Effect of Spraying with Potassium and Kinetin on Specific Physiological and Productive Characteristics of Three Mungbean Genotypes (*Vigna Radiata* L.)

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Abstract. A field experiment was carried out in the fall season of 2019 in Anbar Governorate, Al-Khalidiya city, located at longitude +43.46 and latitude +33.41, in order to study the effect of foliar nutrition with three concentrations of potassium (0, 400, and 800 mg L⁻¹) combined with three concentrations of kinetin (0, 100, and 200 mg L⁻¹) on the physiological and productive characteristics of three Mungbean genotypes (Local Khadrawy, Green Indian VC6089A10, and Black Indian GOLDSTAR). The experiment was implemented by the arrangement of the split-split plot using the Randomized Complete Block Design (RCBD) with three replicates. Thus, the genotypes represented the Main plots, and kinetin represented the Sub-plots, while potassium represented the Sub-subplots. The study findings showed that the potassium concentration of 800 mg K L⁻¹ gave the highest average for leaf area, potassium content in leaves, number of pods/plants, fertility percentage in pods, and seed yield. Whereas, the concentration of 400 mg K L⁻¹ gave the highest activity of nitrate reductase enzyme (NR) and the highest average of the pod length. In the same role, the foliar nutrition with a concentration of kinetin 200 mg L⁻¹ achieved the highest potassium content in leaves and the highest activity of nitrate reductase enzyme (NR). It also gave the highest average of the number of pods/plants, pod length, fertility percentage per pod, and seed yield per unit area. On the other hand, the local genotype was superior in the two characteristics of leaf area and the number of pods/plants, while the green Indian genotype was superior in the potassium content, NR enzyme activity, pod length, and seed yield, while the black Indian genotype was superior after fertility percentage per pod.

1. Introduction

Mungbean (*Vigna radiata* L.) is one of the important plants of the leguminous family (Fabaceae), whose seeds contain a high percentage of protein (19-29%), which is characterized by being rich in the amino acid Lysine that is lacking in many grains. These seeds also contain carbohydrates (62-65%) and fats (1-5%), calcium, iron, and beta-carotene [1], as well as its high ability to increase soil fertility and improve its properties [2]. However, the productivity of the mungbean crop is still low in Iraq compared to the global production, as it suffers from the high percentage of flowers falling during the flowering stage, which reaches 60-80% of the total flowers [1]. Therefore, this high percentage negatively affects the productivity of the crop. One of the solutions to address this problem is the use of Nutrients related to increasing the fertility percentage and nodes in flowers and pods, especially the use of foliar nutrition with potassium. This element has an appositive correlation with increasing the fertility percentage, flower nodes, and reducing their fall. Besides, the plant’s need for this element
may exceed all other nutrients in some stages of plant growth [3]. On the other hand, the growth regulator kinetin also activates cell division, reduces apical dominance, encourages the growth of lateral buds, and encourages the plant towards increasing reproductive buds, and this is reflected in an increase in yield [4]. Accordingly, the current study aims to determine the best concentration of potassium and the growth regulator kinetin. Besides, selecting the best genotype that responds to their addition to improve growth and give a high seed yield per unit area.

2. Materials and Methods of work

2.1. Materials

A field experiment was carried out in the fall season of 2019 in Anbar Governorate in the field of a farmer in the Al-Khalidiyeh area of the Habbaniyah district, located on the right bank of the Euphrates River, at a longitude °43.46 and latitude °33.41, in a soil whose characteristics are shown in Table (1). The current study was carried out to investigate the effect of foliar nutrition for three concentrations of potassium (0, 400, and 800 mg L\(^{-1}\)) and three concentrations of kinetin (0, 100, and 200 mg L\(^{-1}\)) in specific physiological and productive characteristics of three mungbean genotypes (Local Khadrawy, Green Indian VC6089A10, and Black Indian GOLDSTAR). The experiment was carried out by the arrangement of the split-split plot using the Randomized Complete Block Design (RCBD) with three replications. Thus, the genotypes represented the Main plots, and kinetin represented the Sub-plots, while potassium represented the Sub-sub plots. Then, Potassium sulfate was used as a source of potassium (K 50%), potassium and kinetin concentrations were sprayed in two batches, the first before the flowering stage and the second spray at the flowering stage, while the comparison treatment was sprayed with water only. The plants were sprayed before sunset using a 2-liter sprayer and drops of liquid soap were added as a diffuser to reduce the water surface tension and ensure complete wetness of the leaves and increase the efficiency of the spray solution in penetrating the outer surface of the leaf [5]. Experimental land service operations were carried out from plowing, harrowing, and leveling, then it was divided into experimental units with an area of 7.5 m\(^2\) (with dimensions of 3 m x 2.5 m) and it contained five rows of 3 m length, as the distance between one row and another is 50 cm and between one hole and another 25 cm to obtain a plant density of 80,000 plants ha\(^{-1}\). The cultivars seed that was taken from the Agricultural Research Department - the Ministry of Agriculture on were planted at 27/7 with a depth of 2-3 cm by 2-3 seed per hole then they were irrigated, then the experimental plants were thinning to one plant per hole After three days of germination. The experiment land was fertilized with triple superphosphate (P\(_2\)O\(_5\) 46%) at a rate of 75 kg P\(_2\)O\(_5\) before planting. Coupled with, nitrogen fertilizer that was added in the form of urea (46% N) at a rate of 40 kg N ha\(^{-1}\) in two batches, the first one was after germination is completed and the second batch was at the beginning of the flowering stage [6].

Table 1. Shows the chemical and physical characteristics of field soil

| Characteristic      | Value  | Characteristic | Value   |
|---------------------|--------|----------------|---------|
| Sand                | 30.0 % | CaCO\(_3\) (Lime) | 20 Mg.kg\(^{-1}\) |
| Silt                | 46.7 % | Organic Matter O.M | 0.62 Mg.kg\(^{-1}\) |
| Clay                | 23.3 % | N              | 0.42 %  |
| Bulk density        | 1.45 g. cm\(^{-1}\) | P            | 0.22 %  |
| EC                  | 2.3 dc.m\(^{-1}\) | K            | 38.9 %  |
| PH                  |        |                | 7.2     |

2.2. Extracts preparation

Finally, the study traits were included the extraction and estimation of nitrate reductase (NR) activity according to the method proposed by [7]. Likewise, the potassium content in leaves was estimated after 10 days of the second spraying for both (potassium and kinetin) with a Flame Photometer type PGIAutomatic 2000, an English origin that mentioned by [8]. Moreover, the plant leaf area was
estimated after 14 days of measuring the enzyme activity, according to the Disc method, in which 30 leaf discs with a diameter of 1.7 cm are taken from 30 leaves for ten plants. Then, the plant leaves and discs were dried separately and their dry weight was measured and then the leaf area was estimated according to the [9], procedure, using the following equation:

\[
\text{Leaf area} = \frac{\text{the dry weight of plant leaves}}{\text{the dry weight of (30) discs x area of 30 discs}}
\]  

(1)

Similarly, the number of pods was calculated as an average for 10 plants randomly taken from the middle rows of each experimental unit when the experiment was harvested. Pod length (cm) was calculated as an average of 30 pod lengths taken randomly from the pods of the 10 harvested plants. The fertility percentage in the pods was calculated according to the following equation:

\[
\text{Fertility percentage (\%)} = \left( \frac{\text{Number of seeds in a pod}}{\text{Total number of ovaries in a pod}} \right) \times 100
\]  

(2)

The harvest index (ton.ha\(^{-1}\)) was calculated by harvesting the plants of the two middle rows, then their seeds were collected and weighing, then converting the weight from grams to ton.ha\(^{-1}\).

3. Results and discussion

3.1. The activity of nitrate reductase enzyme (NR) (in \(\mu\text{mol NO}_2\cdot\text{g}^{-1}\cdot\text{fresh weight h}^{-1}\))

It is evident from Table (2) that the enzyme activity increased significantly with the addition of potassium, as it increased from 103.1 at the comparison treatment to 125.5 and 124.0 \(\mu\text{mol NO}_2\cdot\text{g}^{-1}\cdot\text{fresh weight h}^{-1}\) at the concentrations 400 and 800 mg K.L\(^{-1}\), respectively. The increase in enzyme activity is due to the role of potassium in activating the activity of many enzymes, including this enzyme [10]. Table (2) showed that there was an increase in the (NR) enzyme activity with an increase in the concentration of kinetin, as the concentration of 200 mg.L\(^{-1}\) of kinetin achieved the highest activity of enzyme amounted to 126.7 \(\mu\text{mol NO}_2\cdot\text{g}^{-1}\cdot\text{fresh weight h}^{-1}\). Besides, this activity did not differ significantly from the activity of concentration 100 mg H.L\(^{-1}\) (119.7 \(\mu\text{mol NO}_2\cdot\text{g}^{-1}\cdot\text{fresh weight h}^{-1}\)). On the contrary, it differed significantly from the comparison treatment (H\(_0\)), which recorded the lowest enzyme activity amounted to 109.4 \(\mu\text{mol NO}_2\cdot\text{g}^{-1}\cdot\text{fresh weight h}^{-1}\). This increase is due to the role of kinetin in stimulating the movement of nutrients from plant parts to the leaves, which has a significant role in the synthesis and stimulation of many enzymes’ activity [4], as well as its role as a growth stimulant.

Table (2) shows that the enzyme activity was high in the plants of the green Indian genotype (V1), which amounted to 127.9 \(\mu\text{mol NO}_2\cdot\text{g}^{-1}\cdot\text{fresh weight h}^{-1}\) and its activity was significantly exceeded in the local genotype (V2) and the black Indian genotype (V3) by 121.7, and 102.9 \(\mu\text{mol NO}_2\cdot\text{g}^{-1}\cdot\text{fresh weight h}^{-1}\). The superiority of the V1 genotype is due to the genetic differences between these genotypes. This result is consistent with [11], that found a significant difference in the activity of this enzyme among the studied genotypes. It was observed from the interaction between potassium and kinetin that plants that were sprayed with concentrations of potassium 400 and 800 mg K.L\(^{-1}\) with spraying kinetin at a concentration of 200 mg.L\(^{-1}\) achieved the highest enzyme activity that reached 142.9 \(\mu\text{mol NO}_2\cdot\text{g}^{-1}\cdot\text{fresh weight h}^{-1}\). In contrast, the comparison plants spraying potassium at a concentration of 200 mg H.L\(^{-1}\) of Kinetin gave the lowest enzyme activity of 94.4 \(\mu\text{mol NO}_2\cdot\text{g}^{-1}\cdot\text{fresh weight h}^{-1}\). Similarly, the results of triple interaction between the studied factors reported that the plants of (V1) genotype at a concentration of 800 mg.L\(^{-1}\) of potassium and 200 mg.L\(^{-1}\) of kinetin achieved the highest enzyme activity that reached 156.9% \(\mu\text{mol NO}_2\cdot\text{g}^{-1}\cdot\text{fresh weight h}^{-1}\). However, the plants of (V3) genotype with a potassium concentration of 800 mg K.L\(^{-1}\) gave the lowest enzyme activity amounted to 73.3 \(\mu\text{mol NO}_2\cdot\text{g}^{-1}\cdot\text{fresh weight h}^{-1}\).
Table 2. Effect of the Foliar Nutrition of Potassium and the Kinetin on nitrate reductase enzyme activity (µmol \(\text{NO}_2\ g^{-1}\) fresh weight h\(^{-1}\)) of Mungbean genotype.

| Cultivars (V) | Kinetin H (mg/l) | Potassium K (mg/l) | V × H |
|--------------|-----------------|-------------------|-------|
|              | 0               | 400               | 800   |
| V1           | 0               | 96.1              | 114.8 |
|              | 100             | 121.2             | 119.4 |
|              | 200             | 118.7             | 156.9 |
|              | 0               | 135.4             | 109.5 |
| V2           | 100             | 118.9             | 116.9 |
|              | 200             | 78.9              | 147.1 |
|              | 0               | 89.4              | 92.2  |
| V3           | 100             | 83.5              | 120.1 |
|              | 200             | 85.6              | 124.6 |
| Mean K       | 103.1           | 125.5             | 124.0 |

L.S.D (0.05) K = 7.43
L.S.D (0.05) V×H=K =23.58

3.2. Leaf area (cm\(^2\) plant\(^{-1}\)):

It is clear from Table (3) that foliar nutrition with potassium concentrations (400 and 800 mg.L\(^{-1}\)) achieved the highest average leaf area of 313.2 and 314.7 cm\(^2\) plant\(^{-1}\), and they did not differ significantly between them. Just, both were significantly superior to the comparison treatment that gave the lowest average for the characteristic reached 267.5 cm\(^2\) plant\(^{-1}\) with an increasing percentage of 17.08 and 17.64%, respectively. The reason for the increase in leaf area by adding potassium is due to its role in stimulating leaf cells to division and elongation and increase the percentage of cellulose and lignin, and thus increase the plant leaf area [12, 13]. These results are consistent with the findings of [14-17] that indicated the positive effect of potassium in increasing the leaf area of the bean plant. Table (3) shows that (V2) was significantly superior with the highest average leaf area of 447.80 cm\(^2\) plant\(^{-1}\) with an increasing percentage of 47.55 and 210.97% compared to the two genotypes V1 (303.5 cm\(^2\) plant\(^{-1}\)) and V3 (144.0 cm\(^2\) plant\(^{-1}\)). The reason for this superiority may be due to its superiority in the number of leaves, and this is reflected in increasing the leaf area. This result agrees with [11, 18, 19] that reported there are significant differences in leaf area between the mungbean genotypes. Furthermore, The above Table results showed that there were significant differences between the interaction treatments (V×K), as the plants of (V2) genotype with a potassium concentration of 400 mg K.L\(^{-1}\) recorded the highest average leaf area amounted to 474.1 cm\(^2\) plant\(^{-1}\), while the comparison treatment for genotype (V3K0) gave the lowest average of 135.9 cm\(^2\) plant\(^{-1}\).
Table 3. Effect of the Foliar Nutrition of Potassium and the Kinetin on Leaf Area (cm/plant) of Mungbean genotype

| Cultivars (V) | Kinetin H (mg/l) | Potassium K (mg/l) | V × H |
|--------------|-----------------|-------------------|-------|
|              | 0               | 400               | 800   |       |
| V1           | 100             | 262.5             | 290.3 | 308.7 | 287.2 | 333.5 |
|              | 200             | 264.2             | 296.9 | 439.4 | 409.1 | 419.2 |
| V2           | 100             | 468.0             | 514.6 | 511.6 | 498.1 |
|              | 200             | 367.2             | 483.3 | 427.6 | 426.0 |
| V3           | 100             | 139.9             | 160.4 | 130.6 | 143.6 |
|              | 200             | 130.1             | 167.3 | 148.1 | 148.5 |
| Mean K       |                 |                   |       |       |
| L.S.D (0.05) |                 | 23.33K = N.S      |       |

| V × K         | Mean V          |
|---------------|-----------------|
| V1            | 246.8           | 308.2           | 355.6 | 303.5 |
| V2            | 419.7           | 474.1           | 449.4 | 447.8 |
| V3            | 135.9           | 157.3           | 138.9 | 144.0 |
| L.S.D (0.05)  | 84.81           | 86.68           |       |

| H × K         | Mean H          |
|---------------|-----------------|
| H             | 0               | 400             | 800   |       |
| 100           | 258.5           | 302.0           | 288.6 | 283.0 |
| 200           | 290.2           | 321.8           | 317.0 | 309.6 |
| L.S.D (0.05)  | N.S             | N.S             |       |

3.3. Potassium content in leaves (mg K.kg⁻¹ dry matter)

In the same role, the plants that sprayed with concentration 800 mg K.L⁻¹ achieved the highest potassium content in their leaves, which was 1.19 mg K.kg⁻¹ dry matter. This concentration differed significantly from plants with a concentration of 400 mg K.L⁻¹ (1.17 mg K.kg⁻¹ dry matter), and the comparison plants that gave the lowest average for the characteristic (1.09 mg K.kg⁻¹ dry matter). This increase is due to the increase in potassium concentration in the spray solution, which was reflected in increasing the plant's content of this element. This result is agreed with the results of [20, 21]. The results of Table (4) show that spraying with a concentration of kinetin 200 mg H.L⁻¹ achieved the highest percentage of potassium in the leaves of 1.18 mg K.kg⁻¹ dry matter. Besides, it was significantly superior to plants of concentration 100 mg H.L⁻¹ and the comparison plants that recorded the lowest average of 1.11 mg H.kg⁻¹ dry matter. The reason is due to the role of kinetin in increasing the use of nutrients with high efficiency [22]. This result is consistent with the findings of [20], that confirmed an increase in the plant content of potassium as a result of the kinetin addition. The (V1) genotype was significantly superior in the leaves content of potassium (1.18 mg K.kg⁻¹ dry matter) over the (V3) genotype (1.15 mg K.kg⁻¹ dry matter), which was significantly superior to the (V2) genotype that gave the lowest percentage of element (1.12 mg K.kg⁻¹ dry matter). This superiority is due to the genetic differences between the genotypes, which were reflected in the difference in their ability to absorb the elements. It was observed from the results of Table (4) that spraying with high concentrations of potassium and kinetin (800 mg K + 200 mg H) L⁻¹ achieved the highest significant average of potassium content in leaves, which was 1.23 mg K.kg⁻¹ dry matter compared to the other interaction.
treatments. Thus, the increasing percentage of 19.42% from the comparison plants for both factors gave the lowest average for the characteristic, which was 1.03 mg K.kg\(^{-1}\) dry matter.

Table 4. Effect of the Foliar Nutrition of Potassium and the Kinetin on Potassium percentage in leaves (Mg/Kg dry matter) of Mungbean genotype

| Cultivars (V) | Kinetin H (mg/l) | Potassium K (mg/l) | V × H |
|--------------|-----------------|-------------------|-------|
|              | 0               | 400               | 800   |
| V1           | 100             | 1.15              | 1.20  | 1.21 | 1.18 | 1.19 |
| V2           | 100             | 1.11              | 1.14  | 1.14 | 1.13 |
| V3           | 100             | 1.13              | 1.14  | 1.14 | 1.14 |
| Mean K       | 1.18            | 1.22              | 1.21  | 1.18 |

L.S.D (0.05) K = 0.01

V × H × K = 0.027

Mean V

| V × K | 0     | 400   | 800   |
|-------|-------|-------|-------|
| V1    | 1.10  | 1.21  | 1.22  | 1.18 |
| V2    | 1.07  | 1.14  | 1.15  | 1.12 |
| V3    | 1.09  | 1.15  | 1.18  | 1.15 |

L.S.D (0.05) N.S 0.025

H × K

| 0     | 1.03  | 1.15  | 1.15  | 1.11 |
| 100   | 1.13  | 1.16  | 1.17  | 1.15 |
| 200   | 1.11  | 1.21  | 1.23  | 1.18 |

L.S.D (0.05) 0.024 0.013

The triple interaction had a significant effect on this characteristic, as the plants of (V1) genotypethat sprayed with concentration 800 mg.L\(^{-1}\) of potassium and 200 mg.L\(^{-1}\) of kinetin recorded the highest percentage of the element amounted to 1.27 mg K.kg\(^{-1}\) dry matter, with an increase of 29.59% over the (V2) plants that was not sprayed with both factors, which gave the lowest percentage of potassium in the leaves of 0.98 mg K.kg\(^{-1}\) dry matter.

3.4. Number of pods/plant

The results in Table (5) show that plants sprayed with a concentration of 800 mg.L\(^{-1}\) of potassium element achieved the highest average of 66.17 pods.plant\(^{-1}\) and significantly exceeded overplants sprayed with a concentration of 400 mg K.L\(^{-1}\) (61.89 pods.plant\(^{-1}\)) and the comparison plants (55.64 pods.plant\(^{-1}\)) with an increasing percentage of 6.92 and 18.93%, respectively. The high percentage of potassium in the leaves when sprayed with a high concentration of potassium as shown in Table 4 contributed to an increase in the fertility percentage and nodulin flowers, and then increased the number of pods in the plant. This result agrees with the outcomes of [17, 23-25], who found a significant increase in the number of pods when potassium was added. It was evident from the results of Table (5) that plants sprayed with a concentration of 200 mg L\(^{-1}\) of kinetin achieved the highest average of 64.61 pods.plant\(^{-1}\) and significantly differed from plants sprayed with a concentration of 100 mg H.L\(^{-1}\) (61.39 pods.plant\(^{-1}\)) and the comparison plants that gave the lowest average for the characteristic was 57.69 pod.plant\(^{-1}\). The increase in the potassium percentage in leaves at the high concentration of kinetin as shown in Table 4, as well as the increase in (NR)enzyme activity as shown in Table 2, was positively reflected in the preparation of the flowers emerging in the plant from the
element’s potassium and nitrogen, which have an important role in increasing the fertility percentage in flowers and then increasing the number of pods. This result is consistent with the results of other studies that indicated the significant effect of kinetin in increasing the number of pods/plants [26-28]. The (V2) genotype had the highest average number of pods/plant, which amounted to 71.27 pods/plant\(^1\), with a significant increase of 12.38% and 45.45% compared to the two Indian genotypes (V3, V1), respectively. This increase is due to the superiority of the local genotype in the characteristic of the leaf area, which may have been reflected in increasing the number of flowers per plant and then increasing the fertility percentage in it. In addition to the important role of potassium in increasing the fertility percentage and nodes in the reproductive stage of the plant (flowers and pods), which is reflected in increasing the number of pods/plants. This result is agreed with the results of [19, 29-31], that noticed a significant difference between the genotypes of the mungbean in the number of pods/plant.

The bilateral interaction between potassium and kinetin at the two concentrations (800 mg K + 200 mg H) L\(^{-1}\) gave the highest average number of pods amounted to 73.87 pods/plant\(^1\) and significantly exceeded the other interaction treatments in which the comparison plants for both gave the lowest average number of 53.56 pods/plant\(^1\). The significance of the interaction between kinetin and genotypes showed that local genotype plants that sprayed with 200 mg H L\(^{-1}\) achieved the highest average of 75.08 pods/plant\(^1\) and did not differ significantly from treatment (V2 + 100 mg H L\(^{-1}\)), as well as from treatment (V1 + 200 mg H L\(^{-1}\)).

However, it significantly exceeded the other interaction treatments in which the treatment (V3H0) gave the lowest average for the characteristic that reached 45.20 pods/plant\(^1\). The triple interaction also had a significant effect on this characteristic, as the (V2) genotype that sprayed with two concentrations (800 mg K + 200 mg H) L\(^{-1}\) recorded the highest average of 90.03 pods/plant\(^1\). Besides, it significantly exceeded other interaction treatments in which the plants of the (V3) genotype that sprayed with (400 mg K + H0) L\(^{-1}\) gave the lowest average amount to 39.47 pods/plant\(^1\).

Table 5. Effect of the Foliar Nutrition of Potassium and the Kinetin on Number of pods/plant of Mungbean genotype

| Cultivars (V) | Kinetin H (mg/l) | Potassium K (mg/l) | V × H |
|--------------|-----------------|--------------------|-------|
|              | 0               | 400                | 800   | 0 × 400 | 800 | 0 × 800 | 0 × 0 |
| V1           | 0               | 60.90              | 65.63  | 60.70   | 62.41 |
|              | 100             | 51.33              | 60.97  | 65.57   | 59.29 |
|              | 200             | 57.43              | 72.23  | 76.03   | 68.57 |
| V2           | 0               | 54.37              | 69.00  | 73.03   | 65.47 |
|              | 100             | 75.20              | 74.40  | 70.23   | 73.28 |
|              | 200             | 64.80              | 70.40  | 90.03   | 75.08 |
| V3           | 0               | 44.83              | 39.47  | 51.30   | 45.20 |
|              | 100             | 50.70              | 51.00  | 53.07   | 51.59 |
|              | 200             | 41.17              | 53.90  | 55.53   | 50.20 |
| Mean K       | 55.64           | 61.89              | 66.17  |         | |

L.S.D (0.05) K = 2.957

V × H × K = 9.63

V × H × K

V × K

Mean V

V1           | 0               | 56.56              | 66.28  | 67.43   | 63.42 |
| V2           | 64.79           | 71.27              | 77.77  | 71.27   | 49.00 |
| V3           | 45.57           | 48.12              | 53.30  | 53.07   | 49.00 |

L.S.D (0.05) N.S

H × K

Mean H

H × K

Mean H

H × K

Mean H

H × K

Mean H

H × K

Mean H

H × K

Mean H

H × K

Mean H

H × K

Mean H

H × K

Mean H

L.S.D (0.05) 5.079 3.170
3.5. Fertility percentage in pods (%)

It is clear from the results in Table (6) that plants sprayed with a potassium concentration of 800 mg.L\(^{-1}\) achieved the highest fertility percentage in pods of 90.56% and significantly exceeded over plants sprayed with a concentration of 400 mg.k.L\(^{-1}\) (88.85%) and the plants of the comparison treatment that recorded the lowest fertility percentage reached 84.30%. The effect of potassium in increasing the leaf area as shown in Table 3 is reflected in the increasing the photosynthetic products that transferred to the emerging pods to feed them and increase the fertility percentage in them. Along with, the effect of potassium in increasing the (NR) enzyme activity as in Table 2, which activates the vital processes in the plant, especially those related to the fertility percentage in flowers. In this regard, [10] indicated that the plant can increase the fertility percentage in flowers and pods, which can be supplied with the products of photosynthesis only. It was observed from the results of Table (6) that spraying with a concentration of 200 mg.L\(^{-1}\) of Kinetin achieved the highest fertility percentage in pods that reached 90.59% and was significantly superior to the concentration of 100 mg.L\(^{-1}\) and the comparison treatment that recorded the lowest fertility percentage of 85.52%. Moreover, the potassium percentage increasing in the leaves by the effect of the concentration 200 mg.H.L\(^{-1}\) as shown in Table 4 was positively reflected in the increasing fertility percentage in pods. As well as, the kinetin role in increasing the fertilization percentage in the flowers and pods of leguminous crops [33]. These agree with [34], that found a significant increase in the fertility percentage when Cytokinins were added. The (V3) genotype gave the highest fertility percentage in the pods, which reached 89.56% that did not differ significantly from the (V1) genotype, but it was significantly superior to the (V2) genotype, which gave the lowest fertility percentage of 86.22% as shown in Table 6. The superiority of the (V3) genotype may be due to its genetic nature to adapt to the surrounding environmental conditions as well as its high efficiency in converting the products of photosynthesis to the emerging flowers and seeds, which led to an increase in the fertility percentage in pods. [34] indicated a difference in the fertility percentage of the pods according to the different studied genotypes, which presents a good agreement with this study's findings. The results of the interaction between potassium and kinetin showed that the treatment (800 mg K + 200 mg H) L\(^{-1}\) gave the highest fertility percentage in pods amounted to 94.89%. Besides, it was significantly superior to the other interaction treatments in which the comparison plants of both factors (K0 + H0) gave the lowest fertility percentage of 81.56 %. Similarly, the interaction between potassium and genotypes also significantly affected this trait as shown in Table 6, as the plants of the (V1) genotype with high potassium concentration (800 mg.K.L\(^{-1}\)) gave the highest fertility percentage in pods that reached 91.11%. It is also significantly superior to the treatments of other interactions in which the comparison plants of the (V2) genotype gave the lowest fertility percentage of 80.22%. In general, there is an increase in the fertility percentage in pods and for all genotypes with an increase in the concentration of potassium nutrition. It is clear from the interaction between the kinetin and the genotypes that the plants of the (V3) genotype that were sprayed with a concentration of kinetin 200 mg.L\(^{-1}\) achieved the highest fertility percentage in pods amounted to 93.78% and significantly superior to the other interaction treatments in which the comparison plants of the local genotype gave the lowest fertility percentage of 84.33%. The results of the triple interaction showed that the plants of the (V3) genotype with a high concentration of potassium and kinetin (800 mg K + 200 mg H) L\(^{-1}\) achieved the highest fertility percentage in pods that reached 97.33% compared to the other interaction treatments in which the comparison plants of potassium in (V2) genotype that sprayed with a concentration of Kinetin 200 mg H.L\(^{-1}\) gave the lowest fertility percentage was 73.67%.
Table 6. Effect of the Foliar Nutrition of Potassium and the Kinetin on Fertility Percentage (%) of Mungbean genotype

| Cultivars (V) | Kinetin H (mg/l) | Potassium K (mg/l) | V × H |
|--------------|------------------|-------------------|-------|
|              | 0                | 400               | 800   |       |
| V1           | 81.67            | 87.00             | 90.67 | 86.44 |
|              | 100              | 82.00             | 87.33 | 89.33 | 86.22 |
|              | 200              | 89.33             | 90.67 | 93.33 | 91.11 |
| V2           | 80.67            | 84.33             | 88.00 | 84.33 |
|              | 100              | 86.33             | 88.00 | 88.00 | 87.44 |
|              | 200              | 73.67             | 93.00 | 94.00 | 86.89 |
| V3           | 82.33            | 86.67             | 88.33 | 85.78 |
|              | 100              | 92.67             | 88.67 | 86.00 | 89.11 |
|              | 200              | 90.00             | 94.00 | 97.33 | 93.78 |
| Mean K       | 84.30            | 88.85             | 90.56 |
| L.S.D (0.05) | K = 1.18         | V × H × K = 3.65  |

3.6. Seed yield (ton.ha\(^{-1}\))

It is evident from the results in Table (7) that plants sprayed with a high potassium concentration of 800 mg.L\(^{-1}\) achieved the highest average seed yield of 1.14 ton.ha\(^{-1}\) and did not differ significantly from plants sprayed with a concentration of 400 mg K.L\(^{-1}\) (1.10 ton.ha\(^{-1}\)). However, both concentrations were significantly superior to the control plants that gave the lowest average seed yield of 0.94 kg.ha\(^{-1}\). The increase in seed yield at high potassium concentration is due to its superiority in the number of pods per plant and the fertility percentage in pods as shown in Tables 5 and 6, which leads to an increase in the yield directly. This result agrees with what was stated by [25, 35, 36], which indicated that the seed yield differs significantly when potassium was added. The results in Table (7) show that plants sprayed with a concentration of 200 mg.L\(^{-1}\) of kinetin gave the highest average seed yield of 1.12 ton.ha\(^{-1}\) and did not differ significantly from plants of concentration 100 mg H.L\(^{-1}\), but both were significantly superior to the control plants that gave the lowest average for the trait amounted to 0.98 ton.ha\(^{-1}\). The reason for the superiority of the high concentration of kinetin in this trait is due to its superiority in the number of pods/plant and the fertility percentage in pods as shown in Table 5 and 6, which is one of the yield components. Accordingly, this led to an increase in the yield, which represents the outcome of the vital activities carried out by the plant, and these results confirm the existence of a positive significant correlation between the seeds yield, number of pods/plant, number of seeds/pod and the fertilization percentage. These results agreed with what was stated by [28, 37], that there is a significant effect of kinetin on seed yield. It appears from the results of Table (7) that the (V1) genotype was significantly superior with the highest average seed yield, which amounted to 1.41 ton.ha\(^{-1}\), with an increase of 0.45 and 0.60 tons over the (V2) and (V3) genotypes, which gave a lower average for this trait was 0.96 and 0.81 ton.ha\(^{-1}\), respectively. The superiority of the (V1) genotype in this trait is due to its distinctiveness in the fertility percentage.
pod as in Table 7 and this may be reflected in increasing the number of seeds per plant and then increasing the seed yield. This is confirmed by the highly significant positive correlation between seed yield and the number of seeds per pod in the plant. The result is consistent with what was stated by [38, 40], who indicated that the cultivars differ significantly among themselves in the characteristic of the total yield.

Table (7). Effect of the Foliar Nutrition of Potassium and the Kinetin on Seed yield (ton/ha) of Mungbean genotype

| Cultivars (V) | Kinetin H (mg/l) | Potassium K (mg/l) | V × H |
|--------------|-----------------|--------------------|-------|
|              | 0               | 400                | 800   |       |
| V1           | 1.121           | 1.452              | 1.465 | 1.346 |
| V2           | 1.251           | 1.477              | 1.472 | 1.400 |
| V3           | 1.045           | 0.891              | 0.901 | 0.946 |

Mean K = 0.126

L.S.D (0.05) K = 0.232

4. Conclusions

This study confirms the positive role that potassium plays, especially when spraying with concentrations higher than 400 mg L⁻¹, in improving the growth characteristics of the mungbean crop. Besides, its possibly affecting the increase in fertility percentages directly or indirectly, which was reflected in the increase in the number of pods and seeds of the plant and then the seed yield during its activation of biological activities and the (NR)enzyme activity. Kinetin also exhibited similar behavior to the behavior of potassium in its effect and improved the performance of the plant and its yield for the mungbean cultivars that showed a difference between them and in their response to the study factors.

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