Effect of Nano Potassium and Cytokinins in the Vegetative Growth Traits of Faba Bean (*Vicia faba* L.)

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Abstract. A field experiment was carried out at the Al-Hsai District / Falluja City / Al-Anbar Province during the winter season 2020-2021. To study the effect of Nano potassium (NK) and Cytokinin (CTK) on the growth, and quality of the local cultivar of faba bean. Split plot system was used according to the design of a completely randomized block design R.C.B.D and three replications. The main blocks included four concentrations of CTK; 0, 50, 100, and 150 mg. L^{-1}, while the secondary blocks included four concentrations of NP; 0, 1, 2, and 3 g.L^{-1}. The results of the experiment were summarized as follows: The NK concentrations influenced all the studied properties. Where the concentration of 2 g.L^{-1} affected most of the studied properties, like the plant height of 122.9 cm, the number of branches per plant of 14.34 branches. plant^{-1}, the number of leaves per plant of 157.9 leaves. plant^{-1}, leaf area 4918 cm² plant^{-1}, and leaf content of chlorophyll of 48.28 SPAD, while the control treatment outperformed in the trait of flowering beginning with the lowest average number of days (61.67 days). The CTK concentration of 100 mg. L^{-1} affected significantly on most of the studied traits. Where it prevails in plant height of 130.97 cm, number of branches per plant 13.55 branches. plant^{-1}, number of leaves per plant of 165.5 leaves. plant^{-1}, and LA of 5689 cm². Plant^{-1}. The highest level of Leaf chlorophyll content of 44.98 SPAD was found in the CTK concentration of 50 mg. L^{-1}, which was not significantly different from 150 mg.L^{-1}. Whereas the lowest number of days from cultivation to flowering starts of 62.58 days were found at control treatment. The interaction between NK and CTK has affected most of the studied traits, as the interaction of 2 gm. L^{-1} and 100 mg. L^{-1} (NK x CTK) has the highest average of plant height (158 cm) and number of leaves per plant (186.1 leaves. plant^{-1}). Whereas the interaction between 1 gm. L^{-1} NP and 50 gm. L^{-1} CTK has the highest number of branches per plant 16.61 branches. Plant^{-1}. Moreover, the highest average of LA (6812 cm² plant^{-1}) was found in the interaction between 1 gm. L^{-1} NP and 100 mg.L^{-1} CTK. The highest Leaf chlorophyll content of 56.53 SPAD was found in the interaction of 2 gm. L^{-1} of NP and 50 gm.L^{-1} of CTK. Whereas, the same interaction has an insignificant difference on number of days from cultivation to flowering starts trait.

1. Introduction

*Vicia faba* L. is the main pod crop that's featured with a high protein content that ranges between 25 – 40%, to be the main source in human nutrition, in addition to its high carbohydrate content; so, it is an important component of needy nation’s food [1]. Faba bean is usually cultured as a soil nitrogen content regenerating crop via rhizome-nodes that transform it to absorbable nitrogen; so, it enhances its agricultural properties[2]. The Iraqi total production reached 7000 tons of seeds as 777.8 kg.donm⁻¹ [3]. Despite if this crop's importance and being cultured in Iraq so long time ago, it still suffers from
many problems; the first of them is the low productivity due to the high percentage of fell flowers at the season end, which caused a big drop in this field productivity. The fell flowers percentage this season reached (76 – 80%) of total flowers. This raised percentage would decrease its productivity [4].

The nano fertilizer is regarded as active and environment-friendly. Their utility technique is still under experience in Iraq, compared with the surrounding countries like KSA, Jordan, and Egypt which made high progress using this technology [5]. The mineral elements release the NF as tiny ions with great surface area, quality, and energy to penetrate the cell wall, being tinier than the cell wall pits and vary between (1 – 100nm) [6]. Potassium has a great role in the direct or indirect influence to activate over 120 enzymes, including those responsible for energy use, nitrogen assimilation, reproduction, stomata motion, and photosynthesis [7]; [8].

The main purpose of growth regulators addition to faba bean is to use their effect to modify and convert the plant physiological processes to increase seed via increasing pods, reducing flowers fall, and balancing stimulators/inhibitors ratio before the flowering begins[9]. CTK, in turn, is a major plant growth regulator that acts vitally in partial growth regulation by stimulating plants to make cell division, cell growth, flower increase, fruit node enhancement, and apical growth reduction by building proteins, carbohydrates, chloroplasts, and increasing enzymes for photosynthesis and late aging [7]. So, it would increase therefore lateral bud growth and increased number of flower and shoot branches [10] to cause crop maintaining leaves ready to feed the other plant parts, leading to increase the number of reproductive buds, thus, the seeds number increase at the season end, our goal. So, the research aims to:

1. Study of the response of vegetative growth of Egyptian fava beans to nano-fertilization and spraying with growth regulator CTK.
2. Determining the best concentration of Nano potassium and CTK growth regulator and their interaction to achieve the highest characteristics of vegetative growth in the areal unit under experimental conditions.

2. Materials and Methods

A field experiment was done in the winter season 2020 – 2021 in a farmer's farm in Al- Hsai District / Falluja City / Al- Anbar Province, 33 north latitude and 43 east longitudes (to study the effect of Nano Potassium (NK) spray and growth regulator cytokinin (CTK) on the growth and local of faba bean crop). Farm soil samples were taken randomly before culture at (0 – 30cm) depth from different spots of farm to make lab analyses and detect physical and chemical properties.

| Measured Trait              | Unit | Value |
|-----------------------------|------|-------|
| Electrical Conductivity EC  | dS.m.⁻¹ | 9.3   |
| PH 1:1                      | ------ | 7.06  |
| Pure Nitrogen N            | mg   | 23.9  |
| Pure Phosphorus P          |      | 8.25  |
| Pure Potassium K           |      | 141.04|
| Organic Matter OM          | %    | 0.74  |
| Gypsum CaSO₄               |      | 33.11 |
| Calcium Carbonate CaCO₃    |      | 26.25 |
| Soil separates             |      |       |
| Sand                       | g.kg⁻¹ soil | 452 |
| Silt                       |      | 312   |
| Clay                       |      | 236   |

Data had been Analyzed in the Central Soil, Water and Plant Analyses Lab / Soil sciences and Water Resources Department/ College of Agriculture / Baghdad University.

Split plot system according to randomized complete block design (R. C. B. D.) in three replications was used. Treatments were randomly distributed in every replication. The main plots contained four CTK concentrations (0, 50, 100, and 150) mg.L⁻¹ and symbolized as C0, C1, C2, and C3,
successively. While the subplots included four NK concentrations (0, 1, 2, and 3) mg.L⁻¹ and symbolized as K0, K1, K2, and K3 sprayed twice in branching and early flowering stages. CTK has been resolved in 95% alcohol with adding 2 – 3 drops of HCl in dusk time using a 15L capacity manual sprayer. The control treatment plants, in return, were only sprayed with distilled water. A spraying substance has been used with water to increase absorption capacity, reduce the superficial water tension and make complete moisture in the shoot system of the faba bean plant. The experiment land was prepared as ploughing, softening, and levelling; also, the land was divided according to the used design into 48 experimental units in 2m * 3m dimensions, so the experimental unit area is 6m². The single experimental unit included five lines, separated by 40cm distance with space 25cm between every two plants in plant density 100,000 plants.h⁻¹. The experimental units were separated from each other with 1m space to avoid mixing between treatments. Three seeds were planted in every hole on Oct 15th for the local class available to the Iraqi gardener and irrigation was done after culture directly; after this, the farm was irrigated as the crop needs. Phosphate fertilizer has been added as tri-super phosphate P₂O₅ 46% at level 150 kg.h⁻¹ before agriculture; while the NTF was added in urea form at level 60 kg N.h⁻¹ in two loads: first at culturing and second at flowering for all the treatments [11]. The plant slipping process was made two weeks after the farm emergence after the PLH reached (15 - 20) cm, to keep a single plant in a hole. Besides, the experiment ground was grassed many times to rid of crops competing for growing jungles. Harvest was done after the plant maturation on 15 April 2021.

**Studied Traits:**

2.1. The number of days from cultivation to flowering starts (FB). It is calculated when the flowers appear in the plant of the experiment unit, as it appears by the eyes in the farms.

2.2. Plant height (PLH) (cm). measured from plant-soil connect point to the highest apical top as average for ten plants.

2.3. The number of branches per plant (NBPP) (branch.plant⁻¹). counted as the average number of vegetative branches for the ten plants taken in every treatment.

2.4. The number of leaves per plant (NLPP) (leaf. plant⁻¹). counted as the average number of leaves for the ten plants taken in every treatment.

2.5. Leaf area (LA) (cm².Plant⁻¹). in plant flowering, leaf area was measured as the average of three leaves for each one of the five plants, chosen randomly in every experiment unit. The average was taken by the following equation:

\[
LA = 0.040.45(LW) \quad [12]
\]

LA = plant leaf area  
L = leaf length  
W = leaf width  

Then the LA is multiplied with NLPP to compute the total plant leaf area.

2.6. Leaf chlorophyll content (LCC) (SPAD). chlorophyll percentage in plant leaves was measured using SPAD apparatus type 502 (Chlorophyll SPAD Meter - 502), taking three readings for three different types a plant and taking three leaves from each branch, then extracting the average reading.

3. Results and Discussion

3.1. The number of days from cultivation to flowering starts (FB) (day). Table (2) results refer to the significant effect of NK and CTK on culture to early FB number. So, the control plants (K0) lasted the shortest time to obtain early flowering that's 61.67 days, while the sprayed plants with (2 g.L⁻¹) NK lasted the longest time to access early flowering as 66.83 days. The potassium element stimulates many enzymes, vital activities, increased cell division, and increased leaf growth, which would postpone plant access to the flowering stage (Jain, 2011 and Hasanuzzaman et al., 2018) [7]; [8].

It's noticed from the same table, the presence of significant differences among CTK concentrations in FB number. So, the control treatment plants lasted a least days number to reach
early flowering as 62.58 days, while the plants sprayed with (100 mg. L\(^{-1}\)) lasted more days to reach early flowering as 65.25 days. It could be explained that CTK functions increasing cell division, biochemical reactions and postpones leaves aging [13],[14].

Table (2) Effect of NK and CTK Spray and their Interaction on the Indicator of FB number of faba bean Crop 2020 – 2021

| CTK Concentration mg. L\(^{-1}\) | NK Concentration g.L\(^{-1}\) | K0 0 g.L\(^{-1}\) | K1 1 g.L\(^{-1}\) | K2 2 g.L\(^{-1}\) | K3 3 g.L\(^{-1}\) | Average CTK |
|---------------------------------|-------------------------------|----------------|----------------|----------------|----------------|---------------|
| C0 (0 mg. L\(^{-1}\))           |                               | 62.00          | 59.00          | 67.00          | 62.33          | 62.58         |
| C1 (50 mg. L\(^{-1}\))          |                               | 63.23          | 63.00          | 67.00          | 63.00          | 63.83         |
| C2 (100 mg. L\(^{-1}\))         |                               | 63.00          | 64.33          | 68.00          | 65.67          | 65.25         |
| C3 (150 mg. L\(^{-1}\))         |                               | 59.33          | 64.67          | 65.33          | 63.67          | 63.25         |
| Average K                       |                               | 61.67          | 62.75          | 66.83          | 63.67          |                |
| LSD%5                           | K                             | 1.876          | 1.013          | N.S            |                |                |

3.2. Plant height (PLH) (cm).
Table (3) results show a significant effect of study factors and the interaction on PLH trait; so, the plants sprayed with (2g.L\(^{-1}\)) NK gave the highest trait average as 140.30 cm, compared with control treatment plants, which gave the least average trait value as 122.9 cm, while there was no difference between the rest treatments and the control treatment. The reason for PLH increase is potassium element that acts important and direct role in stimulating cell division and elongation, especially the meristematic cells in growing tops. In addition, it functions by organizing the plant growth regulators that cause PLH increase [15]. These results agree with what [16] and [17-18] stated, and referred to the superiority of NK concentrations 2 g.L\(^{-1}\) in this trait. Table 3 results indicate significant differences among CTK concentrations in this trait; so, the plants sprayed with 100 mg. L\(^{-1}\) gave the maximum average PLH as 126.84 cm. The reason for PLH could be CTK that increases nucleic acids, widens and elongates cells, and increases their size; leading to increase plant growth and height [19],[20],[21]. These results agree with the results of [22]; [23] who noticed that CTK concentration (100 mg. L\(^{-1}\)) has given the greatest average of this treat. While the results indicated that the interaction between the concentrations of potassium NP and CTK was significant and that the highest mean PLH was recorded in the interaction K2C2 where it reached 158 cm.

Table (3) Effect of NK and CTK Spray and their Interaction on the Indicator of PLH of faba bean Crop 2020 – 2021

| CTK Concentration mg. L\(^{-1}\) | NK Concentration g.L\(^{-1}\) | K0 0 g.L\(^{-1}\) | K1 1 g.L\(^{-1}\) | K2 2 g.L\(^{-1}\) | K3 3 g.L\(^{-1}\) | Average CTK |
|---------------------------------|-------------------------------|----------------|----------------|----------------|----------------|---------------|
| C0 (0 mg. L\(^{-1}\))           |                               | 112.36         | 124.90         | 139.90         | 130.20         | 126.84        |
| C1 (50 mg. L\(^{-1}\))          |                               | 118.56         | 119.76         | 135.00         | 127.90         | 125.30        |
| C2 (100 mg. L\(^{-1}\))         |                               | 123.40         | 119.40         | 158.80         | 122.30         | 130.97        |
| C3 (150 mg. L\(^{-1}\))         |                               | 127.30         | 130.00         | 127.50         | 121.20         | 126.50        |
| Average K                       |                               | 120.40         | 123.51         | 140.30         | 125.40         |                |
| LSD%5                           | K                             | 0.3980         | 0.4004         | 0.7960         |                |                |

3.3. The number of branches per plant (NBPP) (branch. plant\(^{-1}\)).
It's clear from table (4) results that there's a significant effect of NK and CTK concentrations and their interaction in NBPP trait. So, the averages of this trait have significantly increased with the NK concentrations increase; so, the plants sprayed with (2 g.L\(^{-1}\)) concentration scored the highest trait average as 16.67 branch. Plant\(^{-1}\), compared with the control treatment (sprayed with distilled water) which made the least average trait as 11.84 branch. plant\(^{-1}\). Potassium would increase the activity of cell division and vegetative growth increase, lead, therefore, to increase the NBPP, besides its role in
increasing the plant lateral and meristematic tissue growth induction to increase, therefore, the NBPP is increased [24]; [8]. These results have agreed with the results of [17] who referred to the significant effect of (2 g.L⁻¹) concentration in this trait.

While for the CTK concentrations, we notice from the table (4) results that a significant effect exists among these concentrations in the average of NBPP, so the 100 mg.L⁻¹ gave the highest trait average as 15.88 branches.plant⁻¹, compared with the control treatment that made the least average trait as 11.92 branches.plant⁻¹, this superiority could be attributed to CTK antagonism effects of auxins that exist in the terminal buds that cause apical dominance breakdown, lateral buds appearance, NBPP increase [14]. These results agree with the results of [22]; [23] who referred to the superiority (100 mg. L⁻¹) concentration in increasing the branch number significantly in faba bean plants. Results refer that the K1C1 interaction has given the highest average trait 16.61 branches. plant⁻¹, compared with the control treatment which gave the least average trait as 9.00 branches. Plant⁻¹.

| CTK Concentration mg. L⁻¹ | K0 0 g.L⁻¹ | K1 1 g.L⁻¹ | NK Concentration g.L⁻¹ | K2 2 g.L⁻¹ | K3 3 g.L⁻¹ | Average CTK |
|---------------------------|-----------|-----------|------------------------|-----------|-----------|-------------|
| C0 (0 mg. L⁻¹)            | 8.25      | 12.72     | 13.71                  | 13.02     | 11.92     | 11.929      |
| C1 (50 mg. L⁻¹)           | 12.61     | 13.94     | 16.53                  | 12.83     | 13.978    | 13.978      |
| C2 (100 mg. L⁻¹)          | 13.28     | 14.08     | 21.92                  | 14.25     | 15.88     | 15.88       |
| C3 (150 mg. L⁻¹)          | 13.21     | 13.27     | 14.54                  | 12.8      | 11.46     | 11.46       |
| Average K                 | 11.84     | 13.50     | 16.67                  | 13.23     | 13.464    | 13.464      |
| LSD%5                     | K         | C         | K * C                  |           |           |             |
|                           | 0.46      | 1.05      | 0.92                   |           |           |             |

3.4. The number of leaves per plant (NLPP) (leaf. plant⁻¹).

It's seen from table (5) results that there's a significant effect of NK and CTK spray and their interaction in the NLPP trait. So, the averages of NLPP increased by the NK concentration increase, and the plants sprayed with (2 g.L⁻¹) concentration have given the highest average trait as 157.9 leaves. plant⁻¹, compared with the control treatment plants that gave the least average trait as 139.1 leaves. plant⁻¹, while the other treatments haven’t significantly differed from the control treatment. The cause of increased leaves number is potassium element that enhances the vegetative growth properties such as PLH and branches number (table 3 and 4).

The same table results indicated a significant effect of CTK in this trait; so, the concentrations (100 mg.L⁻¹) achieved the highest average NLPP as 165.5 leaves. plant⁻¹, compared with the other concentrations that haven’t significantly differ among themselves. The control treatment made the least average trait as 134.4 leaves. plant⁻¹. The reason behind the increased NLPP is CTK role in cell elongation and division to form leaf (lateral) buds via stimulation of tissue differentiation and development to leaves, in addition to CTK role decreasing the apical dominance to stimulate lateral buds development and growth to increase, thus, the number of leaves [25];[26]. These results x agree with the results of [22]; [23] who referred that (100 mg.L⁻¹) CTK has achieved the best significant effect in faba bean NLPP average trait. Besides, the significant interaction between both study factors in this trait. Also, the treatment K2C2 achieved the highest average leaves number as 186.1 leaves. plant⁻¹, compared with control treatment which gave the least average trait as 128.4 leaves. plant⁻¹.

| CTK Concentration mg. L⁻¹ | K0 0 g.L⁻¹ | K1 1 g.L⁻¹ | NK Concentration g.L⁻¹ | K2 2 g.L⁻¹ | K3 3 g.L⁻¹ | Average CTK |
|---------------------------|-----------|-----------|------------------------|-----------|-----------|-------------|
| C0 (0 mg. L⁻¹)            | 128.4     | 146.0     | 159.7                  | 103.1     | 134.3     | 134.3       |
| C1 (50 mg. L⁻¹)           | 140.5     | 127.1     | 138.5                  | 150.1     | 139.1     | 139.1       |
| C2 (100 mg. L⁻¹)          | 158.4     | 152.7     | 186.1                  | 164.7     | 165.5     | 165.5       |
| C3 (150 mg. L⁻¹)          | 129.3     | 134.2     | 147.3                  | 132.3     | 135.8     | 135.8       |
3.5. Leaf area (LA) (cm².plant⁻¹).

It's seen from table (6) results that significant differences exist among the LA averages at NK and CTK spray and interaction; so, the plants sprayed with (2g.L⁻¹) gave maximum average trait as 4918 cm².plant⁻¹, compared with the control plants that gave minimum average trait 3452 cm².plant⁻¹. The reason for this increase could be the active role in LA increase via stimulating cell division and elongation such as leaf cells, it also increases the photosynthesis product transfer from their manufacture to needy sites [27]. The other reason for LA increase is the vegetative growth traits superiority like PLH, branches number, and leaves number (table 3, 4, 5). Other studies also stated that potassium has a significant effect on LA increase [28]; [29].

CTK concentrations have significantly influenced the LA in the table (8); so, the concentration (100 mg. L⁻¹) achieved the highest average trait as 5689 cm².plant⁻¹, compared with the control treatment that gave the least average trait as 3978 cm².plant⁻¹, while the other treatment didn’t show significant differences from the control treatment. The reason for this increase in CTK is that acts vitally in leaf cell division and growth, leading to LA increase [12]; [29]. In addition, that the treatment superiority in vegetative growth traits is a cause of LA increase (table 5, 6, 7). The mentioned results agree with those of [22]; [31] who referred that the concentration (100 mg. L⁻¹) has given the best average trait in mash and faba bean.

In return to the bi-interaction of both study factors, the treatment K1C2 gave the highest average as 6812 cm².plant⁻¹, compared with the control treatment that gave the least average as 2394 cm².plant⁻¹.

Table (6) Effect of NK and CTK Spray and their Interaction Effect in Plant LA cm².plant⁻¹ for faba bean Crop 2020 – 2021

| CTK Concentration mg. L⁻¹ | NK Concentration g.L⁻¹ | K0 0 g.L⁻¹ | K1 1 g.L⁻¹ | K2 2 g.L⁻¹ | K3 3 g.L⁻¹ | Average CTK |
|---------------------------|------------------------|------------|------------|------------|------------|-------------|
| C0 (0 mg. L⁻¹)            |                        | 2160       | 4364       | 5188       | 4199       | 3978        |
| C1 (50 mg. L⁻¹)           |                        | 3519       | 4095       | 4608       | 4659       | 4220        |
| C2 (100 mg. L⁻¹)          |                        | 4676       | 6812       | 5724       | 5542       | 5689        |
| C3 (150 mg. L⁻¹)          |                        | 3452       | 3786       | 4154       | 4734       | 4031        |
| Average K                 |                        | 3452       | 4764       | 4918       | 4784       |              |

| LSD%5                     | K                      | C          | K * C      |
|---------------------------|------------------------|------------|------------|
| 13.30                     | 18.71                  | 26.59      |            |

3.6. Leaves Content of Chlorophyll (LCC) (SPAD).

Table (7) results indicated a presence of significant effect for both study factors and their interaction in this trait. It's obvious in the table that the plants sprayed with (2 g.L⁻¹) have significantly dominated in LCC to give the highest average 48.28 SPAD, controlled with the other treatments which didn’t differ significantly among them; so, the control treatment gave the least average trait as 40.66 SPAD. The increased percentage of LCC is attributed to potassium role activating many enzymes, including those responsible for chlorophyll synthesis to increase its percentage in leaves [27]. As well as potassium's role in abscisic acid reduction to cause late leaf aging and chlorophyll degradation [32]; so, it means that potassium addition would increase LCC [29]. These results have agreed with those of [17];[18] who indicated the superiority of NK concentration 2 g.L⁻¹ significantly in this trait.

Also, the table (7) results stated that LCC increases with CTK concentration; so, the two CTK treatments (50 mg. L⁻¹ and 150 mg. L⁻¹) achieved the highest average trait as 44.98 and 43.77 SPAD, successively and contained no significant difference, compared to the control treatment which made
the least average trait as 40.88 SPAD. This is attributed to the role of cytokinin in increasing the production of chlorophyll in the plastids located in the leaf blade and developing its action by ([33]; [34] and it works to prevent the degradation of proteins in chloroplasts [35]. These results agreed with the results of [36], which indicated the role of the concentration (50 mg L-1) in increasing the chlorophyll content of the leaves.

Regarding the bilateral interaction between the two factors of the study, the plants sprayed with a concentration of (2 gm. L-1) of nano potassium and (50 mg.L-1) of cytokinin (K2C1) gave the highest LCC of 56.53 SPAD compared to the other treatments.

Table (7) Effect of NK and CTK Spray and their Interaction Effect in LCC (SPAD) for faba bean Crop 2020 – 2021

| CTK Concentration mg. L-1 | NK Concentration g.L-1 | Average CTK |
|---------------------------|------------------------|-------------|
| C0 (0 mg. L-3)            | 36.70                  | 40.88       |
| C1 (50 mg. L-3)           | 42.03                  | 44.49       |
| C2 (100 mg. L-3)          | 39.40                  | 46.80       |
| C3 (150 mg. L-3)          | 44.50                  | 45.20       |
| Average K                 | 40.66                  | 48.28       |

4. Conclusion

1. The foliar feeding with potassium NP showed a clear improvement in all characteristics of vegetative growth.
2. It was found that there was a significant response in all vegetative growth characteristics by spraying CTK on plants.
3. The interaction between potassium NP and kinetin resulted in a better state of nutritional balance in the plant and this was reflected in the improvement of vegetative growth characteristics.

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