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RESPONSE OF CARAWAY (*Carium carvi*, L.) GROWTH AND YIELD COMPONENTS TO NPKMg FERTILIZER RATE AND ANTIOXIDANTS TYPE

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ABSTRACT: An experiment was conducted during the winter season of each of 2015/2016 and 2016/ 2017 at the Experimental field, Faculty of Agriculture, Zagazig University, Egypt in order to evaluate the response of caraway growth and yield under three rates of N:P:K:Mg at 13:5:26:3 ratios/ (0.0, 2.0 and 4.0 g/l) as foliar spray and three types of antioxidants (Control, salicylic acid, vitamin C and vitamin B_1 as well as their combinations). The experiment was applied by a split-plot in randomized complete block design (RCBD) arrangement with three replications. Results proved the superiority of chemical fertilization as foliar spray *via* enhancing yield components of caraway plants in comparing with no application. Salicylic acid (SA), vitamin B_1 (Vitam.B) and vitamin C (Vitam.C) at 100 ppm of each applied three times/season showed the best results in most of the studied growth parameters (plant height, number of leaves and branches per plant, total dry weight, root dry weight and root length) and yield components (number of umbels per plant and fruit yield per plant and per faddan) as compared with control. Accordingly, this study recommends the possibility of using antioxidants treatment (SA+ Vitam.B + Vitam.C) as an improving growth performance and yield components of caraway plants under chemical fertilization rate at 2 g/l.

Key words: *Carium carvi* L., NPK fertilization, antioxidants, growth, yield components.

INTRODUCTION

Caraway (*Carium carvi*, L.) plant is an important annual aromatic and medicinal plant which uses in therapy of several disease belonging to Family Apiaceae. As any medicinal plant, caraway plant is used widely as a traditional medicine or in foods as a cooking spice **Aćimović *et al.* (2014)**. **Schavenbery and Paris (1977)** mentioned that, caraway fruits are used to treat rheumatism and pleurisy, and the plants are used in the manufacture of some spirits. The aroma in caraway seeds comes from essential oil which is about 3 to 7% of the seed weight. Carvone and limonene terpene compounds are the dominant compounds in caraway essential oil. Carvone composes about 50 to 85% and limonene abounds 20 to 30% from the caraway's essential oil contents **Aćimović (2013)**.

Nitrogen, phosphorus, and potassium as macronutrients, are often classified as primary macronutrients, because deficiencies of nitrogen, phosphorus and potassium are more common than the secondary macronutrients, calcium, magnesium, and sulfur. Most of the macronutrients are represent 0.1 to 5%, or 100 to 5000 parts per million (ppm), of dry plant tissue (**Wiedenhoeft, 2006**). **Alizadeh *et al.* (2010)** reported that the use of complete fertilizer increases fresh and dry weigh in *Satureja hortensis* plant.

Salicylic acid (SA), a natural signal molecule, has been shown to play an important role in regulating a number of physiological processes in plants. Its exogenous application to the plant has promoted its performance under biotic and abiotic stresses (**Senaratna *et al.*, 2000**). SA is effectively stimulated the growth and improved the behavioral performance, accompanied by a

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series of ameliorations in the antioxidative defense and anti-inflammatory response in experimental animals (**Ma *et al.*, 2013**). Additionally, SA was beneficial to the utilization of carbon source, thus leading to significant increase in the contents of polysaccharides (**Wang *et al.*, 2009**). Ascorbic acid is synthesized in the higher plants and influences plant growth and development and plays an important role in the electron transport system (**El- Kobisy *et al.*, 2005**). The herb weight studies showed that ascorbic acid (Vitamin C) promoted plant weight and growth, also it was shown that it can counteracted the decreased body weight caused by some chemicals in experimental animals (**Yang *et al.*, 2017**). The efficiency of antioxidant such as salicylic acid and ascorbic acid in enhancing herb dry weight, umbel number, seed yield, volatile oil (%) and yield was studied by many authors, concerning salicylic acid application, **Tanious (2008)** on fennel, **Hemdan (2008)** on anise and **Abdou *et al.* (2012)** on cumin. Thiamine (Vitamin B_1) is necessary for biosynthesis of the coenzyme thiamine pyrophosphate which has a role in carbohydrate metabolism (**Hendawy and Ezz El-Din, 2010; Gaurav *et al.*, 2011**). Additionally, **Bâ (2012)** confirmed a major physiological role of thiamine in the homeostasis of body weight programming, increment and set point regulation in rats. In plants, it is synthesized in the leaves and is transported to the roots where it controls growth (**Hendawy and Ezz El-Din, 2010**). Thiamine at 100 ppm resulted in the best values of growth characteristics, while thiamine at concentration of 50 ppm resulted in the highest essential oil percentage and yield of German chamomile (**Ranjbar *et al.*, 2014**).

The main aim of this study was to evaluate the effect of salicylic acid, ascorbic acid (Vitam. C) and thiamin (Vitam. B_1) at 100 mg of each and their combinations as foliar application under different NPKMg fertilization rate on growth and yield components of *Carium carvi* as important aromatic plant in Egypt.

MATERIALS AND METHODS

The present study was conducted at the Experimental Farm (Ghazala), Fac. Agric., Zagazig Univ., Egypt, during two consecutive seasons of 2015/2016 and 2016/2017. The NPKMg fertilization at different rates (0.0, 2 and 4 g/l), different antioxidants type [salicylic acid (SA), ascorbic acid (Vitam.C), thiamin (Vitam. B1) and their combinations between them as well as control (sprayed with tap water)] and their combination treatments were used as foliar spray to evaluated the growth and yield components of caraway plant. Each treatment of complete fertilization combined with each rate of antioxidants type treatments. The combination treatments between complete fertilization and antioxidants consisted of 24 treatments. These treatments were arranged in a split-plot in randomized complete blocks design with 3 replicates. Chemical fertilization rates were randomly arranged in the main plots and antioxidant types were distributed randomly in the sub plots. The physical and chemical properties of the experimental soil site are shown in Table 1, according to **Chapman and Pratt (1978)**.

Caraway fruits were sown on 28th and 26th October in 2015/2016 and 2016/2017 seasons, respectively. Fruits of caraway were sown at space of 30 cm in one side of the ridge just after irrigation. After three weeks from planting, germinated plants were thinned to two plants/ hill. Experimental plot was 9 m^2 (3×3 m) included five ridges; each ridge was 60 cm apart and 3 m in length.

The used complete fertilizer was Kristalon. It is a product of Hydro Agry company, Rotterdam and it contains N:P:K:Mg at 13:5:26:3 ratio, respectively. The chemical fertilization rates were applied as foliar application 35, 50 and 65 days after sowing. SA, Vitam. C and Vitam. B_1, were obtained from Techno-gene (TG) company, Dokky, Giza and sprayed at 100 ppm of each. The eight treatments (control as tap water, SA, Vitam. C, Vitam. B_1, SA+Vitam. B_1, SA+Vitam. C, Vitam. B_1+Vitam. C and SA + Vitam. C + Vitam. B_1) were applied as foliar application 30, 45 and 60 days after sowing. Each experimental unit received 2 letters solution using spreading agent (Super Film at a rate of 1ml /l).

All caraway plants received normal agricultural practices whenever they needed. All plants were

Table 1. Physical and chemical properties of the experimental farm soil (average of the two seasons)

Mechanical analysis			Soil texture
Clay (%)	Silt (%)	Sand (%)	Clay
40.50	33.20	26.30	

Chemical analysis												
pH	EC (m.mohs/ cm)	Organic matter (%)	Soluble cations (meq./l)				Soluble anions (meq./l)			Available (ppm)		
			Mg^{++}	Ca^{++}	K^{+}	Na^{+}	Cl^{-}	HCO_3^{-}	SO_4^{--}	N	P	K
7.88	1.3	2.05	2.8	1.5	1.3	3.8	4.5	1.5	3.4	280	70	350

fertilized with nitrogen and phosphorus fertilization at the rate of 200 kg/fad., of ammonium sulphate (20.5%N) and 200 kg/fad., of calcium super phosphate (15.5% P_2O_5). Phosphorus fertilizer was added during soil preparation as a soil dressing application. While, nitrogen and potassium fertilizers were divided into three equal portions and were added to the soil after 30, 55 and 75 days of sowing.

Data Recorded

Plant growth

Three random plants from each treatment were used to determine the following growth parameters; plant height (cm), leaf and branch number per plant, total dry weight/plant (g) and root length (cm).

Yield components

At harvesting, the central ridges of each plot were used for yield components determination of caraway plants. Number of umbels/plant, fruit yield/plant (g) were recorded then fruit yield per faddan (Kg) was calculated.

Statistical Analysis

Data of the present work were statically analyzed and the differences between the means of the treatments (chemical fertilization rates and antioxidant types) were considered significant when they were more than the least significant differences (LSD) at the 5% level by using computer program of Statistix version 9 (**Analytical Software, 2008**).

RESULTS AND DISCUSSION

Plant Growth Parameters

Effect of chemical fertilization rate

Results presented in Tables 2 and 3 reveal that, plant height, total dry weight and root length of caraway significantly affected by any chemical fertilization rate during both seasons. Moreover, leaf and branch number per plant were increased by using NPKMg fertilization compared to control. In addition, using chemical fertilization rate at 4 g/l significantly increased growth parameters of *Carium carvi* plant compared to control in both seasons. **Khalid and Shedeed (2015)** on black cumin plant, found that NPK application as foliar spray significantly increased vegetative growth parameters (plant height, leaf number, branch number and herb dry weight) compared to untreated plants.

Effect of antioxidants type

As shown in Tables 4 and 5 all antioxidant type treatments significantly increased plant growth parameters during both seasons. However, the best value in each of plant height, number of leaves and branches per caraway plant, total dry weight, root dry weight and root length was achieved with (SA+ Vitam.C + Vitam.B_1) treatments compared to the other ones under study during first and second seasons. Salicylic acid (SA) plays an important role in regulation of some physiological processes in

Table 2. Influence of chemical fertilization rates on plant height as well as number of both leaves and branches/plant of caraway during 2015/2016 and 2016/2017 seasons

Treatments (g/l) Kristalon	Plant height (cm)		Number of leaves/plant		Number of branches /plant	
	1st season	2nd season	1st season	2nd season	1st season	2nd season
NPKMg fertilization at 13:5:26:3 ratio rate (g/l)						
0.0	104.92	106.96	22.54	24.33	27.79	29.50
2.0 g/l	110.12	111.96	27.50	29.04	32.08	34.25
4.0 g/l	111.25	113.04	30.96	32.58	34.75	36.79
LSD at 5%	**0.44**	**0.34**	**0.42**	**0.60**	**0.82**	**0.32**

Table 3. Influence of chemical fertilization rates on total plant dry weight, root dry weight and root length of caraway during 2015/2016 and 2016/2017 seasons

Treatments (g/l) Kristalon	Total plant dry weight (g)		Root dry weight/ plant (g)		Root length (cm)	
	1st season	2nd season	1st season	2nd season	1st season	2nd season
NPKMg fertilization at 13:5:26:3 ratio rate (g/l)						
0.0	11.21	12.06	0.82	0.96	13.63	13.88
2.0 g/l	12.24	12.71	1.31	1.48	14.42	13.11
4.0 g/l	12.68	13.11	1.66	1.76	14.75	14.88
LSD at 5%	**0.44**	**0.63**	**0.05**	**0.01**	**0.03**	**0.97**

Table 4. Influence of antioxidants type on plant height as well as number of leaves and branches/plant of caraway during 2015/2016 and 2016/2017 seasons

Treatment	Plant height (cm)		Number of leaves/plant		Number of branches/plant	
	1st season	2nd season	1st season	2nd season	1st season	2nd season
Antioxidants type at 100 ppm of each						
Control	98.67	99.78	19.22	20.11	25.56	26.78
SA	108.22	109.22	25.22	26.67	29.67	32.33
Vitam.C	108.00	110.00	25.78	27.67	29.89	32.33
Vitam.B	110.67	113.33	29.00	29.56	32.33	34.33
SA+Vitam.C	108.44	110.00	26.67	28.22	32.11	34.00
SA+Vitam.B	111.89	114.11	28.78	31.33	33.33	35.56
Vitam.C+Vitam.B	112.00	114.11	29.89	32.00	34.56	36.11
SA+Vitam.C+Vitam.B	112.22	114.67	31.44	33.67	34.89	36.67
LSD at 5%	**1.35**	**1.00**	**1.38**	**1.29**	**0.99**	**0.97**

Table 5. Influence of antioxidants type on total plant dry weight, root dry weight and root length of caraway during 2015/2016 and 2016/2017 seasons

Treatment	Total plant dry weight (g)		Root dry weight/ plant (g)		Root length (cm)	
	1st season	2nd season	1st season	2nd season	1st season	2nd season
Antioxidants type at 100 ppm of each						
Control	8.51	8.54	0.86	0.96	12.82	13.19
SA	10.94	11.41	1.07	1.20	14.21	14.44
Vitam.C	11.37	11.61	1.18	1.33	14.49	13.59
Vitam.B	12.30	13.92	1.33	1.50	14.53	14.63
SA+Vitam.C	11.10	13.09	1.21	1.31	14.49	14.61
SA+Vitam.B	15.84	16.10	1.46	1.60	14.53	14.64
Vitam.C+Vitam.B	12.72	13.49	1.51	1.66	14.62	14.72
SA+Vitam.C+Vitam.B	13.56	12.83	1.50	1.63	14.44	14.50
LSD at 5%	**0.72**	**1.20**	**0.09**	**0.10**	**0.10**	**1.30**

plants such as effects on growth and development, ion uptake and transport and membrane permeability (**Simaei *et al*., 2012**). Ascorbic acid has been shown to performance multiple functions in plant growth, such as in cell wall expansion, cell division, and other developmental procedures (**Pignocchi and Foyer, 2003**). These results are in line with those found by **Rahimi *et al.* (2013)** on *Cuminum cyminum*, **Abdou and Mohamed (2014)** on *Mentha piperita* and **Abdelaal *et al.* (2020)** on sweet pepper plants. Also, **Soltani *et al.* (2014)** pointed out that, stem height, fresh and dry weight of *Calendula officinalis* plants increased by application of thiamine (Vitam.B).

Effect of combination between chemical fertilization rate and antioxidants type

Results tabulated in Tables 6 and 7 indicate that, all combination treatments between chemical fertilization rates and antioxidant typies increased caraway growth parameters compared to control during both seasons. However, the best value in plant height was achieved with SA+ Vitam.C+Vitam.B with either 2 or 4g/l of NPKMg rates without significant differences between them during the first and second seasons, compared to the other ones under study in both seasons. In addition, SA+Vitam.C+Vitam. B when combined with chemical fertilization rate at 4g/l of NPKMg as foliar spray significantly increased leaf and branch number per plant compared to the other ones under study in both seasons. Also, the highest value for each of total plant dry weight, root dry weight and root length of caraway was obtained from antioxidant types when combined with two and four g/l of chemical fertilization rate compared to zero g/l in the two seasons, respectively (Table 7).

Gaber (2019) reported that applying of mineral NPK monthly either at 6.0 or 12.0 g/plant combined with ascorbic acid foliar application at either 200 or 400 mg/l; improved the geranium vegetative characteristics *i.e.* plant height, number of branches, number of leaves and plant dry weight compared to control.

Yield Components

Effect of chemical fertilization rate

From results presented in Table 8, it is clear that, number of umbels per caraway plant was increased significantly due to any chemical fertilization rate compared to control during both seasons. Also, each fruit yield per plant and per faddan was significantly increased by using NPKMg fertilization as foliar spray and the

Table 6. Influence of combination between NPKMg (Kristalon) fertilization rate and antioxidants type on plant height as well as number of leaves and branches/plant of caraway during 2015/ 2016 and 2016/2017 seasons

Treatment		Plant height (cm)		Number of leaves/plant		Number of branches/plant	
Kristalon	**Antioxidant**	**1st season**	**2nd season**	**1st season**	**2nd season**	**1st season**	**2nd season**
	Control	95.00	96.00	16.67	17.67	23.00	24.00
	SA	103.33	105.33	20.33	23.00	26.67	28.00
	Vitam.C	104.33	106.33	21.33	23.67	27.33	29.00
	Vitam.B	107.33	110.00	25.67	26.00	29.00	31.00
Control	**SA+Vitam.C**	104.67	106.33	21.33	23.33	27.33	29.00
	SA+Vitam.B	108.00	110.33	25.00	26.67	29.33	31.33
	Vitam.C+Vitam.B	108.33	110.67	25.33	26.67	29.67	31.67
	SA+Vitam.C+Vitam.B	108.33	110.67	24.67	27.67	30.00	32.00
	Control	100.00	101.00	22.00	20.67	26.33	27.67
	SA	110.00	110.00	25.67	26.33	30.00	34.00
	Vitam.C	109.33	111.00	27.00	28.67	30.00	32.67
	Vitam.B	112.33	115.00	30.67	31.33	34.00	36.00
2.0 g/l	**SA+Vitam.C**	109.67	111.00	26.67	28.33	32.33	34.00
	SA+Vitam.B	113.00	115.00	30.00	32.00	34.33	36.33
	Vitam.C+Vitam.B	113.33	115.00	30.33	32.33	35.00	36.33
	SA+Vitam.C+Vitam.B	113.33	115.00	29.67	32.67	34.67	37.00
	Control	101.00	101.00	21.00	22.00	27.33	28.67
	SA	111.33	111.33	29.67	30.67	32.33	35.00
	Vitam.C	110.33	110.33	29.00	30.67	32.33	35.33
	Vitam.B	112.33	112.33	29.00	31.33	34.00	36.00
4.0 g/l	**SA+Vitam.C**	111.00	111.00	32.00	33.00	36.67	39.00
	SA+Vitam.B	114.67	114.67	31.33	35.33	36.33	39.00
	Vitam.C+Vitam.B	114.33	114.33	34.00	37.00	39.00	40.00
	SA+Vitam.C+Vitam.B	115.00	115.00	40.00	40.67	40.00	41.00
LSD 5%		**2.22**	**1.00**	**2.28**	**2.17**	**1.79**	**0.97**

Table 7. Influence of combination between NPKMg (Kristalon) fertilization rates and antioxidants type on total plant dry weight, root dry weight and root length of caraway during 2015/2016 and 2016/2017 seasons

Treatment		Total plant dry weight (g)		Root dry weight/plant (g)		Root length (cm)	
Kristalon	Antioxidant	1st season	2nd season	1st season	2nd season	1st season	2nd season
Control	Control	8.033	8.20	0.43	0.53	11.37	12.37
	SA	10.77	10.97	0.63	0.80	13.60	13.80
	Vitam.C	10.87	11.10	0.73	0.90	13.70	13.90
	Vitam.B	11.97	13.50	1.00	1.00	14.20	14.30
	SA+Vitam.C	10.60	14.63	0.80	0.93	13.80	14.07
	SA+Vitam.B	12.20	12.83	0.97	1.10	14.13	14.20
	Vitam.C+Vitam.B	12.20	12.90	1.00	1.13	14.17	14.23
	SA+Vitam.C+Vitam.B	13.07	12.33	1.00	1.17	14.10	14.17
2.0 g/l	Control	8.60	8.60	1.00	1.07	13.43	13.40
	SA	10.87	11.53	1.13	1.27	14.37	14.70
	Vitam.C	11.43	11.50	1.23	1.40	14.70	11.57
	Vitam.B	12.47	14.13	1.50	1.70	14.70	14.80
	SA+Vitam.C	10.93	11.87	1.23	1.43	14.53	14.60
	SA+Vitam.B	17.40	17.40	1.40	1.60	14.40	14.50
	Vitam.C+Vitam.B	12.67	13.80	1.50	1.70	14.73	14.73
	SA+Vitam.C+Vitam.B	13.57	12.83	1.50	1.63	14.50	14.60
4.0 g/l	Control	8.90	8.83	1.13	1.27	13.67	13.80
	SA	11.20	11.73	1.43	1.15	14.67	14.83
	Vitam.C	11.80	12.23	1.57	1.70	15.07	15.30
	Vitam.B	12.47	14.13	1.50	1.70	14.70	14.80
	SA+Vitam.C	11.77	12.77	1.60	1.57	15.13	15.17
	SA+Vitam.B	17.93	18.07	2.00	2.10	15.07	15.23
	Vitam.C+Vitam.B	13.30	13.77	2.03	2.13	14.97	15.20
	SA+Vitam.C+Vitam.B	14.03	13.33	2.00	2.10	14.73	14.73
LSD at 5%		**1.24**	**1.92**	**0.16**	**0.17**	**0.17**	**2.06**

Table 8. Influence of chemical fertilization rate on yield components of caraway during 2015/ 2016 and 2016/2017 seasons

Treatment	Number of umbels/plant		Fruit yield/plant (g)		Fruit yield/faddan (kg)	
	1st season	2nd season	1st season	2nd season	1st season	2nd season
NPKMg fertilization at 13:5:26:3 ratio rate (g/l)						
0.0	340.00	346.42	21.98	23.39	1025.90	1091.30
2.0 g/l	397.25	405.88	23.77	25.04	1109.40	1168.50
4.0 g/l	404.58	409.67	24.52	25.85	1144.00	1206.30
LSD at 5%	**2.87**	**14.65**	**0.34**	**0.40**	**15.61**	**18.48**

highest values in this connection were recorded with 4 g/l rate compared to control and the other one under study in the two tested seasons. It is well known that chemical fertilizers could enhance plant growth due to the role of nitrogen in nucleic acids and protein synthesis, and phosphorus as an essential component of the energy compounds (ATP and ADP) and phosphoprotein, also the role of potassium as an activator of many enzymes (**Helgi and Rolfe, 2005**). However, **Abdelkader and Hamad (2015)** found that the highest foliar NPK fertilization rate (4 g/l), resulted in the maximum value for each of plant height, number of branches and dry weight per plant of both safflower and fenugreek plants.

Effect of antioxidants type

Results of both seasons in Table 9 reveal that, in most cases number of umbels per plant and fruit yield/plant (g) as well as fruit yield /faddan (kg) of caraway plants were increased with all antioxidants type treatments compared to control in both seasons. The highest significant increase in each of fruit yield/plant and/faddan was achieved with Vitam. B alone or SA+ Vit C.+ Vitam. B combination treatments in the first and second seasons. These results are in similar with those stated by **El-Shawy *et al*. (2008)** on *Linum ustitatissimum*, **Abdelkader *et al*. (2018)** on *Nigella sativa* and **Aminifard *et al*. (2018)** on coriander and fenugreek plants.

Effect of combination between chemical fertilization rate and antioxidants type

Table 10 shows that, umbel number per plant and total yield of fruits per faddan were increased by using the combination treatments between chemical fertilization rate and antioxidants type compared to untreated caraway plants during both seasons. Furthermore, under each 4 and 2 g/l of NPKMg fertilization rate, fruit yield per plant and per faddan of caraway were increased with using Vitam.B at 100 ppm alone and SA+Vitam.C + Vitam.B combination in the first and second seasons, respectively. **Khalid and Shedeed (2015)** reported that the most effective rate was $N_3P_3K_3$ × foliar nutrition interaction, resulting in a positive increase in yield components (capsule number and seed yield per plant) of black cumin during the first and second seasons, respectively. **Azoz *et al*. (2016)** indicated that spraying basil plants with 300 ppm ascorbic acid proved to be the most positive effective concentration with promoting yield components (fresh herb and seeds/plant) compared with control. In addition, foliar application of salicylic acid significantly increased fruit yield and quality of the three cultivars of *Capsicum annuum* as compared with the control plants (**Ibrahim *et al*., 2019**).

Conclusion

The above mentioned results demonstrate foliar spray of *Carium carvi* plants with SA, Vitam. C and Vitam. B1 each at 100 mg/l under 2 g/l of NPKMg fertilization rate increased number of umbels/plant, fruit yield/plant and yield/faddan. Generally, this treatment was more advantageous than other combination treatments and seems promising in the development of sustainable caraway plant production.

Table 9. Influence of antioxidants types on yield components of caraway during 2015/2016 and 2016/2017 seasons

Treatment	Number of umbels/plant		Fruit yield/plant (g)		Fruit yield/faddan (kg)	
	1st season	2nd season	1st season	2nd season	1st season	2nd season
Antioxidants type at 100 ppm of each						
Control	320.44	324.33	20.43	22.29	953.40	1039.90
SA	351.67	354.44	22.98	24.33	1072.10	1135.30
Vitam.C	405.67	407.11	23.73	24.97	1107.30	1165.40
Vitam.B	367.44	399.89	24.74	25.94	1154.50	1210.50
SA+Vitam.C	350.22	351.56	23.78	24.97	1109.40	1165.40
SA+Vitam.B	416.44	420.56	23.79	25.09	1109.90	1170.50
Vitam.C+Vitam.B	414.22	418.22	23.53	24.87	1098.00	1160.70
SA+Vitam.C+Vitam.B	418.78	422.44	24.43	25.62	1140.00	1195.40
LSD at 5%	**6.53**	**18.29**	**0.47**	**0.50**	**22.09**	**23.18**

Table 10. Influence of combination between NPKMg fertilization rate and antioxidants type on yield components of caraway during 2015/2016 and 2016/2017 seasons

Treatment		Number of umbels/plant		Fruit yield/plant (g)		Fruit yield/faddan (kg)	
Kristalon	Antioxidants	1st season	2nd season	1st season	2nd season	1st season	2nd season
	Control	298.33	301.33	19.22	21.73	896.80	1014.00
	SA	335.00	340.00	21.22	22.53	990.20	1051.30
	Vitam.C	336.00	341.00	21.39	22.60	997.90	1054.40
Control	**Vitam.B**	355.67	366.33	23.45	24.63	1094.40	1149.30
	SA+Vitam.C	341.00	346.00	21.69	23.03	1011.90	1074.60
	SA+Vitam.B	352.00	360.67	22.82	24.06	1064.80	1122.80
	Vitam.C+Vitam.B	352.33	361.00	22.89	24.10	1067.90	1124.40
	SA+Vitam.C+Vitam.B	349.67	355.00	23.22	24.43	1083.50	1140.00
	Control	330.00	334.67	20.92	22.36	976.20	1043.50
	SA	355.00	357.33	23.22	24.53	1083.50	1144.60
	Vitam.C	432.33	436.00	24.39	25.60	1137.90	1194.40
2.0 g/l	**Vitam.B**	373.33	416.67	25.39	26.60	1184.60	1241.10
	SA+Vitam.C	344.33	353.00	24.35	25.36	1136.40	1183.50
	SA+Vitam.B	450.00	452.00	23.85	25.20	1113.00	1175.70
	Vitam.C+Vitam.B	443.33	445.67	23.35	24.76	1089.70	1155.50
	SA+Vitam.C+Vitam.B	449.67	451.67	24.72	25.93	1153.50	1209.90
	Control	333.00	337.00	21.15	22.76	987.10	1062.20
	SA	365.00	366.00	24.49	25.93	1142.60	1209.90
	Vitam.C	448.67	444.33	25.42	26.73	1186.10	1247.30
4.0 g/l	**Vitam.B**	373.33	416.67	25.39	26.60	1184.60	1241.10
	SA+Vitam.C	365.33	355.67	25.29	26.53	1179.90	1237.90
	SA+Vitam.B	447.33	449.00	24.69	26.00	1151.90	1213.10
	Vitam.C+Vitam.B	447.00	448.00	24.35	25.76	1136.40	1202.20
	SA+Vitam.C+Vitam.B	457.00	460.67	25.35	26.50	1183.00	1236.40
	LSD at 5%	**10.93**	**32.84**	**0.83**	**0.89**	**38.83**	**41.58**

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استجابة النمو والمساهمات المحصولية لنبات الكراوية لمعدل التسميد بالنيتروجين والفسفور والبوتاسيوم والماغنسيوم ونوع مضادات الأكسدة

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أجريت تجربتان حقليتان خلال موسمي الشتاء لأعوام ٢٠١٥/٢٠١٦ و٢٠١٦/٢٠١٧ في المزرعة التجريبية لكلية الزراعة، جامعة الزقازيق، مصر وذلك لتقييم استجابة نمو ومحصول نباتات الكراوية لثلاث معدلات من النيتروجين والفسفور والبوتاسيوم والماغنسيوم (الكريستالون) بنسب ١٣: ٥: ٢٦: ٣ وكانت بمعدل (صفر ، ٢,٠ و ٤,٠ جم/ لتر) رشاً على الأوراق وثلاثة أنواع من مضادات الأكسدة (الكنترول ، وحمض الساليسيليك، وفيتامين ج وفيتامين ب١ بالإضافة إلى المخاليط بينهم)، كان تصميم التجربة من خلال قطع منشقة مرة واحدة في قطاعات كاملة العشوائية في ثلاث مكررات، أثبتت النتائج تفوق التسميد الكيميائي كرش ورقي من خلال تحسين مكونات إنتاجية نباتات الكاروية مقارنة بمعاملة دون تسميد، أدى استخدام كل من حمض الساليسيليك وفيتامين ب وفيتامين ج بمعدل ١٠٠ جزء في المليون ثلاث مرات/موسم أفضل النتائج في معظم صفات النمو (ارتفاع النبات، عدد الأوراق والأفرع لكل نبات، الوزن الجاف الكلي للنبات، الوزن الجاف للجذور وطول الجذر) والمساهمات المحصولية (عدد النورات لكل نبات ومحصول الثمار لكل نبات وللفدان) مقارنة بالكنترول، وفقًا لذلك، توصي هذه الدراسة بإمكانية استخدام معاملة مضادات الأكسدة (حمض الساليسيليك + فيتامين ج + فيتامين ب) لتحسين صفات النمو ومكونات المحصول لنباتات الكراوية مع التسميد الكيميائي بالكريستالون بمعدل ٢ جم/لتر.

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