EFFECT OF FOLIAR APPLICATION OF AMINO ACIDS, BENZYL ADENINE, AND NANO NPK ON POLLEN TRAITS, AND SOME CHARACTERISTICS OF GRAPE

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ABSTRACT

This study was carried out in a private vineyard, located in Sulaymaniyah governorate, Kurdistan region-Iraq, during the growing season (2022) to investigate the effect of foliar applications of amino acids (0, 5, 10 mL.L^{-1}), benzyl adenine (0, 100, 200 mg.L^{-1}), and Nano-NPK fertilizer (0, 2, 4 g.L^{-1}) and their interactions on the activity of pollen grains and some chemical components. The results confirmed that 10 mg.L^{-1} amino acid produced the highest pollen viability, pollen germination, leaf chlorophyll content, total carotene, and vitamin C, while it caused a significant decrease in total phenol compared to the control. Benzyl adenine, 200mg.L^{-1} gave the highest significant values of the undertaken parameters except for phenol and vitamin C, they were not affected by spraying BA. Nano-NPK fertilizer at 4g.L^{-1} poduced the highest significant means of parameters. Meanwhile, the triple interaction effects of 10 mg.L^{-1} AA + 200mg.L^{-1} BA + 4g.L^{-1} Nano-NPK obtained the superior significant values of pollen viability, pollen germination, leaf chlorophyll content, total carotene, vitamin C, the least significant value of total phenol compared to the remainder treatment combinations and control.

Keywords: Pollen, phenol, Carotene, *Vitis vinifera* L.,' Thompson Seedless'.
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تأثير الرش الورقي للأحماض الأمينية والبنزيل أدينين والأسمدة النانوية على صفات حبوب اللقاح ومحتوى الكلوروفيل والخصائص الكيميائية للعنب

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المستخلص

أجريت هذه الدراسة في مزرعة عنب خاصة تقع في محافظة السليمانية ، إقليم كردستان العراق ، اثناء موسم النمو (2022) لبحث تأثير رش الاوراق بالأحماض الأمينية (0 ، 5 ، 10 مل/ لتر) ، بنزيل أدينين (0 ، 100 ، 200 ملغم/ لتر) ، وسماد نانو NPK (0 ، 2 ، 4 غم/ لتر) وتداخلاتها على نشاط حبوب اللقاح وبعض المكونات الكيميائية. أكدت النتائج أن 10 ملغم/لتر من الأحماض الأمينية أعطت أعلى قيم لحيوية حبوب اللقاح، إنبات حبوب اللقاح، محتوى الكلوروفيل، الكاروتين الكلي، وفيتامين C ، بينما تسبب في انخفاض معنوي في إجمالي الفينول مقارنة بالشاهد. أعطى البنزيل أدينين 200 ملغم/لتر أعلى قيم معنوية للمعلمات التي تم إجراؤها باستثناء الفينول وفيتامين C حيث لم يتأثروا بالرش بالبنزيل ادينين. أعطى سماد نانو NPK عند 4 غم/لتر أعلى متوسطات معنوية للمعلمات. وفي الوقت نفسه، فإن تأثيرات التداخل الثلاثي لـ 10 مغم اخماض امينية + 200 ملغم/لتر بنزيل الادينين + 4 غم/لتر نانو NPK حصلت على القيم المهمة المتفوقة لحيوية حبوب اللقاح، إنبات حبوب اللقاح، محتوى الأوراق من الكلوروفيل، إجمالي الكاروتين، فيتامين C، أقل قيمة معنوية لإجمالي الفينول مقارنة بباقي المعاملات.

الكلمات المفتاحية: حبوب اللقاح، فينول، الكاروتين ، *Vitis vinifera* L. ، ثومبسن سيدلس
جزء من أطروحة دكتوراه للباحث الأول.

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INTRODUCTION

The history of Viticulture began seven to eight thousand years ago when the grape (*Vitis* sp.) was domesticated in some areas in middle Asia (10). The grapes (*Vitis vinifera* L.) refer to the Vitaceae family and are cultivated between 20-50° north and 20-40° south latitudes (7, 35). Grapes are rich in vitamins A, B6, and C, carbohydrates, amino acids, proteins, and indispensable macro and micronutrients, in addition to folates and flavonoids which are considered as very powerful antioxidants, therefore, grape plays an important role in ensuring a healthy and active life (32, 19, 34). Many trials have been carried out for increasing plants fertility, reproductive biology, and fruit quality by the use of different factors. The application of amino acids, plant growth regulators, and Nano-fertilizers (37). The basic component of living cells is proteins, with building block materials; proteins are formed by a sequence of amino acids. Plants synthesize amino acids from the primary elements, the carbon and oxygen obtained from air, and hydrogen from water, forming carbohydrates via photosynthesis and combining them with the nitrogen obtained from the soil, leading to the synthesis of amino acids (8). Plant growth regulators are represented by plant hormones or their synthetic analogs which play important roles either in the promotion or inhibition of hormone biosynthesis, translocation, and hormone receptor blockers (23). Benzyl adenine as the first-generation of synthetic cytokinins, elicit plant growth and development responses, play crucial roles in setting blossoms and stimulating fruit richness by activating cell division (9) and stimulate plant growth (4, 33). Nano-fertilizers (NFs) are synthesized or modified forms of traditional fertilizers, they are either bulk materials or extracted from different vegetative or reproductive plant parts by different chemical, physical, mechanical, or biological methods using Nanotechnology (27). NFs have higher surface area due to the very low size of their particles which are smaller than root and leaf pores (25). In general, NFs are known to protect plants from different biotic and abiotic stresses where they build carbon uptake (14), improve chlorophyll formation and photosynthetic activity (13), increase dry matter (21), increase penetration and uptake of nutrients (18), resulting in better yield and food quality and enhance soil fertility (1, 2, 3, 22). The objective of the present study is to find out the effect of foliar applications of amino acids, benzyl adenine, and Nano fertilizer on some fertility traits including pollen activity, and chemical constituents of grape berries cv. 'Thompson Seedless'.

MATERIALS AND METHODS

This study was carried out in a private vineyard, located in Sulaymaniyah governorate, during the growing season (2022) to investigate the effect of foliar application of amino acids (Tecamin Max) at (0, 5, 10 $mL.L^{-1}$), benzyl adenine (0, 100, 200 $mg.L^{-1}$), and Nano-NPK fertilizer (0, 2, 4 $g.L^{-1}$) and their interactions on the pollen activity and some fruit and leaf chemical components of grape cv. 'Thompson Seedless'. The experiment consisted of 27 treatments, 3 concentrations of each (amino acids × benzyl adenine × Nano-NPK) with 3 replicates, using a grapevine as a replicate, so the total number of grapevines was 81, and the experiment was applied as a factorial (RCBD) experiment. All results were analysed statistically by using SAS program (24). The Duncan's multiple range tests ($P \leq 0.05$) were used to compare the treatment means according to (6). The experimental grapevines were chosen to be uniform as much as possible in vigor. Foliar application of amino acids, benzyl adenine, and Nano-NPK fertilizer was carried out twice per season; the first spray was applied two weeks before full bloom, and the second spray was done two weeks after berry set. The decided concentrations were dissolved in a litre of water, Tween-20, as a wetting agent at 0.1% was added to all spraying solutions, and sprayings were carried out till runoff. All grapevines utilized in this study were receiving the regular agricultural and horticultural operations that are usually carried out in the fruit orchards. Potential effects of the three factors were evaluated in terms of the change in grapevines' characteristics including; The percentage of the pollen grain viability, the pollen germination percentage, chlorophyll content, total carotene, total phenol, and vitamin C (ascorbic acid) contents.

RESULTS AND DISCUSSION

Pollen viability (%): In table (1) are shown the effect of studied factors; amino acid (AA), benzyl adenine (BA), Nano-NPK fertilizer (NF), each solely or their triple interaction on pollen viability of grapevine cv. 'Thompson Seedless'. It is clear that this parameter was significantly affected by all three factors under study. Regarding the effect of amino acid treatments, the significant highest value of pollen viability (88.07%) was resulted from spraying 10 mg.L^{-1} AA, which was significantly superior on other levels, however the lowest value (79.84%) was given by control. As for the effect of BA, 200 mg.L^{-1} resulted in (86.60%) pollen viability which was significantly superior to 100 mg.L^{-1} (83.73%), both of which were statistically superior to control (78.15%). About the effect of Nano-NPK fertilizer, 4 g.L^{-1} gave the value (85.78%) which was significantly higher than that of 2 g.L^{-1} (83.22%), both of these were significantly higher than control (79.49%). The results of triple interaction treatments (AA x BA x NF) showed that the highest mean (93.24%) recorded from (10 mg.L^{-1} AA + 200 mg.L^{-1} BA + 4 g.L^{-1} NF), this combination was significantly superior to the majority of other triple combinations except some of which located under 10 mg.L^{-1} AA. However the lowest significant mean value (66.68%) was shown by control (0 mg.L^{-1} AA + 0 mg.L^{-1} BA + 0 g.L^{-1} N-NPK).

Table 1. Effect of foliar application of amino acids, benzyl adenine and Nano-NPK fertilizers on pollen viability% of grapevine cv. 'Thompson Seedless'

AA † (mg.L^{-1})	BA (mg.L^{-1})	NF (g.L^{-1}) 0		2		4		AA x BA		AA	
	0	66.68	j‡	77.79	g-i	79.41	f-i	74.63	e		
0	100	78.88	f-j	82.47	d-h	84.38	c-g	81.91	cd	79.84	b
	200	80.89	e-i	80.90	e-i	87.14	a-f	82.98	cd		
	0	73.70	i	75.88	hi	78.19	ghi	75.92	e		
5	100	78.76	f-i	80.85	e-i	82.09	d-h	80.57	d	80.57	b
	200	79.90	f-i	84.15	c-h	91.66	a-c	85.24	bc		
	0	81.04	e-i	84.93	b-g	85.78	a-g	83.92	cd		
10	100	87.04	a-f	88.96	a-e	90.11	a-d	88.70	ab	88.07	a
	200	88.55	a-e	93.02	ab	93.24	a	91.60	a		
NF		79.49	c	83.22	b	85.78	a				
AA	0	75.48	e	80.39	cd	83.64	bc				
x	5	77.45	de	80.29	cd	83.98	bc	BA			
NF	10	85.54	ab	88.97	a	89.71	a				
BA	0	73.80	e	79.53	d	81.13	cd	78.15 c		c	
x	100	81.56	b-d	84.09	bc	85.53	bc	83.73 b		b	
NF	200	83.11	b-d	86.02	b	90.68	a	86.60 a		a	

† AA: Amino acids, BA: Benzyl adenine, NF: Nano-NPK fertilizer, N: nitrogen, P: phosphorus, K: potassium.
‡ Means with the same letters are not significantly different according to Duncan multiple ranges test (P≤0.05).

Pollen germination (%)

As indicated in (Table 2) below, significant differences were observed in average pollen germination% of grapevine cv. 'Thompson Seedless' due to the effects of spraying AA, BA, NF and their interactions as well. Spraying with 10 mg.L^{-1} AA caused the highest average of pollen germination (84.42%), which was significantly higher than the averages resulted from both 5 mg.L^{-1} AA (80.00%) and control (81.85%). Concerning the effect of BA, 200 mg.L^{-1} resulted in the highest significant average of pollen germination (84.54%), which was significantly superior to 100 mg.L^{-1} (81.28%) and control (80.45%). Due to the effect of NF, 4 g.L^{-1} with (85.29%) pollen germination percentage was statistically superior to 2 g.L^{-1} (80.25%) and control (80.73%). Three-way interaction effects also caused significant differences in pollen germination%, in which (10 mg.L^{-1} AA + 200 mg.L^{-1} BA + 4 g.L^{-1} NF) with (93.92%) was significantly superior to all other triple combination effects, whereas, the significantly lowest percent pollen germination (70.06%) was resulted from control.

Table 2. Effect of foliar application of amino acids, benzyl adenine and Nano-NPK fertilizers on pollen germination% of grapevine cv. 'Thompson Seedless'

AA † (mg.L^{-1})	BA (mg.L^{-1})	NF (g.L^{-1}) 0		2		4		AA x BA		AA	
	0	70.06	i ‡	83.45	c-f	83.01	c-g	78.84	cd		
0	100	74.83	hi	86.48	bcd	86.38	bcd	82.57	a-c	81.85	b
	200	80.90	d-h	81.46	d-h	90.05	abc	84.14	a		
	0	78.08	e-h	79.20	d-h	80.94	d-h	79.40	bcd		
5	100	81.16	d-h	77.46	fgh	69.83	i	76.15	d	80.00	b
	200	81.78	d-h	76.76	f-j	94.77	a	84.44	a		
	0	83.07	c-g	83.07	c-g	83.12	c-g	83.09	ab		
10	100	91.22	ab	78.55	e-h	85.60	b-e	85.12	a	84.42	a
	200	85.44	b-e	75.81	ghj	93.92	a	85.06	a		
NF		80.73	b	80.25	b	85.29	a				
AA	0	75.27	e	83.80	ab	86.48	a				
x	5	80.34	bcd	77.81	cd	81.85	bc	BA			
NF	10	86.58	a	79.14	cd	87.55	a				
BA	0	77.07	d	81.91	bc	82.36	b	80.45	b		
x	100	82.41	b	80.83	bcd	80.60	b-d	81.28	b		
NF	200	82.71	b	78.01	cd	92.92	a	84.54	a		

† AA: Amino acids, BA: Benzyl adenine, NF: Nano-NPK fertilizer, N: nitrogen, P: phosphorus, K: potassium.
‡ Means with the same letters are not significantly different according to Duncan multiple ranges test (P≤0.05).

Leaf total chlorophyll content (µg.m$^{2-1}$)

Table 3 below shows the significant effectiveness of spraying grapevines cv. 'Thompson Seedless' with different doses of AA, BA, NF and their triple interaction effects on leaf total chlorophyll content (mg.g^{-1} f. w.). As it is clear from the table, spraying with 10 mg.L^{-1} AA resulted in the highest significant mean value (172.63 mg.g^{-1}) which was significantly different from both 5 mg.L^{-1} (165.99 mg.g^{-1}), and control (164.93 mg.g^{-1}). As the result of spraying BA, no significant difference occurred in total chlorophyll content between 200 mg.L^{-1} with (172.68 mg.g^{-1}) and 100 mg.L^{-1} with (168.18 mg.g^{-1}), both of which were significantly dominated onto control (162.69 mg.g^{-1}). Regarding Nano-NPK fertilizer, it was observed that no significant difference occurred between 4 g.L^{-1} (172.00 mg.g^{-1}) and 2 g.L^{-1} (168.59 mg.g^{-1}), however, both of these were statistically dominated on control (162.96 mg.g^{-1}).

Table 3. Effect of foliar application of amino acids, benzyl adenine and Nano-NPK fertilizer on chlorophyll grapevine cv. 'Thompson Seedless'

AA † (mg.L^{-1})	BA (mg.L^{-1})	NF (g.L^{-1}) 0		2		4		AA x BA		AA	
	0	145.58	d ‡	160.17	b-d	170.32	a-c	158.69	c		
0	100	157.23	cd	168.08	a-c	174.85	ab	166.72	bc	164.93	b
	200	163.22	bc	169.97	a-c	174.99	ab	169.39	ab		
	0	157.02	cd	161.69	bc	161.03	bc	159.91	c		
5	100	162.07	bc	170.21	a-c	167.53	a-c	166.60	bc	165.99	b
	200	169.97	a-c	170.16	a-c	174.27	ab	171.46	ab		
	0	167.50	a-c	169.08	a-c	171.86	a-c	169.48	ab		
10	100	169.33	a-c	171.36	a-c	172.98	a-c	171.22	ab	172.63	a
	200	174.72	ab	176.62	ab	180.21	a	177.18	a		
NF		162.96	b	168.59	a	172.00	a				
AA	0	155.34	c	166.07	ab	173.39	a				
x	5	163.02	bc	167.35	ab	167.61	ab	BA			
NF	10	170.52	ab	172.35	a	175.02	a				
BA	0	156.70	d	163.65	b-d	167.74	a-c	162.69	b		
x	100	162.87	cd	169.89	a-c	171.78	a-c	168.18	a		
NF	200	169.30	a-c	172.25	ab	176.49	a	172.68	a		

† AA: Amino acids, BA: Benzyl adenine, NF: Nano-NPK fertilizer, N: nitrogen, P: phosphorus, K: potassium.
‡ Means with the same letters are not significantly different according to Duncan multiple ranges test (P≤0.05).

Triple-effects, on the other hand, caused significant differences in total chlorophyll content, in which the combination of (10 mg.L^{-1} AA + 200 mg.L^{-1} BA + 4 g.L^{-1} NF) was found to give the highest significant value (180.21 mg.g^{-1}), compared to the majority of other combinations, meanwhile, the lowest value (145.58 mg.g^{-1}) was observed from control.

Total Carotene (mg.kg^{-1})

In table (4) below, is notified that there were significant differences in total carotene (mg.kg^{-1}) content of grape barriers cv. 'Thompson Seedless' as affected by different levels of amino acids (AA), benzyl adenine (BA), Nano-NPK fertilizer (NF) and their interactions. The data presented here signify the effect of 10 mg.L^{-1} AA which resulted in the highest value of TC (2.04 mg.kg^{-1}) which was significantly superior on both 5 mg.L^{-1} AA (1.67 mg.kg^{-1}) and control (1.43 mg.kg^{-1}). Regarding benzyl adenine, the highest significant average (1.95 mg.kg^{-1}) was recorded from 200 mg.L^{-1} with no significant difference from 100 mg.L^{-1} (1.70 mg.kg^{-1}). However, the lowest significant value (1.50 mg.kg^{-1}) was recorded from control. As for the effect of Nano-NPK fertilizer (NF), it was found that the level 4 g.L^{-1} gave the value (1.89 mg.kg^{-}) was not significantly different from 2 g.L^{-1} (1.70 mg.kg^{-1}), however the lowest significant average (1.56 mg.kg^{-1}) was recorded from control.

Table 4. Effect of foliar application of amino acids, benzyl adenine and Nano-NPK fertilizers on total carotene of grapevine cv. 'Thompson Seedless'

AA † (mg.L^{-1})	BA (mg.L^{-1})	NF (g.L^{-1}) 0	2	4	AA x BA	AA
	0	1.16 bc ‡	1.22 bc	1.14 c	1.17 c	
0	100	1.24 bc	1.46 bc	1.63 abc	1.44 bc	1.43 b
	200	1.55 bc	1.70 abc	1.81 abc	1.69 bc	
	0	1.39 bc	1.40 bc	1.66 abc	1.48 bc	
5	100	1.62 abc	1.62 abc	1.89 abc	1.71 bc	1.67 b
	200	1.69 abc	1.77 abc	2.00 abc	1.82 ab	
	0	1.49 bc	1.94 abc	2.06 abc	1.83 ab	
10	100	1.86 abc	1.88 abc	2.10 abc	1.95 ab	2.04 a
	200	2.02 abc	2.29 ab	2.73 a	2.34 a	
NF		1.56 b	1.70 ab	1.89 a		
AA	0	1.32 c	1.46 bc	1.53 bc		
x	5	1.57 bc	1.60 bc	1.85 abc	BA	
NF	10	1.79 abc	2.03 ab	2.30 a		
BA	0	1.35 b	1.52 b	1.62 ab	1.50 b	
x	100	1.57 ab	1.65 ab	1.87 ab	1.70 ab	
NF	200	1.75 ab	1.92 ab	2.18 a	1.95 a	

† **AA: Amino acids, BA: Benzyl adenine, NF: Nano-NPK fertilizer, N: nitrogen, P: phosphorus, K: potassium.**

‡ **Means with the same letters are not significantly different according to Duncan multiple ranges test (P≤0.05).**

The tertiary effect of all studied factors showed that the interaction (10 mg.L^{-1} AA + 200 mg.L^{-1} BA + 4 g.L^{-1} NF) again recorded the highest significant value of total carotene (2.73 mg.kg^{-1}) compared to the other triple interactions, while the lowest significant value (1.16 mg.kg^{-1}) was recorded from control.

Total Phenol (%)

As clarified in (Table 5), which shows the effect of different studied factors; AA, BA, NF and their interactions on total phenol% of grape berries cv. 'Thompson Seedless'. The table shows that significant and nonsignificant differences occurred. As the result of amino acids effect, 10 mg.L^{-1} caused the lowest significant value (1.458%) which was not significantly different from 5 mg.L^{-1} with (1.563%), however untreated vines (control) gave the highest significant value (1.618%). Regarding benzyl adenine, no significant differences observed due to the effect of different spray application levels. However, different levels of NF gave significant differences, i.e.; 4 g.L^{-1} gave the lowest significant value of total phenol (1.47%) which was significantly not different from 2 g.L^{-1} (1.54%), whereas the highest significant average of total phenol (1.63%) was recorded from control.

Table 5. Effect of foliar application of amino acids, benzyl adenine and Nano-NPK fertilizers on phenol of grapevine cv. 'Thompson Seedless'

AA † (mg.L^{-1})	BA (mg.L^{-1})	NF (g.L^{-1}) 0		2		4		AA x BA		AA	
	0	2.08	a‡	1.61	b	1.56	b	1.75	a		
0	100	1.63	b	1.55	b	1.52	b	1.57	ab	1.618	a
	200	1.61	b	1.52	b	1.47	b	1.53	a-c		
	0	1.68	b	1.49	b	1.34	b	1.50	bc		
5	100	1.61	b	1.52	b	1.62	b	1.58	ab	1.563	ab
	200	1.58	b	1.59	b	1.64	b	1.60	ab		
	0	1.43	b	1.63	b	1.52	b	1.52	a-c		
10	100	1.51	b	1.48	b	1.57	b	1.52	a-c	1.458	b
	200	1.58	b	1.44	b	0.97	c	1.33	c		
NF		1.63	a	1.54	ab	1.47	b				
AA	0	1.77	a	1.56	bc	1.52	bc				
x	5	1.62	ab	1.53	bc	1.53	bc		BA		
NF	10	1.51	bc	1.51	bc	1.35	c				
BA	0	1.73	a	1.57	ab	1.47	b	1.59	a		
x	100	1.59	ab	1.52	ab	1.57	ab	1.56	a		
NF	200	1.59	ab	1.52	ab	1.36	b	1.49	a		

† AA: Amino acids, BA: Benzyl adenine, NF: Nano-NPK fertilizer, N: nitrogen, P: phosphorus, K: potassium.
‡ Means with the same letters are not significantly different according to Duncan multiple ranges test (P≤0.05).

The triple interaction of all three-factors also caused slight significant differences in the average values of percent total phenol, in which the lowest significant value (0.97%) was given by the interaction (10 mg.L^{-1} AA + 200 mg.L^{-1} BA + 4 g.L^{-1} NF). While the highest significant average (2.08%) was recorded from control.

Vitamin C (mg.100 g^{-1} f. w.)

As clarified in (Table 6), significant differences in vitamin C contents (mg.100 g^{-1} f. w.) of grape berries were resulted from all single and triple factors except BA. Spraying the grapevines with 10 mg.L^{-1} AA led to obtaining the highest significant value of vitamin C (2.92 mg.100 g^{-1} f. w.) without significant difference with 5 mg.L^{-1} AA giving a value of vitamin C (2.75 mg.100 g^{-1} f. w.), whenever the lowest significant value (2.47 mg.100 g^{-1} f. w.) was observed from control. Regarding benzyl adenine, it was noticed that there were no significant differences in vitamin C contents of grape berries. Whereas, Nano-NPK fertilizer caused significant differences in vitamin C content of grape berries, while both treatment levels (4 and 2 g. L^{-1}) of Nano-NPK were significantly similar giving the averages (2.86 and 2.78 mg.100 g^{-1} f. w.), respectively, and both of which were significantly dominated on control (2.49 mg.100 g^{-1} f. w.).

Table 6. Effect of foliar application of amino acids, benzyl adenine and Nano-NPK fertilizers on vitamin C of grapevine cv. 'Thompson Seedless'

AA † (mg.L^{-1})	BA (mg.L^{-1})	N-NPK (g.L^{-1}) 0		2		4		AA x BA		AA	
	0	2.16	b ‡	2.36	ab	2.50	ab	2.34	c		
0	100	2.22	ab	2.59	ab	2.54	ab	2.45	bc	2.47	b
	200	2.43	ab	2.70	ab	2.69	ab	2.61	abc		
	0	2.20	ab	2.92	ab	2.94	ab	2.69	abc		
5	100	2.34	ab	3.09	ab	3.14	ab	2.86	abc	2.75	ab
	200	2.61	ab	2.68	ab	2.85	ab	2.71	abc		
	0	2.50	ab	2.65	ab	2.82	ab	2.65	abc		
10	100	2.93	ab	2.93	ab	3.02	ab	2.96	ab	2.92	a
	200	3.03	ab	3.14	ab	3.25	a	3.14	a		
NF		2.49	b	2.78	ab	2.86	a				
AA	0	2.27	c	2.55	abc	2.58	bc				
x	5	2.39	bc	2.89	ab	2.98	abc		BA		
NF	10	2.82	abc	2.91	ab	3.03	a				
BA	0	2.29	b	2.64	ab	2.76	ab	2.56	a		
x	100	2.50	ab	2.87	a	2.90	ab	2.76	a		
NF	200	2.69	ab	2.84	ab	2.93	a	2.82	a		

† AA: Amino acids, BA: Benzyl adenine, NF: Nano-NPK fertilizer, N: nitrogen, P: phosphorus, K: potassium.
‡ Means with the same letters are not significantly different according to Duncan multiple ranges test (P≤0.05).

The significant effect of triple-combination was noticed slightly, in which the higher vitamin C value (3.25 mg.100 g^{-1} f. w.) was shown by the interaction (10 mg.L^{-1} AA + 200 mg.L^{-1} BA + 4 g.L^{-1} NF), other combinations caused different results. However the lowest significant vitamin C value (2.16 mg.100 g^{-1} f. w.) was noticed from control. It's clear from tables (1- 6) that the foliar applications of amino acid, benzyl adenine and Nano NPK had significant effects on improving pollen traits, chlorophyll content and chemical characteristics of grape cv. Thompson Seedless compared to untreated grapevines, the improvement effect of amino acid (Tecamin max) may be due to the role of its components (humic and fulvic acids, organic matter, nitrogen and potassium oxides) which work as a collective, since humic and fulvic acids, besides of their roles as reservoirs of protein constituents, also involved in a plethora of cellular reactions and therefore they influence a number of physiological processes such as plant growth and development, intracellular pH control, generation of metabolic energy or redox power, and resistance to both biotic and abiotic stresses (15, 32, 35, 12, 20). Likewise, amino acids work to stimulate photosynthesis and build up carbohydrates, also serve to build and promote the action of a number of enzymes and conjugates enzymes (8, 5), also the role of potassium and organic N which can penetrate quickly into the plant cells and tissues compared with inorganic nitrogen (31) where nitrogen plays a role in the formation of proteins, as well as its entry into the formation of vitamins, the mitochondria and chloroplasts (16). The reason for the improvement of the previously mentioned traits can also be attributed to the role of benzyl adenine which is one of the most active cytokinins, that regulates various growth processes in plant and improves yield and chemical constituents of many crops, and recently, BA has been identified as a natural cytokinin in several plants. Nevertheless, physiological responses to BA application may be associated with increased endogenous concentrations of cytokinins (17). Also, benzyl adenine works to elicit plant growth and development responses, setting blossoms and stimulating fruit richness by stimulating cell division (30). The role of Nano NPK may be attributed to its increased spread and dissolution of nutrients and thus their availability to the plant which causes an increase in photosynthesis (26, 29). Likewise, the role of the nitrogen component may be due to an increase in the efficiency of the plant to carry out the process of photosynthesis in conjunction with the element phosphorus. The nitrogen component also stimulates the production of auxins, which encourage cell division and cell elongation, as well as the role of potassium that controls the process of opening and closing the stomata through the osmotic regulation of plant cells (28), and that the reason for increasing the previous traits can be due to the increase in enzymatic activities and the average of their interactions, which leads to the production of raw materials to increase cellular divisions and then increasing the leaf area as a result of treatment with Nano fertilizer (11).

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