Response of some bean varieties *Phaseolus vulgaris* L. in the greenhouse and spraying with nano-zinc oxide on chemical characteristics

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Abstract

The study was conducted at the station of the Department of Horticulture and Garden Engineering / Greenhouse Unit of Tikrit University in the agricultural season 2023-2022. To study the response of four varieties of beans to spraying with zinc oxide nanoparticles at concentrations of 0, 50, 100 mg L^{-1} in Chemical characteristics of bean plants, The results showed significant differences between the varieties, as the Seychelles variety was superior to the rest of the varieties in each of the characteristics of estimating the leaves' content of phosphorus, potassium, and zinc, the percentage of proteins and sugars in the pods, and measuring the percentage of vitamin C in the pods. The Sonesta variety was superior to the rest of the varieties in the characteristic of the percentage of nitrates in the pods, as for spraying with nano-zinc oxide, spraying indicators at a concentration of 100 mg L^{-1} showed superiority in determining the leaf content of phosphorus, potassium, and zinc, and the percentage of proteins and sugars in the pods. Measuring the percentage of vitamin C in the pods. As for the characteristic of the percentage of nitrates in the pods, we note the superiority of the Sonesta variety in the non-spraying treatment with nano-zinc oxide, while the double reaction treatment between the variety and nano-zinc oxide outperformed the Seychelles variety and spraying with a concentration of 100 mg L^{-1} over all interactive treatments in the characteristics of the potassium and zinc content of the leaves. The percentage of proteins and sugars in the pods and measuring the percentage of vitamin C in the pods, As for the binary interaction treatment between the varieties and nano-zinc oxide in terms of leaf phosphorus content, the interaction between the Seychelles variety and spraying at concentrations of 50 and 100 mg L^{-1} was superior to all interaction treatments. As for the binary interaction treatment between the Sonesta variety and not spraying with nano-zinc oxide, it gave The lowest percentage of nitrate in the pods.

Keywords: bean varieties, nano-zinc oxide, chemical properties

Introduction

Phaseolus vulgaris L. is one of the plants of the Fabaceae family. The genus Phaseolus includes more than 150 species of annual and perennial plants [1]. It is considered a herbaceous plant that has grown around the world and is consumed as fresh pods (green pods) or as dry seeds. Over the course of 7,000 years, beans have evolved from a wild plant

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into one of the major crops. South America is considered the original homeland of beans [2]. and it is one of the vegetable crops rich in nutrients (carbohydrates 76 - 52%, protein 14 - % 33) Heated greenhouses can be defined as a sophisticated structure, it provides ideal conditions for plant growth throughout the year and growth factors, including light, are controlled. Food production in heated greenhouses is an additional alternative to meet the increasing demand for food around the world [3]. Heated greenhouses enable us to overcome climate diversity and store thermal energy to retain this heat for use during the night and on cloudy days. The lack of heating has harmful effects on the yield, quality and quantity of production [4]. Nanotechnology is one of the best techniques or means that lead to increasing yields and improving plant quality, and it deals with objects with dimensions ranging from (0.1-100) nanometers [5]. Zinc is an essential element that participates in many plant cell functions, and increases the plant's ability to absorb other elements from the soil [6]. and there are those who consider it the fourth most important nutrient that determines yield after nitrogen, phosphorus, and potassium [7]. It participates in many metabolic reactions for carbohydrates, proteins, and auxins within the plant body [8]. and it has an important role in plant productivity, both quantitatively and qualitatively, through its effect on the process of photosynthesis, nitrogen fixation, respiration, and other metabolic processes [9]. Many researchers have indicated the presence of genetic diversity in bean varieties, and Mexico is the center of genetic diversity for varieties and genotypes of common beans [10]. [11] stated that beans are one of the crops that show the most variation in characteristics in different environments, which helped in their production in a wide range of local environmental systems and conditions and the selection of the most suitable varieties for these agricultural systems.

Research Objectives

Study the response of bean plants to spraying with nano-zinc and its effect on chemical characteristics, the extent of success of newly introduced varieties for cultivation in the country in Salah al-Din Governorate, the effect of the interaction between the two study factors in giving the best chemical characteristics to bean plants.

Materials And Methods

The experiment was carried out in the Department of Horticulture and Garden Engineering / Greenhouse Unit, Faculty of Agriculture, Tikrit University, for the agricultural season 2023-2022. A plastic house with a length of 25 m, width of 9 m and height of 3.5 m was prepared and covered with yellow polyethylene thickness of 200 millimicrons with a distance of 2.5 m from each side of the house for ease of movement and then five terraces were identified for agriculture inside the house with a width of 60 cm and a distance of 1 m between the terraces. Then the irrigation pipe was erected by two pipes per terrace and the distance between one plant and another was 40 cm, the number of experimental units reached 36 units in the greenhouse and by 12 units per repeater and 3 repeaters were planted, the length of one experimental unit is 1.6 m. The experiment was carried out according to the design of the split plod design within the design of the complete random sectors RCBD (Randomized Complete Block Design), where the Item

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factor main plot and zinc oxide spraying with nanoscale parts occupied the secondary pieces as the most important.

Estimation of the mineral content of leaves

1- Estimating the phosphorus content of leaves%.

The concentration of phosphorus was measured according to the method [12], by taking 5 ml from the flask of the digested sample mentioned above and treating it according to the Spectrophotometric Vanadium Phosphomolybdate Method to measure the visible density of phosphorus using a spectrophotometer (type - Bichrom 2005 Libra S22 - UK) at a wavelength of 420 nm, and using the standard phosphorus curve, the phosphorus concentration was extracted and then its percentage was estimated.

2-Estimating the potassium content of leaves%.

Potassium was determined according to the method nof [13] using a flame emission spectrometer.

3- Determination of zinc content of leaves (mg kg^{-1})

The concentration of zinc was measured according to the method [12] by taking 5 ml from the beaker of the digested sample and adding 95 ml of ion-free distilled water to it, and using an atomic absorption spectrometer at a wavelength of (284.56) nm. The wavelength of zinc was measured, and using a curve Standard zinc element concentration was calculated.

4- Percentage of proteins in pods%.

A fixed weight of 0.5 grams was taken from each ground sample, and then the sample was digested using sulfuric acid (H2So4, concentrated 98%) and hydrogen peroxide (H2O2). After the digestion process was completed, the digested sample was transferred to a 100 ml volumetric flask and supplemented with distilled water to The mark limit, and the nitrogen in the sample was estimated using a Micro Kjeldahl device, then the protein percentage was calculated according to the method of [14].

5- Percentage of sugars in pods %.

The percentage of sugars in the fruits was measured as stated in [15]

6- Percentage of nitrate in pods %.

The trait was measured with a spectrophotometer at a wavelength of 395 nm .according to the method of [16]

7- Measuring the percentage of vitamin C in the corns (mg g^{-1}).

Vitamin C was estimated by reducing the dye Dichlorophenol by taking 5 grams of the sample with 50 ml of 6% oxalic acid. After that, 10 ml of it was taken and the volume was completed to 50 ml of 3% oxalic acid [17]

Study Factors

The first factor: the varieties. Sonesta, Ferrari Polish origin, Gia Bean American, Seychelles Dutch origin.

The second factor: zinc oxide nanoparticles. Spraying with zinc oxide nanoparticles According to the following concentrations without spraying, spraying at a concentration of 50 mg L^{-1} and spraying at a concentration of 100 mg L^{-1} and with three sprays, the date of the first spray was 30 days after planting and the second and third spraying 7 days after the previous spray.

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Table (1) Physical and chemical properties of field soil before planting

Physical and chemical qualities of the soil	Unit	the Value	Physical and chemical qualities of the soil	Unit	the Value
Phosphorus	mg L^{-1}	11.2	pH		7.8
Potassium	mg L^{-1}	31	OM	%	1.3
Nitrogen	mg L^{-1}	12.4	Sand	%	29.8
Gypsum	%	7.7	Silt	%	51.5
Lime	%	23.4	Clay	%	18.7
Ec	Milli unit	2.3	Soil texture		Celtic Lomia

Studies Characteristics

Estimating the phosphorus content of leaves %, estimating the potassium content of leaves %, estimating the leaves content of zinc mg kg^{-1}, the percentage of proteins in the pods %, the percentage of sugars in the pods %, the percentage of nitrates in the pods %, measuring the percentage of vitamin C in Pods mg g^{-1}.

Results And Discussion

1- The effect of cultivar on the chemical characteristics of bean plants.

Table 2 shows the occurrence of significant differences between the bean varieties, as it is noted that the Seychelles variety is significantly superior to the rest of the varieties in each of the characteristics of estimating the leaf content of phosphorus, potassium, and zinc, the percentage of proteins and sugars in the pods, and measuring the percentage of vitamin C in the pods, and it gave the highest values of 0.375%, 2.438%, 13.434 mg kg^{-1}, 12.184%, 0.310%, and 27.28 mg g^{-1}, respectively, compared to the lowest values for the traits. Estimation of the leaf content of phosphorus, potassium, zinc, percentage of proteins and sugars, and the percentage of vitamin C in the pods of the Sonesta variety amounted to 0.181%, 1.764%, 8.926 mg. kg^{-1}, 9.463%, 0.169%, and 22.96 mg g^{-1}, respectively. As for the Sonesta variety, it was significantly superior to the rest of the varieties in terms of the percentage of nitrates in the pods, achieving the lowest value of 0.211% compared to the highest nitrate content of the Seychelles variety, which was 0.271%.

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Table (2) The effect of varieties on the chemical characteristics of bean plants

qualities / varieties	Phosphorus content of leaves %	Potassium content of leaves%	Zinc content of leaves mg kg^{-1}	Proteins in pods%	Sugars in pods%	Nitrates in % pods	Vitamin C in the pods mg g^{-1}
Sonesta	0.181 d	1.764 c	8.926 d	9.463 c	0.169 d	0.211 c	22.96 c
Ferrari	0.205 c	1.986 b	9.565 c	10.685 b	0.200 c	0.227 b	23.85 bc
Gia Bean	0.245 b	1.994 b	10.631 b	11.687 ab	0.252 b	0.268 a	24.39 b
Seychelles	0.357 a	2.438 a	13.434 a	12.184 a	0.310 a	0.271 a	27.28 a

Averages with the same alphabet for single factors and their overlaps do not differ significantly according to the Dunkin' polynomial test at a probability level of 0.05

2-The effect of spraying with nano-zinc oxide on the chemical characteristics of bean plants

Table 3 shows the effect of spraying with nano-zinc oxide on the characteristics of estimating the leaves' content of phosphorus, potassium, and zinc, the percentage of proteins and sugars in the pods, and measuring the percentage of vitamin C in the pods. The table shows that spraying with a concentration of 100 mg L^{-1} was superior to the above characteristics and gave the highest values of 0.293%. 2.307%, 12.395 mg kg^{-1}, 12.063%, 0.282%, 27.55 mg kg^{-1}, respectively, compared with the lowest values achieved from the non-spraying treatment with nano-zinc oxide for the characteristics. Estimating the leaf content of phosphorus, potassium, and zinc, and the percentage of proteins and sugars in the pods and measuring The percentage of vitamin C in the pods reached 0.193%, 1.700%, 8.646 mg kg^{-1}, 9.668%, 0.177%, and 21.67 mg kg^{-1}, respectively. As for the percentage of nitrate in the pods, we note that the non-spraying treatment with nano-zinc oxide achieved The lowest value for the characteristic was 0.196% compared to the highest value when spraying at a concentration of 100 mg L^{-1}, which was 0.287%.

Table (3) Effect of spraying with nano-zinc oxide on the chemical characteristics of bean plants

qualities / Zno Nps	Phosphorus content of leaves %	Potassium content of leaves%	Zinc content of leaves mg kg^{-1}	Proteins in % pods	Sugars in pods%	Nitrates in % pods	Vitamin C in the pods mg g^{-1}
0	0.193 c	1.700 c	8.646 c	9.668 c	0.177 c	0.196 c	21.67 c
50 mg L^{-1}	0.255 b	1.979 b	10.875 b	11.283 b	0.239 b	0.250 b	24.64 b
100 mg L^{-1}	0.293 a	2.307 a	12.395 a	12.063 a	0.282 a	0.287 a	27.55 a

Averages with the same alphabet for single factors and their overlaps do not differ significantly according to the Dunkin' polynomial test at a probability level of 0.05

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3-The effect of interaction between varieties and spraying with nano-zinc oxide on the chemical characteristics of bean plants.

The results of Table 4 indicate that there are significant differences when treating the binary interaction between the variety and nano-zinc oxide, as the Seychelles variety and spraying at a concentration of 100 mg L^{-1} excelled in all the interaction coefficients in each of the characteristics of the leaf content of potassium and zinc, the percentage of proteins and sugars in the pods, and the measurement of the percentage of vitamins. C in the pods and gave the highest values amounting to 2.841%, 16.005 mg kg^{-1}, 14.528%, 0.383%, and 30.98 mg g^{-1}, respectively, compared with the lowest values of the interaction between the Sonesta variety and not treated with nano-zinc oxide for the characteristics: leaf content of potassium and zinc and percentage. For proteins and sugars in the pods, the percentage of vitamin C in the pods was measured at 1.546%, 6.698 mg kg^{-1}, 8.383%, 0.131%, 20.44 mg kg^{-1}, As for the double interaction treatment between the Seychelles variety and spraying at a concentration of 50 and 100 mg L^{-1}, it outperformed all the interaction treatments and gave the highest value in the phosphorus content of the leaves, amounting to 0.391 and 0.431%, respectively, compared to the lowest value when interacting between the Sonesta variety and not spraying. With nano-zinc oxide, it reached 0.158%. Regarding the double interaction treatment between the Sonesta variety and not spraying with nano-zinc oxide, it gave the lowest percentage of nitrates in the pods. which amounted to 0.170%, compared to the highest value when interacting between the Seychelles variety and spraying at a concentration of 100 mg L^{-1}, which amounted to 0.313%.

Table (4) Effect of interaction between varieties and spraying with nano-zinc oxide on the chemical characteristics of bean plants

qualities / Zno Nps		Phosphorus content of leaves %	Potassium content of leaves%	Zinc content of leaves mg kg^{-1}	Proteins in pods%	Sugars in pods%	Nitrates in % pods	Vitamin C in the pods mg g^{-1}
Sonesta	0	0.158 f	1.546 g	6.698 g	8.383 g	0.131 h	0.170 e	20.44 f
	50 mg L^{-1}	0.176 ef	1.806 de	8.936 ef	9.978 ef	0.163 g	0.218 d	23.47 e
	100 mg L^{-1}	0.210 cde	1.941 cd	11.145 cd	10.030 ef	0.215 e	0.246 c	24.98 d
Ferrari	0	0.171 ef	1.595 fg	7.491 fg	9.551 f	0.158 g	0.180 e	20.84 f
	50 mg L^{-1}	0.216 de	1.711 ef	9.393 de	11.110 cd	0.228 de	0.243 c	23.10 e
	100 mg L^{-1}	0.230 cd	2.053 c	11.811 cb	11.395 c	0.215 e	0.260bc	27.61 c
Gia Bean	0	0.196 def	1.656 fg	9.496 de	10.453 de	0.185 f	0.213 d	22.64 e
	50 mg L^{-1}	0.238 cd	1.931 cd	11.776 bc	12.308 b	0.255 c	0.280 b	23.90 de
	100 mg L^{-1}	0.301 b	2.396 b	10.621 de	12.301 b	0.316 b	0.313 a	26.65 c
Seychelles	0	0.250 c	2.006 c	10.901 cd	10.288def	0.235 d	0.221 d	22.79 e
	50 mg L^{-1}	0.391 a	2.468 b	13.396 b	11.738 bc	0.313 b	0.261bc	28.09 b
	100 mg L^{-1}	0.431 a	2.841 a	16.005 a	14.528 a	0.383 a	0.331 a	30.98 a

Averages with the same alphabet for single factors and their overlaps do not differ significantly according to the Dunkin' polynomial test at a probability level of 0.05

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Conclusion

It is clear to us from the results of the statistical analysis that there was a significant superiority when treating the varieties, as the Seychelles variety excelled in each of the traits in estimating the content of leaves of phosphorus, potassium, and zinc, the percentage of proteins and sugars in the pods, and measuring the percentage of vitamin C in the pods, and the Sonesta variety was significantly superior. The percentage of nitrate in the pods is shown in Table 2 for the rest of the varieties. The reason may be attributed to the occurrence of differences in the genetic structure between the bean varieties, which differed significantly from each other in chemical characteristics. This discrepancy may be explained by the presence of genetic variation between the varieties [18] . This is in line with [19] . There is a significant difference between the varieties in the percentage of phosphorus in the leaves and the percentage of protein in the pods. The reason is due to the difference in the genetic content of the varieties in addition to the environmental conditions that affect the varieties in different ways from one variety to another, which led to increased plant growth and increased concentration of elements, and this is consistent with [20]. increasing plant activity and efficiency from one variety to another and increasing respiration and transpiration will be the result of increasing the plant's ability to improve vegetative growth and may be attributed to increasing the root content, which may cause increased absorption of nutrients, and this in turn will cause an increase in the percentage of nutrients such as nitrogen and phosphorus. And potassium and its accumulation in plant tissues and the entry of these elements in its elongation and cell division [21] .The variation of varieties in the content of nutrients is due to the influence of genetic factors and the gene responsible for absorbing elements within the genome complex of the variety, as well as its interaction with the prevailing environmental conditions in the area where the experiment was carried out and the response of the varieties to these conditions. Likewise, the superiority of the varieties in the characteristics of plant height, wet and dry weight of the shoots, and chlorophyll content. Total and leaf area, which was directly and positively reflected in its efficiency in absorbing and assimilating nutrients throughout its life cycle. This result is consistent with [22] and [23] in faba beans, [24] in cowpeas, and [25] and the results show us that there is a significant increase when spraying with nano-zinc oxide. At a concentration of 100 mg L^{-1} in each of the characteristics of the leaf content of phosphorus, potassium, and zinc, the percentage of proteins and sugars in the pods, and measuring the percentage of vitamin C in the pods, Zinc is a cofactor for many enzymes that participate in the metabolism of carbohydrates and proteins, so it plays a vital role in the processes of metabolism. Various metabolism, including carbohydrate and protein metabolism, these enzymes are responsible for the processes of protein synthesis. Zinc helps these enzymes function properly and is therefore essential for these metabolic pathways [26]. The superiority in the percentage of protein may be due to the role of zinc in activating many enzymes that have an important role in the production of nucleic acids that contribute to increasing the absorption of nitrogen, which leads to an

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increase in its content in the leaves and thus an increase in the percentage of protein [27] and this result agreed with [28]. and the reason may also be attributed to the role of zinc in increasing the activation of enzymatic reactions, regulating protein and carbohydrate metabolism, and the biosynthesis of plant hormones, especially auxins, which are produced at the tops of branches and work to regulate cell elongation and thus increase growth rates [29]. Zinc also plays a role in the formation of chlorophyll, amino acids, and carbohydrates [30].

Recommendations

Through this study, it was found that the best results achieved for chemical characteristics were for the Seychelles variety using spraying with a concentration of 100 mg L^{-1} of zinc oxide nanoparticles. Therefore, it is recommended that further studies be conducted in the future using other types and different concentrations of ZnO nanoparticles.

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