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Zinc and boron foliar application, An influential treatment on the quality and seed yield of soybean

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Abstract

The objective of this study was to investigate the impact of zinc and boron foliar treatment on some yield components of soybean. For that purpose, a field experiment was conducted in the northeastern region of Homs, Syria during the agricultural season of 2021-2022. The experimental plots were designated based on a randomized block design, consisting of four treatments and three replications. The treatment included a control (Zn_0B_0) without zinc or boron application; zinc-only application at 2 g/l (Zn_2B_0); boron-only application at 2 g/l (Zn_0B_2); and combined application of zinc and boron at 2 g/l each (Zn_2B_2). The foliar spray was applied once during the flowering stage. The number of pods per plant, the weight of pods per plant, seed yield, and protein content in seeds were investigated. The findings demonstrated that the combined application of boron and zinc through foliar spraying (Zn2B2), exhibited superior results in enhancing all the studied parameters. The seed yield under zinc and boron combined treatment exceeded that of the control by more than 50%. Therefore, the current results highlight the importance of these two micronutrients in soybean production.

1. Introduction

The soybean (Glycine max L.) belongs to the Fabaceae family and is one of the earliest cultivated field crops. It is widely acknowledged as the most important legume and oil crop worldwide. The prevailing belief is that the native habitat of this species is Southeast Asia, where its existence was documented approximately seven millennia ago [1]. Soybean seeds are rich in protein (40% on a wet basis) and oil (20% on a wet basis) [2], making them a valuable commodity both as a human food source and for animal feed.

Boron is a micronutrient that plays a crucial role in various aspects of plant growth and development [3]. It promotes the development of flower buds, facilitates cell division, enhances pollen production, improves the fertilization process, and aids in the transportation of carbohydrates. Additionally, boron is essential for protein formation through its involvement in the biological fixation of atmospheric nitrogen [3]. A recent report showed that foliar application of boron resulted in an increased number of soybean pods per plant, weight of 100 seeds, and seed yield [4].

Zinc is a crucial microelement in plant nutrition. Its involvement as an enzymatic cofactor renders it necessary for numerous physiological activities in plants [5]. In fact, the combination of zinc and boron might improve the productivity of legume crops by enhancing the utilization of added fertilizers and other agricultural inputs. A previous report on the broad bean crop [6] showed that foliar spraying with boron and zinc fertilizers, both individually and in combination, can substantially increase branch count, pod count per plant, and weight of 100 seeds

This research is motivated by the crucial role that boron and zinc play in the growth, development, and productivity of legume crops, as well as the strategic importance of soybean as a field crop. The present study seeks to investigate the

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effects of applying boron and zinc foliar spray, both individually and in combination, on the quantity and quality of soybean seeds.

2. Materials and Methods

2.1. Study area

The study was conducted in the northeastern area of Homs, Syria. The soil under study is characterized by its heavy clay composition, with a significant proportion of clay particles. It has a moderate level of organic matter but is deficient in boron and zinc, with concentrations below 1 mg/kg. The climate of the examined area falls within the second stability zone in Syria, with an average annual precipitation of 659 mm.

2.2. Land preparation and agricultural practices

The experimental land was tilled and fertilized with NPK according to soil analysis results (N: 20 kg/ha, P: 30 kg/ha, K: 5 kg/ha) and organic fertilizers (cow manure) at a rate of 40 m^3/ha. Agricultural rows were arranged at a spacing of 70 cm between each row. The sowing of soybean seed was carried out to establish a uniform plant density of ~29 plants/m^2 (5 cm between plants on the same raw). The water requirements of the crop were primarily met through rainfall, and a drip irrigation system was installed for supplemental use as needed. Weed control was conducted manually and no diseases or pests were observed during the experiment.

2.2. Experimental design and foliar fertilization

In this experiment, zinc sulfate ($ZnSO_4.H_2O$) 13%, and Borax ($Na_2B_4O_7.10H_2O$) 17% were prepared at a concentration of 2 g/l of each element and used as a foliar application. The experiment was designed according to a randomized block design with four treatments and three replications. Each experimental plot had an area of 6 m^2 and was divided into 4 cultivation lines. The treatments consisted of :

T_1 - Control (Zn_0B_0) without a foliar application of zinc and boron

T_2 - Spraying with zinc without boron (Zn_2B_0)

T_3 - Spraying with boron without zinc (Zn_0B_2)

T_4 - Spraying zinc and boron combined (Zn_2B_2).

Foliar application of the aforementioned treatment was conducted once during the flowering phase of plants.

2.4. Data collection

The number of pods per plant was assessed at maturity by enumerating all the pods carrying seeds inside each replicate, with a total of 160 plants per replicate.

Seed yield was determined in one of the two central rows for each experimental plot. The seeds were manually removed and clean seeds were collected and weighed. The weights were then expressed as kg/ha.

The protein content in seeds (%) was determined using the Kjeldahl method [7].

2.5. Statistical analysis

Analysis of variance for the collected data (one-way ANOVA) was conducted and the means were compared using Fisher's least significant difference (LSD) at 0.05.

3. Results and Discussion

The application of zinc and boron spray resulted in a substantial rise in the pod count on the plant across all examined treatments, in comparison to the control group which had the lowest count (159.96 pods/plant) (Fig. 1 A). Notably, treatment T4 (Zn_2B_2) exhibited a significant advantage over the other treatments, with the pod count reaching 202.58 pods/plant. Consequently, there was a notable 26.6% augmentation in this characteristic in the combination treatment plants when compared to the control, as well as the plants that received zinc-only and boron-only treatments. This observation may be attributed to the beneficial effects of zinc and boron in enhancing flower formation, cell proliferation, pollen generation, and fertilization, consequently leading to an increase in the number of pods on the plant. This finding aligns with previous studies conducted on soybean and other legume crops [8-11].

The foliar application of a combination of zinc and boron (Zn_2B_2) resulted in a significant enhancement in the weight pods per plant compared to other treatments. It is worth noting that no significant differences were observed between zinc-only (Zn_2B_0) and boron-only (Zn_0B_2) treatments in this trait. The weight of pods per plant reached 130.00 g/plant in Zn_2B_2, whereas the control treatment exhibited the lowest value for this characteristic, measuring 85.10 g/plant (Fig. 1 B). Hence, the observed increase resulting from the combined application of zinc and boron therapy, in comparison to the control, was precisely 52.76%.

All the tested treatments resulted in a significant increase in seed yield compared to control. The highest yield was recorded under Zn_2B_2 treatment (5202 kg/ha). On the other hand, the control treatment exhibited the lowest yield, at 3404 kg/ha (Fig. 1 C). Hence, the utilization of Zn_2B_2 led to a notable 52.82% enhancement in the yield compared to the control. The remarkable resemblance between the increase in seed yield and seed weight per plant compared to control was expected since plant density was similar in all treatments.

The primary cause of the increase in seed weight per plant and total seed yield is mostly ascribed to the augmentation in the number of pods per plant when zinc and boron are applied. Nevertheless, the increased weight of seeds and seed set should have occurred (data not presented) which also played a major role in producing this outcome in the given treatment. In fact, the positive effect of boron and zinc on seed weight and seed set of many legume crops are well documented [12][13]. Additionally, the increase in the total yield of soy under foliar zinc [14] and boron [15] applications was also reported previously. However, the current results highlight the importance of combining these two elements in soybean nutritional programs.

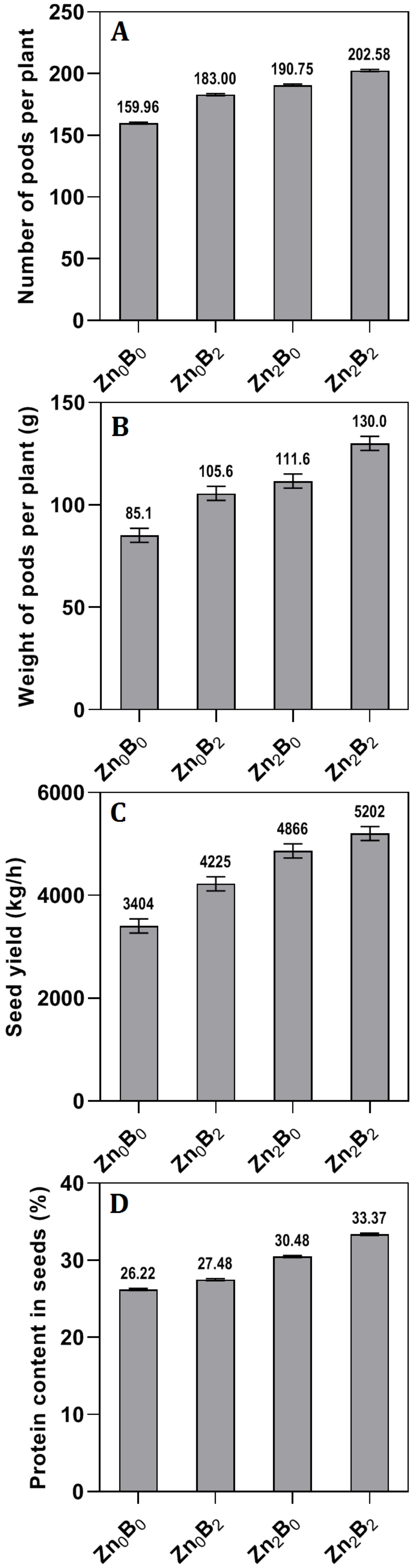

Figure 1. The effect of foliar application with zinc (2 g/l) (Zn_2B_0), boron (2 g/l) (Zn_0B_2), and their combination on the number of pods per plant (A), weight of pods per plant (B), seed yield (C), and protein content in seeds (D) of soybean. The values are represented as means and the error bars represent Fisher's LSD values at 0.05 significance level. Non-overlapped error bars refer to a significant difference between the treatments. $LSD_{0.05}$ for the number of pods per plant, weight of pods per plant, seed yield, and protein content in seeds were 1.59, 6.85, 273.9, and 0.29, respectively.

An evident advantage of using a combination of zinc and boron (Zn_2B_2) over other treatments was observed in terms of protein content in seeds, with the percentage of protein in seeds reaching 33.37%. The control exhibited the lowest protein level, measuring at 26.22%. Zinc influence was more pronounced in increasing protein content (Fig. 1 D). However, both zinc and boron are essential in protein synthesis and assimilates transportation in plants [16][17].

4. Conclusion

The current research highlights the importance of the foliar application of zinc and boron on productivity components and protein content of soybeans. The presented results show that the combination of these micronutrients is essential in enhancing the yield of this economic crop. More research might be conducted to better understand the mechanism by which zinc and boron interaction influences soybean growth and production.

Conflict of interest statement

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Data availability statement

The author declared that all related data are included in the article.

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