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Article

Effect of different fertilizers on growth and nutrient state of fenugreek (*Trigonella foenum–graecum* L.)

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ABSTRACT

A pots plastic experiment was conducted in a plastic –house of the Faculty of Science, Mustansiriyah University, to study the effect of three fertilizers (vermicompost, peat-moss and Di-Ammonium Phosphate (DAP)) levels on some phenotypic characteristics (plant height, fresh and dry weight) and concentration of nutrients (N, P, K and Ca), chlorophyll and protein of fenugreek according to the complete randomized design with six replicates. The treatments consisted of four levels of vermicompost (0, 6, 12 and 18g.pot^{-1}) and one level of both peat-moss(12g.pot^{-1}) and DAP(1g.pot^{-1}). The results showed significant differences between different fertilizer levels on phenotypic characteristics and nutrient state. Also, the highest value of some studied characteristics was found at treatment 12g.pot^{-1} of vermicompost.

Keywords: vermicompost, peat-moss, DAP and fenugreek.

INTRODUCTION

Fenugreek (Trigonella foenum–graecum L.) is one of the plants of the family Fabaceae and is characterized by tap roots containing nodes, leaves compound, flowers are yellow-white color, and pod fruits containing tiny seeds [1]. Seeds contain a high percentage of carbohydrates 58.76%, protein 18.73%, crude fibers 7.64%, fats 5.75%, ash 3.60%, vitamins (C, B and D) and mineral elements(P, K, Ca and Fe) [2].

The earthworms play an important role in the vermicomposting process, and microorganisms are responsible for the breakdown of organic materials through aeration and fragmentation. Also, earthworms indirectly boost microbial biomass and activity, increasing the available surface area for microorganisms and influencing the composition and structure of microbial communities [3, 4].

Vermicomposting is a complementary process of decomposing organic matter by earthworms and produces better and more efficient compounds [5]. Vermicompost is a biological product from earthworm breeding technology; it is dark brown, has no odor, and contains microbes and nutrients [6]. It also includes some enzymes (nitrogenase and cellulose) and plant hormones (ethylene, auxin and gibberellin) that can stimulate plant growth and prevent the invasion of pathogens

that cause various diseases of the plant and contain macro and micronutrients such as N, P, K, B, Cu, Fe, Mn, Mo and Zn [7].

Furthermore, vermicompost affects the soil beneficially because it contains a high concentration of humic acid and fulvic acid that improve plant growth [7] and alters the soil's physical, chemical and biological characteristics, thus promoting plant growth and yield increase [8].

Vermicompost fertilizer caused a significant increase in germination percentage, leaves No., length and diameter of the stem, dry weight and promoting root nodule formation of Cluster bean (Cyamopsis tetragonoloba) compared to control [9]. Also, it showed that adding vermicompost to the Chilli crop (Capsicum annuum L.) led to increased element content and enhanced plant growth [10]. While, vermicompost treatments increased the amount of chlorophyll pigment in leaves, intracellular CO_2 content and rate of transpiration of chickpea (Cice arietinum L.) compared with control [11]. Another study showed organic worm fertilization (vermicompost) and a significant increase in P and K contents in eggplant (Solanum melongena L.) plants [12]. Furthermore, a high level of vermicompost could result in the highest growth and yield of maize (Zea mays L.) and the highest increase of soil chemical properties (organic matter, P and K concentration) [13].

MATERIAL AND METHODS

Preparation of vermicompost:

As shown in Figure 1, six plastic containers were prepared and perforated in the bottom for disposal of excess water and ventilation; each container was 30cm in diameter and 80cm high, and the thickness of the soil was 50cm and put in each container. A layer of coarse gravel is placed on each container 10cm thick, and over it is a layer of fine gravel with a thickness of 5cm. After that, a layer of sand 15cm thick, then a layer of soil with a thickness of 20cm and 34 adult worms are put in each container, and then the container is covered with jute bags [14]. Daily add 500 ml of purified water and 20 g of food(peat-moss) to the containers [15]. Peat moss was used as food for earthworms and to maintain moisture; it is characterized by integrated physicochemical properties. These properties have made peat moss an effective material in the vermicomposting process [16].

After three months, from September (2021) to December (2021), the vermicompost was prepared from these containers and analysis of physical and chemical properties according [to 17] as shown in Table 1.

O.M. (%)	**pH**	**E.C. ($ds.m^{-1}$)**	**N**	**P**	**K**
			(ppm)		
10.0	3.05	1.30	490	24	740

Table 1. Some physical and chemical analysis of the vermicompost.

Figure 1. Bins of earthworms breeding.

This study was conducted in the greenhouse of the biology department, science college/AL-Mustansiriyah University during the growing season from December (2021) to April (2022), to study the effect of three fertilizers from vermicompost, peat-moss and Di-Ammonium Phosphate (DAP) (46% P,18%N) on some growth parameters and nutrient state of fenugreek crop (cv. Local).

The soil was brought from the biotic garden of the department and cleaned by filtering through a 2 mm sieve. Some physical and chemical characteristics of the used soil were analyzed according to [17], and Table 2 shows the soil characteristics.

Soil Particles ($g.kg^{-1}$)			**O.M. (%)**	**pH**	**E.C. ($ds.m^{-1}$)**	**Texture**	**N**	**P**	**K**
Clay	Silt	Sand				Sandy	(ppm)		
89	145	766	3.11	6.51	1.76		39	9	120

Table 2. Some physical and chemical analysis of the investigated soil.

The experiment included 36 treatments:

Four levels of vermicompost fertilizer (0, 6, 12 and 18g.pot^{-1}) that symbol (Con., Ver.1, Ver.2 and Ver.3), respectively, were added before planting

One level of DAP (1g.pot^{-1}) was added before planting.

One level of peat moss (12g.pot^{-1}) was added before planting.

Six replicates.

Sixteen seeds were cultured in each plastic pot (6 kg from the soil) on 15/12/2021 and reduced after germination to ten plants remaining in each pot Figure 2.

Figure 2. Fenugreek plant in 20 days.

The four plants were taken after 63 days to measure some characteristics like plant height (cm), fresh and dry weight (g), and chlorophyll content (Spad). Also, determine the concentration of nitrogen (%) [18], phosphor (%) [19], potassium (%) [17], calcium (%) [20] and protein (%) by multiply factor 6.25.

Experimental Design and Statistical Analysis

The experiment was designed according to the complete randomized design (CRD), and the Least Significant Difference (LSD) was used to compare among means at $P \leq 0.05$ level [21].

RESULTS:

Plant height

As shown in Figure 3 and Table 3, the application of different fertilizers significantly affected at a 5% probability level on fenugreek morphology growth.

Data indicated that the highest value of plant height was achieved in treatment Ver.2 and gave 48.89 cm, while the lowest value was obtained at control reached 36.31cm. The value of treatment Ver.2 significantly differs from other treatments except for treatment Ver.3, which gives 46.50 cm. Also, no significant differences were recorded between Ver.1, peat-moss and DAP treatments that give (43.21, 42.31 and 42.15) cm, respectively.

Fresh weight

Table 3 shows the highest fresh weight value was recorded at treatment Ver.2, which gives 9.80g and is significantly different from all other treatments except

the treatment Ver.3, which gives 9.34g. In contrast, the lowest value was recorded at the control, which gives 5.12g. The Ver.1, peat-moss, and DAP treatments give fresh weights (7.04, 9.07 and 8.41) g, respectively.

Dry weight

Table 3 indicates that significant differences were recorded in dry weight with increasing vermicompost levels at (6, 12 and 18) g.pot^{-1} reached (1.30, 1.91 and 1.72) g, respectively, compared without vermicompost treatment (0.89g). Furthermore, there is no significant difference between peat-moss and DAP treatments that give (1.45 and 1.41) g, respectively.

Figure 3. Effect of different fertilizers on the growth of the fenugreek.

Level (g.pot^{-1})	Plant height (cm)	Fresh weight (g)	Dry weight (g)
Con.	36.31	5.12	0.89
Ver.1	43.21	7.04	1.30
Ver.2	48.89	9.80	1.91
Ver.3	46.50	9.34	1.72
Peat-moss	42.31	9.07	1.45
DAP	42.15	8.41	1.41
LSD 0.05	3.78	0.68	0.07

Table 3. Effect of some fertilizers levels on morphology growth of fenugreek.

Nitrogen concentration

As shown in Table 4, applying different fertilizers had a significant effect at a 5% probability level on fenugreek nutrient content. Data indicated that the highest value of nitrogen concentration was achieved in treatment Ver.2 and gave 3.09%, while the lowest value was obtained in control, reaching 1.07%. The value treatment Ver.2 is significantly different from other treatments. Also, no significant differences were recorded between Ver.3, DAP and peat-moss

treatments give (2.79, 2.56 and 2.54) %, respectively, but there is a significant difference between them, and Ver.1 treatment gives 2.07%.

Phosphorous concentration

Table 4 shows that the highest phosphorous concentration was achieved at treatment Ver.3, which gave 0.34% and significantly differed from all other treatments. At the same time, the lowest value was recorded at the control, which gave 0.21%. Moreover, no significantly different between peat-moss, Ver.1 and control treatments that give a concentration of phosphorous (0.23, 0.23 and 0.21) %, respectively.

Potassium concentration

Table 4 indicates that significant differences were recorded in potassium concentration with increasing vermicompost levels at (6, 12 and 18) $g.pot^{-1}$ reached (1.58, 2.96 and 2.80)%, respectively, compared without vermicompost treatment (1.17%). Furthermore, there was no significant difference between peat-moss and DAP treatments, giving (2.28 and 2.17) %, respectively.

Calcium concentration

Table 4 shows the highest calcium concentration was recorded at treatment Ver.3, which gives 3.37 %, while the lowest calcium concentration was recorded at the control, which gives 1.89 %. Ver.3 significantly differed from all other treatments, and there are also significant differences between Ver.1, Ver.2, peat-moss and DAP treatments that give calcium concentrations (2.20, 3.04, 2.69 and 2.84) %, respectively.

Level ($g.pot^{-1}$)	Nitrogen %	Phosphorous %	Potassium %	Calcium %
Con.	1.07	0.21	1.17	1.89
Ver. 1	2.07	0.23	1.58	2.20
Ver. 2	3.09	0.29	2.96	3.04
Ver. 3	2.79	0.34	2.80	3.37
Peat-moss	2.54	0.23	2.28	2.69
DAP	2.56	0.30	2.17	2.84
L.S.D 0.05	0.25	0.04	0.14	0.13

Table 4. Effect of some fertilizers levels on the nutrient concentration of fenugreek.

Protein concentration

As shown in Table 5, applying different fertilizers had a significant effect on protein concentration at a 5% probability level. Treatment comparison showed the highest protein concentration was achieved in treatment Ver. 2 and gave 19.33 %, while the lowest protein concentration obtained at the control treatment reached 6.71%. The value treatment Ver.2 is significantly different from other treatments. Also, no significant differences were recorded between Ver.3, DAP and peat-moss treatments give (17.44, 16.02 and 15.88) %, respectively.

Chlorophyll concentration (Spad)

Table 5 shows that the highest chlorophyll content in the fenugreek plant was achieved at treatment Ver.2, which gave 55.03 Spad and significantly differed from all other treatments except treatment Ver.3, which give53.87 Spad. At the same time, the lowest value was recorded at control, which gave 36.53 Spad. Furthermore, no significantly different between DAP, peat-moss and Ver.1treatments that give (44.67, 44.60 and 43.27) Spad, respectively.

Level ($g.pot^{-1}$)	Protein (%)	Chlorophyll (Spad)
Con.	6.71	**36.53**
Ver.1	12.93	**43.27**
Ver.2	19.33	**55.03**
Ver.3	17.44	**53.87**
Peat-moss	15.88	**44.60**
DAP	16.02	**44.67**
L.S.D 0.05	1.35	**3.07**

Table 5. Effect of different levels of fertilizers on the concentration of chlorophyll and protein of fenugreek.

DISCUSSION

Generally, the plants in treatment Ver.2 give the best phenotypic characteristics (plant height, fresh and dry weight) compared with the control that gives the lowest values for the abovementioned characteristics. In contrast, treatments Ver.3, peat-moss, DAP and Ver.1 ranked second, third and fourth. These results are in agreement with the results of [9, 13]. Enhancement of growth might be attributed to the presence of macro-micronutrients, as shown in Table 1, beneficial microorganisms such as (nitrogen-fixing bacteria, phosphate solubilizing bacteria and mycorrhizal fungi), growth hormones like (auxins, gibberellin and cytokinins) and humic acids in vermicompost [22]. The humic acids formed from the decomposition of organic waste by earthworms and microorganisms during the vermicomposting process have a positive effect on the growth and development of plants. Soluble humic substances can increase nutrient availability by stimulating the plasma membrane (H^+-ATPase) activity [23]. [24] found that adding vermicompost led to significant increases in the growth of hyacinth beans (Lablab purpureas) comported with chemical fertilizer. Table 4 shows the maximum concentration of K and N observed at treatment Ver.2. In contrast, the maximum concentration of Ca and P was observed at treatment Ver.3. These results are in agreement with many studies that showed the vermicompost is rich with organic materials; they provide soils and plants by nutrients such as K, P and N [25]. Also, [26, 27] found that adding vermicompost increases the plant's nutrient content. [28] found the application of vermicompost led to a significant increase in the fenugreek crop's nitrogen, phosphorus and

potassium content to other treatments and control. [29] found increasing vermicompost doses led to increasing exchangeable Ca content, and most of the nutrients in vermicompost are in more available forms for plants, such as soluble potassium, exchangeable calcium and soluble phosphates; the humic acid present in the vermicompost works to conversion unavailable soil phosphate into available forms for the plant. This increase in nutrient content is because vermicompost is a product rich in plant nutrients, including N, P, K, Ca, Mg, Fe, Mn, Cu and B. The uptake of these nutrients increases photosynthesis and content of chlorophyll and enhances the nutrient content [6]. The results are similar to the results of [12]. [22] reported the increasing chlorophyll content and protein content in the plants might be attributed to the increase of concentration of N and P in the plants, which assimilation of several amino acids that make proteins and nucleic acids, which proved skeleton for chloroplast, mitochondria and other structure in which many biochemical reactions occur. Vermicompost promotes the content of chlorophyll and enhances the process of photosynthesis by increasing the content of soil nutrient elements and thus increasing the availability of these elements for the plant in addition to the presence of humic [2]. [30] found that the use of vermicompost increased the concentration of chlorophyll in pepper plant. Also, [31] reported that the addition of vermicompost to bean plants led to an increase in chlorophyll concentration. These results are in agreement with the results of Hosseeinzadeh et al. (2016).

CONCLUSION

This study concluded the preparation of vermicompost fertilizer and its effect on fenugreek's growth and nutrient state compared with other fertilizers.

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