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Potato Growth and Yield as Affected by Foliar Application with Naa Auxin and 6-Ba Cytokinin

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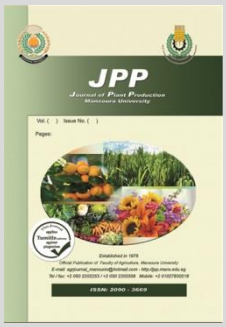

ABSTRACT

Two open field experiments were conducted during summer seasons of 2019 and 2020, in a private farm at Abou El-Matamer district, Behiera Governorate, Egypt. Certified imported potato seeds of 'Cara' cv. were used after splitting-up. Cut seedy explants (*ca*. 40 g) contain two eyes each were planted at 0.80 m wide and 0.20 m apart between hills, using four concentrations of synthetic NAA auxin (control, 25, 50, and 100 mg l^{-1}) and four concentrations of the synthetic cytokinin BA (control, 25, 50, and 100 mg l^{-1}) were foliar applied separately and in combinations. Control plants were sprayed with distilled water. The effects of both variables and their combinations were investigated on the vegetative growth-related characters, yield and its components, leaves and tubers chemical composition. The obtained results declare, in general, that foliar application treatments of auxin (NAA) and cytokinin as BA alone or in combination to potato plants gave, significantly, the highest average values of both yield and chemical content compare to untreated plants. The combination between 100 mg l^{-1} NAA plus 100 mg l^{-1} BA might be considered as an optimal treatment for the production of high yield and good quality of potato plants under the environmental conditions of Behiera Governorate and other similar regions.

Keywords: NAA auxin (*α*-naphthaleneacetic acid), BA cytokinin (6-Benzyladenin), Potato growth attributes, Potato chemical attributes, Cara cv.

INTRODUCTION

Potato (*Solanum tuberosum* L.) considered one of the vital cultivated crops in the world besides wheat, rice and corn (Dowling, 1995) because of its importance as a source of minerals, carbohydrates, and vitamins. Potato tuber has a lot of nutritional energy and protein per unit (McGill, 2013) and, in this case, it is considered one of the major food sources for people having thus a great socio-economic impact. The yearly worldwide potatoes production is around 368.25 million metric tons, reaped from a territory that came to about 17.580 million hectares (ha) (FAO, 2018). In Egypt, the potato has a significant situation among every single vegetable harvest, where about 20% of the complete region of vegetable production is committed to potato. While, the complete developed territory of potatoes arrived at 176,670 feddans, which created 4,896,476 tons. (FAO, 2018).

Cytokinins are plant hormones that plants produce naturally and regulate plant growth, including cell division and leaf senescence. It's one of the important growth promoters, which playing a vital role from seed germination to senescence (Chatsudthipong and Muanprasat, 2009). Cytokinins have been shown to have effect on many other physiological and development processes, including leaf senescence, nutrient moblilzation, apical dominance, the formation and activity of shoot apical meristems, floral development, the breaking of bud dormancy, and seed germination. Cytokinins also appear to mediate many aspects of light-regulated development, including chloroplast differentiation, the development of autotrophic metabolism, and leaf and cotyledon expansion (Gora *et al*., 2018). Synthetic cytokinin such as 6-Benzylaminopurine, benzyl adenine (BAP or BA) can improve plant growth by cell division, break bud dormancy and promotes the growth of the lateral bud (Hossain *et al*., 2006).

NAA is commonly used in horticultural crops to boost up the remarkable vegetative propagation and helps to promote plant growth by enhancing the cell division, cell elongation and cell differentiation which may initiate the development of plant organs and essentially required for the formation of root cambium and epicycle which may induce the formation lateral roots. It also affects the physiological process, hasten maturity and produces better quality fruits and some other aspects such as to increase the number of branches, increased fresh weight, and yield as well as induces early flowering and prevents flower and fruit drop (Gurjar *et al*., 2018; Surendar *et al*., 2020).

Therefore, developing good management practices for potato growers in Egypt find was selected and undertaken in the present research to 1) evaluate the potato cultivar (Cara) for tuber productivity and quality, 2) find out the optimal doses of cytokinin (6-BA) and auxin (NAA) levels as foliar applications to improve yields and economical returns to potato growers, and 3) examine the interaction effect between 6-BA and NAA levels.

MATERIALS AND METHODS

Two field experiments were carried out during the summer seasons of 2019 and 2020, in a private farm, at Abou El-Matamer district, Behiera Governorate, Egypt, under open field conditions in sandy loam soil. The experimental field was polughed and pulverized. Certified

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imported potato seeds of 'Cara' cultivar was used after splitting. Cut seedy explants were, approxemately, 40 g in weight and each seedy explant contained two eyes planted on the 1st January during both seasons in dry soil then irrigated. Cutting seeds were planted at 0.80 m wide and 0.20 m apart between hills on one side of the ridge (25000 plant/fed.). The experimental plot consisted of two ridges with 8.00 m long and 0.80 m width; making an area of 12.80 m^2. Treatments were consisted of two independent variables as a foliar applicants, i.e.; four concentrations of the NAA auxin (control, 25, 50, and 100 mg l^{-1}) and four concentrations of the synthetic cytokinin BA (control, 25, 50, and 100 mg l^{-1}) separately and in combinations. Control plants were sprayed with distilled water. Both conducted experiments were factorial experiments layout in a randomized complete block design (RCBD), with three replicates. Each replicate included 16 treatments which distributed randomly within each block. Potato plants were sprayed with the allocated or assigned treatments twice during the growing seasons, the first one at 60 days (*ca*. 12-15 leaves) after planting, then 15 days after the first one (*ca*. 25-30 leaves). The recommended agricultural practices for commercial potato production were followed.

Harvesting was accomplished after 120 days of planting during both years. Ten plants form each treatment in each replication were, randomly, selected and tagged for records of the growth and total yield as well as tubers quality parameters.

Growth attributes, records, after 85 days from planting, plant height (cm), foliage fresh and dry weights (g) characters were determined. foliage dry weight (g) was conducted in an electrical oven at 70˚ C till obtaining a constant weight, then determined (in gram).

Yield and its component measurements

The following criteria were determined just after harvesting time (120 days from planting) using the average number of tubers of 10 plants.

Number of tubers per plant, average of tuber fresh weight (g), average of tuber yield per plant (g), total tubers yield per feddan (ton).

Chemical composition where leaves chlorophyll content (a , b and total chlorophyll) was expressed as (mg/g f.w.) and N, P and K contents were determined in leaves and tubers.

- **Leaf contents of a, b and total chlorophyll (a+b):** The leaves pigments chlorophyll a, b and total chlorophyll (a+b) for the fourth top leaves of plant were estimated by spectrophotometer as described by Moran and Porath (1980) after 85 days from planting in both seasons. Then they were calculated using the formula of Arnon (1956).
- **N, P and K contents of leaves** and tubers were determined at 85 days after planting as follows: Total N content was determined colorimetrically according to Chapman and Pratt (1978), total P content was determined colorimetrically as described by Singh *et al*. (2005), total K content was determined photometrically using the flame photometer method Jackson (1973).

Statistical Analysis :

All obtained data of the present study were, statistically, analyzed according to the design used by the COSTAT computer software program and were tested by analysis of variance. The revised least significant difference test at 0.05 level of probability was used to compare the differences among the means of the various treatment combinations as illustrated by Duncan (1965) and Gomez and Gomez (1984).

RESULTS AND DISCUSSION

The results, generally, revealed that foliar application with synthetic cytokinin (6-BA), synthetic auxin (NAA) and their combinations affected, more or less, significantly ($p \leq 0.05$), the potato traits of the study as on overall during both seasons of the study.

1. Vegetative growth characters and chlorophyll content:

The results illustrating the effects of auxin (NAA), cytokinin (6-BA) and their combinations on vegetative growth characters as plant height, fresh and dry weight as well as chlorophyll content of potato plants during both seasons of the study, i. e., 2019 and 2020, are presented in Table (1).

Results presented in Table (1), generally, revealed that foliar application of different concentration with NAA as auxin (25, 50 and 100 mg l^{-1}) significantly enhanced vegetative growth parameters and chlorophyll content of potato plant during both seasons of the experiments comparing to the control. The highest mean values for the previously mentioned traits were found to be associated with the addition of NAA at 100 mg l^{-1} as plant height (80.65 and 82.27), plant fresh weight (406.71 and 422.08) and plant dry weight (52.13 and 56.67), respectively for vegetative growth, in the same way chlorophyll a (0.865 and 0.877), chlorophyll b (0.635 and 0.632) and total chlorophyll (1.500 and 1.519) in two seasons. While, the control plants recorded the lowest averages values of all parameters during two

seasons. The significant influence of NAA observed in this experiment might be attributed to the physiological effects of auxins on growth parameters of plants that induces cell division and cell elongation resulting in increased plant growth. The similar trend was also reported by Awati *et al*. (2016) studied effect of foliar application of plant growth regulators on growth and yield of potato seed tubers. Resulted indicated that application of 100 NAA significantly affected on plant growth parameters like crop height and main shoot diameter. Also, Jakhar *et al*. (2018) indicated that application of NAA at 300 ppm to the sprouting broccoli significantly increased the chlorophyll content in leaves (3.01mg/g) as compared to control. Additionally, Gurjar *et al*. (2018) found that foliar application of 25 ppm NAA produced superior growth (plant height, number of branches/plant, number of leaves/plant and shoot girth).

Its revealed from the Table (1) that the maximum plant height (80.33 and 81.82), plant fresh weight (403.80 and 438.75), plant dry weight (51.25 and 55.71), chlorophyll a (0.859 and 00.882), chlorophyll b (0.585 and 0.628) and total chlorophyll (mg g^{-1}) (1.444 and 1.510), respectively in two seasons were recorded with higher concentration of BA as cytokinin at rate of 100 mg l^{-1} comparing with the untreated plants which recorded the lowest values of plant growth parameters. The enhance due foliar application of BA as cytokinin could be attributed to its multiple functions of cytokinins and their derivates. Also, its role in stimulating the cell division, the formation of buds, the tip meristem proliferation. Giving higher concentrations of BA causes the

number of buds that are formed more and more (Chaudhary and Mitta, 2014). Also, George *et al*., (2008) reported that cytokinins stimulate cell division and control morphogenesis, and break apical dominance and release dormant lateral buds from dormancy. These results are in agreement with that obtained by Brengi, (2018) and Sisay *et al.* (2020). Moreover, Lahijani *et al.* (2018) indicated that leaflet chlorophyll content and net photosynthetic rate (Np) tended to increase with foliar application of BAP at tuber initiation stage compare to the control plants.

In respect to interaction effect between all treatments, data in Table (1) indicated that all growth parameters and chlorophyll content previously significantly affected by foliar application with different concentration of both NAA and BA. With increasing concentration of foliar application of both NAA or BA found an increase in all vegetative growth parameters and chlorophyll content comparing with the untreated plants. in this connect, the highest mean values of mention traits in both seasons were recorded with plants sprayed with 100 mg l^{-1} for each of NAA and BA.

Table 1. Averages values of some vegetative growth-related characters and chlorophyll content of potato plants as affected by foliar application with auxin (NAA), cytokinin (BA) and their combinations during the summer seasons of 2019 and 2020.

Treatments		Plant height (cm)		Foliage fresh weight (g)		Foliage dry weight (g)		Leaf chlorophyll content (mg/g, f.w.)					
								Chlorophyll a		Chlorophyll b		Total chlorophyll (a + b)	
		2019	2020	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020
NAA (main effect mg l^{-1})													
Control		66.05^{d}	67.63^{d}	367.51^{d}	399.36^{d}	41.90^{d}	45.56^{d}	0.765^{d}	0.788^{d}	0.538^{d}	0.546^{d}	1.303^{d}	1.334^{d}
25		73.08^{c}	73.53^{c}	387.08^{c}	420.53^{c}	46.73^{c}	50.90^{c}	0.812^{c}	0.836^{c}	0.566^{c}	0.586^{c}	1.378^{c}	1.421^{c}
50		78.25^{b}	78.95^{b}	402.54^{b}	437.50^{b}	51.02^{b}	55.47^{b}	0.851^{b}	0.873^{b}	0.608^{b}	0.620^{b}	1.458^{b}	1.492^{b}
100		80.65^{a}	82.27^{a}	406.71^{a}	442.08^{a}	52.13^{a}	56.67^{a}	0.865^{a}	0.887^{a}	0.635^{a}	0.632^{a}	1.500^{a}	1.519^{a}
BA (main effect mg l^{-1})													
Control		66.87^{d}	68.43^{d}	373.18^{d}	405.37^{d}	43.31^{d}	47.09^{d}	0.775^{d}	0.795^{d}	0.567^{d}	0.553^{d}	1.341^{d}	1.348^{d}
25		73.96^{c}	74.72^{c}	389.54^{c}	423.61^{c}	47.67^{c}	51.85^{c}	0.820^{c}	0.843^{c}	0.590^{c}	0.594^{c}	1.410^{c}	1.436^{c}
50		76.88^{b}	77.42^{b}	397.32^{b}	431.74^{b}	49.55^{b}	53.95^{b}	0.840^{b}	0.862^{b}	0.605^{b}	0.609^{b}	1.445^{b}	1.471^{b}
100		80.33^{a}	81.82^{a}	403.80^{a}	438.75^{a}	51.25^{a}	55.71^{a}	0.859^{a}	0.882^{a}	0.585^{a}	0.628^{a}	1.444^{a}	1.510^{a}
Combinations effects (mg l^{-1})													
NAA	BA												
Control	Control	59.20^{m}	61.20^{m}	358.37^{m}	389.20^{o}	39.77^{p}	43.24^{p}	0.741^{m}	0.764^{p}	0.519^{j}	0.526^{p}	1.260^{m}	1.289^{p}
	25	66.37^{l}	67.70^{l}	363.64^{l}	395.12^{n}	40.76^{o}	44.34^{o}	0.751^{lm}	0.774^{o}	0.525^{j}	0.534^{o}	1.276^{l}	1.308^{o}
	50	68.38^{jkl}	69.73^{kl}	372.38^{j}	404.53^{l}	43.01^{m}	46.76^{m}	0.774^{jk}	0.797^{m}	0.543^{i}	0.552^{m}	1.317^{j}	1.349^{m}
	100	70.27^{ij}	71.87^{ij}	375.64^{j}	408.60^{k}	44.04^{l}	47.90^{l}	0.795^{i}	0.817^{k}	0.564^{g}	0.572^{k}	1.359^{i}	1.389^{k}
25	Control	67.52^{kl}	69.17^{kl}	368.62^{k}	400.31^{m}	41.85^{n}	45.54^{n}	0.763^{kl}	0.786^{n}	0.537^{i}	0.542^{n}	1.300^{k}	1.328^{n}
	25	73.17^{gh}	73.40^{hi}	388.77^{h}	422.74^{i}	47.35^{i}	51.50^{i}	0.817^{h}	0.841^{i}	0.583^{f}	0.591^{l}	1.400^{g}	1.432^{l}
	50	75.07^{fg}	75.00^{gh}	393.13^{g}	427.35^{h}	48.18^{h}	52.72^{h}	0.830^{g}	0.851^{h}	0.593^{e}	0.600^{h}	1.423^{f}	1.452^{h}
	100	76.57^{ef}	76.57^{fg}	397.78^{f}	431.72^{g}	49.55^{g}	53.85^{g}	0.839^{fg}	0.864^{g}	0.551^{h}	0.609^{g}	1.390^{gh}	1.474^{g}
50	Control	69.33^{jk}	70.77^{jk}	381.46^{i}	414.55^{j}	45.26^{k}	49.23^{k}	0.785^{ij}	0.805^{l}	0.597^{e}	0.563^{l}	1.382^{h}	1.368^{i}
	25	77.20^{de}	78.00^{ef}	400.68^{f}	435.80^{f}	50.74^{f}	55.14^{f}	0.851^{ef}	0.872^{f}	0.622^{c}	0.619^{f}	1.473^{e}	1.492^{f}
	50	81.80^{c}	81.67^{cd}	409.40^{d}	444.96^{d}	52.94^{d}	57.57^{d}	0.872^{cd}	0.894^{d}	0.636^{b}	0.636^{d}	1.508^{c}	1.530^{d}
	100	84.25^{b}	85.36^{b}	418.63^{b}	454.70^{b}	55.14^{b}	60.12^{b}	0.894^{ab}	0.919^{b}	0.576^{f}	0.660^{b}	1.470^{e}	1.579^{b}
100	Control	71.43^{hi}	72.57^{ij}	384.25^{i}	417.41^{j}	46.35^{j}	50.37^{j}	0.810^{h}	0.828^{j}	0.612^{d}	0.581^{j}	1.422^{f}	1.409^{j}
	25	79.10^{d}	79.77^{de}	405.08^{e}	440.79^{e}	51.85^{e}	56.42^{e}	0.861^{de}	0.884^{e}	0.629^{bc}	0.629^{e}	1.490^{d}	1.514^{e}
	50	82.27^{c}	83.27^{bc}	414.36^{c}	450.12^{c}	54.05^{c}	58.74^{c}	0.885^{bc}	0.906^{c}	0.648^{a}	0.647^{c}	1.533^{b}	1.553^{c}
	100	89.80^{a}	93.47^{a}	423.13^{a}	459.98^{a}	56.26^{a}	61.15^{a}	0.906^{a}	0.928^{a}	0.650^{a}	0.671^{a}	1.556^{a}	1.600^{a}

- NAA auxin (*α*-naphthaleneacetic acid); BA, cytokinin 6-Benzyladenin

- Values having the same alphabetical letter (s) in common, within each column, do not significantly differ, using the revised L.S.D. test at 0.05 level of probability.

2. Yield characters

Results presented in Table (2) expressed that foliar application of potato plant cv. 'Cara' with synthetic auxin (NAA), synthetic cytokinin as 6-BA and their combinations; affected significantly ($p \leq 0.05$) all tested characteristics of the potato cultivar during both seasons.

It's clear from the data at Table (2), the effect of foliar application by NAA at different concentration (25, 50 and 100 mg l^{-1}) on yield and its components comparing with the untreated plants. from the data found a significant differences effect between all treatments with control, while concentration of 50 and 100 mg l^{-1} had no significant effect with all parameters except average weight of tuber in the 2nd season which significantly affected with four treatments. The highest mean values of yield parameters recorded with plants sprayed by 100 mg l^{-1} NAA as auxin, which approximately around the treatment of 50 mg l^{-1}. These results agree with Awati *et al.* (2016) indicated that application of 100 NAA significantly affected on number of tuber per plant and total yield of tuber. In the same arrangement, Singh *et al.* (2017) revealed that NAA at 60 ppm increased fruit weight (169.66g), no of fruit per plant (9.87), no of seeds per fruit (110.78), fruit yield per plant (1.67kg), fruit yield per plot (15.07kg), fruit yield per hectare (69.76t), With the above result it can be concluded that NAA at 60 ppm is very much beneficial for the growth and yield of capsicum. The present results are in agreement with those obtained by several authors Tapdiya *et al.* (2018) and Chanwala *et al.* (2019).

Foliar application of treatments with different concentration by BA as cytokinin significantly affected all yield parameters over the ubtereated plants under investigation during both seasons of the experiment. Except the diffrences between treatment of 50 and 100 mg l^{-1} in the first seasons with number of tuber, and total yield, which had no significant effect with near values together. In this respect; the highest values (8.08 and 9.42), (122.54 and 125.76), (17.88 and 21.37) were achived with 100 mg l^{-1} for number of tuber, average tuber weight and total yield, respectively during two seasons. Wile, the lowest values recorded with the control.

The present results are in agreement with those obtained by several authors El Dessoky *et al.* (2016) illustrated that the highest recorded values of tuberization percentage, weight (25%) and number of microtuber per shoot (29%) were obtained with 5mg/l benzyl amino purine (BAP). Also, Gora *et al*. (2018) found that an application of benzyl adenine increased the yield. Significant increase in seed yield of could be ascribed to cumulative effect of yield components viz., number of fruit, number of seeds and test weight which increased seed yield and ultimately led to greater seed production per unit area.

Table 2. Averages values of some yield characters of potato plants as affected by foliar application with auxin (NAA), cytokinin (BA) and their combinations during the summer seasons of 2019 and 2020.

Treatments		Number of tuber/plant		Average tuber weight (g)		Total yield/feddan (ton)	
		2019	2020	2019	2020	2019	2020
NAA (main effect mg l^{-1})							
Control		4.97^{a}	4.94^{a}	146.09d	148.27d	18.27^{c}	18.27^{c}
25 mg.l^{-1}		4.98^{a}	4.99^{a}	158.73^{c}	159.36^{c}	19.79^{b}	19.88^{b}
50 mg.l^{-1}		4.99^{a}	5.00^{a}	167.80^{b}	167.80^{b}	20.95^{a}	21.04^{a}
100 mg.l^{-1}		5.02^{a}	5.03^{a}	171.58^{a}	170.75^{a}	21.53^{a}	21.90^{a}
BA (main effect mg l^{-1})							
Control		4.91^{a}	4.93	150.00^{d}	150.66^{d}	18.41^{c}	18.59^{c}
25 mg.l^{-1}		4.64^{a}	4.99	159.42^{c}	161.17^{c}	20.12^{b}	20.11b
50 mg.l^{-1}		5.00^{a}	5.00	165.17^{b}	165.47^{b}	20.65^{b}	21.12^{a}
100 mg.l^{-1}		5.03^{a}	5.03	169.60^{a}	168.88^{a}	21.35^{a}	21.26^{a}
Combinations effects (mg l^{-1})							
NAA	BA						
Control	Control	4.80^{a}	4.77^{b}	142.40^{kl}	142.77^{k}	17.08^{j}	17.01^{k}
	25	5.07^{b}	5.00^{ab}	139.58^{l}	145.45^{jk}	18.21^{ij}	18.18^{jk}
	50	5.00^{a}	5.00^{ab}	150.07^{j}	150.50^{i}	18.76^{ij}	18.81^{hij}
	100	5.00^{a}	5.00^{ab}	152.30^{ij}	154.35^{h}	19.04^{ghi}	19.07^{hij}
25	Control	4.93^{a}	5.00^{ab}	147.50^{jk}	147.86^{ij}	18.20^{ij}	18.48^{ij}
	25	5.00^{a}	4.97^{ab}	160.37^{gh}	161.46^{g}	20.04^{e-h}	20.04^{e-h}
	50	5.00^{a}	5.00^{ab}	162.40^{fgh}	162.87^{fg}	20.33^{d-g}	20.36^{d-g}
	100	5.00^{a}	5.00^{ab}	164.63^{efg}	165.25^{ef}	20.58^{c-ff}	20.66^{def}
50	Control	4.93^{a}	4.97^{ab}	153.41^{ij}	155.40^{h}	18.92^{hi}	19.29^{g-j}
	25	5.00^{a}	5.00^{ab}	167.73^{def}	167.46^{de}	20.96^{b-e}	20.93^{de}
	50	5.00^{a}	5.00^{ab}	172.45^{bcd}	172.61^{bc}	21.56^{bcd}	21.57^{cd}
	100	5.03^{a}	5.03^{a}	177.60^{b}	175.72^{b}	22.35^{ab}	22.35^{bc}
100	Control	4.97^{a}	5.00^{ab}	156.70^{hi}	156.60^{h}	19.45^{f-i}	19.57^{f-i}
	25	5.00^{a}	5.00^{ab}	170.00^{cde}	170.30^{cd}	21.25^{b-e}	21.28^{cde}
	50	5.00^{a}	5.00^{ab}	175.77^{bc}	175.90^{b}	21.97^{bc}	23.75^{a}
	100	5.10^{a}	5.10^{a}	183.87^{a}	180.21^{a}	23.45^{a}	22.97^{ab}

- NAA auxin (*α*-naphthaleneacetic acid); BA, cytokinin 6-Benzyladenin

- Values having the same alphabetical letter (s) in common, within each column, do not significantly differ, using the revised L.S.D. test at 0.05 level of probability.

Data illustrated in Table (2), showed the interaction effect between different concentration of NAA and BA. All treatments significantly effect on yiled and its components during both seasons over the control. The highest mean values of all parameters recorded with foliar application with 100 mg l^{-1} for each NAA or BA in two sesaons.

3. Nutrition values (N, P and K%) of leaves and tubers:

Result outline in Table (3) exhibited that both variables of study (*i.e.* NAA and BA concentrations) either individually or their combination showed significant ($p \leq 0.05$) effects on leaf and tuber nutrient content (N, P, and K) of potato plants during both seasons 2019 and 2020 of the investigation.

According to the data illustrated in Table (3) it is evident that using foliar application of NAA at different concentration significantly increased leaves and tuber N, P and K% during both seasons. The highest mean values of all nutrient recorded with the level of 100 mg l^{-1}. Comparing with the control treatment, the rate of increases was accounted to be in leaves (33.83, 31.36%), (31.08, 32.92%), (30.07, 29.37%) and in tubers were (48.96 and 49.35%), (41.55 and 37.65%) and (45.36 and 39.80 %) over the control treatment for N, P and K%, respectively in the season of 2018-2019 and 2019-2020. Similar results were obtained by Abbasi *et al.* (2013) stated that higher level of $CaCl_2$ (1%) with NAA (0.02%) increased mineral uptake of tomato plants (N, P, K and Ca%).

Nutrition values of potato tubers as affected by BA as cytokinin illustrated in Table (3). with foliar application by BA the content of N, P and K% in tuber significantly increased. The highest mean values recorded with the highest concentration at level of 100 mg l^{-1} in leaves as (3.60 and 3.77) for N%, (0.291 and 0.319) for P% and (3.72 and

3.92) for K%, and in tubers as (2.12 and 2.26) for N%, (0.213 and 0.230) for P% and (2.59 and 2.74) for K%, respectively in 2018-2019 and 2019-2020. While, the lowest values recorded with the untreated plants. the same trend was happed during both seasons. The finding was also supported by Brengi, (2018) revealed that spraying of synthetic cytokinins were superior and significantly increased N%, P%, K% in fruits. However, spraying of kinetine at 25ppm gave the highest mean values of N%, P%, K%, and mucilage in fruits compared to other treatments.

Concerning the interaction effect between NAA and BA at different concentration, data at the same Table indicated that all treatments sprayed together significant parameters of N, P and K in leaves and tuber. In this connect, the highest values recorded with plants sprayed by high concentration of both NAA and BA at rate of 100 mg l^{-1}, while the lowest mean values of the same traits were recorded with the untreated plants.

Table 3. Averages values of nutrient content in leaves and tubers of potato plants as affected by foliar application with auxin (NAA), cytokinin (BA) and their combinations during the summer seasons of 2019 and 2020.

Treatments		Nutrient contents of leaf (% d.w.)						Nutrient contents of tuber (% d.w.)					
		N		P		K		N		P		K	
		2019	2020	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020
NAA (main effect mg l^{-1})													
Control		2.61^{d}	2.78^{d}	0.215^{d}	0.234^{d}	2.78^{d}	2.94^{d}	1.45^{d}	1.54^{d}	0.154^{d}	0.170^{d}	1.83^{d}	2.01^{d}
25		3.09^{c}	3.29^{c}	0.253^{c}	0.276^{c}	3.24^{c}	3.42^{c}	1.78^{c}	1.90^{c}	0.184^{c}	0.200^{c}	2.22^{c}	2.35^{c}
50		3.51^{b}	3.69^{b}	0.285^{b}	0.312^{b}	3.63^{b}	3.83^{b}	2.06^{b}	2.19^{b}	0.210^{b}	0.226^{b}	2.53^{b}	2.68^{b}
100		3.66^{a}	3.82^{a}	0.295^{a}	0.324^{a}	3.77^{a}	3.97^{a}	2.16^{a}	2.30^{a}	0.218^{a}	0.234^{a}	2.66^{a}	2.81^{a}
BA (main effect mg l^{-1})													
Control		2.69^{d}	2.87^{d}	0.222^{d}	0.240^{d}	2.86^{d}	3.03^{d}	1.50^{d}	1.61^{d}	0.160^{d}	0.177^{d}	1.91^{d}	2.10^{d}
25		3.19^{c}	3.37^{c}	0.260^{c}	0.284^{c}	3.33^{c}	3.51^{c}	1.85^{c}	1.96^{c}	0.190^{c}	0.209^{c}	2.28^{c}	2.46^{c}
50		3.40^{b}	3.57^{b}	0.275^{b}	0.302^{b}	3.52^{b}	3.71^{b}	1.99^{b}	2.11^{b}	0.202^{b}	0.214^{b}	2.45^{b}	2.54^{b}
100		3.60^{a}	3.77^{a}	0.291^{a}	0.319^{a}	3.72^{a}	3.92^{a}	2.12^{a}	2.26^{a}	0.213^{a}	0.230^{a}	2.59^{a}	2.74^{a}
Combinations effects (mg l^{-1})													
NAA	BA												
Control	Control	2.33^{p}	2.52^{p}	0.196^{l}	0.211^{n}	2.53^{p}	2.69^{p}	1.27^{n}	1.36^{p}	0.138^{l}	0.153^{m}	1.61^{o}	1.82^{o}
	25	2.47^{o}	2.63^{o}	0.204^{k}	0.221^{m}	2.65^{o}	2.81^{o}	1.35^{m}	1.43^{o}	0.148^{k}	0.160^{l}	1.71^{n}	1.91^{n}
	50	2.68^{m}	2.88^{m}	0.221^{i}	0.241^{k}	2.85^{m}	3.03^{m}	1.52^{k}	1.61^{m}	0.159^{j}	0.177^{j}	1.92^{l}	2.08^{l}
	100	2.94^{k}	3.09^{k}	0.239^{h}	0.262^{j}	3.10^{k}	3.25^{k}	1.67^{j}	1.78^{k}	0.170^{i}	0.189^{i}	2.08^{j}	2.25^{j}
25	Control	2.56^{n}	2.75^{n}	0.212^{j}	0.230^{l}	2.74^{n}	2.91^{n}	1.43^{l}	1.53^{n}	0.152^{k}	0.169^{k}	1.81^{m}	2.01^{m}
	25	3.15^{l}	3.36^{l}	0.259^{f}	0.281^{h}	3.29^{l}	3.48^{l}	1.83^{h}	1.93^{i}	0.188^{h}	0.214^{f}	2.27^{i}	2.51^{g}
	50	3.28^{h}	3.45^{h}	0.265^{f}	0.291^{g}	3.42^{h}	3.60^{h}	1.90^{g}	2.02^{h}	0.194^{g}	0.198^{h}	2.35^{h}	2.32^{i}
	100	3.38^{g}	3.59^{g}	0.276^{e}	0.300^{f}	3.52^{g}	3.71^{g}	1.98^{f}	2.12^{g}	0.201^{f}	0.222^{e}	2.43^{g}	2.55^{g}
50	Control	2.81^{i}	3.00^{i}	0.231^{h}	0.249^{k}	2.97^{i}	3.14^{i}	1.57^{k}	1.70^{l}	0.170^{i}	0.184^{i}	1.99^{k}	2.18^{k}
	25	3.50^{f}	3.71^{f}	0.283^{e}	0.312^{e}	3.63^{f}	3.83^{f}	2.07^{e}	2.20^{f}	0.208^{e}	0.229^{d}	2.53^{f}	2.66^{f}
	50	3.73^{d}	3.91^{d}	0.303^{c}	0.333^{c}	3.84^{d}	4.06^{d}	2.23^{c}	2.35^{d}	0.222^{c}	0.242^{c}	2.72^{d}	2.83^{d}
	100	3.98^{b}	4.16^{b}	0.321^{a}	0.354^{a}	4.07^{b}	4.30^{b}	2.37^{b}	2.53^{b}	0.239^{a}	0.250^{b}	2.87^{b}	3.03^{b}
100	Control	3.04^{j}	3.22^{j}	0.247^{g}	0.271^{i}	3.20^{j}	3.38^{j}	1.74^{i}	1.85^{j}	0.182^{h}	0.204^{g}	2.23^{i}	2.40^{h}
	25	3.64^{e}	3.80^{e}	0.294^{d}	0.322^{d}	3.74^{e}	3.94^{e}	2.13^{d}	2.28^{e}	0.216^{d}	0.234^{d}	2.62^{e}	2.76^{e}
	50	3.88^{c}	4.05^{c}	0.312^{b}	0.344^{b}	3.97^{c}	4.16^{c}	2.32^{b}	2.45^{c}	0.232^{b}	0.240^{c}	2.80^{c}	2.93^{c}
	100	4.09^{a}	4.24^{a}	0.329^{a}	0.360^{a}	4.18^{a}	4.41^{a}	2.46^{a}	2.63^{a}	0.241^{a}	0.260^{a}	2.98^{a}	3.14^{a}

- NAA auxin (*α*-naphthaleneacetic acid); BA, cytokinin 6-Benzyladenin

-Values having the same alphabetical letter (s) in common, within each column, do not significantly differ, using the revised L.S.D. test at 0.05 level of probability.

RECOMMENDATION

This study recommends that foliar spraying of a combination of both NAA and BA at 100 mg l^{-1} and 100 mg l^{-1} respectively could enhance the productivity and chemical content of potato plants Cara cultivar.

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نمو و إنتاجية نبات البطاطس المتأثره بالرش الورقى بنفثالين أستيك أسيك كأوكسين و٦ بنزيل أمين سيتوكينين

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أجريت تجربتان حقليتان خلال الموسمين الصيفيين ٢٠١٩ ، ٢٠٢٠ ، في مزرعة خاصة بمنطقة أبو المطامير – محافظه البحيره، مصر باستخدام تقاوي البطاطس المستوردة و المعتمده من صنف "كارا" بعد تقطيعها. تم تقطيعها الى قطع بوزن ثابت تقريبا ٤٠ جم كل منها تحتوى على عينين. تمت الزراعة على خطوط عرضها ٨٠ سم والمسافة بين النباتات داخل الخط ٢٠ سم لدراسة تأثير الرش الورقي بأربع مستويات مختلفه من النفثالين أستيك أسيد (كنترول (رش بماء الصنبور)، ٢٥، ٥٠ و ١٠٠ ملجم/لتر) و ٤ مستويات من السيتوكينين (كنترول (رش بماء الصنبور)، ٢٥، ٥٠ و ١٠٠ ملجم/لتر) و التفاعل المشترك بينهم في تجربة عاملية ذات عاملين في تصميم تجريبي كامل عشوائي في ثلاث مكررات. تم دراسة تأثير كلا العاملين و التفاعل بينهم على صفات النمو الخضري و المحصول و التركيب الكيميائى للأوراق و الدرنات. أظهرت النتائج بوضوح أنه بصفه عامة عند استخدام الرش الورقى سواء بالاوكسين او السيتوكينين بصورة فردية او مشتركة على نبات البطاطس أدى الى تأثير معنوي و وجد أن أعلى القيم للصفات المدروسه للمحصول و التركيب الكيميائى مقارنه بمعاملة الكنترول سجلت عند الرش باستخدام ١٠٠ ملجم/لتر لكل من الاوكسين و السيتوكينين بصورة فردية او مشتركة و التي سجلت أفضل النتائج تحت ظروف التجربة بمحافظة البحيرة.