Evaluating the Potential Effect of Foliar Fertilizers on Cowpea Growth and Yield

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ABSTRACT

A experiment to evaluate performance of foliar fertilizers on cowpea growth and yield was conducted in the 2015/16 Zimbabwean summer season. This experiment was laid out in a randomized complete block design with 4 replications. Treatments were; a control (no fertilizer), 300 kg/ha compound D only, 300 kg/ha compound D + foliar fertilizers, 150 kg/ha compound D + foliar fertilizers and foliar fertilizers only. Leaf number, branch number, pod number, biomass, pod weight and grain weight were measured. Application of foliar fertilizers had a significant ($p < 0.05$) effect on growth by increasing the leaf number per plant at 5 weeks after planting. Leaf number was in the order of 112.05 (300 kg/ha compound D + foliar fertilizers)>104.8 (300kg/ha compound D only) >84.55 (150 kg/ha compound D + foliar fertilizers >76.6 (control)> 73.95 (foliar fertilizers only). Foliar fertilizer application also had a significant ($p < 0.05$) effect on pod number. A combination of compound D + foliar fertilizers had the highest pod number 29.55 followed by compound D (26.72) and the least was from control (16.9). Grain yield of compound D + foliar fertilizers (0.35) was not statistically different from that of compound D only (0.32), but both were significantly ($p < 0.05$) different from the other treatments. Results showed that the effect of foliar fertilizers is most attributed if used in combination with compound D (basal fertilizer). There is need for further research to investigate if residual soil fertility can affect the yield of cowpea concerning the foliar applications.

Keywords: *Biomass, Fertilization, Folia, Growth, Legume, Mobilization, Volatilization.*

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Highlights of this paper

- The study was to evaluate foliar fertilizers as supplements in conjunction with soil applied fertilizers to improve nutrient uptake in cowpeas.
- A combination of compound D and foliar fertilizers affected cowpea growth rate by increasing the number of leaves and branching.

1. INTRODUCTION

Cowpea (*Vigna unguiculata* (L.) Walp) is one of the most protein rich legumes in crop production, with a protein content range of 20 to 25%, which is twice that of cereal crops [1]. Currently, it is a source of protein for animal feed, as it is regarded to as the second alternative to soybean. Worldwide, particularly in Africa, millions of people depend on cowpea as a source of food [1]. Cowpeas are resilient, which makes or allows them to perform better under sand, barren and drought conditions. The cowpeas are capable of fixing nitrogen symbiotically in association with rhizobia, enabling them to improve soil fertility [2]. Therefore, the importance of the cowpea crop to nutrition and soil necessitates the need to improve its production. This can be done by applying the best crop management practises that positively enhance yield, nitrogen fixation not leaving out increased protein composition. Use of foliar fertilizers has been proven to have some positive effects to crops e.g. maize, tobacco.

Foliar fertilization or feeding refers to the application of fertilizers to the crops in the form of spray through the leaves. The introduction of foliar fertilizers is not to replace the well-known soil fertilizer placement method, but rather to aid to the root supply [3]. These foliar fertilizers occur in the form of liquid or some wettable powders. Like soil applied fertilizers, foliar fertilizers are composed of the macronutrients nitrogen (N), phosphorus (P), potassium (K) [3]. For example, Zimbabwe basal fertilizer compound D from the Zimbabwe Fertilizer Company (ZFC) has 7% N: 14% P_2O_5: 7% K_2O, whilst the ZFC Quick start foliar applied fertilizer has an NPK of 10% N:20% P_2O_5:10% K_2O. These nutrient compositions allow the foliar fertilizers to have similar effect to the crop growth as soil applied fertilizers. However, foliar fertilizers reveal noticeable effects to the crop because besides macronutrients they also contain micronutrients [4]. Most of these foliar fertilizers contain zinc (Zn), boron (B), copper (Cu), iron (Fe) and are referred to as trace elements [5]. Apart from the major functions of NPK such as involvement in respiration, photosynthesis, the trace elements are mainly involved in maintenance of the crops' physiological balances [6].

Supplementation of macronutrients to crops through foliar is effective in that they are in small quantities, thus absorbed and utilized at a quicker rate. The fast absorption by crop's leaves allows the fertilizers to improve the crop health as well as yields. Tests done by Brady and Weil [7] proved an increase in crop yields from 12 to 25% under foliar fertilization in comparison to soil fertilization alone. According to the data obtained from University of Michigan Research Trials, crops utilized more than 90% of the foliar applied fertilizer's nutrients whilst in contrast the same amount when soil applied, 10% only of the nutrients was assimilated. The same trials also added that under sandy soil conditions, the effectiveness of foliar fertilizers is 20 times greater than when applied to the soil. This brings up a positive fact that when the soil conditions are not favourable or conducive for roots to take-up nutrients, foliar fertilizers get to be essential. Most crop roots fail to absorb as much nutrients as in soils prone to high leaching levels, low pH and low CEC (Cation Exchange Capacity).

These constructive advantages as well as proven data on use of foliar fertilizers result in the need to consider the integration of soil applied and foliar applied fertilizers to increase, improve crop production [8]. This study therefore evaluated foliar fertilizers as supplements in conjunction with soil applied fertilizers to improve crop nutrient uptake for growth, flowering and yield.

2. MATERIALS AND METHODS

2.1. Study Site

The experiment was carried out at the Marondera University of Agricultural Sciences and Technology (MUAST), Mashonaland East Province, Zimbabwe. This area is situated at 18.19° South latitude, 31.55° East longitude and 1689 m elevated above the sea level. Sandy loam soils are most dominant at MUAST which are characterised by low water retention and fertility. The average rainfall received in the area ranges from 600 mm to 1000 mm, per annum as it is in the Natural Region IIb. It also experiences an average temperature of 25°C in summer.

2.2. Experimental Design and Treatments

The five treatments were laid out in a Randomised Complete Bock Design (RCBD), with four replications. Slope was considered during the blocking. The treatments of each block are shown in Table 1.

Table-1. Treatment combination of the fertilizers used.

Treatment	Description
1	No fertilizer application (control)
2	300 kg/ha Compound D
3	300 kg/ha Compound D plus 1 kg/ha foliar fertilizers (Quick start, Quick grow, Best bloom)
4	150 kg/ha Compound D plus 1 kg/ha foliar fertilizers (Quick start, Quick grow, Best bloom)
5	1 kg/ha foliar fertilizers (Quick start, Quick grow, Best bloom)

Key: Compound D (7% N, 14% P_2O_5, 7% K_2O), Quick start (10% N, 20% P_2O_5, 10% K_2O), Quick grow (20% N, 10% P_2O_5, 20% K_2O), Best bloom (15% N, 5% P_2O_5, 35% K_2O).

2.3. Treatment Materials

Cowpea seed of variety CBC2 was used in this experiment. In terms of fertilizers Zimbabwe Fertilizer Company (ZFC), Compound D is the conventional fertilizer that was used as the basal treatment. Quick start is a foliar fertilizer with the potential to initiate vigorous seedling growth as well as root establishment and growth. These properties are stimulated by the high levels of phosphorus that are the main constituencies of the fertilizer. Quick grow is also a fertilizer mostly applied at the vegetative stage of the crop. It stimulates and promotes the vegetative growth of a given crop due to the nitrogen ratios it contains. Best bloom contains more potassium, which allows it to have the potential to stimulate and promote flowering in crops. Therefore, it is foliar applied at the crops' point of flowering or reproduction stage.

2.4. Agronomic Procedures

2.4.1. Plot Size and Planting

The whole experimental area measured 30 m length × 18 m width, giving 540 m^2. A total of twenty treatment plots were pegged with each plot measuring 3 × 2 m and 1 m pathways were left between plots. Six rows of cowpea were planted in each plot with an inter-row of 0.45 m and in-row of 0.05 m. The seed was planted by hand using the drill method.

2.4.2. Fertilizer Applications

Compound D was used as basal fertilizer at planting as per treatment requirement Table 1. Quick start was applied in the first week after crop emergence, thus at the beginning of the crop growth cycle to initiate a rapid/vigorous growth. Quick grow was applied at the peak vegetative growth of the crop. This treatment was applied to the respective plots for two consecutive weeks. Best bloom was applied at the reproductive stage of the crop to initiate flowering and pod formation.

2.4.3. Weed Management

Mechanical weeding by the use of hand hoes and hand pulling was done. The weeding interval was 3 weeks between each weeding. This weeding regime was done until the crop had developed a full crop cover to smother the weeds. The most problematic weed was yellow nutsedge (*Cyperus esculentus*) and others such as black jack (*Bidens pilosa*), pig weed (*Amaranthus hybridus*) were also presented problems.

2.5. Data Collection

2.5.1. Measurements

The following parameters; leaf number, branch number, number of pods per plant, dry biomass and final grain yield were measured. These measurements were taken from five randomly tagged plants in each experimental plot.

The tagged plants were selected at random.

i. Leaf number; measurements started 3 weeks after planting, from the tagged plants. These measurements were collected fortnightly thereafter for 2 consecutive intervals.
ii. Branch number; measurements were taken similarly as in (i).
iii. Number of pods; data collection started 2 weeks after flowering and weekly thereafter for 2 consecutive intervals. The number of pods was manually counted and recorded from the same five tagged plants used in (i) and (ii).
iv. Dry biomass; was collected 13 weeks after planting. A small sub plot of 1.2$m^2$was made in each treatment plot. Ten plants were collected from the two inner rows of the small sub plot, thus 5 plants from each row. The ten collected plants were then put in well labelled sample bags. The collected samples were oven dried at a temperature of 60^{o}C for 72 hours. The dried samples were then weighed using a hanging digital scale to estimate the total plant biomass.
v. Pod weight; after obtaining the total dry biomass, pods were then separated from the mother plant and put in labelled khaki bags. The samples were then weighed on a digital scale to estimate the weight.
vi. Final grain yield; soon after pod weighing the pods from (v) were shelled and put in khaki packs. The final collected grain samples were weighed on a digital scale.

2.6. Data Analysis

The collected data was tested for homogeneity of variance before being subjected to an analysis of variances using Minitab version 16. Means were separated at $\alpha \leq 0.05$ using F-test (Fisher's LSD test).

3. RESULTS

3.1. The Effect of Foliar Fertilizers on Cowpea Leaf Number

At 3 weeks after planting there was a significant ($p<0.05$) effect of foliar fertilizers on cowpea leaf number. Compound D + foliar fertilizers produced the highest number of leaves, whilst half compound D + foliar fertilizers and foliar fertilizers only were not statistically different. At 5 weeks there was a significant difference at ($p<0.05$), with compound D + foliar fertilizers having the highest number of leaves from half compound D + foliar fertilizers and foliar fertilizers only which were statistically similar to the control Figure 1.

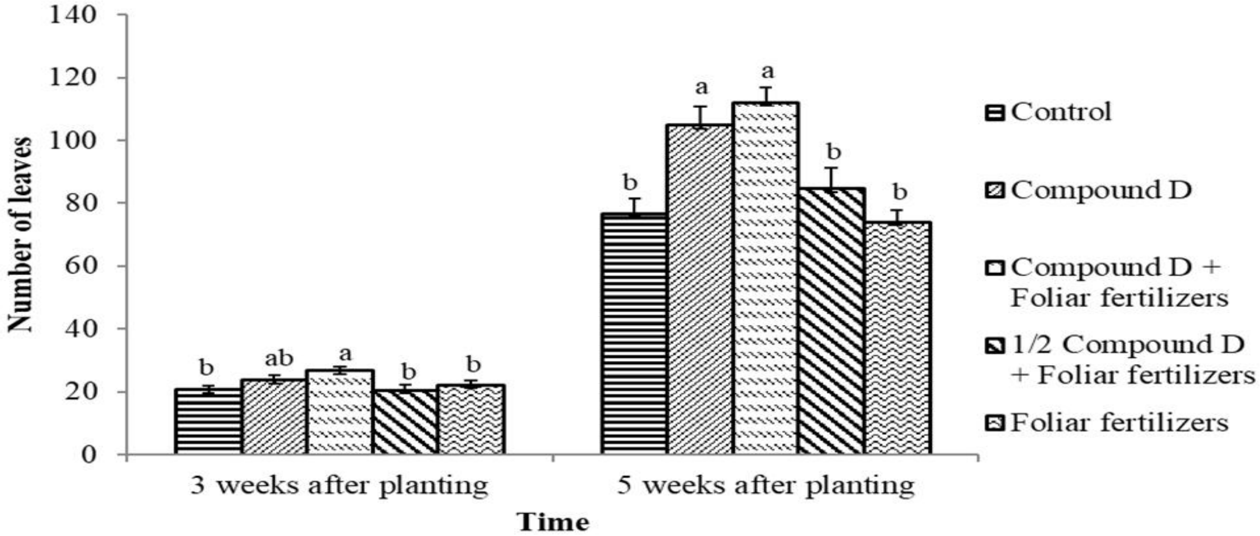

Figure-1. The effect of foliar fertilizers on cowpea leaf number. The error bars represent the S.E and different letters indicate a significant difference at $p < 0.05$.

Source: Experiment done at the Marondera university of agricultural sciences and technology research farm, Zimbabwe.

3.2. The Effect of Foliar Fertilizers on Cowpea Branch Number

There was a significant ($p<0.05$) effect of foliar fertilizers on branch number at both 3 and 5 weeks after planting. Compound D + foliar fertilizers produced the highest number of branches at both 3 and 5 weeks after planting whilst other treatments were similar. At both 3 and 5 weeks after planting, half compound D + foliar fertilizers and foliar fertilizers only were statistically similar to the control Figure 2.

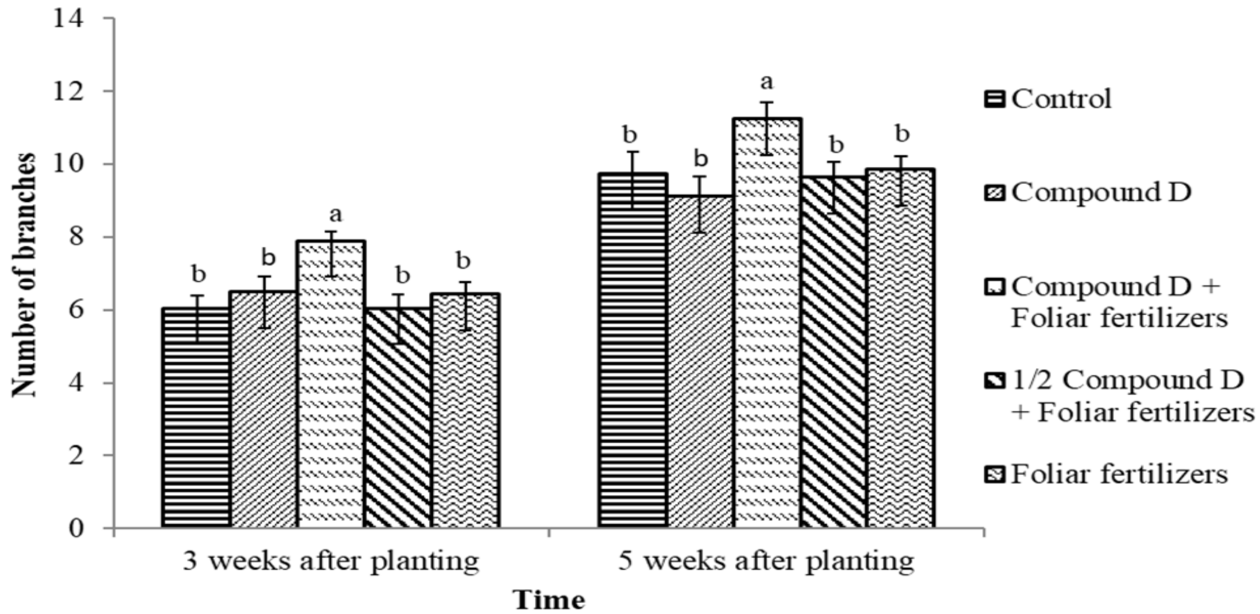

Figure-2. The effect of foliar fertilizers on cowpea branch number. The error bars represent the S.E and different letters indicate a significant difference at $p < 0.05$.

Source: Experiment done at the Marondera university of agricultural sciences and technology research farm, Zimbabwe.

3.3. The Effect of Foliar Fertilizers on Cowpea Pod Number

At 2 weeks after flowering, there was a significant ($p<0.05$) effect of foliar fertilizers on number of pods. Compound D + foliar fertilizers had the highest number of pods, but it was statistically similar to that of compound D. The control was not statistically different from half compound D + foliar fertilizers and foliar fertilizers only. At

3 weeks after flowering compound D + foliar fertilizers, compound D only were statistically similar but they were significantly different from halfcompound D + foliar fertilizers, foliar fertilizers only and the control Figure 3.

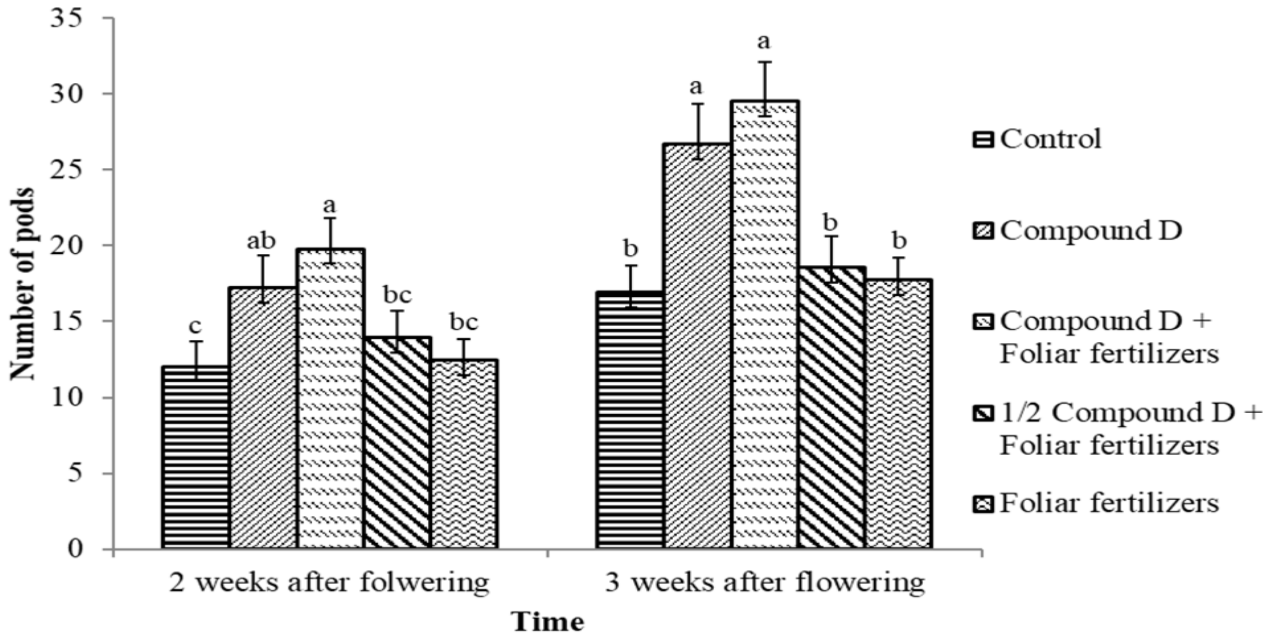

Figure-3. The effect of foliar fertilizers on cowpea pod number. The error bars represent the S.E and different letters indicate a significant difference at $p < 0.05$.

Source: Experiment done at the Marondera university of agricultural sciences and technology research farm, Zimbabwe.

3.4. The Effect of Foliar Fertilizers on Cowpea Biomass

There was a significant ($p<0.05$) effect of foliar fertilizers on the dry biomass of cowpea. Compound D produced the highest dry biomass of 1kg, but it was not statistically different from compound D + foliar fertilizers and half compound D + foliar fertilizers. The lowest dry biomass was produced from the control plot and it was statistically similar to foliar fertilizers only Figure 4.

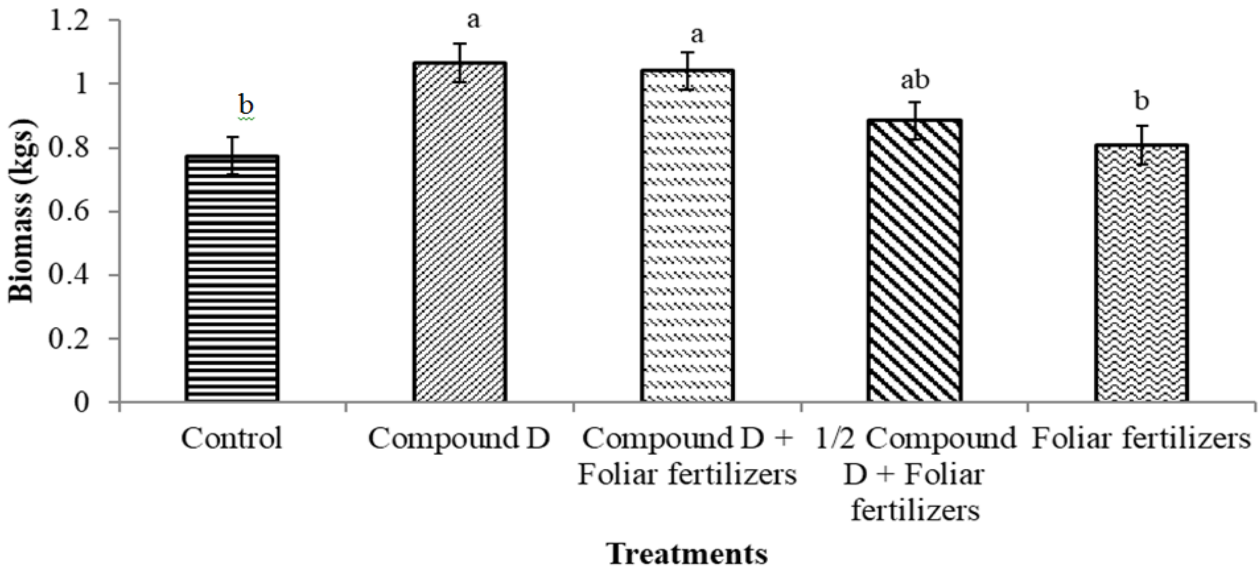

Figure-4. The effect of foliar fertilizers on cowpea biomass. The error bars represent the S.E and different letters indicate a significant difference at $p < 0.05$.

Source: Experiment done at the Marondera university of agricultural sciences and technology research farm, Zimbabwe.

3.5. The Effect of Foliar Fertilizers on Cowpea Pod Weight

There was a significant ($p<0.05$) effect of foliar fertilizers on pod weight. Statistically, compound D, compound D + foliar fertilizers and half compound + foliar fertilizers were not different, with pod weight of the same range. Half compound D + foliar fertilizer and foliar fertilizers were both not significantly different from the control, thus making them similar Figure 5.

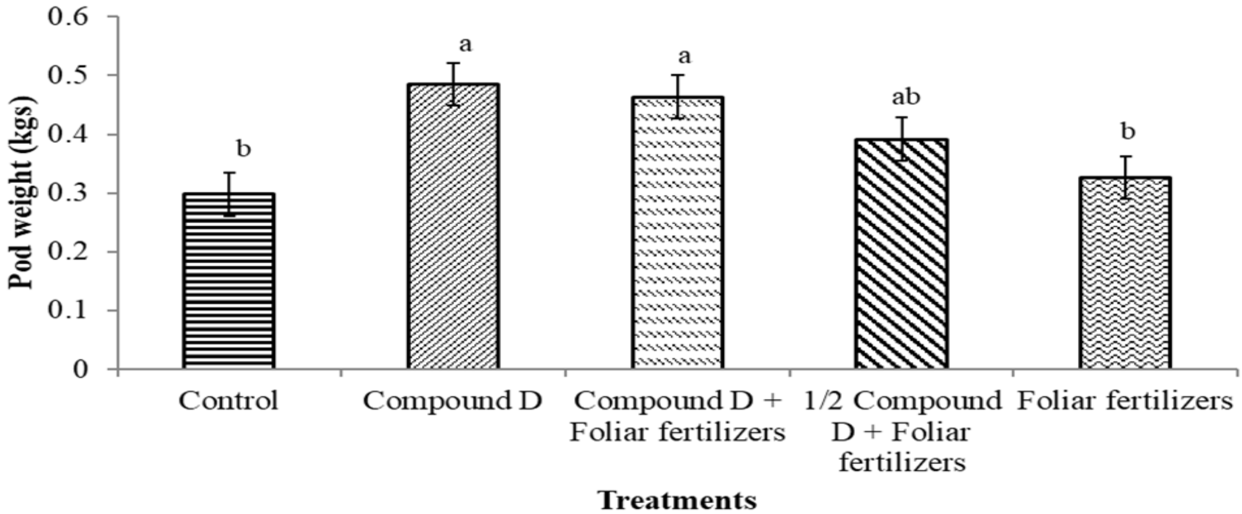

Figure-5. The effect of foliar fertilizers on cowpea pod weight. The error bars represent the S.E and different letters indicate a significant difference at $p < 0.05$.
Source: Experiment done at the Marondera university of agricultural sciences and technology research farm, Zimbabwe.

3.6. The Effect of Foliar Fertilizers on Cowpea Grain Weight

There was a significant ($p<0.05$) effect of foliar fertilizers on the grain weight of cowpea. Compound D only produced the highest yield, but it was not statistically different from compound D + foliar fertilizers and half compound D + foliar fertilizers. Though the control had the lowest yield, it was statistically similar to half compound D+ foliar fertilizers and foliar fertilizers only Figure 6.

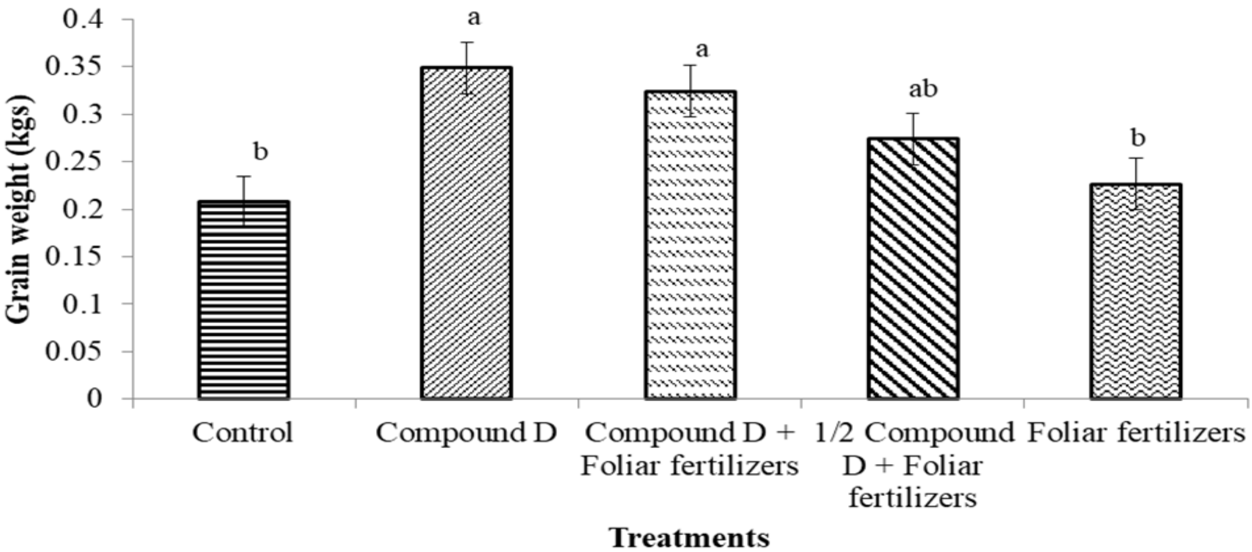

Figure-6. The effect of foliar fertilizers on cowpea grain weight. The error bars represent the S.E and different letters indicate a significant difference at $p < 0.05$.
Source: Experiment done at the Marondera university of agricultural sciences and technology research farm, Zimbabwe.

4. DISCUSSION

4.1. The Effect of Foliar Fertilizers on Cowpea Leaf and Branch Number

There was an increase in number of leaves and branches. This effect was more pronounced where there was a combination a basal fertilizer compound D and foliar fertilizers (Quick start, Quick grow and Best bloom). This could be the due to effect of phosphorus (P_2O_5) that was supplied by both fertilizers (compound D and quick start) to enhance crop root establishment and growth. Once the roots are well established, crop was able to take up enough nutrients to enhance the leaf and branch growth. Similar results were also observed in an experiment by Foilett, et al. [9] that foliar feeding increased the rate of nutrient uptake by pea (***Pisum sativum***) roots from the soil. This increased growth rate could also have been caused by the micronutrients such as zinc (Zn), boron (B) that were supplied by quick grow during the vegetative stage. Zinc is usually involved in the production of the IAA enzyme which is responsible for shoot growth in most plants. According to Brady and Weil [7] the supplied micronutrients could have positively enhanced the plant biological activities such as photosynthesis, carbohydrate assimilation and synthesis of proteins that directly attributes to plant growth.

4.2. The Effect of Foliar Fertilizers on Cowpea Pod Number

There was increased number of pods where there was a combination of compound D + foliar fertilizers than where half compound D + foliar fertilizers and foliar fertilizers only were applied. This could be due to the high levels of (K_2O) supplied by best bloom (15:5:35) at the reproduction stage of the cowpea crop. The potassium (K^+) supplied in the form of K_2O by the fertilizer stimulated the flowering and thus forming more flowers per plant. This was also reported by Azarpour, et al. [10] that the application of foliar fertilizers increased the number of pods produced per plant. The availability of the potassium could have increased the levels of the phytohormones such as florigen that triggers and control flowering in cowpea plants. This phytohormone could also have prevented the flowers from aborting and thus initiating formation of more pods. The application of foliar fertilizers with high levels of micronutrients was also reported to have increased the average number of pods [11, 12].

4.3. The Effect of Foliar Fertilizers on Cowpea Biomass, Pod Weight and Grain Weight

There were no differences of compound D + foliar fertilizers and compound D only on cowpea biomass, pod weight, and grain weight. This shows that the foliar fertilizers did not work and could be due to the soil residual nutrition that was readily available for the cowpea crop. According to Food and Agriculture Organization (FAO) [13] if the cowpea crop is well nutritionally nourished it will not take up any more nutrients for production as it can fix its own nitrogen (N). The residual nutrition effect is suspected to have caused foliar fertilizers not showing any effect on increasing biomass, pod weight as the crop had enough supply from the basal fertilizer. Since the basal fertilizer was applied at the same rate it is the showing the same effect and thus not showing a significant difference from the two treatments. The absence of a difference in cowpea pod weight, biomass and grain weight could also be due to the application rate of the foliar fertilizers. Maybe the application rate that was used (1kg/ha) was not sufficient to supply adequate nutrients and express in increased effect on the crop parameters. The intervals at which the foliar fertilizers were applied can also be a contributing factor. Maybe the foliar fertilizers required increased application intervals for them to show a positive effect on the residing crop parameters.

5. CONCLUSION

The study revealed that foliar fertilizers have a potential effect on cowpea growth rate by significantly increasing the number of leaves and branches. This effect is most attributed when they are in combination with a basal fertilizer, in this case compound D. Foliar fertilizers also have a contribution to flower initiation and thus contributing to more pods being produced per plant. The research has to be repeated at different sites for better and convincing results. There is need for further research to investigate on the effect of residual soil nutrition to foliar fertilizer effect.

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