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Mung Bean Plant Growth and Development Stability Analysis in Bloemfontein District of Free State, South Africa

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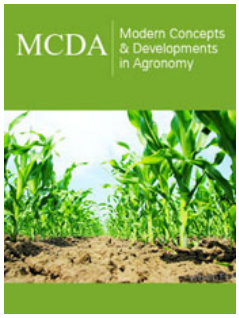

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Abstract

Mungbean is a highly nutritious, versatile pulse crop that is primarily grown for human consumption and green manuring in regions such as East Africa, South Asia and Australia. However, the plant-environmental interactions in other regions have not been thoroughly evaluated. Plant-soil interaction and growth stability of mungbean evaluated in Bloemfontein district of Free State, South Africa. The experiment was conducted during the summer season, which had predicted seasonal rainfall and optimal air temperature for mungbean germination, plant growth, and development, over two consecutive years. Yield and yield contributing traits; grain yield plant^{-1}, plant height, number of branches plant^{-1}, number of pods plant^{-1}, pod length and number of seeds pod^{-1} were evaluated. Data analysis using a T-test revealed no significant relationship between two years of evaluation for plant growth and yield contributing traits. Despite these findings, the foreign mungbean germplasm requires further evaluation to determine its maximum yield potential and stability. Additionally, data on plant-pest and -disease interactions will be necessary to ensure sustained plant growth and future cultivation.

Keywords: Adaptation; Crop performance; Dryland cultivation; Ecophysiology; Yield sustainability

Introduction

Mungbean [*Vigna radiata (L.) Wilczek*] is a high nutritional, short duration and warm season crop widely cultivated in Asia, Australia and East Africa [1]. It is an affordable source of protein (14.6-33%) and is rich in iron (40-70ppm), calcium, zinc and carotenoids [2,3]. Its dietary fiber, vitamins A and B, minerals and bioactive compounds including anti-melanocyte, anti-angiotensin, antioxidant, anti-diabetic and anticancer activities have recently increased nutritional importance [4]. Mungbean seeds, known for their high protein content and easy digestibility, are used in soups and sprout salads, while green pods serve as vegetables [5] and livestock feed [6]. Legume crops play an essential role in human nutrition and soil fertility through biological nitrogen fixation [7]. Mungbean, a low-requirement crop with a short growth duration (60-90 days), thrives in arid and semi-arid agroclimatic zones [8]. Mungbean-winter wheat cropping is more efficient than soybean-wheat cropping [9], improving soil texture by adding organic carbon soil and nitrogen storage. Maize-mungbean intercropping increases land use efficiency by 48-68% [10] and enhances yields by 44.7% [11] compared to monocropping. It also serves as green manure, adding 7257-19050kg of organic matter hectare-1 [6]. It grows well in hot and humid weather with optimal air temperatures of 298.15-308.15K and low water requirements under rainfed conditions (400-550mm) [12]. Its growth and maturity depend on air temperature, moisture and day length and it thrives in sandy loam soil with good internal drainage. However, waterlogging and flooding severely affect its growth and development [13].

Mungbean introduced in Australia in the 1930s, was cultivated for green manure and grain harvest, supporting sustainable and profitable farming [14]. As a cover crop, it reduces

pest infestation cycles when used in crop rotation or intercropping [13]. Its wide adaptability makes it tolerate environmental stressors, evaluated in south-eastern Queensland [15]. Chen et al. [16] identified the wide adaptability of mungbean cultivars in southern Guangxi and similar ecological environments. The Bloemfontein district, with average air temperatures ranging from 288.15-307.15K and monthly rainfall of approximately 65mm during the summer season, is suitable for mungbean cultivation. Its surrounding region is well-sorted with fine sandy loam and loamy fine sand making it suitable for mungbean cultivation [17]. Evidence suggests that mungbean is cultivated in the Mpumalanga and Limpopo provinces of South Africa (SA, Department of Agriculture, Forestry and Fisheries, SA, Mungbean Brochure 2014). However, no research evidence or cultivar names have been reported for these regions and previously there is no report of mungbean cultivation in the Free State province. The Free State province could be ideal for mungbean cultivation, either as a monocropping or intercropping with maize during the summer season from November to February, in rainfed areas with air temperatures between 298.15-308.15K and optimal rainfall [18]. Seasonal rainfall in November-March ranges from 251 to 600mm in northern, eastern and western Free State provinces is sufficient for mungbean cultivation [19]. The study hypothesized that mungbean plant growth and development will exhibit significant variation when cultivated in the Bloemfontein district of the Free State, SA, with potential changes in germination, plant yield and yield contributing traits. These factors may be influenced by either air temperature, precipitation pattern or soil moisture leading to positive or negative impacts.

Materials and Methods

To evaluate mungbean plant growth and development, experiments were conducted in the agricultural research field of the University of the Free State, Bloemfontein. No known mungbean cultivar seeds are available in SA. However, imported mungbean seed intended for edible purposes, with unspecified countries of origin, was used to test seed germination, plant growth and development. The germination test was repeated the following year using previously harvested seeds to assess growth stability. The study site is in a semiarid agroecological zone with well drained, red-brown, sandy loam and moderately acidic soil with pH 5.2 up to 0.3m depth. The soil had a clay, silt and sand fraction of 8.5%, 7% and 85% respectively, soil texture analyzed by [20] during 2019-2020 in same experiment site. Furthermore, they reported that soil sample of kg^{-1} contain 1.03×10^{-5}kg of $NH^{4-}N$, 1.12×10^{-5}kg of $NO^{3-}N$, 7.0×10^{-5}kg of phosphorous, 2.2×10^{-5}kg of sodium, 1.42×10^{-4}kg of potassium, 3.36×10^{-4}kg of calcium and 1.0×10^{-4}kg of magnesium up to depth of 0.3m. The experiment was conducted in three repeats, each measuring 1m×3m. Mungbean seeds were planted in three rows $plot^{-1}$, with row spacing of 0.25m and plant spacing of 0.10m, maintained by thinning. The plants were grown under rainfed conditions without any fertilization, although tillage operations were performed six weeks after snowing. Data for yield-contributing traits and plant grain yield like the number of seeds pod^{-1}, number of pods $plant^{-1}$, pod length, number of branches $plant^{-1}$, and plant height were collected to evaluate the agroecological interaction and plant growth stability.

Results and Discussion

The data collected for yield and yield-contributing traits from 2020 and 2021 were analyzed to evaluate plant growth stability and plant-environment interaction. The data were analyzed using PROC-GLM SAS 9.4 (SA Institute, 1989) linear model to perform student's T-test and correlation analysis performed between two years of cultivation. The research findings indicated that mungbean performs well in Bloemfontein summer season in rainfed areas (Figure 1 & 2). Plant yield and yield contributing traits did not show significant differences in two years of plantation (Table 1). Parallel findings have been reported by Mbeyagala et al. [21], where they introduced mungbean cultivars to the different climatic regions of Uganda and found three best-performing foreign verities in two climatic zones. They reported mungbean can perform well in air temperatures ranging from 290.55-302.95K and rainfall ranging from 391 to 547mm. Likewise, Islam et al. [22] reported that BMX-010015 variety showed yield and yield contributing traits stability, and water deficient tolerance making it widely adaptable in Bangladesh. The number of pods $plant^{-1}$ and yield $plant^{-1}$ (Figure 3) were higher in the second year of evaluation signifying its adaptability. Furthermore, correlation analysis of mungbean yield and yield contributing traits showed a highly positive correlation (r=0.988) from 2021 to 2022. The current research findings align with Wang et al. [23], who reported sustainable yield performance of the mungbean cultivar $Zhonglv^{-5}$ over two cropping years in eastern Inner Mongolia. Statistical analysis indicated that mungbean can grow successfully in Bloemfontein, Free State province, SA [24]. However, foreign mungbean germplasm needs to be evaluated in the Free State, SA to assess yield stability and plant-soil interaction. Additionally, studies on nitrogen fixation and intercropping efficiency are required [25]. It is also necessary to investigate insect pests and disease resistance in these new environments. Moreover, germplasm should be evaluated for optimal growth conditions and showing times in the Free State, SA.

Table 1: T-test analysis for mungbean yield and yield contributing traits of two-year data at 5.0% significance.

	Number of Seeds Pod^{-1}	Number of Pods $Plant^{-1}$	Pod Length (m)	Number of Branches $Plant^{-1}$	Plant Height (m)	Yield $Plant^{1}$ (kg)
T-test p-values	$0.1839^{n.s}$	$0.1893^{n.s}$	$0.2388^{n.s}$	$0.4210^{n.s}$	$0.4630^{n.s}$	$0.3621^{n.s}$

n=15, p>0.05=nonsignificant (n.s), p=probability, data collected from two years of evaluation 2021 and 2022.

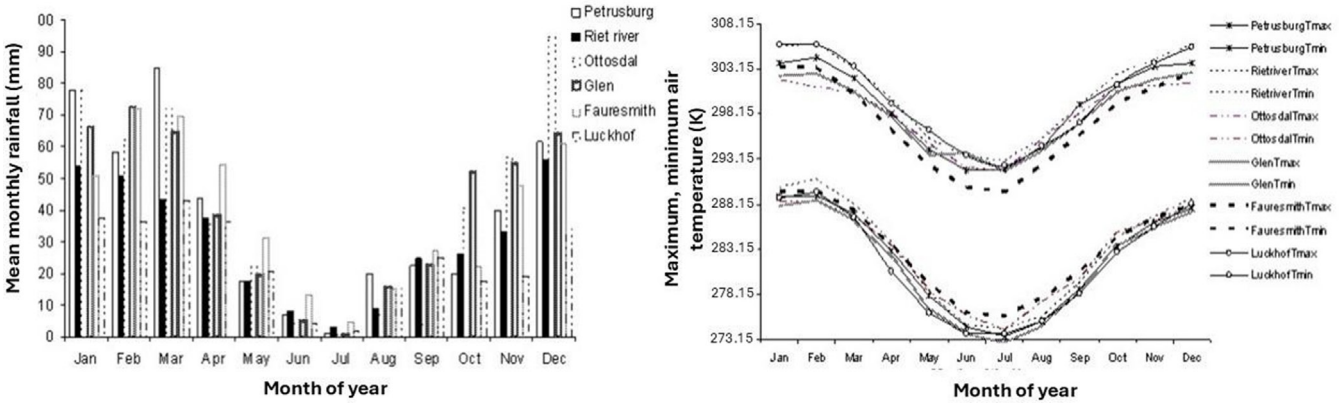

Figure 1: Monthly rainfall and average air temperature in the free state, South Africa (Gugulethu et al. [24]).

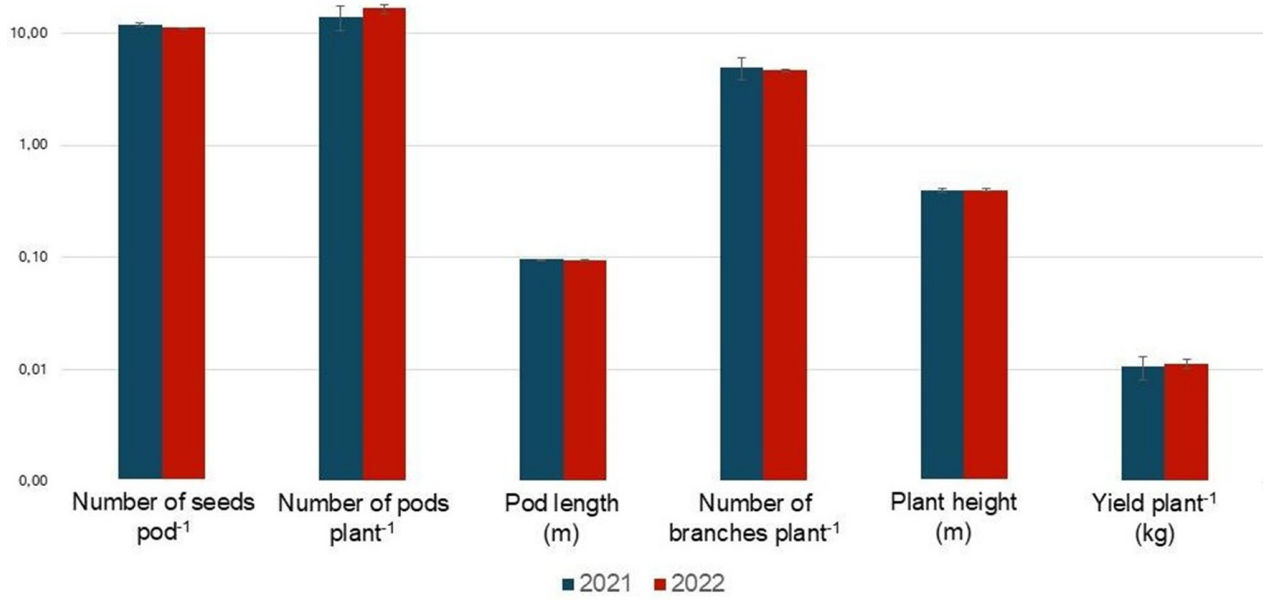

Figure 2: Plant yield and yield contributing traits of mungbean agroclimatology evaluation in 2021 and 2022 in Bloemfontein district of Free State, South Africa, Mean values ± standard error.

Figure 3: Mungbean plant growth and pod formation in two years of evaluation in Bloemfontein district of the Free State, South Africa. (a)=March 2021, (b)=January 2020.

Conclusion

The two-year study demonstrated that mungbean performs consistently in the rainfed areas of Bloemfontein, Free State. While no significant differences were observed in yield between the years, further evaluation of foreign germplasm is required to ensure long-term stability. Future studies should also address pest and disease resistance for broader cultivation.

Author contributions

Huzaifa Bial conceptualized and designed the experiment, collected data and wrote the first draft. Acknowledgements: I would like to acknowledge Dr Weldemichael Tesfuhuney, Department of Soil, Crop and Climate Science, University of the Free State, Bloemfontein, South Africa for the use of facilities.

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