EFFECT OF BIO-ORGANIC AND MINERAL FERTILIZATION, ON THE GROWTH AND YIELD OF CAULIFLOWER *(Brassica oleraceae Var.botrytis)*

*Ola. M. S. Aldolaimy **H. A. Abdul- Ratha *B. K. Abduljabar
Researcher Prof. Researcher
*Office of Agricultural Research- Ministry of Agriculture. Iraq.
**Dept of Desert. Combat. Coll. Agric. Engin. Sci. University of Baghdad
Olasabri20@gmail.com

ABSTRACT

A field experiment was carried out to study the effect of three factors, the first was biofertilization with four types (without addition, combination of *A.brasilense* + *A. chroococcum* combination of *G.mosseae* + *T. harzianum*, and combination of the two previous combinations), The second factor four types of organic fertilizer(without adding,vermicompost ,Orgevit, a combination of the two previous organic fertilizers),and the third factor mineral fertilizer with two levels (0% and 50%) of the fertilizer recommendation in addition to the full fertilizer recommendation treatment (second comparison).RCBD was used with three replications. The results showed that the triple interaction of the biofertilization treatments added with the organic fertilizer combination of organic fertilizer with 50% of the mineral fertilizer recommendation showed the highest averages for the characteristics of growth and the total yield, which gave79.740 Mg ha^{-1}, and the content of leaves and the curd from N, P and K after harvest and the content of the soil of N, P and K after harvesting, which amounted to 70.81, 38.19, 370.44 mg kg soil^{-1},in comparison with the no addition treatment which gave the lowest averages .

Key words: biofertilizer, Earthworms, bacteria, vegetables plant.

[*] Part of Ph.D. dissertation of the 1th author

تأثير التسميد الحيوي – والعضوي والمعدني في نمو وحاصل القرنابيط *Brassica oleracea Var.botry*

علا موفق صبري الدليمي * حسن علي عبد الرضا ** بسام كنعان عبد الجبار *
الباحثة استاذ الباحث العلمي
*دائرة البحوث الزراعية –وزارة الزراعة ،العراق. **قسم مكافحة التصحر – كلية علوم الهندسة الزراعية– جامعة بغداد، العراق.

المستخلص

نفذت تجربة حقلية لدراسة تاثير ثلاثة عوامل الاول هوالتسميد الحيوي بإربع أنواع (بدون اضافة وتوليفة من *A.brasilense* + *A.chroococcum* وتوليفة من *G.mosseae* + *T.harzianum*،توليفة من التوليفتين الحيويتين) ،العامل الثاني أربع أنواع من السماد العضوي(بدون اضافة والفيرميكمبوست والأورجفيت وتوليفة من السمادين العضويين) والعامل الثالث السماد المعدني بمستويين (0 و50%) من التوصية السمادية بالأضافة الى معاملة التوصية السمادية الكاملة (مقارنة ثانية).استخدم تصميم القطاعات العشوائية الكاملة وبثلاث مكررات.أظهرت النتائج إن التداخل الثلاثي لمعاملات التسميد الحيوي مع التوليفة السماد العضوي و50 % من التوصية السمادية المعدنية اعلى المتوسطات لصفات النمو والحاصل الكلي إذ أعطت 79.740 ميكاغرام هـ$^{-1}$ومحتوى الأوراق والأقراص الزهرية من النتروجين والفسفور والبوتاسيوم بعد الجني ومحتوى التربة من النتروجين و الفسفور والبوتاسيوم بعد الجني والتي بلغت 70.81، 38.19، 370.44 ملغم كغم تربة$^{-1}$ بالمقارنة مع عدم الاضافة التي اعطت اقل المتوسطات.

الكلمات المفتاحية: السماد الحيوي ،ديدان الأرض ،بكتريا ، نباتات الخضر.

***البحث مستل من اطروحة دكتوراه للباحث الاول**

Received:26/4/2022, Accepted:14/8/2022

INTRODUCTION

Many researchers in different countries of the world stimulate to counter challenges by developing long-term plans and strategies for the purpose of achieving sustainable agriculture and increasing productivity as achieving an increase in agricultural production is not limited to the use of mineral fertilizers only, as the expansion of their use means an expansion in increasing the chances of soil, water and air pollution, as well as avoiding the use of chemical pesticides in combating agricultural pests which plays the same role in environmental pollution, so the world has turned towards clean agricultural technologies to reduce as much as possible the sources of pollution. Therefore, the use of natural resources such as organic and biological fertilizers is a suitable alternative or supplement to mineral fertilizers (14,16). Biofertilizer are modern technologies, and they are preparations that contain one or two types or combinations of microorganisms that are added to the seeds, soil, or both. This technique includes maximizing the use of beneficial microorganisms for the purpose of employing them in improving the physical, chemical and biological properties of the soil and maintaining the balance of nutrients in agricultural lands to convert them into available forms for plant nutrition in order to provide those nutrients for plant growth during its life cycle which can dispense with at least part of the mineral fertilizers and thus increase production as well as its contribution to reducing agricultural production costs (22). Some of the microorganisms used in biofertilization, supply nitrogen through symbiotic and free fixation of gaseous nitrogen, such as Rhizobia, Azotobacter and Azospirillum, and some dissolve phosphate compounds, such as vesicular-arbuscular mycorrhiza, that symbiosis with most economic crops such as wheat, barley and vegetable crops through dissolve phosphate compounds and increase its availability and absorption by the plant, other microorganism relase potassium (15). In recent years, the use of vermicompost has developed, it is one of the environmentally friendly organic fertilizers, which has received great importance in Iraq for its role in increasing plant productivity (2), improving soil properties and increasing its content of available nutrients, organic matter and enzymes that increase the activities of microbial mass, which is positively reflected on soil and plant health and productivity. As well as the use of organic fertilizer that bears the commercial name Orgevit prepared from poultry waste, which contains major and minor elements and beneficial organisms for the plant in the form of pellets (pellets 4-5 mm), Orgevit stimulates the biological activity of the soil and stimulates plant enzymes, in addition to its effective role in improving the chemical and physical properties of the soil. Therefore, the integration in the use of biological and organic fertilizers will create a balanced environment for the activity of microorganisms and increase the release of nutrients in line with the needs of the plant (6). Cauliflower (*Brassica oleracea Var. Botrytis*), which belongs to the cruciferous family (Cruciferae), is one of the cool-temperature-loving vegetable crops, and it is an important crop in Iraq and other countries of the world. It is an important food crop for its high nutritional value and has many health benefits, as it contains many nutrients, vitamins, carbohydrates, fats, and low calories (7). This study was aimed to evaluate the role of different combinations of bio and organic fertilizers with half of the mineral fertilizer recommendation in the growth and yield of cauliflower.

MATERIALS AND METHODS

A field experiment was carried out at the agricultural season 2020-2021 at the Soil Research Station of the Agricultural Research Department / Ministry of Agriculture in a Silty Clay Loam soil, a composite sample was taken from the field from different locations from a depth of 0-30 cm to determine its physical, chemical and fertility characteristics before planting and Table (1) shows these characteristics. The soil was prepared for cultivation by plowing, smoothing and leveling, and then preparing the meadows, then the field was divided into experimental units with an area of 10.8 m^2 as each experimental unit in each sector included three meadows. Then 30 holes were made in each experimental unit, which were planted with 30 plants. The biofertilizer was added in four types: (No combination B0,the first combination consisting of *Azospirillum brasilense* + *Azotobacter chroococcum* B1, the second combination consisting of *Glomus mosseae* + *Trichoderma harzianum* B2,the third consist of combination B1 and B2 and its symbol B3, The organic fertilizer was also added in four types: (without adding O0, adding vermicompost O1, adding Orgevit O2, combining fertilizers of O1 and O2 and its symbol O3), and mineral fertilizer added with two levels(0% and 50%) and its symbol (C0 and C1)fertilizer recommendation for cauliflower (Bulletin of the Ministry of Agriculture). The inoculum were prepared from the above mentioned bacterial isolates in a Nutrient Broth, then the roots of cauliflower seedlings were immersed in these media for 15 minutes in the presence of a sterile solution of gum arabic (20%). As for the mineral fertilizer, it was added in two doses, the first during planting and the second at the beginning of curd forming. At the end of the experiment, the following parameters were studied for six randomly selected plants from each experimental unit (curd diameter, curd weight, curd dry weight, total yield), (Leaf content of nitrogen, phosphorous and potassium after harvesting), (content of curd of nitrogen, phosphorous and potassium), soil content of available nitrogen, phosphorous and potassium after harvesting.

Table 1. Some chemical, physical and fertility properties of the study soil before planting

No	Properties		Amount	Unit
1	pH (1:1) Soil Reaction		7.6	
2	EC(1:1) Electrical Conductivity		2.80	dSm^{-1}
3	CEC Cationic Exchange Capacity		21.3	$Cmol+kg^{-1}$ soil
4	SOM		9.8	
5	Carbonate ($CaCO_3$)		215	gm kg^{-1}soil
6	Gypsum ($_2H_2O.CaSO_4$)		0.6	
7	Positive Ions	Ca^{+2}	10.25	
		Mg^{+2}	6.25	
		Na^{+}	10.4	
		K^{+}	1.05	Mmol L^{-1}
8	Negative Ions	Cl^{-}	14.5	
		$SO_4^{=}$	10.85	
		HCO_3^{-}	2.0	
		CO_3^{-}	Nil	
9	Elements Available	Available N	35.0	Mg kg^{-1} soil
		Available P	12.7	
		Available K	230	
10	physical Properties	Bulk density	1.36	Mgm^{-3}
		Volumetric moisture content at 0.330 bar	0.39	
		Volumetric moisture content at 15 bar	0.20	cm^3cm^{-3}
		Available water	0.19	
		Sand	200	
		Silt	435	gm.kg^{-1}soil
		Clay	365	
11	Texture	Silt Clay Loam		
12	Total bacteria	4.8×10^6		$cfug^{-1}$ dry soil
13	Total Fungi	1.1×10^3		

RESULTS AND DISCUSSION

Effect of the different study factors on some growth and yield parameters of cauliflower, the diameter of the curd (cm), the weight of the curd (gm), the dry weight of the vegetative shoot (gm), the total yield (Mg ha^{-1}). The results of the statistical analysis of the triple interaction between the averages of the biological, organic and mineral fertilizer treatments showed that there were significant differences between the rates of curd diameter, as the treatment of double biofertilization of bacteria and fungi with the addition of vermicompost and Orgevit together and 50% of the fertilizer recommendation $B_3O_3C_1$ was superior and gave an average curd diameter of 33.87 cm, followed by the treatment of using the same combination without adding the fertilizer recommendation($B_3O_3C_0$) which gave curd diameter value 33.22 cm. compared with the control treatment ($B_3O_3C_0$), which gave the lowest rates, amounting to 20.15 cm, while the treatments ($B_3O_3C_1$,$B_1O_3C_1$) were superior and gave a curd weight of 2711 g and 2625 g, compared with the control treatment, which amounted to 931g,on the other hand the treatments ($B_3O_3C_1$ and $B_3O_3C_0$)were significantly for the dry weight of the vegetative shoot gave a values of 390.08 g and 380.01 g in comparison with the control treatment, the treatments ($B_3O_3C_1$and $B_1O_3C_1$) were significantly superior in its total yield and gave value of 79.74 Mg $ha^{-1}$and 77.21 Mg ha^{-1} respectively compared with the control treatment that gave 27.370 Mg ha^{-1}. Data in Table (2) shows significant effects of adding bio-fertilizer, and this may be due to effect of this combination which contain bacteria that stimulate plant growth, as they produce many growth regulators such as auxins, gibberellins and cytokines, in addition to increase the availability of macro and micro nutrients that improve the growth of vegetative part by increasing cell division and elongation, this is reflected in the diameter and weight of the curd and the increase in the dry weight of the vegetative shoot and the total yield, Thus, these microorganisms played a vital role in the early stages of the plant's life and thus increased production. These results came in agreement with (8). As for the effect of organic fertilizer on these characteristics, it was significant, and this could be due to its role in increasing the density and efficency of microorganisms in the soil that decomposes the organic matter and releases the nutrients (5, 17). Mineral fertilizer could be increase the available of the macronutrients in the soil solution, which are easily absorbed by the plant and in quantities that are sufficient for its growth well and are necessary in building its tissues, and are important in regulating the effectiveness of hormones responsible for vital processes, for example, nitrogen plays a role in the effectiveness of meristematic cells and the production of auxin in quantities sufficient to reflect positively on plant growth parameters as is evident in the above-mentioned characteristics.

Table 2. The effect of the different study factors on some growth and yield parameters of cauliflower

Treatment	Parameters			
	diameter of the curd (cm)	weight of the curd (gm)	dry weight of the vegetative shoot (gm)	total yield (mcg ha^{-1})
B0O0C0	20.15	931	239.72	27.370
B0O0C1	20.18	1859	250.92	54.690
B0O1C0	23.87	1301	281.39	38.270
B0O1C1	24.83	2194	291.79	64.530
B0O2C0	21.82	1128	257.03	33.190
B0O2C1	23.00	1949	268.22	57.320
B0O3C0	25.96	1497	301.32	44.040
B0O3C1	26.48	2378	311.69	69.960
B1O0C0	22.81	1204	254.82	35.400
B1O0C1	23.32	2022	265.95	59.480
B1O1C0	26.19	1637	321.76	48.150
B1O1C1	26.94	2484	334.14	73.070
B1O2C0	24.10	1290	300.96	37.940
B1O2C1	24.87	2122	312.26	62.420
B1O3C0	28.35	1762	341.84	51.810
B1O3C1	29.40	2625	353.16	77.210
B2O0C0	22.04	1065	246.82	31.340
B2O0C1	22.49	1918	257.98	56.400
B2O1C0	25.34	1406	299.49	41.350
B2O1C1	26.65	2300	310.99	67.650
B2O2C0	22.78	1163	276.25	34.200
B2O2C1	23.48	1978	286.59	58.170
B2O3C0	26.63	1530	317.01	44.990
B2O3C1	26.85	2422	327.81	71.230
B3O0C0	25.00	1253	272.26	36.860
B3O0C1	25.48	2079	282.12	61.140
B3O1C0	29.85	1703	360.17	50.100
B3O1C1	30.87	2560	371.38	75.310
B3O2C0	28.22	1377	339.26	40.510
B3O2C1	28.97	2041	349.93	60.020
B3O3C0	33.22	1928	380.01	56.720
B3O3C1	33.87	2711	390.08	79.740
LSD B*O*C	0.610	195.0	1.21	5.74
NPK	25.44	2496	302.52	73.410

Effect of different study factors on the concentration of NPK% in curd: The results of the triple interaction showed that there were statistically significant differences between the treatments in the concentration of nitrogen in the curd, as it was noted that the treatment of adding organic fertilizer from vermicompost and Orgevit together with the double biofertilizer of bacteria and fungi with the presence of 50% of the fertilizer recommendation ($B_3O_3C_1$), which amounted to 4.79% compared to the control treatment ($B_0O_0C_0$) which gave 2.06%,the same treatment was significantly superior in phosphorous and potassium concentration, which amounted to 0.79%,4.35% respectively compared to the control treatment, which gave 0.27% and 2.23% respectively. Table (3) show that the addition of biofertilizer in the form of an integrated combination consisting of bacterial inoculums of *A.brasilense* + *A.chroococcum* and the combination of fungal inoculums of *Glomus mosseae* + *Trichoderma harzianum* with the vermicompost and Orgevit and the addition of 50% of mineral fertilizers recommendation ,led to a significant increase in the content of the curd from nitrogen, phosphorous and potassium. This may be due that the bio fertilizer consists of a combination of bacteria that stimulate plant growth that secrete some hormones which increase the size of the root, its absorption of nutrients increases and it has a high ability to fix atmospheric nitrogen freely or associatively with the help of the nitrogenase enzyme, as well as the secretion of enzymes that have a role in increasing the available of nutrients in the soil solution, that the plant uptake after stimulating the roots to absorb by bacteria, which increases the concentration of nitrogen and other nutrients inside the plant and thus is reflected on the yield and qualitative characteristics of the crud and fruits. On the other hand, the reason for the increase of phosphorous may be due to the fact that the biofertilizer contain an organisms that dissolve phosphate and stimulate root growth, it dissolves insoluble phosphorous compounds and makes them available for absorption by the plant. The roots encourage their absorption in large quantities, which leads to an increase in their concentration in the fruits, the reason may be due to the role of the added mineral fertilizer and the organic matter that improves soil qualities and activates microorganisms efficiency that secrete enzymes, thus facilitating the nutrients for the plant and its reflect on the content of the crud (3, 4, 12, 13, 21) .

Table 3.Effect of different study factors on the concentration of NPK% in curd

	Parameters		
Treatment	**N %**	**P %**	**K %**
B0O0C0	2.06	0.27	2.23
B0O0C1	2.94	0.38	2.54
B0O1C0	3.42	0.49	2.68
B0O1C1	3.64	0.56	2.76
B0O2C0	2.60	0.40	2.46
B0O2C1	2.78	0.49	2.55
B0O3C0	3.65	0.60	2.90
B0O3C1	3.95	0.64	3.00
B1O0C0	2.46	0.40	2.40
B1O0C1	3.04	0.47	2.43
B1O1C0	3.59	0.53	2.70
B1O1C1	3.43	0.59	2.78
B1O2C0	2.84	0.49	2.52
B1O2C1	2.93	0.53	2.61
B1O3C0	3.64	0.62	2.88
B1O3C1	3.86	0.65	2.92
B2O0C0	2.52	0.35	2.29
B2O0C1	2.89	0.35	2.35
B2O1C0	2.93	0.46	2.70
B2O1C1	2.68	0.50	2.80
B2O2C0	2.54	0.40	2.47
B2O2C1	2.59	0.44	2.52
B2O3C0	3.18	0.60	2.78
B2O3C1	2.81	0.67	2.85
B3O0C0	2.77	0.48	2.57
B3O0C1	3.13	0.52	2.68
B3O1C0	3.68	0.69	4.19
B3O1C1	4.57	0.71	4.27
B3O2C0	3.22	0.64	3.95
B3O2C1	3.45	0.67	4.10
B3O3C0	4.33	0.76	4.25
B3O3C1	4.79	0.79	4.35
LSD B*O*C	0.167	0.051	0.136
NPK	3.41	0.68	3.92

Effect of different study factors on the availability of N, P and K in the soil after harvest.: The results showed that the triple interaction between biofertilizer, organic and mineral fertilizers had significant effects on the available nitrogen in the soil after harvesting, the treatment of between vermicompost and Orgevit together and with the bacterial and fungal biofertilization in the presence of 50% of the mineral fertilizer recommendation $B_3O_3C_1$ gave 70.81 mg N kg soil^{-1} as well as the treatment of $B_1O_3C_1$, in which the available of nitrogen was 68.11 mg N kg soil^{-1} compared to the control treatment $B_0O_0C_0$ which amounted to 22.50 mg N kg soil^{-1}, and the same treatments showed a significant superiority of the available phosphorous, which gave values of 38.19, 36.66 mg P kg soil^{-1},compared to the control treatment, that gave value of 9.13 mg P kg soil^{-1}. The same treatments were also significantly superior in the available potassium and gave values of 370.44 mg K kg^{-1}soil. The $B_3O_3C_0$ treatment gave available potassium reached to 361.26 and was also superior to that of the control treatment, which amounted to 199.47 mg K kg^{-1} soil. It was clear from the results in Table (4) that the biofertilization in the form of a complete combination of bacterial and fungal fertilizers led to a significant increase in the soil's nitrogen content because this combination contain *Azospirillum brasilense* that stimulates root growth and fixes nitrogen, as increasing the rate of nitrogen fixation leads to an increase in the available amount of it in the soil (1, 10) on the other hand the presence of *Azotobacter chroococcum*, which fix freely nitrogen in the soil, as well as the amount of nitrogen that is released in the form of ammonia after the death and decomposition of Azotobacter and the production of plant hormones and growth regulators contributes to the high available nitrogen values in the field soil inoculated with these bacteria, and a significant increase in the concentration of IAA, being a bacteria that stimulates plant growth, and adding it in interaction with phosphate-dissolving bacteria leads to an increase in the amount of available nitrogen in the soil, especially because there is no antibiosis between them and this is confirmed by (20).The increase in the available phosphorous and potassium in the soil, came as a result of fungi addition that interact with the other microorganisms and stimulate the growth and increase the availability of the these elements. Rather, it increases the amount of it dissolved in the medium in which it is located, and this is confirmed by (11), as for the added organic fertilizer, it activates microorganisms as well as being a source of energy for them and improves soil properties such as soil structure and its ability to retain water and thus leads to an increase in the availability of the nutrients, especially nitrogen, phosphorous and potassium (9).

Table 4. Effect of different study factors on the availability of N, P and K in the soil after harvest

Treatment	Parameters		
	N mg kg soil^{-1}	P mg kg soil^{-1}	K mg kg soil^{-1}
B0O0C0	22.50	9.13	199.47
B0O0C1	38.60	22.94	222.29
B0O1C0	36.70	20.18	260.93
B0O1C1	56.55	28.82	271.72
B0O2C0	29.48	22.01	241.64
B0O2C1	43.50	26.63	251.90
B0O3C0	45.02	29.71	285.66
B0O3C1	61.76	31.49	296.81
B1O0C0	31.95	22.12	245.59
B1O0C1	45.75	26.10	256.66
B1O1C0	47.22	26.93	302.03
B1O1C1	59.00	29.57	311.40
B1O2C0	37.17	24.42	275.91
B1O2C1	52.53	27.26	286.04
B1O3C0	52.09	30.05	321.01
B1O3C1	68.11	33.05	336.38
B2O0C0	26.04	20.51	229.69
B2O0C1	42.43	24.02	241.41
B2O1C0	41.36	24.61	276.15
B2O1C1	56.06	27.62	286.35
B2O2C0	31.49	22.34	260.88
B2O2C1	45.37	24.99	272.01
B2O3C0	46.19	27.91	305.45
B2O3C1	57.41	30.33	316.60
B3O0C0	36.71	29.84	264.15
B3O0C1	50.50	31.71	276.77
B3O1C0	54.52	34.18	340.81
B3O1C1	66.76	36.66	351.11
B3O2C0	45.34	32.05	295.95
B3O2C1	59.39	34.74	315.94
B3O3C0	65.54	35.16	361.26
B3O3C1	70.81	38.19	370.44
LSD B*O*C	0.765	0.716	1.083
NPK	61.00	29.50	276.80

Effect of different study factors on the concentration of NPK% in leaves after harvesting: The results of the statically analysis showed that addition of biofertilizer in combination with organic fertilizer had a significant effect on nitrogen concentration in leaves, the interaction treatment of vermicompost and Orgevit with bacterial and fungal bio-fertilizer fungi with or without the addition of the mineral fertilizer recommendation $B_3O_3C_1$ and $B_3O_3C_0$ were superior and gave a nitrogen concentration value of 3.11%, 3.08% respectively compared to control treatment ($B_0O_0C_0$). That gave 1.99 % only. The results also showed significant differences in the phosphorous concentration in the leaves, as it reached 0.61% in the

$B_3O_3C_1$ treatment, followed by the $B_3O_1C_1$ treatment and reached to 0.56% compared to the control treatment, which amounted to 0.20% only .The results also showed significant differences in the potassium concentration rates in the leaves, as the $B_1O_2C_1$ treatment was superior, followed by the $B_3O_3C_1$ treatment, and gave potassium concentration of 3.13% and 3.10%, respectively, compared to control treatment that was 1.98% only .

The results in Table (5) show that there were positive significant differences for the triple interaction between biological, organic and mineral fertilizers in the concentration of nitrogen, phosphorous and potassium in the leaves, this may be due to the positive interaction between bacterial and fungal biofertilizer with organic fertilizer in the presence of 50% of mineral fertilizers.

The microorganisms in bio-fertilizer have the ability to increase the availability of the necessary elements and encourage the plant to grow well and it has good properties in terms of organic acids and energy compounds that benefit microorganisms in the soil (19), this may be due to the role of microorganisms in increasing the nutrients content of leaves, during different growth stage of plant, for example, Azotobacter and Azospirillum have a role in increasing their nitrogen content by the process of nitrogen fixation, as well as the phosphate-dissolving fungi, have an effect on increasing phosphorus from its unavailable sources and increasing its concentration in the plant. Organic fertilizers have an important role in increasing the effectiveness of these bacterial species that stimulate plant growth. It fixes atmospheric nitrogen and dissolves phosphorous from its insoluble compounds through the production of organic acids, also, the organic fertilizer contains the available nutrients after its decomposition, and in the presence of the mineral fertilizer, the available and sufficient quantity increases for what the plant needs for good growth after increasing its ability to absorb because the nutrient are available in the soil solution and this was came in agreement with (18).

Table 5.Effect of different study factors on the concentration of NPK% in leaves after harvesting

Treatment	Parameters		
	N %	P %	K %
B0O0C0	1.99	0.21	1.98
B0O0C1	2.22	0.28	2.34
B0O1C0	2.34	0.32	2.44
B0O1C1	2.38	0.36	2.53
B0O2C0	2.30	0.31	2.38
B0O2C1	2.37	0.35	2.43
B0O3C0	2.48	0.36	2.59
B0O3C1	2.59	0.39	2.69
B1O0C0	2.41	0.32	2.37
B1O0C1	2.49	0.34	2.42
B1O1C0	2.58	0.35	2.46
B1O1C1	2.60	0.37	2.54
B1O2C0	2.41	0.33	3.05
B1O2C1	2.47	0.36	3.13
B1O3C0	2.64	0.45	2.63
B1O3C1	2.72	0.51	2.70
B2O0C0	2.24	0.30	2.29
B2O0C1	2.32	0.36	2.32
B2O1C0	2.32	0.31	2.50
B2O1C1	2.41	0.41	2.52
B2O2C0	2.36	0.32	2.48
B2O2C1	2.40	0.41	2.54
B2O3C0	2.46	0.36	2.56
B2O3C1	2.55	0.39	2.61
B3O0C0	2.58	0.32	2.38
B3O0C1	2.61	0.39	2.42
B3O1C0	2.76	0.52	2.57
B3O1C1	2.94	0.56	2.68
B3O2C0	2.65	0.37	2.41
B3O2C1	2.79	0.48	2.47
B3O3C0	3.08	0.53	2.97
B3O3C1	3.11	0.61	3.10
LSD B*O*C	0.075	0.063	0.072
NPK	2.87	0.49	2.58

REFRENCES

1.Al-Khafaji, A. M. H. H., and K. D. H. Al-jubouri. 2024. Individual and interactive utility of biological and physical invigoration for various carrots seeds orders and study their field performance. Iraqi Journal of Agricultural Sciences, 55(4) :1566-1573. https://doi.org/10.36103/66873c67

2.Al-Khafaji, A. M. H. H., N. J. K. Al-Amri, and N. H. A. Al-Dulaimi. 2022. Growth, yield, and antioxidant traits of different parts of beetroot as affected by vermicompost and glutathione. Iraqi Journal of Agricultural Sciences, 53(5): 1107-1114. https://doi.org/10.36103/ijas.v53i5.1623

3.Al-Gebory, K. D. H. and A. M. H. Al-Khafagy. 2011. Effects of some organic fertilizers on growth, productivity and leaf content from N, P, and K elements of onion plant. Kufa Journal for Agricultural Science, 3(1):47-55.

4.Al-Rubaie, A. T. O. 2018. Producing a local Bio-fertilizer From *Bacillus megaterium Pseudomonas fluorescens* and *Azotobacter chrococcum* and Comparing its Effect With an Imported Bio-fertilizer on The Growth and Yield of Potato (*Solanum tubersum.L)*. M.Sc Thesis, Faculty of Agricultural Engineering Sciences. Baghdad University.pp: 431-445.

5.Al-Zuhairi, G. F. H. 2019**.** Effect of a Combination of Biofertilizer, Earthworm Compost and Chemical Fertilization on The Growth and Yield of Flax (*Limun usitatissimum* L.). M.Sc Thesis, College of Agricultural Engineering Sciences, University of Baghdad.pp:1-140.

6.Awasthi, M.K., S. Sarsaiya, S. Wainaina, K. Rajendran , S. Kumar, W. Quan, Y. Duan, , S.K. Awasthi, H. Chen, A. Pandey , Z. Zhang , A.Jain and M.J Taherzadeh .2019. A critical review of organic manure biorefinery models toward sustainable circula r bioeconomy: technological challenges, adva ncements, innovations, and future perspectives. Renew. Sustain. Energy Rev. 111, 115–131. https://doi.org/10.1016/j.rser.2019.05.017.

7.Boras, M, B. Abu-Turabe and I. Al-Baset. 2011. Vegetable Crop Production. The Theoretical Part. Damascus University Publication. College of Agriculture, Syria,pp.466.

8.Alsilmawy, N. A. J. and H A. Abdul-Ratha.2023. Effect of biofertilizer,vermicomp ost and phosphate fertilizer on growth and yield of cauliflower (*Brassica oleraceae* Var.botrytis). Iraqi Journal of Agricultural Sciences. 54(2):505-515. https://doi.org/10.36103/ijas.v54i2.1726 .

9.Devi, C. and M. Khwairakpam . 2020**.** Bioconversion of lantana camara by vermicomposting with two different earthworm species in monoculture. Bioresource Technolog. Journal Pre-Proofs. 296:122308. https://doi.org/10.1016/j.biortech.2019.122308.

10.Dubey, R., K. V.Tripathi , R. Prabha ,R. Chaurasia, D. P. Singh, C. S. Rao and P.C.Abhilash.2020**.**Belowground Microbial Communities: Key Players for Soil and Environmental Sustainability. In Unravelling the Soil Microbiome pp:5-22. https://doi:10.1007/978-3-030-15516-2_2.

11.Ekin, Z. 2019**.** Integrated use of humic acid and plant growth promoting rhizo bacteria to ensure higher cauliflower (*Brassic a oleracea var. botrytis* L productivityyinsustainable agriculture. Sustainability. 11: 3417. https://doi.org/10.3390/su11123417.

12..Ekinci, M., M. Turan, E. Yildirim, A. Güneú, R. Kotan and A. Dursun. 2014. Effect of plant growth promoting rhizobacteria on growth, nutrient, organic acid, amino acid and hormone content of cauliflower (*Brassica oleracea var. botrytis* L) transplants. Acta Sci. Pol., Hortorum Cultus 13: 71-85. https://doi: 10.3906/tar-1308-62.

13.. Khafagy, A. M. H. and K. D. H. Al-Gebory. 2010. Influences of fertilizers and organic nutrients on growth and seed yield of onion. Diyala Journal of Agricultural Sciences. 2 (2): 64 – 84

14..Ijaz, M., Q., Ali, S., Ashraf, M., Kamran, and A., Rehman, 2019. Development Of future bioformulations for sustainable agriculture. Microbiome in Plant Health and Disease. Springer, Berlin/Heidelberg, Germany. V (No): 421–446 . https://doi:10.1007/978-981-13-8495-0_19.

15.Nirmalnath, P. Jones. 2010**.** molecular diversity of arbuscular Mycorrhizal Fungi and pink pigmentedfacultative methylotrophic bacteria and their influence on grapevine (*Vitis vinifera*). University of Agricultural Sciences. Dharwad. 4(1): 27-31. https://doi: 10.1007/s00572-013-0518-7 .

16.Odoh, C.K.; C.N Eze; U.K Akpi; and V.U Unah.2019.Plant growth promoting rhizobacteria (PGPR): A novel Agent for sustainable Food production. Am. J. Agric. Biol. Sci., 14,35–54. https://doi.org/10.3844/ajabssp.2019.35.54.

17..Olaniyi J.O. and A.T. Ajibola. 2008 .The effects of inorganic and organic fertilizers pplication on the growth, fruit yield and quality tomato (Lycopersiconlycopersicum). Journal of Applied Biosciences 8(1): 236-242. https://doi: 10.2478/fhort-2018-0027.

18..Parewa H.P, V. S Meena, L. K Jain and A. Choudhary.2018**.** Sustainable crop production and soil health management through plant growth-promoting rhizobacteria. Role of Rhizospheric Microbes in Soil. V (No): 299–329. https://doi:10.1007/978-981-10-8402-7_12.

19.Piya, S. ,I. Shrestha, D. P. Gauchan and J. Lamichhane.2018**.**Vermicomposting in organic Agriculture: Influence on the soil nutrients and plant growth. International Journal of Research, 5: 1055-1063. https://doi.org/10.36094/sc.v89.

20.Ramandeep, S.S., S.Kumari and S. K. Singh. 2018. Impact of bio-fertilizers and fertilizers on potato (*Solanum tuberosum* L.) cv. Kufri Pukhraj and Kufri Jyoti cultivation. *IJCS* 6: 29-31. doi**:** https://dx.doi.org/10.22271/chemi.

21.Singh, M.; S. K.Biswas ; D.Nagar ; K. Lal,and J.Singh . 2017. Impact of biofertilizer on growth parameters and yield of potato. Int. J. Curr. Microbiol. Appl. Sci, 6 (5)v: 1717-1724. https://doi.org/10.20546/ijcmas.2017.605.186.

22.Verma, T.; Pal, P. 2020 . Isolation and screening of rhizobacteria for various plant growth promoting attributes. Journal of Pharmacognosy and Phytochemistry, 9,1514–1517. https://doi:10.22271/phyto.2020.v9.i1z.10678 .