RESPONSE OF GROWTH AND YIELD OF POTATO PLANTS TO ADDITION OF BIOFERTILIZERS ,NILE FLOWER PEAT FERTILIZER AND SPRAYING WITH ITS EXTRACT

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ABSTRACT

This study was aimed to demonstrate effect of adding some Bio-fertilizers,Nile flower peat fertilizer and spraying with its extract on growth and yield of potato, Tow field experiment at spring and fall season2022 was carried out Horticulture Development Station in the kut district of the Directorate of Agriculture ofWasit Governorate The experiment was implemented using factorial arrangement (4×3×2) within randomized complete block design with three replicates, The First factor included the addition of biofertilizers (M) ,which is M_0-without adding , M_1- added the Mycorrhizae in an amount of 25 g tuber^{-1} , M_2- added the Trichoderma of 4 gtuber^{-1} and M_3- added Mycorrhizae and Trichoderma fungi together, The second factor included the addition of Nile flower peat fertilizer (N), which is N_0- without adding , N_1- added 15 mg ha^{-1} and N_2- added 30 mg ha^{-1} , the third factor included spraying with Nile flower peat fertilizer extract (E), spraying with distilled water(E_0) and spraying with extract 2 ml L^{-1} (E_1), The results of the statistical analysis showed the significant increase of biofertilizers in vegetative and yield characteristics as number of aerial stems, leaf area ,leaves chlorophyll content, number of tuber , total yield and percent of carbohydrates in the tubers compared with control (M_0), M3 treatment produced greatest value of this characteristics which reached4.911 ,4.714 stem plant^{-1}, 183.0 ,167.1 dm^{2}plant^{-1}, 198.3,240.8 mg 100g^{-1}, 10.56 , 6.977 tuber plant^{-1}, 57.78, 43.95 Mgha^{-1} and 18.64 ,19.26%for spring and fall seasons respectively. Organic fertilizer showed significant increase in the above characteristics, N_2treatmentproduced greatest value which reached 4.837 ,4.554 stem plant^{-1}, 187.9 ,170.6 dm^{2}plant^{-1} ,203.3, 244.3mg 100g^{-1}, 11.01 , 7.229 tuber plant^{-1}, 61.61 , 46.42 Mgha^{-1}and 18.53 , 19.55%for spring and fall seasons respectively.

Keywords: mycorrhizae ,trichoderma, sustainability, food safety, responsible consumption and production, climate action

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استجابة نمو وحاصل نبات البطاطا لإضافة الاسمدة الحيوية وسماد خث زهرة النيل والرش بمستخلصه

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المستخلص

تهدف الدراسة لبيان تأثير إضافة بعض الاسمدة الحيوية وسماد خث زهرة النيل والرش بمستخلصه في نمو وحاصل البطاطا , نفذت تجربتين حقليتين في الموسمين الربيعي والخريفي لسنة 2022في محطة تطوير البستنة في قضاء الكوت التابع الى مديرية الزراعة في محافظة واسط ، نفذ البحث كتجربة عاملية (4×3×2) وفق تصميم القطاعات الكاملة المعشاة وبثلاثة مكررات ، شمل العامل الاول إضافة الاسمدة الحيوية (M) ، وهيM_0 –من دون اضافة و M_1–إضافة فطر المايكورايزا بكمية 25 غم درنة$^{-1}$ و M_2 –إضافة فطر الترايكوديرما بكمية 4 غم درنة$^{-1}$ وM_3 – إضافة فطري المايكورايزاوالترايكوديرما معا , وشمل العامل الثاني إضافة سماد خث زهرة النيل (N) , هي N_0 –من دون اضافة و N_1– إضافة 15ميكاغرام هـ$^{-1}$ و N_2– إضافة 30ميكاغرام هـ$^{-1}$, وشمل العامل الثالث الرش بمستخلص سماد خث زهرة النيل (E) , هي الرش بالماء المقطر (E_0) والرش بالمستخلص بتركيز 2 مل لتر$^{-1}$(E_1) ، أظهرت نتائج التحليل الاحصائي تفوق التسميد الحيوي معنويا في صفات النمو الخضري والحاصل المتمثلة بعدد السيقان الهوائية والمساحة الورقية ومحتوى الاوراق من الكلوروفيل وعدد الدرنات للنبات والحاصل الكلي والنسبة المئوية للكاربوهيدرات في الدرنات مقارنة بمعاملة القياس M_0 , وتميزت المعاملة M_3 بإعطائها أعلى القيم لهذه الصفات بلغت 4.911 , 4.714 ساق نبات$^{-1}$ و 183.0, 167.1 دسم^2 نبات$^{-1}$ و 198.3 , 240.8 ملغم100 غم$^{-1}$ و 10.56 , 6.977 درنة نبات$^{-1}$ و 57.78 , 43.95 ميكاغرام هـ$^{-1}$ و 19.26 ,18.64 % للموسمين بالتتابع, وأظهرت معاملات التسميد العضوي زيادة معنوية في الصفات أعلاه , واعطت المعاملة N_2 اعلى القيم بلغت 4.837 , 4.554 ساق نبات$^{-1}$ و 187.9 , 170.6 دسم^{2}نبات$^{-1}$ و 203.3 , 244.3 ملغم100 غم$^{-1}$ و 11.01 , 7.229 درنة نبات$^{-1}$ و 61.61 , 46.42 ميكاغرام هـ$^{-1}$ و 18.53 , 19.55 % للموسمين بالتتابع .

الكلمات المفتاحية: مايكورايزا، ترايكوديرما, استدامة, سلامة الغذاء، الاستهلاك والانتاج المسؤولان، العمل المناخي

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INTRODUCTION

Potato (*Solanum tuberosum* L.) which belongs to Solanaceae family, is among the four most important crops in the world in terms of nutritional importance after wheat, corn and rice. It is one of the most used vegetable crops and tops the tuber crops. Its tubers are characterized by their high content of starches, in addition to containing significant proportions of proteins and vitamins. (C, A, and B), nutrients, sugars, potassium salts, and phosphorus (22), it rich in amino acids, as it contains 18 out of 20 essential amino acids necessary for the human body, that add also a high vital value (17). The total cultivated area in Iraq reached 24.12 thousand hectares, with a total production of 674.8 thousand ton, and an average yield of 27.98Mg ha^{-1} (3), which are low rates in relation to the cultivated area unit due to the fact that the soil conditions are not ideal and the insufficient or lack of availability of nutrients for plants and lack of interest in service and fertilization operations, and from here it was necessary to think scientifically and deliberately to increase production per unit area with the introduction of the principle of recycling and sustain the environment, as the negative effects of mineral fertilization lie in the consumption of crop plants less than half of the amount of fertilizer added and the remaining part to be fixed in the soil or leached into the ground water, which contributes to the pollution of water and air through the process of volatilization or leaching (33). The efforts involved in the agricultural sector focused on the introduction of a clean farming method (Bio or Organic or both), which adapted the preservation of the soil, improving its properties, addressing environmental degradation, and producing healthy and safe food (1, 2, 31, 36). The use of biofertilizers has become one of the promising methods to increase plant growth and productivity and improve the quality characteristics of the crop. Defining them as preparations that contain beneficial microorganisms added to the soil that can provide plants with part of their nutritional needs by converting them from unavailable elements to available and absorb forms, in addition to providing plants with materials that encourage and stimulate growth and protect the plant from infection with pathogens endemic in the soil and increase its tolerance to environmental stress (37, 38). There is a linear relationship between the components of organic soil matter and the functions of soil microbiology, hence the use of biofertilizers complements the action of organic fertilizers in increasing agricultural production, improving its quality, and reducing environmental pollution (9, 27) showed that the use of biofertilizers (mycorrhizae) led to an increase in antioxidant enzymes and marketable plant yield of potatoes, Al-Khafaji and Al-jubouri (12) found when studied the effect of using Trichoderma and mycorrhizae fungus as a biofertilizer as invigorators of carrots seeds, A significant increase was found for all the studied traits in each of the percentage of emergence, plant length, fresh weight and dry weight compared to control treatment. The interest in the use of organic fertilizers led researchers to take advantage of the available natural resources for the purpose of producing manufactured organic fertilizers (liquid or solid) that are sprayed directly on the plant or added to the soil for the purpose of improving its physical, chemical and biological properties and the nutrients it contains for the purpose of increasing production and improving its quality, One of the most important components of these fertilizers humic acid ,which has an important role in improving the vegetative growth and yield of plants(10). Recent research has focused on the use of organic extracts of decomposing organic waste that is sprayed on the vegetative system according to the foliar application, which is an effective method in increasing the amount of yield and improving its quality, as well as the abundance of vegetative growth (25). This study was aimed to investigate the effect of adding some fungal biofertilizers, peat fertilizer from Nile flower, spraying with its extract, and the interaction between them on growth and yield of potatoes.

MATERIALS AND METHODS

The research was carried out in the Station of the Horticultural Development in the city of Kut affiliated to the Directorate of Agriculture of Wasit Governorate, with the aim of studying the effect of adding some biofertilizers and Nile flower peat fertilizer

and spraying with its extract on the growth and yield of potato plant, Arizona variety, for the spring and fall seasons 2022. The area allocated for the experiment was divided into three equal sectors, with 24 experimental units for each replicate. The area of each plot was 3.4 m^2. Each plot was represented by three lines, the length of each line was 1.5 m, and the distance between one line and another was 0.75 m. Each line contained 6 plants, the distance between one plant and another. 0.25 m and the number of plants in the experimental unit was 18 plants. The drip irrigation system was installed and field lines were extended according to the design of the experiment. Ten random samples were taken from the soil of the field before planting at a depth of 0.30 m for the purpose of conducting the analysis (Table 1). Elite potato tubers were planted on 24/1/2022 in the spring season, and tubers for the same variety were planted on 22/9/2022 for the fall season. The tubers were planted at a depth of 10 cm, crop service operation such as weeding, export, control and drip irrigation performed according to plant needs, the study was carried out using the factorial experiment with three factors within the randomized complete block design (RCBD) and with three replications. The first factor included four treatments for adding biofertilizers (M), which are M_0 (without addition), M_1 (adding *Glomus mosseae* fungus in an amount of 25g $tuber^{-1}$), M_2 (adding *Trichoderma harzianum* fungus in an amount of 4 g $Tuber^{-1}$) and M_3 (M_2 +M_1), biological fertilizers were added at the bottom of the tubers during cultivation,The second factor included three treatments for adding organic fertilizer (Nile flower peat fertilizer, which chemical properties exhibited in table 2, N_0 (without addition), N_1 (adding 15 $Mgha^{-1}$ of organic fertilizer) and N_2 (adding 30 $Mgha^{-1}$ of organic fertilizer), organic fertilizers were added before planting by digging a 20 cm deep incision at the top of the meadow and then mixed well with the soil, the third factor included two treatments of spraying Nile flower peat extract (E), which was prepared from organic fertilizer Nile flower peat, whose chemical properties are shown Table 3,the above analyses were carried out in table 1,2,3 according to Page *et al*.,(30), Treatments of E are E_0 (spraying with distilled water) and E1 (spraying the extract, At a concentration of 2 mlL^{-1}) , and with three sprays, the first spray is in the vegetative growth stage, the second spray is in the tuber emergence stage, and the third spray is in the tuber size increase stage. The spraying process was carried out until complete wetness and in the evening to avoid high temperatures. The harvest carried out on 20/5/2022 for the spring season and 21/1/2023 for the fall season, the results were analyzed according to the statistical software Genstat, and the arithmetic means were compared using the Least Significant Difference L.S.D at a probability level of 5% . The study traits were determination of the following; number of aerial stems (stem $plant^{-1}$), plant leaf area (dm^2 $plant^{-1}$), leaves chlorophyll content (mg $100g^{-1}$f.w.) (21), number of tubers per plant (tuber $plant^{-1}$), total yield (Mg ha^{-1}) and percent of carbohydrates (%)(23).

Table . 1 Some physical ,chemical properties of field soil before planting

Character	Value		Unit
	Spring	Fall	
pH $_{1:1}$	7.4	7.36	
EC $_{1:1}$	2.71	2.64	dsm^{-1}
N (Avialable)	24.64	21.38	$mgkg^{-1}$
P (Avialable)	9.7	9.4	$mgkg^{-1}$
K (Avialable)	104.6	113.5	$mgkg^{-1}$
Fe (Avialable)	3.8	3.5	$mgkg^{-1}$
Zn (Avialable)	2.5	2.3	$mgkg^{-1}$
Ca (Soluable)	6.8	6.6	$mmol^{-1}$
Mg (Soluable)	2.8	2.9	$mmol^{-1}$
O.M	8.34	8.51	$gkg^{-1}soil$
Sand	230	233	$gkg^{-1}soil$
Silt	455	442	$gkg^{-1}soil$
Clay	315	325	$gkg^{-1}soil$
Tuxture	Clay Loam	Clay Loam	

The analysis was carried out in the laboratories of the College of Science University of Baghdad

Table 2. Chemical properties of organic fertilizer (Nil flower peat).

Character	Value	Units
pH $_{1:1}$	7.01	
EC $_{1:1}$	3.35	dsm^{-1}
N (Total)	19.3	gkg^{-1}
P	5.4	gkg^{-1}
K	16.4	gkg^{-1}
C	329.5	gkg^{-1}
Ca	3.4	gkg^{-1}
Mg	1.8	gkg^{-1}
Fe	162	$mgkg^{-1}$
Zn	153.5	$mgkg^{-1}$
C/N	17.07	

The analysis was carried out in the laboratories of the College of ScienceUniversity of Baghdad

Table 3.Chemical properties of Nile flower peat extract

Character	Value	Units
pH 1:1	8.03	
N (Total)	21.0	gL^{-1}
P	18.6	$g\ L^{-1}$
K	40.1	$g\ L^{-1}$
Ca	7.8	$g\ L^{-1}$
Mg	8.0	$g\ L^{-1}$
Fe	9.5	mgL^{-1}
Zn	3.5	mgL^{-1}

Theanalysis was carried out in the laboratories of the College of ScienseUniversity of Baghdad

RESULTS AND DISCUSSION

Number of aerial stems (stem $plant^{-1}$)

The results in table 4 show that the double inoculation treatment (M_3) had a significant effect by produced the highest rate the number of plant stems of 4.911, 4.714 $stemplant^{-1}$ for spring and fall seasons respectively, and the lowest rate given by the control treatment (M_0) amounted to 3.979, 3.731 $stemplant^{-1}$ for spring and fall seasons respectively. The results also showed that the treatment of organic fertilization N_2 had a significant effect on this trait and gave the highest rate of 4.837, 4.554 $stemplant^{-1}$ compared to the control treatment (N_0), which the produced lowest rate of 4.092, 3.849 $stemplant^{-1}$ for spring and fall seasons respectively. Spraying with peat extract of Nile flower had significant effect on the number of plant stems during the spring and fall seasons. The results of the interaction of biofertilizers and organic fertilizers had a significant effect on the number of plant stems, and the interaction treatment M_3N_2 produced the highest rate (5.308, 5.128 $stemsplant^{-1}$), and the lowest rate found control M_0N_0 (3.303, 3.160 $stemplant^{-1}$) for spring and fall seasons respectively. Interaction treatment between biofertilizers and foliar application with Nile flower peat extract M_3E_1 was significantly superior in the number of plant stems and produced the highest rate (4.944, 4.704 $stemsplant^{-1}$)compared to the control treatment M_0E_0, which produced the lowest rate of 3.961, 3.663 stem $plant^{-1}$ for both seasons respectively. From the results of the same table, it was found that the interaction treatment between organic fertilizer and spraying with Nile flower peat extract N_2E_1 was significantly superior by produced the highest rate (4.912, 4.675 stem $plant^{-1}$) compared to the control treatment N_0E_0, which produced the lowest rate of 4.025, 3.803 $stem.plant^{-1}$ for both seasons respectively. The triple interaction treatments had a significant effect on this trait, and the treatment $M_3N_2E_1$ recorded the highest rate (5.383, 5.173 stem $plant^{-1}$) for spring and fall seasons respectively, The control treatment ($M_0N_0E_0$) produced the lowest rate (3.367, 3.147 stem $plant^{-1}$) for spring and fall seasons respectively .

Plant leaf area (dm^2plant^{-1})

The results of table 5 show that the biofertilization treatments had a significant effect on increasing the leaf area of the potato plant, compared with the control treatment (M_0), which produced the lowest average leaf area of 156.9 ,145.3 dm^2 $plant^{-1}$ for the spring and fall seasons, respectively, and the double inoculation treatment (M_3) produced the highest rate were (183.0, 167.1 dm^2 $plant^{-1}$) for the spring and fall seasons respectively . The organic fertilizer treatments showed a significant effect on this trait compared to the control treatment, and treatment N_2 produced the highest rate of 187.9, 170.6 dm^2 $plant^{-1}$, and the lowest rate was recorded by the control treatment N_0, which amounted to 154.1, 138.6 dm^2 $plant^{-1}$ for spring and fall seasons respectively, and the treatment of spraying with Nile flower peat extract (E_1) had a significant effect as it produced the highest rate of 176.1, 159.8 dm^2 $plant^{-1}$ compared to the control treatment (E_0), which recorded a rate of 165.5, 151.8 dm^2 $plant^{-1}$ for two seasons respectively. The results of the same table showed that the effect of the interaction treatments between M and N was significant in increasing the leaf area of the plant, and the interaction treatment M_3N_2 recorded the highest rate of 200.9 , 183.0 dm^2 $plant^{-1}$for spring and fall seasons respectively , and the control treatment M_0N_0 recorded the lowest rate of 139.5 , 123.7 dm^2 $plant^{-1}$ for spring and fall seasons respectively . The interaction among M and E had a significant effect on this trait, as the M_3E_1 treatment produced the highest rate of 188.3, 171.6 dm^2 $plant^{-1}$, and the control treatment M_0E_0 produced the lowest rate of 151..3, 141.2 dm^2 $plant^{-1}$ for two seasons respectively. The results of the same table also indicated that the interaction between N and E had a significant effect on

the leaf area of the plant, and the treatment N_2E_1 was significantly superior to all treatments by producing the highest leaf area 193.8 , 175.6 dm^2 $plant^{-1}$, The control treatment (N_0E_0) was recorded the lowest leaf area (149.2, 135.1 dm^2 $plant^{-1}$) for spring and fall seasons respectively. The triple interaction treatments had a significant effect, as the treatment $M_3N_2E_1$ recorded the highest average (206.7, 188.0 dm^2 $plant^{-1}$), The control treatment $M_0N_0E_0$ produced the lowest leaf area (133.8, 120.0 dm^2 $plant^{-1}$) for two respectively.

Table 4. Effect of adding biofertilizers, Nile flower peat fertilizer, spraying with its extract and the interaction between them on number of aerial stems of potato (stem $plant^{-1}$) for spring and fall seasons 2022

M M1- Mycho M2- Tricho	N (Mg ha^{-1})	Spring 2022 E (ml L^{-1}) E0(0)	E1(2)	M × N	Fall 2022 E (ml L^{-1}) E0(0)	E1(2)	M × N
	N0 (0)	3.367	3.240	3.303	3.147	3.173	3.160
M0 (0)	N1 (15)	3.767	3.833	3.800	3.507	3.543	3.525
	N2 (30)	4.750	4.917	4.833	4.337	4.677	4.507
	N0 (0)	3.967	4.250	4.108	3.587	3.757	3.672
M1 (25g)	N1 (15)	4.050	4.333	4.192	3.743	3.893	3.818
	N2 (30)	4.467	4.367	4.417	4.033	4.133	4.083
	N0 (0)	4.300	4.467	4.383	3.977	4.183	4.08
M2 (4 g)	N1 (15)	4.333	4.733	4.533	4.147	4.317	4.232
	N2 (30)	4.600	4.983	4.792	4.277	4.717	4.497
	N0 (0)	4.467	4.683	4.575	4.503	4.467	4.485
M3 (M1+M2)	N1 (15)	4.933	4.767	4.850	4.583	4.473	4.528
	N2 (30)	5.233	5.383	5.308	5.083	5.173	5.128
$LSD_{(0.05)}$		1.291		0.913	1.094		0.774
E		4.353	4.496		4.209	4.770	
$LSD_{(0.05)}$		N.S			N.S		
				M			M
M	M0	3.961	3.997	3.979	3.663	3.798	3.731
×	M1	4.161	4.317	4.239	3.788	3.928	3.858
E	M2	4.411	4.728	4.569	4.133	4.406	4.269
	M3	4.878	4.944	4.911	4.723	4.704	4.714
$LSD_{(0.05)}$		0.745		0.527	0.632		0.446
				N			N
N	N0	4.025	4.160	4.092	3.803	3.895	3.849
×	N1	4.271	4.417	4.344	3.995	4.057	4.026
E	N2	4.762	4.912	4.837	4.433	4.675	4.554
$LSD_{(0.05)}$		0.645		0.456	0.547		0.387

Table 5.Effect of adding biofertilizers, Nile flower peat fertilizer, spraying with its extract and the interaction between them on the leaf area of potato plant (dm^2 $plant^{-1}$) for spring and fall seasons 2022

M M1- Mycho M2- Tricho	N (Mg ha^{-1})	Spring 2022 E (ml L^{-1}) E0(0)	E1(2)	M × N	Fall 2022 E (ml L^{-1}) E0(0)	E1(2)	M × N
	N0 (0)	133.8	145.2	139.5	120.0	127.4	123.7
	N1 (15)	153.1	164.1	158.6	146.3	155.5	150.9
M0 (0)	N2 (30)	167.0	178.1	172.6	157.4	165.6	161.5
	N0 (0)	151.0	158.7	154.9	138.1	143.7	140.9
	N1 (15)	163.1	172.5	167.8	151.0	159.3	155.2
M1 (25 g)	N2 (30)	181.6	193.3	187.4	162.2	174.0	168.1
	N0 (0)	152.8	161.0	157.4	137.4	146.0	141.7
	N1 (15)	165.9	177.6	171.7	148.3	156.8	152.6
M2 (4 g)	N2 (30)	184.5	197.0	190.7	164.4	174.9	169.7
	N0 (0)	159.2	170.4	164.8	145.1	151.4	148.3
	N1 (15)	178.5	187.8	183.2	164.8	175.2	170.0
M3 (M1+M2)	N2 (30)	195.1	206.7	200.9	178.1	188.0	183.0
$LSD_{(0.05)}$		13.13		9.286	11.36		8.035
E		165.5	176.1		151.8	159.8	
$LSD_{(0.05)}$		3.791			3.28		
				M			M
M	M0	151.3	162.5	156.9	141.2	149.5	145.3
×	M1	165.2	174.9	170.1	150.4	159.0	154.7
E	M2	167.7	178.9	173.3	150.0	159.2	154.6
	M3	177.6	188.3	183.0	162.7	171.6	167.1
$LSD_{(0.05)}$		7.582		5.361	6.561		4.639
				N			N
N	N0	149.2	159.1	154.1	135.1	142.1	138.6
×	N1	165.2	175.5	170.3	152.6	161.7	157.2
E	N2	182.0	193.8	187.9	165.5	175.6	170.6
$LSD_{(0.05)}$		6.566		4.643	5.682		4.018

Leaves chlorophyll content (mg 100g^{-1}f.w.)

The results of table 6 showed that double inoculation treatment (M_3) had a significant effect on the total chlorophyll content of leaves (198.3, 240.8 mg100 g^{-1}) for spring and fall seasons respectively, and the lowest rate produced by control treatment (M_0) (165.5, 212.8 mg 100 g^{-1}) for the two seasons, and results showed that organic fertilization treatment N_2 had a significant effect on this trait and produced highest rate of 203.3, 244.3 mg 100 g^{-1} compared to control treatment (N_0) which produced the lowest rate of 164.2 , 208.9 mg 100 g^{-1} for two seasons respectively, and treatment of spraying with the extract (E_1) had a significant effect on the concentration of total chlorophyll in the leaves as it produced highest rate of 188.6 , 233.1 mg 100 g^{-1} compared to the control treatment (E_0) which recorded an average of 177.6, 223.2 mg 100 g^{-1} for two seasons respectively. The results of the interaction of M and N had a significant effect on the leaves concentration of total chlorophyll, the interaction treatment M_3N_2 produced the highest rate of 218.1, 258.1 mg 100 g^{-1} for the two seasons respectively, and lowest rate appeared in the control treatment M_0N_0 amounted to 149.1, 195.0 mg 100 g^{-1} for two seasons respectively. The interaction between M and E had a significant effect on this characteristic, and the treatment M_3E_1 produced the highest rate of 203.6, 245.4 mg 100 g^{-1} for the two seasons respectively, and control treatment M_0E_0 producedthe lowest rate of 159.0, 207.2 mg 100 g^{-1}for both seasons respectively. From the results of the same table, it was found that the interaction between N and E had a significant effect, and treatment N2E1 produced the highest rate of 208.4, 248.7 mg 100 g^{-1} for the two seasons respectively, and the control treatment N0E0 recorded the lowest rate of 158.1, 203.8 mg 100 g^{-1} for both seasons respectively. The triple interaction treatments showed a significant effect on this trait, and the treatment $M_3N_2E_1$ recorded the highest rate, which reached 223.9, 262.8 mg 100 g^{-1} for the two seasons respectively, without a significant difference with it, the treatments M3N2E0 and M2N2E1 for the spring and fall seasons. The control treatment ($M_0N_0E_0$) recorded the lowest rate of 141.7 , 188.5 mg 100 g^{-1}for the two seasons respectively.

Table 6. Effect of adding biofertilizers, Nile flower peat fertilizer, spraying with its extract, and interaction between them on total chlorophyll in leaves (mg 100g^{-1}wet weight) for the spring and fall seasons 2022

M M1- Mycho M2- Tricho	N (Mg ha^{-1})	Spring 2022 E (ml L^{-1}) E0(0)	 E1(2)	M × N	Fall 2022 E (ml L^{-1}) E0(0)	 E1(2)	M × N
	N0 (0)	141.7	156.6	149.1	188.5	201.4	195.0
	N1 (15)	153.7	165.9	159.8	208.3	219.4	213.9
M0(0)	N2 (30)	181.7	193.4	187.5	224.8	234.5	229.6
	N0 (0)	156.4	168.0	162.2	204.1	213.9	209.0
	N1 (15)	178.1	189.2	183.6	227.0	238.4	232.7
M1(25 g)	N2 (30)	197.1	206.8	201.9	239.9	247.5	243.7
	N0 (0)	159.7	172.7	166.2	206.5	216.4	211.5
	N1 (15)	182.3	190.2	186.2	228.7	239.3	234.0
M2 (4 g)	N2 (30)	201.2	209.8	205.5	241.7	249.9	245.8
	N0 (0)	174.6	183.7	179.1	215.9	224.7	220.3
	N1 (15)	192.0	203.2	197.6	239.4	248.7	244.0
M3 (M1+M2)	N2 (30)	212.3	223.9	218.1	253.3	262,8	258.1
$LSD_{(0.05)}$		16.42		11.61	13.99		9.890
E		177.6	188.6		223.2	233.1	
$LSD_{(0.05)}$		4.740			4.041		
				M			M
M	M0	159.0	172.0	165.5	207.2	218.4	212.8
×	M1	177.2	188.0	182.6	223.6	233.3	228.4
E	M2	181.1	190.9	186.0	225.7	235.2	230.4
	M3	193.0	203.6	198.3	236.2	245.4	240.8
$LSD_{(0.05)}$		9.481		6.712	8.080		5.710
				N			N
N	N0	158.1	170.2	164.2	203.8	214.1	208.9
×	N1	176.5	187.1	181.8	225.8	236.5	231.2
E	N2	198.1	208.4	203.3	239.9	248.7	244.3
$LSD_{(0.05)}$		8.211		5.810	6.991		4.951

Number of tubers per plant (tuber plant^{-1})

The results of table 7 show that biofertilization had a significant effect on the number of tubers of the potato plant, and the double inoculation treatment (M_3) recorded the highest rate of 10.56, 6.977 tuberplant^{-1}, and the control treatment recorded the lowest rate, amounting to 9.136, 5.755 tuber plant^{-1}for the two seasons respectively. The organic fertilization treatments were significant in this regard compared to the control treatment, which produced the lowest rate of 8.662, 5.559 tuber plant^{-}, as treatment N_2 recorded the highest rate of 11.01, 7.229 tuberplant^{-1} for the two seasons respectively, and the treatment of spraying with Nile flower peat extract (E_1) was significantly affected. In the average number of tubers, it produced the highest rate of 10.12 , 6.630tuberplant^{-1}compared to the control treatment (E_0), which produced9.549, 6.232tuberplant^{-1} for the two seasons respectively. The interaction between biological and organic fertilizers had a significant effect on the average number of tubers, and the treatment M_3 N_2 recorded the highest rate of 11.53, 7.734 tuber plant^{-}, and the control treatment M_0N_0 produced lowest rate of 7.918, 4.618 tuberplant^{-1}for the two seasons respectively. The results of the interaction of M and E showed a significant effect on this trait, as the treatment M_3E_1 recorded the highest rate of 10.84, 7,150 tuberplant^{-1}, and the control treatment (M_0E_0) recorded the lowest rate of 8.896, 5.495 tuberplant^{-1}for the two seasons respectively. The interaction among N and E had a significant effect on the average number of tubers compared to the control treatment (N_0E_0), which produced the lowest rate of 8.462, 5.361 tuberplant^{-1} for the two seasons respectively, as the treatment N_2E_1 recorded the highest rate of 11.28, 7.412 tuberplant^{-1} for spring and fall seasons respectively. The results of the same table also indicated that the triple interaction treatment had a significant effect on increasing the average number of tubers, and the treatment $M_3N_2E_1$ produced the highest rate, which amounted to 11.82, 7,879 tuberplant^{-1}, and the control treatment ($M_0N_0E_0$) produced the lowest rate of 7,684, 4,348 tuberplant^{-1}for spring and fall seasons respectively.

Table 7. Effect of adding biofertilizers, Nile flower peat fertilizer, spraying with its extract, and the interaction between them on number of tubers of potato plant (tuber plant^{-1}) for spring and fall seasons 2022

M M1- Mycho M2- Tricho	N (Mg ha^{-1})	Spring 2022 E (ml L^{-1}) E0(0)	 E1(2)	M × N	Fall 2022 E (ml L^{-1}) E0(0)	 E1(2)	M × N
	N0 (0)	7.684	8.153	7.918	4.348	4.888	4.618
	N1 (15)	8.654	9.324	8.989	5.620	6.240	5.93
M0 (0)	N2 (30)	10.35	10.65	10.50	6.518	6.915	6.716
	N0 (0)	8.493	8.834	8.663	5.469	5.779	5.624
	N1 (15)	9.268	10.20	9.732	6.105	6.510	6.307
M1 (25 g)	N2 (30)	10.71	11.28	10.99	6.924	7.383	7.153
	N0 (0)	8.570	8.898	8.734	5.683	6.070	5.877
	N1 (15)	9.377	10.27	9.823	6.553	6.835	6.694
M2 (4 g)	N2 (30)	10.62	11.39	11.01	7.149	7.473	7.311
	N0 (0)	9.103	9.561	9.332	5.943	6.289	6.116
	N1 (15)	10.50	11.13	10.81	6.879	7.281	7.080
M3 (M1+M2)	N2 (30)	11.25	11.82	11.53	7.588	7.879	7.734
LSD$_{(0.05)}$		1.361		0.962	1.191		0.842
E		9.549	10.12		6.232	6.63	
LSD$_{(0.05)}$		0.393			0.344		
				M			M
M	M0	8.896	9.376	9.136	5.495	6.014	5.755
×	M1	9.491	10.10	9.796	6.166	6.557	6.362
E	M2	9.524	10.18	9.854	6.462	6.793	6.627
	M3	10.28	10.84	10.56	6.804	7.150	6.977
LSD$_{(0.05)}$		0.786		0.556	0.688		0.486
				N			N
N	N0	8.462	8.862	8.662	5.361	5.756	5.559
×	N1	9.449	10.23	9.839	6.289	6.717	6.503
E	N2	10.73	11.28	11.01	7.045	7.412	7.229
LSD$_{(0.05)}$		0.681		0.481	0.595		0.421

Total yield (Mg ha^{-1})

Data in table 8 shows that the biological fertilization of potato plants had a significant effect on increasing the total yield of the spring and fall seasons, compared to the treatment without the addition (M_0), which produced the lowest mean of the total yield, which amounted to 41.91. 33.02 Mg ha^{-1}for two seasons, respectively. The double inoculation treatment (M_3) had the highest rate of total yield (57.78, 43.95Mg ha^{-1}) for the two seasons, respectively. Organic fertilization treatments also significantly affected the total yield compared to the control treatment (N_0), which produced the lowest rate of 38.17, 31.07 Mgha^{-1}, as treatment N_2 produced the highest rate of 61.61, 46.42 Mgha^{-1} for the two seasons sequentially, and spraying potato plants with Nile flower peat extract (E_1) had a significant effect on this characteristic as it produced a rate of 52.68, 40.81Mg ha^{-1}compared to the control treatment (E_0), which produced of 46.81, 36.95Mg ha^{-1} for two seasons Sequentially. The interaction among M and N achieved a significant effect on the average total yield compared to the control treatment, which produced the lowest rate of 30.28, 23.26 Mg ha^{-1}for the spring and fall seasons, respectively. The treatment M_3N_2 recorded the highest rate of 69.35, 51.75 Mg ha^{-1} for two seasons respectively. The results also showed that the interaction between M and E had a significant effect on the total yield compared to the control treatment (M_0E_0), which recorded the lowest rate of 39.50 and 30.75 Mg ha^{-1}, as the treatment of overlap M_3E_1 produced the highest rate of 61.07, 45.77 Mg ha^{-1}for the two seasons respectively. Also, the interaction between N and E had a significant effect on this characteristic compared to the control treatment (N_0E_0), which produced the lowest rate of 36.01 , 29.30 Mg ha^{-1}, and the binary interaction treatment N_2E_1 outperformed all treatments by giving it the highest rate. it reached 64.84. 48.40 Mg ha^{-1}for the two seasons respectively. The results of the same table indicated that the triple interaction had a significant effect on increasing the total yield rate compared to the control treatment, which recorded the lowest rate for this characteristic, amounting to 28.51, 21.16 Mgha^{-1}and the treatment $M_3N_2E_1$ produced the highest rate, which amounted to 72.93, 53.69 Mg ha^{-1}for spring and fall seasons respectively.

Table 8. Effect of adding biofertilizers, Nile flower peat fertilizer, spraying with its extract, and interaction between them on total yield of potato plants (Mg ha^{-1}) for spring and fall seasons 2022

M M1- Mycho M2- Tricho	N (Mg ha^{-1})	Spring 2022 E (ml L^{-1}) E0(0)	 E1(2)	M × N	Fall 2022 E (ml.L^{-1}) E0(0)	 E1(2)	M × N
	N0 (0)	28.51	32.05	30.28	21.16	25.36	23.26
	N1 (15)	37.85	44.04	40.95	31.42	36.87	34.15
M0(0)	N2 (30)	52.13	56.89	54.51	39.68	43.63	41.65
	N0 (0)	36.36	40.37	38.37	30.25	33.28	31.76
	N1 (15)	44.23	51.38	47.81	36.22	40.49	38.35
M1 (25 g)	N2 (30)	57.21	63.7	60.46	43.46	47.87	45.66
	N0 (0)	37.69	41.84	39.76	31.56	35.15	33.36
	N1 (15)	45.85	52.78	49.32	38.39	41.34	39.86
M2 (4 g)	N2 (30)	58.38	65.83	62.11	44.86	48.40	46.63
	N0 (0)	41.47	47.09	44.28	34.23	37.54	35.89
	N1 (15)	56.25	63.19	59.72	42.38	46.07	44.23
M3 (M1+M2)	N2 (30)	65.78	72.93	69.35	49.80	53.69	51.75
$LSD_{(0.05)}$		6.807		4.813	7.143		5.051
E		46.81	52.68		36.95	40.81	
$LSD_{(0.05)}$		1.965			2.062		
				M			M
M	M0	39.50	44.33	41.91	30.75	35.29	33.02
×	M1	45.93	51.82	48.88	36.64	40.54	38.59
E	M2	47.31	53.48	50.4	38.27	41.63	39.95
	M3	54.5	61.07	57.78	42.14	45.77	43.95
$LSD_{(0.05)}$		3.930		2.779	4.124		2.916
				N			N
N	N0	36.01	40.34	38.17	29.30	32.83	31.07
×	N1	46.05	52.85	49.45	37.10	41.19	39.15
E	N2	58.37	64.84	61.61	44.45	48.4	46.42
$LSD_{(0.05)}$		3.404		2.407	3.572		2.526

Percent of carbohydrates (%)

It was found from the results of table 9 that the biofertilization treatments had a significant effect on the percentage of carbohydrates in potato tubers, and the treatment M_3 produced highest percentage of 18.64, 19.26% for spring and fall seasons respectively, which did not differ significantly with the treatments M_2 and M_1 for the fall season, and control treatment recorded the lowest percentage it reached 16.27, 17.76% for the two seasons respectively, as well as the organic fertilization treatments had a significant effect on this trait and produced the N_2 treatment highest percentage of 18.53 , 19.55% for the two seasons respectively, and the control treatment recorded the lowest percentage of 16.28, 17.58% for the two seasons respectively, and the spraying treatment with Nile flower peat extract (E_1) had a significant impact as it produced highest rate of 19.02, 17.92% compared to control treatment (E_0), which produced 18.23, 17.06% for the two seasons respectively. The results of the same table showed that the interaction of M and N had a significant effect on the percentage of carbohydrates in the tubers, and M_3N_2 treatment produced highest percentage of 19.62, 20.26% for the two seasons respectively, and control treatment(M_0N_0) it produced the lowest percentage of 14.71, 16.61% for the two seasons respectively. The interaction treatment M_3E_1 produced the highest percentage of 19.03 , 19.62% for the two seasons respectively, and the control treatment M_0E_0 produced the lowest percentage of 15.75, 17.29% for the two seasons respectively. The interaction treatment of N and E showed a significant effect on this trait, and treatment N_2E_1 produced the highest percentage of 18.92 , 19.90% for the spring and fall seasons respectively, which did not differ significantly with the treatment N_2E_0 for the two seasons and treatment N_1E_1 for the spring season, and the measurement treatment (N_0E_0) recorded the lowest percentage. it reached 15.82 , 17.12% for the two seasons respectively. Also, the triple interaction treatments $M_3N_2E_1$ produced the highest percentage of 19.98, 20.62% for the two seasons respectively. The control treatment $M_0N_0E_0$ recorded the lowest percentage of 14.06, 16.14% for the two seasons respectively.

Table 9. Effect of adding biofertilizers, Nile flower peat fertilizer, spraying with its extract, and interaction between them on percent of carbohydrates (%) for spring and fall seasons 2022

M M1- Mycho M2- Tricho	N (Mg ha^{-1})	Spring 2022 E (ml L^{-1}) E0(0)	 E1(2)	M × N	Fall 2022 E (ml.L^{-1}) E0(0)	 E1(2)	M × N
	N0 (0)	14.06	15.36	14.71	16.14	17.07	16.61
	N1 (15)	16.06	17.15	16.61	17.36	18.41	17.89
M0(0)	N2 (30)	17.12	17.88	17.50	18.35	19.20	18.78
	N0 (0)	15.98	16.77	16.38	17.14	18.19	17.67
	N1 (15)	17.14	17.95	17.54	18.54	19.02	18.78
M1 (25 g)	N2 (30)	17.99	18.86	18.43	19.13	19.79	19.46
	N0 (0)	16.15	16.95	16.55	17.39	18.34	17.87
	N1 (15)	17.24	18.11	17.68	18.69	19.32	19.01
M2 (4 g)	N2 (30)	18.20	18.94	18.57	19.41	19.97	19.69
	N0 (0)	17.07	17.93	17.50	17.79	18.60	18.20
	N1 (15)	18.42	19.17	18.79	18.99	19.64	19.32
M3 (M1+M2)	N2 (30)	19.26	19.98	19.62	19.89	20.62	20.26
$LSD_{(0.05)}$		1.652		1.168	1.599		1.131
E		17.06	17.92		18.23	19.02	
$LSD_{(0.05)}$		0.477			0.462		
				M			M
M	M0	15.75	16.80	16.27	17.29	18.23	17.76
×	M1	17.04	17.86	17.45	18.27	19.00	18.63
E	M2	17.20	18.00	17.60	18.50	19.21	18.86
	M3	18.25	19.03	18.64	18.89	19.62	19.26
$LSD_{(0.05)}$		0.954		0.675	0.923		0.653
				N			N
N	N0	15.82	16.75	16.28	17.12	18.05	17.58
×	N1	17.22	18.10	17.66	18.39	19.10	18.75
E	N2	18.14	18.92	18.53	19.20	19.90	19.55
$LSD_{(0.05)}$		0.826		0.584	0.800		0.565

The results in Tables 4, 5, 6, 7 , 8 and 9 show that the biofertilization treatments have a clear effect on improving the vegetative growth characteristics of the potato plant, which led to an improvement in the yield characteristics and its components. This may be attributed to the role of biofertilizers in improving the physical, chemical and biological soil characteristics and production plant growth regulators, antibiotics, and increasing the availability and absorption of essential nutrients for plant growth, which achieves an increase in the growth of the root and vegetative system through increasing the efficiency of the carbon metabolism process and increasing the outputs of this process, which is reflected in increasing yield and its components.As the mycorrhizae fungus has a positive role in increasing the colonization of plant roots as a result of the symbiotic relationship with it, which led to an increase in the absorption of nutrients, and it has the ability to secrete growth hormones (auxin, cytokinin, gibberellins) and this in turn leads to increased root and vegetative growth as a result of increased cell division and expansion and plant tissues, which increases the yield and its components (32). It can also secrete glomalin, which works to hold soil particles and increase its ability to retain water, and then improves water consumption and soil structure. It has the ability to secrete some organic acids, enzymes, and chelating compounds such as a compound Siderophores that chelate micro nutrients, especially iron (4). As a result of the increase in the availability and absorption of water and nutrients, the activities of carbon metabolism in the plant and the accumulation of its products increased (24), as the increase in the products of the carbon metabolism process is reflected in the increase in growth, yield and its components (12), and this is consistent with the results of Othman *et al*. (29) who found an increase in yield and its components for potato plants inoculated with mycorrhizae compared to uninoculated plants. Trichoderma fungus also has a role in the decomposition of organic matter in the soil and in increasing the availability of nutrients for plants (18), It has the ability to stimulate the growth of roots and secrete some enzymes and produce substances that stimulate growth and antibiotics to discourage the growth of harmful organisms and their competition for infection this in turn is reflected in increasing the efficiency of the carbon metabolism process and increasing the manufacture of nutrients that are used to build a strong vegetative complex and this is reflected in the yield and its components (34,35) The superiority of the double inoculation treatment between the Mycorrhizae and Trichoderma fungi compared to the single inoculation treatments may be attributed to the synergistic and positive role of both in improving the physical, chemical and vital properties of the soil and increasing the availability of the essential nutrients for growth, which improved the nutritional status of the plant, which reflected positively on improving the vegetative indicators and yield and its components for plant, and this is found by (18, 26). The superiority of the organic fertilization treatments over the comparison treatment (without fertilization) may be due to the role of organic fertilization in improving the physical, chemical and biological properties of the soil, as organic fertilizers increase the number and activity of microorganisms as a result of the increase in organic matter in the soil, which leads to an increase in the decomposition of organic compounds and the liberation of elements nutrients, as well as reduce soil pH, which leads to increase the availability of some nutrients, and these nutrients have an important role in plant growth and development, as they enter into many physiological and vital activities or stimulate their performance, which are related to the process of carbon metabolism and food processing in plants as well as stimulating cell division and elongation (11), or the reason for this may be attributed to the role of organic fertilizers in increasing water use efficiency (15) and its content of essential nutrients for growth, increasing the availability and absorption of these elements, and increasing their concentration in the leaves, which leads to an increase in the indicators of vegetative growth and yield of the plant (7). It was found that plants that supplied with abundant and balanced amounts of the necessary nutrients tend to increase the number of leaf cells and

increase their size, and increase in the number of aerial stems , total leaf area and leaves chlorophyll content led to an increase in carbon metabolism, an increase in the accumulation of carbohydrates, and the provision of amino acids needed to build proteins, and its reflection on increasing the yield and its components. These results are consistent with the results (6, 8, 28) where they found that when adding organic fertilizers, it improved the characteristics of vegetative growth and yield for plants. The reason for the superiority of spray treatments of Nile flower peat extract in the vegetative growth characteristics and yield may be due to the fact that the leaves are an important center in which many physiological and vital processes occur, in addition to the fact that foliar application is an effective method for better transport of nutrients within the plant (11).The reason may be attributed to the contents of this extract of macro nutrients (nitrogen, phosphorus, potassium, calcium and magnesium) and micronutrients (iron and zinc) (Table 3), in addition to humic organic acids (humic and fulvic) and non-humic organic acids (oxalic and lactic) and amino acids (glutamic, serine, methionine, and threonine) and sugars (glucose and maltose) (5, 19),and its effect on increasing vegetative growth, which affected the increase in carbon metabolism and the increase in the accumulation of processed foodstuffs and their transfer to places where they are stored (tubers)and to provide the requirements for growth increased in size and then their weight and numbers increased (16). These results are consistent with (13,14,20), as they found an increase in the indicators of vegetative growth, yield and its components when spraying plants with organic nutrients. In conclusion, the application of biofertilizers presents a sustainable and environmentally friendly alternative to chemical fertilizers, offering significant benefits for plant growth, soil health, and ecosystem balance. Thus, the adoption of biofertilizers represents a pivotal step toward a more sustainable and resilient agricultural system. The use of Nile flower peat in agriculture presents a promising and sustainable approach With their intrinsic bioactive compounds, these extracts can enhance crop resilience, promote soil health, and reduce reliance on synthetic mineral fertilizers. Furthermore, the adoption of plant-based solutions can contribute to environmental conservation by minimizing chemical runoff and protecting beneficial organisms.

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