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Impact of moisture stress and elevated temperature on physiological and yield traits of Blackgram

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Abstract

Drought, salinity, moisture stress and increasing temperature are the key abiotic factors that results in the reduction of crop yield severely all over the world. A pot culture study was conducted in ACRC to study the effect of heat and moisture stress on Blackgram productivity. The aim of this study is to assess the response of Blackgram to moisture stress on photosynthetic gas exchange and yield parameters under both ambient and elevated temperature (+2 °C). Two major Blackgram varieties (CO 6 and VBN 6) were taken for this study. The experiment results revealed that, moisture stress at vegetative phase restricted the plant height, Net Photosynthetic Rate, Stomatal Conductance, and Transpiration Rate in both cultivars. Similarly, the plants under stressed condition during flowering stage exhibited reduction in number of pods per plant on average of 9.7 and seeds per pod on average of 3.9 in CO 6 whereas VBN 6 under ambient condition resulted in 18.5 pods per plant and 8.6 seeds per pod. The results revealed that, VBN 6 is physiologically efficient and resulted in moderate yield compared to CO 6 even with water stress and high temperature condition.

Keywords: Blackgram, moisture stress, elevated temperature, yield

Abbreviations: FCRD – Factorial complete randomized design, PPS - Portable photosynthetic system

Introduction

Water is a key input not only in improving crop yield, but also directly or indirectly involves in all physiological processes in plants that influence the morphological features of plants directly (Dahanayake *et al.*, 2015) [3]. Pulses are thermo sensitive. As they are vulnerable to high temperature, it negatively impacts the flowering, pod setting and yield of crops (Anitha *et al.*, 2015) [1]. Compared to cereals and oil seeds, pulse crops are more prone to climate variability (Mishra *et al.*, 2017) [9]. High temperature and moisture deficit stress are the key abiotic factors which adversely affect the growth and yield of black gram (Vanaja *et al.*, 2006) [11]. Blackgram is a short duration pulse crop grown well with an ideal temperature of 27 – 35 °C rainfall ranging from 600 to 1000 mm per annum. The growth and yield of blackgram depends on soil moisture availability, temperature and solar radiation. Significant declines in production of blackgram in India have grown in recent years. Among the factors, lack of suitable varieties and genotypes suited to local environments are the important factors affecting its productivity (Vanaja *et al.*, 2006) [11]. (Lawson and Blatt, 2014) [6] Stated that rise in temperature alters the stomatal conductance and photosynthetic rate and also increases transpiration which leads to lower production.

As there is a shortage of sufficient trails under moisture stress on productivity of blackgram, the current research study have been attempted to assess the impact of moisture stress with elevated temperature on growth and yield of blackgram.

Materials and Methods

A pot culture study was conducted in Agro Climate Research Centre, Tamil Nadu Agricultural University, and Coimbatore during the year 2019 – 2020. The geographic coordinates of the study site falls under latitude of 11° N and longitude of 77° E and is located on an altitude of about 426.7 meters above mean sea level in western agro climatic zone of Tami Nadu. The weather parameters observed during the study trial was illustrated in (Fig 1). The experiment consists of 32 pots made out of plastic with a diameter of 26 cm and a depth of 25 cm.

Experimental design

The pot culture study was laid out in Factorial Completely Randomized Block Design (FCRD) with three factors (variety, temperature and moisture), 16 treatments were attained and replicated twice.

Plant analysis

Blackgram varieties used for this study were obtained from Department of Pulses, TNAU, and Coimbatore. Five seeds per pot were sown and life irrigation was given. The samples were obtained from each pot at different stages and analyzed for leaf gas exchange and yield parameters and the plants were subjected to water stress by restricting water supply at vegetative, flowering and pod development stages in both ambient and elevated temperature.

Physiological leaf gas exchange parameters

Leaf gas exchange parameters (Photosynthetic rate, transpiration rate, stomatal conductance) commenced during vegetative, flowering and pod filling stages were recorded from 3rd uppermost leaf from the tagged plants grown under well watered and moisture deficit stress in both thermal condition. The readings were measured using Portable Photosynthetic System (PPS). The observations were made between 1000 hrs. and 1200 hrs.

Yield attributes

Number of pods per plant

Two plants per pot were tagged. The tagged plants from each treatment and replication were harvested and the yield parameters were recorded. The total number of pods produced by plants in each treatment and replication was documented at the harvest stage and the average was represented in numbers.

Seed yield per plant

Total number of seeds produced in each pods from the tagged plants in each treatment and replication at the harvest stage were counted and the average is expressed in numbers

Statistical analysis

From the pot trial, the data associated to growth and yield parameters were statistically analyzed to assess the significance of the factors (variety, temperature and moisture) and their interaction at $P < 0.05$ interaction level.

Results and Discussion

Effect of moisture stress on leaf gas exchange parameters

The result of the trail shows that under both thermal

conditions, the introduction of moisture stress reduced the chlorophyll content which affected the rate of photosynthesis. T_{16} ($29.30 \mu\text{mol.CO}_2/\text{m}^2/\text{s}$) had the maximum photosynthetic rate, in all three stages, in which the plant was well irrigated under open field condition. The least was recorded in T_{11} ($21.90 \mu\text{mol.CO}_2/\text{m}^2/\text{s}$), where the plant is subjected to moisture stress under elevated temperature ($+2^\circ\text{C}$) (Fig 2). Similar results were also observed by Mathur *et al.*, (2014)^[8] and Mohapatra *et al.*, (2020)^[10] that at elevated temperature, the loss of chlorophyll is high which leads to the reduction of photosynthetic process, results in the reduction of yield.

The obtained data on stomatal conductance is similar to that of photosynthetic rate where T_8 ($0.35 \text{ mol.H}_2\text{O}/\text{m}^2/\text{s}$) recorded the maximum, and the least was recorded in T_{11} ($0.09 \text{ mol.H}_2\text{O}/\text{m}^2/\text{s}$) (Fig 3). The leaf transpiration rate significantly increased when subjected to heat stress. The maximum was recorded in T_{11} ($11.5 \text{ mol.H}_2\text{O}/\text{m}^2/\text{s}$) while the minimum in T_{16} ($7.6 \text{ mol.H}_2\text{O}/\text{m}^2/\text{s}$) (Fig 4). Similar result was observed by Maghsoudi *et al.* (2016)^[7] when the wheat crops were subjected to moisture deficit condition.

Effect of moisture stress on yield parameters

The average mean yield of two blackgram varieties with two moisture levels under both ambient and elevated temperature in all three stages were presented in (Fig 5). When both varieties have been introduced to moisture stress condition, the number of pods produced per plant was reduced and further reduced under elevated temperature ($+2^\circ\text{C}$). The maximum number of pods was recorded in T_{16} (20.5) which is grown under well watered condition in ambient temperature, and the lowest was observed in T_3 (9.7), where the plants are subjected to moisture stress under elevated temperature ($+2^\circ\text{C}$). Similar results were observed by Baroowa and Gogai (2012)^[2] during flowering stage, the moisture stress decreased the number of pods in both blackgram and greengram. Farooq *et al.* (2009)^[4] stated that, the reduction in yield parameters due to water stress is correlated with the disruption of leaf gas exchange properties, which limits the size of source and sink tissue and also phloem loading and partitioning of dry matter.

A study done by Gurumurthy *et al.* (2019)^[5] reveals that, moisture deficit stress introduced at reproductive stage, directly affects the seed yield in blackgram. Similar results were observed in this study, in which the lowest seed yield per plant was recorded in T_3 (3.1g/ plant) while the highest was recorded in T_{16} (5.0g/ plant).

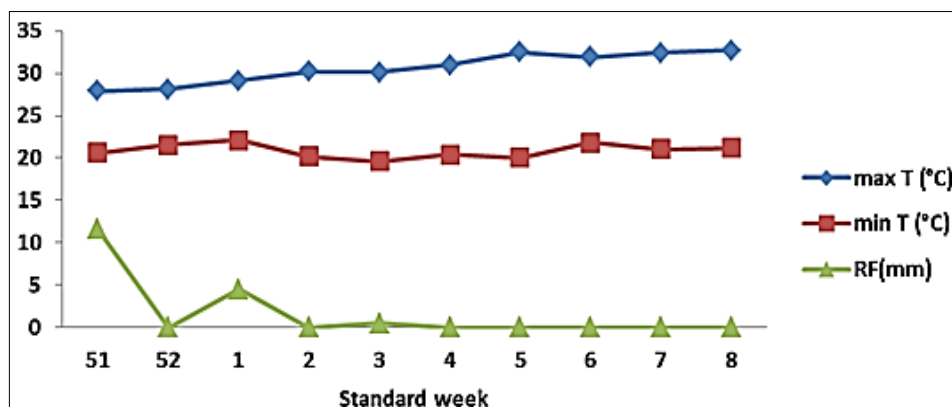


Fig 1: Weather prevailed during the study period

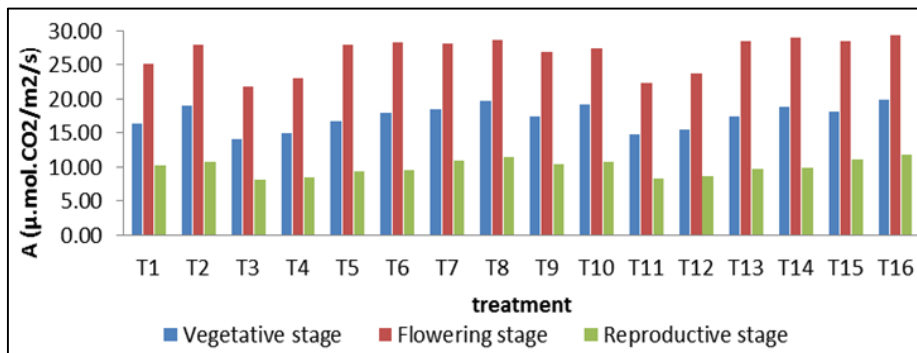


Fig 2: Effect of moisture stress on photosynthetic rate of blackgram

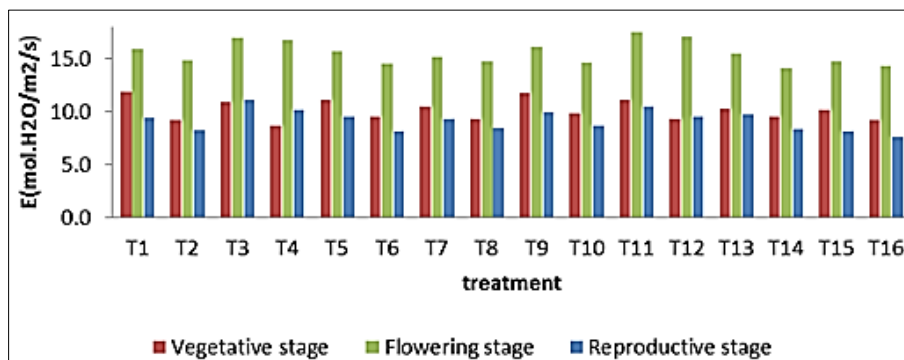


Fig 3: Effect of moisture stress on transpiration rate of blackgram

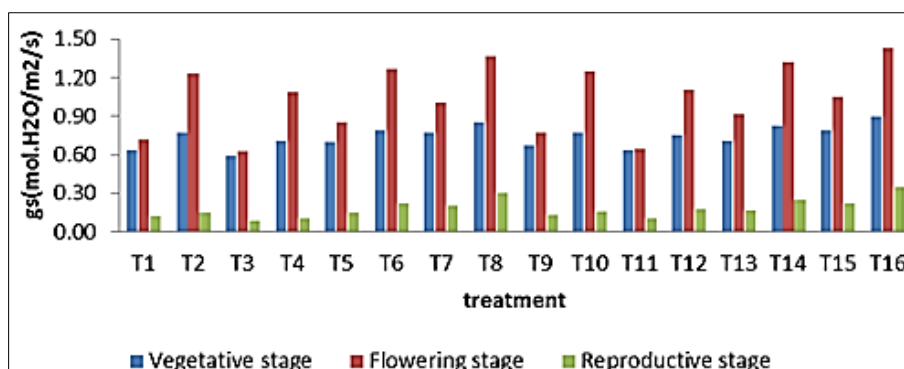


Fig 4: Effect of moisture stress on stomata conductance of Blackgram

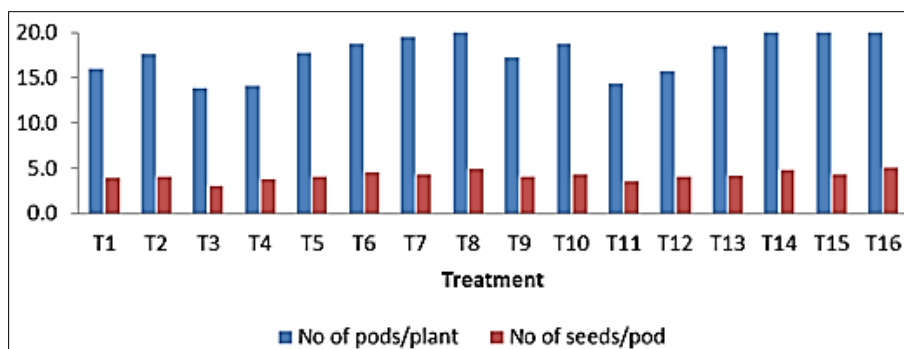


Fig 5: Effect of moisture stress on no. of pods per plant and seed yield per plant of Blackgram

Conclusion

From the results, it can be concluded that moisture stress irrelevant of the thermal condition restricted both physiological and yield traits in Blackgram. Among two varieties, VBN 6 performed is well under both irrigated and moisture deficit stress condition and recorded high yield, while CO 6 is sensitive to moisture stress in both ambient and elevated temperature. It is concluded that VBN 6 is capable of

tolerating moisture deficit stress and physiologically efficient and produce moderate yield.

Application of research: The study focuses mainly on impact of elevated temperature and moisture stress on black gram.

Research Category: Climate study

Abbreviations: FCRD-Factorial complete randomized design, PPS -Portable Photosynthetic System,

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***Chairperson of research:** Dr. N. Maragatham

University: Tamil Nadu Agricultural University

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Author statement: All authors read, reviewed, agreed and approved the final manuscript. Note-All authors agreed that-Written informed consent was obtained from all participants prior to publish / enrolment

Study area / Sample Collection: Climate control chamber, Agro Climate Research Centre, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India -641 003

Conflict of Interest: None declared

Ethical approval: This article does not contain any studies with human participants or animals performed by any of the authors.

Ethical Committee Approval Number: Nil

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