Role of zinc carriers in pecan production

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The production of pecan nuts in South Africa is currently expanding at a rapid rate. Pecan nuts became more profitable per hectare, which led producers to convert arable land used for cash (row) crops to establish pecan nut orchards. A total of 40 000 ha have already been planted across South Africa, most in the Northern Cape irrigation schemes. According to the American Pecan Council (APC), South Africa will produce more than 10 percent of global pecan nut production by 2027. As a result, South Africa will be the third-largest producer of pecan nuts in the world.

The significant economic growth of the South African pecan nut industry over recent years emphasizes the need for information regarding successful orchard management and production.

Zinc is a micronutrient that regularly shows deficiencies in pecan nut orchards of South Africa. The application of zinc is, therefore, a standard practice in pecan nut cultivation. Pecan rosette, where leaf margins curl and leaf internodes begin shortening, is the most common symptom observed when zinc is deficient (Figure 1). Interveinal necrotic spots can develop in severe zinc shortages.

Numerous researchers have studied the importance of zinc in the production of pecan nuts. Zinc influences the pecan tree physiology and nut quality. It is an essential micronutrient needed for several enzymes to produce proteins, cell membrane integrity maintenance, auxin synthesis, and pollen production. The presence of zinc also influences the viability of pollen and photosynthesis. Carbonic anhydrase, a zinc metalloenzyme, plays a vital role during photosynthesis. It is responsible for the conversion of carbon dioxide to bicarbonate, known as carboxylation. Zinc is needed to form the pigment chlorophyll, which is essential for light absorption during photosynthesis. Lastly, zinc plays a role in the opening and closure of the stomata, which influences the tree's water usage efficiency.

Figure 1: Severe zinc deficiency symptoms

Soils in the Vaal- and Orange-river irrigation schemes of the Northern Cape are characterized by high pH, alkali, and calcareous conditions. These conditions limit the availability of unprotected (unstable) soil-applied zinc fertilization.

Unprotected zinc in the soil reacts with carbonates and hydroxyls, forming compounds with a low solubility that limit root absorption. Zinc chelated with appropriate ligands like EDTA (ethylenediaminetetraacetic acid), are called protected zinc sources. Due to the low solubility of soil-applied unprotected zinc and poor root absorption, the application of zinc as a foliar spray, remains a very viable option. Foliar application of zinc has become mandatory for pecan nut production to ensure higher quality nut yields and must form part of a well-managed fertilizer program.

The timing of foliar zinc application is a crucial aspect of pecan nut production. Foliar applied zinc is immobile in the tree, meaning that when the leaves absorb zinc, it is not transported through the tree's vascular system. As a result, zinc is only metabolically active in leaves covered by foliar zinc spraying.

Young, expanding leaves, early in the growing season, must be provided with zinc for optimum growth to maturity and prevent transient deficiencies later in the growing season. With zinc sprays, fully expanded leaves (physiological matured leaves) already subjected to zinc shortages will not recover. Vigorous growing juvenile trees must also receive more zinc sprays than older trees.

The spraying of zinc commence just after bud-break when leaves are expanded one-third of their final size. After that, zinc is applied in 2–3 week intervals, with a total of up to 6 applications.

There are many zinc carriers available on the market, making it difficult for pecan nut producers as to which zinc carrier is the most efficient in alleviating zinc deficiencies.

Zinc sulphate, zinc nitrate, and zinc oxide are the most common zinc carriers used in pecan orchards. These three zinc carriers are inexpensive and have a high active zinc concentration. Other zinc carriers used in the production of pecan nuts include chelated complexes. The most commonly used include zinc chelated with EDTA and also organic molecules like amino acids or sugars. Zinc-EDTA is protected against soil adsorption (complexing), while the organic complexes are not. Both these molecules can be applied as foliar sprays.

Research on determining the best carrier for improving pecan production can assist pecan nut producers in optimal orchard management.

A pot and field trial was conducted at the University of the Free State in partnership with the South African Pecan Nut Association (SAPPA) and Kynoch starting in 2020. The objective of this study was to compare different zinc carriers to determine the most effective formulation of zinc to apply in pecan nut orchards.

Figure 2: Two-year old 'Wichita' trees used in the pot-trial on the campus of the University of the Free

Figure 3: Five-year old 'Wichita' trees

The four different zinc carriers that were used included zinc sulphate ($ZnSO_4$), zinc nitrate ($ZnNO_3$), Zn-EDTA, and an organic zinc complex (amino-acid). Each carrier was applied at three different concentrations (0.5, 1, and 1.5%) and at two application times, namely; November (early season) and February (late season) for the pot trial. The organic zinc complex with the lowest active zinc concentration, was used for concentration calculations.

Zinc for the field trial was applied according to a fertilization program with five sprays, starting just after bud-break (middle October). Spraying continued throughout pollination and the water stage of fruit formation, till the end of December. The concentrations of the pot-trial were duplicated.

During the 2020/2021 growing season, leaf sampling for analysis (nutrient, chlorophyll, and protein content) was collected just before and seven days after zinc application for the pot trial. Preliminary results showed significant differences between the applied zinc carriers when mineral, chlorophyll and protein content of the leaves were considered.

The leaf zinc content increased after applying the different zinc carriers for both the early and late applications. For the early season spray, the zinc absorption when NO_3 was used as a carrier was significantly higher than EDTA. The absorption of zinc between SO_4, ORG, and NO_3 carriers did not significantly differ from each other (Figure 4). The leaf zinc content did not significantly differ between the carriers for the late season spray (Figure 5).

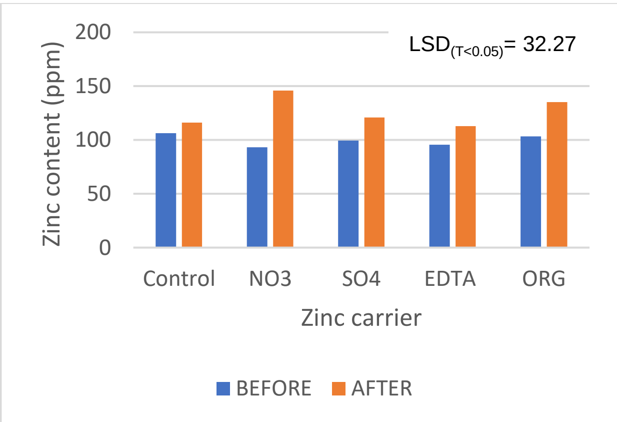

Figure 4: Zinc content (ppm) of pecan leaves before and 7 days after application of different zinc carriers for the November 2020 spray

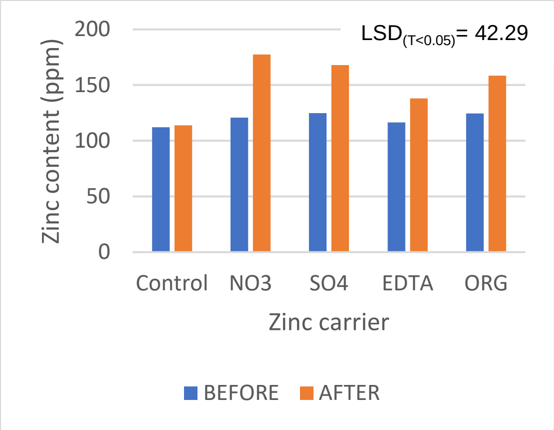

Figure 5: Zinc content (ppm) of pecan leaves before and 7 days after application of different zinc carriers for the February 2021 spray

Foliar applied zinc increased leaf protein content for both the early and late season application, but there was no significant difference between the carriers (Figure 6). Carotene, a chlorphyll pigment preventing damage due to over light absorbance, was increased by the early season zinc foliar spray. The total carotene content however did not differ significantly between the different carriers (Figure 7).

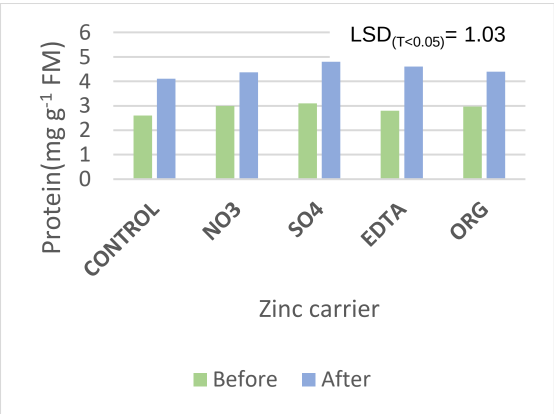

Figure 6: Leaf protein content before and 7 days after application (mg g^{-1} FM) of different zinc carriers *for the November 2020 spray*

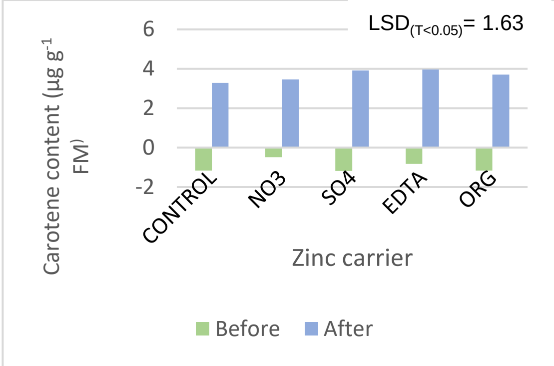

Figure 7: Leaf carotene content before and 7 days after application (µg g^{-1} FM) of different zinc carriers for the November 2020 spray

From the results, it is clear that zinc influences the leaf Zn-content, chlorophyll and protein content regardless of the zinc carrier applied. All these factors are important role players in pecan tree physiology.

The five year old 'Wichita' trees of the field trial was harvested in July 2021. The average nut yield per tree was not significantly influenced by the different zinc carriers (Figure 8). The concentration of the different applied zinc carriers did not differ significantly for the measured parameters in both the pot- and field trial.

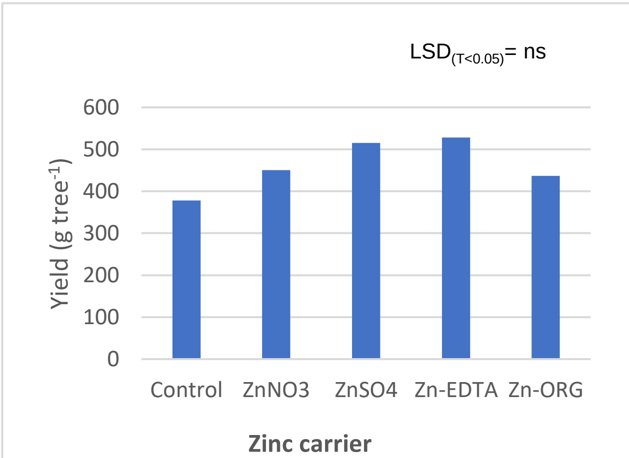

Figure 8: Nut yield (g $tree^{-1}$) influenced by the application of different zinc carriers in five-year old 'Wichita' pecan trees

The aim of this project was to determine the zinc carrier that benefits the pecan nut tree the most to help producers make informed decisions. With input costs increasing annually and profit margins aslo declining, producers need to make informed decisions regarding the different input factors, such as fertilization, to keep the input cost as low as possible to ensure profitable yields.

Data obtained from the study shows that the application of zinc is more important than the specific carrier of zinc used. Producers can consequently apply the cheapest carrier limiting the cost of foliar zinc applications.

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