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Response of Growth and Potato Tubers Yield to Potassium Fertilization and Some Bio- Extracts

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ABSTRACT
Two field experiments were carried out at a Private Farm, El-Harsha District, Zawia Region, Libya representing sandy loam soil during the winter seasons of 2020/2021 and 2021/2022 to study the effect of potassium fertilization with some different bio-extracts (dry yeast and seaweeds) on growth, tuber yield and its components and chemical content of leaves and tuber of potato cv. Spunta. The experiment included 8 treatments, i.e. control without any addition, potassium sulphate (100kg/ha), dry yeast extract (5g./L), seaweed extract (5g/L), potassium sulphate (50 kg/ha) + dry yeast extract (2.5 g/L), potassium sulphate (50 kg/ha) + seaweed extract (2.5 g/L), dry yeast extract (2.5 g/L) + seaweed extract (2.5 g/L), and potassium sulphate (50 kg/ha) +), dry yeast extract (2.5 g/L) + seaweed extract (2.5 g/L).This experiment was arranged in a randomized complete block design(RCBD) with three replications. The obtained results are summarized as follows; The triple treatment of potassium sulphate fertilizer (50 kg/ha) + dry yeast extracts (2.5 g/L) + seaweeds extract (2.5 g/L) gave the heaviest increased vegetative growth, tuber yield and its components, as well as chemical content, carbohydrates, starch, TSS and protein of potato, cv. Spunta.

Keywords: Potassium fertilizer – bio extracts – potato cv. Spunta.

1. Introduction
Potato (*Solanum tuberosum* L.) is one of the most important food and leading vegetable crop growing for local and export.

The tuber of potato are a good source of carbohydrates, proteins, vitamins, and essential minerals in human nutrition (Blagoeva *et al.,* 2004). Potato plants require high quantities of nutrients, like N, P, K and various micro-nutrients (Bogatsevska *et al.,* 2008).

Potassium is absolutely necessary element for potatoes (Kumar and Sharma, 2013).

The vegetative growth and tuber yield of potato gradually and significantly increased by increasing level of potassium application (Asmaa and Hafez, 2010 and Habtam *et al.,* 2018).

Dry yeast as a natural source of cytokinins-stimulates cell division and enlargement, as well as the synthesis of protein, nucleic acid and chlorophyll (Fathy and Farid, 1996). Hussain and Khalaf (2007) demonstrated that spraying potato with yeast extract significantly increased plant height, number of branches/plant, dry matter of vegetative growth, number of tubers/plant, yield/plant and TSS in potato tubers. As well as, Sarhan and Abdulah (2010) stated that dry yeast extract caused a gradual significant increase in plant height, number of aerial stems per plant, leaves area, total chlorophyll and nutrients.

Seaweed extract add as foliar fertilizer has been noted to have various beneficial effects on many crops (Blunden *et al.,* 1974 and Paavo, 1989). Most commercial seaweed products are manufactured from red algae (*Rithothammium calcareum*) and brown (*Ascophyllum nodosu*, *Ecklonia maxima, Sargassum* spp., and *Durvillaea* spp.), microalgae (Craige, 2011). Wadas and Dziugeial (2019) showed that the application of seaweed extracts resulted in a faster rate of plant growth, and increased tubers yield of potato.

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The aim of the study was to determine the effect of potassium fertilizer, dry yeast and seaweed extracts on plant growth and marketable tuber yield and quality of potato.

2. Materials and Methods

Two field experiments were carried out at a Private Farm, El-Harsha District, Zawia Region, Libya representing sandy loam soil during the winter seasons of 2020/2021 and 2021/2022 to study the effect of potassium fertilization under some different bio-extracts (dry yeast and seaweeds) on growth, tuber yield and its components and chemical content of leaves and tuber of potato cv. Spunta.

Some physical and chemical properties of the studied soil, which were measured and determined before planting were presented in Table (1). The drip irrigation system was used for soil irrigation, and the analysis of the water used are shown in Table (2).

Table 1: Mechanical properties and chemical analysis of the experimental soil

Parameters values	Unit	Value	Parameters values	Unit	
Coarse sand	**%**	26.95	**Organic matter**	**%**	1.39
Fine sand	**%**	28.79	**$CaCO_3$**	**%**	0.56
Silt	**%**	22.11	**Total nitrogen**	**%**	0.26
Clay	**%**	22.15	**Total phosphorus**	**%**	0.18
Textural class	**Sandy loam**		**pH**		7.67
			EC	**(dS/m)**	0.66

EC = Electric Conductivity

Table 2: The analysis of the used irrigation water

Characters	Units	Value
Total Salts	**ppm**	1113
Ca^{++}	**meg/L**	14
Mg^{+}	**meg/L**	16.8
Na	**meg/L**	12.7
K^{+}	**meg/L**	2.01
SO_4^{--}	**meg/L**	4.22
HCO_3^{-}	**meg/L**	3.03
EC	**dS/m**	0.60

EC = Elecrtic Conductivity

The experiment included 8 treatments, i.e. control without any addition, potassium sulphate (100kg/ha), dry yeast extract (5g./L), seaweed extract (5g/L), potassium sulphate (50 kg/ha) + dry yeast extract (2.5 g/L), potassium sulphate (50 kg/ha) + seaweed extract (2.5 g/L), dry yeast extract (2.5 g/L) + seaweed extract (2.5 g/L), and potassium sulphate (50 kg/ha) +), dry yeast extract (2.5 g/L) + seaweed extract (2.5 g/L).

This experiment was arranged in a randomized complete block design (RCBD) with three replications. The plot area was 8.4 m^2 planted in ridges, 70 cm apart, and 25 cm between plants.

K fertilizer in the form of potassium sulphate (48% K_2O) with the level of 100 kg/ha. The K fertilizer was applied in two equal portions, the first one was added before cultivation and the second one at one month from cultivation. All the treatments were received a basal application of nitrogen fertilizer which was added at the rate of 150 kg N/ha, as ammonium sulphate (20.6%N).

Phosphorus fertilizer was added at the rate of 75 kg $P_2 O_5$/ha, as calcium superphosphate (16.5 % $P_2 O_5$). Nitrogen and phosphorus fertilizer were added in three equal portions, at preparing the soil to cultivate, after 4 and 6 weeks from sowing, respectively.

Yeast solution was prepared according to the method described by Morsi *et al.,* (2008). Yeast activation done overnight by sucrose sugar before spray treatment and prepared from brewer's yeast (*Saccharomyces cerevisiae*), dissolved in water followed adding sugar at ratio of 1 : 1, and kept overnight in a warm place for reproduction. The plants were treated by dry yeast extract two times during the plant life, the first spray was after 45 days from cultivation and the second was two weeks later. Chemical analysis of activated yeast as shown in Table (3).

The seaweed extract used in the trials was a commercial seaweed product marketed as Ghareen was produced from Green Has Italia Company, which contained on 90% brown seaweed was mixed with distilled water for concentrate the used extract as 5 ml/L).

The chemical analysis of seaweed used was presented in Table (4). The plants were treated with seaweed extract two times, 45 and 60 days from cultivation, respectively.

Potato (Spunta variety) were planted on 15th October 2020 and 2021, respectively, and harvested after 105 days.

Table 3: The analysis of dry yeast

Contents	Value (%)
N	1.2
P	0.13
K	1.2
Mn	0.01
Ca	0.02
Na	0.01
Mg	0.07
Zn	0.04
Cu	0.04
B	0.08
Mo	0.001
Total protein	5.3
Total Carbohydrates	4.7
Auxin (IAA)	0.50
Gibberellin	0.03

IAA = Indole Acetic Acid

Table 4: The analysis of seaweed extract

Parameters	Units	Value
Total organic matter	**g/100g**	8.22
Nitrogen (N)	**g/100g**	0.51
Phosphorus (P)	**g/100g**	0.02
Potassium (K)	**g/100g**	32.79
Calcium (Ca)	**g/100g**	1.11
Sulphur (S)	**g/100g**	1.49
Zinc (Zn)	**Mg/kg**	47.17
Manganese (Mn)	**Mg/kg**	33.53
Boron (B)	**Mg/kg**	117.59
Iron (Fe)	**Mg/kg**	0.03
Copper (Cu)	**Mg/kg**	13.93
Auxin	**%**	5.05
Cytokinin	**%**	0.06
Gibberellin	**%**	0.15
Total amino acids	**g/100g**	0.51

Plant length (cm), number of leaves and fresh and dry weight of above – ground plant parts/plant (g/plant) were measured in five plants at 90 days from planting. Dry weight of tuber / plant (g/plant) was estimated at harvesting time in five plants taken randomly, number of tubers/plant,

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average tuber weight, from each treatment. Tuber yield (ton/ha) and marketable tubers yield (ton/ha) and marketable tubers yield percentage were also measured and recorded.

Plant samples after harvesting, dried at 70 ºC, ground, digested and assigned for analyzing the percentage of N, P and K, in both leaves and tubers of potato in the second season only. Nitrogen was determined using modified Kjeldahl method and phosphorus was determined calorimetrically using ammonium molybdate and ammonium meta vanadate according to the procedure outlined by Ryan *et al.,* (1996) and A.O.A.C. (2000).

Potassium was determined using the flame spectrophotometry method (Black *et al.,* 1983).

A total soluble solids (TSS) in the fresh potato tuber sap was done using a hand refract meter (Cox and Pearson, 1962) in the second season only. Protein content was calculated by multiplying N content by 6.25 (Rangann, 1977). Total Carbohydrates, in tuber were determined calorimetrically according to the methods described by Dubois *et al.,* (1956) in the second season too.

All the chemical analyses were done at the laboratory of horticulture, Faculty of Technology and Development, Zagazig University, Egypt.

Statistical analysis was carried out according to Snedecor and Cochran (1980). The difference between the mean values of various treatments were compared by Least Significant Difference (LSD) test of comparison at 5% probability level using SAS (2004) software for data analysis.

3. Results and Discussion

3.1. Vegetative growth characters

Data presented in Table (5) reveal that potato growth parameters expressed as plant length, number of leaves / plant, fresh and dry weight of whole plant as affected by the application of potassium fertilizer and dry yeast and seaweed extracts.

It could be observed that the triple treatment of potassium fertilizer + dry yeast extract + seaweed extract gained higher vigor plant growth parameters than the other treatments. This treatment followed by the treatments of potassium fertilizer + dry yeast extract, potassium fertilizer + seaweed extract and potassium fertilizer (potassium sulplate), respectively.

Table 5: Effect of potassium fertilizer and bio- extracts (dry yeast and seaweeds) on vegetative growth characters of potato during 2020/2021 and 2021/2022 seasons.

Treatments	**Plant length (cm)**		**Number of leaves**		**Fresh weight of whole plant (g)**		**Dry weight of whole plant (g)**	
	1st season	**2nd season**	**1st season**	**2nd season**	**1st season**	**2nd season**	**1st season**	**2nd season**
Control	40.2	40.4	19.8	19.7	117.4	116.7	16.3	16.1
Potassium sulphate (100 kg/ha)	44.7	44.2	25.4	24.9	147.5	146.4	21.1	20.8
Dry yeast extract (5 g /L)	42.1	41.8	21.7	20.9	126.7	126.3	19.4	19.6
Seaweed extract (5 ml /L)	41.3	41.1	20.1	20.3	123.2	123.5	18.5	18.7
Potassium sulphate (50 kg/ha)+ Dry yeast extract (2.5 g /L)	47.3	47.3	30.3	29.7	175.4	174.6	22.9	22.6
Potassium sulphate (50 kg/ha)+ Seaweed extract (2.5 ml /L)	45.1	45.0	27.5	27.2	163.2	163.6	22.5	22.1
Dry yeast extract (2.5 g /L) + Seaweed extract (2.5 ml /L)	43.5	43.1	22.3	22.5	135.4	134.7	20.7	20.4
Potassium sulphate (50 kg/ha)+ Dry yeast extract (2.5 g /L)+ Seaweed extract (2.5 ml /L)	50.4	49.7	33.5	33.2	183.2	181.9	24.3	24.5
LSD(0.05)	1.2	1.4	2.5	2.3	88.7	9.3	1.6	1.8

Regarding the important role of potassium in plant growth, Mengle and Kirkby (2001) illustrated that potassium is directly involved in enzyme activation, maintenance of water status, energy relations, and translocation of assimilates and protein synthesis, and hence greatly enhances plant growth.

In addition, using dry yeast extracts as foliar application gave in most cases higher values of plant growth parameters than those un sprayed plants, the beneficial effect of dry yeast extract on the growth parameters of potato plants may be due to that yeast as a natural source for cytokinins had stimulatory effects on cell division and enlargement, protein and nucleic acid synthesis and chlorophylls formation (Spencer *et al.,* 1983 and Malah *et al.,* 2011).

As well as, in this concern, seaweed extract plays a vital role in plant growth characters, because seaweed extracts using as a natural source of proteins, vitamins, sugars and some elements, such as potassium and magnesium that play an important role in bio processes in plant, i.e. photosynthesis, activating some enzymes and proteins formation (Shafeek *et al.,* 2001).

These results supported by those recorded by Kumar and Sharma, (2013) and Habtam *et al.,* (2018) who using potassium fertilization, Fathy and Farid (1996), Hussain and Khalaf (2007), and Sarhan and Abdulah (2010) who using dry yeast extracts, and Blunden *et al.,* (1974), Paava, 1989, Sarhan (2011) and Wadas and Dzingesal (2019) who using seaweed extracts on plant as foliar spraying.

3.2. Tuber yield and its components

Results listed in Tables (6 and 7) expose the effect of potassium fertilizer, dry yeast extract and seaweeds extract and its combined effect on tuber yield and its components of potato. The triple treatment of potassium fertilizer + dry yeast extract + seaweeds extract significantly increased potato tuber yield and its components, expressed as tuber yield/plant, number of tubers / plant, average tuber weight, tuber yield/hectare and marketable tuber yield (ton/ hectare and percentage).

This treatment followed by the treatments of potassium sulphate fertilizer + dry yeast extract, potassium sulphate + seaweeds extract and potassium sulphate fertilizer, respectively. Meanwhile, the lowest value was recorded as a result of the control treatment.

Table 6: Effect of potassium fertilizer and bio- extracts (dry yeast and seaweeds) on tuber yield/plant, number of tuber/ plant and average tuber weight of potato during 2020/2021 and 2021/2022 seasons.

Treatments	Tuber yield / plant (g)		Number of tubers / plant		Average tuber weight (g)	
	1st season	2nd season	1st season	2nd season	1st season	2nd season
Control	496.2	494.9	4.29	4.26	87.05	87.28
Potassium sulphate (100 kg/ha)	625.9	624.7	6.63	6.65	94.40	93.94
Dry yeast extract (5 g /L)	549.1	544.6	6.23	6.20	88.14	87.84
Seaweed extract (5 ml /L)	525.4	523.9	5.75	5.72	91.37	91.59
Potassium sulphate (50 kg/ha)+ Dry yeast extract (2.5 g /L)	652.4	660.7	7.07	7.01	92.28	94.25
Potassium sulphate (50 kg/ha)+ Seaweed extract (2.5 ml /L)	647.5	647.1	6.81	6.83	95.08	94.74
Dry yeast extract (2.5 g /L) + Seaweed extract (2.5 ml /L)	587.3	583.5	6.47	6.43	90.77	90.75
Potassium sulphate (50 kg/ha)+ Dry yeast extract (2.5 g /L)+ Seaweed extract (2.5 ml /L)	671.2	667.3	7.13	7.10	94.14	93.99
LSD(0.05)	8.9	8.6	0.04	0.05	4.12	4.12

Table 7: Effect of Effect of potassium fertilizer and bio- extracts (dry yeast and seaweeds) on tuber yield/hectare, marketable tuber yield (ton / hectare) and marketable tuber yield percentage of potato during 2020/2021 and 2021/2022 seasons.

Treatments	Tuber yield / hectare (ton)		Marketable tuber yield (ton / hectare)		Marketable tuber yield (%)	
	1st season	2nd season	1st season	2nd season	1st season	2nd season
Control	9.775	9.778	7.175	7.197	73.4	73.6
Potassium sulphate (100 kg/ha)	12.966	12.967	11.332	11.294	87.4	87.1
Dry yeast extract (5 g /L)	12.117	12.110	10.081	9.942	83.2	82.1
Seaweed extract (5 ml /L)	11.853	11.856	9.660	9.615	81.5	81.1
Potassium sulphate (50 kg/ha)+ Dry yeast extract (2.5 g /L)	13.659	13.663	12.498	12.379	91.5	90.6
Potassium sulphate (50 kg/ha)+ Seaweed extract (2.5 ml /L)	13.127	13.125	11.827	11.642	90.1	88.7
Dry yeast extract (2.5 g /L) + Seaweed extract (2.5 ml /L)	12.559	12.561	10.700	10.740	85.2	85.5
Potassium sulphate (50 kg/ha)+ Dry yeast extract (2.5 g /L)+ Seaweed extract (2.5 ml /L)	14.750	14.747	13.850	13.508	93.9	91.6
LSD(0.05)	1.013	1.011	2.3	2.1	4.7	4.4

Regarding the effect of potassium nutrient, dry yeast and seaweeds extracts on increasing the tuber yield of potato plants, Habtam *et al.,* (2018) concluded that the beneficial effect of potassium nutrition has been well documented in photosynthesis, increasing enzyme activity, improving synthesis of protein, carbohydrates and fats translocation of photosynthetic and then the compounds stored in tuber that increased the tuber yield. Moreover, as the role of dry yeast in increasing the tuber yield of potato, Fathy and Farid (1996) and Hussain and Khalaf (2007) illustrated that yeast as a natural source of cytokinins stimulates cell division and enlargement, as well as, the synthesis of protein, nucleic acid and chlorophyll. In addition, yeast increased tuber yield of potato because its content of many nutrient elements and being productive compounds of semi growth regulator compound like auxins and giloberllins that in courage compound formation and its translocate to stored parts.

Moreover, concerning the important role of seaweed extract in improving and increasing tuber yield of potato, Sharma *et al.,* (2014) Al-Juthery *et al.,* (2018), and Ibrahim *et al.,* (2018) demonstrated that many plant growth stimulating compounds, such as auxins, cytokinins, gibberllins, polyamines, abscisic acid, and minerals were identified from seaweed extracts. These compounds affect plants leading to improved plant growth and crop yield.

These results supported by those recorded by Al-Moshileh and Errebi (2004) and Neshev and Manolov (2016); Ahmed *et al.,* (2011); Issa *et al.,* (2019), Wadas and Dziugiel (2019) and Dziugiel and Wadas (2020) who working on potassium, dry yeast and seaweeds extract, respectively.

3.3. Chemical contents of leaves and tuber of potato

It seems from Tables (8 and 9) that the triple treatment of potassium sulphate fertilizer + dry yeast extract + seaweeds extract gave the heaviest mineral content, i.e. N, P and K in both of leaves and tubers of potato, as well as total carbohydrates, TSS and protein contents in tubers. These results followed by the double treatment of potassium sulphate fertilizer + dry yeast extract compared to the other treatments and control In this concern, potassium is the prevalent cation in plant and may be involved in maintenance of ionic balance in cells and it bounds ionically to the enzyme pyruvate kinase, which is essential in respiration and carbohydrates metabolism, Moreover, it has a beneficial effect of water consumption, and then allows to the nutrient increased in the different parts of plant (Edmond *et al.,* 1981 and Mengle and Kirkby, 2001).

In addition, dry yeast extract is very important in increasing the minerals content in leaves and tubers, may be due to its content of hormones and nutrients which in turn increasing the

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carbohydrates, protein and TSS too (Asmaa and Hafez, 2010, Fathy and Farid (1996) and Hussain and Khalaf (2007).

These results followed the same patterns of Kumar and Sharma (2013) and Habtam *et al.,* (2018) who used potassium fertilizer, Sarhan and Abdulah (2010) who used dry yeast extract, and Dziugiel and Wadas (2020) who used seaweeds extract on plants.

Table 8: Effect of potassium fertilizer and bio- extracts (dry yeast and seaweeds) on chemical content of leaves and tuber potato during 2021/2022 season.

Treatments	Leaves (%)			Tuber (%)		
	N	P	K	N	P	K
Control	3.97	0.30	3.35	2.01	0.30	1.58
Potassium sulphate (100 kg/ha)	4.21	0.34	3.56	2.25	0.33	2.13
Dry yeast extract (5 g /L)	4.11	0.32	3.55	2.11	0.32	1.97
Seaweed extract (5 ml /L)	4.07	0.32	3.51	2.09	0.31	1.75
Potassium sulphate (50 kg/ha)+ Dry yeast extract (2.5 g /L)	4.57	0.35	4.07	2.51	0.34	2.33
Potassium sulphate (50 kg/ha)+ Seaweed extract (2.5 ml /L)	4.27	0.34	3.99	2.39	0.33	2.30
Dry yeast extract (2.5 g /L) + Seaweed extract (2.5 ml /L)	4.15	0.33	3.71	2.15	0.32	2.07
Potassium sulphate (50 kg/ha)+ Dry yeast extract (2.5 g /L)+ Seaweed extract (2.5 ml /L)	4.64	0.37	4.13	2.57	0.34	2.47
LSD(0.05)	0.03	0.01	0.04	0.01	NS	0.02

NS = Not Significant

Table 9: Effect of Effect of potassium fertilizer and bio- extracts (dry yeast and seaweeds) on nutritive value of potato tuber during 2021/2022 season

Treatments	Total carbohydrates (%)	Total Soluble Solids (TSS)	Starch (%)	Protein (%)
Control	21.89	5.03	12.17	12.56
Potassium sulphate (100 kg/ha)	22.96	5.44	16.33	14.06
Dry yeast extract (5 g /L)	22.33	5.29	15.22	13.19
Seaweed extract (5 ml /L)	22.07	5.15	14.73	13.06
Potassium sulphate (50 kg/ha)+ Dry yeast extract (2.5 g /L)	23.68	5.53	18.37	15.69
Potassium sulphate (50 kg/ha)+ Seaweed extract (2.5 ml /L)	23.45	5.50	17.15	14.94
Dry yeast extract (2.5 g /L) + Seaweed extract (2.5 ml /L)	22.47	5.39	16.25	13.44
Potassium sulphate (50 kg/ha)+ Dry yeast extract (2.5 g /L)+ Seaweed extract (2.5 ml /L)	23.87	5.63	18.75	16.06
LSD(0.05)	0.05	0.02	1.12	0.09

4. Conclusion

It can be concluded that the triple treatment of potassium sulphate fertilizer (50 kg/ha) + dry yeast extracts (2.5 g/L) + seaweeds extract (2.5 g/L) gave the heaviest increased vegetative growth, tuber yield and its components, as well as chemical content, carbohydrates, starch, TSS and protein of potato, cv. Spunta.

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