Effect of zinc and yeast extract foliar application with potassium fertilizer on faba bean (*Vicia faba* L.) grown under new reclaimed soil conditions.

BY

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SUMMARY

During the 2017/18 and 2018/19 consecutive growing seasons, from October to April (fall seasons and winter), two experiments were performed in sandy loam soil (newly reclaimed soil) at the Demo research farm of the faculty of Agriculture, Fayoum University, Egypt. The purpose of this study was to examine the performance of faba bean as an important legume plant under the effects of three potassium amounts, namely 0 K_2O fed^{-1} (K_0), 50 K_2O fed^{-1} (K_1), and 75 K_2O fed^{-1} (K_0), three yeast extract concentrations, namely 0 ml L^{-1} (YE_0), 4 ml L^{-1} (YE_1), and 8 ml L^{-1} (YE_2), and three zinc sources, namely zinc sulphate (ZS), zinc oxide (ZO), and zinc chelated (ZC), and their interactions. Potassium rates were allocated to the main plots, varied concentrations of yeast extract to the sub-plots, and zinc kinds to the sub-sub plots in a split-split plot in randomized complete blocks with three replicates.

A summary of the information gathered is as follows

Potassium levels (K).

1- Growth characters

potassium levels were significant effect on plant height, number of branches $plant^{-1}$, number of leaves $plant^{-1}$, leaf area $plant^{-1}$, dry matter accumulation $plant^{-1}$, leaf chlorophyll content at 70, 91, and 112 days after sowing and absolute crop growth rate, net assimilation rate, and relative growth rate at two growth periods. The tallest plants were measured by adding the third level of potassium (K_2) at 70, 91, and 112 DAS, as evidenced by these numbers (37.16, 60.40, and 60.40 cm), respectively. The application of 75 K_2O fed^{-1} produced the most branches (4.34, 4.79, and 4.79) of $plant^{-1}$ in the first, second, and third ages. At 70, 91, and 112 days after sowing, the highest level of potassium as a soil fertilizer resulted in the highest leaf number $plant^{-1}$ (46.34, 73.24, 88.99). Using the third level of potassium (K_2) caused the largest leaf

area plant^{-1}, as indicated by these values (3177.69, 4945.30, and 7175.70 cm^2) at various ages. Using the third level of potassium (K_2) produced the maximum dry matter accumulation plant^{-1}, as shown by these results (10.33, 17.59, and 25.65 g) at various ages. The best results for chlorophyll content (66.37, 53.48, and 50.45) were obtained by using the highest level of potassium (K_2) at 70, 91, and 112 DAS, respectively. In terms of absolute crop growth rate, 75 K_2O fed^{-1} yielded the highest results (0.662 and 0.380 g d^{-1}) in the first (70-91 DAS) and second (91-112 DAS) periods, respectively. While the relative growth rate showed that using 0 K_2O fed^{-1} achieved first place in the first and second growth periods, as shown by the following numbers (0.013 and 0.009 g g d^{-1}), respectively. Applying 50 K_2O fed^{-1} during the first growth stage (70-91 days after sowing) resulted in the highest net assimilation rate (0.100 mg cm^2 d^{-1}), but applying 0 K_2O fed^{-1} during the second growth stage (91-112 DAS) resulted in the highest net assimilation rate (0.067 mg cm^2 d^{-1}).

2- yield and yield components

Potassium levels had a significant effect on plant height, number of branches plant^{-1}, first pod height, pod length, number of pods plant^{-1}, seed weight plant^{-1}, number of seeds pod^{-1}, seed weight plant^{-1}, 100-seed weight, biological yield, and seed yield fed^{-1}. Application 75 K_2O level fed^{-1} as a soil fertilizer (K_2) resulted in the tallest plant (66.54 cm), biggest number of branches plant^{-1} (4.77), highest height to first pod (20.01 cm), greatest pod length (13.40 cm), the maximum number of pods plant^{-1} (10.29), the heaviest pods weight plant^{-1} (45.10 g), the maximum number of seeds pod^{-1} (4.41), the heaviest seeds weight plant^{-1} (33.87 g), greatest 100-seed weight (111.81 g), maximum biological yield (4.75 t fed^{-1}), maximal seed yield fed^{-1} (11.94 aradab). On the other hand, the harvest index is insignificant.

3- Chemical analysis characters

Potassium levels caused significant differences in protein percentage, potassium content, and zinc content in dry seeds. 75 K_2O fed^{-1} gave topmost

values for protein percentage, potassium content, and zinc content (29.46%, 2.84 mg g^{-1} dry weight, and 0.634 mg g^{-1} dry weight), respectively.

Yeast extract.

1- Growth characters

The yeast extract treatments had significant effects on plant height, number of branches $plant^{-1}$, number of leaves $plant^{-1}$, leaf area $plant^{-1}$, dry matter accumulation $plant^{-1}$, leaf chlorophyll content, absolute crop growth rate, and relative crop growth rate at 70, 91, and 112 days after sowing. Spraying faba bean plants with the highest concentration of yeast extract (YE_2) gave the superiority at 70, 91, and 112 DAS as obtained from next numbers respectively in plant height (36.79, 61.41, and 61.41 cm), maximum branches number $plant^{-1}$ (4.24, 4.83, and 4.83), topmost leaves number $plant^{-1}$ (44.57, 69.69, and 90.88), biggest leaf area $plant^{-1}$ (2991.27, 4794.70, and 7423.60 cm), heaviest dry matter accumulation $plant^{-1}$ (9.70, 17.59, and 26.04 g), greatest chlorophyll content (66.76, 54.73, and 51.57). The superiority for absolute crop growth rate was also due to the use of the highest concentration of yeast extract (8 ml L^{-1}) at 70-91 DAS and 91-112 DAS, as shown in the following numbers (0.663 and 0.400 g d^1), the same direction was appeared in relative growth rate but not significant at first vegetative period for net assimilation rate.

2- yield and yield components

Yield and yield components such as plant height, the number of branches $plant^{-1}$, the number of pods $plant^{-1}$, pod length, height to first pod, the number of pods $plant^{-1}$, pod weight $plant^{-1}$, the number of seeds pod^{-1}, seed weight $plant^{-1}$, 100 seed weight, biological yield (4.94 t fed^{-1}), and seed yield fed^{-1} (12.37 aradab), all of it increased significantly when the highest concentration of yeast extract (YE_2) was used. However, it is not statistically significant on the harvest index.

3- Chemical analysis characters

When it came to the effect of different yeast extract concentrations on protein percentage, potassium content, and zinc content in dry seeds, the results showed that the highest dose of yeast extract was superior.

Zinc sources (Zn)

1- Growth characters

All of the growth parameters of faba bean plants were significantly affected by the application of zinc sources. According to the data, adding zinc chelated to faba bean plants improved plant height, number of branches plant^{-1}, number of leaves plant^{-1}, leaf area plant^{-1}, dry matter accumulation plant^{-1}, chlorophyll content, absolute crop growth rate, net assimilation rate, and relative crop rate.

2- Yield and yield components

Zinc chelates increased yield and yield components like plant height, number of branches plant^{-1}, the height of the first pod, pod length, number of pods plant^{-1}, pod weight plant^{-1}, number of seeds pod^{-1}, seed weight plant^{-1}, 100 seed weight, biological yield (5.10 t fed^{-1}), seed yield (13.01 aradab fed^{-1}), and harvest index (39.76 %) when compared to other zinc sources.

3- Chemical analysis characters

Treatment (ZC) resulted in the greatest increases in protein % (30.16%), potassium content (2.87 mg g^{-1} dry weight), and zinc content (0.656 mg g^{-1} dry weight).

Effect of potassium levels × yeast extract interaction.

1- Growth characters

The interaction between K ×YE had a significant effect on plant height, the number of leaves plant^{-1} and leaf area plant^{-1} at 70, 91, and 112 days after sowing. When it comes to the traits listed above, the K_2 × YE_2 interaction achieved the superiority. During the first and second vegetative periods, the highest values of net assimilation rate and relative growth rate were obtained

when the highest level of potassium was combined with the highest concentration of yeast extract. The results were insignificant when it comes to chlorophyll content and dry matter accumulation plant^{-1} 91 days after sowing. At 70 and 112 DAS, the results were significant in terms of chlorophyll content and dry matter accumulation plant^{-1}, and the $K_2 \times YE_2$ interaction was caused for the superiority. In terms of the number of branches plant^{-1}, the results were insignificant at 70 and 91 days after sowing. Despite this, the factor had a significant impact at 112 DAS. The data on absolute crop growth rate was not significant during the first growth stage but was substantial during the second growth stage.

2- Yield and yield components

The potassium rates and yeast extract interaction significantly influenced plant height, number of branches plant^{-1}, the height of the first pod, number of pods plant^{-1}, pod weight plant^{-1}, number of seeds pod^{-1}, seed weight plant^{-1}, 100 seed weight, and harvest index, as indicated by the results. However, no significant differences in pod length, biological yield, or seed output were found. The $K_2 \times YE_2$ interaction resulted in the supreme mean values of plant height (69.62 cm), branch number plant^{-1} (5.04), height to first pod (21.88 cm), the number of pods plant^{-1} (11.26), pod weight plant^{-1} (51.96 g), the number of seeds pod^{-1} (4.91), seed weight plant^{-1} (37.38 g), 100 seed weight (113.56 g), and harvest index (40.50%).

3- Chemical analysis characters

The results reveal that the interaction between potassium levels and yeast extract had a significant effect on potassium content in dry seeds. However, no significant variations in protein percentage or zinc content were found. The $K_2 \times YE_2$ interaction produced the highest potassium content (2.93 mg g^{-1} dry weight).

Effect of potassium levels × zinc sources interaction.

1- Growth characters

The effect of K × Zn on branch number plant^{-1}, leaf number plant^{-1}, and chlorophyll content 70 days after sowing was not significant. on the other hand, at 91 and 112 days after sowing, the preceding attributes were significant. The effect of potassium levels combined with zinc sources on dry matter accumulation plant^{-1} was not significant at 91 days after sowing, but it was significant at 70 and 112 days. During the first growth stage (70-91 days after sowing), the absolute crop growth rate wasn't really significant, but it was significant during the second growth stage (91-112 days after sowing). In the interaction between K and Zn, the net assimilation rate and relative growth rate during the first and second growth periods were significant. At 70, 91, and 112 days after sowing, the K × Zn interaction caused significant changes on plant height and leaf area plant^{-1}.

2- Yield and yield components

The data demonstrated non-significant variations in the interaction application of K × Zn in terms of height to first pod and pod length. However, harvest data indicates that this interaction had a significant impact on plant height, branch number plant^{-1}, number of pods plant^{-1}, pod weight plant^{-1}, number of seeds pod^{-1}, seed weight plant^{-1}, seed weight plant^{-1}, 100 seed weight, biological yield fed^{-1}, and seed yield fed^{-1}, and harvest index. The K_2 × ZC yielded in the tallest plants (71.55 cm), the maximum branches number plant^{-1} (5.20), the greatest number of pods plant^{-1} (12.08), heaviest pods weight plant^{-1} (49.75 g), maximal number of seed pod^{-1} (5.02), heaviest seed weight plant^{-1} (38.68 g), hugest 100 seed weight (116.18 g), greatest biological yield (5.42 t fed^{-1}), and greatest seed yield fed^{-1} (13.86 aradab). On the other hand, the supreme value of the harvest index (40.03%) was recorded from the interaction between (K_1 × ZC).

3- Chemical analysis characters

The interaction between potassium levels and zinc sources (K × Zn) was significant in terms of protein percent and potassium content. K_2 × ZC interaction owned the superiority in protein % (31.55 %) and potassium content (2.98 mg g^{-1} dry weight). On the other hand, the interaction K × Zn had no effect on zinc content.

Effect of yeast extract × zinc sources interaction.

1- Growth characters

The interaction of different yeast extract concentrations and zinc sources has no significant effect on plant height at 91 DAS, chlorophyll content at 70 DAS, branch number $plant^{-1}$, number of leaves $plant^{-1}$, dry matter accumulation $plant^{-1}$, and leaf area $plant^{-1}$ at 70 and 91 DAS, as well as absolute crop growth rate, net assimilation rate, and relative growth rate at the first growth period. However, the interplay of yeast extract and zinc kinds had a great impact on plant height at 70 and 112 days after sowing, chlorophyll content at 91 and 112 DAS, branch number $plant^{-1}$, leaf number $plant^{-1}$, and dry matter accumulation $plant^{-1}$ at 112 days after sowing. As well, there was a significant effect also absolute crop growth rate, net assimilation rate, and relative growth rate at the second growth period. the YE_2 × ZC interaction achieved superiority in all significant attributes.

2- Yield and yield components

The interaction of yeast extract × zinc sources had a significant effect on plant height, branch number $plant^{-1}$, number of pods $plant^{-1}$, height to the first pod, pod weight $plant^{-1}$, number of seed pod^{-1}, seed weight $plant^{-1}$, and 100 seed weight, but not on pod length, biological yield, seed yield fed^{-1}, or harvest index at harvest. The YE_2 × ZC interaction achieved the maximal values in terms of plant height (74.38 cm), branch number $plant^{-1}$ (5.19), the height to the first pod (23.26 cm), number of pods $plant^{-1}$ (12.84), pod weight $plant^{-1}$ (55.94 g), number

of seeds pod^{-1} (5.08), seed weight plant^{-1} (41.10 g), and 100 seed weight (116.40 g).

3- Chemical analysis characters

The interaction between yeast extract (YE) and zinc sources application significant effect on the chemical composition, such as protein content, potassium seed content, and zinc seed content (Zn). Protein content (31.49%), potassium content (3 mg g^{-1} dry weight), and zinc content (0.720 mg g^{-1} dry weight) were all highest in faba bean plants treated with the highest concentration yeast extract and zinc-chelated.

Effect of potassium levels × yeast extract × zinc sources interaction.

1- Growth characters

At 91 days after sowing, there were no significant differences between (K × YE × Zn) in plant height. Also, at 70 days after sowing, there were no significant differences between (K × YE × Zn) in chlorophyll content. The application of (K × YE × Zn) interaction to faba bean plants exerted no significant influence on branch number plant^{-1}, dry matter accumulation plant^{-1}, and leaf area plant^{-1} at 71 and 91 DAS. Furthermore (K × YE × Zn) interaction had a non-important effect on net assimilation rate and relative growth rate at the first growth period. With regard to (K × YE × Zn) interaction appeared significant effects on plant height at 70 and 112 days after sowing, leaves number plant^{-1} at 70, 91, and 112 DAS, chlorophyll content at 91 and 112 DAS, branch number plant^{-1}, dry matter accumulation plant^{-1}, leaf area plant^{-1} at 112 days after sowing, net assimilation rate and relative growth rate at second growth period, also at first and second periods in absolute crop growth rate. application the interaction between K_2 × YE_2 X ZC yielded in the superiority in plant height (41.07 and 71.57 cm) at 70 and 112 DAS, branch number plant^{-1} (5.87) at 112 DAS, leaves number plant^{-1} (52.23, 83.07, and 110.07) at 70, 91, and 112 DAS, dry matter accumulation plant^{-1} (34.21 g), chlorophyll content (60.68 and 53.88) at 91 and 112 days after sowing, net assimilation rate (1.00

mg cm^2 d^1), and absolute crop growth rate (0.62 g d^{-1}) at second growth period, on the other hand, the maximal absolute crop growth rate (0..803 g d^{-1}) at second growth period was achieved by $K_1 \times YE_2 \times ZC$ at 112 DAS. but the superiority at leaf area $plant^{-1}$ (8731.90 cm^2) appeared as a result of interaction between $K_2 \times YE_1 \times ZC$ at 112 DAS. As can be observed from these number (0.012 mg cm^2 d^1), the interaction between $K_0 \times YE_0 \times ZC$ achieved the superiority in terms of relative growth rate.

2- Yield and yield components

On yield per feddan and pod length, the interaction between (K × YE × Zn) had a non-significant effect. On the other hand, the interaction between (K × YE × Zn) significantly affected plant height, branch number $plant^{-1}$, height to the first pod, number of pod $plant^{-1}$, pod weight $plant^{-1}$, number of seed pod^{-1}, seed weight $plant^{-1}$, 100 seed weight, biological yield fed^{-1}, and harvest index. From the data analysis, it turns out that faba bean plants which were treated with the highest amount of potassium (K_2) combined with the topmost dose of yeast extract (YE_2) and the 3rd source of zinc (ZC) gave the maximum values of plant height (76.73), branch number $plant^{-1}$ (5.62), the height of the first pod (24.68 cm), number of pods $plant^{-1}$ (14.28), pod weight $plant^{-1}$ (57.64 g), number of seeds pod^{-1} (6.17), seed weight $plant^{-1}$ (43.50 g), and 100 seed weight (118.50 g). The interaction ($K_1 \times YE_2 \times ZC$) had the superiority in terms of biological yield fed^{-1} However, in the harvest index, the interaction ($K_0 \times YE_0 \times ZS$) gave us an upper hand.

3- Chemical analysis characters

The K × YE × Zn interaction had a significant effect on protein % and zinc content, but a non-significant on potassium content. The interaction of $K_2 \times YE_2 \times ZC$ resulted in the greatest protein percentage (33.02%), while, the interaction of $K_1 \times YE_2 \times ZC$ resulted in the highest zinc content (0.749 mg g^{-1} dry weight).

According to the results of the current study trial, 75 K_2O fed^{-1} combined with yeast extract at 8 ml L^{-1} and zinc chelated as a foliar application is a beneficial interaction capable of achieving acceptable fava bean seed yield and quality traits.