

Sustainable Strategies for Boosting Alfalfa Yield and Quality under Drought Condition

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Abstract: Climate change is increasing the frequency and severity of drought stress in forage production systems, posing a serious threat to global food security and livelihoods, and necessitating sustainable input strategies. This study aimed to evaluate the effectiveness of biostimulants, with or without foliar fertilizer containing silicon, calcium to improve alfalfa performance under drought conditions. A field experiment assessed the applications of control (T0), biostimulants plus foliar fertilizer (T1) and biostimulants alone (T2) under drought stress in alfalfa cultivation. The results showed that these treatments significantly improved fresh herbage yield, protein content, and protein yield compared to the control under moderate drought stress. Notably, the combined strategy (T1) increased fresh herbage yield and protein yield by 22.5% and 33.4%, respectively, over the control. Overall, combining biostimulants with foliar fertilization represents an effective and sustainable approach to enhancing alfalfa forage yield and quality under drought stress.

Introduction

The intensification of climate change, particularly drought stress, significantly limits alfalfa yield and forage quality, posing challenges to sustainable agriculture.

Biostimulants and foliar fertilizers containing silicon, calcium, and other macronutrients have shown potential to enhance plant resilience to water deficits.

Therefore, this study aims to evaluate the effectiveness of biostimulants with or without foliar fertilizers as a sustainable strategy to improve alfalfa performance under drought conditions.

Material and method

Study Design and treatment used

The experiment was conducted during the 2024 cropping season at the research garden of the University of Debrecen, Hungary. The experiment was arranged in a randomized complete block design (RCBD), with three treatments replicated three times under field conditions.

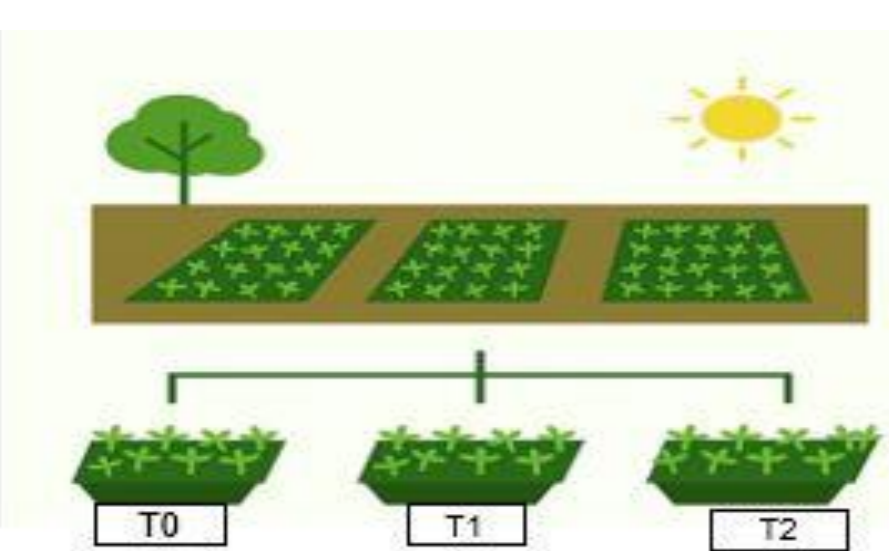


Table 1: Treatment labels and levels used

Code	Treatments	Dosage
T0	Control	-
T1	Tricho Immun + Ino Green	3 + 3 L ha ⁻¹
T2	Tricho Immun	3 L ha ⁻¹

Treatment application procedure

Tricho Immun was soil applied a day after harvest whereas Ino Green was also foliar applied a week after regrowth to the leaves

Data collection and drought assessment

1. Fresh herbage yield (FHY), 2. protein content, 3. protein yield. NB: Protein yield (kg ha⁻¹) = Dry matter yield × protein content.

Drought severity was classified as moderate drought stress with Pálfi Drought Index (PaDI) value of 6.5 PaDI °C 100 mm⁻¹



Results and discussions

The results are shown in Figures 1 and 2 demonstrating that the application of the treatments significantly ($P < 0.001$) improved the fresh herbage yield, crude protein content, and protein yield of alfalfa under drought stress. Notably, fresh herbage yield was significantly increased by 22.5% under T1, followed by T2 with 13.5%, compared to the control. Similarly, protein yield was significantly increased by 33.4% and 25.8% under T1 and T2, respectively, compared to the control. Furthermore, crude protein content was significantly higher in T2, followed by T1.

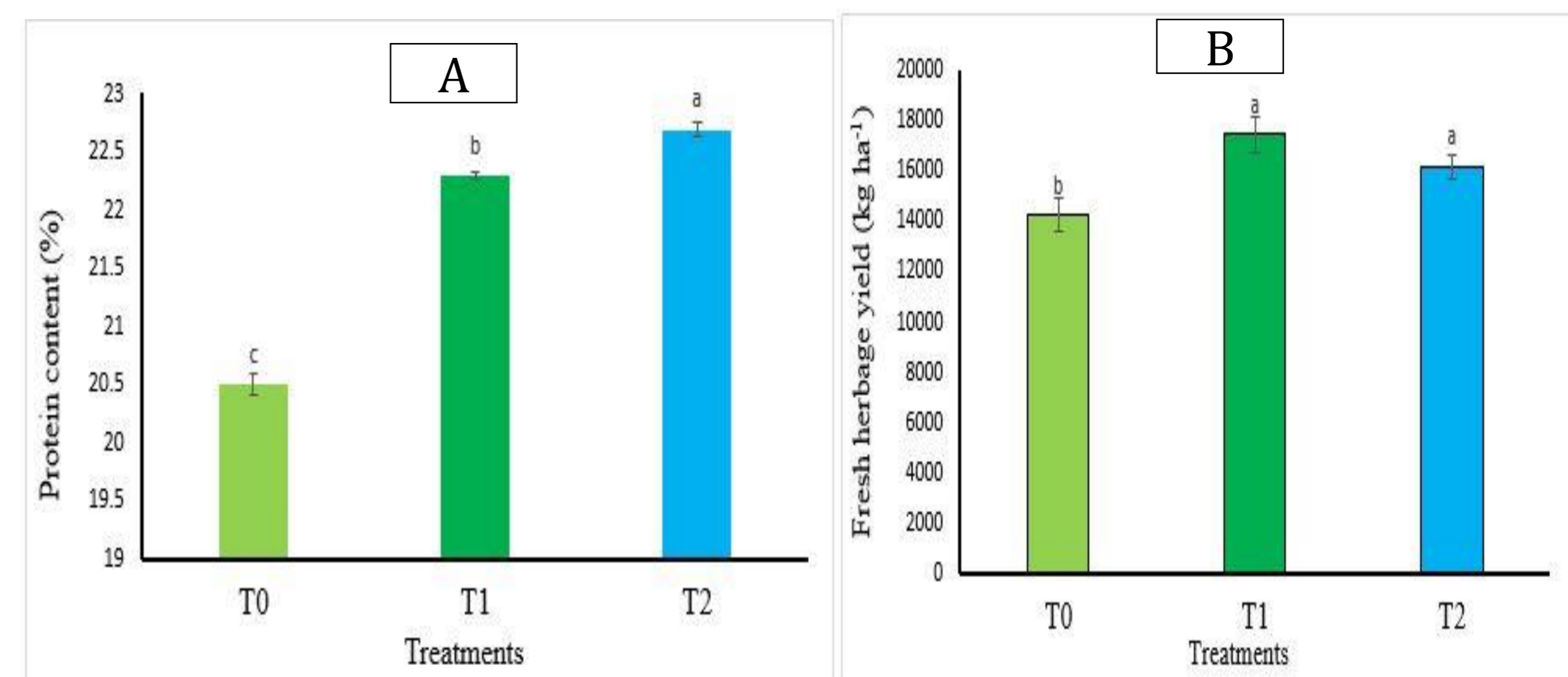


Figure 1: Effect of biostimulant with or without foliar fertilizer on protein content (A) and herbage yield (B) of alfalfa under drought stress

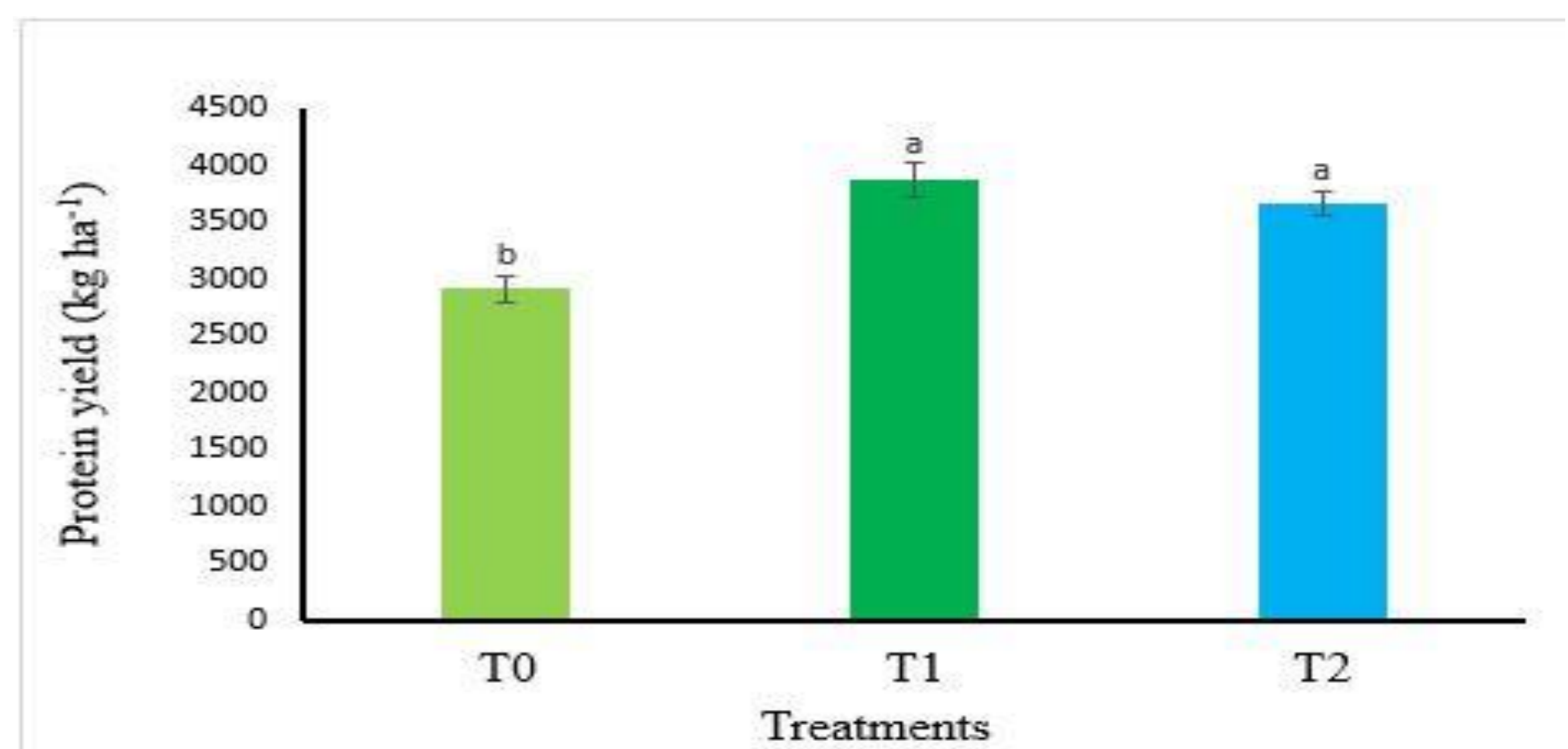


Figure 2: Effect of biostimulant with or without foliar fertilizer on protein yield of alfalfa under drought stress

Conclusions

We conclude that the application of biostimulants with or without foliar fertilizers containing silicon, calcium significantly improved alfalfa yield and forage quality under drought conditions. The combined application T1 showed the greatest effectiveness by increasing fresh herbage yield and protein yield by 22.5% and 33.4%, respectively, indicating a synergistic effect. Overall, these strategies provide a sustainable approach to improving alfalfa resilience and productivity under water-limited environments.

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