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Mungbean: A New Alternative Crop for Kansas Farmers

Natalia da Silva Volpato
Kansas State University

Claire Bott
Kansas State University

Victor Gimenez
Kansas State University

See next page for additional authors

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Mungbean: A New Alternative Crop for Kansas Farmers

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Authors

Natalia da Silva Volpato, Claire Bott, Victor Gimenez, Ana Julia Paula Carcedo, and Ignacio A. Ciampitti

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N.S. Volpato, C. Bott, V. Gimenez, A.J.P. Carcedo, and I.A. Ciampitti

Summary

Over the last two decades, mungbean demand has significantly increased worldwide and in the United States (US), driving production increases. This crop is primarily used for human consumption due to its high content of protein. However, the factors causing yield variability are not widely known. Therefore, the objective of this study is to determine the critical period for seed yield in mungbean crops. A field experiment was conducted using shading treatments at different periods throughout the crop cycle to investigate the effects of plant stress at different stages. The critical period for seed yield determination seems to be concentrated during the R1 through R4 growth stages (flowering until the end of grain filling). Changes in the number of seeds per unit area and seed weight were correlated with the crop growth rate during the critical period for yield determination.

Introduction

Mungbean [*Vigna radiata* (L. Wilczek)] is a short-season legume known for its high tolerance to heat and drought stress. Valued for its protein content (~23% protein; Akpapunam, 1996), mung bean seeds are a staple food in Asia. The increasing global demand along with market price promoted its commercial production, positioning mungbean as a profitable legume crop in cereal rotation farming systems (Keatinge et al., 2011). In Kansas, where continuous winter wheat is the dominant farming system, one strategy for diversification is adding mungbean as a summer crop option. This crop is well-suited for double cropping due to its short growing cycle length, thriving in the challenging conditions of a short growing season, especially during the hot and dry months of July and August. Despite its adaptability, mungbean yields are highly variable across locations and seasons (Kaur et al., 2015; Patriyawaty et al., 2018), and the factors causing this variability are poorly understood. Based on this rationale, the aims of this study were 1) to define the critical period for seed yield, and 2) to identify which yield components were more sensitive to changes in incident radiation during the stress period.

Procedures

Field Experiments

In the 2023 season, a mungbean trial was established at Kansas State University in the Experiment Field at Manhattan (39°12'22" N, 96°35'38" W) on a silty clay loam soil (Figure 1). Initial soil analyses a week before sowing are described in Table 1.

The experiment was arranged as a completely randomized design with four replications. Plot length was set to 15 feet long by 5 feet wide with four rows and 15 inches of inter-row spacing. The variety Jade-AU, widely grown in Australia, was sown at two planting dates (June 5 and July 3) and plant density was 120,000 plants per acre. All the plots were fertilized using a rate of 65 lb/a of urea (46-0-0). The crop was maintained without water limitation through the application of irrigation during the crop cycle and plots were hand-weeded to control the weeds.

To investigate the effects of plant stress at different times of the crop's growing cycle, shading treatments were installed in different moments of mungbean phenology (VE, V3, V4, V7, V8, R1, R4, and R7) (GRDC, 2017). Black nylon nets were placed 7.87 inches above the top of the canopy, reducing incident radiation by about 90% during the treatment. The shading was kept for two weeks in each treatment. Detailed tracking of the phenology was done in the control plots once a week, in the fourth row of the plot. Five consecutive plants were marked to account for leaf number and tracking of leaf appearance rate, flowering, and physiological maturity date.

After physiological maturity (R7), 3.3 ft of the two central rows of the plot were sampled to determine total biomass and grain yield. Biomass was separated into pods and vegetative biomass (i.e., stems + leaves). After counting the number of pods, biomass was oven-dried at 140°F or 72 h and weighed. To estimate seed yield per unit area, pods were hand-threshed, and seeds were weighed. The seed weight was estimated in a sub-sample of 200 seeds. The seed number was estimated as the ratio between yield and seed weight. Seed number per pod was estimated as the ratio between the seed number and the number of pods.

Statistical Analysis

To analyze the effect of stress on seed yield and yield components, mixed effect models were fitted with the lme4 (Bates et al., 2015) package in R software (R Core Team, 2023) and then analyzed employing analysis of variance and Tukey's test with a significance level set at $\alpha = 0.05$. Treatment was set as a fixed effect factor, while block was included as a random effect.

Results

The mean seed yield for both planting dates across control treatments was approximately 1000 lb/a. Planting dates did not modify seed yield, vegetative biomass, or yield components.

The critical period for seed yield, pod number, seed number, and seed weight determination tended to be during flowering through the end of grain-filling (Figure 2). Grain yield and grain number presented a larger critical period (V8-R6) compared to seed weight, which concentrated in R4 (Figure 2A, B, and D).

Seed yield in shading reproductive treatments was 375 lb/a, 63% less than the control (Figure 3A). This decrease aligns with the reduction in seed number (~55%) and to a lesser extent the reduction in grain weight (~10%) (Figure 3C, D). Aboveground biomass was not significantly affected by the stress treatments either during the vegetative period or in the reproductive stages (Figure 3B).

Conclusion

This study indicates that the reproductive stages (R1 through R4) are the most susceptible to yield losses leading to reductions of up to 63%. Notably, stresses occurring before the reproductive stages did not significantly impact the final seed yields. The decline in seed yield was mainly driven by a reduction in the number of seeds per unit of area. Furthermore, aboveground biomass was not reduced by the stress treatments. These findings offer valuable insights for management decisions such as choosing planting dates. This implies aligning periods with a lower frequency of stressful conditions (e.g. heat or drought) with the reproductive phases to avoid yield penalties.

Acknowledgments

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Table 1. Soil characterization of the mung bean experiment carried out in Manhattan, KS, in 2023

Depth	pH	OM	P	K	Ca	Sand	Silt	Clay	N-NO ₃	N-NH ₄ ⁺
inches		%	ppm	ppm	ppm	%	%	%	ppm	ppm
0–8	6.8	2.9	11	254	3470	12	47	41	15	17.6
0–24	---	---	13	304	3687	---	---	---	12.5	18.3

OM = organic matter.



Figure 1. Mung bean developmental stages at the field trial. Plant height ranges from 24–30 inches.

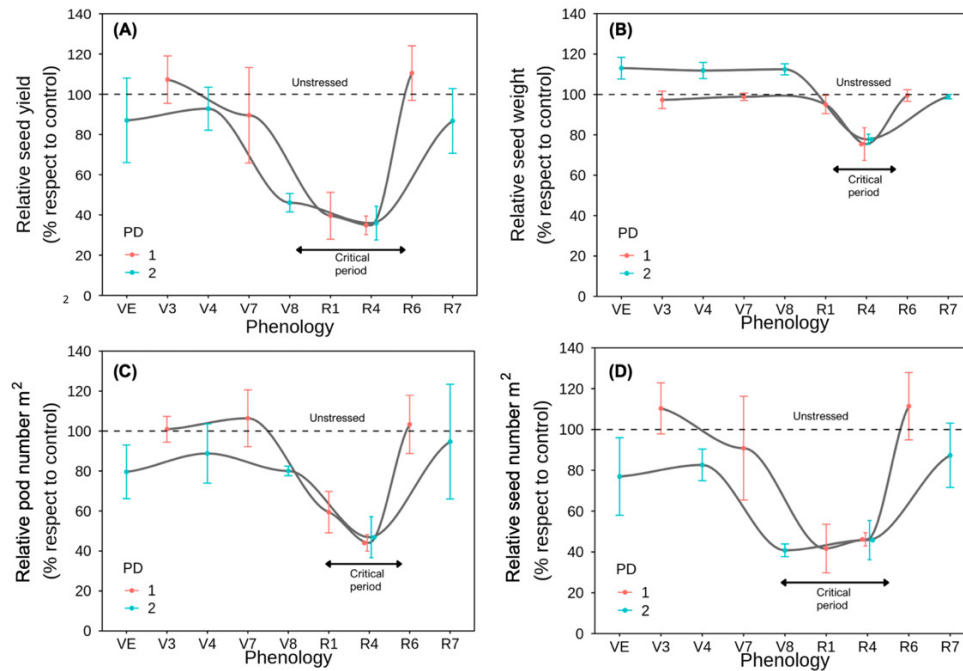


Figure 2. Seed yield (panel A), seed weight (panel B), pod number per unit area (panel C), and seed number per unit area (panel D) relative to control unshaded treatment. The horizontal arrows show the critical period.

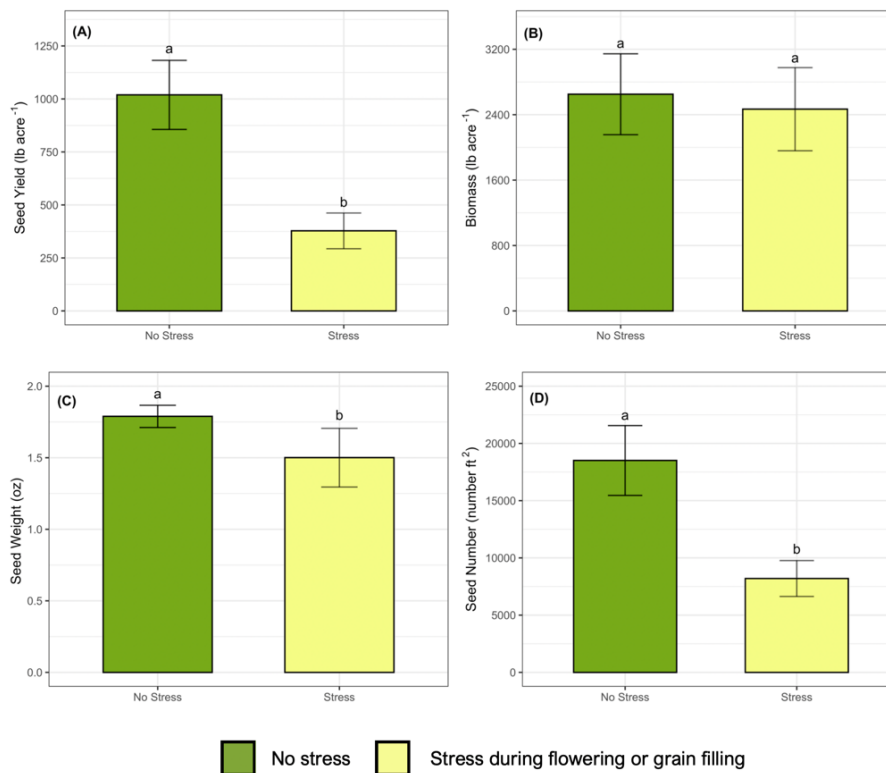


Figure 3. The effect of stress during flowering and grain filling on mung bean seed yield, seed weight, seed number, and plant biomass. Different letters stand for significant differences among groups.