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Effect of Phosphorus Fertilizer Sources and Foliar Spray with Some Growth Stimulants on Vegetative Growth, Productivity and Quality of Globe Artichoke

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Authors' contributions

This work was carried out in collaboration between both authors. They managed the literature searches, designed the study and managed the experimental process. They also wrote the manuscript and finally approved the final manuscript.

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ABSTRACT

Two field experiments were conducted during two successive seasons of 2013/2014 and 2014/2015 at the experimental farm of the Faculty of Agriculture, Moshtoher, Benha University to investigate the effect of phosphorus fertilization sources i.e., phosphoric acid, bio-phosphorus (Al-Mowaffer bio), calcium superphosphate and rock phosphate and foliar spray with benzyladenine (BA) at 20 ppm, naphthalene acetic acid (NAA) at 40 ppm, salicylic acid (SA) at 50 ppm and monopotassium phosphate at 2 g/l in addition to the control treatment as well as their interactions on vegetative growth, chemical constituents of plant foliage, total flower head yield and its components as well as head quality of globe artichoke (*Cynara scolymus* L.) cv. French. The results showed that application of bio-phosphorus and phosphoric acid fertilizers reflected the highest values of plant growth, chemical constituent, head yield and its quality compared with other used phosphorus sources. Spraying plants with BA at 20 ppm led to significant increases in most vegetative growth parameters and total number and yield of flower head. Using 2 g/l monopotassium phosphate-sprayed plants was responsible for the highest numbers of early head and quality traits of produced head. The combination treatments between bio-phosphorus fertilizer

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form (Almowaffer bio) and spraying plants with BA or monopotassium phosphate were superior in most cases.

Keywords: Globe artichoke; phosphorus sources; growth stimulants; growth; chemical composition flower head yield and quality.

1. INTRODUCTION

Globe artichoke (*Cynara scolymus* L.) is considered as one of the most important vegetable crops grown in Egypt for local consumption and exportation. It has an important nutritional value due to its high contents of phenolic compounds, flavonoids, inulin, fibers and minerals [1]. Its extracts contain also cynarin, which has vital effects on hepatobitary diseases and cholesterol metabolism [2]. Egypt is occupied the fifth position among the world producers for artichoke with a total production of 266196 ton from 12651 ha according to the statistics of Ministry of Agriculture in 2013/2014 season. Artichoke is grown in the newly reclaimed lands. Nowadays, more attention is given to promote artichoke production in order to satisfy the increased demands of the local consumption as well as the exportation purposes.

Phosphorus (P) is the second major nutrient for plant growth because it has an important role in the formation of nucleic acids, nucleotides, phospholipids and phosphoproteins [3,4]. Plants are usually suffered from P deficiency in most of Egyptian soils and this can lead to high reductions in crop production [5,6]. Most of P forms in the soils are presented in un-available forms for plants. So, phosphate dissolving bacteria and soil microorganisms can play vital roles in improving plant growth and phosphate uptake. Phosphate solubilizing bacteria have high ability to increase P availability for plants through production of organic acids, which can convert the in-soluble phosphates to soluble forms [7,8] and plant growth promoting substances [9]. In this regard, [10] reported that application of biofertilizer stimulated the vegetative growth, nutrient contents as well as increased early and total yield. Moreover, they showed that using biofertilizer improved head quality traits and changed the yield pattern distribution. Fertilizing artichoke plants with 150-200 kg P_2O_5/fed significantly increased plant height, number of leaves, and number of flower heads per plant [11]. The effect of two phosphorus fertilization rates 50 and 150 kg P_2O_5 /ha and they found that the highest P supply significantly increased vegetative growth and productivity of artichoke plants [12] In addition, using rock phosphate plus biofertilizer (mycorrhizae) recorded the highest artichoke plant growth, total yield and improved the quality of head compared with calcium superphosphate [13].

The use of plant growth regulators is a common horticultural practice to improve metabolic processes and the plant resistance to temperature or water stresses and yield [14]. In this respect, foliar spray of tomato plant with NAA at 30 ppm significantly increased its vegetative growth, fruit yield and quality [14]. Spraying faba bean plant with NAA at 20 ppm gave the highest values of vegetative growth, chemical constituents of plant foliage, flowering behavior, total yield and fruit quality [15]. Application of NAA at 0.02% increased plant growth and yield of tomato plants by improving mineral uptake [16]. Benzyladenine is recognized by its ability to induce cell division in certain plant tissues [17], and it can also overcome the apical dominance of many plants and stimulate the lateral buds to develop the plants. Benzyladenine can delay senescence and cause transport of many solutes from older leaves into the treated zone [18].

Foliar application with chemical desiccant is one of the promising approaches to diminish the environmental stress on plants [19]. Salicylic acid naturally occurs in very low amounts and participates in the regulation of physiological processes in plants such as nutrient uptake and chlorophyll synthesis [20,21]. In this regard it was mentioned that foliar spray of salicylic acid at 100 ppm led to the highest vegetative growth values, fresh and total yield, physical and chemical quality of artichoke plants [22]. Application of salicylic acid at (100 mg/l) increased vegetative growth parameter and was more effective in accelerating earlier yield and total yield/plant and quality of artichoke [23]. Foliar spray of salicylic acid caused significant increases in artichoke leaf number, leaf area, dry matter and total yield [24].

Many authors demonstrated that growth and flowering of many vegetables plants are greatly influenced by monopotassium phosphate. The use of monopotassium phosphate (KH_2PO_4) at 1 g/l improved vegetative growth, flowering and yield of tomato plants [25]. In addition, foliar spray with monopotassium phosphate at 3 g/l significantly increased plant height, number of branches, leaf area, total chlorophyll content, chemical constituent of plant foliage, fruit yield and quality of cantaloupe plants [26].

Therefore, this study aimed to enhance the production and quality of globe artichoke cv. French using different phosphorus fertilizers sources phosphoric acid, bio phosphorus, calcium superphosphate and rock phosphate as soil application and foliar spray with benzyladenine (BA), naphthalene acetic acid (NAA), salicylic acid (SA) and monopotassium phosphate.

2. MATERIALS AND METHODS

Two field experiments were carried out during two successive seasons of 2013/2014 and 2014/2015 at the experimental farm of Faculty of Agriculture, Moshtoher, Benha University, Egypt to evaluate the effect of phosphorus fertilization sources i.e., phosphoric acid, bio phosphorus, calcium superphosphate and rock phosphate as soil application and foliar spray with benzyladenine (BA), naphthalene acetic acid (NAA), salicylic acid (SA) and monopotassium phosphate as well as their combination on vegetative growth characters, chemical composition, head yield and quality of globe artichoke (*Cynara scolymus* L.) cv. French. Random soil samples were collected from the experimental farm at the depth of 0-30 cm before planting to analyze their physical and chemical properties. Physical and chemical characteristics of the used soil are shown in Tables a and b. Physical analysis was estimated according to [27], while chemical analysis was determined according to [28]. Old crowns (taken from the previous plants) were used as a plant material for propagation and planted in July 28th and 4th of August in the first and second seasons, respectively. This experiment was set up in a split plot design with three replicates in both seasons of study. Each experimental plot included five ridges, 1.0 m width and 4.0 m length with an area of 20 m^2. A guard ridge was left between each adjacent plots.

Table a. Physical analysis of the experimental soil

Parameters	Unit	Seasons	
		2013/2014	2014/2015
Coarse sand	%	5.28	4.72
Fine sand	%	15.78	16.53
Silt	%	25.16	26.21
Clay	%	53.78	52.54
Textural class	------	Clay	Clay

Table b. Chemical analysis of the experimental soil

Parameters	Unit	Seasons	
		2013/2014	2014/2015
$CaCO_3$	%	1.17	1.12
Organic matter	%	2.36	2.02
Available nitrogen	mg kg^{-1}	43.21	38.35
Available phosphorus	mg kg^{-1}	21.37	19.43
Available potassium	mg kg^{-1}	124.6	108.9
EC	$dS.m^{-1}$	1.03	1.11

EC= electrical conductivity

The old crowns were planted at a distance of 1 m apart on one side. The recommended organic fertilizer (compost) for growing globe artichoke was applied at a rate of 70.4 m^3 /ha to the soil during its preparation. Nitrogen fertilizer at a rate of 357.1 kg N/ha in the form of ammonium sulphate (20.6% N) and 238.1 kg Potassium sulfate (48.5% K_2O) were applied at three equal doses 1, 2 and 3 months from planting. The phosphorus fertilizer treatments were distributed in the main plots, while the foliar spray treatments with growth stimulants were located randomly in the sub plots.

This experiment included 20 treatments resulted from the combination between four phosphorus fertilizer treatments and five growth stimulant treatment as follows:

a. Phosphorus fertilizer treatments:

1- Phosphoric acid (80% P_2O_5) was applied at 142.8 l/ha, which was equivalent to the recommended dose of calcium superphosphate (714.3 kg/ha, 15.5 P_2O_5). It was added at three times started after one month from planting, with one month interval, during the two growing seasons.
2- Bio-phosphorus (El-Mowaffer-bio^R): fertilizer treatment was considered as a new generation of biological phosphate-nitrogen fertilizer, and registered in the

Egyptian Ministry of Agriculture & Land Reclamation (MALR), under No. 7703/2004. It was added at one dose at 714.3 kg/ha as recommended with the manufactured company before the planting.

3- Rock phosphate (27% P_2O_5) was obtained from Abu Zaabal fertilizer and chemical Co., Egypt and added at 396.7 kg/ha before the planting.
4- Calcium superphosphate (15.5% P_2O_5) was obtained from Abu Zaabal fertilizer and chemical Co., Egypt and added at 714.3 kg/ha before the planting.

b. Spray treatments:

1- Benzyladenine (BA) at 20 ppm.
2- Naphthaline acetic acid (NAA) at 40 ppm.
3- Salicylic acid (SA) at 50 ppm.
4- Monopotassium phosphate at 2 g/l.
5- Control treatment (spray with tap water).

The volume of the spraying solution was maintained just to cover completely the plant foliage until drip. Globe artichoke plants were subjected to foliar spray with the aforementioned growth stimulants six times, each at two weeks by interval, the first one was after one month form planting time in both seasons. A surfactant (Tween 20) at a concentration of 0.01% was added to all tested solutions including the control.

2.1 Data Recorded

2.1.1 Vegetative growth characters

Vegetative growth aspects of globe artichoke plants were estimated at 120 days after planting. Representative sample of five plants from each experimental plot was taken for measuring vegetative growth aspects as follows: plant height, which was measured from the soil surface to the tip of the largest linear blade in plant, number of leaves/plant and number of offshoots /plant was accounted at the end of harvesting.

2.1.2 Chemical constituents of plant foliage

Total carbohydrates, nitrogen, phosphorus and potassium were determined according to [29,30,31,32], respectively.

2.1.3 Early and total flower head yield

The early yield was calculated from the start of harvest until the end of February, where late yield was estimated during March up to end of May. Many parameters were evaluated for each plot in both seasons of the study as follows: number of early heads/plant, number of late heads/plant, number of total heads/plant and total yield (ton/ha).

2.1.4 Head quality

2.1.4.1 Physical head characters

Five heads from each plot were randomly taken at every harvest period (early and late) in both seasons of study for measuring the physical head characters of globe artichoke, including head length (It was measured by calipers), head diameter (It was measured by calipers), average head fresh weight and average edible part fresh weight.

2.1.4.2 Chemical constituents of heads

Samples of heads (edible part) were taken at the beginning and the end of harvesting season and dried in an electric oven at 70℃ to constant weight. In addition, the digested dry matter of each heads was taken for chemical determinations. Inulin concentration was determined according to [33], while the fibers were determined according to [34].

2.2 Statistical Analysis

All obtained data in both seasons of study were subjected to analysis of variance as factorial experiments in split plot design. Duncan's analysis was used to differentiate means according to [35].

3. RESULTS AND DISCUSSION

3.1 Vegetative Growth Parameters

Data recorded in Table 1 show the effect of soil addition of phosphorus fertilizers and foliar spray with growth stimulators and their interaction on vegetative growth parameters of artichoke plants, including plant height, number of leaves and offshoots per plant during the two experimental seasons.

Concerning the effect of phosphorus fertilizer sources treatments, data in Table 1 indicate that there were significant differences in all measured vegetative growth parameters, i.e., plant height, number of leaves and offshoots per plant in the two seasons among the tested phosphorus

sources. In this respect, using bio-phosphorus reflected the highest value in all measured growth parameters, followed by using phosphoric acid, calcium super phosphate and rock phosphate in descending order. Such results are true during both seasons. In this connection, the increments in vegetative growth parameters as a result of using bio-phosphorus may be due to the presence of nitrogen fixing bacteria and phosphorus dissolving. This can increase the nitrogen and phosphorus availability in roots rhizosepher and in turn increase its uptake by plant, which is consequently played main role in cell division and then resulting in increasing plant growth traits [36]. Furthermore, the enhancing effect of phosphoric acid on vegetative growth may be due to the main role in reducing soil pH, which can improve the availability of mineral elements and make them more soluble and available for absorption by plants and in turn increased the vegetative growth [37]. Obtained results are agree with those reported by [10,11, 12,13]

With regard to the effect of growth stimulants foliar spray, the same data in Table 1 indicate that spraying artichoke plants with tested growth stimulants significantly increased all measured vegetative growth parameters compared with the control treatment in both seasons. In this regard, spraying the plants with naphthalene acetic acid (NAA) at 40 ppm exhibited the highest values of plant length. However, using Benzyladnine (BA) at 20 ppm significantly recorded the highest number of leaves and offshoots/plant as compared with the other tested treatments. Moreover, using salicylic acid at 50 ppm, monopotassium phosphate at 2 g/l and NAA at 40 ppm positively enhanced number of leaves and offshoots /plant when compared with the control treatment. Such enhancing effect of tested growth stimulants may be attributed to the effect of such compounds on cell division, cell elongation, keeping plants against disease and as a source for energy and macro-elements (k and p), which had positive effects on plant growth. Furthermore, the obtained results might be resulted from the role of kinetin on promoting protein synthesis, increasing cell division and enlargement [17]. Moreover, these results might be explained according to the role of kinetin on promoting proteins, soluble and non-soluble sugars synthesis, or due to the ability of kinetin for making the treated area to act as a sink in which nutrients from other parts of the plant are drawn [18]. Similar results were reported by [22,23,24 on artichoke] and [38,16,25 on tomato] [15] on faba bean and [26] on cantaloupe.

As for the effect of the interaction, such data in Table 1 indicate that using bio-phosphorus (El-Mowaffer- bio) at 714.3 kg/ha. combined with 40 ppm NAA-sprayed plants recorded the highest values of plant height. In addition, using the same soil addition treatment (El-Mowaffer- bio) combined with 20 ppm BA-sprayed plants resulted in the highest number of leaves and offshoots per plant during the two seasons.

3.2 Chemichal Constituents of Plant Foliage

Data in Table 2 show that fertilizing the plants with phosphoric acid, bio-phosphorus, rock phosphate and calcium superphosphate positively affected all assigned macro - elements and total carbohydrates percentages during the two seasons. Using bio-phosphorus scored the highest values in all assayed macro-elements and total carbohydrates, followed in descending order by phosphoric acid and calcium superphosphate, expect for phosphorus% as phosphoric acid showed its superiority in this concern. In this connection, the superiority of bio-fertilizer and phosphoric acid in increasing the determined macro-elements and total carbohydrates may be due to their role in fixing atmospheric nitrogen, reducing soil PH and increasing solubility of phosphorus and potassium in root rizhosphere and consequently increased nutrient uptake and accumulation by plants and also increased the photosynthetic pigment assimilation and their content in plant foliage. Obtained results are agree with those reported by [10,11,12,13] on artichoke and [36] on wheat, faba bean and onion.

Concerning the effect of growth stimulants foliar spray treatments, the same data in Table 2 refer that spraying globe artichoke plants six times during the growing season with tested growth stimulants significantly increased all assayed chemical constituents in plant foliage compared to the control treatment. In this respect, using BA at 20 ppm reflected the highest values of total nitrogen and carbohydrates percentages. The highest phosphorus and potassium percentages were registered by monopotassium phosphate at 2g/l in the two seasons. These results may explain the role of cytokinins in promoting proteins and pigments synthesis and their ability to delay senescence and withdraw sugars and other solutes from older parts of a plant to the

new organs [18]. In the same line, [39] stated that cytokinins stimulate the movement of sugars, starch, amino acids and many other solutes from mature organs to primary tissues of other ones. Furthermore, may be due to the role of kinetin on increasing the promoters in the plant tissues at the expense of the inhibitors to increase roots growth. Moreover, it is well established that cytokinins stimulate lateral roots initiation, absorption and thus increasing the nutrients uptake [40]. Also, the positive effect of NAA and salicylic acid may be due to their main roles on cell division and increasing the ability of plant to absorption capacity and in turn increased their accumulations in plant foliage. Obtained results are similar to those reported by [22,23,24] on artichoke and [38,16,25] on tomato, [15] on faba bean and [26] on cantaloupe.

As for the effect of the interaction, the same data in Table 2 clearly indicate that fertilizing the plants with bio-fertilizer (Al-mowaffer-bio) enriched with spray the plant with BA at 20 ppm reflected the highest values of nitrogen and total carbohydrates percentages, while using the same fertilizer treatment combined with spraying the plants with monopotassium phosphate at 2 g/l exhibited the highest values of phosphorus and potassium during the two seasons.

3.3 Yield Parameters

Data recorded in Table 1 show the effect of soil addition of phosphorus fertilizers and foliar spray with growth stimulators and their interaction on vegetative growth parameters of artichoke plants, including plant height, number of leaves and offshoots per plant during the two experimental seasons.

Concerning the effect of phosphorus fertilizer sources, data in Table 3 indicate that application of all tested phosphorus fertilizer sources positively affected the total flower head yield and its component expressed as number of early and late flower head as well as total number and weight of flower heads/ha in the two seasons. In addition, application of bio-phosphorus reflected the highest values in all measured flower head yield and its components compared with other tested phosphorus sources. Moreover, phosphoric acid application ranks the second, followed by using calcium super phosphate and rock phosphate in descending order during the two seasons. In this connection, such increment effect of bio-phosphorus and phosphoric acid may be attributed to their positive effects on vegetative growth parameter (Table 1) and chemical constituents (Table 2), which are reflected on number of flower formation and consequently increased the produced yield. Also, the treatments increased the number and weight of flower head formation and increased the productivity of plants. Obtained results are agree with those reported by [10,11,12,13] on artichoke and [36] on wheat, faba bean and onion.

With regard to the effect of growth stimulants foliar spray, data in the same Table clearly indicate that spraying the plants with different studied growth stimulants significantly increased the early, late and total number of head per plant and total head yield per hectare compared with the control during the two seasons. In this connection, spraying the plants with monopotassium phosphate at 2 g/l reflected the highest number of early flower heads per plant, while the highest number of late and total head/plant as well as total produced yield per hectare were recorded as a result of spray plants with 20 ppm BA compared with other tested growth stimulants treatments and the control one. Obtained results behaved the same trend during the two seasons of growth. Such results are connected with the effect of tested spray treatments on increasing the vegetative growth i.e., number of offshoots (Table 1) and chemical constituents (Table 2) and in turn affect positively all produced flower head yield. In this regard, [22,23,24] on artichoke and [38,16,25] on tomato, [15] on faba bean and [26] on cantaloupe reported that foliar spray with growth stimulants increased their yield production.

As for the effect of the interaction, the same data in Table 3 show that all resulted combination between the tested phosphorus sources fertilizer and growth stimulants foliar spray statistically succeeded in increasing yield parameters of artichoke plants as compared with the control treatment in the two seasons. However, the highest values of early yield per plant were recorded as a result of the combination treatment of using Al-Mowaffer bio as a source of phosphorus fertilizer and spraying plants with monopotassium phosphate at 2g/l as it scored 6.42 and 6.84 heads/plant, in the first and second seasons respectively. The highest values of number of late flower head (10.28 and 11.18) and total number per plant (14.90 and 16.40) as well as the total head yield/ha. (37.25 and 41.42 ton) were recorded due to combination between bio-phosphorus fertilizer and spraying plants with

BA at 20 ppm in the first and second seasons, respectively.

3.4 Flower Head Quality Parameters

Data in Table 2 show that fertilizing the plants with phosphoric acid, bio-phosphorus, rock phosphate and calcium superphosphate positively affected all assigned macro - elements and total carbohydrates percentages during the two seasons. Using bio-phosphorus scored the highest values in all assayed macro-elements and total carbohydrates, followed in descending order by phosphoric acid and calcium superphosphate. In this connection, superiority of bio-fertilizer and phosphoric acid in increasing the determined macro-elements and total carbohydrates may be due to their roles in fixing atmospheric nitrogen, reducing soil PH and increasing solubility of phosphorus and potassium in root rizhosphere and consequently increased nutrient uptake and accumulation by plants and also increased the photosynthetic pigment assimilation and their content in plant foliage. Obtained results are agree with those reported by [10,11,12,13] on artichoke and [36] on wheat, faba bean and onion.

Concerning the effect of growth stimulators treatment the same data in Tables 4 and 5 shows that spraying the plants with all tested growth stimulus increased all determined physical flower head quality traits as compared with the control treatment. Generally, the highest values in all measured quality parameters, i.e., average head length, diameter, weight and weight of edible part were obtained as a result of spraying plants with monopotassium phosphate at 2 g/l when compared with other tested treatments. On the other hand, using NAA scored the highest value in head length, while the thickest flower head was gained by BA-sprayed plants in the two seasons. Obtained results may be contributed to increase of macro-element (NPK) uptake and total carbohydrates synthesis which were play main roles in the product ability of plants. In this regard, [22,23,24] on artichoke and [38,16,25] on tomato and [26] on cantaloupe reported similar results.

As for the effect of the interaction, the same data in Tables 4 and 5 indicate that using bio-phosphate and spraying the plants with monopotassium phosphate reflected the highest values of average head fresh weight as well as edible part weight, while using same phosphorus source combined with spray the plants by NAA gave the highest value of average head length. The combined treatment between Al-Mowaffer bio and 20 ppm BA-sprayed plants showed to be the most effective one for inducing the highest head diameter as compared with the rest combination and the control for early and late flower heads. Obtained results are similar in the two seasons of growth.

3.5 Chemical Flower Head Quality

Data in Table 6 indicate that fertilizing the plant with phosphoric acid, AL-Mowaffer bio, calcium super phosphate and rock phosphate tended to increase the inulin percentage in edible plant. On contrast, it tended to decrease fiber percentage in both early and late flower heads in both seasons. In addition, the highest fiber percentage in early and late flower heads was recorded in case of using rock phosphate in both seasons of study. In this regard, similar results were reported on artichoke [10,11,12,13].

Concerning the effect of growth stimulants as foliar spray treatments, the same data in Table 6 indicate that spraying artichoke plants with different tested growth stimulants significantly increased inulin percentage in edible flower head part, with superior for monopotassium phosphate-sprayed plants in both early and late flower heads as compared with the control treatment. On the other hand, such treatments significantly decreased the fiber percentage in early and late flower heads in both seasons. Such results are connected with the effect of these treatments on carbohydrate assimilation and storage form in flower heads. In this regard, similar results were reported on artichoke [22,23,24].

As for the effect of the interaction, the same data in Table 6 refer that both inulin and fiber percentages in early and late flower heads were significantly affected by the interaction treatments during the two seasons of study. In this respect, the highest values of inulin percentage and the lowest values of fiber percentage in both early and late flower head edible part were recorded as a result of fertilizing the plants by phosphoric acid combined with spraying the plants with monopotassium phosphate at 2g/l, whereas the lowest values of fiber % in both early and late flower head edible part were scored by the combined treatment between bio-phosphorus and BA-sprayed plants in the two seasons.

Table 1. Effect of phosphorus fertilizer sources and growth stimulants foliar spray and their interaction on globe artichoke vegetative growth characters during 2013/2014 and 2014/2015 seasons

Treatments		First season2013-2014			Second season 2014-2015		
Phosphorus fertilizer sources	**Growth stimulants**	**Plant height(cm)**	**No. of leaves/plant**	**No. of offshoots/ plant**	**Plant height(cm)**	**No. of leaves/plant**	**No. of offshoots/plant**
Phosphoric acid		107.1b	33.4b	6.82b	118.0a	35.0b	7.49b
Al-Mowaffer-bio		110.3a	35.2a	7.26a	119.7a	36.7a	8.68a
Calcium superphosphate		101.5c	30.1c	6.35c	111.4b	32.6c	7.21c
Rock phosphate		94.39d	27.2d	5.81d	104.4c	29.1d	6.52d
	Benzyladenine(BA)	106.6b	34.8a	7.93a	118.1b	36.3a	8.86a
	Naphthaline acetic acid(NAA)	110.3a	32.9b	6.80b	122.7a	34.7b	7.90b
	Salicylic acid(SA)	100.2c	29.9c	6.04d	109.6d	32.3c	7.04d
	Monopotassium phosphate	103.2c	31.5b	6.49c	112.3c	33.6ab	7.48c
	control	95.7d	28.3d	5.53e	104.3e	29.9d	6.66e
Phosphoric acid	Benzyladenine(BA)	110.5bcd	36.4ab	8.21b	122.1b	37.9abc	9.10b
	Naphthaline acetic acid(NAA)	113.3ab	35.1bc	7.05e	126.4a	36.2bcde	8.60cd
	Salicylic acid(SA)	104.9fgh	31.6de	6.19g	115.2def	33.7efg	7.36g
	Monopotassium phosphate	106.4def	33.8bcd	6.98e	117.2cde	35.1def	7.75f
	control	100.6ghi	30.5ef	5.70h	109.4hi	32.3ghi	6.93hi
Al-Mowaffer-bio	Benzyladenine(BA)	112.1bc	38.7a	8.75a	121.7b	39.6a	9.95a
	Naphthaline acetic acid(NAA)	117.6a	36.5ab	7.43d	129.1a	38.1ab	9.06b
	Salicylic acid(SA)	107.5cdef	33.1cde	6.87ef	116.4de	35.2cdef	8.13e
	Monopotassium phosphate	110.4bcd	34.9bc	7.14de	118.6bcd	36.8bcd	8.82bc
	control	103.7fgh	32.9cde	6.12g	112.5fgh	33.9efg	7.45g
Calcium superphosphate	Benzyladenine(BA)	105.2efg	33.7bcd	7.84c	117.1cde	35.4bcdef	8.50d
	Naphthaline acetic acid(NAA)	109.8bcde	31.9de	6.67h	120.7bc	34.1defg	7.42g
	Salicylic acid(SA)	98.5ij	28.2fg	5.92gh	106.9i	31.6ghij	6.67ij
	Monopotassium phosphate	101.7ghi	30.4ef	6.10g	110.6h	32.9fgh	7.16gh
	control	92.4k	26.3gh	5.23i	101.5j	29.4jk	6.30kl
Rock phosphate	Benzyladenine(BA)	98.4ij	30.6ef	6.94ef	111.3gh	32.3ghi	7.89ef
	Naphthaline acetic acid(NAA)	100.5hi	28.4fg	6.08g	114.5eg	30.6hijk	6.52jk
	Salicylic acid(SA)	92.7k	26.7g	5.19i	99.8j	28.7k	6.02lm
	Monopotassium phosphate	94.2jk	27.2g	5.75h	102.8j	29.9ijk	6.20lm
	control	86.1l	23.5h	5.10i	93.6k	24.3l	5.98m

Means of the same column followed by the same letter were not significantly different according to Duncan MRT at 5%

Table 2. Effect of phosphorus fertilizer sources and growth stimulants foliar spray as well as their interaction on globe artichoke chemical constituents of plant foliage during 2013/2014 and 2014/2015 seasons

Treatments		First season2013-2014				Second season 2014-2015			
Phosphorus fertilizer source	**Growth stimulants**	**N%**	**P%**	**K%**	**Total carbohydrates%**	**N%**	**P%**	**K%**	**Total carbohydrates%**
Phosphoric acid		1.77b	0.36a	2.63b	11.36b	1.86b	0.30a	2.80a	12.50ab
Bio-phosphorus		1.83a	0.34ab	2.75a	11.77a	1.93a	0.28ab	2.74b	12.78a
Calcium superphosphate		1.70c	0.33bc	2.55c	10.69c	1.81b	0.28b	2.72b	12.09b
Rock phosphate		1.61d	0.31c	2.45d	10.25d	1.74c	0.25c	2.66c	11.36c
	Benzyladenine(BA)	1.99a	0.34ab	2.78b	12.77a	2.18a	0.30ab	2.73b	13.85a
	Naphthaline acetic acid(NAA)	1.75b	0.33bc	2.56c	10.72c	1.81b	0.28bc	2.70b	12.03b
	Salicylic acid(SA)	1.64c	0.32bc	2.50d	10.18d	1.73cd	0.26cd	2.60c	11.83b
	Monopotassium phosphate	1.69c	0.36a	2.89a	11.76b	1.77bc	0.31a	3.20a	12.34b
	control	1.58d	0.31c	2.24e	9.64e	1.69d	0.25d	3.20d	10.85c
Phosphoric acid	Benzyladenine(BA)	2.08a	0.38ab	2.76cd	13.26ab	2.27ab	0.33ab	2.94cd	14.36ab
	Naphthaline acetic acid(NAA)	1.76c-f	0.35a-e	2.61e-h	11.16d	1.82de	0.30a-e	2.72f g	12.24c-e
	Salicylic acid(SA)	1.68e-h	0.36a-d	2.55f-i	10.19ef	1.74e-h	0.28c-f	2.61g- j	11.98c-e
	Monopotassium phosphate	1.73d-g	0.39a	2.98b	12.34c	1.79ef	0.34a	3.29a	12.71cd
	control	1.62g-i	0.34b-f	2.28k-m	9.84e-g	1.72e-h	0.27d-f	2.47k-m	11.19ef
Bio-phosphorus	Benzyladenine(BA)	2.13a	0.35a-e	3.04ab	14.13a	2.32a	0.31a-d	2.36mn	15.27a
	Naphthaline acetic acid(NAA)	1.86bc	0.35a-e	2.67d-f	11.30d	1.94cd	0.29b-f	2.78ef	12.39c-e
	Salicylic acid(SA)	1.72d-g	0.33c-f	2.58e-i	10.62de	1.81e	0.26e-g	2.67f-i	12.17c-e
	Monopotassium phosphate	1.79c-e	0.37a-c	3.14a	12.92bc	1.83de	0.32a-c	3.41a	12.84c
	control	1.69e-h	0.33c-f	2.32kl	9.89e-g	1.78ef	0.26e-g	2.49j -m	11.21ef
Calcium	Benzyladenine(BA)	1.94b	0.34b-f	2.69de	12.34c	2.16b	0.29b-f	2.86de	13.29bc
superphosphate	Naphthaline acetic acid(NAA)	1.71e-g	0.33c-f	2.53g-i	10.26ef	1.79ef	0.28c-f	2.69f-h	12.14c-e
	Salicylic acid(SA)	1.63g-i	0.32d-g	2.51hi	9.98e-g	1.71e-h	0.27d-f	2.58h-k	12.07c-e
	Monopotassium phosphate	1.67f-h	0.36a-d	2.83c	11.16d	1.76e-g	0.31a-d	3.10b	11.94c-e
	control	1.55ij	0.31e-g	2.21lm	9.71fg	1.65gh	0.25fg	2.41l-n	11.02ef
Rock phosphate	Benzyladenine(BA)	1.83b-d	0.31e-g	2.63e-h	11.37d	1.98c	0.27d-f	2.79ef	12.46c-e
	Naphthaline acetic acid(NAA)	1.69e-h	0.32d-g	2.46ij	10.17ef	1.72e-h	0.26e-g	2.64g-i	11.37d-f
	Salicylic acid(SA)	1.53ij	0.30fg	2.37jk	9.93e-g	1.68f-h	0.25fg	2.54i-l	11.10ef
	Monopotassium phosphate	1.58hi	0.34b-f	2.64d-g	10.64de	1.71e-h	0.29b-f	3.02bc	11.87c-e
	control	1.46j	0.28g	2.17m	9.14g	1.62h	0.22g	2.31n	9.99f

Means of the same column followed by the same letter were not significantly different according to Duncan MRT at 5%

Table 3. Effect of phosphorus fertilizers sources and growth stimulants foliar spray as well as their interaction on globe artichoke flower head yield parameters during 2013/2014 and 2014/2015 seasons

Treatments		First season2013-2014				Second season 2014-2015			
Phosphorus fertilizer	**Growth stimulants**	**No. of early heads/plant**	**No. of late heads/plant**	**No. of total heads/plant**	**Total yield (ton/ha.)**	**No. of early heads/plant**	**No. of late heads/plant**	**No. of total heads/plant**	**Total yield (ton/ha.)**
Phosphoric acid		5.03b	8.13a	13.17b	32.34b	5.28b	8.94a	14.22b	35.00b
Bio-phosphorus		5.18a	8.54a	13.73a	35.23a	5.70a	9.34a	15.04a	37.79a
Calcium superphosphate		4.23c	7.32b	11.56c	27.32c	4.88c	8.07b	12.96c	30.97c
Rock phosphate		3.78d	6.56c	10.35d	24.83d	4.49d	7.00c	11.50d	26.85d
	Benzyladenine(BA)	4.01d	9.24a	13.26a	32.67a	4.58d	10.37a	14.95a	36.51a
	Naphthaline acetic acid(NAA)	4.88b	7.52b	12.41b	29.70bc	5.58b	8.31b	13.90b	32.05c
	Salicylic acid(SA)	4.50c	7.27b	11.78c	28.81cd	5.30c	7.76cd	13.07c	31.28c
	Monopotassium phosphate	5.43a	7.01b	12.44b	30.88b	6.01a	7.33d	13.35bc	34.55b
	control	3.96d	7.15b	11.12d	27.59d	3.96e	7.93bc	11.90d	28.86d
Phosphoric acid	Benzyladenine(BA)	4.18e	10.08a	14.26ab	34.95a-d	4.91hi	10.91a	15.82ab	38.92a-c
	Naphthaline acetic acid(NAA)	5.27c	7.85c-f	13.12d-f	32.12d-g	5.99b-d	8.47d-g	14.46c-f	34.25ef
	Salicylic acid(SA)	4.60d	8.22b-d	12.82e-g	31.90e-g	5.32e	8.63c-f	13.95d-h	33.84ef
	Monopotassium phosphate	5.55b	8.20b-d	13.75b-e	33.24b-f	6.13bc	8.02e-h	14.15d-g	37.61bc
	control	5.57b	6.33gh	11.90g-i	29.47gh	4.05k	8.70c-f	12.75hi	30.36gh
Bio-phosphorus	Benzyladenine(BA)	4.62d	10.28a	14.90a	37.25a	5.22ef	11.18a	16.40a	41.42a
	Naphthaline acetic acid(NAA)	5.72b	8.08b-e	13.80b-d	35.36a-c	6.17b	9.48b-d	15.65a-c	37.18b-d
	Salicylic acid(SA)	5.25c	7.99b-e	13.24c-f	34.75a-e	5.91d	8.84b-f	14.75b-e	36.63c-e
	Monopotassium phosphate	6.42a	7.68c-f	14.10a-c	36.10ab	6.84a	8.23e-g	15.07a-d	39.75ab
	control	3.92f	8.70bc	12.62f-h	32.68c-f	4.36j	9.00b-e	13.36f-h	33.97ef
Calcium	Benzyladenine(BA)	3.67g	8.96b	12.63f-h	30.36f-h	4.24j	9.87b	14.11d-g	34.75d-f
superphosphate	Naphthaline acetic acid(NAA)	4.61d	7.29d-g	11.90g-i	26.52i-k	5.36e	8.18e-g	13.54e-h	30.63gh
	Salicylic acid(SA)	4.48d	6.62g	11.10i-l	25.17k-m	5.05f-h	7.81f-i	12.86g-i	29.56hi
	Monopotassium phosphate	5.13c	6.62g	11.75h-j	28.93hi	5.98cd	6.94ij	12.92g-i	32.52fg
	control	3.28h	7.14e-g	10.42k-n	25.64j-l	3.81lm	7.56g-i	11.38jk	27.37i-k
Rock phosphate	Benzyladenine(BA)	3.59g	7.66d-f	11.25i-k	28.12h-j	3.95kl	9.51bc	11.46e-h	30.93gh
	Naphthaline acetic acid(NAA)	3.94f	6.88fg	10.82j-m	24.81k-m	4.82i	7.12h-j	11.94ij	26.15j-l
	Salicylic acid(SA)	3.68g	6.27gh	9.95mn	23.42lm	4.95g-i	5.78k	10.73jk	25.10kl
	Monopotassium phosphate	4.62d	5.56h	10.18l-n	25.26j-m	5.10fg	6.15jk	11.25jk	28.32h-jl
	control	3.10h	6.43gh	9.53n	22.56m	3.64m	6.48jk	10.12k	23.75l

Means of the same column followed by the same letter were not significantly different according to Duncan MRT at 5%

Table 4. Effect of phosphorus fertilizers sources and growth stimulants foliar spray as well as their interaction on globe artichoke early physical flower head quality during 2013/2014 and 2014/2015 seasons

Treatments		First season2013-2014				Second season 2014-2015			
Phosphorus fertilizer	**Growth stimulants**	**Head length (cm)**	**Head diameter (cm)**	**Average head fresh weight (g)**	**Average edible fresh weight(g)**	**Head length (cm)**	**Head diameter (cm)**	**Average head fresh weight (g)**	**Average edible fresh weight (g)**
Phosphoric acid		9.30b	8.19b	237.6b	73.70b	9.74b	8.77b	256.8b	85.22b
Bio-phosphorus		9.50a	8.52a	249.1a	85.98a	9.98a	9.12a	271.2a	91.86a
Calcium superphosphate		9.16c	7.77c	227.6c	68.22c	9.49c	8.40c	245.0c	73.20c
Rock phosphate		9.03d	7.49d	211.4d	61.34d	9.19d	7.98d	230.6d	67.30d
	Benzyladenine(BA)	9.22b	8.29a	238.8b	73.38b	9.63b	8.95a	258.9b	81.15b
	Naphthaline acetic acid(NAA)	9.43a	7.85c	226.6d	69.53c	9.76a	8.44b	246.6c	76.40c
	Salicylic acid(SA)	9.19b	7.97b	233.4c	73.88b	9.57b	8.58b	254.0b	82.10b
	Monopotassium phosphate	9.36a	8.20a	247.7a	79.63a	9.77a	8.83a	268.8a	86.30a
	control	9.05c	7.64d	210.6e	65.15d	9.27c	8.03c	226.3d	71.03d
Phosphoric acid	Benzyladenine(BA)	9.28de	8.42b	244.5b-d	73.70fg	9.84c-e	9.11a-c	269.1bc	86.80de
	Naphthaline acetic acid(NAA)	9.51b	8.07c-e	235.4e-g	70.30gh	9.97bc	9.72ef	250.9d-f	81.70fg
	Salicylic acid(SA)	9.21e-g	8.17c	240.3c-e	74.50f	9.72d-f	8.85c-e	262.5b-d	88.20d
	Monopotassium phosphate	9.43bc	8.40b	252.1b	81.20de	9.89cd	9.03a-e	273.2ab	90.10cd
	control	9.10g-j	7.92ef	215.7ij	68.80hi	9.32h-j	8.16g-i	228.3h-j	79.30g
Bio-phosphorus	Benzyladenine(BA)	9.42b-d	8.86a	253.2b	87.60b	9.99bc	9.34a	276.1ab	94.30b
	Naphthaline acetic acid(NAA)	9.72a	8.42b	242.9c-e	83.90cd	10.18a	9.00b-e	268.2bc	89.50d
	Salicylic acid(SA)	9.45bc	8.51b	248.4bc	86.50bc	9.96bc	9.09a-d	271.8ab	93.60bc
	Monopotassium phosphate	9.66a	8.70a	269.6a	92.80a	10.13ab	9.28ab	285.3a	98.70a
	control	9.27ef	8.11cd	231.5fg	79.10e	9.65f	8.90c-e	254.7c-e	83.20ef
Calcium superphosphate	Benzyladenine(BA)	9.13f-i	8.02c-e	237.1d-f	69.30h	9.55fg	8.93c-e	252.3d-f	73.20hi
	Naphthaline acetic acid(NAA)	9.32c-e	7.64g	221.8hi	65.60ij	9.65f	8.13g-j	241.6e-h	70.10ij
	Salicylic acid(SA)	9.13f-i	7.82fg	234.5e-g	70.90f-h	9.46gh	8.36gh	247.5e-g	74.50h
	Monopotassium phosphate	9.24e-g	7.95d-f	241.9c-e	74.20f	9.70ef	8.77d-f	267.1bc	80.90fg
	control	8.99i-k	7.43h	202.7k	61.10kl	9.11kl	7.82j	216.4jk	67.30jk
Rock phosphate	Benzyladenine(BA)	9.06h-j	7.89ef	220.5hi	62.90jk	9.17j-l	8.45fg	238.1f-i	70.30ij
	Naphthaline acetic acid(NAA)	9.18e-h	7.28hi	206.3k	58.30l	9.25i-k	7.93ij	225.5ij	64.30k
	Salicylic acid(SA)	8.98jk	7.39h	210.6jk	63.60jk	9.15j-l	8.05h-j	234.2g-i	72.10hi
	Monopotassium phosphate	9.11g-j	7.77fg	227.1gh	70.31gh	9.38g-i	8.25g-i	249.7d-f	75.50h
	control	8.85k	7.12i	192.7l	51.60m	9.01l	7.26k	205.6k	54.30l

Means of the same column followed by the same letter were not significantly different according to Duncan MRT at 5%

Table 5. Effect of phosphorus fertilizers sources and growth stimulants foliar spray as well as their interaction on globe artichoke late physical flower head quality during 2013/2014 and 2014/2015 seasons

Treatments		First season2013-2014				Second season 2014-2015			
Phosphorus fertilizer	**Growth stimulants**	**Head diameter (cm)**	**Head length (cm)**	**Average head fresh weight (g)**	**Average edible fresh weight (g)**	**Head diameter (cm)**	**Head length (cm)**	**Average head fresh weight (g)**	**Average edible fresh weight (g)**
Phosphoric acid		9.56b	7.99a	207.5b	62.00b	10.06b	8.30b	215.6b	65.54b
Bio-phosphorus		9.74a	8.25a	214.9a	68.88a	10.15a	8.71a	227.0a	70.66a
Calcium superphosphate		9.27c	7.44b	197.3c	56.68c	9.77c	8.03c	208.9c	60.04c
Rock phosphate		9.22c	7.02c	174.9d	51.20d	9.41d	7.49d	191.9d	55.57d
	Benzyladenine(BA)	9.49b	7.98a	208.3b	61.43b	9.85b	8.42a	220.4b	65.28b
	Naphthaline acetic acid(NAA)	9.66a	7.53bc	191.6d	58.55c	9.98a	8.09b	203.9c	61.68c
	Salicylic acid(SA)	9.36bc	7.69ab	198.2c	60.88b	9.77b	8.17b	209.0c	63.10c
	Monopotassium phosphate	9.43bc	7.86a	219.2a	66.28a	10.02a	8.31a	235.5a	72.05c
	control	9.29c	7.33c	176.1e	51.33d	9.59c	7.68c	195.6d	52.66d
Phosphoric acid	Benzyladenine(BA)	9.63b-e	8.16a-c	219.6bc	62.80de	10.09b-e	8.47c	228.2bc	65.20ef
	Naphthaline acetic acid(NAA)	9.92ab	7.95a-e	198.5e-h	60.50d-f	10.17a-c	8.263c-f	206.3e-i	63.90f
	Salicylic acid(SA)	9.43e-h	8.02a-d	207.8c-f	63.30d	10.01c-f	8.35cd	210.6d-g	66.40d-f
	Monopotassium phosphate	9.59c-f	8.13a-c	223.4b	67.50bc	10.14b-d	8.40cd	237.2b	74.80b
	control	9.23g-i	7.70c-g	188.2hi	55.90gh	9.87fg	8.05f-h	195.9h-j	57.40ij
Bio-phosphorus	Benzyladenine(BA)	9.85a-c	8.53a	225.1ab	71.40b	10.15bc	8.96a	236.3b	73.20bc
	Naphthaline acetic acid(NAA)	9.98a	8.16a-c	205.7d-g	68.20bc	10.36a	8.73b	215.4d-f	69.30c-e
	Salicylic acid(SA)	9.63b-e	8.27a-c	210.1c-e	70.10b	10.08b-e	8.82ab	219.5cd	71.21bc
	Monopotassium phosphate	9.82a-d	8.48ab	237.2a	75.90a	10.25ab	8.90ab	259.4a	80.40a
	Control	9.45e-g	7.85b-f	196.5f-h	58.80e-g	9.92ef	8.18d-g	204.6f-i	59.20hi
Calcium	Benzyladenine(BA)	9.31e-i	7.94a-e	206.7d-f	58.20fg	9.83f-h	8.30c-e	217.8c-e	63.20f-h
superphosphate	Naphthaline acetic acid(NAA)	9.50d-g	7.13g-j	193.6g-i	55.60gh	9.95d-f	8.02gh	208.5d-h	58.70ij
	Salicylic acid(SA)	9.28f-i	7.45d-i	201.2e-g	57.90fg	9.67h	8.10e-h	211.6d-g	59.50g-i
	Monopotassium phosphate	9.08i	7.63c-h	216.4b-d	64.30cd	9.99c-f	8.22d-g	228.2bc	69.50cd
	control	9.18g-i	7.05g-j	168.6k	47.40j	9.42i	7.52jk	178.3k	49.30k
Rock phosphate	Benzyladenine(BA)	9.18g-i	7.30e-j	181.6ij	58.30hi	9.36ij	7.95hi	199.3g-i	59.50g-i
	Naphthaline acetic acid(NAA)	9.27f-i	6.89ij	168.5k	49.90ij	9.45i	7.36k	185.4jk	54.80j
	Salicylic acid(SA)	9.11hi	7.02h-j	173.6jk	52.20hi	9.35ij	7.42k	194.2ij	55.30ij
	Monopotassium phosphate	9.23g-i	7.21f-j	199.7e-h	57.40fg	9.72gh	7.74ij	217.2c-f	63.50fg
	control	9.31e-i	6.72j	151.2l	43.20k	9.18j	6.98l	163.6l	44.73l

Means of the same column followed by the same letter were not significantly different according to Duncan MRT at 5%

Table 6. Effect of phosphorus fertilizers sources and growth stimulants foliar spray as well as their interactions on globe artichoke early and late chemical quality of flower head during 2013/2014 and 2014/2015 seasons

Treatments		First season2013-2014				Second season 2014-2015			
Phosphorus fertilizer	**Growth stimulants**	**Early inulin%**	**Early fiber%**	**Late inulin%**	**Late fiber%**	**Early inulin%**	**Early fiber%**	**Late inulin%**	**Late fiber%**
Phosphoric acid		1.69a	4.87b	1.36a	6.98c	1.63a	4.38b	1.31a	7.01c
Bio-phosphorus		1.67a	4.67c	1.34a	6.88d	1.62a	4.25c	1.29a	6.83d
Calcium superphosphate		1.62ab	4.93b	1.32a	7.22b	1.57a	4.47ab	1.27a	7.18b
Roch phosphate		1.58b	5.07a	1.30a	7.39a	1.55a	4.56a	1.27a	7.35a
	Benzyladenine(BA)	1.75a	4.24d	1.38ab	6.33e	1.73ab	4.03c	1.36a	6.21e
	Naphthaline acetic acid(NAA)	1.60b	4.76c	1.33bc	6.53d	1.62b	4.32b	1.28b	6.59d
	Salicylic acid(SA)	1.55bc	5.24b	1.28c	7.42b	1.43c	4.42b	1.23bc	7.47b
	Monopotassium phosphate	1.83a	4.79c	1.41a	7.04c	1.77a	4.41b	1.37a	7.04c
	control	1.48c	5.41a	1.25c	8.28a	1.41c	4.89a	1.18c	8.16a
Phosphoric acid	Benzyladenine(BA)	1.83a-c	4.20k	1.41a-c	6.24mn	1.76ab	3.96jk	1.38a-c	6.12lm
	Naphthaline acetic acid(NAA)	1.69c-g	4.51h-j	1.36a-d	6.49j-l	1.67a-e	4.43d-g	1.32a-h	6.39jk
	Salicylic acid(SA)	1.54f-j	5.46ab	1.30b-d	7.38ef	1.47c-f	4.39d-h	1.27b-i	7.46de
	Monopotassium phosphate	1.92a	4.82fg	1.49a	6.89h	1.84a	4.31f-i	1.42a	6.94g-i
	control	1.51h-j	5.37a-c	1.26cd	7.94c	1.41d-f	4.83b	1.20f-i	8.14a
Bio-phosphorus	Benzyladenine(BA)	1.79a-d	4.13k	1.39a-d	6.19n	1.73a-c	3.81k	1.35a-e	5.96m
	Naphthaline acetic acid(NAA)	1.64d-i	4.39i-k	1.34a-d	6.43kl	1.61a-f	4.19hi	1.29a-h	6.31j-l
	Salicylic acid(SA)	1.59e-j	4.93e-g	1.29b-d	7.19g	1.49b-f	4.35e-i	1.24b-i	7.14fg
	Monopotassium phosphate	1.87ab	4.67g-i	1.43ab	6.73hi	1.81a	4.20hi	1.39ab	6.84i
	control	1.49ij	5.26b-d	1.26cd	7.89c	1.46c-f	4.71bc	1.90g-i	7.92b
Calcium	Benzyladenine(BA)	1.71b-f	4.29jk	1.37a-d	6.38lm	1.74a-c	4.14ij	1.33a-g	6.24kl
superphosphate	Naphthaline acetic acid(NAA)	1.58e-j	5.01d-f	1.32b-d	6.58i-k	1.63a-f	4.31f-i	1.28a-i	6.74i
	Salicylic acid(SA)	1.56f-j	5.21b-e	1.28b-d	7.48de	1.39ef	4.46d-f	1.23d-i	7.58a
	Monopotassium phosphate	1.81a-d	4.76f-h	1.39a-d	7.31e-g	1.74a-d	4.56c-e	1.36a-d	7.10f-h
	control	1.48ij	5.41a-c	1.25d	8.37b	1.39ef	4.90b	1.18hi	8.25a
Rock phosphate	Benzyladenine(BA)	1.68c-h	4.34jk	1.35a-d	6.52j-l	1.70a-c	4.21g-i	1.40ab	6.52j
	Naphthaline acetic acid(NAA)	1.50ij	5.13c-e	1.30b-d	6.62ij	1.59a-f	4.37d-h	1.26b-i	6.92hi
	Salicylic acid(SA)	1.53g-j	5.36a-c	1.26cd	7.63d	1.40ef	4.51c-f	1.21e-i	7.70c
	Monopotassium phosphate	1.74b-e	4.93e-g	1.36a-d	7.26fg	1.69a-d	4.59cd	1.34a-f	7.29ef
	control	1.46j	5.63a	1.24d	8.92a	1.38f	5.14a	1.17i	8.35a

Means of the same column followed by the same letter were not significantly different according to Duncan MRT at 5%

4. CONCLUSION

It could be concluded that under such condition of the experiment, fertilizing artichoke plants with bio-phosphorus fertilizer and spraying plants with BA at 20 ppm was recommended for increasing vegetative growth and number and weight of total produced head flowers of artichoke. Moreover, spraying plants with monopotassium phosphate was recommended to obtain the highest number of early flower heads with good quality.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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