

Effect of Mineral and Bio NPK Fertilizers and Foliar Spray with Some Growth Stimulants on Growth and Productivity of Potato

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Abstract

Potato is highly responsive to NPK fertilizer, chemical fertilizers have several negative impacts on environment and sustainable agriculture. Therefore, two field experiments were carried out during the two successive summer seasons of 2018 and 2019 at the experimental farm of the Faculty of Agriculture, Moshtohor, Benha University to investigate the effect of different levels of mineral NPK fertilizers added with bio fertilizer to the soil (F₁, 100% mineral NPK fertilizer (as recommended dose); F₂, 80% mineral NPK fertilizer + Bio fertilizer and F₃, 60% mineral NPK fertilizer + Bio fertilizer) and foliar spray with growth stimulant such as Potassium citrate at 5g/L, Yeast extract at 5%, Seaweed extract at 5%, Garlic extract at 5% and Control (without spraying) as well as their interaction on vegetative growth characters, chemical constituents of plant foliage, total tuber yield, physical and chemical quality of potato tubers (*Solanum tuberosum* L.) cv. Sponta. Results indicate that applying the treatment 80% RDF+ biofertilizer followed by treatment 100% RDF without bio fertilizer reflected significantly and the highest values in all measured vegetative growth aspects (plant height, No. of branches, No. of leaves, total fresh and dry weight/plant); chemical constituent of N, P, K and carbohydrate percentage; total produced tuber yield and its components expressed as total yield/plant, total yield/fed, average tuber weight, tuber length and tuber diameter; and chemical tuber quality expressed as content of N, P, K, total protein, total Starch and NO₃ of potato plants compared with 60% NPK fertilization at the recommended dose of mineral fertilizer which gave the lowest values in the two seasons of study. In this regard, spraying the plants with yeast extracts at 5% or seaweed extract at 5 ml/l gave the significant highest values of all studied characteristics of potato plants in both seasons. Results also indicate that fertilizing potato plants with 80% RDNPK added with bio fertilizer combined with either yeast extracts at 5% or seaweed extract at 5 ml/l spraying every 10 days during the growth season gave the highest values in all studied characteristics.

Key words: Potato – mineral- Bio-NPK fertilizers – growth stimulants- tuber yield - quality

Introduction

Potato (*Solanum tuberosum* L.) is one of major crops contributing to the world's food security. Potato is one of the most important field crops not only to its local consumption but also to increase meeting income through its exportation among different countries in the world. The cultivated area of potato in Egypt in 2016/2017 reached about 376631 feddans, which yielded 4113441 tons of tubers with an average of about 12.567 ton/fed. The potato exports reached around 673000 Tons last season (2018/2019). Potato is highly responsive to NPK fertilizer, especially on sandy soils (Errebhi *et al.*, 1998). Chemical fertilizers have several negative impacts on environment and sustainable agriculture. Recently, the use of slow release fertilizers has become a new trend to save fertilizer consumption and to minimize environmental pollution. Therefore, bio fertilizers are recommended in these conditions and growth promoting bacteria have been used as a replacement of chemical fertilizers (Wu *et al.*, 2005). Using biofertilizers leads to not only increase in population of beneficial microorganisms but also decrease environmental effects. Use of biofertilizers can have a great complementary impact in increasing fertilizers use efficiency.

Moreover, many plant growth-stimulating compounds such as yeast extract, seaweed extract or garlic extract and potassium citrate affect cellular metabolism in treated plants, leading to increased tolerance to abiotic stresses, improved plant growth and crop yield (Craig, 2011; Sharma *et al.*, 2014). Seaweed extract is known as a source of plant growth regulators (Herrera *et al.*, 2014) organic osmolites, amino acids mineral nutrients, vitamins and vitamin precursors. Yeast extract has stimulatory effects on cell division and enlargement, protein and nucleic acid synthesis, and chlorophyll formation. Garlic is characterized by a high content of amino acids, which contain sulfur such as Methionine and Cysteine and contains vitamins, hormones and disinfectants that are concentrated in lobes such as Allicin. Potassium is a major plant nutrient and plays an essential role in a variety of physiological processes, i.e. photosynthesis, protein synthesis and maintenance of water status in plant tissues (Marschner, 2012).

Therefore, this investigation was carried out to investigate the effect of reparation the deficit of recommended dose of mineral fertilizer by added bio-fertilizer or foliar spray application with some active stimulants such as yeast extract, seaweed extract or garlic extract and potassium citrate as well as their combination on vegetative growth, chemical

composition of plant foliage, yield productivity and quality of potato tubers.

Materials and Methods

Two field experiments were carried out during the two successive summer seasons of 2018 and 2019 at the experimental farm of the Faculty of Agriculture, Moshtohor, Benha University to investigate the effect of different levels of mineral NPK fertilizers added with bio fertilizer to the soil and foliar spray with growth stimulant such as yeast extract, garlic extract, seaweed extract and potassium citrate as well as their interaction on vegetative growth characters, chemical constituents of plant foliage, total tuber yield, physical and chemical quality of potato tubers (*Solanum tuberosum* L.) cv. Sponta.

Potato tubers were planted on 6th January in the first and second seasons. This experimental was carried out in a split plot design with three replicates where the main plot comprises the following NPK-treatments (F₁, 100% mineral NPK fertilizer (as recommended dose); F₂, 80% mineral NPK fertilizer + Bio fertilizer and F₃, 60% mineral NPK fertilizer + Bio fertilizer). The subplots received foliar application of Potassium citrate at 5g/L, Yeast extract at 5%, Seaweed extract at 5%, Garlic extract at 5% and Control (without spraying). Each experimental plot included four rows 4m in length and 80 cm in width with an area of 12.8 m². Potato tubers were planted 30cm apart on one side of the ridges.

The recommended rates of mineral NPK fertilizers were 150 kg N per Fed. (As ammonium nitrate 33% N), 60 kg P₂O₅ (As Calcium superphosphate 16% P₂O₅) and 96 kg K₂O per Fed. (As potassium sulphate 48% K₂O). Where Mineral N fertilizer in the form of ammonium nitrate NH₄NO₃, (33% N) was divided into three equal portions and was added after complete germination, and every two weeks by interval. Mineral P₂O₅ fertilizer in the form of Calcium superphosphate (16% P₂O₅) was divided and added at two equal parts during soil preparation and planting date. Meanwhile, Mineral K₂O fertilizer in the form of potassium sulphate (48% K₂O) was divided at two equal parts during and added after two months from planting and after two weeks by interval. Concerning treatments which included bio fertilizer, soil was inoculated two times with Rhizobacterin, Phosphorin and Potassine at tubers planting time and after complete germination at rate of 1 kg/fed. for each Rhizobacterin, Phosphorin and Potassine. The foliar application treatments with of yeast extract, garlic extract, seaweed extract and potassium citrate were added five times started after 21 days from planting and every 10 days interval.

After 70 days from planting, three plants were taken as representative sample from each experimental plot then recorded the plant height (cm), Number of branches/plant, Number of leaves/plant, Fresh weight/plant (g) and Dry weight/plant (g). Total

nitrogen, phosphorus, potassium and carbohydrate contents were determined in the digested dry matter of plant leaves according to methods described by **Pregl (1945)**, **John (1970)**, **Brown and Lilleland (1946)** and **Herbert *et al.* (1971)** for nitrogen phosphorus, potassium, and carbohydrate, respectively. Potato tubers were harvested after 120 days from planting and recorded the Tuber yield (g/plant), Total tuber yield (t/fed) and Number of tubers/plant. At harvest time a random sample of 10 tubers from each experimental plot were taken to determine weight, length, diameter and size of each tuber. In addition, the digested dry matter of each sample was taken for chemical determination of each N, P and K as well as total protein, starch, total carbohydrate and finally nitrate contents were determined according to the methods described by **Pregl (1945)**, **John (1970)**, **Brown and Lilleland (1946)**, **A.O.A.C., (1990)** **Herbert *et al.* (1971)** and **Cataldo *et al.* (1975)**, respectively. All collected data were subjected to statistical analysis according to **Snedecor and Cochran (1991)** where the least significant difference at 5% of the probability was considered when even possible.

Results and Discussion

Vegetative growth characteristics:

Data presented in Table 1 show that there were differences in all studied morphological vegetative growth parameters of potato plants among the used different levels of NPK mineral fertilizer added with bio fertilizer. In this respect, applying the treatment 80% RDF+ biofertilizer followed by treatment 100% RDF without bio fertilizer reflected significantly and the highest values in all measured vegetative growth aspects (plant height, No. of branches, No. of leaves, total fresh and dry weight/plant) of potato plants compared with 60% NPK fertilization at the recommended dose of mineral fertilizer which gave the lowest values in the two seasons of study. Such increments in vegetative growth parameters in case of using 80% or 100% in fertilization may be due to its highest soil content of available nutrient elements which may be attributed to the main role of macromartnets (N, P and K) on formation of protoplasmic material, cells division and elongations bio – chemicals interaction which affect the rate of plant growth.

In this connection, bio-fertilizer may induce growth promotion by production of phytohormons, improving availability of nutrients, non-symbiotic nitrogen fixation and stimulation of disease resistance mechanisms (**Zdor and Anderson 1992**), which all together may promote the vegetative growth. Obtained results are coincided with those mentioned by **Doklega (2017)**, **Hosseini *et al.* (2017)**, **Singh *et al.* (2017)**, **Lallawmkima *et al.* (2018)**, **Verma *et al.* (2018)** and **Ramandeep *et al.* (2018)**.

As for the effect of foliar spray treatments, the same data in Table 1 indicate that spraying potato plants with anyone of studied growth stimulants such as yeast and garlic extracts at 5%, seaweed extract at 5 ml/l and potassium citrate at rate of 5 g/l starting after 21 days from planting and every ten days by intervals during growth season increased all measured growth aspects expressed as plant height, number of leaves and branches/plant, fresh and dry weight of plant compared with the control treatment in the two seasons of study. In this regard, spraying the plants with yeast extracts at 5% or seaweed extract at 5 ml/l followed by treatment which received potassium citrate at rate of 5 g/l gave the significant highest values of all vegetative growth characteristics of potato plants in both seasons. Obtained data may be due to that yeast and seaweed extracts increase content of macro nutrients content which affect positively on growth rate of potato plants. Seaweed extract maybe contains various micro elements (Cu, Zn, Mo, B, Co) in addition to macro elements and contain auxins, gibberellins, and cytokinins, also Yeast extract is as a natural source of cytokinins-stimulates. So Yeast and Seaweed extracts have stimulatory effects on cell division and enlargement, protein and nucleic acid synthesis, and chlorophyll formation (Barnett *et al.*, 1990). Obtained results are in agreement with those reported by Ibrahim (2016) and Backeset *et al.* (2017) in case of seaweed extract and El-Fadl *et al.* (2017) in case of Yeast extract.

With regard to the effect of the interaction between soil addition fertilizers and foliar spray treatments, such data in Table 1 indicate that fertilizing potato plants with 80% RDNPK added with bio fertilizer combined with either yeast extracts at 5% or seaweed extract at 5 ml/l spraying every 10 days during the growth season gave the highest values in all growth aspects followed by plants which fertilized with 100% the recommended dose of mineral fertilizer without bio fertilizer with foliar spray either yeast or seaweed extracts compared with other interaction treatments. Obtained result, are true during both seasons of study.

Chemical composition of plant foliage:

It's clear from recorded data in Table 2 that fertilizing potato plants with 100%, 80% and 60% of recommended dose added with bio fertilizer show significant difference in all determined chemical constituent of N, P, K and carbohydrate percentage in two seasons. In this respect, treatment 80% RDF+ biofertilizer followed by treatment 100% RDF without biofertilizer gave significant increased nitrogen, phosphor, potassium and carbohydrate percentage compared with treatment 60% RDF+ biofertilizer in both season of study.

Such increments in N, P and K content as a result of increments in increasing the amounts of added mineral fertilizers may be due to the increase of such nutrient in roots biosphere and consequently increases its uptake and accumulation of such macro- nutrients

Also the increase in total carbohydrate content might attributed to the main role of used macro-nutrients (NPK) as constituents of photosynthetic pigment molecules and assimilation rate for precursors of carbohydrates in leaves. In addition, such enhancing effect may be due to the main role of tested bio-fertilizer in atmospheric nitrogen rotation and solubilizing of phosphorus fertilizer and make it more available to be absorbed by plants and accumulated in plant foliage. Obtained results coincided with those reported El-Sayed *et al* (2015), Ibrahim (2015), Kolodziejczyk (2016) and Mijwel (2018).

Regarding the effect of foliar spray treatments, the same data in Table 2 indicate that spraying potato plants after 21days from planting and every ten Days with either yeast extract, garlic extract at 5%, seaweed extract at 5 ml/l or potassium citrate at rate of 5 g/l reached the level of significance during both seasons compared with control. In addition, sprayed plant with seaweed extract at 5 ml/l followed by treatment received yeast extract gave significantly increased of most measure aspects, i.e, nitrogen, phosphor, and carbohydrate percentage in both seasons. While applied potassium citrate or seaweed extract gave the highest values of potassium percentage. Obtained results are similar to those reported by Jasim *et al.* (2013), Lola – Luz *et al* (2014) and Ibrahim (2016) in case of seaweed extract and Salim *et al.* (2014) and Abd El-Gawad *et al.* (2017) in case of potassium.

As for the effect of the interaction data in Table 4 indicate that fertilizing the plants with 80% of mineral NPK fertilizer added with bio fertilizer combined with spraying the plant with seaweed extract at 5 ml/l reflected the highest values in all measure i.e nitrogen, potassium, phosphor, and total carbohydrate content in the two seasons of study. On the other hand, fertilizing potato plants with 60% of recommended dose of NPK and without foliar spray (control treatments) gave the lowest values in all assayed aspects during both seasons of study.

Yield and its components:

Data in Table 3 indicate that there were a differences in total produced tuber yield and its components expressed as total yield/plant, total yield/fed, average tuber weight, tuber length and tuber diameter among the used fertilizer level i.e., 100%, 80%, 60% NPK at recommended dose and added bio fertilizer with the two lowest levels in the two seasons of study. In this respect, such differences reached the level of significantly between 80% RDF + biofertilizer followed by treatment of 100% RDF without biofertilizer compared with 60% RDF in all case of tuber yield and its components during the two season of study. In this connection, using 60% from recommended dose reflected the lowest values in produced tuber yield and its components. Such increments in produced total yield/plant, total yield/fed, average tuber weight, tuber length and tuber diameter as a result of bio-fertilizer inoculation may

be due to the increasing of vegetative growth parameters (Table, 1) which in turn might affect positively number and weight of pods produced by plant and consequently increased the total produced yield per feddan. Obtained results are in agreement with those reported by *Jayapal et al. (2016)*, *Yadav et al. (2016)*, *El-Sayed et al. (2017)*, *Sarkar et al. (2017)*, *Tiwari et al. (2017)*, *Yadav et al. (2017)*, *Lallawmkima et al (2018)*, *Ramandeep et al. (2018)* and *Rajiv (2019)* who found that bio-fertilizer positively influenced number and weight of tubers/plant and tubers yield/unit area.

As for the effect of spray treatments on total produced tuber yield and its components, such data in Table 3 show that spraying potato plants after 3 weeks from planting and every 10 days by interval during the growth seasons with yeast extract 5%, garlic extract 5%, seaweed extract 5 ml/l and potassium citrate 5 g/l significantly increased total produced tuber yield and its components. In this connection, potato plants which sprayed with seaweed extract at rate 5 ml/l followed by plants which sprayed potassium citrate at rate 5 g/l reflected the highest produced total tuber yield and its components expressed as total yield/plant, total yield/fed, average tuber weight, tuber length and tuber diameter compared with the control one during the two seasons of study. In this regard, the superiority of using seaweed extract and potassium citrate on total produced yield and its components may be attributed to the photosynthesis stimulation, transpiration reduction and increasing plant resistance to biotic and abiotic stresses which lead to increased plant growth and consequently increased tubers formation. Obtained results are in agreement with those reported by *Haider et al. (2012)*, *Wasim et al (2012)*, *Ibrahim (2016)* and *Asha et al. (2017)* in case of seaweed extract and *El-Sawy (2011)*, *Jasim et al. (2013)*, *Salim et al. (2014)* and *Abd El-Gawad et al. (2017)* in case of potassium.

Data in Table 3 also reveal that spraying potato plants with either seaweed extract at rate 5 ml/l or potassium citrate at rate 5 g/l plus fertilizing the plants with 80% RDF with added bio fertilizer reflected the highest values in total produced tuber yield and its components whereas, fertilizing potato plants with 60% of NPK recommended dose and without foliar spray (control) gave the lowest values of produced yield.

Chemical quality of tubers:

data in Table 4 show that there were differences among the fertilization treatments in all measured chemical tuber quality expressed as content of N, P, K, total protein, total Starch and NO_3 during both seasons of study. In this regard, fertilizing potato plants with using 80% of mineral NPK fertilizer at the recommended dose with added bio fertilizer gave the highest values in all assayed chemical constituents in both seasons of study compared with using 60% NPK.

Such effect may be attributed to the main role of phosphorus solubilizing bacteria on enhancing the solubility and availability of phosphorus to be absorbed by plants and consequently accumulated in tubers. In this respect, *Mohammadi et al. (2013)*, *Farag et al. (2013)*, *Wichrowska et al. (2015)*, *Dhawan et al. (2016)*, *Kolodziejczyk (2016)* and *El-Sayed et al. (2017)* reached to the same results.

Data in Table 4 also revealed that spraying potato plant with yeast extract 5%, garlic extract 5%, seaweed extract 5 ml/l or potassium citrate 5 g/l increased all measured chemical quality traits compared with the control treatment during the two seasons of study. Such increments reached the level of significance in all measure under study. In addition, spraying the plants with seaweed extract 5 ml/l exhibited the highest values in content of N, P, total protein, total Starch and NO_3 under study during the two seasons meanwhile the highest values of K contents were recored by spray potassium citrate 5 g/l compared with control without spray. Such results may be due to the main role of these growth stimulants on assimilation and formation of carbohydrates, protein, phosphor and potassium content. Obtained results are coincided with those reported by *Haider et al. (2012)*, *Wasim et al (2012)*, *Malash et al (2014)* and *Ibrahim (2016)* in case of seaweed extract and *Abd El-Gawad et al. (2017)* in case of potassium.

As for the effect of the interaction, such data in Table 4 indicate that fertilizing potato plants with 80% of NPK recommended dose and added bio fertilizer with spraying the plants by seaweed extract 5 ml/l reflected the highest values of all measure chemical quality parameters in both seasons.

It could be concluded that under such condition of this experiment using bio-fertilizers (Rhizobacterin, Phosphorin and Potassine) as soil inoculation two times during planting date and after complete germination and fertilizing the grown plants with 80% of the recommended NPK [150 kg N per Fed. (As ammonium nitrate 33% N), 60 kg P_2O_5 (As Calcium superphosphate 16% P_2O_5) and 96 kg K_2O per Fed. (As potassium sulphate 48% K_2O)] combined with the foliar application of seaweed extract at 5% five times started after 21 days from planting and every 10 days interval can be recommended for producing the best vegetative growth with the highest tubers yield components with the best physical and chemical tubers quality of Sponta cultivar adapted for exportation.

Table 1. Effect of soil addition and foliar spray as well as their interaction treatments on vegetative growth characteristics of individual potato plant during 2017 and 2018 seasons.

Treatments		Plant height (cm)	No. of branches/plant	No. of leaves /plant	Total fresh weight (g/plant)	Total dry weight (g/plant)	Plant height (cm)	No. of branches/plant	No. of leaves /plant	Total fresh weight (g/plant)	Total dry weight (g/plant)
		First Season						Second Season			
Soil App.	100% N,P,K	49.5	3.5	22.0	166.7	27.9	54.7	3.9	24.1	179.7	31.5
	80% N,P,K+Bio	53.2	4.1	25.1	181.9	30.7	55.4	4.9	28.6	202.1	35.8
	60% N,P,K+Bio	46.8	3.1	18.9	154.5	25.7	48.1	3.3	21.3	269.4	26.4c
	LSD	0.82	0.16	1.2	1.7	0.78	2.35	0.14	2.0	4.1	0.38
Foliar spray	Potassium citrate	50.0	3.5	22.0	166.9	28.4	53.0	4.0	25.0	185.6	31.9
	Garlic Ex.	48.2	3.2	20.4	160.8	27.1	51.0	3.7	23.3	342.7	30.1
	Yeast Ex.	53.3	3.8	23.5	173.7	29.3	56.4	4.3	26.4	190.0	32.4
	SW Ex.	51.9	4.3	25.4	182.8	30.8	54.9	4.5	27.4	197.8	34.4
	control	45.9	3.0	18.8	154.4	24.8	48.4	3.6	21.2	169.1	27.4
	L.S.D	1.9	0.2	1.6	3.0	1.7	1.4	0.3	1.2	4.1	1.6
	Interaction										
100% N,P,K	Potassium citrate	49.5	3.5	22.1	166.4	28.1	54.6	3.9	24.8	181.6	31.9
	Garlic Ex.	47.6	3.1	20.4	160.2	27.5	53.3	3.6	22.6	174.7	30.5
	Yeast Ex.	53.1	3.8	23.6	171.6	28.6	58.1	4.1	26.2	180.9	32.7
	SW Ex.	51.6	4.2	25.2	182.9	30.2	56.7	4.3	25.7	194.7	34.5
	control	45.6	2.9	18.7	152.6	25.1	50.8	3.5	21.1	166.5	27.8
80%N,P, K+Bio	Potassium citrate	53.2	4.1	25.3	180.2	30.9	55.8	4.9	28.6	202.7	36.9
	Garlic Ex.	51.6	3.8	23.6	175.6	28.6	52.9	4.5	27.5	193.6	34.2
	Yeast Ex.	56.2	4.3	26.4	186.3	32.4	59.3	5.3	29.7	209.5	37.2
	SW Ex.	54.8	4.9	28.5	195.1	33.6	57.5	5.3	31.8	214.6	38.8
	control	50.4	3.6	21.8	172.4	27.9	51.7	4.6	25.3	190.2	31.9
60%N,P, K+Bio	Potassium citrate	47.2	3.0	18.7	154.0	26.3	48.6	3.2	21.5	172.6	26.8
	Garlic Ex.	45.3	2.8	17.2	146.6	25.3	46.9	3.0	19.8	659.9	25.6
	Yeast Ex.	50.6	3.4	20.4	163.2	26.8	51.9	3.6	23.2	179.6	27.2
	SW Ex.	49.2	3.8	22.5	170.5	28.7	50.4	3.9	24.6	184.0	29.9
	control	41.8	2.4	15.9	138.2	21.3	42.7	2.6	17.2	150.7	22.6
L.S.D		3.2	0.3	3.0	6.0	2.7	2.8	0.4	2.3	7.1	2.5

Table 2. Effect of soil addition and foliar spray as well as their interaction treatments on N, P, K and total carbohydrate percentages of potato foliage during 2017 and 2018 seasons.

Treatments	N %	P %	K %	Total Carbohydrates %	N %	P %	K %	Total Carbohydrates %	
	First Season				Second Season				
Soil App.	100% N,P,K	1.84	0.37	2.20	12.19	2.01	0.41	2.38	13.36
	80% N,P,K+Bio	2.09	0.43	2.44	13.45	2.32	0.47	2.69	14.45
	60% N,P,K+Bio	1.63	0.30	2.17	11.84	1.74	0.37	2.28	12.45
Foliar spray	LSD	0.07	0.02	0.12	1.15	0.09	0.02	0.10	0.85
	Potassium citrate	1.86	0.37	2.41	12.42	2.03	0.42	2.62	13.35
	Garlic Ex.	1.74	0.34	2.29	11.99	1.93	0.39	2.37	12.92
	Yeast Ex.	1.93	0.38	2.24	12.83	2.11	0.44	2.44	13.94
	SW Ex.	2.04	0.42	2.31	13.49	2.21	0.48	2.51	14.68
	control	1.68	0.31	2.11	11.73	1.83	0.36	2.31	12.21
	L.S.D	0.09	0.02	0.14	0.65	0.07	0.02	0.07	0.72
100% N,P,K	Potassium citrate	1.86	0.38	2.33	12.19	2.03	0.42	2.57	13.32
	Garlic Ex.	1.71	0.33	2.16	11.39	1.92	0.38	2.30	12.86
	Yeast Ex.	1.91	0.39	2.19	12.64	2.10	0.44	2.36	13.92
	SW Ex.	2.05	0.43	2.26	13.17	2.18	0.48	2.43	14.47
	control	1.65	0.30	2.05	11.56	1.82	0.35	2.24	12.21
80%N,P,K +Bio	Potassium citrate	2.08	0.43	2.65	13.15	2.32	0.47	2.86	14.37
	Garlic Ex.	2.00	0.41	2.35	12.95	2.24	0.45	2.61	13.96
	Yeast Ex.	2.16	0.43	2.41	13.72	2.39	0.49	2.68	14.93
	SW Ex.	2.23	0.48	2.49	14.85	2.48	0.53	2.75	15.85
60%N,P,K +Bio	control	1.97	0.39	2.31	12.56	2.16	0.42	2.53	13.15
	Potassium citrate	1.63	0.30	2.24	11.92	1.75	0.38	2.42	12.36
	Garlic Ex.	1.51	0.27	2.36	11.63	1.64	0.33	2.21	11.93
	Yeast Ex.	1.72	0.32	2.11	12.13	1.84	0.40	2.28	12.96
	SW Ex.	1.85	0.36	2.17	12.45	1.97	0.43	2.34	13.72
L.S.D	1.42	0.24	1.97	11.07	1.50	0.30	2.15	11.26	
L.S.D	0.16	0.04	0.25	1.60	0.13	0.03	0.13	1.32	

Table 3. Effect of soil addition and foliar spray as well as their interaction treatments on the tuber yield and its components of potato plants during 2017 and 2018 seasons.

Treatments	Total Yield /Plant (g)	Total Yield / Fed. (kg)	Tuber Weight (g)	Tuber Length (cm)	Tuber Diameter (cm)	Total Yield /Plant (g)	Total Yield / Fed. (kg)	Tuber Weight (g)	Tuber Length (cm)	Tuber Diameter (cm)	
	First Season					Second Season					
Soil App.	100% N,P,K	757.3	15.600	218	10.6	5.9	852.5	17.050	239	11.0	6.0
	80% N,P,K+Bio	839.9	16.811	251	11.2	6.2	882.0	17.641	263	11.6	6.5
	60% N,P,K+Bio	697.7	13.955	198	10.2	5.7	753.6	15.071	219	10.6	5.7
	LSD	26.7	2.210	2.3	0.21	0.49	4.8	9.577	6.1	0.39	0.27
Foliar spray	Potassium citrate	786.1	15.724	228	10.9	6.1	852.4	17.049	244	11.4	6.2
	Garlic Ex.	734.2	15.083	216	10.4	5.8	804.0	16.081	235	10.8	5.8
	Yeast Ex.	769.5	15.411	222	10.7	5.9	827.1	16.543	240	11.0	6.0
	SW Ex.	825.6	16.756	236	11.3	6.3	883.5	17.669	255	11.7	6.6
	control	709.5	14.302	209	10.1	5.5	779.7	15.595	228	10.4	5.7
	L.S.D	34.0	0.418	5.5	0.3	0.2	9.5	0.190	7.8	0.3	0.1
	100% N,P,K	Potassium citrate	769.2	15.384	226	10.9	6.1	872.5	17.450	237	11.3
Garlic Ex.		705.4	15.308	211	10.4	5.6	833.7	16.674	235	10.6	5.7
Yeast Ex.		775.8	15.516	218	10.6	5.8	853.6	17.072	238	10.9	5.9
SW Ex.		817.3	17.079	232	11.1	6.3	891.4	17.828	256	11.6	6.5
control		718.9	14.711	203	10.1	5.7	811.2	16.224	227	10.4	5.6
80%N,P,K+ Bio	Potassium citrate	863.5	17.270	253	11.4	6.5	898.6	17.972	268	11.9	6.6
	Garlic Ex.	815.2	16.304	247	10.9	6.0	853.2	17.064	259	11.5	6.2
	Yeast Ex.	837.6	16.812	251	11.2	6.2	874.2	17.484	263	11.4	6.5
	SW Ex.	895.2	17.904	261	11.9	6.7	952.6	19.052	274	12.3	6.9
60%N,P,K+ Bio	control	788.2	15.764	242	10.7	5.8	831.6	16.632	253	11.1	6.1
	Potassium citrate	725.5	14.517	205	10.5	5.8	786.2	15.725	226	10.9	5.9
	Garlic Ex.	681.9	13.638	189	9.9	5.8	725.2	14.504	211	10.2	5.5
	Yeast Ex.	695.2	13.904	197	10.2	5.6	753.6	15.072	218	10.7	5.7
	SW Ex.	764.2	15.284	214	10.8	6.0	806.4	16.128	234	11.3	6.3
L.S.D	621.5	12.430	183	9.6	5.1	696.4	13.928	204	9.8	5.3	
L.S.D	56.7	0.684	8.9	0.5	0.4	16.9	0.338	12.6	0.5	0.3	

Table 4. Effect of soil addition and foliar spray as well as their interaction treatments on some chemical constituents of potato tubers during 2017 and 2018 seasons.

Treatments		N % of Tuber	P % of Tuber	K % of Tuber	Total Protein %	Total Stretch %	No ₃ (ppm)	N % of Tuber	P % of Tuber	K % of Tuber	Total Protein %	Total Stretch %	No ₃ (ppm)
		First Season						Second Season					
Soil App.	100% N,P,K	2.23	0.41	2.95	13.93	14.90	206	2.42	0.44	3.00	15.10	16.20	213
	80% N,P,K+Bio	2.46	0.46	3.11	15.33	16.58	223	2.70	0.51	3.29	16.94	17.25	240
	60% N,P,K+Bio	1.94	0.37	2.79	12.14	13.81	190	2.17	0.40	2.87	13.58	15.33	209
	LSD	0.09	0.54	0.09	0.54	0.35	6.2	0.04	0.20	0.09	0.20	0.11	11.2
Foliar spray	Potassium citrate	2.23	0.41	3.05	13.93	15.43	208	2.44	0.45	3.20	15.22	16.49	230
	Garlic Ex.	2.13	0.38	2.88	13.31	14.70	201	2.38	0.42	2.99	14.85	15.96	214
	Yeast Ex.	2.31	0.44	2.96	14.45	15.06	211	2.48	0.46	3.06	15.47	16.16	225
	SW Ex.	2.44	0.46	3.00	15.19	15.90	222	2.59	0.51	3.14	16.27	16.97	231
	control	1.94	0.36	2.85	12.12	14.38	190	2.27	0.40	2.89	14.20	15.72	204
L.S.D		0.09	0.5	0.07	0.50	0.37	8.2	0.08	0.5	0.09	0.51	0.09	15.2
100% N,P,K	Potassium citrate	2.23	0.41	3.05	13.93	15.25	208	2.42	0.44	3.11	15.12	16.32	213
	Garlic Ex.	2.16	0.37	2.84	13.50	14.45	202	2.39	0.42	2.98	14.93	15.92	210
	Yeast Ex.	2.31	0.47	2.92	14.43	14.70	211	2.47	0.46	3.01	15.43	16.09	217
	SW Ex.	2.44	0.45	2.98	15.25	16.07	218	2.53	0.49	3.07	15.81	16.95	224
	control	2.01	0.36	2.94	12.56	14.02	192	2.27	0.38	2.84	14.19	15.74	199
80% N,P,K +Bio	Potassium citrate	2.49	0.46	3.18	15.56	16.95	224	2.70	0.51	3.46	16.87	17.25	240
	Garlic Ex.	2.35	0.43	3.07	14.68	16.12	218	2.62	0.48	3.22	16.37	17.09	233
	Yeast Ex.	2.54	0.48	3.14	15.99	16.63	224	2.75	0.51	3.28	17.18	17.17	246
	SW Ex.	2.72	0.52	3.18	16.83	17.26	239	2.89	0.57	3.32	18.39	17.86	254
	control	2.18	0.41	2.96	13.56	15.92	212	2.54	0.48	3.15	15.87	16.86	229
60% N,P,K +Bio	Potassium citrate	1.97	0.37	2.93	12.29	14.09	192	2.19	0.39	3.02	13.68	15.91	237
	Garlic Ex.	1.88	0.35	2.72	11.75	13.52	182	2.12	0.37	2.76	13.24	14.86	198
	Yeast Ex.	2.07	0.38	2.81	12.94	13.85	199	2.21	0.42	2.88	13.81	15.21	211
	SW Ex.	2.16	0.41	2.85	13.50	14.36	209	2.34	0.46	3.03	14.60	16.11	216
	control	1.64	0.32	2.65	10.25	13.21	167	2.01	0.34	2.68	12.56	14.56	184
		0.15	0.96	0.13	0.98	0.74	14	0.14	0.89	0.14	0.90	0.17	24

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تأثير التسميد المعدني والحيوي بالنتروجين والفوسفور والبوتاسيوم والرش الورقي ببعض منشطات النمو على نمو وإنتاجية البطاطس

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قسم البساتين ، كلية الزراعة ، بمشتهر ، جامعة بنها .

تتميز البطاطس باستجابة عالية لسماذ NPK ، والأسمدة الكيماوية لها العديد من الآثار السلبية على البيئة والتنمية المستدامة. لذلك تم إجراء تجربتين حقليتين خلال الموسم الصيفي لعامي 2018 و 2019 في المزرعة البحثية بكلية الزراعة بمشتهر جامعة بنها لدراسة تأثير ثلاث مستويات مختلفة من الأسمدة المعدنية النيتروجينية المضافة مع الأسمدة الحيوية وهي 100% سماذ NPK معدني (حسب المعدل الموصى به) ؛ 80% سماذ NPK معدني + سماذ حيوي و 60% سماذ NPK معدني + سماذ حيوي) والرش الورقي ببعض منشطات النمو مثل سترات البوتاسيوم بتركيز 5 جم / لتر ، مستخلص الخميرة بتركيز 5% ، مستخلص الطحالب البحرية بتركيز 5% ، مستخلص الثوم بتركيز 5% ومعاملة الكنترول (بدون رش) بالإضافة إلى التفاعل بينهما على صفات النمو الخضري ، التركيب الكيميائي للمجموع الخضري ، محصول الدرنات، صفات الجودة لدرنات البطاطس صنف اسبونتتا. وقد اوضحت النتائج المتحصل عليها ان تسمد نباتات 80% من السماذ المعدني NPK بالمعدل الموصى به + السماذ حيوي اعطى اعلى القيم في قياسات النمو الخضري (ارتفاع النبات ، عدد الافرع ، عدد الأوراق ، الوزن الطازج والجاف /نبات)؛ المحتوى الكيميائي للمجموع الخضري لنسبة من النيتروجين - الفوسفور - البوتاسيوم و الكربوهيدرات الكلية ؛ و محصول الدرنات ومكوناتها معبراً عنه محصول الكلى للنبات ، المحصول الكلى/ الفدان ، متوسط وزن الدرنه ، طول وقطر الدرنه ؛ وكذلك صفات الجودة الكيميائية للدرنات بمحتواها من N ، P ، K ، البروتين الكلى ، النشا و اقل محتوى من النترات NO₃. بينما أعطى الرش الورقي النباتات بمستخلصات الخميرة بتركيز 5% أو مستخلص الطحالب البحرية بتركيز 5 مل / لتر أعطت أعلى القيم لجميع الصفات المدروسة لنباتات البطاطس في كلا الموسمين. وقد ادى التفاعل بين تسميد نباتات البطاطس بنسبة 80% من المعدل الموصى به من NPK مع الأسمدة الحيوية والرش الورقي بمستخلص الخميرة بتركيز 5% أو مستخلص الأعشاب البحرية بتركيز 5 مل / لتر أعطت أعلى القيم في جميع الصفات المدروسة.