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RESPONSE OF MUNGBEAN GENOTYPES WITH RELATION TO GROWTH, BIOCHEMICAL AND PHYSIOLOGICAL BEHAVIOR AS INFLUENCED BY SOWING DATES

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Abstract

Mungbean production, when sown after wheat, has been experiencing a decline over the years due to heat stress and unpredictable rainfall during critical reproductive growth stages. Identifying the optimum sowing time could potentially improve mungbean yield by mitigating these adverse environmental factors. To investigate this, a two-year field experiment was conducted at the Agronomic Research Station in Karor-Layyah during the Kharif seasons of 2018 and 2019. The experiment utilized a Randomized Complete Block Design (RCBD) with a Split Plot arrangement, including three replications. The main plot treatments consisted of four different sowing dates: D_1: 1st April, D_2: 15th April, D_3: 1st May, D_4: 15th May. In the sub-plots, three mungbean varieties were tested: V_1: Bahawalpur Mung-2017, V_2: NIAB Mung-2016, V_3: AZRI Mung-2006. Over the course of two years, data revealed that the highest leaf area index (LAI), crop growth rate, total dry matter, relative water content, and relative stress injury were observed in crops sown on the earliest date, 1st April (D_1). In contrast, the lowest values for these parameters were recorded for crops sown on the latest date, 15th May (D_4). The early-sown crop (D_1) showed significantly better growth, biochemical, and physiological parameters compared to the late-sown crop (D_4). Specifically, growth parameters demonstrated an increasing trend up to 60-75 days after sowing in the D_1 treatment, whereas other treatments followed this trend only up to 60 days before a noticeable decline due to leaf senescence. Among the mungbean varieties, NIAB Mung-2016 exhibited the highest LAI, followed by AZRI Mung-2006, with Bahawalpur Mung-2017 showing the lowest LAI. Furthermore, the crops sown on 1st April (D_1) and 15th April (D_2) showed a remarkable increase in growth parameters, especially during the reproductive stage. In conclusion, the findings suggest that sowing mungbean earlier in the season, particularly around 1st April, can significantly enhance growth and yield by avoiding the detrimental effects of heat stress and erratic rainfall.

Keywords: Mungbean; Sowing time, Varieties, Crop growth rate, Leaf area index

Introduction

Mungbean (Vigna radiata [L.] Wilczek) is a crucial legume crop during the Kharif season, valued for its nutritional content. Its seeds are rich in carbohydrates (60.4%), protein (24.20%), and fat (1.30%) (Imran *et al*., 2015). Mungbean is also a significant source of vitamins and minerals, including iron, magnesium, and folate, making it an important component of diets in many developing countries. Additionally, mungbean contributes to soil fertility by fixing atmospheric nitrogen, thereby reducing the need for synthetic fertilizers in crop rotations.

However, climate change has negatively impacted mungbean production, affecting both the maturity period and yield. Habib-Ur-Rahman, (2022) observed climate extremes i.e. drought, intense and erratic rainfall, heat, insect pest outbreak, storms, flood are threatening the livelihood of farmers. These climatic changes can lead to heat stress and water shortages during critical growth stages, reducing overall productivity. Dynamic crop simulation models have been used to assess crop growth, but they often require extensive input data, including weather, soil, and management practices. While these models are useful, they can be cumbersome and impractical for many farmers. Simplified growth and yield prediction models, requiring less data, can address this issue effectively, providing more accessible tools for farmers to optimize their practices.

Understanding the physiological basis for yield differences among mungbean genotypes and their sowing times is crucial. This involves quantifying growth components and variations during the cropping season to improve crop yields. Sowing time is a critical factor influencing plant performance and yield (Sadeghipour, 2008). It impacts mungbean productivity in terms of growth, production, and yield (Soomro and Khan, 2003). Proper timing ensures that the plants can maximize their use of available resources, such as sunlight and water, and avoid periods of adverse weather. The sowing date significantly affects dry matter production in green gram (Rahman *et al*., 2002) and leaf area development in peas (Ahmad *et al*., 2021). Differences in dry matter accumulation and pod production among genotypes are related to factors like leaf area index (LAI), crop growth rate (CGR), net assimilation rate (NAR), and total dry matter (TDM). These parameters are critical indicators of plant health and productivity. For instance, a higher LAI indicates a greater leaf surface area for photosynthesis, leading to better growth and yield.

Mondal *et al*. (2012) studied six mungbean varieties and found variations in CGR, NAR, relative growth rate (RGR), and LAI, identifying physiological causes of yield differences. High economic yield requires not only high TDM production but also efficient partitioning between

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vegetative and reproductive parts. This means that plants must effectively allocate resources to produce more pods and seeds rather than just leaves and stems. Currently, only three mungbean varieties are in production in the study area, highlighting the need for ongoing research and development to optimize yields under changing climatic conditions. Breeding programs can focus on developing new varieties that are more resilient to heat and drought, have higher nutritional content, and exhibit better growth characteristics. Moreover, integrated pest management (IPM) practices can be employed to minimize crop losses due to pests and diseases, which are likely to increase with climate change. Education and extension services are also vital to disseminate knowledge about optimal cultivation practices and new technologies to farmers. In conclusion, while mungbean remains a vital crop for both nutrition and agriculture, it faces significant challenges due to climate change. Through targeted research, simplified modeling, and improved agricultural practices, it is possible to enhance mungbean production, ensuring its benefits for future generations.

Materials and Methods:

A two years field experiment was laid out in Split Plot Design with three replications. The treatments consisted of four dates of sowing; 1st April, 15th April, 1st May and 15th May was set as main plot treatment and three cultivars; Bahawalpur Mung-2017 (BHW-2017), NIAB Mung-2016 (NM-2016) and AZRI Mung-2006 (AZRI-2006) as sub plot treatment at Agronomic Research Station, Karor-Layyah during the Kharif season of 2018 and 2019. All other agronomic practices were kept uniform for all the treatments. Crop growth rate (g m^{-2} d^{-1}) was determined by sun drying the plant samples and then placing then in in an oven at 75 °C for 48 hours until they reached a constant weight. Total dry matter was calculated by weighing oven dried samples. The crop growth rate was calculated using Hunt's formula (1978).

$$CGR = W_2 - W_1 / t_2 - t_1$$

Where W_1 is Total dry matter at first harvest, W_2 is Total dry matter at second harvest, t_1 is Date of observation of first dry matter and t_2 is Date of observation of second dry matter.

Where, W_1 and W_2 are, the dry weight and time interval of t_1 and t_2, respectively.

For the determination of Leaf area index (LAI) plants were harvested from a unit area in each plot, their leaves were detached, and their weight was measured using a digital electronic balance. A sub sample of 5g leaves was taken, and the leaf area meter (Model CI-202, CID, Inc., USA) was

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used to calculate the leaf area of all leaves. Finally, the leaf area index was calculated as the ratio of the leaf area to the ground area procedure mentioned by (Watson, 1947).

$$\text{LAI} = \{\text{Total green Leaves Area (cm2)/ Area occupied by the Plants(cm2)}\}$$

For determination of Relative stress injury (electrolyte leakage) Electrolyte leakage methods were used to assess leaf injury (Premchandra *et al*., 1990). Fresh leaf samples (1 g) were collected and washed several times with deionized water to remove electrolyte material from the leaf surface and stored in 20 mL vials containing 10 ml de-ionized water at 25 °C on a rotary shaker for 24 hours. The EC of the solution (L_1) was determined using a conductivity meter. The samples were then immersed in a boiling water bath for two hours to kill the tissue completely. After cooling, the solution's EC was measured again and designated as (L_2). The leakage of electrolytes was calculated as follows:

$$\text{EL (\%)} = (\text{L1}/\text{L2}) \times 100$$

For determination of Relative water content (RWC) of leaf (%) at mid-day (between 8:30 am and 10:30 am), the third fully expanded leave from the plant top was separated from shoots and sealed in polythene bags and transferred to the laboratory and weighed to determine the fresh weight (FW). After that, leaves were placed in Petri dishes filled with water for three hours. Afterwards, leaves were again weighed to determine the turgid weight (TW) and again they were oven dried (80ºC) until constant dry weight (DW). Later on, RWC were calculated according to the given below formula:

$$\text{RWC (\%)} = (\text{FW} - \text{DW}) / (\text{TW} - \text{DW}) \times 100$$

The recorded were analyzed statistically using Fisher's Analysis of Variance Technique and treatment's means were compared using Tukey's Honestly Significant Difference (HSD) test. (Steel *et al*., 1997).

Results

Growth Parameters (LAI, CGR and TDM) were significantly different in all growth stages by sowing dates and genotypes during both periods of study. (Fig.1). There was significant decrease in all growth parameters seen with delayed sowing of mungbean from April 15th to 15th May. Early sown mungbean (1st April) took higher LAI from 45-60 days after sowing and after 60 days the trend declined in all the sowing dates. In case of LAI regarding sowing dates maximum LAI was given by the 1st of April sowing followed by 15th April and least LAI was shown by sowing of crop on 15th May. Variation in LAI found significant in all genotypes. In case of varieties

NIAB-Mung-2016 was ranked first for LAI followed by AZRI-2006 and the minimum was recorded by Bhawalpur-Mung-2017.The increase in LAI was recorded from 45 – 60 days after sowing and after 60 days the decreasing trend was seen in all the genotypes. Gradual changes in the raising trend of leaf area index with the passage of time are also indicated in the graph. Crop growth rate (CGR) (g m^{-2} d^{-1}) (Fig.2) is an index of crop dry matter accumulation per m^{-2} on per day basis. There was a steady increase in CGR up to 45 DAS but after that its rate of increasing was very fast till 60 DAS. A gradual reducing trend in case of CGR was noted after 60 DAS during both years. Among varieties highest CGR was shown by NIAB-Mung-2016 followed by AZRI-2006 and BWP-Mung-2017. Almost variation in CGR was noted in various sowing dates. Higher CGR was observed on 1st April sowing followed by 15th April and minimum CGR was shown in 15th May during both period of study.

Sowing dates and cultivars significantly influenced total dry matter production (TDM) (g m^{-2}) of mungbean during both periods of study for the year 2018 and 2019 (Fig 3). The highest total dry matter was produced from first sowing date followed by 15th April sowing date and the rest of the last two sowing dates did not show statistically significant differences during both periods of study. The sowing of crop on 1st April produced 30, 35 and 40% higher final total dry matter compared to the second, third, and fourth sowing dates, respectively. Thereafter, there was a remarkable increase in TDM was initiated from 30 DAS in all sowing dates and maximum TDM was recorded until 45-60 DAS in all sowing dates and after 60 DAS the dry matter production showed a declining trend. Among genotypes, there was significant differences between the three cultivars for total dry matter production were recorded. The greater total dry matter was noted in variety NIAB-MUNG-2016 followed by AZRI-MUNG-2006 from 45 DAS to 60 DAS during the both years and after 60 DAS the decreasing trend in TDM was noted in all the genotypes.

Relative water content has good relation to the leaf and determined the amount of water is present in the leaf due to different environmental stresses. High temperature stress is one of the major abiotic stresses that have adversely effects on plant water status in the leaf. The data regarding relative water content differed significantly among genotypes and date of sowing for the year, 2018 and 2019 but result of genotypes for the first year was observed non-significant. However non-significant variation was found in case of interaction during both years of study (Table 1). The higher relative water content (72.96%) was recorded on 1st of April sowing which was statistically at par with sowing of crop on 15th of April. The least relative water content

(63.32%) was seen on 15th of May. The significant variation in genotypes and planting dates were noted during the year, 2019. The maximum relative water content (67.12%) was found by first of April sowing which was statistically at par with sowing of crop on 15th April and 1st May that produced 65.05% and 63.09% relative water content. The relative water content in the leaves decreased for delayed sowing because rate of transpiration increased due to higher temperature. The lower relative water content (61.36%) was showed by fifteen of May sowing. The higher and lower relative water content (66.78%) and (60.85%) was recorded by NM-2016 and BWP-Mung-2017 among different genotypes.

The result mentioned in the (Table 1) investigated the effect of sowing date and varieties on relative stress injury found to be highly significant during the both years 2018 and 2019. However, interaction effects were non-significant during both periods of study. The maximum relative stress injury (37.34%) was found in late sown crop when the crop was sown on 15th May which was statistically at par with 1st May that produced (34.47%) relative stress injury during the year, 2018. The lowest value of relative stress injury (28.46%) was noted when the crop was sown on 1st April. Among genotypes, the variety Bahawalpur Mung-2017 produced the highest (38.61%) followed by variety AZRI-Mung-2006 which produced (34.30%) relative stress injury. The lowest (26.76%) relative stress injury was noted by variety NM-2016 during the period 2018, respectively. During the second year (Table 1), greater relative stress injury (35.05%) was found in the delayed sowing of 15th May and followed by sowing date 1st May gave (31.35%) relative stress injury. The lowest value of relative stress injury (25.66%) was recorded when the crop was sown on 1st April. Among genotypes, the variety Bahawalpur Mung-2017 produced the highest (32.96%) followed by variety AZRI-Mung-2006 which produced (30.37%) of relative stress injury. The minimum (27.37%) relative stress injury was seen by variety NM-2016.

Discussion:

Leaf area index is measure of photosynthetic area of crop canopy which is also an indicator of crop growth stage or biomass accumulation. The possible reason for significant difference of leaf area index due to sowing dates manipulation might be favorable growth conditions and increased leaf length and width in case of early sowing. In case of varieties, it may be due to in built genetic difference of each variety and leaf senescence. The finding of current study are similar to that of Ali *et al*. (2021) who found that LAI was greater in early sowing dates as compared to delay in sowing LAI was also reduced. These results are in line with the findings of Islam and Razzaque,

(2010) in which the highest leaf area was produced by variety due to their genetic variability. Higher crop growth rate with early sown crop might be due to accumulation of maximum amount of dry matter production with harvesting of more sun shine hours along with suitable temperature. Effect of sowing date and varieties on CGR was significant and similar to the findings of Sadeghipour and Aghaei, (2012). Normal sowing of 30th March produced maximum relative water in leaf due to suitable temperature at the time of leaf development as compared to late planting in case of sowing dates Kaur *et al*. (2015). Similar trend was seen by Kumar *et al.* (2013). The membrane damage increased due to increasing temperature in late sown mungbean as compared to early sown mungbean genotypes (Wahid *et al*., 2007; Hasanuzzaman *et al*., 2013). Elevated temperature in late sowing increased the membrane damaged percentage due to severe effect of heat stress (Sharma *et al*., 2016).

Conclusion:

Keeping in view the above mentioned outcomes of study it was concluded that suggest that sowing mungbean earlier in the season, particularly around 1st April, can significantly enhance growth and avoid the heat stress indicated by better leaf relative water contents and less membrane damage. This may improve the production of farmer and his life style.

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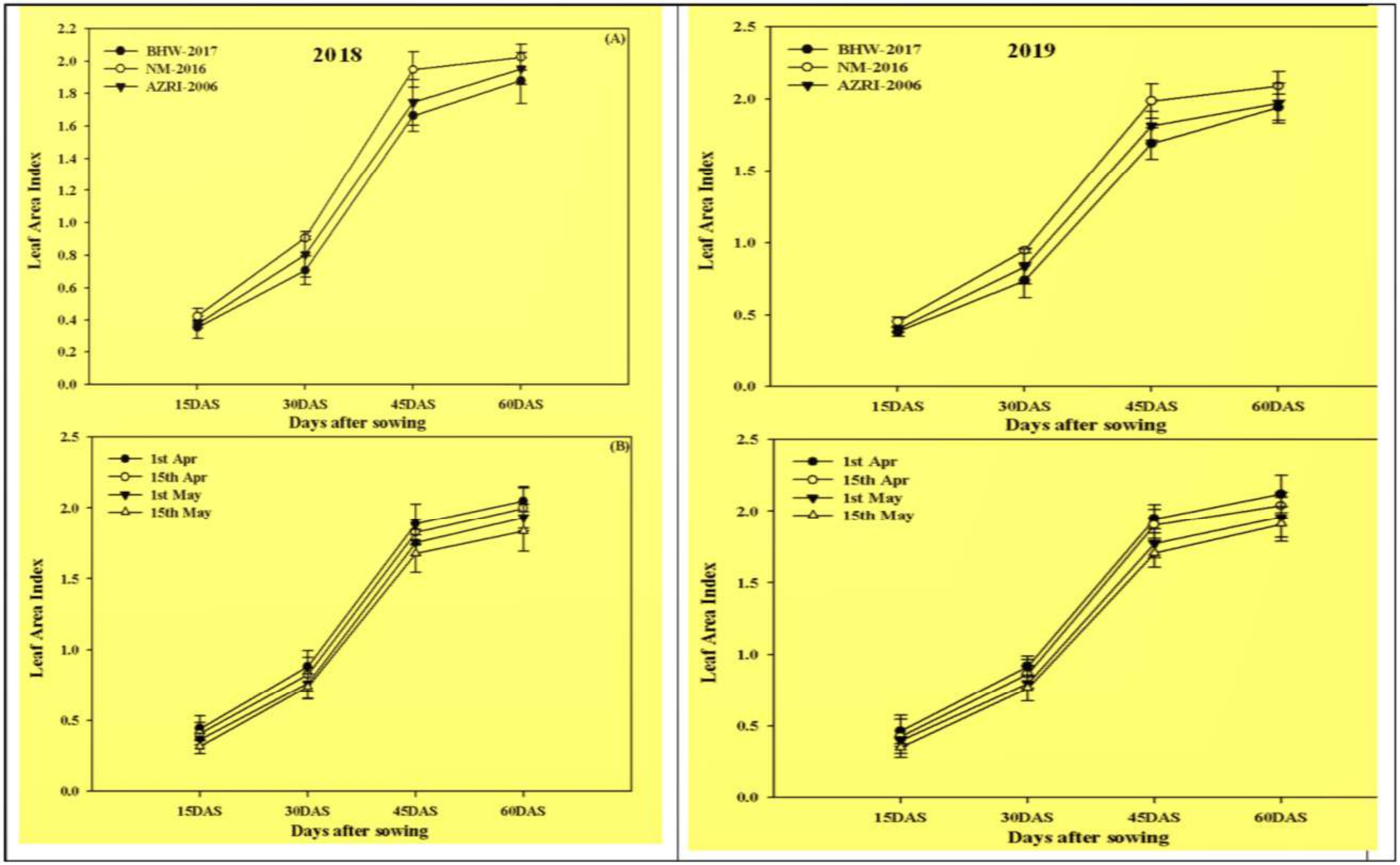

Figure 1: Leaf area index influenced by date of sowing and genotypes during 2018 (a, b) and 2019 (a, b).

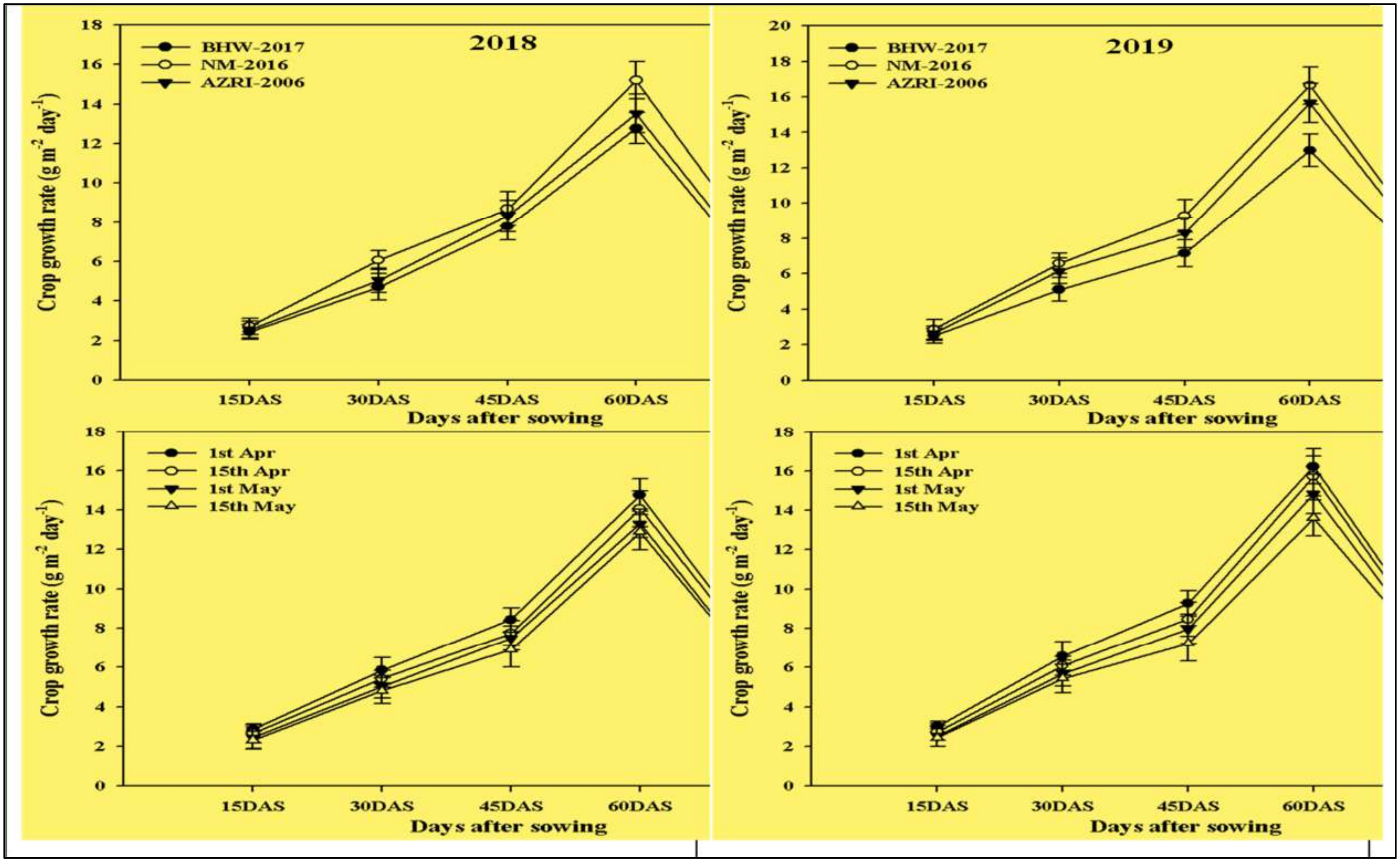

Figure 2: Crop Growth Rate influenced by date of sowing and genotypes during 2018 (a, b) and 2019 (a, b)

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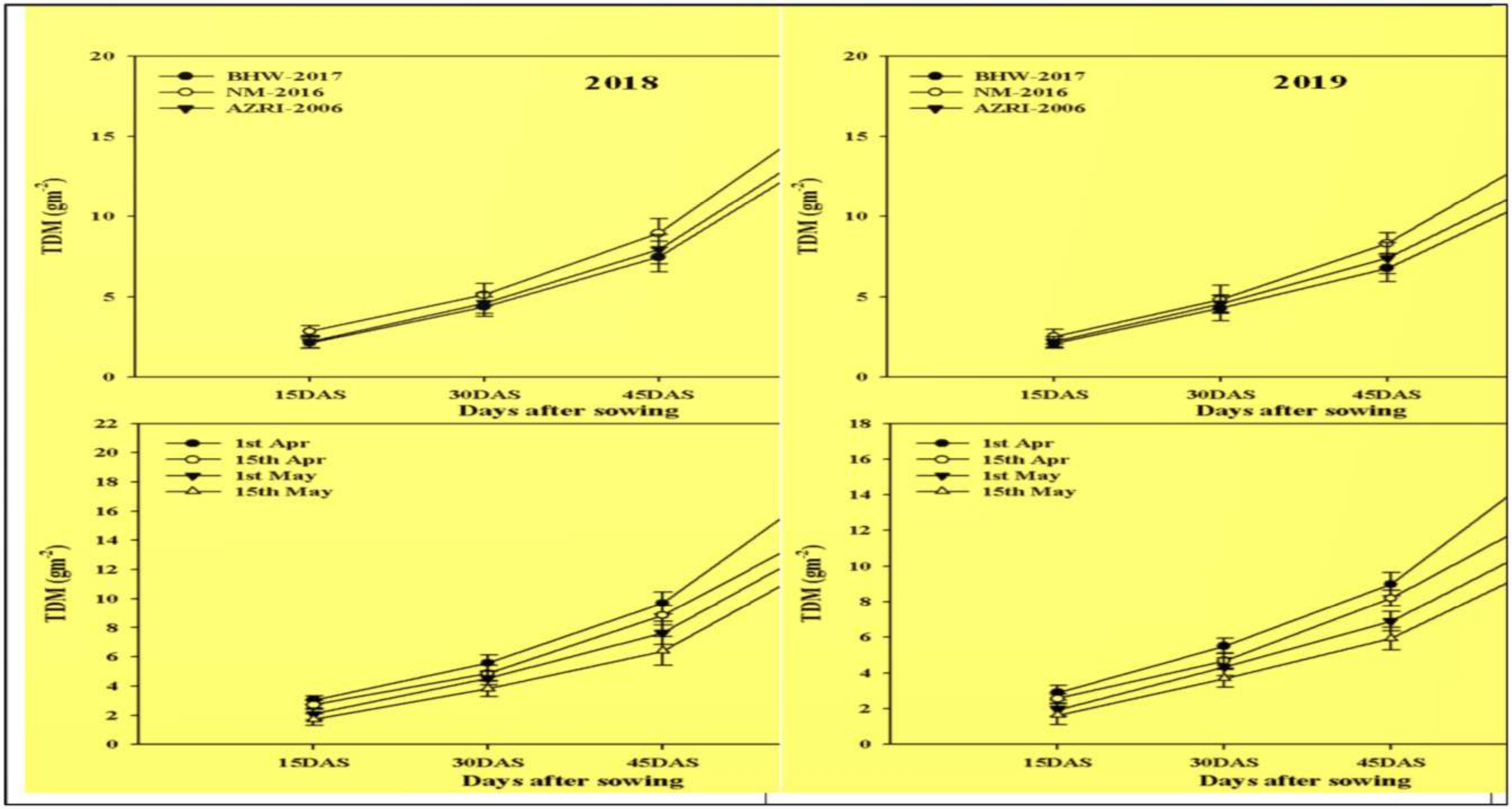

Figure 3: Total Dry Matter (TDM) influenced by date of sowing and genotypes during 2018 (a, b) 2019 (a, b).

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Table 1: Leaf Relative Water Contents and Relative Stress Injury of different mungbean genotypes under different sowing dates during 2018 and 2019

Treatment	RWC (%)		RSI (%)	
Sowing Dates	**2018**	**2019**	**2018**	**2019**
1st April	72.96a	67.12a	28.46c	25.66c
15th April	70.02ab	65.05ab	32.62b	28.86b
1st May	67.40bc	63.09ab	34.47ab	31.35b
15th May	63.32c	61.36b	37.34a	35.05a
SEm±	**1.66**	**1.32**	**1.15**	**0.93**
HSD at 5 %	**4.69**	**4.44**	**3.26**	**2.64**
Genotypes				
BWP-2017	67.20	60.85b	38.61a	32.96a
NM-2016	69.94	66.78a	26.76c	27.37c
AZRI-2006	68.13	64.83ab	34.30b	30.37b
SEm±	**1.11**	**1.04**	**0.89**	**0.40**
HSD at 5 %	**NS**	**5.89**	**3.20**	**1.41**
Interaction	**NS**	**NS**	**NS**	**NS**

*Means not sharing a letter in common differ significantly at ($p \leq 0.05$).