Effect of Different Levels of Organic, Mineral Fertilization and Foliar Application with Some Nutrition Elements on Dry Seed Yield of Cowpea Plants

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ABSTRACT
The effective nutrients management is requiring for increase the productivity and development of cowpea crop as suitable agronomic practice. A field experiment was conducted during the two summer seasons of 2018 and 2019 at Sakha Agricultural Research Station Farm, Kafr El-Sheikh Governorate, Egypt on cowpea (Vigna unguiculata L.) cv. Kafr El-Sheikh to study the impact of organic and inorganic fertilizers and foliar spray with K, Ca and B and their interactions on vegetative parameters, seed yield and leaf chemical composition as well as protein content and seeds germination percentage. Results indicated that, the highest values of vegetative growth parameters i.e., plant height (cm), No. of branches/plant, plant fresh and dry weights and chemical compositio

Keywords: Cowpea, compost, foliar application, K, Ca, B, growth and yield

Introduction
Cowpea (Vigna unguiculata L.) is one of the most important crops of the family Fabaceae and a major grain legume grown in semi-arid regions. It is a major source of protein, minerals (Dube and Fanadzo, 2013). Cowpea is commonly referred for seeds which containing 18-34% protein, leaves and green pods are consumed as vegetable and the dried grains are used in many different food preparations. In Egypt, cowpea has been introduced as a promising double purpose forage and seed crop for its green canopy or using it in animal diets as dry seeds as well as it is a primary source of plant protein for humans and animals (Hamd Alla et al., 2014). The excessive use of mineral fertilizers represents the major factor of plant production cost, increase soil salinity, lead to serious health hazards and makes some pollution of agro-ecosystem (Fisher and Richter, 1984). The optimum fertilizer requirements for cowpea plants production can be realized not only with the recommended quantity, but also through using proper sources that are considered one of the most important factors affecting the plant growth. Organic fertilizers such as animal manure, green manure, plant residues and composts have gained motivation in organic farming to boost agricultural production for its important multi various features such as being rich in nutrients, vitamins, growth regulators, free from pathogens and containing immobilized micro flora (El-Gisy, 1994). Moreover, composts play an important role in nutrients solubility and activate physiological and biochemical processes in plants leading to increasing plant growth and nutrients uptake (Sarhan et al., 2011). Fertilizer is a vital input to boost the crop yields. Among the methods of fertilizer application, foliar nutrition is recognized as an important method of fertilization and faster for absorption, since foliar nutrients usually penetrate the leaf cuticle or stomata and enters the cells facilitating easy and rapid utilization of nutrients (Elayaraja and Angayarkanni, 2005). Several investigators reported that, K, Ca and B as foliar applications had an important role in plant growth, yield and its quality. Potassium is an important nutrient for plant growth and physiological functions, including regulation of water and gas exchange in plants, protein synthesis, enzyme activation, photosynthesis and carbohydrate translocation in
plants (Bednarz and Oosterhuis (1999) and Zekri and Obreza (2009). Calcium, uptake as Ca$^{2+}$, is an essential element for the growth of the plants and fruit development, and it is important in the resistance of the plants to pathogens due to the protection of the cell wall. Also, it plays an important biochemical functions and supports many metabolic processes, in addition to activating several enzymatic systems, thus contributing to the proper development of plants (El Habbasha and Ibrahim, 2015). Legume crops required more amounts of boron compared to other field crops; boron plays vibrant role in proper development of reproductive organs. The organic fertilizers combined with chemical fertilizers is more suitable to achieve high crop yields (Wijewardana, 1993). Hence, the objective of this work was to study the effect of organic and inorganic fertilizers and foliar spraying with K, Ca and B nutrients and their combination on vegetative growth parameters, seed yield and leaf chemical constituents of cowpea plants in both seasons.

Materials and Methods

This study was carried out during the two summer seasons of 2018 and 2019 at Sakha Agricultural Research Station Farm, Kafr El-Sheikh Governorate, Egypt on cowpea (Vigna unguiculata L.) cv. Kafr El-Sheikh to study the effect of organic and inorganic fertilizers and foliar application with nutrients (K, Ca and B) and their combination on vegetative growth parameters, seed yield and leaf chemical constituents. The physical and chemical properties of the experimental soil are given in Table (1).

### Table 1: Physical and chemical and properties of experimental soil before conducting the experiments in 2018 and 2019 seasons

| Seasons | O.M (%) | Clay (%) | Silt (%) | Sand (%) | Texture class | EC (dS/m) | PH | Available (mg/Kg soil) |
|---------|---------|----------|----------|----------|--------------|-----------|----|-----------------------|
|         |         |          |          |          |              |           |    | N         | P | K         |
| 1st     | 1.86    | 42.40    | 23.97    | 33.63    | Clay         | 3.75      | 7.7 | 25        | 9.2 | 651       |
| 2nd     | 2.22    | 43.22    | 23.21    | 33.57    | Clay         | 3.60      | 7.6 | 36        | 12  | 681       |

The experimental layout was split-split plots system in a randomized complete blocks design with three replicates. Organic and inorganic fertilizers (Table 2) were randomly distributed in the main plots which were subdivided to three sub-plots, each one contained foliar application, i.e., control (tap water spray), potassium sulfate (48% K$_2$O) at rate 1cm/l, calcium chelated (10% Ca) at rate 1g/l and boric acid (17% B) at 0.5g/l were sprayed three times to plants at two-week intervals starting after two weeks from sowing date.

Mineral fertilizers, as calcium super phosphate (15.5% P$_2$O$_5$) was added with the soil preparing at rate 300 kg/fed., ammonium nitrate (33.5% N) was added in two equal portions after 25 and 40 days from sowing date at rate 100 kg/fed., while potassium sulfate (48 % K$_2$O) was add at rate 50 kg/fed. after 30 days from sowing date as the 100% recommended mineral fertilizers requirements for cowpea plants according to the recommendation of Ministry of Agriculture and Land reclamation 2018.

### Table 2: Description of used treatments in the field experiments within the current study

| Treatments Details | Main plot | Sub-plot |
|--------------------|-----------|----------|
| 1- Control (unfertilized) | 1- Control (unsprayed) | |
| 2- 100% mineral | 2- Spray application of potassium sulfate at rate 1cm/l |
| 3- 50% organic + 50% mineral | 3- Spray application of calcium chelated at rate 1g/l |
| 4- 100% organic (compost) | 4- Spray application boric acid at 0.5g/l |

Organic fertilizer (compost) amounts was determined according to its nitrogen content (total nitrogen in compost 1.2 and 1.3 % in both seasons, respectively.

The compost (100% organic) was added with the soil preparing at rate 2.792 and 2.577 ton/fed. This experiment included 16 treatments as a combination between 4 fertilizer sources in main plots, and 4 foliar applications in subplots in both seasons. Cowpea seed were sown in hills at 20 April
The following data were recorded:

1. Vegetative growth parameters
   A random sample of five plants were taken from each plot at the flowering stage (Days after sowing) for measuring the growth parameters, i.e., plant height (cm), No. of branches/plant, plant fresh and dry weights (g) according to Koller (1972).

1. Seed yield and its components
   At harvest time, a random sample of five plants from each plot were taken to evaluate seed yield, No. of pods/plant, No. of seed/pods, dry seed yield/plant and seed index (weight of 100 seeds) as well as seed yield/ fed.

2. Chemical constituents of leaves
   The samples of leaves were randomly taken for estimating chemical constituents. Nitrogen was determined using the Micro-Kjeldahl method (Piper, 1950). Phosphorus was determined by spectrophotometer (Murphy and Riely, 1962). Potassium was determined according to (Jackson, 1967). Calcium was determined according to Jackson and Ulrich (1959). Meanwhile, boron was determined according to (A.O.A.C, 1990).

3. Protein content and seed germination (%)
   Crude protein percentage in dry seeds of cowpea was determined according to (A.O.A.C, 1990), also 100 seeds were used from each treatment for calculation the germination percentage.

Statistical analysis
   Data were tested by analysis of variance according to Little and Hills (1975). Duncan’s Multiple Range test was used for comparison among treatments means (Duncan, 1955).

Results and Discussion

1. Vegetative growth parameters
   Data presented in Table (3) reveal that the highest values of plant growth parameters (plant height, No. of leaves, No. of branches, plant fresh and dry weights) were produced by plants fertilized with 50% organic + 50% mineral fertilizers treatment followed by 100% mineral, while the lowest values were obtained by control (untreated plants) in both seasons. Improving vegetative growth parameters due to applying of compost plus chemical fertilizers compared to using each alone. This favorable effect can be attributed to that applying mineral N stimulated the rate of decomposition of compost and produced higher humus substances which in turn improve the physical and chemical properties of the soil as well as increase both the exchangeable water soluble of nutrients and their uptake (Cooke, 1972), consequently increased the vegetative growth parameters. In this concern, Mafadi and Gohar (1975) attributed that to NH + ion adsorbed on the surface of composts and became available to plant uptake. Similarly, Jha et al., (1996) stated that applying chemical fertilizer with organic manures increased both N mineralization and nitrification which in turn improve the access to NH4-N and result in greater number of viable cells of nitrifying bacteria, especially with chemical fertilization. The superiority of 50% compost + 50% mineral N treatment in improving growth of cowpea plants may be due to that such organic manure is capable as a source of many essential macro and micronutrients to plants (Remington and Frances, 1955) to serve as a good natural soil texture conditioner being rich in organic matter and increase availability and uptake of N, P and K which positively reflected on plant cell elongation and division as well as stimulate photosynthesis and metabolic processes. The obtained results are in accordance with those of El-Mansi et al., (2004) on pea, Ahmed and Elzaawely (2010), Dey et al., (2017), Abd El Lateef et al., (2018), Chemutai et al., (2018), Jinendra et al., (2018) on Cowpea and Zeid et al., (2015) on radish plants.
Table 3: Vegetative growth parameters of cowpea plants as affected by different sources of organic, mineral fertilizers and foliar application with K, Ca and B during 2018 and 2019 seasons

| Treatments                              | 1<sup>st</sup> season | 2<sup>nd</sup> season |
|-----------------------------------------|------------------------|-----------------------|
|                                         | Plant height (cm) | No. of leaves/ plant | No. of branches/plant | Fresh weight (g/plant) | dry weight (g/plant) | Plant height (cm) | No. of leaves/ plant | No. of branches/plant | Fresh weight (g/plant) | dry weight (g/plant) |
| Control (Without fertilizer)            | 57.38d | 16.12d | 5.05d | 169.17d | 25.22d | 58.85d | 17.58d | 5.05c | 172.57d | 26.54d |
| 100% Mineral                            | 65.29b | 19.41b | 5.43c | 273.34b | 38.55b | 65.32b | 20.55b | 5.42b | 277.18b | 39.95b |
| 50% Mineral + 50% Organic               | 70.61a | 20.75a | 5.85a | 306.79a | 43.53a | 71.43a | 21.87a | 5.83a | 310.78a | 44.63a |
| 100% Organic                            | 61.62c | 17.71c | 5.53b | 251.53c | 34.16c | 62.33c | 18.50c | 5.53b | 256.13c | 35.05c |
| L.S.D at 0.05                           | 0.328  | 0.191  | 0.064 | 1.063   | 0.780  | 1.342  | 0.333  | 0.175  | 1.550   | 0.536  |

Fertilizer sources

| Foliar spray                            |  |  |  |  |  |  |  |  |  |  |
|-----------------------------------------|------------------------|-----------------------|
|                                         | Plant height (cm) | No. of leaves/ plant | No. of branches/plant | Fresh weight (g/plant) | dry weight (g/plant) | Plant height (cm) | No. of leaves/ plant | No. of branches/plant | Fresh weight (g/plant) | dry weight (g/plant) |
| Control                                 | 52.33d | 15.09d | 4.68d | 180.92d | 27.54d | 53.68d | 16.38d | 4.64d | 184.83d | 28.93d |
| K                                       | 69.80a | 20.86a | 6.50a | 290.31a | 40.78a | 70.47a | 22.14a | 6.50a | 294.64a | 41.70a |
| Ca                                      | 67.63b | 19.73b | 5.80b | 275.56b | 38.08b | 68.37b | 20.68b | 5.80b | 279.88b | 39.68b |
| B                                       | 65.15c | 18.30c | 4.88c | 254.04c | 35.07c | 65.42c | 19.29c | 4.88c | 257.30c | 35.86c |
| L.S.D at 0.05                           | 0.522  | 0.292  | 0.103 | 1.481   | 0.416  | 1.357  | 0.255  | 0.085  | 1.735   | 0.483  |

Any values on the same vertical line for the same character having the same letter are not statistically different according to DMRT.
Concerning the effect of foliar application (K, Ca and B), it was found that all growth parameters were increased in the two growing seasons as a result to all foliar treatments compared with the check treatment (control). Results in Table (3) clearly show that the highest significant values of plant height, No. of leaves, No. of branches, plant fresh and dry weights were recorded by spraying plant with potassium (K) following by spraying with Ca, while the check treatment (control) recorded the lowest values of vegetative parameters in both seasons. Regarding the growth enhancing potential of potassium foliar application might be attributed to potassium is an important nutrient for plant meristematic growth and physiological functions, including regulation of water and gas exchange in plants, protein synthesis, enzyme activation, photosynthesis and carbohydrate translocation in plants. Potassium has favorable effects on metabolism of nucleic acids, proteins, vitamins and growth substances (Bednarz and Oosterhuis, 1999). Salami and Saadat (2013) pointed out that K plays an essential role in enzyme activation, protein synthesis, photosynthesis, osmoregulation, stomata movement, energy transfer, phloem transport, cation-anion balance and stress resistance. Potassium is a part of many important regulatory roles in the plant. It is essential in nearly all processes needed to sustain plant growth and reproduction, i.e. photosynthesis, translocation of photosynthesis products, protein synthesis, control of ionic balance, regulation of plant stomata, turgor maintenance, stress tolerance and water use, activation enzymes and many other processes (Cakmak, 2005). In the same tendency Sangakar et al., (2001), Priyadhurshini and Seran (2009) and Chavan et al., (2011) on cowpea.

As for the effect of the interaction, the results presented in Table (4) noticed that the highest values of growth parameters were recorded by the plants were fertilized with 50% organic + 50% mineral and sprayed with potassium (K) followed by the combination of 50% organic + 50% mineral treatment and foliar application by Ca comparing with the other combination treatments in both seasons.

### 2. Seed yield and its components

Data in Table (5) illustrated the effect of organic and mineral fertilizers on seed yield and its components of cowpea plants; i.e. No. of pods/plant, No. of seed/pods, dry seed yield /plant, seed index (100 seeds weight) as well as dry seed yield (kg/fed.). It can be concluded that, seed yield and its components were significantly increased by addition 50% organic + 50% mineral fertilizers compared with the control in both seasons. This increment in seed yield characteristics may be attributed to the high levels of nutrients in the organic fertilizers that could encourage the vegetative growth (Table, 3) of cowpea plants to go forward and accelerate the photosynthetic rate. The results are in conformity with those obtained by Singh et al., (2010), they noted a significant increase in grain yield (seeds/pod, pod/plant and seed weight) of kabuli chickpea crop with the application of farmyard manure in combined with mineral fertilizers . In the same line, Mahatele et al., (2011) on pigeon pea, Abd El Lateef et al., (2018), Chemutai et al., (2018), Jinendra et al., (2018) on Cowpea. Similar findings were also found by El-Fakhhrani, (1997) on broad beans and Gabr, (2000) on snap bean.

Significant differences in seed yield and its components were noticed among foliar treatments and the control (Table 5). Plants were sprayed with potassium (K₂SO₄) showed the highest values of No. of pods/plant (33.11 and 34.13), No. of seed /pod (10.99 and 11.56), dry seed yield /plant (25.22 and 25.67g) as well as dry seed yield /fed. (882.73 and 904.17 kg) while the control plants recorded the lowest values of No. of pods/plant (24.36 and 24.92), No. of seed /pods (9.03 and 9.55), dry seed yield /plant (23.46 and 24.06 g) and dry seed yield /fed. (821.16 and 841.98 kg) in the 2018 and 2019 seasons, respectively. The other treatments showed an intermediate values in most cases in both seasons.

The superiority of potassium sulfate treatment may be due to the active role of potassium in dividing and wideness of meristem cells and the speeded raise in the absorption of nutrients and activation of enzymes effect especially those related with the treatment of energy transformation (Tisdal et al., 1997). The improving effect of potassium on growth due to potassium spraying reflected on the seed yield comparing to check treatment (Mengel and Kirby, 1987). These results are in the same line with those obtained by Zedan (2011), Marschner, (2012), Salim et al., (2014), and JafarUllah et al., (2007) on cowpea plants.

Concerning the effect of combination of the interaction, the statistical analysis for data in Table (6) showed that, a significant effect of fertilization treatments and K, Ca and B spraying was found to exist on the seed yield aspects. Fertilization treatment of 50% mineral + 50% organic combined with
Table 4: Vegetative growth parameters of cowpea plants as affected by the interaction between fertilizer sources (organic and inorganic) and foliar application with K, Ca and B during 2018 and 2019 seasons

| Seasons          | Treatments       | 1st season                  | 2nd season                  |
|------------------|------------------|------------------------------|-----------------------------|
|                  | Plant height     | No. of leaves/plant          | No. of branches/plant        | Fresh weight (g/plant) | dry weight (g/plant) | Plant height     | No. of leaves/plant | No. of branches/plant | Fresh weight (g/plant) | dry weight (g/plant) |
|                  | (cm)             |                              |                             |                            |                       | (cm)             |                             |                             |                            |                       |
| Control          | K                | 48.63l                       | 13.57                       | 4.20k                      | 155.40m                | 24.83l           | 50.60l                       | 15.03i                      | 4.20i                    | 159.53m                | 25.73k|
| (Without fertilizer) | Ca              | 63.20g                       | 18.47                       | 6.10d                      | 183.77j                | 28.17j           | 63.93f                      | 20.77e                      | 6.10c                    | 187.23j                | 29.07j|
|                  | B                | 57.50i                       | 15.57                       | 4.50j                      | 166.17l                | 23.40m           | 58.73h                      | 16.50h                      | 4.50g                    | 168.17l                | 23.73i|
| 100% Mineral     | Control          | 50.63k                       | 15.67                       | 4.50j                      | 172.63k                | 27.93j           | 52.43k                      | 17.07h                      | 4.47h                    | 174.23k                | 29.93i|
|                  | K                | 71.23d                       | 21.73                       | 6.50b                      | 321.97c                | 44.23c           | 71.97c                      | 22.80c                      | 6.50b                    | 327.13c                | 45.43c|
|                  | Ca               | 70.80d                       | 20.60                       | 5.90e                      | 306.90d                | 42.03d           | 70.70d                      | 21.67d                      | 5.90d                    | 312.00d                | 43.23d|
|                  | B                | 68.5e                        | 19.63                       | 4.80i                      | 291.87e                | 40.00e           | 66.17e                      | 20.67e                      | 4.80g                    | 295.33e                | 41.20e|
| 50% Mineral + 50% Organic | Control          | 53.23j                       | 16.57                       | 4.80i                      | 183.67j                | 30.57i           | 54.30j                      | 17.83g                      | 4.70h                    | 185.30j                | 31.70h|
|                  | K                | 78.43a                       | 23.40                       | 7.10a                      | 381.83a                | 52.47a           | 78.87a                      | 24.40a                      | 7.10a                    | 387.17a                | 53.73a|
|                  | Ca               | 76.30b                       | 22.77                       | 6.20cd                     | 357.60b                | 49.10b           | 76.87b                      | 23.63b                      | 6.20c                    | 361.90b                | 50.30b|
|                  | B                | 74.47c                       | 20.27                       | 5.30gh                     | 304.07d                | 42.00d           | 75.70b                      | 21.60d                      | 5.30f                    | 308.77d                | 42.80d|
| 100% Organic     | Control          | 56.80i                       | 14.57                       | 5.20h                      | 211.97i                | 26.83k           | 57.40i                      | 15.60i                      | 5.20f                    | 220.27i                | 28.37j|
|                  | K                | 66.33f                       | 19.83                       | 6.30c                      | 273.67f                | 38.23f           | 67.10e                      | 20.60e                      | 6.30b                    | 277.03f                | 38.60f|
|                  | Ca               | 63.20g                       | 18.70                       | 5.70f                      | 266.40g                | 36.70g           | 63.77f                      | 19.40f                      | 5.70e                    | 270.30g                | 37.53f|
|                  | B                | 60.13h                       | 17.73                       | 4.90l                      | 254.07h                | 34.87h           | 61.07g                      | 18.40g                      | 4.90g                    | 256.93h                | 35.70g|

L.S.D at 0.05 1.238 0.693 0.129 3.513 0.986 1.238 0.606 0.202 4.114 1.144

Any values on the same vertical line for the same character having the same letter are not statistically different according to DMRT
Table 5: Seed yield and its components of cowpea plants as affected by different sources of organic, mineral fertilizers and foliar application with K, Ca and B during 2018 and 2019 seasons

| Seasons | 1st season | 2nd season |
|---------|------------|------------|
|         | No. of pods/plant | No. of seeds/pod | Seed index 100 seeds wt. (g) | Dry seed yield (g/plant) | No. of pods/plant | No. of seeds/pod | Seed index 100 seeds wt. (g) | Dry seed yield (g/plant) | Dry seed yield (kg/fed.) |
| **Fertilizer sources** | | | | | | | | | |
| Control | 17.05d | 8.58d | 17.86d | 21.75c | 761.07d | 17.89d | 9.10d | 18.32d | 22.22d | 777.01d |
| 100% Mineral | 33.07b | 10.75b | 28.24b | 24.32b | 851.03b | 34.20b | 11.33b | 28.84b | 24.89b | 877.10b |
| 50% Mineral + 50% Organic | 38.47a | 11.43a | 29.25a | 26.97a | 943.88a | 39.01a | 11.90a | 29.86a | 27.53a | 963.94a |
| 100% Organic | 29.47c | 9.94c | 25.46c | 24.21b | 821.13c | 30.47c | 10.59c | 26.75c | 24.59c | 851.70c |
| L.S.D at 0.05 | 0.118 | 0.057 | 0.082 | 1.303 | 3.867 | 0.410 | 0.122 | 0.633 | 0.149 | 3.701 |
| **Foliar spray** | | | | | | | | | |
| Control | 24.36d | 9.03d | 21.78d | 23.46b | 821.16d | 24.92d | 9.55d | 22.31d | 24.06d | 841.98c |
| K | 33.11a | 10.99a | 27.98a | 25.22a | 882.73a | 34.13a | 11.56a | 28.59a | 25.67a | 904.17a |
| Ca | 31.24b | 10.71b | 26.03b | 24.24ab | 848.45b | 32.09b | 11.24b | 27.27b | 25.25b | 882.73b |
| B | 29.34c | 9097c | 25.03c | 24.32ab | 824.78c | 30.24c | 10.57c | 25.61c | 24.27c | 840.87c |
| L.S.D at 0.05 | 0.081 | 0.092 | 0.116 | 1.109 | 3.104 | 0.186 | 0.073 | 0.496 | 0.140 | 2.420 |

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Table 6: Seed yield and its components of cowpea plants as affected by the interaction between fertilizer sources (organic and inorganic) and foliar application with K, Ca and B during 2018 and 2019 seasons

| Treatments          | Seasons | 1st season | 2nd season | 1st season | 2nd season |
|---------------------|---------|------------|------------|------------|------------|
|                     |         | No. of pods/plant | No. of seeds/pod | Seed index 100 seeds wt. (g) | Dry seed yield (g/plant) | Dry seed yield (kg/fed.) | No. of pods/plant | No. of seeds/pod | Seed index 100 seeds wt. (g) | Dry seed yield (g/plant) | Dry seed yield (kg/fed.) |
| Control (Without fertilizer) | Control K | 15.83o | 7.56f | 16.52k | 21.28c | 744.79j | 16.46p | 7.87g | 16.73h | 21.72h | 760.32i |
|                     | Ca      | 18.30l | 9.33d | 19.30h | 22.27bc | 779.57j | 19.27m | 9.77e | 19.83ef | 22.83g | 799.05g |
|                     | B       | 17.50m | 9.26d | 18.24i | 22.13bc | 774.43i | 18.31n | 9.86e | 18.86fg | 22.62g | 787.97h |
|                     | Control | 16.56n | 8.18e | 17.38j | 21.30c | 745.50j | 17.50o | 8.91f | 17.86gh | 21.70h | 760.72j |
| 100% Mineral Control | K       | 27.29j | 10.24c | 25.16f | 24.16bc | 845.72f | 28.29k | 10.83d | 25.83d | 24.79e | 867.54e |
|                     | Ca      | 37.39d | 11.25b | 30.18b | 25.27 | 884.57d | 38.57d | 11.83c | 30.84b | 25.16e | 903.93d |
|                     | B       | 35.36e | 11.26b | 29.29c | 24.42bc | 854.58e | 36.37e | 11.81c | 29.84bc | 25.81d | 903.35d |
|                     | Control | 32.22g | 10.24c | 28.33d | 23.41bc | 819.23g | 33.56g | 10.87d | 28.83c | 23.82f | 833.59f |
| 50% Mineral + Control | K       | 28.52i | 10.13c | 25.22f | 25.26abc | 883.95d | 28.75j | 10.75d | 25.85d | 25.84d | 904.28d |
|                     | Ca      | 43.33a | 12.16a | 32.21a | 29.19a | 1021.53a | 44.15a | 12.82a | 32.89a | 29.81a | 1044.63a |
|                     | Organic B | 41.72b | 12.14a | 30.34b | 27.22ab | 952.66b | 41.93b | 12.39b | 30.84b | 27.75b | 971.37b |
| 100% Organic Control | K       | 40.30c | 11.27b | 29.24c | 26.21abc | 917.35c | 41.21c | 11.62c | 29.88bc | 26.73c | 935.48c |
|                     | Ca      | 25.70k | 8.19e | 20.21g | 23.15bc | 810.13h | 26.17i | 8.75f | 20.83e | 23.88f | 835.80f |
|                     | B       | 33.42f | 11.22b | 30.24b | 24.15bc | 845.25f | 34.52f | 11.83c | 30.79b | 24.86e | 869.05e |
| L.S.D at 0.05      |         | 0.192 | 0.217 | 0.275 | 2.630 | 7.360 | 0.441 | 0.172 | 1.177 | 0.333 | 5.739 |

Any values on the same vertical line for the same character having the same letter are not statistically different according to DMRT
potassium sulfate at 1 cm/l as foliar application had expressively higher seed yield values than the other combinations in both seasons.

3. Chemical constituents in leaves

Chemical constituents (N, P, K, Ca and B) concentrations of cowpea leaves were significant increased by fertilizers sources compared with the control in both seasons. Data presented in Table 7 show that cowpea plants fertilized with 50% mineral + 50% organic recorded the highest contents of N, P, Ca and B in leaves followed by plants received 100% mineral treatment singly compared to control plants which resulted the lowest values. Meanwhile, the highest K% in leaves was obtained by 100% mineral treatment followed by applying 50% mineral + 50% organic, 100% organic and finally control treatment. In the same tendency, Ahmed and Elzaawely (2010) and Abd El Lateef et al., (2018) on cowpea, they found that fertilizing plants with organic plants increased macro- and microelements contents in leaves and seeds.

Concerning with the effect of foliar application of K, Ca and B, data in Table (7) showed that foliar application of potassium sulfate treatment was increased leaves N, P and K contents, while foliar application of calcium recorded the highest leaf Ca content. Also, the plants which sprayed with boron produced the highest leaf B content comparing with the control in both seasons. Similarly, Nurzynska-Wierdak et al., (2012) on garden rocket plants. Also, Behairy et al., (2015) on onion, Zyada and Bardisi (2018) on garlic and Zyada et al., (2020) on cowpea, found that potassium spraying increased the contents of N, P and K in leaves.

Generally, the interaction between fertilizers sources and foliar application of K, Ca and B increased the contents of N, P, K, Ca and B in cowpea leaves as compared to control. In addition, the highest percentage of N and P in leaves were obtained from the interaction between 50% mineral + 50% organic and potassium spray in both seasons, with a significant increase compared to untreated cowpea plants. Likewise, Ca and B were increased in leaves with the combination of 50% mineral + 50% organic with Ca spray and 50% mineral + 50% organic with B spray, respectively (Table 8).

4. Protein content in dry seeds and seed germination (%)

As for the effect of fertilizers sources on protein % in dry seeds, data in Table (9) show that, cowpea plants fertilized with 50% mineral + 50% organic treatment gave the highest protein content and the highest seed germination followed by applying 100% mineral, 100% organic and finally control treatment which resulted the lowest values in both seasons. In the same tendency Ahmed and Elzaawely (2010), Abd El Lateef et al., (2018) and Jinendra et al., (2018) on cowpea.

Regarding to the effect of foliar applications, data in Table (9) clearly indicated that spraying K, Ca and B greatly improved the protein content and germination percentage of dry seeds as compared to untreated plants. The highest values in this respect were obtained by spraying cowpea plants with potassium sulfate at 1 cm/l followed by plants sprayed with Ca and B in both seasons. In the same line, Zyada et al., (2020) on cowpea, found that application of potassium fertilizer as soil or foliar application was recorded the best treatments for increasing all cowpea growth and seed yield components as well as N, P, K and protein percentage in seeds such as compared with control treatment. About the effect of interaction between foliar application and fertilizer treatments on the percentage of protein and germination seeds of cowpea, data in Table (10) show that there were significant differences among treatments in both seasons. Cowpea plants fertilized with 50% mineral + 50% organic and sprayed with potassium sulfate at 1 cm/l gave the highest values in this respect followed by plants fertilized with 50% mineral + 50% organic and sprayed with calcium chelated at rate 1 g/l in both seasons.
### Table 7: Chemical composition in leaves of cowpea plants as affected by different sources of organic, mineral fertilizers and foliar application with K, Ca and B during 2018 and 2019 seasons

| Treatments                      | Seasons | 1st season |          |          |          | 2nd season |          |          |          |
|---------------------------------|---------|------------|----------|----------|----------|------------|----------|----------|----------|
|                                 |         | N%         | P%       | K%       | Ca%      | B ppm      | N%       | P%       | K%       | Ca%      | B ppm      |
| **Fertilizer sources**          |         |            |          |          |          |            |          |          |          |          |            |
| Control                         |         | 2.49d      | 0.674d   | 1.40d    | 0.065c   | 21.78d     | 2.58d    | 0.676d   | 1.41d    | 0.075d   | 22.84d     |
| 100% Mineral                    |         | 3.24b      | 0.735b   | 1.82a    | 0.113b   | 23.00c     | 3.33b    | 0.736b   | 1.83a    | 0.123c   | 23.97c     |
| 50% Mineral + 50% Organic       |         | 3.63a      | 0.798a   | 1.72b    | 0.145a   | 25.04a     | 3.73a    | 0.790a   | 1.73b    | 0.155a   | 26.11a     |
| 100% Organic                    |         | 3.04c      | 0.698c   | 1.61c    | 0.120b   | 24.18b     | 3.13c    | 0.700c   | 1.63c    | 0.130b   | 25.26b     |
| L.S.D at 0.05                   |         | 0.018      | 0.001    | 0.011    | 0.014    | 0.145      | 0.009    | 0.002    | 0.002    | 0.004    | 0.035      |
| **Foliar spray**                |         |            |          |          |          |            |          |          |          |          |            |
| Control                         |         | 3.16a      | 0.708d   | 1.58d    | 0.085d   | 21.90d     | 3.26a    | 0.710d   | 1.59d    | 0.095d   | 22.95d     |
| K                               |         | 3.18a      | 0.745a   | 1.69a    | 0.120b   | 23.99b     | 3.25a    | 0.747a   | 1.70a    | 0.130b   | 25.06b     |
| Ca                              |         | 3.11b      | 0.727b   | 1.66b    | 0.140a   | 23.06c     | 3.12b    | 0.729b   | 1.67b    | 0.150a   | 24.06c     |
| B                               |         | 2.95c      | 0.715c   | 1.62c    | 0.098c   | 25.06a     | 3.05c    | 0.717c   | 1.63c    | 0.108c   | 26.12a     |
| L.S.D at 0.05                   |         | 0.018      | 0.001    | 0.009    | 0.010    | 0.124      | 0.013    | 0.001    | 0.011    | 0.009    | 0.042      |

Any values on the same vertical line for the same character having the same letter are not statistically different according to DMRT.
Table 8: Chemical composition in leaves of cowpea plants as affected by the interaction between fertilizer sources (organic and inorganic) and foliar application with K, Ca and B during 2018 and 2019 seasons

| Treatments                   | Seasons | 1st season                  | 2nd season | B ppm | 1st season | 2nd season | B ppm |
|------------------------------|---------|-----------------------------|------------|-------|------------|------------|-------|
|                             |         | N%  | P%  | K%  | Ca% | B ppm | N%  | P%  | K%  | Ca% | B ppm |
| Control (Without fertilizer) |         |     |     |     |     |       |     |     |     |     |       |
| Control                      |         | 2.43i | 0.664n | 1.33k | 0.05h | 20.24i | 2.53h | 0.666n | 1.35k | 0.06h | 21.251 |
| K                            |         | 2.62h | 0.682k | 1.48h | 0.07fgh | 22.27g | 2.69g | 0.684k | 1.50h | 0.08fgh | 23.34j |
| Ca                           |         | 2.47i | 0.678l | 1.42i | 0.08efg | 21.27h | 2.55h | 0.680l | 1.44i | 0.09efg | 22.34k |
| B                            |         | 2.44i | 0.670m | 1.36j | 0.06gh | 23.36e | 2.53h | 0.672m | 1.38j | 0.07gh | 24.43g |
| 100% Mineral                 |         |     |     |     |     |       |     |     |     |     |       |
| Control                      |         | 3.06e | 0.711h | 1.78e | 0.08efg | 21.32h | 3.18d | 0.712h | 1.79b | 0.09efg | 22.39k |
| K                            |         | 3.41d | 0.761e | 1.85a | 0.12cd | 23.42de | 3.49c | 0.762e | 1.86a | 0.13cd | 24.49g |
| Ca                           |         | 3.38d | 0.742f | 1.83a | 0.15b | 22.74f | 3.48c | 0.744f | 1.84a | 0.16b | 23.48i |
| B                            |         | 3.09e | 0.725g | 1.80b | 0.10de | 24.50c | 3.17d | 0.727g | 1.81b | 0.11de | 25.54e |
| 50% Mineral + 50% Organic    |         |     |     |     |     |       |     |     |     |     |       |
| Control                      |         | 3.54 | 0.765d | 1.68e | 0.12cd | 23.46de | 3.66b | 0.768d | 1.69e | 0.13cd | 24.50g |
| K                            |         | 3.74a | 0.811a | 1.75c | 0.15b | 25.56b | 3.81a | 0.812a | 1.76c | 0.16b | 26.53c |
| Ca                           |         | 3.71a | 0.795b | 1.72d | 0.18a | 24.55c | 3.82a | 0.797b | 1.74cd | 0.19a | 25.62e |
| B                            |         | 3.55c | 0.782c | 1.71d | 0.13bc | 26.61a | 3.65b | 0.783c | 1.72d | 0.14bc | 27.68a |
| Control                      |         | 3.61b | 0.690j | 1.52g | 0.09ef | 22.57f | 3.65b | 0.692j | 1.54g | 0.10ef | 23.64h |
| 100% Organic                 |         |     |     |     |     |       |     |     |     |     |       |
| Control                      |         | 2.93f | 0.725g | 1.67e | 0.14bc | 24.70c | 3.01e | 0.728g | 1.69e | 0.15bc | 25.77d |
| K                            |         | 2.89f | 0.695i | 1.66e | 0.15b | 23.69d | 3.00e | 0.696i | 1.67e | 0.16b | 24.80f |
| Ca                           |         | 2.73g | 0.683k | 1.60f | 0.10de | 25.75b | 2.86f | 0.685k | 1.62f | 0.11de | 26.82b |

L.S.D at 0.05

0.043 0.003 0.020 0.023 0.295 0.031 0.003 0.025 0.021 0.100

Any values on the same vertical line for the same character having the same letter are not statistically different according to DMRT
Table 9: The percentage protein in dry seeds and seed germination of cowpea as affected by different sources of organic, mineral fertilizers and foliar application with K, Ca and B during 2018 and 2019 seasons

| Treatments                | 1st season | 2nd season | 1st season | 2nd season |
|---------------------------|------------|------------|------------|------------|
| **Protein %** | **Germination ratio (%)** | **Protein %** | **Germination ratio (%)** |
| Control                  | 15.55d     | 83.97d     | 16.11d     | 84.23d     |
| 100% Mineral             | 20.26b     | 92.25b     | 20.83b     | 92.87b     |
| 50% Mineral + 50% Organic| 22.73a     | 95.07a     | 23.34a     | 95.44a     |
| 100% Organic             | 17.49c     | 90.55c     | 18.08c     | 91.01c     |
| L.S.D at 0.05            | 0.037      | 0.056      | 0.067      | 0.112      |

**Fertilizer sources**

| Foliar spray | **Protein %** | **Germination ratio (%)** | **Protein %** | **Germination ratio (%)** |
|--------------|---------------|---------------------------|---------------|---------------------------|
| Control      | 18.26d        | 85.71d                    | 18.85d        | 86.14d                    |
| K            | 19.81a        | 93.53a                    | 20.34a        | 93.90a                    |
| Ca           | 19.49b        | 92.05b                    | 20.07b        | 92.68b                    |
| B            | 18.46c        | 90.56c                    | 19.09c        | 90.84c                    |
| L.S.D at 0.05| 0.053         | 0.031                     | 0.073         | 0.047                     |

Any values on the same vertical line for the same character having the same letter are not statistically different according to DMRT

Table 10: The percentage protein in dry seeds and seed germination of cowpea as affected by the interaction between fertilizer sources (organic and inorganic) and foliar application with K, Ca and B during 2018 and 2019 seasons

| Treatments          | 1st season | 2nd season | 1st season | 2nd season |
|---------------------|------------|------------|------------|------------|
| **Protein %**       | **Germination ratio (%)** | **Protein %** | **Germination ratio (%)** |
| Control (Without fertilizer) | 15.21m | 82.14o | 15.84h | 82.50p |
| K                   | 16.25k     | 86.27k     | 16.84g     | 86.48l     |
| Ca                  | 15.50l     | 84.2m      | 15.89h     | 84.44n     |
| B                   | 15.25m     | 83.27n     | 15.85h     | 83.50o     |
| L.S.D at 0.05       | 0.125      | 0.073      | 0.174      | 0.112      |

Any values on the same vertical line for the same character having the same letter are not statistically different according to DMRT

Conclusions

It can be concluded that the best results on growth parameters, leaves chemical composition were resulted when cowpea plants fertilized by 50% mineral as ammonium nitrate (50 kg/fed.) + 50% organic as compost (1.396 or 1.289 ton/fed.) and sprayed with potassium sulfate at 1cm/l thrice to plants at two-week intervals starting after two weeks from sowing date. Therefore, this treatment could be recommended for improving cowpea plants performance under similar condition of this study.
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