Effect of spraying with arginine and fertilizing with nano fertilizer on the growth of fenugreek plants

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Abstract

The experiment was conducted in one of the private fields in Babylon province / Al-Kifl District - Al-Hamad area for the autumn agricultural season of the academic year 2023, as the seeds were planted on 10/1/2023 Verify the planting date to know effect of spraying with the amino acid arginine and soil fertilization with the compound nano fertilizer NPK on the vegetative growth,). The experiment was designed as a factorial experiment according to the randomized complete block design (RCBD) with three replicates. The first factor included four concentrations (0, 250, 500, 750) mg.L^{-1}, and the second factor was the nano-compound fertilizer NPK also with four concentrations (0, 10, 15, 20) kg.ha^{-1}. The plants were sprayed with three sprays between each spray 14 days apart. At the end of the experiment, the results were taken and statistically analyzed, and the averages were compared according to the Least Significant Differences Test (L.S.D). The most important results obtained were the following: The spray treatment with the amino acid arginine at a concentration of 750 mg.L^{-1} was significantly excelled, and gave the highest results in some vegetative growth indicators such as the number of main branches 3.78 branches.$plant^{-1}$, the leaf area 684 cm^2.$plant^{-1}$, and the dry weight of the vegetative growth 3.73 g.plant -1 Chlorophyll content 50.53 SPAD. The soil fertilization treatment with the compound nano fertilizer NPK at a concentration of 20 kg.ha^{-1} was significantly excelled in most of the studied traits such as vegetative growth indicators, plant height 40.69 cm.plant-1, number of main branches 3.78 branches.$plant^{-1}$, and leaf area 638 cm^2.$plant^{-1}$. The results of the statistical analysis showed the presence of significant interactions, as the interaction consisting of the amino acid arginine at a concentration of 750 mg.L^{-1} and the compound nano fertilizer NPK at a concentration of 20 kg.ha^{-1} was excelled in most of the studied traits such as vegetative growth indicators such as plant height 43.77 cm.plant-1, number of main branches 4.60 branches.$plant^{-1}$, leaf area 762 cm^2.$plant^{-1}$, and chlorophyll content 51.65 SPAD.

Keywords: Fenugreek, Arginine, NPK nano fertilizer

Introduction

Fenugreek plant (*Trigonella foenum-graecum* L). is one of the plants of the legume family Fabaceae. It is said that its original home is West Africa and it is now widely cultivated in Asia and Latin America as well.[25]. Fenugreek is one of the commonly used plants in most countries of the world due to its wide range of benefits, as it is used in many fields, whether in medical aspects or in the pharmaceutical and cosmetic industries[3]. Studies indicate that fenugreek plant production of alkaloids increases by spraying amino acids, which are the basic structure for building all proteins, and they are also the raw materials for generating some hormones, purines, pyrimidines, porphyrins and vitamins. Therefore, amino acids are of great importance due to their direct or indirect effect s on the physiological processes of the plant through their role in forming the basic organic compounds for the formation of protoplasm, as well as their participation in the formation of enzymes, energy and storage[18]. Among the 21 protein amino acids, arginine has the highest nitrogen to carbon ratio, making it one of the stored forms of organic nitrogen, which is one of the determinants of plant growth and is needed by plants in large quantities to build nucleic acids and proteins[24]. Arginine affects vegetative growth through its role in stimulating physiological and biological

processes that increase cell building and increase carbohydrates, which is positively reflected in plant growth, in addition to its role in reducing ABA and increasing the biosynthesis of GA3 and IAA, and thus arginine increases cell division[13]. Adding fertilizers is an important factor in agricultural production management due to its impact on the quality of the crop and increasing its quantity[8]. Nano-fertilizers are among the most important fertilizers, as they work to enhance global food production while protecting natural and environmental resources. Nanotechnology is one of the modern technologies that has the ability to modify the current artificial framework used in agricultural systems by increasing the efficiency of agricultural fertilizers, and providing solutions to agricultural and environmental problems[17 ,23]. The use of nano-nutrients is the basis of fertilizers in agricultural production and one of the modern technologies that serve to increase production and reduce costs. It also diversifies the use of different elements that support the nutritional system of field crops, as well as diversifies the methods and times of adding them to the soil in order to improve its properties or biological components, or loading them on organic materials and mixing them with the soil to improve the soil and feed the plant, or spraying them directly on plants in order to increase their growth and improve productivity .[9].The same applies to plants of medical importance, especially those that manufacture essential oils, as these nutrients effect ively increase oil production and quality .[22].including NPK nano-fertilizers, they are characterized by the speed of preparing nutrients for the plant, their ease of absorption, and the increase in the duration of their effect .[15].

Materials and methods:-

Field soil preparation:-

The experiment was coundected in one of the private fields in the autumn agricultural season of the academic year 2023, as the seeds were planted on Sunday 10/1/2023 Verify the planting date in Babylon Governorate / Al-Kifl District - Al-Hamad area, ten random samples were taken from several locations in the field soil from depths of 0-30 cm, then they were mixed well and after air drying, they were ground and analyzed in the laboratories of the Department of Soil and Water in the College of Agriculture / Al-Qasim Green University.

Table (1) shows some chemical and physical properties of the soil of the experimental field

Units	Values	Traits
	3.9	Electrical conductivity
	8.1	pH
%	**11.02**	Calcium carbonate
%	**0.827**	Organic matter
Ppm	**10.3**	Available phosphorus
Ppm	**51.25**	Available nitrogen
L/meq	**19**	Calcium
L/meq	**6**	Magnesium
L/meq	**3.12**	Potassium
%78.5	Sand	**Soil separators**
%17.500	Silt	
%4	Clay	
Sandy/silty/clay		**soil texture**

The field was prepared by plowing the land twice perpendicularly using a Mold-board plows, and decomposed organic fertilizer was added between the two plowings to ensure its mixing with the soil [1]. After that, the land was smoothed using disc harrows and then leveled using a Land plat machine. The field was divided into three replicates, with a distance of 1 m between each replicate for the passages between the replicates. Then each replicate was divided into 16 experimental units, the area of each experimental unit was 1 m2 with dimensions of 1 x 1 m. Spaces were left between the experimental units of about 0.5 m to ensure that the spray of arginine did not evaporate. The experimental units were planted in three planting lines, the distance between one line and another was 1 m and the distance between one plant and another was 25 cm. Agriculture and soil service operations:

The amount of fenugreek seeds sufficient to complete the experiment was provided from the local markets, the "yellow local" variety,

and the germination percentage was tested in the Seed Technology Laboratory of the College of Agriculture/Al-Qasim Green University by planting 100 seeds in four Petri dishes, each dish containing 25 seeds taken randomly from the seed package. The dishes were moistened with distilled water evenly and then placed in the germination device at a temperature of 25 degrees Celsius for 48 hours, after which the germination percentage was calculated and was 98.5%. The seeds were planted on 10/1/2023 and the plants were treated with the experimental factors in three batches, 14 days between each batch, the first after 14 days from planting, i.e. after the thinning process and the seedlings entering the beginning of the rapid growth stage (logarithmic), and the second batch after 30 days from planting.[4]. The experimental field was irrigated immediately after planting with drip irrigation for all experimental units equally to ensure a good germination rate, and the irrigation process was repeated in the early morning according to the plant's need Using well water.

Table (2): Analysis of water used for irrigation

Units	Values	Traits
	1.6	Electrical conductivity
	7.8	Reactivity degree
meq/L	**0.4**	Potassium
meq/L	**10.9**	Sodium
meq/L	**5**	Calcium
meq/L	**3**	Magnesium

Treatments and experimental design: -

A factorial field experiment was applied using a complete randomized block design (RCBD) with two factors. The first factor is spraying with arginine at four concentrations (0, 250, 500, 750 mg.L-1), and the second factor is the compound nano fertilizer NPK at four levels (0, 10, 15, 20 kg.H-1) with three replicates. The averages will be compared using the least significant difference (LSD) test at the 5% level. The treatments including all the expected combinations were distributed in a factorial experiment according to a Randomized Complete Block Design (RCBD) with three replicates, and the means were compared according to the Least Significant Differences Test (LSD) at a probability level of 0.05 .[5].

Studied traits:-

Ten plants were randomly taken for each experimental unit, and the following indicators were measured:

Vegetative growth indicators:

Plant height (cm.plant^{-1})

This characteristic was measured from the point of contact of the stem with the soil to the top of the plant using a steel measuring tape and according to the average for each experimental unit.

Number of main branches in the plant (branch.plant^{-1}):-

The number of branches for ten random plants for each treatment was calculated and the average was taken from it.

Total number of leaves (leaf.plant^{-1}):-

The leaves of ten random plants were counted for each experimental unit and according to the average.

Leaf area (dm^2.plant^{-1}):-

The leaf area was measured by taking ten leaves of fully expanded plants located in the middle part of the plant from each experimental unit and was measured using the method used by [6] and described by [20] using a scanner and Image program loaded on the computer, then the total leaf area of the plant was calculated by multiplying the average area of one leaf by the average number of leaves per plant for each experimental unit Write down the measurement method completely.

Dry weight of the vegetative growth (g.plant^{-1}):-

After taking the fresh weight of the samples, they were dried initially by placing them on a polyethylene mat (nylon) in the shade in a well-ventilated room for 72 hours, after which the samples were placed in an electric oven for 30 minutes at a temperature of 60 °C until the weight stabilized .[21].

Total chlorophyll pigment content of leaves (SPAD):-

The total chlorophyll pigment content of leaves was measured by Chlorophyll Meter type SPAD-205 equipped by Minolta Japanese company, by taking the fourth leaf from each of ten plants.

Results and discussion:-

Vegetative traits:-

Average plant height (cm. plant^{-1}):

The results of Table (4) show significant differences between the concentrations of the amino acid arginine in the plant height trait, as the concentration 500 mg. L^{-1} excelled and gave the highest value on the rest of the concentrations, reaching 41.07 cm. plant^{-1}, while control treatment gave the lowest value in plant height, 35.22 cm. plant^{-1}. The results of the same table also indicate that there are significant differences between the concentrations of the NPK nano-compound fertilizer in the plant height trait, where the concentration of 20 kg.ha^{-1} was excelled and gave the highest value over the rest of the concentrations in plant height of 40.69 cm.plant^{-1}, while control treatment gave the lowest value in plant height of 34.99 cm.plant^{-1}. The results of the same table also showed that the interaction between the amino acid arginine and the NPK nano-compound fertilizer led to significant differences in plant height, as the interaction consisting of the fourth concentration of 750 mg.L-1 of the amino acid arginine and the fourth concentration of 20 kg.ha^{-1} of the NPK nano-compound fertilizer was excelled and gave the highest plant height of 43.77 cm.plant^{-1}. While the comparison achieved the lowest average for the plant height trait, which was 33.87 cm.plant^{-1}. There were significant differences when spraying with the amino acid arginine, and the reason may be attributed to the fact that arginine acts as a vegetative growth stimulant in plants, as it produces masses of proteins and enzymes that are important for physiological processes, especially the growth, division and expansion processes of plant cells faster and better due to their direct entry through the stomata into the guard cells, which encouraged the processes of longitudinal growth and lateral expansion of plant cells [11],[2]. The increase in vegetative growth in the studied traits may be due to the role of nanofertilizers as an activator for enzymes involved in receiving protein and carbohydrates, as well as their role in increasing the rates of carbon dioxide absorption, which leads to a greater increase in the synthesis and transport of photosynthetic products used and in the formation of new cells and enhancing vegetative growth and the formation of a greater number of leaves per plant with increasing the concentration of the compound nanofertilizer (NPK) [7].

Table (4) Effect of spraying the amino acid arginine and the compound nanofertilizer NPK and the interaction between them on the plant height (cm.plant^{-1}) of fenugreek.

average A	NPK nanofertilizer				Arginine acid
	B4:20 Kg.ha^{-1}	B3:15 Kg.ha^{-1}	B2:10 Kg.ha^{-1}	B1:0Kg.ha^{-1}	
35.22	36.70	35.43	34.87	33.87	A1:0 mg.L^{-1}
36.65	38.57	37.57	35.63	34.83	A2:250 mg.L^{-1}
41.07	43.73	41.63	40.73	38.17	A3:500 mg.L^{-1}
37.07	43.77	35.23	36.20	33.07	A4:750 mg.L^{-1}
	40.69	37.47	36.86	34.99	average B

Interaction	NPK nanofertilizer	Arginine acid	L.S.D 0.05
6.408	3.204	3.204	

Average number of main branches (branch.plant^{-1}):-

The results of Table (5) indicated that there were significant differences between the concentrations of spraying with the amino acid arginine in trait of the number of main branches, as the fourth concentration of 750 mg.L^{-1} gave 3.78 branches.plant^{-1}, and control treatment gave the lowest average in the

number of main branches, reaching 2.52 branches.plant^{-1}. It was also noted that there were significant differences between the concentrations of spraying with the compound nano fertilizer NPK in trait of the number of main branches, as the interference consisting of the fourth concentration of 20 kg.ha^{-1} of the compound nano fertilizer NPK was excelled and gave the highest number of main branches, reaching 3.67 branches.plant^{-1}, while control treatment gave the lowest average for trait of the number of main branches, reaching 2.73 branches.plant^{-1}.

The results of the same table showed that the interaction between the amino acid arginine and the nano-complex fertilizer NPK led to significant differences in the number of main branches, as the interaction consisting of the fourth concentration of 750 mg.L^{-1} of the amino acid arginine and the fourth concentration of 20 kg.ha^{-1} of the nano-complex fertilizer NPK was excelled and gave the highest number of main branches, reaching 4.60 branches.plant^{-1}, while control treatment gave the lowest average for the number of main branches, reaching 2.23 branches.plant-1. Effect of the nano-complex fertilizer NPK in increasing it may be due to the presence of phosphorus, which plays a direct role in most vital processes inside plant cells, as it helps in the formation and division of cells, in addition to its participation in the formation of energy-rich compounds, and thus activating vegetative growth and increasing the number of branches. It may be attributed to the role of phosphorus in stimulating the plant to produce cytokinins, which play a role in encouraging lateral buds, which leads to an increase in the number of vegetative branches in the plant. [14].

Table (5) Effect of spraying the amino acid arginine and the nano-complex fertilizer NPK and the interaction between them on the number of main branches (branch.plant^{-1}) of fenugreek plant

average A	NPK nanofertilizer				Arginine acid
	B4:20 Kg.ha^{-1}	B3:15 Kg.ha^{-1}	B2:10 Kg.ha^{-1}	B1:0Kg.ha^{-1}	
2.52	2.97	2.57	2.30	2.23	A1:0 mg.L^{-1}
3.21	3.47	3.30	2.97	3.10	A2:250 mg.L^{-1}
3.21	3.63	3.40	3.10	2.70	A3:500 mg.L^{-1}
3.78	4.60	4.23	3.43	2.87	A4:750 mg.L^{-1}
	3.67	3.38	2.95	2.73	average B
Interaction		NPKnanofertilizer		Arginine acid	L.S.D $_{0.05}$
0.434		0.217		0.217	

Average number of total leaves (leaf.plant^{-1})

The results of Table (6) showed significant differences between the concentrations of spraying with the amino acid arginine in trait of the total number of leaves, as the concentration 500 mg.L^{-1} excelled and gave the highest value of 62.25 leaves.plant^{-1}, while control treatment achieved the lowest value in the total number of leaves, amounting to 51.43 leaves.plant^{-1}. The results of the same table also indicate significant differences between the concentrations of the compound nano fertilizer NPK in trait of the total number of leaves, as the concentration 15 kg.ha^{-1} excelled and gave the highest value of 61.65 leaves.plant^{-1}, while control treatment achieved the lowest value in the total number of leaves, amounting to 54.40 leaves.plant^{-1}.The results of the same table also indicated that the interaction between the amino acid arginine and the nano-complex fertilizer NPK led to significant differences in the total number of leaves, as the interaction consisting of the third concentration of 500 mg.L^{-1} of the amino acid arginine and the third concentration of 15 kg.ha^{-1} of the nano-complex fertilizer NPK was excelled and gave the highest total number of leaves, reaching 69.7 leaves. plant^{-1}, while the comparison achieved the lowest average for the total number of leaves, reaching 48.2 leaves. plant^{-1}.

Table (6) Effect of spraying the amino acid arginine and the nano-complex fertilizer NPK and the interaction between them on the total number of leaves (leaf. plant^{-1}) of fenugreek plant

average A	NPK nanofertilizer				Arginine acid
	B4:20 Kg.ha^{-1}	B3:15 Kg.ha^{-1}	B2:10 Kg.ha^{-1}	B1:0Kg.ha^{-1}	
51.43	50.4	55.5	51.6	48.2	A1:0 mg.L^{-1}
57.15	68.4	52.0	53.1	55.1	A2:250 mg.L^{-1}
62.25	49.4	69.7	69.2	60.7	A3:500 mg.L^{-1}
60.58	69.1	69.4	50.2	53.6	A4:750 mg.L^{-1}
	59.33	61.65	56.03	54.40	average B

Interaction	NPK nanofertilizer	Arginine acid	L.S.D 0.05
2.812	1.406	1.406	

Leaf area rate (dm^2.plant^{-1}):-

The results of Table (7) show significant differences between the concentrations of spraying with the amino acid arginine in the leaf area trait, as the fourth concentration 750 mg.L-1 excelled and gave the highest value of 684 dm2.plant-1, while control treatment gave the lowest value of 490 dm2.plant-1.The results of the same table also indicate significant differences between the concentrations of the compound nano fertilizer NPK in the leaf area trait, as the fourth concentration 20 kg.ha^{-1} excelled and gave the highest value of 638 dm^2.plant^{-1}, while control treatment gave the lowest value of 481 dm^2.plant$^{-1.}$ The results of the same table also showed that the interaction between the amino acid arginine and the nano-complex fertilizer NPK led to significant differences in leaf area, as the interaction consisting of the fourth concentration of 750 mg.L^{-1} of the amino acid arginine and the fourth concentration of 20 kg.ha-1 of the nano-complex fertilizer NPK was excelled and gave the highest leaf area of 762 dm2.plant-1, while the comparison achieved the lowest average for the leaf area trait of 365 dm2.plant-1. The increase is due to the fact that the nano-complex fertilizer has a high penetration efficiency of the cell membranes to reach its functional work centers, which is necessary for the synthesis of chlorophyll, food production, and encouraging energy transfer and metabolism processes, cell division, and increasing their number, affecting the increase in the leaf area of the plant.[16].

Table (7) Effect of spraying the amino acid arginine and the nano-complex fertilizer NPK and the interaction between them on the leaf area (dm2.plant-1) of fenugreek plant

average A	NPK nanofertilizer				Arginine acid
	B4:20 Kg.ha^{-1}	B3:15 Kg.ha^{-1}	B2:10 Kg.ha^{-1}	B1:0 Kg.ha^{-1}	
490	577	572	448	365	A1:0 mg.L^{-1}
524	644	434	624	397	A2:250 mg.L^{-1}
565	569	478	634	580	A3:500 mg.L^{-1}
684	762	696	695	584	A4:750 mg.L^{-1}
	638	545	600	481	average B

Interaction	NPKnanofertilizer	Arginine acid	L.S.D 0.05
6.266	3.133	3.133	

Average dry weight of the vegetative growth (g. plant^{-1}):-

The results of Table (9) showed no significant differences between the concentrations of spraying with the amino acid arginine in the dry weight of the vegetative growth, as the fourth concentration of 750 mg. L-^{1} was excelled and gave the highest value of 3.73 g. plant-1, while control treatment gave the lowest value in the dry weight of the vegetative growth of 2.86 g. plant^{-1}.It also showed the presence of significant differences between the concentrations of spraying with the compound nano fertilizer NPK in the dry weight of the vegetative growth, as the third concentration of 15 kg. ha-1 was excelled and gave the highest value of 3.48 g. plant-1, while the second concentration of 10 kg. ha-1 gave the lowest value in the dry weight of the vegetative growth of 2.90 g. plant-1.The results of the same table also indicated that the interaction between the amino acid arginine and the nano-complex fertilizer NPK led to significant differences in the dry weight of the vegetative growth, as the interaction consisting of the fourth concentration of 750 mg.L^{-1} of the amino acid arginine and the third concentration of 15 kg.ha^{-1} of the nano-complex fertilizer NPK was excelled and gave the highest value for the dry weight of the vegetative growth, which amounted to 3.93 g.plant^{-1}, while control treatment achieved the lowest average for the dry weight of the vegetative growth, which amounted to 2.37 g.plant^{-1}. The reason for the increase is the role of nano-complex fertilizer in increasing some qualitative and quantitative traits such as the nitrogen content of the leaves and increasing the leaf area, Table (7), which leads to higher rates of absorption of CO2 and water to continue the photosynthesis process and withdraw nutrients from the soil, which leads to an increase in growth and dry weight of the vegetative growth. [12].

Table (9) Effect of spraying the amino acid arginine and the nano-complex fertilizer NPK and the interaction between them on the dry weight of the vegetative growth (g. plant^{-1}) of fenugreek plant.

average A	NPK nanofertilizer				Arginine acid
	B4:20 Kg.ha^{-1}	B3:15 Kg.ha^{-1}	B2:10 Kg.ha^{-1}	B1:0K g.ha^{-1}	
2.86	3.00	3.20	2.87	2.37	A1:0 mg.L^{-1}
3.16	3.37	3.77	2.53	2.97	A2:250 mg.L^{-1}
2.97	3.20	3.03	2.52	3.13	A3:500 mg.L^{-1}
3.73	3.93	3.93	3.67	3.37	A4:750 mg.L^{-1}
	3.37	3.48	2.90	2.96	average B

Interaction	NPK nanofertilizer	Arginine acid	L.S.D 0.05
0.784	0.392	0.392	

Total chlorophyll content of leaves (SPAD):-

The results of Table (10) showed significant differences between the concentrations of spraying with the amino acid arginine in trait of the total chlorophyll content of leaves (SPAD), as the concentration exceeded 750 mg. L^{-1} in total chlorophyll and gave the highest value of 50.53 SPAD, while control treatment gave the lowest value of 49.91 SPAD.

Significant differences were also observed between the concentrations of spraying with the compound nano fertilizer NPK in trait of the total chlorophyll content of leaves (SPAD), as the concentration of 10 kg. ha-1 gave the highest value in the average total chlorophyll content of leaves (SPAD) over the rest of the concentrations, which reached 50.65 SPAD, while control treatment gave the lowest rate of 49.47 SPAD.

The results of the same table also showed that the interaction between the amino acid arginine and the nano-complex fertilizer NPK led to significant differences in the leaf content of total chlorophyll (SPAD), as the interaction consisting of the fourth concentration of 750 mg. L-1 of the amino acid arginine and the fourth concentration of 20 kg. ha^{-1} of the nano-

complex fertilizer NPK was excelled and gave the highest leaf content of total chlorophyll (SPAD. 51.56 SPAD, while control treatment of the amino acid arginine and the nano-complex fertilizer NPK achieved the lowest average for the leaf content of chlorophyll, which amounted to 48.30 SPAD. Arginine affects the traits of vegetative growth and its important role in stimulating physiological and biological processes. Therefore, spraying it on the vegetative system leads to its easy absorption by the leaves and enables the plant to use it directly to increase cell building, increase carbohydrates, reduce (ABA), inhibit the activity of enzymes responsible for ethylene formation, and increase the biosynthesis of GA3 and IAA. Therefore, arginine increases cell growth and division, in addition to being a source of carbon, nitrogen and energy important for building most secondary and natural products such as alkaloids, phenolic acids and vitamins, in addition to its work to increase the percentage of chlorophyll in the leaves, as it is the source of nitrogen necessary for the formation of chlorophyll, in addition to its role in delaying leaf aging .[10].The reason for the increase may be due to the speed of arrival of nutrients added by foliar spraying through the stomata in the leaves, reaching the cells in a faster time, which helps in the speed and continuity of supplying nutrients and elements necessary for metabolic processes in the plant, including the construction of chlorophyll pigments .[19].

Table (10) Effect of spraying the amino acid arginine and the nano-complex fertilizer NPK and the interaction between them on the total chlorophyll content of leaves (SPAD) for fenugreek plants

average A	NPK nanofertilizer				Arginine acid
	B4:20 Kg.ha^{-1}	B3:15 Kg.ha^{-1}	B2:10 Kg.ha^{-1}	B1:0Kg.ha^{-1}	
49.91	50.37	50.18	50.77	48.30	A1:0 mg.L^{-1}
50.24	50.17	49.78	51.15	49.88	A2:250 mg.L^{-1}
50.0	48.9	50.21	50.8	50.07	A3:5
0	2		0		00 mg.L^{-1}
50.53	51.56	51.08	49.88	49.63	A4:750 mg.L^{-1}
	50.25	50.31	50.65	49.47	average B
Interaction		NPKnanofertilizer		Arginine acid	L.S.D $_{0.05}$
0.684		0.342		0.342	

Conclusions:-

1. Spraying with amino acid arginine improved the vegetative traits of fenugreek plant. Spraying with nano compound fertilizer NPK improved the vegetative traits of fenugreek plant. Treatment with spraying amino acid arginine at a concentration of 750 mg. L-1 and nano compound fertilizer NPK at a concentration of 20 kg. ha-1 gave the best results in most vegetative traits of fenugreek plant.

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