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Effect of Foliar Spray with Biostmulants on Growth, Head Yield, Phytohormones and Nutrients of Cabbage (*Brassica oleracea* var. Capitata)

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THERE IS a recent tendency to use biostimulants in horticultural crops as natural and environmental friendly substances. Two field experiments were carried out at Sakha Agricultural Research Station Farm, Kafr El-Shiekh Governorate, Egypt during two successive winter seasons of 2009/2010 and 2010/2011. The objective of the present study was to evaluate the impact of foliar application of some biostimulants such as ascorbic acid (Vit. C) and Atonik, which generally regarded as safe compounds, on growth, yield and quality as well as hormones and N, P, and K% in cabbage plants, Brunswick cultivar. Spraying was done three times with two Atonik and ascorbic acid levels, 100, 200 ppm and their combinations. The most important results could be summarized as follows: spraying plants with Vit. C at 200 ppm alone and Vit. C at 200 ppm + Atonik at 200 ppm produced higher weight of edible leaves and head yield per feddan than control. Vit. C (200 ppm) alone, also its combination with Atonik at 100 or 200 ppm resulted in heavier average head weight and more ascorbic acid content than control. The treatments of Vit.C (200 ppm) +Atonik (200 ppm), followed by Vit. C (100 ppm) +Atonik (100 ppm) decreased inedible leaves number in comparison with the other treatments. Atonik (200 ppm) alone and Vit. C (200 ppm) + Atonik (200 ppm) increased TSS% over control. The low level of Atonik alone decreased cabbage head diameter. All biostimulant treatments increased head compactness compared with the control. Moreover, all biostimulant treatments increased IAA and GA_3 but decreased ABA when compared with control. The highest values of IAA and GA_3 were obtained with Vit. C (100 ppm) + Atonik (100 ppm) treatments. Atonik (200 ppm) alone and also the combination between ascorbic acid and Atonik at any level gave more N%.

Keywords: Biostimulants, Atonik, Ascorbic acid, Cabbage, Growth, Head yield, Phytohormons.

Most of Egyptian farmers use huge amounts of fertilizers, especially nitrogen, for increasing yield without any care to the soil pollution and human hygienic. Increasing the ability of plant for growing and the reduction of malefic environment and hygienic human is considered very important. There is an increasing desire to the chemical input in agriculture and there has been change

towards integrated plant management and sustainable, environmental – friendly systems.

Biostimulants may be of natural or synthetic origins consists of various organic and/ or inorganic components having positive effect plant vital processes, ascorbic acid and Atonik belong to biostimulants substances (Calvo *et al*., 2014).

Ascorbic acid (Vit. C) is known as a growth biostimulant that influence many physiological processes such as the synthesis of enzymes, nucleic acids and protein in addition to it's function as co-enzymes (Smirnoff, 2011). It is very popular for its antioxidant properties. Consequently, there are many important aspects of Vit C multifaceted molecule including the remarkable function as a co-substrate of many dioxygenases. Vit.C retards senescence and increases cell metabolic rate. The role of Vit. C in regenerating enzymes and the known pathways of Vit. C catabolism, as well as the intriguing function of Vit.C in gene expression is well known (Conklin *et al*., 1998 & Arrigoni and De Tullio, 2002).

Vit. C has a stimulatory effect on plant growth and yields of some vegetables: Agwah (1990) concluded that Vit. C sprayed at 250 or 500 ppm enhanced lettuce fresh weight and yield. The application of Vit. C during cold season caused significant increases on growth parameters and total yield of tomato (Abdel-Halim, 1995). Also, Gamal El-Din, 2005 concluded that Vit. C sprayed at 40 and 60 mg/l led to significant increase in plant height, number of leaves, head diameter of sunflower plants over the control.

Other investigators found similar results on the stimulatory effects of Vit. C on other plants such as pepper (Shehata *et al*., 2002), cucumber (El-Greadly, 2002), potato (El-Banna *et al*., 2006) and pea plants (Helal *et al*., 2005).

Atonik is a Japanese synthetic biostimulant composed of three phenolic compounds stimulates plant growth without causing malformation or toxicity as well as accelerates the plasma streaming of the cells by increasing the endogenous auxin level (Przybysz, *et al*. 2014).

Atonik has positive effect on growth and yield of various crops. The growth stimulating with positive effect on biochemical and physiological processes in sugar beet plants after spraying with Atonik solution were found by Cerny *et al*., (2002). Seed treatment of Atonik at 3 ppm in tomato was found to be the best in recording maximum germination and increasing seedling physiological processes, this may be correlated to the internal auxins content (Djanaguiraman *et al*., 2005).

Castro (1982) obtained an increase in pepper fruits weight as a result of Atonik treatment. Bolosa (1984) observed a higher economic efficiency and an improvement in the mineral composition of pepper fruits when using Atonik. Djumai (1986) demonstrated an increase in number of flowers and fruits as well as in yield by 23.0

to 31.0% in sweet pepper as results of Atonik treatment. Arora and Kumar (1991) on the summer squash and round melon found that a foliar spray of 0.05% Atonik solution given at weekly and fortnightly intervals from the 3 to 4 true leaf stage until fruit set, significantly increased vine length, number of branches/ plant, number of fruits/ plant and total yield but decreased sex ratio in both crops. El-Greadly (1994) found that spraying globe artichoke plants with Atonik at 0.1, 0.2 and 0.3% alone or in combinations with gibberellic acid increased earliness, number and weight of heads per plant or per feddan for both early and total yields. Panajotov (1997) found that spraying pepper plants with Atonik increased fruit yield between 107-113 %, as high concentration of Atonik was more effective.

Materials and Methods

This study was conducted on the Experimental Research Farm, Sakha Experimental Station, Agricultural Research Center, Ministry of Agricultural, Egypt during winter seasons of 2009/2010 and 2010/2011. The mechanical and chemical properties of the used soil are shown in Table (1).

Seeding of cabbage (*Brassica oleraceae* var. *capitata*) cultivar Brunswick was done in the nursery beds on August 1st in the first season and July 27th in the second one. After two months of sowing the nursery bed seedling were transplanted into the open field on one side of the ridge at a spacing of 40 cm within the row on October 31th and October 27th in the first and second seasons, respectively. The plot area was 16.8 m^2, contained 12 ridges of 2.0 m length and 0.7 m width, leaving a guard raw between the experimental units.

The experiment included nine treatments (two Atonik and ascorbic acid levels and their combinations in addition to control). The plants were sprayed with the previous biostimulants thrice, the first spray was done after 30 days of transplanting date, the second was after two weeks from the first one while the third was after two weeks later.

TABLE 1. Mechanical and chemical analysis of soil before conducting the experiments in 2009/2010 and 2010/2011 seasons.

Soil analyses	Season 2009/10	Season 2010/11
Mechanical analysis:		
Clay%	53.21	49.17
Silt%	25.14	26.11
Sand%	21.65	24.72
Texture	clay	clay
Chemical analyses:		
pH(1:2.5 soil: water suspension)	8.05	8.2
EC dSm-1 (soil paste extract)	2.1	2.4
Organic matter (%)	1.7	1.6
Available-N mg-1 (1 M KCI extracts)	36	28
Available-P mg-1 (0.5 N NaHCO3 extracts)	6.1	5.8
Available-K mg-1(ammonium acetate extracts	280	214

Treatments in experiment were randomly arranged in a complete blocks design with three replicates. Each replicate consisted of twenty plants. The treatments were as follows:

- The control (plants were sprayed with tap water).
- Ascorbic acid at 100 ppm.
- Ascorbic acid at 200 ppm.
- Atonik at 100 ppm.
- Atonik at 200 ppm.
- Ascorbic acid at 100ppm and Atonik at 100 ppm.
- Ascorbic acid at 100ppm and Atonik at 200 ppm.
- Ascorbic acid at 200ppm and Atonik at 100 ppm.
- Ascorbic acid at 200ppm and Atonik at 200 ppm.

Atonik is a Japanese synthetic biostimulant composed of three phenolic compounds (sodium 5-nitroguaiacolate + sodium 1-nitrophenolate + 4-nitrophenolate)

All the cultural practices, i.e irrigation, chemical fertilization, diseases and insects control for cabbage production were followed according to the recommendation of Ministry of Agricultural. Harvesting started at 90 days after transplanting and extended for about 21 days. Cabbage heads were harvested in seven pickings at three days interval.

Collected data were as follows

Vegetative growth parameters

Five plants/every treatment were randomly collected at harvesting in both seasons and the following data were recorded.

- umber of inedible and edible leaves/ head.
- Weight of edible leaves/ head (kg).

Head yield

Total head yield per feddan (ton).

The heads of cabbage were harvested at three days interval from every plot, the head yield was determined as whole heads (outer and inner leaves and stem) of each plot were weighed in kg and converted to estimate in ton per feddan (3800 m^2).

Head quality

It was determined for five cabbage plants randomly taken from each plot at harvesting and the following data were recorded:

- Average head whole weight (kg).
- Head diameter (cm).
- Head compactness (kg/cm^2). It was determined by Magnus Pressurs Tester.

- Total Soluble Solids (T.S.S. %). The percentage of total soluble solids in juice of edible leaves was estimated using a hand refractometer.
- Ascorbic acid content (mg/ 100g f. wt.). It was determined by titration with 2, dichlorophenol blue according to A.O.A.C. (1965).

Endogenous phytohormones

Endogenous phytohormones were estimated in samples which were taken from plants after 67 days from transplanting for every treatment in the first season, samples of the fresh green leaves were collected for preparation and extraction of auxins as indole acetic acid (IAA), gibberellins as gibberellic acid (GA_3) and abscisic acid (ABA) (µg /100g fresh leaves) were done by the method described by Badr *et al*., (1971) that were detected by HPLC.

Mineral contents

Nitrogen, phosphorus and potassium contents in leaves were estimated according to FAO (1980).

The obtained data were tested by analysis of variance (Little and Hills, 1972), and treatment means were compared by using revised L.S.D test according to the procedure outlined by Snedecor and Cochran (1972).

Results and Discussion

Vegetative growth

Number of inedible and edible leaves/ head

The number of inedible and edible leaves of the cabbage head as affected by the various treatments are shown in Table 2.The results revealed that the application of Vit. C (200 ppm) + Atonik (200 ppm) caused a significant decrease in the number of inedible leaves followed by Vit. C (100 ppm) + Atonik (100 ppm), while the other treatments did not significantly differ in the first season. In the second one, all treatments had non-significant effect on number of inedible leaves compared with the control.

Concerning the number of edible leaves in cabbage head, data in the same table indicated that the highest number was obtained from plants treated with Vit. C (200 ppm) and Atonik (100 ppm), while the lowest record was obtained from the control plants. The other treatments occupied an intermediate position among plants which had the highest and that gave the lowest number without significant differences of each other in most cases during both seasons.

Weight of edible leaves/ head.

The weight of edible leaves for the cabbage head as affected by the various treatments is presented in Table 2. The data indicated that, the combination between high level of both Vit. C and Atonik gave significantly highest weight of edible leaves followed by Vit. C (200 ppm) alone, while the lowest weight

was achieved with control plants. The other treatments showed non-significant increase in most cases.

TABLE 2. Effect of ascorbic acid, Atonik and their combinations on number of inedible and edible leaves and weight of edible leaves (kg) of cabbage plant in both seasons.

Treatments	No. of inedible leaves per head		No. of edible leaves per head		Edible leaves wt./head (kg.)	
	2009/10	2010/11	2009/10	2010/11	2009/10	2010/11
Control	13.0 ab	9.67	90.0 c	93.0 d	2.73 d	2.66 d
Vit.C, 100 ppm	12.3 a-d	9.67	102.7 bc	98.0 cd	2.89 cd	2.82bcd
Vit.C, 200 ppm	11.7 a-d	9.67	107.0 ab	112.0 ab	3.18 b	3.02 ab
Atonik, 100 ppm	11.0 bcd	9.67	92.7 bc	105.0 bc	2.80 cd	2.75 cd
Atonik, 200 ppm	12.7 abc	9.33	97.3 bc	106.0 bc	2.99 bc	2.87bcd
Vit.C, 100 ppm+ Atonik, 100 ppm	10.7 cd	9.33	101.3 bc	104.7 bc	2.90 cd	2.84bcd
Vit.C, 100 ppm+ Atonik, 200 ppm	13.3 a	9.33	99.3 bc	109.7 ab	2.95 cd	2.83bcd
Vit.C, 200 ppm+ Atonik, 100 ppm	13.0 ab	9.67	118.7 a	116.0 a	3.00 bc	2.92 bc
Vit.C, 200 ppm+ Atonik, 200 ppm	10.3 d	9.00	100.0 bc	103.0 bc	3.43 a	3.19 a
F. test	*	NS	*	*	**	**

Means separation in columns by revised L.S.D test, at 5% level.

The increase in vegetative growth parameters by using vitamin C and Atonik treatments may be due to the auxin and GA_3 contained in such compounds (Table 5) these hormones promote cell division, cell elongation and protein synthesis, thus increasing growth and improving quality of yield (Smirnoff, 2011 and Przybysz, *et al*. 2014).

The positive effect of ascorbic acid may be due to that (Vit. C) as an organic compound required in a trace amount to maintain normal growth in higher plants. It influences mitosis and cell growth in plants (Noctor and Foyer, 1998, Smirnoff and Wheeler, 2002). It also affects phytohormone – mediated signaling processes during the transition from the vegetative to the reproductive phase as well as the final stage of development and senescence (Barth *et al*., 2006).

Increasing nitrogen percentage in the leaves of cabbage plants treated with ascorbic acid and Atonik treatments (Table 6) may be positively affected vegetative growth. These results are in harmony with those of El-Greadly (1994) on globe artichoke, Abdel-Halim (1995) on tomato and El-Greadly (2002) on cucumber.

Head yield

Date presented in Table 3 show that, foliar spray with Vit. C, Atonik and their combinations had highly significant effect on total head yield per feddan. Therefore, the largest head yield was obtained from spraying the highest level of Vit. C (200 ppm) alone or in combination with Atonik at 200 ppm in both seasons. In contrast, the lowest head yield was achieved with Atonik (100 ppm) and the control. The remainder five treatments occupied an intermediate position between the treatments which had the largest yield and that gave the lowest

values without significant differences from each other in most cases during both seasons.

TABLE 3. Effect of ascorbic acid (Vit. C), Atonik and their combinations on total head yield/ feddan and average head weight of cabbage plants in both seasons.

Treatments	Total head yield ton /fed.		Average head wt. (kg)	
	2009/10	2010/11	2009/10	2010/11
Control	25.47 e	26.01 e	2.83 d	2.89 e
Vit.C, 100 ppm	28.98 bc	28.44 bcd	3.22 b	3.16 c
Vit.C, 200 ppm	32.22 a	30.78 ab	3.58 a	3.42 a
Atonik, 100 ppm	27.18 de	27.45 de	3.02 cd	3.05 de
Atonik, 200 ppm	28.98 bc	28.53 bcd	3.22 b	3.17 c
Vit.C, 100 ppm+ Atonik, 100 ppm	29.43 bc	28.89 bcd	3.27 b	3.21 bc
Vit.C, 100 ppm+ Atonik, 200 ppm	28.35 cd	27.99 cde	3.15 bc	3.11 cd
Vit.C, 200 ppm+ Atonik, 100 ppm	30.87 ab	30.24 bc	3.43 ab	3.36 ab
Vit.C, 200 ppm+ Atonik, 200 ppm	32.67 a	31.05 a	3.63 a	3.45 a
F. test	**	**	**	**

Means separation in columns by revised L.S.D test, at 5% level.

These results gave a clear indication of the previous effects of Vit.C and Atonik and their mixtures on contents and activities of natural auxins and growth inhibitors within cabbage plant, which was reflected on the growth and yield. These results were evident by changes in the balance of the endogenous phytohormone, that is clear shown by increasing the content of endogenous promoting hormones such as indole acetic acid (IAA) and gibberellins (GA_3) and reduced the content of the inhibitor abscisic acid (ABA), as had been revealed by El-Greadly (1994) on globe artichoke, El-Greadly (2002) on cucumber, Djanaguiraman *et al*. (2005) and El-Tohamy *et al*., (2008) on eggplant.

Head quality

Average head weight.

Data presented in Table 3 indicate that foliar spray with Vit. C, Atonik and their combination had highly significant effect on average head weight. The heaviest head weight was obtained from spraying the highest level of Vit. C (200) ppm alone or in combination with Atonik at 100 or 200 ppm in both seasons, while the lightest head weight value was obtained from control plants followed by spraying with Atonik (100 ppm) alone.

This increase in the average head weight may be a result of increasing weight and number of leaves (Table 2), such increase with Atonik treatment was probably due to better uptake and accumulation of the mineral nutrients (Haroun *et al*., 2011).The increase in the average head weight was reflected on the total yield of crop.

Head diameter

The effect of various treatments on head diameter of cabbage crop (Table 4) was significant in both seasons. However, there were non-significant increases

among most of treatments. In contrast, the low level of Atonik alone considerably decreased head diameter as compared with the control in both seasons.

Head compactness

Data presented in the same table show that plants treated with Vit. C alone, Atonik alone or their combinations recorded significant increase in head compactness (kg/cm^2) of cabbage plant over the control, except for Vit. C (100 ppm) in the first season and Vit. C at both levels (100 and 200 ppm), in the second season as the differences were non-significant.

Total soluble solids (TSS %)

Data presented in Table 4 show that, the highest TSS values were obtained from plants sprayed with Atonik (200 ppm) and those sprayed with Vit. C (200 ppm) plus Atonik (200 ppm), followed by Atonik (100 ppm) or the combination with Vit. C (200 ppm) and Atonik (100 ppm) compared with the other treatments including control which gave the lowest values without significant differences from each other.

TABLE 4. Effect of ascorbic acid, Atonik and their combinations on head quality (Head diameter, compactness, Vit. C % and TSS) of cabbage plants.

Treatments	Head diameter (cm)		Head compactness (kg/cm^2)		TSS (%)	Vit.C (mg/100gm f.wt)
	2009/10	2010/11	2009/10	2010/11	2009/10	2009/10
Control	21.67 abc	22.33 ab	0.180 c	0.175 c	5.41 cd	47.32 g
Vit.C, 100 ppm	23.00 a	23.00 ab	0.190 bc	0.187 bc	5.39 d	56.65 d
Vit.C, 200 ppm	23.00 a	24.00 a	0.207 ab	0.188 bc	5.40 cd	57.93 c
Atonik, 100 ppm	19.67 c	19.33 c	0.200 b	0.210 a	5.74 b	52.43 f
Atonik, 200 ppm	20.67 bc	21.33 abc	0.208 ab	0.200 ab	5.98 a	54.21 e
Vit.C, 100 ppm+ Atonik, 100 ppm	21.00 abc	22.00 ab	0.210 ab	0.195 ab	5.56 bcd	57.83 c
Vit.C, 100 ppm+ Atonik, 200 ppm	20.67 bc	21.00 bc	0.206 ab	0.203 a	5.59 bc	58.06 bc
Vit.C. 200 ppm+ Atonik, 100 ppm	22.00 ab	22.33 ab	0.210 ab	0.199 ab	5.77 b	58.88 ab
Vit.C, 200 ppm+ Atonik, 200 ppm	22.00 ab	22.67 ab	0.230 a	0.210 a	6.07 a	59.07 a
F. test	*	*	**	**	**	**

Means separation in columns by revised L.S.D test, at 5% level.

Ascorbic acid content

Data presented in the same table show that, the effect of various treatments on ascorbic acid (Vit. C) content in cabbage leaves was highly significant. Therefore, the highest values were obtained from Vit. C. at 200 ppm plus any level of Atonik, while the lowest record was achieved with the control.

Increasing of Vit. C percent and TSS % in the leaves of cabbage plants as treated with ascorbic acid and Atonik treatments are agreed with those results of El-Greadly (1994) on globe artichoke and El-Tohamy *et al*. (2008) on eggplant.

Endogenous phytohormones content

Data presented in Table 5 show that spraying cabbage plants with vitamin C, Atonik and their combinations significantly increased the content of endogenous indole acetic acid (IAA) and gibberellic acid (GA_3) but they decreased abscisic acid (ABA) when compared with the control plants. Therefore, the highest values of IAA and GA_3 were resulted from the treatment of vitamin C at 100 ppm plus Atonik at 100 ppm. On the other hand, the lowest values of ABA were obtained from application of the lowest level of both biostimulants together.

These results emphasize that the two biostimulants application had a vital role on the balance between phytohormones in plants, these results agreed with those of Arrigoni and De Tullio (2002), Smirnoff (2011) and Przybysz, *et al*. (2014).

TABLE 5. Effect of ascorbic acid (Vit. C), Atonik and their combinations on endogenous phytohormones (GA_3, IAA and ABA) of cabbage plants.

Treatments	GA_3 (µg/g fresh weight)	IAA (µg /g fresh weight)	ABA (µg /g fresh weight)
	2009/2010	2009/2010	2009/2010
Control	10.66 e	13.67 d	7.18 a
Vit.C, 100 ppm	18.19 b	19.11 b	5.10 d
Vit.C, 200 ppm	15.57 d	16.50 c	5.15 d
Atonik, 100 ppm	17.59 bc	14.34 d	6.07 c
Atonik, 200 ppm	15.14 d	13.20 d	6.71 ab
Vit.C, 100 ppm+ Atonik, 100 ppm	22.22 a	25.23 a	4.13 e
Vit.C, 100 ppm+ Atonik, 200 ppm	16.04 cd	17.16 c	4.89 d
Vit.C, 200 ppm+ Atonik, 100 ppm	16.83 bcd	16.23 c	5.31 d
Vit.C, 200 ppm+ Atonik, 200 ppm	15.12 d	16.79 c	6.50 bc
F. test	**	**	**

Means separation in columns by revised L.S.D test, at 5% level.

Mineral contents

Foliar application of Atonik, ascorbic acid and their combinations increased nitrogen, phosphorus and potassium in cabbage leaves relative to the untreated control (Table 6). The differences were significant only for nitrogen, the highest nitrogen content was obtained from cabbage plants treated with Atonik at 200 ppm and also with the combination between Atonik and ascorbic acid at any level, while the lowest N content resulted from Vit. C at any level and control. These results agreed with those of El-Greadly (1994) on globe artichoke, El-Shazly and El-Masri (2003) on cotton, El-Banna *et al*. (2006) on potato and El-Tohamy *et al*. (2008) on eggplant.

TABLE 6. Effect of ascorbic acid, Atonik and their combinations on minerals (%) of cabbage leaves after 75 days from transplanting.

Treatments	N (%)	P (%)	K (%)
Control	3.61 c	0.52	2.56
Vit.C 100 ppm	3.62 c	0.53	2.56
Vit.C 200 ppm	3.63 c	0.54	2.58
Atonik 100 ppm	3.95 b	0.54	2.48
Atonik 200 ppm	4.07 a	0.55	2.47
Vit.C 100 ppm+ Atonik 100 ppm	3.97 ab	0.55	2.57
Vit.C 100 ppm+ Atonik 200 ppm	3.99 ab	0.56	2.57
Vit.C 200 ppm+ Atonik 100 ppm	3.96 b	0.57	2.58
Vit.C 200 ppm+ Atonik 200 ppm	3.97 ab	0.58	2.63
F. test	**	NS	NS

Means separation in columns by revised L.S.D test, at 5% level.

It is recommended, however to apply either ascorbic acid at 200 ppm or combined with Atonik at 200 ppm to obtain the highest yield with the best head quality of cabbage var. Brunswick. The application must be thrice beginning 30 days after transplanting and then fortnightly.

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تأثير الرش ببعض المنشطات الحيويه على النمو و محصول الرؤوس و الهرمونات و المحتوى المعدنى لمحصول الكرنب

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و** قسم النبات - المركز القومى للبحوث - القاهرة - مصر.

إن الاتجاه الحديث هو لاستخدام المنشطات الحيويه لمحاصيل البساتين حيث انها مواد طبيعيه و غير ضاره للبيئه. اجريت دراسه حقليه لمدة عامين للموسم الشتوى ٢٠١٠/٢٠٠٩ و ٢٠١١/٢٠١٠ فى المزرعه البحثيه لمحطة البحوث الزراعيه بسخا – محافظة كفرالشيخ – مصر. الهدف من الدراسه تقييم الرش بمنشطات طبيعيه مثل حامض الاسكوربيك (فيتامين سى) و الاتونك كمواد امنه و تأثيرها على النمو ، المحصول، الجوده، محتوى الهرمونات و النسبه المئويه للنيتروجين و الفوسفور و البوتاسيوم فى نباتات الكرنب صنف البرونزويك. تم الرش ثلاث مرات بتركيزين ١٠٠&٢٠٠ جزء فى المليون لكلتا المادتين المستخدمتين و التوليفات بينهما. و تم تلخيص اهم النتائج المتحصل عليها كما يلى: المعامله بفيتامين سى بتركيز ٢٠٠ جزء فى المليون منفرداً كذلك فيتامين سى ٢٠٠ + اتونك ٢٠٠ جزء فى المليون اعطت اعلى وزن للاوراق المأكوله و اعلى محصول رؤوس للفد ان عن الكنترول. المعامله بفيتامين سى بتركيز ٢٠٠ جزء فى المليون منفرداً او مقترناً مع الاتونك بتركيزيه ١٠٠,٢٠٠ جزء فى المليون انتجت اعلى متوسط وزن للرأس و اعلى محتوى لحامض الاسكوربيك مقارنة بالكنترول. ادت المعامله بفيتامين سى ٢٠٠ + الاتونك ٢٠٠ جزء فى المليون يتبعها المعامله بفيتامين سى ١٠٠ + الاتونك ١٠٠ جزء فى المليون الى تقليل عدد الاوراق غير المأكوله بالمقارنه بباقى المعاملات. المعامله بالاتونك ٢٠٠ جزء فى المليون منفرداً و كذلك المعامله بفيتامين سى ٢٠٠ + الاتونك ٢٠٠ جزء فى المليون ادت لزيادة النسبه المئويه للمواد الذائبه الكليه مقارنة بالكنترول. ادت المعامله بالتركيز المنخفض من الاتونك لتقليل قطر الرأس. جميع معاملات الرش بالمنشطات الحيويه ادت لزيادة اندماج الرأس مقارنة بالكنترول. جميع معاملات الرش بالمنشطات الحيويه ادت لزيادة اندول حمض الخليك و الجبرلين و تقليل حمض الابسيسك مقارنه بالكنترول، بينما نتجت اعلى القيم المتحصل عليها من معاملة فيتامين سى ١٠٠+اتونك ١٠٠ جزء فى المليون . ادت المعامله بكل من الاتونك ٢٠٠ منفرداً و كذلك التوليفات بين فيتامين سى و الاتونك بأى تركيز لزيادة النسبه المئويه للنيتروجين فى الاوراق.