Response of caraway plant to zinc and humic acid treatments

BY

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THESIS

Submitted in Partial Fulfillment of the Requirements for the Master Degree

In

Agricultural Sciences (Horticulture - Floriculture)

Department of Ornamental Plants and Landscape Gardening
Faculty of Agriculture
Assiut University

2020

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Summary

A field experiment was carried out during 2018/2019 and 2019/2020 seasons to study the effect of foliar application of humic acid (potassium humate) and two zinc forms: chelated zinc (Zn-EDTA) and Zn-nanoparticles on growth, chemical composition of leaves, productivity and quality of seeds, as well as quantitative and qualitative characteristics of the essential oil of caraway.

Humic acid at the concentrations of 0 (control), 200 and 400 ppm and the two zinc forms each at 50 and 100 ppm, in addition control were applied in aqueous solutions as foliar spray three times, monthly interval (February, March and April).

The experiment consisted of 15 treatments (3 humic acid x 5 zinc) were distributed randomly in a split-plot design, humic acid treatments as main-plots and Zn treatments as sub-plots, each of 3 m^2 including 3 rows with 50 distance, each row contained six hills spaced at 25 cm and two plants per hill.

The study presented three important concepts:

1- Growth characteristics, nutrients contents and uptake by plants of macro and micronutrients, photosynthetic pigments (chlorophyll "a", chlorophyll "b" and carotenoids), total carbohydrates and total protein contents in leaves.
2- Seed yield and quality measurements (seed germination attributes and some active biochemical constituents).
3- Quantitative and qualitative characteristics of the essential oil.

The following results obtained:

1 – Growth characteristics and chemical composition of plant

- Humic acid treatments improved growth characteristics (plant height, branch number per plant, and herb and root dry weights) compared to control. Since the treatment of humic acid at 400 ppm was more effective resulting in higher significant increase than a rate of 200 ppm in most growth characteristics.
- Each of Zn treatments showed favourable influences in growth parameters compared to control. Hence, Zn-EDTA at 100 ppm was the most effective treatment followed by Zn-nano at 100 ppm, the difference between them was significantly in most cases.
- The treatment of Zn-EDTA at 50 ppm showed intermediate results, contrast to this, Zn-nano at 50 ppm gave the minimum values of all measurements.
- A direct relationship between leaf nutrients content and their uptake by plant from soil solution was found in most cases.
- Leaf chemical analysis cleared many negative interactions (antagonistic) among macro and micronutrient elements whereas the concentration of one nutrient decreased and the other increased under the different treatments.
- Antagonistic influences was apparently associated with the treatment of humic acid at 400 ppm showing significant increases in the concentrations of N, P, K, Mg and Mn in leaves that associated with great reductions of Ca, Zn and Fe compared to control.
- The treatment of Zn-EDTA at 100 ppm showed significant increases in leaf contents of N, Mg, Zn and Mn, but markedly decreases in P, K, Ca and Fe were noticed compared to control. These findings indicated that this treatment was the most effective in inducing the antagonism among these elements.

- The optimum growth was closely associated with the adequate level of macro and micronutrients resulted from the best treatments of humic acid at 400 ppm and Zn-EDTA at 100 ppm.
- It was found systematically positive relationship between the formation of leaf pigments, carbohydrates accumulation and protein synthesis, and the increased leaf nutrients content which are constituted mainly of them and accompanied with treatments which produced the favourable growth.

2 – Seed yield and quality measurements

- The best treatments of humic acid at 400 ppm and Zn-EDTA at 100 ppm which produced better growth gave the highest umbel number per plant, as well as increased seed yield per plant and per feddan compared to the other treatments.
- Harvested seeds of the previous treatments showed strongly stimulative effect on germination attributes (germination percentage, mean daily germination and germination velocity). These findings were correlated with high levels of endogenous promoting hormones (IAA and GA) contents and low ABA level in seeds.
- Biochemical analysis of harvested seeds produced by humic acid at 400 ppm and Zn-EDTA at 100 ppm showed the greatest contents of carbohydrates, protein, total fatty acids and antioxidants (phenolics, flavonoids, vitamin C and vitamin B_1), but cleared great reductions of NO^-_3 and NO^-_2 that correlated with better-quality seeds.
- The highest biochemical constituents in seed were associated with the highest 1000-seed weight led to increase seed production with more vitality and quality.

3 – Quantitative and qualitative characteristics of the essential oil

- Each of humic acid and Zn treatments generally improved essential oil characteristics (oil percentage, oil yield per plant and per feddan) compared to control.
- The treatments of humic acid at 400 ppm cleared significant increase in oil yield compared to a rate of 200 ppm also Zn-EDTA at 100 showed a similar influence compared to other Zn treatments.
- The maximum oil production was correlated with optimum growth, the highest seed yield, 1000-seed weight and active biochemical constituents which mentioned previously.
- The gas liquid chromatography (GLC) analysis of the essential oil showed twenty compounds, among them there were two main components, carvone and limonene. Furthermore, GLC analysis for all components shown the presence of β-pinene, anethole, estragole, carveol, myrcene, fenchone and others were present in small amounts in the seeds volatile oil.
- The treatment of humic acid at 400 ppm resulted in the highest carvone (67.41%) and the lowest limonene (21.212%) compared to humic acid at 200 ppm or control and carvone/limonene (C/L) ratio equivalent 3.18.
- The treatment of Zn-EDTA at 100 ppm gave carvone 63.22% and limonene 15.93% of total oil composition and C/L ratio 3.97.
- Following the later treatment, Zn-nano at 100 ppm since it appeared carvone 47.80%, limonene 25.15% and C/L ratio 1.90.
- The treatment of Zn-EDTA at 50 ppm showed intermediate component percentages of essential oil, while Zn-nano at 50 ppm cleared the lower contents than the previous treatments, but the control gave the lowest carvone (34.27%), the highest limonene

(42.51%) and C/L ratio 0.81. These findings indicated that better-quality of essential oil is considered to correlate with the higher C/L ratio also with increases of antioxidants which reduce the oxidation rate in the essential oil and maintain it against adulteration.

- Results of chemical properties of essential oil (iodine number, ester number, acid number and saponification number) indicated that their adequate values showed positive relationship with better-quality of the essential oil resulted from humic acid at 400 ppm and Zn-EDTA at 100 ppm.
- The interaction effects among different combined treatments declared that the best combination was humic acid at 400 ppm plus Zn-EDTA at 100 ppm since this treatment closely correlated with improvement of growth characteristics and chemical composition of plant, increases in seed production (771 kg/fed) and essential oil yield (33 l/fed), the highest carvone (79.22%), the lowest limonene (12.47%) and the maximum C/L ratio (6.35). These findings indicated that better-quality of the essential oil obtained by the best treatment. So it could be recommended to supply caraway plants with this combined treatment for commercial production.