



Effect of Plant Growth Regulators on Cowpea (*Vigna unguiculata* (L.) Walp) Productivity under High Temperature Stress

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

High temperature stress severely interrupts the physiological and biochemical functions in plants which hinders the growth, development and productivity of cowpea. The present study evaluates the potential roles of Naphthalene Acetic Acid and Brassinolide for mitigating the adverse effects of high temperature in cowpea. The study was carried out during the year 2021 in cowpea variety CO 7 using Temperature Gradient Tunnel (TGT) located at Agro Climate Research Centre, Tamil Nadu Agricultural University (TNAU), Coimbatore. The experimental design followed was Factorial Completely Randomized Design (FCRD). Different treatments were imposed on plants exposed to ambient and ambient +2°C temperature. The effect of treatments on leaf area index, photosynthetic rate, chlorophyll index and seed yield were studied. The application of brassinolide @ 0.2ppm showed a positive effect on stressed plants and produced the highest seed yield of 8.78 g plant⁻¹.

Keywords: High temperature; plant growth regulators; NAA, brassinolide; cowpea.

ABBREVIATIONS AND ACRONYMS

TGT : Temperature Gradient Tunnel;
BL : Brassinolide;
NAA : Naphthalene Acetic Acid.

1. INTRODUCTION

Global warming has well-defined effects on plant growth, development, and crop productivity. The primary impact of global warming is the increase in surface air temperature. The IPCC has outlined those temperatures would rise by 3-4°C over current levels after 2050 with major impacts of climate change on rainfed crops [1]. Furthermore, continuous increase in heatwaves has contributed to a 0.5°C increase in mean global temperature which has a severe impact on growth, yield and product quality [2].

Cowpea (*Vigna unguiculata*), a protein-rich nutritious crop and an important grain legume that is cultivated widely. Cowpea is a multifunctional legume supplying vegetables (green pods), food (seed), fodder and is also used as green manure and cover crop. In course of global climate change, heat stress-related episodes are becoming an intense problem and maybe of prodigious alarm for global food security. The growth and yield of cowpea are significantly interrupted by heat stress in the major cowpea growing areas [3]. Thus, to sustain cowpea yield under high-temperature stress, necessary management should be taken.

Plant Growth Regulators (PGRs), are the compounds synthesized by plants that can act locally or transport to distant sites of the plant body to accelerate growth and development in both stressful and non-stress conditions. Foliar applications of PGR promote growth and development includes Brassinolide (BL) and Naphthalene Acetic Acid (NAA). [4] reported that NAA, a synthetic plant hormone belongs to the auxin family that alleviates heat damage in reproductive organs. Brassinolide (BL), the first isolated brassinosteroid plant hormone, performs a key role in several cellular and physiological processes like stem elongation, pollen tube growth, root inhibition, grain development, xylem differentiation, and photosynthesis [5]. With this background, the study was formulated to know the suitable foliar application for cowpea under high temperatures.

2. MATERIALS AND METHODS

The experiment was carried out under a temperature gradient tunnel (TGT). The

experimental design was based on a combination of two factors: temperature (ambient temperature and ambient +2°C) and exogenous treatment (Br @ 0.2ppm and NAA @ 40ppm). Based on the recommendation given by [6], the foliar application was made two times i.e., at flower initiation and 50% flowering stage. There were six treatment conditions as follows: (i) RDF-check (C – ambient temperature); (ii) BL; (iii) NAA; (iv) RDF - check (S – ambient +2°C); (v) S+ BL; (vi) S+ NAA. This experiment was designed as a Factorial Completely Randomised Design (FCRD) with three replications for each treatment. The cowpea plants variety CO 7 was grown under this treatment condition for 75 days.

The measurements such as LAI, chlorophyll index (Soil Plant Analysis Development (SPAD) a portable chlorophyll meter) and photosynthetic rate (Portable Photosynthetic System (PPS)) were taken from each treatment at 30, 45 and 60DAS as per standards of procedure. The seed yield was measured after harvest from each treatment and noted as g plant⁻¹. The results were statistically analyzed using the ANOVA table given by [7] at 5% level of significance.

3. RESULTS AND DISCUSSION

3.1 Leaf Area Index (LAI)

Cowpea plants under high temperatures showed a significant decrease in LAI compared to those plants grown under ambient conditions. However, BL and NAA-treated plants exhibited a significant increase in LAI in both stress and non-stressed plants. The maximum LAI under stress conditions was recorded in BL treated plants with 0.3, 2.3 and 2.4 at 30,45 and 60DAS (Fig. 1). This might be due to the plant meristem tissues activity that increases the number and size of the cells, which ultimately increases the leaf area [8]. The leaf area maximization with the foliar treatment of BL parallels the enhancement of the photosynthetic area, which contributes to an increase in the growth trait of the plants. Influence of BL application on leaf area increment was also reported in wheat (*Triticum aestivum*) [9] and pigeon pea (*Cajanus cajan*) [10] under stress conditions.

3.2 Photosynthetic Rate ($\mu\text{mol CO}_2 \text{ m}^{-2} \text{ s}^{-1}$)

The photosynthetic rate (Pn) of cowpea plants was reduced under high temperature on comparing with ambient temperature plants.

However, the increase in photosynthetic rate was observed in BL and NAA treated plants where BL is superior to NAA in both the temperature levels. The treatment S+BL recorded 14.2, 39.7 and 22.1 $\mu\text{mol CO}_2 \text{ m}^{-2} \text{ s}^{-1}$ at 30, 45 and 60DAS (Fig. 2). Decreases in Pn during stress may occur due to the effect of stomatal factors that reduce the activity of Rubisco which is the key enzyme in the Calvin cycle that fix CO_2 to regulate photosynthesis [11]. BL application improved the photosynthesis efficiency, either by stomatal (Rubisco activity) or non-stomatal characters (photosynthetic pigment) or by their combinations [12]. [13] reported that BL acts photosynthesis and growth-promoting agent. In this study, BL application increased Pn by improved chlorophyll content (the photoreaction center) [14] demonstrated that the positive effects of BL on

photosynthesis and growth indices are caused by enhanced cell division and cell enlargement.

3.3 Chlorophyll Index

The leaves of cowpea plants under stress conditions documented a significant decrease in chlorophyll values compared to control plants. However, the plants treated with BL recorded a high chlorophyll index (38.6, 43.9 and 42.0 at 30, 45 and 60DAS) under high temperature (Fig. 3). This may be due to the enhancement of CO_2 absorption by treated leaves i.e., increased photochemical efficacy resulted in an increased accumulation of chlorophyll pigments [15]. Similar results of increased chlorophyll content through the BL application have been reported by [16,17].

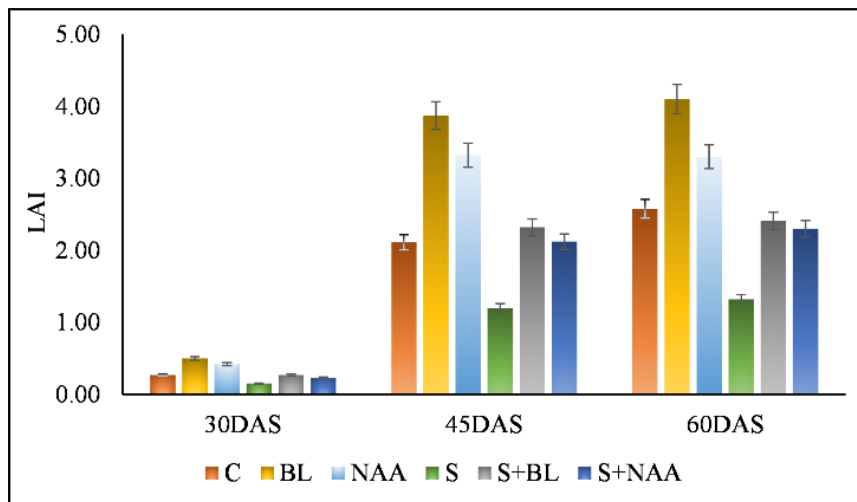


Fig. 1. Effect of brassinolide and NAA on LAI of cowpea under high temperature

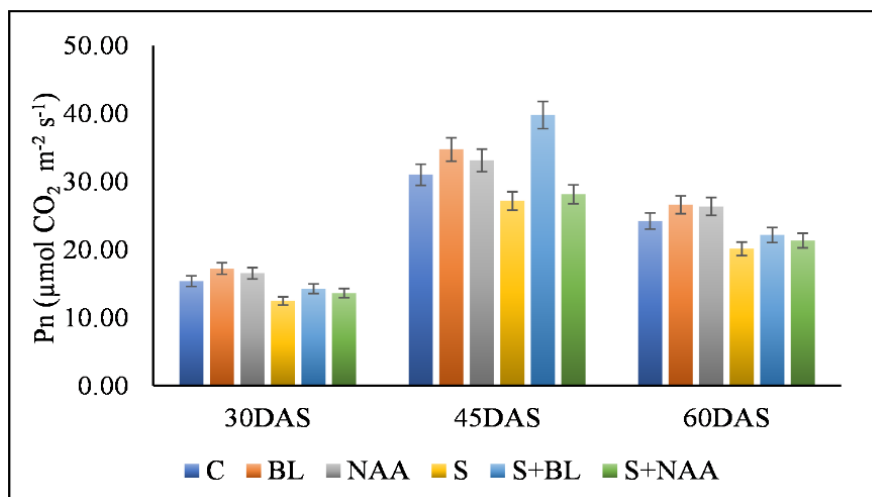


Fig. 2. Effect of brassinolide and NAA on the photosynthetic rate of cowpea under high temperature

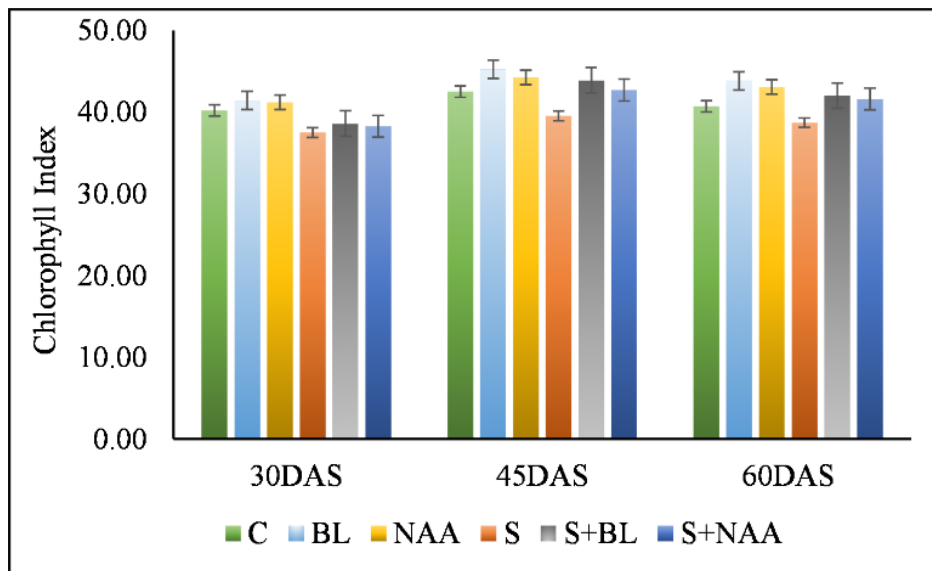


Fig. 3. Effect of brassinolide and NAA on chlorophyll index of cowpea under high temperature

3.4 Seed Yield (g plant⁻¹)

A significant yield reduction was observed in stressed plants compared to ambient temperature. Application of BL and NAA under stress conditions brought about significant improvements in the productivity of cowpea plants as compared to stressed plants. However, the maximum increment in seed yield was recorded by BL application (8.78 g plant⁻¹) (Fig. 4). The regression analysis between seed yield and LAI ($p=0.0003$), photosynthetic rate ($p=0.029$), chlorophyll index ($p=0.003$) of cowpea showed that the relationship was significant and positive

(Fig. 5). Plants regulate the sink size based on the volume of assimilates but the plants under stress reduced the supply of assimilates by leaf area reduction and disrupting the process of absorption and transfer of nutrients, which resulted in reduced seed yield. Application of BL resulted in increased leaf area, photosynthetic pigments, and photosynthetic rate that attributed to enhanced seed yield. BL application stimulated the assimilate flux from source to sink by the enrichment of phloem uploading and sink strength [18]. The application of BL has been reported to increase the seed yield of soybean [16], chickpea [19], and sunflower [15].

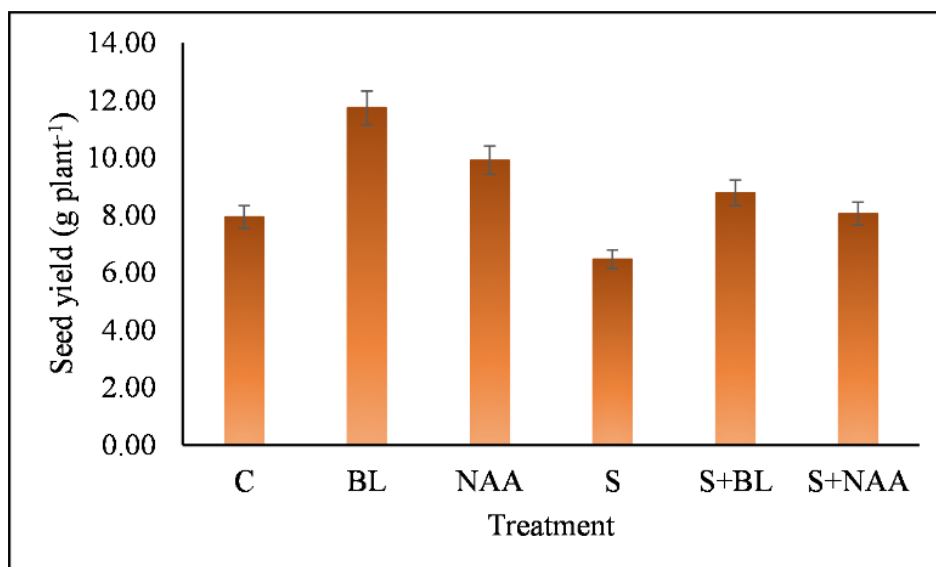


Fig. 4. Effect of brassinolide and NAA on seed yield of cowpea under high temperature

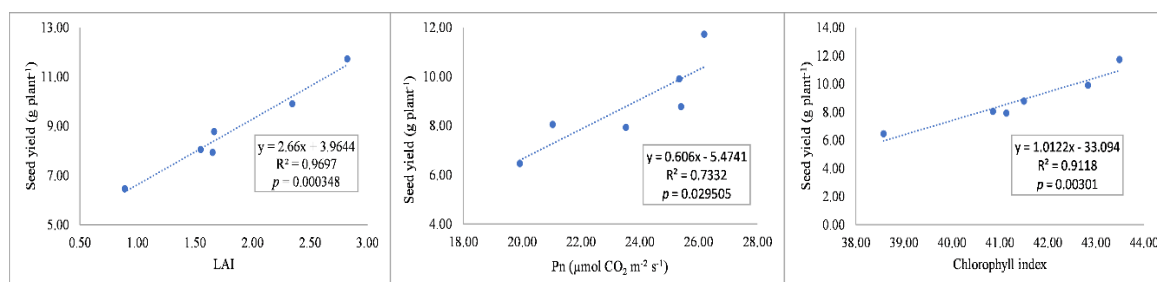


Fig. 5. Regression analysis between seed yield and LAI, photosynthetic rate and chlorophyll index of cowpea

4. CONCLUSION

The present study concluded that the application of plant growth regulators aids in alleviating the heat stress in plants. Among the PGRs sprayed, brassinolide has shown more ability in reducing the effects of heat stress by increased LAI, chlorophyll index, photosynthetic rate and ultimately ends in increased seed yield of cowpea. However, future studies should be involved at the root level on large scale using different concentrations of NAA or BL applications to an extensive range of crop species to find out the constructive roles of NAA or BL in the management of heat stress under different agro-climatic regions.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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