.70	0.78
A4 (20 GA3)	8	8	7	8	0.9	0.7	0.7	0.8	305	238	226	256	305.00	238.00	202.00	245.00	0.87	0.81	0.75	0.81
A5 (40 GA3)	8	8	8	8	1.1	1.1	0.8	1.0	342	249	232	274	342.00	242.00	210.00	251.67	0.89	0.83	0.75	0.82
A6 (3 CPPU + 10 GA3)	11	9	9	10	1.2	1.0	0.9	1.0	260	215	198	224	260.00	207.00	186.00	216.33	0.72	0.70	0.62	0.68
A7 (3 CPPU+ 20 GA3)	12	11	10	11	1.3	1.1	1.1	1.2	295	226	207	243	295.00	226.00	193.00	236.67	0.75	0.72	0.64	0.70
A8 (3 CPPU+ 40 GA3)	13	11	10	11	1.4	1.2	1.1	1.2	328	286	265	293	385.00	231.00	200.00	244.00	0.78	0.73	0.68	0.73
A9 (5 CPPU+ 10 GA3)	10	8	8	9	1.0	0.8	0.7	0.8	330	238	213	260	330.00	238.00	208.00	243.00	0.81	0.75	0.69	0.75
A10 (5 CPPU+ 20 GA3)	11	8	8	9	1.1	0.9	0.8	0.9	367	259	238	288	367.00	255.00	231.00	261.33	0.84	0.76	0.71	0.77
A11 (5 CPPU+ 40 GA3)	12	10	9	10	1.2	1.0	0.8	1.0	385	276	255	305	328.00	272.00	235.00	281.67	0.86	0.79	0.73	0.79
A12 (control)	5	5	5	5	0.4	0.4	0.4	0.4	155	155	155	155	155.00	182.00	182.00	182.00	0.61	0.61	0.61	0.61
Means(B)	9	9	8		1.0	0.9	0.8		293	230	213		273.58	226.08	202.83		0.82	0.77	0.70	
new L.S.D. (0.05) :																				
new L.S.D. (A) =	3				0.2				26				34.00				0.08			
new L.S.D. (B) =	1				0.1				10				13.60				0.03			
new L.S.D. (AXB) =	5				0.3				44				57.80				0.14			

B1 (beginning of vegetative growth
B2 (75% bloom)
B3 (berry set)

Table (3): Foliar spraying of Sitofex and GA3 and their effect on cluster weight and physical characteristics of berries at the first season

Treatments	Average cluster weight				Average weight of 100 berries				Average size of 100 berries				Average berry length				Average berry diameter				Berry shape index			
	D1	D2	D3	Means(A)	D1	D2	D3	Means(A)	D1	D2	D3	Means(A)	D1	D2	D3	Means(A)	D1	D2	D3	Means(A)	D1	D2	D3	Means(A)
A1 (3 CPPU)	550	525	512	529	215.6	209.2	203.2	209.3	210	200	190	200	1.85	1.83	1.81	1.83	1.45	1.43	1.41	1.43	1.28	1.28	1.28	1.28
A2 (5 CPPU)	592	548	526	555	237.2	228.8	223.2	229.7	220	210	210	213	1.90	1.83	1.81	1.85	1.55	1.53	1.52	1.53	1.23	1.20	1.19	1.20
A3 (10 GA3)	650	560	548	586	249.2	230.0	221.6	233.6	240	220	210	223	1.85	1.80	1.78	1.81	1.52	1.38	1.35	1.42	1.22	1.30	1.32	1.28
A4 (20 GA3)	758	580	560	633	263.2	249.2	248.4	253.6	250	240	240	243	1.90	1.85	1.80	1.85	1.43	1.42	1.40	1.42	1.33	1.30	1.29	1.31
A5 (40 GA3)	783	638	625	682	299.6	291.6	251.2	280.8	280	280	240	267	1.90	1.88	1.84	1.87	1.45	1.44	1.40	1.43	1.31	1.31	1.31	1.31
A6 (3 CPPU + 10 GA3)	700	645	629	658	264.0	261.6	240.0	255.2	250	230	200	227	1.88	1.85	1.83	1.85	1.44	1.43	1.40	1.42	1.31	1.29	1.31	1.30
A7 (3 CPPU+ 20 GA3)	775	718	689	727	291.2	265.6	263.2	273.3	275	255	250	260	1.95	1.95	1.90	1.93	1.45	1.44	1.42	1.44	1.34	1.35	1.34	1.35
A8 (3 CPPU+ 40 GA3)	788	730	716	745	314.0	304.8	276.4	298.4	290	260	200	250	2.00	1.98	1.97	1.98	1.48	1.47	1.42	1.46	1.35	1.35	1.39	1.36
A9 (5 CPPU+ 10 GA3)	565	525	519	536	222.8	220.4	209.2	217.5	200	200	200	200	1.84	1.80	1.80	1.81	1.46	1.42	1.40	1.43	1.26	1.27	1.29	1.27
A10 (5 CPPU+ 20 GA3)	650	638	615	634	254.0	246.8	234.8	245.2	235	225	220	227	1.86	1.83	1.81	1.83	1.48	1.43	1.42	1.44	1.26	1.28	1.27	1.27
A11 (5 CPPU+ 40 GA3)	700	688	671	686	263.6	258.0	247.6	256.4	250	245	240	245	1.87	1.86	1.84	1.86	1.50	1.48	1.46	1.48	1.25	1.26	1.26	1.26
A12 (control)	485	485	485	485	173.2	173.2	173.2	173.2	160	160	160	160	1.57	1.57	1.57	1.57	1.34	1.34	1.34	1.34	1.17	1.17	1.17	1.17
Means(D)	666	607	591		254.0	244.9	232.7		238	227	213		1.86	1.84	1.81		1.46	1.43	1.41		1.27	1.29	1.29	

new L.S.D. (0.05) :

	Average cluster weight	Average weight of 100 berries	Average size of 100 berries	Average berry length	Average berry diameter	Berry shape index
new L.S.D. (A) =	18	9.3	14	0.02	0.05	0.07
new L.S.D. (B) =	7	3.7	6	0.01	0.02	0.03
new L.S.D. (AXB) =	31	15.8	24	0.03	0.09	0.12

B1 (beginning of vegetative growth) B2 (75% bloom) B3 (berry set)

Table (4): Foliar spraying of Sitofex and GA3 and their effect on cluster weight and physical characteristics of berries at the second season

Treatments	Average cluster weight				Average weight of 100 berries				Average size of 100 berries				Average berry length				Average berry diameter				Berry shape index			
	D1	D2	D3	Means(A)	D1	D2	D3	Means(A)	D1	D2	D3	Means(A)	D1	D2	D3	Means(A)	D1	D2	D3	Means(A)	D1	D2	D3	Means(A)
A1 (3 CPPU)	590	558	532	560	234.8	229.0	224.0	229.3	225	220	220	222	1.87	1.85	1.83	1.85	1.55	1.45	1.45	1.48	1.21	1.28	1.26	590
A2 (5 CPPU)	610	565	548	574	258.2	251.0	236.8	248.7	250	245	230	242	1.95	1.87	1.85	1.89	1.56	1.55	1.55	1.55	1.25	1.21	1.19	610
A3 (10 GA3)	678	608	546	611	262.0	239.6	235.2	245.6	255	230	230	238	1.93	1.90	1.88	1.90	1.54	1.40	1.40	1.45	1.25	1.36	1.34	678
A4 (20 GA3)	810	625	590	675	265.6	258.0	253.6	259.1	255	250	245	250	1.96	1.91	1.85	1.91	1.50	1.44	1.42	1.45	1.31	1.33	1.30	810
A5 (40 GA3)	826	679	639	715	306.0	299.6	267.2	290.9	280	280	255	272	2.20	1.95	1.84	2.00	1.47	1.47	1.45	1.46	1.50	1.33	1.27	826
A6 (3 CPPU + 10 GA3)	763	675	658	699	276.4	273.6	265.6	271.9	260	260	260	260	1.94	1.90	1.88	1.91	1.45	1.43	1.43	1.44	1.34	1.33	1.31	763
A7 (3 CPPU+ 20 GA3)	805	728	705	746	298.0	282.8	272.0	284.3	280	270	260	270	1.98	1.97	1.92	1.96	1.47	1.45	1.44	1.45	1.35	1.36	1.33	805
A8 (3 CPPU+ 40 GA3)	823	756	729	769	316.0	310.8	284.0	303.6	290	290	275	285	2.50	2.05	1.99	2.18	1.54	1.53	1.46	1.51	1.62	1.34	1.36	823
A9 (5 CPPU+ 10 GA3)	618	550	537	568	238.0	235.2	219.6	230.9	225	220	210	218	1.90	1.87	1.82	1.86	1.46	1.43	1.42	1.44	1.30	1.31	1.28	618
A10 (5 CPPU+ 20 GA3)	715	651	639	668	262.4	252.8	238.0	251.1	250	240	220	237	1.94	1.89	1.83	1.89	1.46	1.45	1.45	1.45	1.33	1.30	1.26	715
A11 (5 CPPU+ 40 GA3)	735	703	688	709	273.2	268.8	253.6	265.2	260	250	230	247	1.95	1.90	1.85	1.90	1.57	1.53	1.48	1.53	1.24	1.24	1.25	735
A12 (control)	510	510	510	510	180.0	180.0	180.0	180.0	165	165	165	165	1.63	1.63	1.63	1.63	1.32	1.32	1.32	1.32	1.23	1.23	1.23	510
Means(D)	707	634	610		264.2	256.8	244.1		250	243	233		1.98	1.89	1.85		1.49	1.45	1.44		1.28	1.34	1.29	707

new L.S.D. (0.05) :

	Average cluster weight	Average weight of 100 berries	Average size of 100 berries	Average berry length	Average berry diameter	Berry shape index
new L.S.D. (A) =	15	11.2	11	0.03	0.04	0.06
new L.S.D. (B) =	6	4.5	4	0.01	0.02	0.02
new L.S.D. (AXB) =	26	19.0	19	0.05	0.07	0.10

B1 (beginning of vegetative growth) B2 (75% bloom) B3 (berry set)

There was a gradual and significant increase in the cluster weight with increasing concentrations of CPPU from 3 to 5 ppm and GA_3 from 10 to 40 ppm. Combined application of both growth regulators was necessary for attaining higher cluster weight. This increase can be interpreted in view of the fact that these treatments lead to the increase in photosynthetic activity in the leaves.

As a consequence of that, immigration of assimilates from leaves towards cluster is enhanced.

The data also revealed that sitofex application had a positive effect on cluster weight especially when applied at the beginning of vegetative growth as compared to the other stages in both seasons of the study. Heaver clusters were attained by the higher CPPU concentration. The same trend was observed in both seasons. The benefit of spraying sitofex on cluster weight was previously reported by Reynolds *et al* (1992), Abdul *et al* (1998) Ezzahauani (2000) and Elzayat *et al* (2004) noticed that cluster weight of (Sovereign Coronation) grapes increased linearly with increasing CPPU concentration. As for GA_3 applications data in Table (3 and 4) showed that application of GA_3 either at 10, 20 or 40 ppm increased significantly cluster weight in comparison with the control, this result holds true for both seasons. The results are in harmony with those of Navarro *et al* (2001) and El-Gendy et al (2006) who reported that, there was a significant increase in cluster weight after GA_3 application.

The increment may be mainly due to advancing the growing season starting from the beginning of vegetative growth attributed to the acceleration of carbohydrates and proteins synthesis consequently, reflecting their effect by on the availability of more organic nutrients and their movement towards the clusters causing a remarkable increase in berry weight and size.

The interaction between CPPU and GA_3 treatments recorded the maximum of the cluster weight (CPPU at 3 ppm plus GA_3 at 40 ppm). Meanwhile (CPPU at 3 ppm plus GA_3 at 20 ppm) at the beginning of vegetative growth came next. The data go in line with the results reported by Mervat *et al*., (2001) and El-Zayat *et al* (2004) who studied the effect of sitofex and its combination with GA_3 on grape cv. Thompson Seedless, the results showed that sitofex applied alone or in combination with GA_3 significantly increased the cluster weight. Meanwhile, the other treatments (CPPU plus GA_3) ranked second with significant increases over the control.

Physical characteristics of berries:

Data in Table (3 and 4) show the effect of the tested treatments on berry weight and size of 100 berries, berry length, diameter and berry index shape in the two seasons of the study spraying sitofex at 3 to 5 ppm and / or GA_3 at 10 to 40 ppm had significantly increased weight, size, length, diameter and berry index shape of berries of Thompson Seedless grapevines as compared the control.

Increasing the concentration of either CPPU or GA_3 was followed by a gradual increase in the physical characteristics of berries. Yet, a slight increase was noticed by sitofex applications than that of GA_3. The results indicated that applying sitofex at the beginning of vegetative growth increased weight, size, length, diameter and berry index shape of berries more than in the other stages (75% bloom and berry set). In this concern, the increase in these parameters due to application of sitofex might be described to its positive action on enhancing both cell division and cell elongation as well as its great role in activating the biosynthesis of proteins, RNA and DNA (Nickell, 1985a). The present results concerning the effect of sitofex on the characteristies of berries are in harmony with those obtained by Sourial *et al* (2004), El-zayat *et al* (2004), Flaishman *et al* (2006) and Maha (2008). Moreover, spraying GA_3 at the beginning of vegetative growth stage at 40 ppm was found to increase significantly these parameters. In this respect, the enhancing effect of GA_3 on the quality of berries may be ascribed to the positive action of GA_3 on stimulating cell elongation process, enhancing the water absorption and stimulating the biosynthesis of proteins which leading to the increase in berry weight, size, length and diameter. These results are in agreement with those obtained by Dokoozlian *et al* (2001), Reynolds and Savigny (2004) and Abd-Elgawad (2007) who reported that, GA_3 sprayed at 15 and 40 ppm caused a significant increase in berry volume and berry dimensions in comparison with those of control in both cultivars Thompson Seedless and Flame Seedless.

As for berry shape it was significantly increased by spraying CPPU and / or GA_3 compared with the untreated vines and it is also obvious that berry shape showed a linear increase from the onset of berries. This trend holds true with all treatments. The results obtained may be attributed to the stimulation of CPPU to periclinal berry growth resulting in a proportionally greater increase in berry diameter than berry length. In contrast, GA_3 treatments stimulated anticlinal growth, resulting in elongated berries. Berries of CPPU treated grapevines were more spherical than those of GA_3. The shape of berries becomes more global rounder when treated with cytokinins, (Dokoozlian *et al*, 1994, Retamales *et al*,1995, Mervet *et al* (2001) and Flaishman *et al* (2006).

Concerning the interaction among different CPPU and GA_3 treatments, the data clearly disclosed that distinguished increments took place in both seasons of the study. In other words, the interaction between CPPU and GA_3 (CPPU at 3 ppm plus GA_3 at 40 ppm) and (CPPU at 3 ppm plus GA_3 at 20 ppm) came next at berry set which is considered as the best in improving these parameters. The data go in line with the results reported by Dokoozlian *et al* (1994), Mervet *et al* (2001) who studied the effect of CPPU and its combination with GA_3 at 40 ppm and / or CPPU at 3 and 5 ppm on grape cv. Thompson Seedless. The results showed that sitofex alone or in combination with GA_3 significantly increased berry growth.

Chemical characteristics of berries:

The data regarding the effect of sitofex, GA_3 and their interaction on TSS, acidity and TSS / acid ratio in the berries of Thompson Seedless grapevines in both seasons are presented in Table (5 and 6). It is apparent that the single application of sitofex (CPPU) increased the percentage of total soluble solids and lowered the total acidity of the juice as compared with the control. In this respect, 5 ppm CPPU gave generally better results as it increased TSS and reduced acidity than the lower concentration. The results agree with those obtained by Cai Li Hong *et al* (1996) who showed that CPPU increased soluble solids content in ⁽Fujiminori⁾ grape and Nie *et al* (2000) in Langan. Cv. Shixia Moreover, Duane (2001) noticed that the total soluble solids of ⁽Macintosh⁾ apple were increased by spraying CPPU. As for the effect of CPPU on juice acidity, it took an opposite trend to that noticed with TSS. GA_3 foliar application was found to increase TSS percentage and decrease total acidity in berry juice. Increasing the concentration of GA_3 was followed by a gradual increase in TSS and a decrease in acidity. Moreover, GA_3 at 40 ppm gave generally better results and reduced acidity more than the lower concentration.

These results confirm those findings obtained by Shaaban *et al* (1992) who reported that manipulation with GA_3 resulted in an increase in TSS% in grape juice of Thompson Seedless and Reynolds and Savigny (2004) who found that GA_3 sprayed at 15 and 40 ppm on ⁽Sovereign Coronation⁾ caused a slight increase in degrees Brix.

These findings could be due to the enhancing effect of GA_3 on increasing leaf area and amount of assimilates directed to the berries (Mostafa 1989). However, the effect of GA_3 on reducing acidity was given by Mahmoud *et al* (1989), Singh *et al* (1994) and Reynolds and Savigny (2004) who pointed out that GA_3 application resulted in a decrease in the total acidity percentage of berry juice.

More pronounced effects were obtained by combined treatments of CPPU and GA_3 which achieved higher increase in TSS percentage and decreases in acidity. The data revealed that, CPPU at 3 ppm plus GA_3 at 40 ppm and CPPU at 5 ppm plus GA_3 at 40 ppm treatments achieved the highest TSS and lowest acidity without any significant differences among treatments in both seasons.

Abdul *et al* (1998) found that the combined treatment CPPU and GA_3 reduced titratable acidity and increased TSS of ⁽Fujiminori⁾ grape. However, significant differences were noticed among treatments regarding the effect of application data on TSS and acidity, in the two seasons under study, Moreover, spraying at the beginning vegetative growth stage gave the best results, while, spraying at the berry set stage recorded the least values of theses parameters. The increase in TSS as a result of spraying at the beginning of vegetative growth stage as compared to other stages can be interpreted in view of the fact that in this stage surface area and shoot length were increased leading to the increase in photosynthetic activity of leaves. As a consequence of that, immigration of assimilates from leaves towards berries is enhanced.

TSS / acidity:

Data shown in Table (5 and 6) revealed that CPPU at 3 ppm concentration significantly decreased this ratio compared to the control. This decrease showed an opposite trend to CPPU concentrations in the first season, whereas the differences between CPPU at 3 to 5 ppm were insignificant in the second season. Concerning GA_3 application data revealed that, increasing concentration of GA_3 from 10 to 40 ppm resulted in significant increases in TSS / acidity in both seasons. The results are in line with those obtained by Tambe (2002) who studied the effect of Gibberellic acid at 7, 10, 20, 30 or 40 ppm on Thompson Seedless cv. and found GA_3 caused an increase in the values of TSS / acid ratio.

The data also indicated that spraying CPPU and / or GA_3 had a positive effect on TSS / acidity especially when applied at the beginning of vegetative growth stage compared to the other stages in the two seasons. A similar trend was noticed as a result of the interaction between CPPU and GA_3. CPPU at 3 ppm plus GA_3 at 40 ppm and CPPU at 5 ppm plus GA_3 at 40 ppm gave the highest values but without significant differences between them. This result may be ascribed to the higher concentration of sitofex.

From the foregoing results, it can be concluded that, the spraying at the beginning of vegetative growth with sitofex and / or GA_3 at lowest concentrations (CPPU at 3 ppm or GA_3 at 10 ppm) gave the highest increase of bud burst and fruitful buds percentage using a combination of CPPU at 3 ppm plus GA_3 at 40 ppm resulted in improving vegetative growth, cluster weight and berry quality in Thompson Seedless grapevines.

Table (5): Foliar spraying of Sitofex and GA_3 and their effect on chemical characteristics of berries at the first season

Treatments	TSS				Acidity				TSS/acid ratio			
	D1	D2	D3	Means(A)	D1	D2	D3	Means(A)	D1	D2	D3	Means(A)
A1 (3 CPPU)	18.2	18.0	17.5	17.9	0.59	0.60	0.69	0.63	30.8	30.0	25.4	28.7
A2 (5 CPPU)	18.3	18.6	18.6	18.5	0.56	0.57	0.59	0.57	32.7	32.6	31.5	32.3
A3 (10 GA3)	18.6	18.3	18.1	18.3	0.57	0.59	0.60	0.59	32.6	31.0	30.2	31.3
A4 (20 GA3)	19.1	18.9	18.5	18.8	0.55	0.56	0.57	0.56	34.7	33.8	32.5	33.6
A5 (40 GA3)	19.5	19.0	18.8	19.1	0.50	0.53	0.56	0.53	39.0	35.8	33.6	36.1
A6 (3 CPPU + 10 GA3)	19.5	19.0	18.8	19.1	0.54	0.55	0.56	0.55	36.1	34.5	33.6	34.7
A7 (3 CPPU+ 20 GA3)	19.8	19.6	19.2	19.5	0.53	0.54	0.55	0.54	37.4	36.3	34.9	36.2
A8 (3 CPPU+ 40 GA3)	20.1	19.8	19.6	19.8	0.51	0.53	0.54	0.53	39.4	37.4	36.3	37.7
A9 (5 CPPU+ 10 GA3)	18.9	18.8	18.5	18.7	0.55	0.55	0.56	0.55	34.4	34.2	33.0	33.9
A10 (5 CPPU+ 20 GA3)	19.8	19.5	19.0	19.4	0.51	0.53	0.55	0.53	38.8	36.8	34.5	36.7
A11 (5 CPPU+ 40 GA3)	20.1	19.6	19.4	19.7	0.50	0.52	0.53	0.52	40.2	37.7	36.6	38.2
A12 (control)	16.9	16.9	16.9	16.9	0.73	0.73	0.73	0.73	23.2	23.2	23.2	23.2
Means(B)	19.1	18.8	18.6		0.55	0.57	0.59		32.1	33.9	34.7	

new L.S.D. (0.05) :	TSS	Acidity	TSS/acid ratio
new L.S.D. (A) =	0.3	0.05	1.7
new L.S.D. (B) =	0.1	0.02	0.7
new L.S.D. (AXB) =	0.5	0.09	2.9

B1 (beginning of vegetative growth) B2 (75% bloom) B3 (berry set)

Table (6): Foliar spraying of Sitofex and GA_3 and their effect on chemical characteristics of berries at the second season

Treatments	TSS				Acidity				TSS/acid ratio			
	D1	D2	D3	Means(A)	D1	D2	D3	Means(A)	D1	D2	D3	Means(A)
A1 (3 CPPU)	18.5	18.3	17.8	18.2	0.56	0.58	0.68	0.61	33.0	31.6	26.2	30.3
A2 (5 CPPU)	18.8	18.4	18.0	18.4	0.56	0.57	0.59	0.57	33.6	32.3	30.5	32.1
A3 (10 GA3)	18.8	18.6	18.3	18.6	0.56	0.56	0.59	0.57	33.6	33.2	31.0	32.6
A4 (20 GA3)	19.5	19.0	18.8	19.1	0.54	0.55	0.56	0.55	36.1	34.5	33.6	34.7
A5 (40 GA3)	19.7	19.5	19.1	19.4	0.53	0.53	0.55	0.54	37.2	36.8	34.7	36.2
A6 (3 CPPU + 10 GA3)	19.9	19.8	19.0	19.6	0.53	0.54	0.56	0.54	37.5	36.7	33.9	36.0
A7 (3 CPPU+ 20 GA3)	20.1	20.0	19.5	19.9	0.50	0.52	0.55	0.52	40.2	38.5	35.5	38.0
A8 (3 CPPU+ 40 GA3)	20.3	20.3	19.8	20.1	0.49	0.51	0.54	0.51	41.4	39.8	36.7	39.3
A9 (5 CPPU+ 10 GA3)	19.1	18.8	18.5	18.8	0.55	0.56	0.56	0.56	34.7	33.6	33.0	33.8
A10 (5 CPPU+ 20 GA3)	20.2	19.6	18.9	19.6	0.50	0.52	0.56	0.53	40.4	37.7	33.8	37.3
A11 (5 CPPU+ 40 GA3)	20.4	20.1	20.0	20.2	0.49	0.50	0.50	0.50	41.6	40.2	40.0	40.6
A12 (control)	16.5	16.5	16.5	16.5	0.75	0.75	0.75	0.75	22.0	22.0	22.0	22.0
Means(B)	18.8	19.0	19.3		0.58	0.56	0.55		32.9	34.7	35.7	

new L.S.D. (0.05) :	TSS	Acidity	TSS/acid ratio
new L.S.D. (A) =	0.2	0.04	1.3
new L.S.D. (B) =	0.1	0.02	0.5
new L.S.D. (AXB) =	0.3	0.1	2.2

B1 (beginning of vegetative growth) B2 (75% bloom) B3 (berry set)

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