Journal of Horticultural Science & Ornamental Plants 11 (3): 232-243, 2019
ISSN 2079-2158

DOI: 10.5829/idosi.jhsop.2019.232.243

Impact of Agricultural Treatments on Production and Quality of Potato Tubers

Zaki M. El-S., M.H.M. Mohamed and S.S. Halwa

Horticulture Department, Faculty of Agriculture, Benha University, Egypt

Abstract: Two field experiments were carried out during the two successive Summer seasons of 2017and 2018 at the experimental farm of the Faculty of Agriculture, Moshtohor, Benha University to investigate the effect of two propagation methods (cutting or mini tubers), four sources of N fertilizers in either organic or mineral forms (100% mineral N fertilizer (as recommended dose120kg N/fed), 50% mineral + 50% organic, 25% mineral + 75% organic and 100% organic-N fertilizers) combined with three soil addition with effective microorganisms (EM) at 10%, seaweed extract at 1% and yeast extract at 10% as well as their combinations on vegetative growth characters, chemical constituents of plant foliage yield, physical and chemical quality of produced potato (*Solanum tuberosum* L.) cv. Spunta. This experiment was set up in a split split-plot design. Obtained results showed that planting potato by cutting tubers then fertilized with 50% of the recommended (N-fertilizers in the mineral form (ammonium nitrate 33% N) and 50% in organic form (chicken manure) combined with the soil addition of seaweed extract at 1% three times significantly surpassed mostly all studied vegetative growth parameters, chemical constituents of plant foliage, total yield per plant or feddan and the best physical and chemical quality of produced tubers during both seasons of study.

Key words: Potato · Propagation method · Organic N fertilizer · Growth stimulants · Growth · Tuber yield and quality

INTRODUCTION

Potato (*Solanum tuberosum* L.) is one of the major world food crops. The contribution of potato in world food basket is only after wheat, rice and maize According to the recorded data obtained from the Department of Agricultural Economics and Statistics, Ministry of Agriculture and Land Reclamation, Egypt, the cultivated area of potato in 2016/2017 reached about 376631 feddans, which yielded 4113441tons of tubers with an average of about 12.567 ton/fed. Yearly Egypt imports 120602 tons of potato from European Union as a seed to be cultivated in the summer season. Potato propagated by three methods, firstly by tubers which are considered as the commercial method or mini tubers, which are produced sexually from true seed or through tissue culture technique [1].

Organic manures, particularly chicken manure, have traditionally been used by potato farmers. The use of organic matter to meet the nutrients requirements of crops would be a specific practice in coming years, particularly for resource-poor farmers. Furthermore, ecological and environmental concerns over the increased and indiscriminate use of inorganic fertilizers have made efforts towards the researches on the use of organic materials as a source of essential nutrients [2]. Organic manures, like chicken manure, can play a vital role in potato productivity. These sources can reduce the shortage in soil nutrients and improve soil organic matter, humus and overall soil productivity. Soil organic matter acts as “cement” for water holding clay and soil particles together, thus contributing to the crumb structure of the soil, providing resistance against soil erosion, binds micronutrient metal ions in the soil prevents its leaching out of surface soils [3]. Moreover, potato plant has high nutrients requirements, especially, mainly due to its shallow root system and short growth duration. Still, its recovery of N fertilizer-N is often quite low. Therefore, the liberal application of mineral N-fertilizers to maintain an adequate level of N in the rhizosphere leads to the accumulation of excessive levels of NO_3-N in the plant as well as contribute to high NO_3-N content of groundwater. A sophisticated combination of organic manures, inorganic fertilizers and biofertilizers might help obtain high potato productivity and good soil health for

Corresponding Author: Zaki M. El-S., Horticulture Department, Faculty of Agriculture, Benha University, Egypt

sustainability. Therefore, integrated nutrient management (INM) in which organic manures, inorganic fertilizers and biofertilizers are used simultaneously has been suggested as the most effective method to maintain a healthy and sustainable soil system as well as increasing crop productivity [4]. There is evidence from field researches that high and sustainable yields are possible with integrated use of organic, inorganic and biofertilizers [5].

The effective microorganism is an organic fertilizer used for soil and foliar application to promote growth and increase yield and is made from a solution of EM and molasses usually added to bran or straw and then fermented. It has been shown that the application of EM can improve photosynthetic efficiency and capacity due to an increase in nutrients availability, as well as increase roots mass [6]. Use of the microorganisms as a soil addition, which should improve soil physical-chemical and biological properties and increase organic matter, cation exchange capacity, available mineral nutrients as environment-friendly biofertilizer helps to reduce the use of much expensive phosphatic fertilizers [7].

Worldwide, seaweed-based agricultural products are commonly employed in organic or reduced-input cropping systems. Seaweed extract is known as a source of plant growth regulators organic osmolites, amino acids, mineral nutrients, vitamins and vitamin precursors [8]. Seaweed extract as a soil conditioning agent combines with metabolic radicals to form cross-link polymers, which increase water-holding characteristics of the rhizosphere contribute to creating an environment more suitable for the growth of roots and root-associated beneficial micro-organisms [9].

Yeast extract was suggested to share a beneficial role during the vegetative and reproductive growth stage through improving flower formation and their set of some plants due to its high auxin and cytokinin contents and enhancement of carbohydrate accumulation [10]. Also, it has stimulatory effects on cell division and enlargement, protein and nucleic acid synthesis and chlorophyll formation [11]. Besides, Application of yeast as soil addition significantly increased plant growth and yield of potato plants [12].

Therefore, the present study was an attempt to improve the vegetative growth, productivity and quality of potato plants during the early summer season by using two propagation methods (cutting or mini tuber) organic and mineral nitrogen fertilization and soil addition with some growth stimulants such as yeast extract, seaweed extract or EM.

MATERIALS AND METHODS

Two field experiments were carried out during the two successive summer seasons of 2017and 2018 at the experimental farm of the Faculty of Agriculture, Moshtohor, Benha University to investigate the effect of propagation methods, sources of N fertilizers in either organic or mineral forms and soil addition with effective microorganisms (EM), seaweed extract or yeast extract as well as their combinations on vegetative growth characters, chemical constituents of plant foliage, total tuber yield, physical and chemical quality of potato tubers (*Solanum tuberosum* L.) cv. Spunta. The physical and chemical characteristics of the used soil as an average of both seasons are shown in Table 1. The physical analysis was estimated according to Jackson [13], whereas chemical analysis was determined according to Black *et al.* [14].

Potato tubers were planted on 2nd January in the first and second seasons. This investigation was set up in a split-plot design with three replicates in both seasons of study. Each experimental plot included four rows of 4 m in length and 80 cm in width, with an area of 12.8 m^2. Potato tubers were planted 30 cm apart on one side of ridges. A split split-plot design with three replicates was adopted where propagation methods were randomly distributed in the main plots, while nitrogen fertilizer treatments were randomly distributed in the subplots and the soil addition treatments were randomly distributed in the sub-sub plots. Cultural management, disease and pest control programs were followed according to the recommendation of the Egyptian Ministry of Agriculture. Each experiment included 24 treatments resulted from the combination of two propagation methods with four nitrogen fertilizer sources and three soil addition treatments as follows.

Propagation Methods:

- Cutting tubers: - every piece weight is 40-50 g and has 2-3 eyes
- Mini tubers: - every one piece weight is 20-25 g and has 2-3eyes.

Nitrogen Fertilizer Sources:

- 100% mineral N fertilizer (as recommended dose120kg N/fed).
- 50% mineral-N + 50% organic-N fertilizers.
- 25% mineral-N + 75% organic-N fertilizers.
- 100% organic-N fertilizers

Table 1: Average values of the soil mechanical and chemical analysis of the used soil during both seasons of study

Physical analysis							
Coarse sand	Fine sand	Silt	Clay	Texture class	Soil pH	E.C, dS/m	Organic matter
7.14%	17.22%	23.64%	52%	Clay loam	7.8	2.16	3.26%
Chemical analysis							
Cations (meq/l)				Anions (meq/l)			
Ca^{++}	Mg^{++}	Na^{+}	K^{+}	CO_3^{--}	HCO_3^{-}	Cl^{-}	SO_4^{--}
8.54	4.27	6.41	1.28	Zero	5.56	5.86	9.08
Available NPK (mg/kg)							
N	23.9	P	8.7	K	112	---	---

Table 2: Physical and chemical properties of the organic fertilizer (chicken manure) during the two seasons.

		Chicken manure	
Item	Unit	2017	2018
Moisture content	%	12.3	11.9
Bulk density	Kg/m^3	382	361
pH (1:2.5)		6.5	6.7
EC (1:2.5)	dS/m	2.3	2.2
Total nitrogen	%	1.91	1.84
Total phosphorus	%	0.96	0.92
Total potassium	%	1.38	1.31
Organic matter	%	31.8	33.2
C: N ratio		17:1	15:1

Mineral N fertilizer in the form of ammonium nitrate [NH_4NO_3, 33%N] was used. Nitrogen sources were used at a rate of 120kg N/fed as recommended by the Ministry of Agriculture.

The amounts of organic fertilizer (chicken manure) were added during soil preparation. Meanwhile, the mineral-N fertilizers were divided into three equal portions and were added after three weeks from planting and every two weeks by the interval. The chemical analysis of the used chicken manure in the first and second seasons is shown in Table (2).

Soil Addition Treatments:

- Effective microorganisms (EM) at 10%.
- Yeast extract at 10%.
- Seaweed extract at 1%.

Yeast Preparation: The analysis of prepared yeast extract stock solution was: total protein (5.3%), total carbohydrates (4.7%), N (1.2%), P (0.13%), K (0.3%), Mg (0.013%), Ca (0.02%), Na (0.01%); micro-elements (ppm), Fe (0.13), Mn (0.07), Zn (0.04), Cu (0.04), Mo (0.0003), IAA (0.5 µg/ml) and GA (0.3 µg/ml). Such analysis were according to Malash *et al.* [11].

Effective Microorganisms: (EM as commercial name) was obtained from Ministry of Agriculture and Land Reclamation it includes: Effective Microorganisms (EM) preparation contains photosynthetic bacteria (*Rhodopseudomonas palustrus* and *Rhodobacter space*), milk bacteria (*Lactobacillus casei, Streptococcus lactis*), yeast (*Saccharomyces albus* and *Candida utilis*), actinomycetes (*Streptomyces albus* and *Streptomyces griseus*) and moulds (*Aspergillus oryzae* and *Mucom hiemalis*) [15].

Seaweed Extract at 1%: It is used commercial product Rootmost produce by Leili Agrochemistry Co. Ltd. It includes: seaweed extract100g/l, organic matter 20g/l, total nitrogen 0.4g/l, $P_2O_5$12g/l, K_2O30g/l, GA_3 0.001%, IAA 0.1% and Cytokinin 0.008%.

The soil addition treatments with EM, yeast and seaweed extract were added three times started after 21 days from planting and every 15 days intervals.

Data Recorded

Vegetative Growth Characteristics: After 70 days from planting, three plants were taken as a representative sample from each experimental plot and the following data were recorded: - plant height (cm), number of branches/plant, number of leaves/plant, total fresh weight/plant (g) and total dry weight/plant (g).

Chemical Composition of Plant Foliage: Total nitrogen, phosphorus, potassium and carbohydrates content were determined in the digested dry matter of plant leaves according to methods described by Pregl [16]; John [17]; Brown and Lilleland [18] and Herbert *et al.* [19] for nitrogen phosphorus, potassium and total carbohydrates, respectively.

Tuber Yield and its Components: Tuber yield (g/plant) as well as number of tubers/plant was calculated from tuber yield/plot while total tuber yield (ton/fed).

Tuber Quality:

Physical Quality: At harvest time, a random sample of 10 tubers from each experimental plot was taken to determine weight, length, diameter and size of each tuber.

Chemical Quality: Tubers samples were taken at harvest time and dried in an electric oven to constant weight at 70°C and total dry matter was calculated. In addition, the digested dry matter of each sample was taken for chemical determination of total starch, total carbohydrates protein and nitrate content were determined according to the methods described by A. O. A. C. [20]; Herbert *et al.* [19]; Pregl [16] and Cataldo *et al.* [21], respectively.

Statistical Analysis: All collected data in both seasons of the study were subjected to statistical analysis of variance as factorial experiments in split split-plot design, according to Snedecor and Cocharn [22] where the least significant difference was considered when even possible.

RESULTS AND DISCUSSION

Vegetative Growth Characteristics: Data in Table (3) shows the effect of propagation methods, nitrogen fertilizer sources and soil addition treatments as well as their interactions on the vegetative growth characteristics of potato plants during the summer seasons of 2017 and 2018.

As for the propagation methods, using either cutting tubers or mini tubers as potato seeds did not show any significant differences regarding plant height during both seasons of growth. However, the number of both branches and leaves, as well as fresh and dry weight per plant were significantly increased as cutting tubers were used as compared with mini tubers during both seasons. Obtained results are in agreement with those of Akhtar [23]; Ozturk and Yildrim [24] and Kawakami and Iwama [25].

Concerning the effect of nitrogen fertilizer sources, it is evident from data presented in Table (3) that adding all amounts of nitrogen fertilizers (120 kg N/fed) as 50% in mineral form (60 kg/fed) as ammonium nitrate (33%) plus 50% in organic form (60 kg/fed) as chicken manure (N2) exceeded significantly all other treatments regarding the number of branches as well as fresh and dry weight per plant during both seasons.

On the other hand, adding all amounts of nitrogen as 100% in mineral form as 120 kg /fed of ammonium nitrate (N1) produced the longest plants and the highest number of leaves per plant during both seasons. Besides, adding 25% of nitrogen fertilizer in mineral form plus 75% in the organic forms (N) laid in-between. Finally, adding 100% of the nitrogen fertilizer rate in organic form (N4) only ranged last in all studied vegetative growth traits as it produced the least significant values of all the studied vegetative growth parameters in the two seasons. The increase in plant growth due to supplementation of mineral nitrogen with organic nitrogen may be attributed to that organic fertilizers release nitrogen slowly during the growing season, while mineral fertilizer can compensate the needed N. Besides, organic fertilizer plays a vital role in improving soil physical properties and reducing pH value which affects availability of soil nutrients for uptaking by plant and consequently increased plant growth. Cooke [26] suggested that the application of organic and mineral N fertilizers together may increase the exchangeable water-soluble of NPK and the uptake of these elements. Also, the increase in plant growth parameters was connected with the increase in photosynthetic pigments and determined macro-nutrient content (Table 4) and inturn increased plant growth. Obtained results are in the same direction with those reported by Mohamed [27]; Doklega [12] and Hosseini [28].

As for the effect of soil addition treatments, data presented in Table (3) show that adding seaweed extract at 1% three times started after 21 days from planting and every 15-day intervals as soil amendment surpassed significantly all other amendments, followed by yeast extract at 10%. Meanwhile, effective microorganisms (EM) at 10% came the last in affecting all the studied vegetative growth characteristics in the two seasons of study. In this connection, such increment in growth aspects due to soil amendments with tested organic compounds may be due to the improvement of root growth, soil physical condition and increasing organic acids which affect soil PH and nutrient availability and decreasing the microbial diseases infection and increasing the activity of beneficial microorganisms which in turn affect positively the efficiency of mineral nutrients absorption by root and consequently increased morphological growth characteristics of plant. Obtained results are similar to those obtained by Wasim [29]; Malash *et al.* [11] and Ibrahim [30]. Concerning the interaction between propagation methods, nitrogen fertilizer sources and soil addition treatments, data presented in Table (3) show that planting potato cutting tubers then fertilized with 50% of the recommended N-fertilizers in the mineral (ammonium nitrate 33%N) and 50% in organic forms (chicken manure) combined with the soil addition of seaweed extract at 1% significantly surpassed mostly all

Table 3: Effect of propagation methods, nitrogen fertilizer sources and soil addition treatments as well as their interactions on vegetative growth characteristics of potato plant during the two seasons of 2017 and 2018

Treatments			First Season 2017					Second Season 2018				
Propagation Methods	Nitrogen fertilization	Soil Addition	Plant height (cm)	Number of branches	Number of leaves	Fresh weight (g)	Dry weight (g)	Plant height (cm)	Number of branches	Number of leaves	Fresh weight (g)	Dry weight (g)
Cutting			52.1	4.85	25.29	152.2	25.87	43.9	3.29	19.4	123.5	20.53
Mini tubers			51.0	4.60	23.99	136.2	23.15	43.5	2.89	18.1	112.6	19.42
	L.S.D.		N.S	0.21	1.14	11.6	1.56	N.S	0.24	1.18	10.8	0.81
	N1		53.68	4.39	29.53	130.9	22.26	45.32	2.83	20.3	105.7	17.97
	N2		52.61	6.05	26.61	171.2	29.11	44.44	3.81	19.5	139.4	23.71
	N3		51.51	5.08	22.34	149.3	25.38	43.64	3.2	18.2	125.2	21.28
	N4		48.46	3.38	20.08	125.2	21.28	41.39	2.52	17.0	101.9	16.93
	L.S.D.		4.81	0.97	1.97	18.46	3.13	2.64	0.31	1.7	13.2	1.95
		EM	48.5	4.04	20.96	129.1	21.52	41.85	2.50	14.88	102.9	17.21
		Yeast	51.65	4.71	24.31	142.2	24.35	43.87	3.21	18.95	118.1	20.08
		Seaweed	54.54	5.42	28.65	161.2	27.65	45.38	3.56	22.48	133.1	22.63
	L.S.D.		2.95	0.44	1.44	11.15	1.79	2.45	0.48	1.87	11.37	1.52
Cutting tubers	100% mineral N(N1)	EM	52.4	3.6	21.07	117.8	20.02	44.77	1.6	16.2	93.3	15.86
		Yeast	54.63	4.5	26.07	129.6	22.04	45.4	3.5	23.3	116.1	19.73
		Seaweed	55.27	5.0	42.27	158.3	26.91	45.97	3.5	25.4	119.4	20.3
	50% mineral +	EM	49.4	5.4	26.2	153	26.0	42.63	3.7	15.5	124.5	21.17
	50% organic N (N2)	Yeast	52.17	6.4	27.77	180.9	30.75	44.6	4.2	20.3	147.2	25.02
		Seaweed	56.97	7.4	28.33	214.6	36.49	46.13	4.7	24.63	159.4	27.1
	25% mineral +	EM	49.33	4.8	21.2	120.7	20.52	41.97	2.5	14.73	109.4	18.6
	75% organic N (N3)	Yeast	53.1	4.8	23.97	179.9	30.58	44.1	3.1	18.07	120.5	20.49
		Seaweed	54.3	5.6	25.97	186.1	31.64	46.4	4.4	23.17	165.6	28.15
	100% organic N(N4)	EM	46.2	3.1	16.17	113.3	19.26	38.63	1.9	13.3	121.4	14.97
		Yeast	50.07	3.4	19.2	119	20.23	42.53	3.1	17.63	102.2	17.37
		Seaweed	51.73	3.8	25.3	152.6	25.95	43.63	3.1	21.07	103.3	17.56
Mini tubers	100% mineral N(N1)	EM	48.53	3.6	25.97	120.7	20.52	44.3	2.2	15.97	77.13	13.11
		Yeast	53.53	4.6	29.97	124.4	21.15	45.77	2.8	19.2	105.5	17.94
		Seaweed	57.73	4.8	31.87	134.8	22.91	45.73	3.3	21.77	122.7	20.86
	50% mineral +	EM	51.3	5.4	20.73	148.5	25.25	41.97	3.0	15.27	118.9	20.21
	50% organic N (N2)	Yeast	52.53	5.7	24.77	163.3	27.76	44.07	3.4	18.53	136.1	23.14
		Seaweed	53.27	5.9	31.87	167	28.39	47.27	3.7	22.77	150.6	25.6
	25% mineral +	EM	46.63	3.7	18.4	140.5	20.58	42.2	2.8	14.2	105	17.85
	75% organic N (N3)	Yeast	50.6	4.5	21.87	121.3	22.04	43.53	3.1	17.4	114.1	19.39
		Seaweed	55.07	6.9	22.63	147.2	26.91	43.63	3.2	21.97	136.6	23.23
	100% organic N(N4)	EM	44.2	2.5	17.97	117.8	20.02	38.3	2.0	13.83	73.83	15.88
		Yeast	46.6	3.6	20.87	119	20.23	40.97	2.4	17.2	103.3	17.57
		Seaweed	51.97	3.7	20.97	129.3	21.98	44.3	2.5	19.1	107.3	18.24
	L.S.D.		5.3	1.2	4.07	23.52	3.07	6.951	1.3	5.30	24.16	4.32

other tested treatments combination during both seasons of this experiment. On the other hand, adding 100% of the recommended N- fertilizers only in organic form (chicken manure) when combined with effective microorganisms (EM) at 10% came last and induced significant the least values of most studied vegetative growth characteristics during both seasons. In this regard, the other tested interactions produced mostly intermediate values of individual plant height, number of branches and leaves as well as fresh and dry weight per potato plant during both seasons.

Chemical Composition of Plant Foliage: Data outlined in Table (4) reveal that using either cutting tubers or mini tubers as potato seeds exhibited mostly significant differences regarding N, P, K ratio and total carbohydrates percentages during both seasons. In this respect, potato plants raised from cutting tubers surpassed those derived from mini tubers regarding all studied chemical parameters of plant foliage in both seasons. Obtained results came in line with those reported by Akhtar [23]; Ozturk and Yildrim [24] and Kawakami and Iwama [25].

With regard to the effect of nitrogen fertilizer sources it is evident from the same data that adding all amounts of nitrogen fertilizers as 50% in organic form as 60 kg/fed of ammonium nitrate (33%) and 50% in organic form as chicken manure significantly exceeded N , P and total carbohydrates as compared to other treatments. Meanwhile, adding 25% of nitrogen fertilizer in mineral form plus 75% in the organic form produced the highest K percentage in plant foliage. However, adding 100% of the nitrogen fertilizer rate only either in the organic or mineral form recorded the least values in this concern as it produced the least significant values regarding N, P, K and total carbohydrate percentages during both seasons.

Table 4: Effect of propagation methods, nitrogen fertilizer sources and soil addition treatments as well as their interaction on chemical constituents of potato plants foliage during the two seasons of study 2017 and 2018

Treatments			First Season 2017				Second Season 2018			
Propagation Methods	Nitrogen fertilization	Soil Addition	N%	P%	K%	Total carbohydrate%	N%	P%	K%	Total carbohydrate%
Cutting			1.91	0.396	3.39	14.69	1.57	0.355	3.06	13.82
Mini tubers			1.61	0.365	3.03	13.87	1.47	0.336	2.80	13.13
	L.S.D.		0.08	0.032	0.13	0.47	0.06	N.S	0.05	0.30
	N1		1.58	0.367	3.05	13.67	1.47	0.330	2.79	13.20
	N2		1.80	0.421	3.36	15.87	1.64	0.386	3.08	14.81
	N3		1.70	0.391	3.63	14.87	1.57	0.357	3.45	13.76
	N4		1.48	0.343	2.81	12.70	1.41	0.308	2.41	12.12
	L.S.D.		0.08	0.001	0.20	0.57	0.07	0.001	0.11	0.52
		EM	1.54	0.354	3.51	13.78	1.42	0.321	3.19	12.90
		Yeast	1.63	0.380	2.95	14.25	1.51	0.342	2.63	13.48
		Seaweed	1.75	0.407	3.16	14.80	1.64	0.373	2.98	14.03
	L.S.D.		0.08	0.018	0.14	0.57	0.05	0.001	0.10	0.59
Cutting tubers	100% mineral N(N1)	EM	1.50	0.370	3.82	13.49	1.40	0.320	3.27	13.05
		Yeast	1.62	0.380	3.00	14.02	1.53	0.340	2.67	13.57
		Seaweed	1.71	0.400	3.19	14.97	1.62	0.363	2.86	14.23
	50% mineral + 50% organic N (N2)	EM	1.78	0.403	3.83	15.27	1.60	0.373	3.56	14.43
		Yeast	1.87	0.430	3.13	16.12	1.69	0.380	2.7	15.12
		Seaweed	1.95	0.470	3.31	16.67	1.83	0.423	3.13	15.97
	25% mineral + 75% organic N (N3)	EM	1.62	0.380	4.05	14.62	1.51	0.346	3.79	13.53
		Yeast	1.73	0.410	3.58	15.15	1.62	0.366	3.13	14.11
		Seaweed	1.81	0.440	3.68	15.77	1.70	0.410	3.66	14.41
	100% organic N(N4)	EM	1.42	0.330	3.19	12.91	1.31	0.293	2.90	11.96
		Yeast	1.57	0.360	2.85	13.46	1.49	0.316	2.44	12.35
		Seaweed	1.64	0.386	3.12	13.82	1.59	0.333	2.54	13.10
Mini tubers	100% mineral N(N1)	EM	1.45	0.320	3.02	12.53	1.35	0.290	2.90	12.18
		Yeast	1.53	0.350	2.52	13.14	1.40	0.313	2.34	12.78
		Seaweed	1.68	0.386	2.74	13.86	1.52	0.356	2.72	13.37
	50% mineral + 50% organic N (N2)	EM	1.65	0.386	3.51	15.63	1.49	0.366	3.15	13.63
		Yeast	1.72	0.406	3.07	15.50	1.53	0.376	2.78	14.54
		Seaweed	1.88	0.430	3.30	16.03	1.72	0.400	3.08	15.18
	25% mineral + 75% organic N (N3)	EM	1.59	0.346	3.87	14.01	1.45	0.313	3.71	13.06
		Yeast	1.67	0.370	3.17	14.61	1.49	0.343	2.86	13.45
		Seaweed	1.79	0.400	3.44	15.04	1.65	0.366	3.56	14.00
	100% organic N(N4)	EM	1.30	0.300	2.82	11.76	1.24	0.270	2.26	11.39
		Yeast	1.39	0.336	2.32	12.00	1.38	0.306	2.03	11.92
		Seaweed	1.59	0.350	2.54	12.27	1.49	0.333	2.27	12.00
	L.S.D.		0.22	0.002	0.39	1.63	0.15	0.001	0.30	1.67

Increasing in macronutrients (NPK) may be attributed to the effect of organic fertilizer on reducing the pH value of the soil, increasing the soil microbial biomass and humate, which affect the decomposition and availability of such nutrients which in turn increase its uptake by plant roots. Also, the addition of mineral nitrogen fertilizer increases its concentration in soil solution and in turn, increased the absorption by the plant. Obtained results are in accordance with those reported by Mohamed [27]; Doklega [12] and Hosseini [28].

As for the effect of adding various soil amendments, data presented in Table (4) show that adding seaweed extract at 1% three times showed to be the most effective treatment for inducing the highest values in this concern, followed in a descending order by yeast extract at 10%. Meanwhile, effective microorganisms (EM) mostly occupied the last in its effect on N, P, K and total carbohydrates percentages in the two seasons of study. In this regard, such increment in the concentration of determined macronutrients may be due to the enhancing effects of such compounds on root growth and elongation as well as increasing root zone, which increases uptake capability of root and availability of macronutrients to be absorbed and accumulated by the plant. Obtained results are an agreement with those reported by Wasim [29]; Malash *et al.* [11] and Ibrahim [30].

As for the interaction between the three studied factors on the chemical constituents of potato plants foliage, it was found that planting potato from cutting tubers then fertilized with 50% of the recommended N-fertilizers in the mineral form (ammonium nitrate 33% N) + 50% in the organic form(chicken manure) combined with the soil addition of seaweed extract at 1% significantly scored the most significant values of N, P and total carbohydrates percentages during both seasons of this experiment. Moreover, using cutting tubers then supplemented with 25% N in mineral form plus 75% N in the organic form with soil addition of EM at 1% produced the highest values of K ratio. On the other hand, using mini tubers and 100% of the recommended N- fertilizers only in organic form (chicken manure) when combined with effective microorganisms (EM) at 10% came last and induced significant the least values of most studied chemical constituents during the two seasons of study. The remained treatments came in between the treatments mentioned above during both seasons.

Tuber Yield and its Components: Concerning the effect of propagation methods using either cutting or mini tubers as potato seeds data in Table(5) showed significant differences regarding total yield and its components per plant as well as fed during both experimental seasons of study. However, the number of tubers per plant did not show any significant differences as cutting tubers and mini tubers were used during both seasons. In this respect, potato plants derived from cutting tubers exceeded significantly those derived from mini tubers in both seasons regarding total yield and yield per plant either per plant or fed. Obtained results are in accordance with those reported by Akhtar [23]; Ozturk and Yildrim [24] and Kawakami and Iwama [25].

As for the effect of nitrogen fertilizers sources it is evident from the data presented in Table (5) that adding all amounts of nitrogen fertilizers (120 kg/fed) as 50% in mineral form as ammonium nitrate (33%) and 50% in organic form as chicken manure exceeded all other treatments significantly regarding to total yield/fed and yield per plant followed by adding 25% of nitrogen fertilizer in mineral form plus 75%in organic from during both seasons.. The highest total yield per plant and per fed in case of fertilization using half of the recommended dose of nitrogen as chicken manure and another half as mineral nitrogen may be attributed to induce a balanced in the uptake of N, which resulted in the highest yield production per plant or per feddan. Mondal *et al.* [4] indicated that organic fertilizer encourages the plant to have proper root development and additionally the mineral-N fertilizers might help the living organisms in organic matter to multiply. Obtained results are parallel with those reported by Mohamed [27]; Doklega [12] and Hosseini [28].

With regarding to the Effect of soil addition treatments, data presented in Table (5) show that adding seaweed extract at 1% three times started after 21 days from planting and every 15 day intervals as soil amendment except produced number of tuber per plant it surpassed significantly all others treatments in total yield and yield per plant. Moreover, yeast extract at 10% came second in this concern, meanwhile, effective microorganisms (EM) came last in their effect on total yield and yield per plant during both experimental seasons. But it produced the highest significant values in the number of tubers during both seasons of study. The increment in total yield and its components as a result of using such tested organic constituents are connected with the increase in vegetative growth characteristics (Table 3) and macronutrients concentration (Table 4), which affected positively the vegetative growth of the plant and consequently the produced yield. In this regard, obtained results are in parallel to that reported by Wasim [29]; Malash *et al.* [11] and Ibrahim [30].

As for the effect of the interaction treatment between propagation methods, nitrogen fertilizer sources and soil addition treatments, data presented in Table (6) show the impact of the interaction of the three studied factors on yield and it is components. It is evident clearly that planting potato by using cutting tubers then fertilized with 50% of the recommended N-fertilizers in the mineral form (ammonium nitrate 33%N) and 50% in organic form(chicken manure) combined with the soil addition of seaweed extract at 1% significantly surpassed mostly all other tested treatments regarding total yield per plant and feddan as well during both seasons of this experiment. Simultaneously, it gave the lowest number of tubers per plant especially in the second season. On the other hand, using mini tubers and adding 100% of the recommended N- fertilizers only in organic form (chicken manure) when combined with effective microorganisms (EM) at 10% came last and induced significant the least values of total yield and yield per plant during both seasons. Meanwhile, it produced the highest values of the number of tubers per plant. In this regard, the other tested interactions produced mostly intermediate values of total yield and yield per plant during both seasons.

Physical Tuber Quality: Data illustrated in Table (6) show the effect of propagation methods, nitrogen fertilizer sources and soil addition treatments as well as their interactions on physical tubers quality characteristics of potato plants during the summer seasons of 2017 and 2018. In this regard, using either cutting tubers or mini tubers as potato seeds did not show any significant differences regarding tuber weight, size, diameter as well as length during both seasons. Obtained results are in accordance with those reported by Akhtar [23] and Kawakami and Iwama [25].

Table 5: Effect of propagation methods, nitrogen fertilizer sources and soil addition treatments as well as their interactions on tuber yield and its components of potato plants during the two seasons of study 2017 and 2018

Treatments			First Season 2017			Second Season 2018		
Propagation Methods	Nitrogen fertilization	Soil Addition	Tuber yield/plant(g)	No. of Tubers/ plant	Total yield(t/fed)	Tuber yield/plant(g)	No. of Tuber/ plant	Total yield(t/fed)
Cutting tubers			711.0	3.27	14.25	660.0	3.21	13.20
Mini tubers			687.5	3.29	13.74	641.6	3.22	12.83
	L.S.D.		12.1	N.S	0.34	10.8	N.S	0.40
	N1		679.5	3.28	13.65	647.4	3.27	12.95
	N2		752.9	3.19	15.04	675.2	3.07	13.51
	N3		697.9	3.23	13.96	653.4	3.17	13.07
	N4		666.8	3.42	13.34	627.1	3.36	12.54
	L.S.D.		28.5	0.22	0.59	18.0	0.15	0.55
		EM	677.0	3.44	13.53	634.7	3.37	12.70
		Yeast	697.0	3.27	13.94	650.2	3.21	13.00
		Seaweed	723.8	3.13	14.52	667.5	3.07	13.35
	L.S.D.		22.8	0.14	0.45	13.8	0.10	0.27
Cutting tubers	100% mineral N(N1)	EM	682.3	3.52	13.65	640.7	3.49	12.81
		Yeast	696.9	3.28	13.94	646.6	3.19	12.93
		Seaweed	687.5	3.00	14.08	667.6	2.99	13.35
	50% mineral +	EM	755.2	3.23	15.10	671.2	3.33	13.46
	50% organic N (N2)	Yeast	769.8	3.17	15.40	683.9	3.01	13.68
		Seaweed	789.5	3.18	15.79	696.8	2.97	13.94
	25% mineral +	EM	681.8	3.40	13.64	642.4	3.34	12.85
	75% organic N (N3)	Yeast	700.0	3.17	14.00	658.1	3.10	13.16
		Seaweed	758.5	3.15	15.17	675	2.96	13.50
	100% organic N(N4)	EM	650.2	3.60	13.00	634.9	3.56	12.70
		Yeast	675.0	3.34	13.50	638.5	3.31	12.77
		Seaweed	685.6	3.24	13.71	664.1	3.30	13.28
Mini tubers	100% mineral N(N1)	EM	632.3	3.52	12.65	623.5	3.52	12.47
		Yeast	681.0	3.41	13.65	647.8	3.41	12.96
		Seaweed	696.9	2.97	13.94	658.3	3.05	13.17
	50% mineral +	EM	697.6	3.14	13.85	649.4	3.04	12.99
	50% organic N (N2)	Yeast	735.5	3.22	14.71	667.7	3.07	13.35
		Seaweed	769.8	3.20	15.40	682.3	2.99	13.65
	25% mineral +	EM	670.8	3.45	13.42	627.6	3.31	12.55
	75% organic N (N3)	Yeast	654.2	3.11	13.08	653.1	3.25	13.06
		Seaweed	722.4	3.10	14.45	664.1	3.07	13.28
	100% organic N(N4)	EM	645.9	3.64	12.92	587.5	3.39	11.75
		Yeast	664.1	3.48	13.28	605.8	3.35	12.12
		Seaweed	680.1	3.22	13.60	631.9	3.22	12.64
	L.S.D.		64.7	0.41	1.29	39.0	0.29	0.78

As for the Effect of nitrogen fertilizer sources, it is evident clearly from the data presented in Table (6) that adding all amounts of nitrogen fertilizers as 50% in the mineral form as ammonium nitrate (33%N) and 50% in the organic form as chicken manure surpassed significantly all other treatments regarding tuber weight, size, diameter and length during both seasons, followed by adding 25% of nitrogen fertilizer in mineral form plus 75% in the organic form then followed by adding 100% mineral N in the third level. Finally, adding 100% of the nitrogen fertilizer in organic form only ranged last in all studied yield quality traits, as it produced the least significant values in this regard during both seasons. In this concern, the highest values in tuber physical parameters due to the used of nitrogen fertilizer in a mineral and organic forms together (120kgN/fed) may be due to the role of nitrogen in increasing the moisture content of tuber cells and also increasing the size and number of cells in tuber receptacle which affect the measured tuber parameters. In this respect, Mohamed [27]; Doklega [12] and Hosseini [28] reported similar results.

Data presented in Table (6) show the effect of adding seaweed extract at 1% three times started after 21 days from planting and every 15-day intervals as soil amendment surpassed significantly all other amendments followed by yeast extract at 10 %, meanwhile, using effective microorganisms (EM) came last in this regard during both seasons of study. Such an increasing effect especially of using seaweed extract on chemical constituents of tubers may be due to the increase of root growth and availability of nutrient elements in the soil which in turn may affect macronutrients concentration of plant foliage and consequently affected the assimilation of such constituents of tubers. Also, its impact on the concentration of N, P, K and carbohydrate content, which play the central role on the components of photosynthetic

Table 6: Effect of propagation methods, nitrogen fertilizer sources and soil addition treatments as well as their interactions on tuber physical quality of potato tubers during the two seasons of 2017 and 2018

Treatments			First Season 2017				Second Season 2018			
Propagation Methods	Nitrogen fertilization	Soil Addition	Tuber weight (g)	Tuber size	Diameter tuber (cm)	Tuber length (cm)	Tuber weight (g)	Tuber size	Diameter tuber (cm)	Tuber length (cm)
Cutting tuber			217.7	199.0	6.14	10.79	207.0	184.2	6.02	10.66
Mini tubers			210.0	189.8	6.04	10.63	200.1	181.1	5.90	10.42
	L.S.D.		N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S
	N1		207.8	190.5	5.97	10.60	198.6	180.2	5.85	10.53
	N2		235.8	207.6	6.38	10.96	221.8	189.5	6.19	10.76
	N3		216.4	195.9	6.16	10.77	206.3	184.9	6.03	10.51
	N4		195.3	183.6	5.84	10.51	187.7	176.1	5.78	10.37
	L.S.D.		10.6	7.6	0.18	0.26	8.8	5.8	0.10	0.17
		EM	197.1	187.3	5.96	10.54	189.7	175.9	5.83	10.39
		Yeast	213.3	192.9	6.05	10.69	203.5	182.0	5.93	10.53
		Seaweed	231.1	203.0	6.25	10.90	217.6	190.1	6.13	10.71
	L.S.D.		6.2	5.9	0.13	0.16	5.0	4.84	0.10	0.21
Cutting tubers	100% mineral N(N1)	EM	188.7	184.3	5.97	10.57	183.1	173.3	5.75	10.50
		Yeast	212.3	192.7	6.04	10.66	202.5	179.4	5.92	10.57
		Seaweed	231.0	205.8	6.12	10.84	222.7	186.2	6.05	10.76
	50% mineral + 50% organic N (N2)	EM	233.3	209.0	6.18	10.87	210.3	185.4	6.09	10.73
		Yeast	242.3	214.5	6.29	11.11	226.9	191.8	6.15	10.91
		Seaweed	248.3	212.7	6.83	11.26	234.1	201.4	6.50	11.10
	25% mineral + 75% organic N (N3)	EM	200.0	192.5	6.12	10.61	192.0	180.2	5.97	10.47
		Yeast	220.3	200.1	6.14	10.84	212.4	187.4	6.01	10.69
		Seaweed	241.7	211.7	6.36	11.00	227.9	193.6	6.27	10.88
	100% organic N(N4)	EM	181.3	180.3	5.77	10.45	178.2	171.9	5.78	10.32
		Yeast	201.7	184.2	5.84	10.57	193.5	177.2	5.83	10.47
		Seaweed	211.7	200.4	6.04	10.72	200.8	182.9	5.98	10.58
Mini tubers	100% mineral N(N1)	EM	180.3	179.3	5.82	10.42	177.3	175.3	5.72	10.33
		Yeast	200.0	187.5	5.89	10.55	189.7	180.1	5.75	10.41
		Seaweed	234.7	193.4	6.00	10.55	216.3	186.8	5.95	10.63
	50% mineral + 50% organic N (N2)	EM	221.7	200.1	6.16	10.62	213.7	178.5	5.94	10.35
		Yeast	229.3	200.9	6.24	10.62	218.2	182.3	6.10	10.65
		Seaweed	240.0	208.5	6.56	11.26	227.3	197.7	6.39	10.83
	25% mineral + 75% organic N (N3)	EM	194.3	181.4	6.00	10.50	189.1	173.4	5.82	10.27
		Yeast	210.0	185.7	6.15	10.74	200.5	182.9	6.00	10.32
		Seaweed	232.3	203.8	6.22	10.93	215.8	191.6	6.11	10.44
	100% organic N(N4)	EM	177.3	171.2	5.70	10.29	173.8	168.9	5.61	10.17
		Yeast	190.3	177.6	5.81	10.41	184.3	175.1	5.68	10.25
		Seaweed	209.3	187.9	5.90	10.63	195.7	180.4	5.83	10.43
	L.S.D.	17.5	16.6	0.37	0.47	14.4	13.7	0.29	0.61	

pigments molecules, that may in turn affect the formation and accumulation of such photosynthetic products in the tuber. Obtained results are similar with those reported by Wasim [29]; Malash *et al.* [11] and Ibrahim [30].

Concerning the interaction between propagation methods, nitrogen fertilizer sources and soil addition treatments, data presented in Table (6) show the effect of the interaction of the three studied factors on tuber physical quality properties. It is evident that planting potato by cutting tubers then fertilized with 50% of the recommended N-fertilizers in the mineral form (ammonium nitrate 33%N) and 50% in organic form (chicken manure) combined with the soil addition of seaweed extract at 1% significantly surpassed mostly all other tested treatments during both seasons of this experiment. On the other hand, using mini tubers and 100% of the recommended N- fertilizers only in organic form (chicken manure) when combined with effective microorganisms (EM) at 10% came last and induced significant the least values of most studied tuber quality characteristics during both seasons. In this regard, the other tested interactions produced mostly intermediate values of individual tuber weight, size, diameter and length during both seasons.

The Chemical Quality of Tubers: Data illustrated in Table (8) show the effect of propagation methods, nitrogen fertilizers and soil addition treatments as well as their interactions on the tuber content of the dry matter starch, carbohydrate, protein and NO_3 of potato tubers during the summer seasons of 2017 and 2018.

Regarding the effect of the propagation methods, tubers of potato plants derived from cutting tubers exceeded significantly those derived from mini tubers in both seasons regarding starch, protein and NO_3 of tubers.

Table 7: Effect of propagation methods, nitrogen fertilizer sources and soil addition treatments as well as their interactions on tuber chemical quality of potato plants during the two seasons of study 2017 and 2018

Treatments			First Season 2017					Second Season 2018				
Propagation Methods	Nitrogen fertilization	Soil Addition	Dry matter%	Starch%	Carbohydrate%	Protein%	NO_3 mg/100g	Dry matter%	Starch%	Carbohydrate	Protein%	NO_3 mg/100g
Cutting tubers			21.87	16.19	89.17	13.25	222.7	22.56	15.51	88.28	12.50	216.2
Mini tubers			22.08	15.92	88.67	12.43	212.7	21.76	15.23	87.21	11.50	210.3
	L.S.D.		N.S	0.06	N.S	0.13	5.36	N.S	0.18	N.S	0.05	3.76
	N1		21.49	15.59	86.52	12.43	214.8	21.96	15.21	84.77	11.68	209.2
	N2		22.76	16.70	90.9	13.81	229.7	23.07	16.40	89.66	12.62	223.3
	N3		23.55	17.39	94.35	13.18	224	23.61	17.07	93.41	12.56	220.8
	N4		20.1	14.55	83.89	11.93	202.4	20.01	12.81	83.12	11.18	199.7
	L.S.D.		0.39	0.24	1.99	0.18	11.05	0.83	0.13	1.50	0.07	5.72
		EM	22.52	16.55	90.57	12.06	215.7	22.74	15.98	89.1	11.18	211.6
		Yeast	21.41	15.59	87.34	12.75	217.6	21.66	14.81	86.14	11.93	211.8
		Seaweed	21.99	16.03	88.84	13.68	219.8	22.08	15.32	87.99	12.93	216.4
	L.S.D.		0.33	0.38	1.45	0.10	5.99	0.53	0.32	1.20	0.07	5.67
Cutting tubers	100% mineral N(N1)	EM	22.54	16.47	88.27	12.00	218.7	22.84	16.17	87.3	11.25	212.3
		Yeast	20.95	15.3	85.57	13.00	220.5	21.7	14.58	83.43	12.50	200.8
		Seaweed	21.75	15.78	86.13	13.75	222.3	22.15	15.41	85.93	13.31	221.1
	50% mineral +	EM	23.32	17.3	92	13.68	233.2	23.7	16.95	91.23	12.81	221.2
	50% organic N (N2)	Yeast	22.38	16.21	89.13	14.25	234.4	22.57	16.02	88.27	13.31	225
		Seaweed	22.83	16.72	91	15.00	235.7	23.09	16.46	90.2	13.31	229.6
	25% mineral +	EM	23.83	17.8	95.77	12.62	223.5	24.16	17.52	94.67	12.06	221.9
	75% organic N (N3)	Yeast	23.21	17.26	93.37	13.81	226.8	23.63	16.85	92.8	13.31	222.3
		Seaweed	23.45	17.47	94.47	14.68	232.2	23.84	17.08	93.9	13.87	224.8
	100% organic N(N4)	EM	20.24	14.87	86.43	11.56	206.1	21.24	13.87	85.87	10.62	201.5
		Yeast	18.46	14.36	83.6	12.00	209.4	20.73	12.08	81.8	11.31	205.9
		Seaweed	19.5	14.76	84.3	13.12	210	21.13	13.13	83.93	12.62	208.1
Mini tubers	100% mineral N(N1)	EM	22.05	16.33	90.07	11.18	208	22.69	15.68	85.4	10.12	204.7
		Yeast	20.55	14.57	83.43	11.87	208.7	20.94	14.64	82.53	11.12	207.1
		Seaweed	21.07	15.08	85.67	12.81	210.4	21.44	14.74	84.03	12.00	209.1
	50% mineral +	EM	23.07	17.18	92.3	12.56	221.9	23.55	16.71	91	11.56	220
	50% organic N (N2)	Yeast	22.05	16.07	89.33	13.31	225.5	22.43	15.68	87.17	11.56	221.4
		Seaweed	22.93	16.71	91.65	14.18	227.5	23.07	16.57	90.1	13.43	222.4
	25% mineral +	EM	23.96	17.63	95.1	11.75	219.8	23.79	17.42	93.6	10.93	218.3
	75% organic N (N3)	Yeast	23.31	16.97	93.23	12.62	220.3	23.05	16.68	92.3	11.93	217.6
		Seaweed	23.53	17.2	94.17	13.68	221.5	23.21	16.84	93.2	13.31	219.9
	100% organic N(N4)	EM	21.19	14.82	84.63	11.18	194.7	19.97	13.54	83.73	10.12	192.5
		Yeast	20.34	13.97	81.03	11.56	195.7	18.27	11.94	80.8	10.75	193.9
		Seaweed	20.87	14.54	83.37	12.50	198.7	18.72	12.3	82.6	11.75	196.4
	L.S.D.		0.94	1.09	4.11	0.18	16.96	1.52	0.92	3.40	0.22	16.04

As for dry matter as well carbohydrate percentage of potato tubers, no significant differences could be detected during both seasons. Obtained results are in accordance with Akhtar [23] and Kawakami and Iwama [25].

Regarding the effect of nitrogen fertilizer sources, it is evident from data presented in Table (7) that adding half the amounts of nitrogen fertilizers in mineral form (60 kg/fed) of ammonium nitrate (33%) plus 50% in organic form as chicken manure exceeded protein and nitrate contents significantly during both seasons. Also, adding 25% of the nitrogen fertilizer in mineral form plus 75% organic produced the highest values regarding dry matter, starch and carbohydrate contents of tubers. Finally, adding 100% of the nitrogen fertilizer rate in organic form only ranged last in all studied parameters as it produced the least significant values during both seasons Obtained results are in the same direction with those reported by Mohamed [27]; Doklega [12] and Hosseini [28] on potato plants.

With regard to the effect of soil addition treatments, data presented in Table (8) show that adding seaweed extract at 1% three times started after 21 days from planting and every 15-day intervals as soil amendment surpassed significantly in nitrate as well as protein contents followed by yeast extract at 10 %. Meanwhile, effective microorganisms (EM) came in the first rank in their effect dry matter, starch and carbohydrate contents of tubers. Meanwhile, yeast extract came last in its effects in this concern. Obtained results are similar to those obtained by Wasim [29]; Malash *et al.* [11] and Ibrahim [30].

As for the interaction between propagation methods, nitrogen fertilizer sources and soil addition treatments, data presented in Table (8) show the effect of the interaction of the three studied factors on dry matter, starch, carbohydrate, protein and nitrate contents of tubers. It is evident that planting potato cutting tubers then fertilized with 50% of the recommended N-fertilizers in the mineral form (ammonium nitrate 33%N) and 50% in organic form (chicken manure) combined with the soil addition of either yeast extract at 10% or seaweed extract significantly surpassed mostly all other used treatments regarding nitrate contents during both seasons of this experiment.

Meanwhile, use cutting tuber with 25% N in mineral plus 75% in organic form combined with EM produced the highest values of dry matter and starch contents during the second season. On the other hand, using mini tuber and 100% of N- fertilizers only in organic form (chicken manure) when combined with effective microorganisms(EM) at 10% came last and induced significantly the least values of nitrate contents during both seasons but using mini tuber with 100% N in organic form + yeast extract gave significantly last values of dry matter and starch. However, the other tested interactions produced mostly intermediate values.

CONCLUSION

It can be concluded, under such conditions, planting potato by cutting tubers then fertilized with 50% of the recommended (N-fertilizers in the mineral form (ammonium nitrate 33%N) and 50% in organic form (chicken manure) combined with the soil addition of seaweed extract at 1% three times are recommended to obtain the highest vegetative growth, produced tuber yield with best quality of potato grown in summer season.

REFERENCES

1. Djurdjina, R., M. Milinkovic and D. Milosevic, 1997. In vitro propagation of potato (*Solanum tubersum* L). Act. Hort., pp: 959-963.
2. Upadhyaya, N.C., N. Singh, S. Ranwal and P. Kumar, 2003. Response of two potato cultivars to vermicompost and inorganic fertilizers. Journal of the Indian Potato Association, 30: 85-86.
3. Jenssen, B.H., 1993. Integrated nutrient management: The use of organic and mineral fertilizer. In: The role of plant nutrients for sustainable food crop production in Sub-Saharan Africa, Eds. H. Van Reuler and W. H. Prins, pp: 89-105. Leidschendam, The Netherlands: VKP.
4. Mondal, S.S., D. Acharya, A. Ghosh and A. Bug, 2008. Integrated nutrient management on the growth, productivity and quality of potato in Indo-Gangetic plain of West Bengal. Potato Journal, 32: 75-78.
5. Singh, S.N., B.P. Singh, O.P. Singh, R. Singh and R.K. Singh, 2007. Effect of nitrogen application in conjunction with bio-inoculant on the growth, yield and quality of potato under Indo-Gangetic plain region. Potato Journal, 34: 103-104.
6. Lindani, N. and C. Bvenura, 2012. Effects of the integrated use of effective micro-organisms, compost and mineral fertilizer on greenhouse-grown tomato. African J. Plant Sci., 6(3): 120-124.
7. Idris, I.I., M.T. Yousif, M.E. Elkashif and F.M. Baraka, 2018. Response of tomato (*Lycopersicon esculentum* Mill.) to application of effective microorganisms. Gezira J. Agric. Sci., 6(1): 43-56.
8. Herrera, R.M.H., F.S. Ruvalcaba, M.A.R. Lopez, J. Norrie and G.H. Carmona, 2014. Effect of liquid seaweed extracts on growth of tomato seedlings (*Solanum lycopersicum* L.). J. Appl. Phy., 26(1): 619-628.
9. Sutharsan, S., S. Nishanthi and S. Srikrishnah, 2014. Effects of foliar application of seaweed (*Sargassum crassifolium*) liquid extract on the performance of *Lycopersicon esculentum* Mill. in sandy regosol of Batticaloa district Sri Lanka. American-Eurasian J. Agric. & Environ. Sci., 14(12): 1386-1396.
10. Barnett, J.A., R.W. Payne and D. Yarrow, 1990. Yeast characteristics and identification. Cambridge. Camb. CBZBR, pp: 999.
11. Malash, N.M., M.A. Fattah Allah, F.A. Aly and N.M. Morsy, 2014. Effect of the combination between organic and mineral nitrogen along with or without bio-fertilizers and yeast extract on potato growth and productivity. Minufiya, J. Agric. Res., 39(2): 231-244.
12. Doklega, S.M.A., 2017. Impact of magnetized water irrigation, soil mineral fertilization and foliar spraying with Nanomaterial on potato plants. J. Plant Productions, Mansoura Univ., 8(11): 1113-1120.
13. Jackson, M.L., 1973. Soil Chemical Analysis. Printice-Hall of India. Privat Limited, New Delhi.
14. Black, C.A., D.O. Evans, L.E. Ensminger, J.L. White, F.E. Clark and R.C. Dinauer, 1982. Methods of soil analysis. Part 2. Chemical and Microbiological Properties. 2nd ed. Soil Sci., Soc. of Am. Inc. Publ., Madison, Wisconsin, U.S.A.

15. Allahverdiyev, S.R., E. Kirdar, G. Gunduz, D. Kadimaliyev, V. Revin, V. Filonenko, D.A. Rasulova, Z.I. Abbasova, S.I. Ganizade and E.M. Zeynalova, 2011. Effective microorganisms (EM) technology in plants. Tech. Agric. Res., 14: 103-106.
16. Pregl, E., 1945. Quantitative Organic Micro Analysis. 4th ed. J. Chundril, London.
17. John, M.K., 1970. Colorimetric determination of phosphorus in soil and plant material with ascorbic acid. Soil Sci., 109: 214-220.
18. Brown, J. and O. Lilleland 1946. Rapid determination of potassium and sodium in plant material and soil extracts by flame photometric. Proc. Amer. Soc. Hort. Sci., 48: 341-346.
19. Herbert, D., P.J. Phipps and R.E. Strange 1971. Determination of total carbohydrates, Methods in Microbiology, 5(8): 290-344.
20. A.O.A.C., 1990. Official Methods of Analysis. Association of Official Analytical Chemists, 15th ed. Washington, D.C, U.S.A.
21. Cataldo, D.A., M. Haroon, L.E. Schader and V.L. Yongs, 1975. Rapid colorimetric determination of nitrate in plant tissue by nitration of Salicylic acid. Communications in Soil Science and Plant Analysis, 6(1): 71-80.
22. Snedecor, G.W. and W.G. Cocharn. 1991. Statistical methods. 8th Ed., Iowa State Univ. press, Iowa. USA.
23. Akhtar, P., S.J. Abbas, A.H. Shah and N. Ali, 2010. Effect of growth behavior of potato mini tubers on quality of seed potatoes as influenced by different cultivars. Pak. J. Pl. Sci., 16(1): 1-9.
24. Ozturk, G. and Z. Yildrim, 2010. A comparison of field performances of mini tubers and micro tubers used in seed potato production. Turkish J. Field Crops, 15(2): 141-147.
25. Kawakami, J. and K. Iwama, 2012. Effect of potato micro tuber size on the growth and yield performance of field grown plants. Plant Prod. Sci., 15(2): 144-148.
26. Cooke, G.W, 1972. Fertilization for maximum yield. Richard clay, Chaucer Press, LTD, Bungary, Suffox. UK.
27. Mohamed, M.H.M., 2016. Effect of organic fertilizer in combination with some safety compounds on growth and productivity of potato plants grown in winter season. Zagazig J. Agric. Res., 43(4): 1181-1197.
28. Hosseini, A., S.H. Nemati, M. Khajehoseini and H. Aroiee, 2017. Effects of different nitrogen and solupotasse fertilizer rate on yield and yield components of potato. J. Fruit and Ornamental Plant Res., 8(1): 93-97.
29. Wasim, M., C. Haider, M. Ayyub, M. Aslam, H. Abdul, M. S .Raza and I. Ashraf, 2012. Impact of foliar application of seaweed extract on growth, yield and quality of potato (*Solanum tuberos*um L). J. Soil Envir., 31(2): 157-162.
30. Ibrahim, S.H.M., 2016. Effect of phosphorus, sulfur and some bio stimulants on productivity of potato. Ph. D. Thesis., Fac. Agric. Ain Shams Uni., pp: 134.