

Effect of Cultivars, Apical Pinching and Copper Nano-Fertilizer on Green Pods Characteristics of Broad Bean (*Vicia faba* L.) was Fadhiliya area

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ABSTRACT

The study was Fadhiliya area (2021). The experiment included a study of three factors, the first of which was the use of three different bean sprout cultivars (Spanish, American, and Dutch), the second of which was the condition of apical pinching (apical pinching and without pinching), and the third of which was the use of copper Nano-fertilizer at three different concentrations (zero, 1, and 1.5 milligrams per liter), for a total of 18 (treatments) (2 x 3 x 3). Research was conducted in the field using a factorial experiment with split-plots in R.C.B.D. Varieties were planted in the main plots, and the correlation between pinching and copper Nano-fertilizer concentrations was observed in the sub-plots. The Duncan multiple range test, with a 5% significance level, was used to analyze the data and compare the means. This is how the findings add up: A- Dutch cultivar plants were significantly superior in the number of pods, while the plants of the American cultivar were superior in the yield of pods, while the Spanish and American cultivars were superior in the characteristic of pod weight and length of the pod. B- The treatment of apical pinching excelled in all the studied traits compared to the treatment of no pinching. C- The use of copper Nano-fertilizer at two concentrations of 1 and 1.5 g L⁻¹ resulted in significant effects on all the studied traits compared to the comparison plants. D- Most of the effects of the binary and triple interactions of the studied factors were consistent with the single effect of each factor for most of the previous characteristics.

1. Introduction

One of the legume family of plants, the broad bean (*Vicia faba* L.) (Fabaceae). Produced primarily in China and Ethiopia, it is the fourth most important grain crop overall, after chickpeas, lentils, and peas, and helps ensure food security in some regions [1]. This is because it naturally coexists with rhizobium bacteria, which improves soil properties and fixes atmospheric nitrogen. Each 100 grams of these seeds contains 72.6 grams of water, 0.73 grams of fat, 17.63 grams of carbohydrates, 7.5 grams of fiber, 1.55 milligrams of iron, 1.55 milligrams of magnesium, 129 milligrams of phosphorus, 332 milligrams of potassium, 3.7 milligrams of vitamin C, 0.133 milligrams of thiamine, 0.104 milligrams of vitamin B, 17 milligrams of vitamin A, and 88 calories. The exact numbers are dependent on the cultivar and growing circumstances. Protein levels in the dry seeds are between 15 and 21 percent. Choosing the right cultivar for each environment is fundamentally important for the success of the agricultural process and for obtaining high production in quantity and quality, and so plant breeders and producers strive to introduce new varieties of high production and adaptation. In accordance with regional circumstances, which provide the foundation for increasing the crop's cultivated area [2-5].

In recent years, the world has tended to study several modern technologies in the agricultural field, especially the study of the possibility of using nanotechnology to improve the efficiency of fertilizer use towards manufacturing and developing what is known as Nano-fertilizers [6,7]. The use of Nano-fertilizers leads to an increase in plant productivity by increasing the absorption of nutrients [8]. It also significantly improves the growth of roots and seedlings and enhances the metabolism of the plant [9,10].

Recently, the idea of using fertilizers manufactured using nanotechnology has been adopted, which it is hoped will solve the problem of excessive use of conventional fertilizers [11,12]. Many studies indicated that there is strong competition for nutrients between the reproductive and vegetative parts and it is necessary to find some operations that aim to provide nutrients for the reproductive parts for the purpose of increasing production and improving quality ,the most important of these operations is pinching the growing tip of the main stem and side branches, as this process achieves the perfect balance between the vegetative and reproductive system and contributes to giving a large crop of good quality [13].

1.1. Research Aims

Evaluation and behavioral study of three cultivars of broad bean under the conditions of Nineveh Governorate, in order to choose which one is best suitable for cultivation under the conditions of the region, study the apical pinching in order to raise and improve Characteristics of vegetative growth of broad bean, and to find the best concentration of Nano-copper fertilizer that plants respond to and affect the vegetative growth characteristics, and to find the best triple overlap between cultivars , planting distances and boron Nano fertilizer concentrations.

2. Methodology

During the 2021 growing season, researchers from the conducted an experiment in the Fadiliya area. The experiment examined the effects of three variables: first, three different broad bean seed cultivars (Spanish, American, and Dutch), second, two different apical pinching conditions (apical pinching, and no apical pinching), and third, three different concentrations of copper nano-fertilizer (0, 1, and 1.5 g L⁻¹), Nano-fertilizer was applied to the plants at three different stages: immediately after complete germination (30 days), mid-growth (15 days), and late-growth (30 days).

Thus, this experiment included 18 treatments with three replications, using a factorial experiment within split-plots in R.C.B.D, varieties were placed in the main plots and the correspondence between pinching and copper Nano-fertilizer concentrations in sub-plots. Four ridges were among the experimental units that were created by dividing the land., 1.8 m long and 75 cm wide. The area of the experimental unit was 5.4 m², the seeds were planted in the field on 9/12/2021 at a distance of 30 cm between one seed and another in the upper third and on one side of the ridges, number of plants 24 plants/experimental unit. The agricultural activities were conducted naturally and in accordance with the guidelines utilized in the broad bean cultivation and production.

All treatments were fertilized with urea (46% nitrogen) potassium sulfate (48% K₂O) rates of 100 kg ha⁻¹, triple superphosphate (45% P₂O), 150 kg ha⁻¹, and 150 kg K₂O per hectare, respectively in three stag : first 15 days after planting, with all of the phosphate fertilizer applied, second, following the completion of field emergence, with all of the potassium fertilizer applied, third, following a month from the second, with the second half of the nitrogen fertilizer applied.. The data were statistically analysed according to the [14] based on the Duncan's test's methodology for the probability level of 0.01- 0.05[15].

1.2. Studied Traits

- Pods number.
- Pods length.
- Pod weight.
- Pods yield.

3. Results and Discussion

1.3 Pods Number (pod plant⁻¹)

According to the data in table (1), Dutch cultivar plants produced much more pods than their Spanish and American counterparts. When comparing non-pinched and pinched plants with their growing tips, the data in the table demonstrates that pinching has a far more favorable influence on the targeted trait. Compared to the control treatment, treatments with 1 and 1.5 g. L⁻¹ of copper nanoparticles greatly increased this property, whereas treatments with greater concentrations of this fertilizer showed no significant difference. As for the interaction between the cultivars and the pinching, the results show that the highest value in the number of pods reached 14.25 pods plant⁻¹ in the case of Dutch cultivar plants with the pinching treatment, and this interaction treatment was significantly superior to all treatments of this interaction. According to the results of the bilateral interaction between the cultivars and the Nano-copper fertilizer, the Dutch cultivar plants that used the Nano-copper fertilizer at a concentration of 1.5 g L⁻¹ recorded the highest value in the number of pods, amounting to 13.63 pods plant⁻¹, significantly outperforming all treatments of this interaction. According to the results of the bilateral interaction between pinching and copper Nano-fertilizer in terms of pod yield, the best treatment by a wide margin was the combination of pinching and a concentration of 1.5 mg L⁻¹ of copper Nano-fertilizer, which yielded 13.08 pods plant⁻¹. Except for the treatment of the same interaction at a

dose of 1 mg L⁻¹, the lowest value in this feature amounted to 7.50 pods plant⁻¹ when neither pinching nor adding copper Nano-fertilizer was used. The highest value in this trait, 16.00 pods plant⁻¹, was found in Dutch cultivar plants subjected to pinching treatment with a concentration of 1 g L⁻¹ of copper Nano-fertilizer, while the lowest value, 5.67 pods plant⁻¹, was recorded in the Spanish cultivar plants without pinching.

Table 1. Effect of cultivars, Case of pinching, Nano-copper fertilizer and the interaction between them on pods number (pod plant⁻¹).

Cultivars	Case of pinching	Concentration of Nano- copper fertilizer			Cultivars X	Average effect of Cultivars
		0	1	1.5		
Spanish	Without	5.67 g	8.25 ef	11.75 bc	8.56	9.81
	pinching	9.17 d-f	11.50 b-d	12.50 b	11.06 ^c	
American	Without	7.33 fg	10.00 b-e	10.75b-d	9.36 ^b	10.43
	pinching	11.5 b-d	11.50 b-d	11.50 b	11.50 ^c	
Dutch	Without	9.50 c-f	11.25 b-d	12.00 bc	10.92 ^b	12.58
	pinching	11.5 b-d	16.00 a	15.25 a	14.25 ^b	
Cultivars X Nano- copper fertilizer	Spanish	7.42 e	9.88 cd	12.13 ab	a	Average effect of pinching case
	American	9.42 d	9.83 c	11.50 b		
	Dutch	10.50 b-d	13.63 a	13.63 a		
Case of pinching X Nano- copper fertilizer	Without	7.50d	9.83c	11.50b	9.61	Average effect of Nano- copper fertilizer
	pinching	10.72 bc	13.00a	13.0a	12.27 ^b	
		9.11b	11.42 a	12.2a	a	

Averages that share the same letter for each factor and each interaction do not differ significantly between them according to Duncan's polynomial test at the probability level ($P < 0.05$).

1.3. Pods Length (cm pod⁻¹)

Table (2) shows that when comparing different cultivars, the Spanish and American cultivars clearly outperforms the Dutch cultivar in terms of pod length. When comparing the effects of pinching and not pinching on this trait, the table shows that pinched plants fare better when treated at the growth tip than their non-pinched counterparts. Treatment with 1 and 1.5 g.L⁻¹ of Nano-copper resulted in a statistically significant increase in this feature compared to the comparison treatment, but the differences between the two concentrations of this nano-fertilizer did not achieve statistical significance. When looking at the overlap between cultivars and pinching treatment, the data show that the Spanish cultivar plants with the pinching treatment had

the longest pods at 25.29cm pod-1. The Spanish variety plants and the usage of Nano-copper fertilizer at a concentration of 1 g L-1 recorded the greatest value in the pod length of 25.39 cm, according to the findings of the bilateral interaction between the cultivars and the fertilizer. The lowest value in pod length was recorded in Dutch cultivar plants in the control treatment, at 16.87cm, pod-1, when treated with copper Nano-fertilizer. The highest value in pod length was found in the overlap between the pinching treatment and the concentration of 1.5 g L-1 of copper Nano-fertilizer, amounting to 23.65cm pod-1, while the lowest value in this characteristic amounted to 16.70cm was found when the treatment of no pinching and not adding copper Nano-fertilizer. The highest value in this trait, 26.16cm pod-1, was found in plants of the Spanish variety when non-pinching was used in conjunction with a concentration of 1.5 g L-1 of copper Nano-fertilizer, making this treatment significantly better than most treatments in this overlap. In contrast, the lowest value in this trait, 15.58cm Pod-1, was recorded in the American cultivation.

Table 2. Effect of cultivars, Case of pinching, Nano-copper fertilizer and the interaction between them on Pods length (pod plant-1).

Cultivars	Case of pinching	Concentration of Nano- copper fertilizer			Cultivars X Case of pinching	Average effect of Cultivars
		0	1	1.5		
Spanish	Without pinching	17.33 d	25.44ab	26.16a	22.44 ab	23.87 a
	pinching	24.55ab	25.33ab	24.39ab	25.29 a	
American	Without pinching	15.58 d	23.49ab	23.67ab	20.91 b	22.08 a
	pinching	25.25ab	23.05ab	21.41bc	23.24 ab	
Dutch	Without pinching	17.19d	17.66cd	16.3 d	17.06 c	18.57 b
	pinching	16.5d	18.55cd	25.16ab	20.09 b	
Cultivars X Nano- copper fertilizer	Spanish	21.7b-d	25.39 a	24.47ab	Average effect of pinching case	
	American	20.42de	23.27a-c	22.54b-d		
	Dutch	16.8f	18.11ef	20.75c-e		
Case of pinching X Nano- copper fertilizer	Without pinching	16.70b	22.20a	21.52 a	22.84b	
	pinching	22.65a	22.31a	23.65 a	24.04a	
Average effect of Nano- copper fertilizer		19.68b	22.26a	22.59 a		

Averages that share the same letter for each factor and each interaction do not differ significantly between them according to Duncan's polynomial test at the probability level (P < 0.05).

1.4. Pod Weight (g pod-1)

Table (3) shows that when comparing average pod weight, the Spanish and American cultivars clearly outperformed the Dutch cultivar, while showing no significant differences amongst themselves. With regards to how pinching affects this trait, the data in the table clearly demonstrate that pinch-treated plants do better than their non-pinched counterparts when it comes to this particular aspect. In terms of the impact of Nano-copper fertilizer, the findings suggest that a considerable improvement in this quality follows treatment with a concentration of 1 and 1.5 g.L-1 Nano copper. As for the two-way interaction between cultivars and pinching condition, the data show that the Spanish cultivar under pinching conditions yielded the heaviest pods, with an average weight of 32.36g pod-1. According to the results of the bilateral interaction between the cultivars and the copper Nano-fertilizer, plants of the American variety grown with 1.5 g L-1 of copper Nano-fertilizer recorded the highest value in average pod weight (35.94 g), significantly outperforming some treatments dependent on this interaction.

The lowest value was recorded by plants of the Dutch cultivar grown in the comparison treatment. In terms of average pod weight, the results of the bilateral interaction between pinching and copper Nano-fertilizer indicate that the highest value in this characteristic was found in the case of overlap between the treatment of pinching and the concentration of 1 g L-1 of copper Nano-fertilizer, amounting to 33.65 g pod-1, and that this treatment was significantly superior to all treatments the others . According to the results of the triple interaction between the factors studied in the average pod weight, the highest value in this trait was 41.08g pod-1 found in the plants of the American cultivar and when using the pinching treatment and concentration of 1.5 g L-1 of copper, making this treatment significantly superior to some treatments of this interaction. The lowest value in this trait was recorded in the plants of the Dutch cultivar and the pi treatment, at 17.96g Pod-1.

Table 3. Effect of cultivars, Case of pinching, Nano-copper fertilizer and the interaction between them on Pod weight (g pod-1).

Cultivars	Case of pinching	Concentration of Nano- copper fertilizer			Cultivars X Case of pinching	Average effect of Cultivars
		0	1	1.5		
Spanish	Without pinching	24.95c-f	23.90c-g	27.03b-d	25.29bc	28.90a
	pinching	26.98c-f	40.98a	29.11bc	32.36a	
American	Without pinching	24.92c-f	34.95ab	25.41c-f	28.43ab	29.08a
	pinching	19.95e-g	27.88b-d	41.08a	29.63ab	
Dutch	Without pinching	17.96g	19.85fg	20.02d-g	19.28d	21.66b
	pinching	19.94fg	25.76c-f	27.09b-e	24.27c	
Cultivars X Nano- copper fertilizer	Spanish	25.59cd	34.21a	25.91bc	Average effect of pinching case	
	American	22.21c-e	31.09ab	35.94a		
	Dutch	19.55e	21.36de	23.05c-e		

Case of pinching	Without pinching	21.30c	24.12c	28.30b	24.57b
X					
Nano- copper fertilizer	pinching	23.61c	33.65a	28.30b	28.52a
Average effect of Nano-copper fertilizer		22.4b	28.8a	28.30a	

Averages that share the same letter for each factor and each interaction do not differ significantly between them according to Duncan's polynomial test at the probability level ($P < 0.05$).

1.5. Pods Yield (g plant-1)

Based on the data shown in the table (4), the American cultivar produced much more pods per plant than the Dutch and Spanish cultivars. In terms of how the pinching condition affects this trait, the data in the table demonstrate that the pinched plants benefit more from having their growth tips cared for than the non-pinched plants do. The findings for copper nanofertilizer show that both 1 and 1.5 g. L-1 of copper nanoparticles significantly increased this feature compared to the control treatment. As for the two-way interaction between cultivars and pinching condition, the data show that the American cultivar under pinching conditions yielded the heaviest pods, with an average weight of 332.29g pod-1.. According to the results of the two-way interaction between cultivars and copper Nano-fertilizer, plants of the American variety treated with 1.5 g L-1 of copper Nano-fertilizer recorded the highest value in pod yield for the plant, at 378.43g plant-1, significantly outperforming all treatments in the comparison plants, and plants of the Spanish cultivar recorded the lowest value, at 186.31g plant-1. In terms of yield of plant pods, the results of the bilateral interaction between the case of pinching and the concentration of 1.5 g L-1 of copper show that the highest value in this trait was found in the case of interaction between the treatment of pinching and the concentration of 1.5 g L-1 of copper, amounting to 358.49g plant-1. Not pinching and not adding copper Nano-fertilizer yielded the lowest value, amounting to 171.48g plant-1. The maximum pod output of 457.67g plant-1 was seen in American cultivar plants grown with the pinching treatment and a concentration of 1.5 g L-1 of copper Nano-fertilizer, demonstrating that this treatment was considerably superior to other treatments evaluated. The lowest value in this characteristic was found in plants of the Spanish cultivar and the non-pinching comparator plants when copper Nano-fertilizer was not utilized.

Table 4. The impact of cultivars, pinching, nano-copper fertilizer, and their interaction on pod yield (g plant-1).

Cultivars	Case of pinching	Concentration of Nano- copper fertilizer			Cultivars X	Average effect of Cultivars
		0	1	1.5		
Spanish	Without pinching	148.40 g	338.03 bc	343.79 b	276.74 h	275.24 b
	pinching	224.21 f	298.29 c-e	298.71 c-e	273.74 h	
	Average effect of pinching case					
American	Without pinching	179.30 g	340.87 b	299.20 c-e	273.13 h	302.71 a
	pinching	225.37 f	313.83 b-d	457.67 a	332.29 h	
	Average effect of pinching case					
Dutch	Without pinching	186.74 fg	287.70 de	323.14 b-d	265.86 h	268.70 b
	pinching	223.85 f	271.66 e	319.10 b-d	271.54 h	
	Average effect of pinching case					
Cultivars	Spanish	186.31 d	318.16 b	321.25 b	Average effect of pinching case	
	American	202.33 d	327.35 b	378.43 a		

X	Dutch	205.29	279.68	321.12	
		d	c	b	
Nano- copper Case of pinching	Without	171.48	322.20	322.04	271.91
		e	b	b	
X	pinching	224.47	294.59	358.49	292.52
Nano- copper	pinching	d	c	a	
Average effect of Nano- copper fertilizer		197.97c	308.40	340.27	
		c	b	a	

Averages that share the same letter for each factor and each interaction do not differ significantly between them according to Duncan's polynomial test at the probability level ($P < 0.05$).

The differences between the varieties under study in the studied growth characteristics may be explained by the fact that the genetic and phenotypic diversity in the studied traits leads, therefore, to the high heritability of those traits increasing most of the growth indicators in the case of using the pinching process, perhaps due to the fact that it results from pinching the growing tip, a decrease in Auxin production in the apical bud, an increase in the distribution of nutrients and their growth on the lateral buds, and an increase in branching [16], and significant increases in the traits in which Nano-fertilization was used it may be attributed to the fact that foliar application with copper has an important role in improving plant performance and that its deficiency causes a defect in plant growth through its participation in the photophosphorylation process in photosynthesis and redox processes in the chain transport electron (in aerobic respiration) [17,18].

4. Conclusion

This research concludes that using the tip-pinching technique with Nano-copper fertilizer significantly increased all study characteristics. As a result, we advise using copper Nano-fertilizer and a pinching procedure while growing broad beans in fields, as was done in this research.

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