Effects of Foliar NPK Spraying with Micronutrients on Yield and Quality of Cowpea Plants

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ABSTRACT---- ***The aim of this investigation was to estimate the effects of foliar application of NPK compound with Fe, Zn and Mn at different doses on cowpea plants. field experiment was conducted at Al Sharkia Governorate, Egypt in a private farm through a project of soil and water use Dept. of the National Research Center. This experiment design with three replicates. Cowpea seeds were sown on the 15th of June, 2014. In addition, soluble fertilizers contain (19 - 19 - 19) from N, P and K and 500 ppm Fe, 300 ppm Zn and 300 ppm Mn were applied. Four treatments of fertilization were tested: control (no fertilization),(50%),(100%)and (125%).The NPK fertilizers were sprayed every 15 days .The results are as follows: 1.Foliar fertilization NPK with Fe, Zn and Mn reflected increases in vegetative growth, yield and its components and nutrient concentration of cowpea plant compared with control. 2. Higher values of vegetative growth, yield components and nutrient concentrations by cowpea plant were obtained by foliar NPK application with Fe, Zn and Mn at 125%. The study results explain that foliar fertilization NPK with micronutrient may have a possibility role for increasing cowpea yield.***

Keywords---- Cowpea, Foliar fertilization, NPK, Micronutrients.

1. INTRODUCTION

Cowpea *(Vigna Unguiculata* L.) is an important plant nutrition in Egypt. The cowpea seeds are a high nutritional value which include the proteins and vitamins for human, feed for animals, and also it is increase the national economy. The little leaves and yeasty pods are eaten as vegetables. This plant such as family leguminous increased the nitrogen in soil by fixed it from the air this role for this plants are very important especially when the soil suffer from a lack of nitrogen. [10].

Due to nutrition importance and economic significance, it is necessary to improve new technique methods for increasing the crop production. Using foliar fertilization including micronutrients is one of these new methods that are treated more effective on yield, protein content and nitrogen fixation. In addition, cowpea is the most important crop of legume family that can be cultivated in semiarid district.

Cowpea plant need a small rate of nitrogen fertilization which roots have nodules include bacteria called *Rhizobia* help to fix nitrogen from the air. [10]. But, when the soil are sub fertility so its need to applied the nitrogen taking into not increase the rate of nitrogen because the plant will grow luxuriantly and decreased the total yield. In addition, the cowpea needs to increase the amount of phosphorus form of single super phosphate [10].

More research have been directed to increase cowpea production and quality for the objective of increasing exported yield. Application of adequate amounts of micronutrients such as Fe, Zn and Mn is one of the most important factors concerned in improving plant growth, yield and quality of cowpea. The nutrition of plants by foliar application is not only an addition channel of nutrients but also a mean of regulating root absorption by such plants [12].

Micronutrients (MNs) are important to world agriculture and human health. Over 3 billion people across the world suffer from micronutrient eficiencies. Zinc (Zn), iron (Fe), manganese (Mn) and copper (Cu) have become yield -limiting factors and are partly responsible for low food nutrition. Although crops use low amounts of MNs (<2.4 kg/ha), about half of the cultivated world's soils are deficient in plant bioavailable MNs, due to their slow replenishment from the weathering of soil minerals, soil cultivation for thousand s of years and insufficient crop fertilization. Relevant MN deficiencies occur more frequently in neutral to alkaline soils, under anaerobic conditions and in arid or semi -arid regions. The use efficiency (MUE) of most commercial fertilizers added to soils or foliage is 2.5/%to 5% of applied, due to their rapid stabilization by soil components, low leaf penetration and low mobility in plants. In soil-plant systems, fertilizer -MNs interact with macronutrients resulting in synergistic, antagonistic or neutral response affecting yield and food quality. [25].

The importance of foliar fertilization with micronutrients , Fe, Zn and Mn can be accounted by its essential role in respiration, their metabolism activation of the enzyme, photosynthesis, chloroplast formation, chlorophyll synthesis and natural hormone biosynthesis [14]; [26]. [25] found that foliar application of translocated to the developing pods, which macro and micro nutrients play an important role in the production of good crop and higher yield of cereal crops. Foliage

applied micro and macronutrients at critical stages of crops were efficiently absorbed and much filled and more number of pods in cowpea [32]. The presence of nutrients like Nitrogen, Phosphorus, Potassium, Sulfur and Magnesium are essential in balanced form for major processes of development of plants and production of yield [19]. Plants also require the trace elements (B, Cu, Mn, Zn and Mo) for their normal growth and development [19].

However, the foliar application with macronutrients such as NPK affect plant growth and development, they are depending on micronutrients availability such as Fe, Zn, B, Cu and Mn they are used in lower amounts compared to macronutrients, such as N, P and K. They have an important role in cell division and development of meristematic tissues, photosynthesis, respiration and acceleration of plant maturity [39]. Micronutrients show a vital role in the enhancement of yield. They are required in trace quantities, but their suitable stream increases the availability of other macro and micro nutrients and confidently affects the physiology of cell that is also revealed in yield [34]. Zinc and Mn are a trace mineral elements required for normal growth of crops and deficiency of Zn and Mn severely affect the crops and reduces the yield. Zinc is an essential element for plants that act as a metal component of various enzymes or as a functional structural or regulatory cofactor and for protein synthesis, photosynthesis, the synthesis of auxin, cell division, and sexual fertilization. Also, zinc plays a special role in synthesizing proteins, RNA and DNA [24]. Iron has many essential roles in plant growth and development, including chlorophyll synthesis, thylakoid synthesis and chloroplast development [26].

Furthermore, the application of micronutrients is very important to cowpea plant which add by foliar or in soil that its play necessary roles in CO2 flowing out, vitamin A improvement and resistant system activities. So, deficiency of the micronutrients decreases the plant production of cowpea. Particularly, amounts of iron, boron and zinc in soil are more than the plant needs but cannot readily be absorbed by plants. Therefore, it is better to be used foliar application, as it is more effective than adding fertilizer to soil. Also, foliar application can provide the nutrients for plants quickly to obtain high performance guarantee. From an ecological perspective, foliar fertilization is more passable, because the small amounts of nutrients is used for rapid use by plants [22]. Foliar feeding, using foliar fertilizer, is an effective method for correcting soil deficiencies and over coming the soil's inability to transfer nutrients to the plant. Tests have shown that up to 60% of a foliar fed nutrient solution can be found in the smallest root of a plant within 60 minutes of application. The absorption takes place through the stomata of the leaves and also through the epidermis. Movement of elements is usually faster through the stomata, but the total absorption may be as great through the epidermis. Plant is also able to absorb nutrients through their bark [35].

However, root is common to be first part of plant that adsorbed nutrients from soils, but nutrients availability might be limited then affects fertilizer efficiency. So, it is better to used foliar application that extend nutrients for plant [3].

There is some information of the foliar fertilization with micronutrients of cowpea. So, this study effects the efficiency of foliar application of macronutrients beside to the micronutrients at different doses on cowpea plants.

2. MATERIALS AND METHODS

A field experiment was executed in Sharkia Governorate, Egypt, to effects the efficiency of foliar NPK application with micronutrients Fe, Zn and Mn on nutrient concentration and yield of cowpea (*Vigna Unguiculata* L.). Cowpea seeds were sown on the 15th of June, 2014. Samples of the commonly used commercial fertilizers were obtained from soluble fertilizers contain (19 - 19 - 19) and 500 ppm Fe, 300 ppm Zn and 300 ppm Mn (mixed micronutrients). Levels up to these concentration were selected as previous studies revealed that its higher concentrations than this can adversely affects nitrogen absorption in plant which resulted in reduction in yield [31].

The required quantity of foliar spray fertilizers was applied to the crop with irrigation. Total six irrigations were applied during the growth period of the crop. The control treatment was sprayed with ordinary water. Treatments were sprayed by hand sprayer resulting smoothly wet surface area. The treatments were:

1- Control (no foliar).
2- NPK 50% + (mixed micronutrients MN).
3- NPK 100% + (mixed micronutrients MN).
4- NPK 125% + (mixed micronutrients MN).

The experimental plots were fertilized with (30 kg N/fed as a form of ammonium sulphate (20.5% N), 30 kg P2O5 /fed as a form of calcium superphosphate (15.5 % P2O5). and 50 kg K2O /fed as potassium sulphate (50 % K2O)..

The experimental design and treatments:

Treatments were arranged in a complete randomized block design with 3 replicates:

1. The main plots were assigned to the two fertilization methods foliar application and control (no application).
2. The sub-plots were occupied by the four fertilization rates F_0 (control), F_1 (50%), F_2 (100%), F_3 (125%) of recommended rates.

Therefore, the main objective of this study depended on the efficiency of foliar fertilization with macronutrients compound with micronutrients at different levels on plant growth and quality of cowpea plants.

Vegetative growth characters:

The following growth attributes were measured after six weeks of sowing, using thee random plants from each treatment,: plant height (cm), number of leaves/plant, leaf area (cm2) / plant, plant fresh weight (g) and plant dry weight (g).

Seed yield and its components:

The crop was harvested after 90 days from sowing, samples of three random plants from each treatment were used to record the following characters: number of pods/plant, pod length (cm), number of seeds/pod, seeds weight/pod (g), seed yield (g/ plant), total seed yield (ton/ fed).

Methods of analysis

Soil and plant samples were carried out to the laboratory in the National Research Center, oven dried, fine grounded, wet digested and prepared for chemical analysis. Mechanical analysis of the experimental soil was determined according to the international Pipette method and calcium carbonate content of the soil was determined volumetrically using Calcimeter as described by [30].

Soil pH was measured using a glass-electrode pH meter with a combined glass reference at soil: water 1:2.5 [8].

EC extract was determined by using the bridge, [18].

Calcium carbonate was determined using a calcimeter and calculated as CaCO3 % as described by [30].

Organic matter content was analyzed according to the modified Walkley-Black method [18].

Carbonate and bicarbonate ions, were determined by titration with a standard solution of sulfuric acid using phenolphthalein as an indicator for CO3- and methyl-orange for HCO3- as described by Jackson [30]. Chloride ions were determined by titration with silver nitrate using potassium chromate as an indicator according to Mohr, s method [30]. Sulfates ions were determined by difference between total cations and total anions.

Extraction of exchangeable calcium and magnesium was done, and two cations were determined by titration with versinate along with extract of exchangeable sodium and potassium using 1 M ammonium acetate solution and two cations was determined flame photo metrically [30].

Total nitrogen in soil was determined using microKjeldahl method) Jackson [18].

Total potassium in soil was determined by flame photometer according Jackson [18].

Total phosphorus in soil was determined colourmetrically using ascorbic acid method was measured according to [39].

The data obtained was subjected to analysis variance procedure using Duncan's Multiple Range Test was adopted for the means comparison among treatments showing significant difference. Effect of N and P fertilizer was partitioned into linear and quadratic components and regressions were calculated for effects significant at 0.05 level of probability [11].

Some physical and chemical characteristics of the studied soil and material fertilizers are presented in Tables 1 and 2.

Table (1): Some Physical and Chemical Analysis of Experiments Soil.

Soil characteristics	**Soil content**
Mechanical analysis:	
Fine sand%	24.66
Coarse sand%	9.92
Silt%	12.80
Clay%	52.62
Textural	Clayey
Chemical analysis:	
Organic matter%	1.88
pH *	8.01
EC (dS m^{-1})**	0.15
$CaCO_3$ g kg^{-1}	0.22
Soluble ions (mmol^{-1})	
Ca^{++}	0.46
Mg^{++}	0.28
Na^{+}	0.84
K^{+}	0.08
CO^{-}_3	-
HCO^{--}_3	0.56
Cl^{-}	0.40
SO^{---}_4	0.70
Available-N (g kg^{-1})	3.61
Available-P (g kg^{-1})	1.62
Available-K (g kg^{-1})	0.81

*Soil- water suspension 1:2.5 ** Soil water extract 1:5

Table (2): Chemical analysis of NPK fertilizer used during the experiment.

Fertilizer	Contents
N %	19
P %	19
K %	19
Fe ppm	500
Zn ppm	300
Mn ppm	300

3. RESULTS AND DISCUSSION

Plant Growth Parameters:

Vegetative Characters: Results show that the effect of foliar fertilization of cowpea plants with NPK with micronutrients Fe, Zn and Mn,) at different concentrations on vegetative growth. Concerning the effect of foliar NPK with micronutrients on vegetative growth, data presented in Table (3), showed that the foliar NPK fertilization with micronutrients was generally more effective than the control plants. These results may be due to the effect of foliar application on photosynthetic rates, plant stomatal conductance and transpiration. These results were in agreement with the results obtained by [19] and [29] who revealed that foliar application significantly increased vegetative growth. Plant height, number of leaves, leaf area, plant fresh weight and plant dry weight were significantly increased with foliar NPK fertilizer rates from 50% to 125%.

The maximum mean values of this characteristics were found with foliar NPK fertilizer rates with micronutrients at 100% and 125%. On the other hand, the minimum values of the vegetative growth were occurred with foliar NPK fertilizer with micronutrients at 50%. These results may be due to the effect of these with micronutrients in plant physiology; Fe plays a prominent role in several vital processes in plant such as photosynthesis consequently affecting plant growth; Zn is important for C fixed in the primary photosynthetic process [23]. Zn increased photosynthetic efficiency, which was reflected as simulative effect on vegetative growth plant and also zinc is a component of a variety of enzymes such as dehydrogenase, proteinase, peptidase and phosphohydrases (metabolism of carbohydrates, protein and phosphate) and Zn is known to stimulate plant resistance to dry and hot weather [24]. Zn is also well reduction known to be directly involved in biosynthesis of IAA hormone which induces cell division and cell elongation; Mn is involved in the evolution of O_2 in photosynthesis (Hill reaction). It is a component of several enzyme systems. It has also function in chloroplast as a part of electron-transfer (oxidation-reduction) reactions and electron transport system [35]. Mn is a part of nitrate reductase, which is involved in reduction of NO_3 to NH_4 after its absorption by plants. Also, it is structural component of nitrogenase, which involved in nitrogen fixation of N_2 into the ammonium form in a symbiotic relationship with legumes [9] and [5].

Improving effect of foliar NPK with Fe, Zn and Mn on vegetative growth might be attributed to their positive role on enhancing photosynthesis, biosynthesis of proteins and carbohydrate assimilation [14]. This is in coincidence with the findings of [16] on sweet potato, [1] and [27] on potato plants.

Data in the same Table, illustrate that NPK foliar spraying treatments with micronutrients increased significantly the fresh weight and dry weight compared with control. The positive effect of Fe, Zn and Mn, on fresh weight and dry weight could be attributed to that Fe, Zn and Mn have vital roles in plants. These results are in conformity with those obtained by [4] and [2].

The foliar application of NPK with micronutrients data in the same Table, obtained that the maximum means of fresh and dry weight were obtained at 100% and 125%. But, the minimum of fresh and dry weight were found with control. These results may be due to the effect of these with micronutrients in plant physiology such as photosynthesis, enzyme systems, function in chloroplast and nitrogen fixation [9], [5], [23] and [24].

Table (3): Effect of foliar NPK fertilizers with micronutrients on vegetative growth of cowpea plants.

Type of fertilizers	Plant height (cm)	Number of leaves per plant	leaf area (cm2) / plant	plant fresh weight (g)	plant dry weight (g)
Foliar application	58.62	40.87	38.32	27.60	8.74
Control	47.97	30.14	28.39	22.16	7.24
50%+MN	54.27	38.12	35.44	25.21	8.25
100% +MN	59.21	41.26	38.25	27.36	8.63
125%+MN	62.37	43.23	41.26	30.24	9.33
LSD at 0.05	1.15	1.45	2.16	0.28	0.56

Yield and its components:

Data in Table (4) obtained that the number of pods/plant, pod length (cm), number of seeds/pod, seeds weight/plant (g) and total seed yield (ton/ fed) as affected by foliar NPK fertilizer with micronutrients under experimental conditions.

The maximum values of this characteristics were produced from foliar NPK application with micronutrients. While, the minimum values of aforementioned attribute were obtained with control. These results are in harmony with those obtained by [15] who suggested that there are several potential benefits of providing nitrogen to cereals via the foliage as NPK fertilizer. These include: reduced nitrogen losses through denitrification and leaching compared with nitrogen fertilizer application to the soil; the ability to provide nitrogen when root activity is impaired in saline or dry condition, and uptake late in the season to increase nitrogen concentration. Foliar NPK application may also hinder crop productivity although the explanation for this vary, and include desiccation of leaf cells and the disruption of carbohydrate metabolism. When damage has not been severe, foliar application have increased yield, particularly when applied before flag leaf emergence and when nitrogen availability is limiting.

Data showed that all spraying treatments NPK with micronutrients greatly improved the yield and its components of cowpea plants compared with control; number of pods/plant, pod length, number of seeds/pod were significantly improved with increasing of foliar NPK with micronutrients concentrations from 50% up to 125% . In the same trend, seeds weight/plant and total seed yield were significantly increased with increasing foliar NPK with micronutrients concentrations from 50% up to 125%. These results may be due to the effect of these micronutrients (Fe, Zn and Mn) in plant physiology such as photosynthesis consequently affecting plant growth, important for ^{14}C fixed in the primary photosynthetic process. [23]. The obtained results are in harmony with those of [13] and [30] where they found that yield and its components increased markedly by foliar spray of NPK with micronutrients compared with the untreated plants.

Results in the same Table, showed that spraying cowpea plants with NPK with micronutrients (Fe, Zn and Mn) at different concentrations 50%, 100% and 125% were increased the total yield with increasing concentrations from 50% up 125%. The increase in total yield owed directly to the increase in vegetative growth. These increases might be ascribed to the favorable role of the used micronutrients and the positive effect of Fe, Zn and Mn, on dry weight could be attributed to that Fe, Zn and Mn have vital roles in plants as follows: Iron is activator of enzymes associated with energy transfer, nitrogen reduction and fixation and lignin formation [25]. Zinc is a component of many enzymes such as dehydrogenase, proteinase, peptidases and phosphohydrolase important for metabolism of carbohydrate, protein and phosphate [35]. Manganese involves in the evolution of O_2 in photosynthesis. These results are in conformity with those obtained by [4] and [2].

Table (4): Effect of foliar NPK fertilizers with micronutrients on yield and its components of cowpea plants.

Type of fertilizers	number of pods/plant	pod length (cm)	number of seeds/pod	seeds weight/pod (g)	seed yield (g/ plant)	total seed yield (ton/ fed)
Foliar application	5.69	8.55	5.27	2.96	21.06	6.05
Control	4.97	5.33	3.23	1.70	12.45	4.73
50%+MN	5.24	6.17	4.49	2.45	18.46	5.78
100%+MN	5.68	9.67	5.60	2.96	22.17	6.14
125%+MN	6.14	9.81	5.71	3.47	22.56	6.23
LSD at 0.05	5.46	NS	NS	0.46	0.25	0.11

Nutrient concentration:

Results showed that the application of foliar NPK fertilizer with micronutrients on nitrogen, phosphorus and potassium concentration (%) and its uptake (g plant-1). The results in Table (5) show that application of foliar NPK fertilizer with micronutrients significantly increased nutrient concentration of cowpea compared to control treatment. These results were in harmony with those obtained by [15] who showed that the sparing with macronutrients beside micronutrients decrease the denitification of nitrogen and loss of nitrogen by leaching compared the nitrogen when applied in soil. [36] who found that the sparing of NPK with micronutrients increased the concentration and the uptake from phosphorus that its increased the absorption of phosphorus compared with the phosphorus in the soil which become fixed in soil and unavailable to plant. [20] who found that the application of NPK with micronutrients sparing to leaves increased of potassium concentration and its uptake. [22] indicated that foliar application is a convenient and efficient operate and provides a low - cost approach for correcting K deficiency by allowing low rates frequent applications, thus avoiding excess use and build up of salts while maintaining high nutrient availability.

The results indicate that the highest concentration of nitrogen and it is uptake at 100% and 125%, but the lowest concentration of nitrogen at control Also, the results show that the highest concentration of phosphorus and potassium and it is uptake absorbed at 100% and 125% treatment compared with treatment of control.

The maximum values of phosphorus concentration were obtained with sparing NPK fertilizer with micronutrients compared with control. These results are in harmony with those obtained by [38] showed that the sparing of NPK with micronutrients increased the absorbed of many elements such as K, Ca, Mg and P, which may be attributed to decreased transpiration. Data in the same Table, obtained that the highest values of phosphorus concentration were observed with sparing fertilization at 125%. And the highest values of P uptake were obtained with sparing NPK with micronutrients at 100% and 125%.

Foliar application of macronutrients and micronutrients increased K concentration and its uptake. Data in Table (5), observed that the maximum values of K concentration and uptake were recorded with application of NPK with micronutrients. And the minimum values of K concentration and uptake were obtained with control. These results are in agreement with the results obtained by [20] who found that the sparing fertilizers with NPK and micronutrients increased the K concentration which increased the absorbed of potassium.

It might be due to participation of foliar NPK with micronutrients as Fe, Zn and Mn which iron in the formation of chlorophyll [21] Zinc plays a role in plant enzymes [7]. It has been found that iron is activator of many of enzymes and its plays important roles in plant growth and production, including chlorophyll synthesis, protein synthesis and chloroplast development. Also, zinc is an important nutrient which include in many enzymes or as a functional structural or regulatory cofactor and for protein synthesis, photosynthesis, the synthesis of auxin, cell division, and sexual fertilization [24]. Also, zinc plays a special role in synthesizing proteins, RNA and DNA. Mn is a part of nitrate reductase, which is involved in reduction of NO_3 to NH_4 after its absorption by plants. Also, it is structural component of nitrogenase, which involved in nitrogen fixation of N_2 into the ammonium form in a symbiotic relationship with legumes [9] and [5].

Table (5): Effect of foliar NPK fertilizers with micronutrients on N, P and K concentration (%) and its uptake (g plant^{-1}).

Type of fertilizers	N %	P %	K %	N uptake (g plant^{-1})	P uptake (g plant^{-1})	K uptake (g plant^{-1})
Foliar application	3.28	0.44	1.74	28.67	3.85	15.21
Control	2.08	0.34	1.42	15.06	2.46	10.28
50%+MN	3.14	0.39	1.56	25.91	3.22	12.87
100%+MN	3.23	0.45	1.82	27.87	3.88	15.71
125%+MN	3.46	0.48	1.84	32.28	4.48	17.17
LSD at 0.05	0.26	0.11	0.14	1.46	0.31	1.05

4. CONCLUSION

Recently the work related to plant nutrition reported nutrients on growth and yield of cowpea has come to conclusion that foliar application of macro and micro nutrients play an important role in the production of good crop and higher yield. The obtained results show that the vegetative growth, yield and quality of cowpea plants were enhanced by foliar application of NPK with micronutrients. The treatment of with 100% and 125% + micronutrients gave better results of growth and yield characters of cowpea.

5. ACKNOWLEDGMENT

Many thanks also to the staff members of soil and water use Department National Research Center for great help during this study.

6. REFERENCES

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