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Morphometric traits and proximate analysis of ten accessions of Mung Bean (*Vigna radiata* [L.] Wilczek)

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Abstract

Diets in Africa feature various types of beans, with Mung beans being one variety that has minimal data regarding its nutritional makeup. The Mung bean samples examined in this research have not been assessed for morphological and nutritional composition in earlier research efforts. The experiment was arranged utilizing a randomized complete block design (RCBD) with three repetitions at the Teaching and Research Farm of the Federal University Oye-Ekiti. Mung bean seeds were planted to a depth of 2 to 2.5 centimeters with a spacing of 0.5 meters on raised beds. The basic composition was analyzed following the procedures established by the Association of Official Agricultural Chemists. The dried powdered sample of the accessions of Mung bean were homogenized and stored in deep freezer (-18ºC) and used for proximate analysis. PROC GLM procedure in SAS was used for the determination of variability among the Mung bean accessions and their means were separated using Tukey HSD. Average performance across the 10 accessions displayed notable ($p \leq 0.01$ and 0.05) variations. TVr-10 had the highest number of leaflets ranging from 51.61-42.43, TVr-49 had the highest leaf length ranging from 13.22-11.05 mm, TVr-19 had the highest leaf width ranges from 11.44-8.51 mm, TVr-100 had the highest 100-seed weight ranging from 5.69 - 2.66 g and protein content ranges between 18-25% with the highest (24.74 %) from Tvr-43. This research demonstrated that there was considerable difference among the 10 Mung bean accessions examined in this study and will be a veritable tool in future breeding programme.

Keywords: Accessions, morphometric, variability, Vigna radiata, and proximate composition

Introduction

Mung bean, also called green gram, is a plant that mainly reproduces by itself. It is part of the Ceratotrops group and belongs to the Fabaceae family. Mung beans have two sets of chromosomes, totaling 22. Their genome size is between 494 and 579 million base pairs. Mung bean is the third most important legume crop after chickpeas and pigeon peas because it offers a cheap source of protein for eating [1]. Mung beans originate from India or the Indo-Burma area, as well as the Central Asian region, which serves as the main hub of genetic variety due to the wide range of both cultivated and wild species present. In addition, they are grown in various agricultural climates and soil varieties across nations such as China, Thailand, the Philippines, Indonesia, Myanmar, Nigeria, and other warm, arid areas of Southern Europe and the Southern United States [2]. Mung bean grain contains 51% of carbohydrate, 26% of protein, 10% moisture, 4% mineral and 3% Vitamin. The amino acid profile of Mung bean (in g/16g N) complements the amino acid profiles of cereal grains with a composition of lysine (7), cystiene (0.6), methionine (1), threonine (3.5) and tryptophan (0.4) [3]. Mung bean is a versatile plant that serves several purposes as it is important for the nourishment of small-scale farmers and families in Nigeria. Additionally, it holds the capability to contribute to the nation's foreign exchange earnings by being exported to regions such as Asia and Europe [4].

Mung bean is acknowledged for its abundance of vital nutrients that can assist in broadening dietary options and reducing malnutrition in impoverished rural populations. This is attributed to its significant carbohydrate content of 55%-65% (approximately 630 g/kg of dry weight), along with being high in protein, fats, and micronutrients [5]. In terms of nutrition, Mung bean consists of roughly 20% to 50% protein based on its total dry weight [6, 7], with a higher concentration of sulfur-containing amino acids, although it has less lysine when compared to chickpeas and horse gram [8]. Compared to other grains, Mung bean has fewer calories, making it appealing for individuals who are overweight or have diabetes. Additionally, it contains carbohydrates that are easy to digest, resulting in less gas and hypoallergenic effects, particularly in children, compared to other legumes that are not as commonly used. Mung bean is often called the "poor man's meat" as it provides a valuable source of easily digestible proteins for vegetarians at an affordable price [1, 5, 7].

Genetic diversity is essential for any breeding initiative, as it allows plant breeders to choose genotypes with high yields. Data on morphometric characteristics, yield, and its different elements serve as the foundation for selecting enhanced varieties [9]. The analysis demystifying the relationship among these traits and their association with seed yield is essential to establish selection criteria [10].

Insufficient consumption of proteins, vitamins, and various micronutrients has significantly impacted individuals in underdeveloped nations [11]. Numerous healthcare organizations have advocated for the adoption of plant-oriented diets to combat malnutrition and enhance overall health. Consequently, a diverse array of nutritious plant-based foods has been integrated into health programmes [12]. Among these options, Mung bean (*Vigna radiata* L.) is widely recognized for its health advantages. It serves as an important plant-based nutritional resource and is noted for its detoxifying effects [5]. Furthermore, it aids in managing a variety of illnesses, including enhancing mental well-being and alleviating heat-related illnesses [11, 13].

Even though Mung bean has significant nutritional benefits and economic value, the average production yield still poses a critical challenge that requires prompt action. In India, the cultivated area of Mung bean spans 3.7 million hectares, producing an average yield of 406.98 Kg per hectare, which is inadequate for the nation's needs [14]. This shortfall may stem from a lack of genetic diversity in the existing cultivars, excessive growth of vegetative parts, limited disease resistance, and the unavailability of superior varieties. It is essential for breeders to focus on the ongoing assessment of Mung bean accessions and the nutritional analysis to develop high-yielding varieties that can satisfy the demands of the growing population. The nutritional quality and composition of Mung bean are crucial for both human consumption and animal feed. At present, research efforts concerning the evaluation of Mung bean accessions in both national and international gene banks are scarce, and there is limited information regarding the nutritional components and dietary values of various widely cultivated Mung bean strains in Nigeria.

Nevertheless, various studies have documented the close composition of Mung beans across different varieties [15]. This composition is affected by both genetic and environmental variables. Thus, it is essential to examine additional varieties to pinpoint those with higher yields and evaluate their nutritional value. This study aimed to evaluate ten accessions of Mung bean and analyze proximate composition.

Materials and Methods

Plant Materials

The Mung bean accessions (Table 1) used in the study were procured from Genetic Resource Centre, International Institute of Tropical Agriculture (IITA) Ibadan. The seeds were checked for their uniformity and surface sterilized with 0.5% NaCl solution for 12 minutes before planting.

Study area

The study took place at the Teaching and Research Farm, part of the Department of Crop Science and Horticulture, situated at the Federal University Oye-Ekiti, Ikole Campus, in Ekiti State, Nigeria. The location is positioned at a longitude of 7^{0}N $48^{1}.550^{11}$ and a latitude of 005^{0}E$29^{1}.788^{11}$. The area where the experiment was conducted experiences a bimodal rainfall distribution, with yearly precipitation totaling 1000 mm and an average temperature of 28 degrees Celsius.

Experimental design

The field was manually cleared and seed beds prepared in June 2023/2024 on an open field during the cropping season. The field design was a Randomize Complete Block Design (RCBD) with three replications. The seed of Mung bean was sown carefully in a continuous seeding to a depth of 2.0 - 2.5 cm with a spacing of 0.5 m in a full plot size of 9.5 m x 11.5 m. The spacing between two replica block was kept at 1 m. The spacing between individual plants was kept at 6-8 cm, and between every row was kept at 1 m to properly facilitate intercultural and data collection operations. Two seeds were placed in each planting hole, and all additional farming practices like weeding and fertilizing were carried out to maintain a clear and thriving field. The control of aphids, thrips, and other pests was achieved using cypermethrin 5% emulsifiable concentrate (20 ml combined with water in a 20-liter backpack sprayer) at 25 days post-sowing. This treatment was administered every 7 days.

Data collection

Ten variables observed for the characterization were considered (Table 1). The descriptor developed by the National Plant Genetic Resources Laboratory in 2018 for Mung bean [16] was used for this study.

Table 1: List of descriptors observed

Descriptors	Code	Period of observation	Evaluation method
1. Plant height	PLH	Six weeks	measured with a "1m" meter rule from cotyledon scar to the tip of plant
2. Number of pods per plant	NPP	Fully developed green pod	counted number of pods per plant
3. Pod length	PL cm	Harvest maturity	length from point of pod attachment to the tip of the pod
4. Pod girth	PG cm	Harvest maturity	Measure around the same pods taken for length
5. Number of seeds per pods	NSP	Harvest maturity	counted number of seeds per pods
6. Leaf length	LL	Six weeks	length of leaf taken by meter rule
7. 100 seed weight	Hsdw g	Matured seeds	seeds were counted and weighed using a digital electric weighing scale
8. Leaf width	LW	Six weeks	length of the widest part of the same expanded terminal leaf measured for length
9. Chaff weight/ Shelling percentage	SHP	Harvest maturity	Shelling percentage was determined as the weight of Mung bean seed divided by the weight of the pod and multiplied by 100
10. Seed weight/plot	SW g	Matured seeds	The total weight of the Mung bean harvested from each plots.

Results

Analysis of Variance of morphological traits observed on 10 Mung bean accessions

Table 2 showed analysis of variance (ANOVA) on the observed quantitative traits of the Mung bean accessions used in the study. The findings showed that notable variations existed in the traits that were measured across the accessions. The findings pointed out significant variations in seven quantitative traits that were measured, such as weight of seeds, length of petioles, seed count per pod, weight of 100 seeds, width of leaflets, weight of chaff, and girth of pods. A high coefficient of variation (CV) suggested more diversity, which can be advantageous for evaluating genetic diversity or stability within a population during a breeding initiative, although some traits displayed low coefficients indicating less variability. Nine of the measured quantitative characteristics showed a low coefficient of variation (CV<20), with notable differences observed in leaf width, pod length, seeds per pod, pod circumference, seed mass, and weight of 100 seeds. Chaff weight (CHFWG) exhibited significant variation and recorded the highest CV (50.73%) among the studied quantitative characteristics. The variability in the number of seeds per pod was significantly different among the accessions (2.07), as was the weight of 100 seeds (2.09) at significance levels of 0.05 and 0.01, respectively. The coefficients of variation noted for several traits were as follows: weight of 100 seeds (17.19%), number of leaflets (16.29%), seed weight gain (14.53%), width of leaflets (14.00%), length of leaflets (10.82%), height of the plant (9.50%), overall plant growth rate (7.89%), and the length of petiole (6.67%).

Table 2: Mean square value of the analysis of variance for morphological characters in Mung bean accessions

SOV	df	PH (cm)	NL	LL	LW	PL	NSP	PG	SWG	CHFWG	100-seed wt.
Accession	9	40.60ns	22.32ns	1.67ns	3.13*	0.82*	2.07*	0.03*	394.69*	73.82*	2.09**
Replication	2	719.82***	1387.58***	13.94**	18.14**	0.04ns	0.06ns	0.02ns	2124.53**	353.77**	0.06ns
Error	18	44.91	61.66	1.79	2.11	0.35	0.8	0.02	211.17	34.83	0.44
%CV		9.5	16.29	10.82	14	6.67	6.29	7.89	14.53	50.73	17.19

SOV= Source of variation, df= degree of freedom, ns= non-significant, ***p<0.001; **p<0.01; *p<0.05; PH=Plant height, NL=Number of leaflets, LL=leaflets length, LW=leaflets width, PLCM=pod length cm, NSP=Number of seed per pod, PGCM=Pod girth in cm, SWG=seed weight in gram, CHFWG=Chaff weight g, HSWg=100-seed weight g.

Proximate analysis of Mung bean

Proximate composition analysis across ten distinct accessions of Mung bean within the investigation revealed significant differences among the accessions as presented in Table 3. Significantly, the proximate analysis results for all varieties exhibited noteworthy distinctions at P ≤ 0.001.

Table 3 Mean square values of the Analysis of variance for proximate composition of 10 accessions of Mung bean

SOV	Df	MC	PROTEIN	FAT	ASH	CRUDE FIBER	CARBOHYDRATE
Accession	9	0.77***	9.33***	8.28***	1.311***	1.86***	7.15***
Replication	2	0.001	0.003	0.025	0.002	0.001	0.001

SOV= Source of variation, df= degree of freedom, MC=Moisture content, ns= non-significant, ***p<0.001; **p<0.01; *p<0.05

Mean separation for the morphological characteristics of Mung bean

As shown in Table 4, the highest quantity of leaflets was found in Tvr-10 (51.61), with Tvr-6 (50.86), Tvr-49 (49.59), Tvr-145 (49.46), Tvr-46 (49.01), Tvr-70 (48.70), Tvr-19 (48.36), Tvr-100 (46.38), Tvr-48 (45.52), and Tvr-43 (42.43) following behind in numbers, where Tvr-43 had the lowest count. Likewise, Tvr-49 displayed the longest leaf length at 13.22 cm, while Tvr-43 recorded the shortest length at 11.05 cm. Among the samples examined, Tvr-19 had the widest leaf at 11.71 cm, and Tvr-43 was noted for having the narrowest width at 8.51 cm. The mung bean varieties with the most seeds per plant included Tvr-48 (15.49), Tvr-19 (15.45), and Tvr-43 (14.84). The variability analysis indicated that Tvr-46 and Tvr-100 exhibited the highest PGCM at 2.03, while Tvr-48 had the lowest PGCM at 1.85. Furthermore, according to Table 4, the maximum SGW was found in Tvr-100 (43.57 g), followed by Tvr-145 (32.03 g) and Tvr-6 (31.86 g), with Tvr-43 having the minimum SGW at 9.39 g. Additionally, CHFWG values spanned from 6.61 to 20.33, with Tvr-100 holding the highest CHFWG value, and Tvr-10 recording the lowest.

Table 4 Mean separation of morphological characters in 10 accessions of Mung bean

Accessions	NL	LL (mm)	LW (mm)	PL(cm)	NSP	PG (cm)	SGW/P (g)	CHFWG (g)	100-seed wt (g)
TVr-10	51.61a	12.73a	11.44a	8.44a	13.99ab	1.94ab	9.90b	6.61bc	3.57bc
TVr-6	50.86a	13.17a	10.84ab	9.37a	14.36ab	1.97ab	31.86ab	17.33ab	4.31b
TVr-49	49.59a	13.22a	11.16ab	8.66ab	13.25b	1.86ab	18.39ab	8.99abc	4.67b
TVr-145	49.46a	12.84a	10.32ab	9.37a	14.63ab	1.88ab	32.03ab	14.18abc	3.67bc
TVr-46	49.01a	12.32a	10.05ab	9.28a	13.85ab	2.03a	21.57ab	9.58abc	4.11b
TVr-70	48.70a	11.26a	9.14ab	7.79b	13.19b	1.72b	30.26ab	13.80abc	3.19bc
TVr-19	48.36a	12.02a	11.71a	8.64ab	15.45a	1.87ab	29.73ab	13.12abc	3.48bc
TVr-100	46.38a	12.80a	10.79ab	9.01a	13.62b	2.03a	43.57a	20.33a	5.69a
TVr-48	45.52a	12.35a	9.79ab	8.64ab	15.49a	1.85ab	14.95b	7.05bc	2.66c
TVr-43	42.43a	11.05a	8.51b	9.39a	14.84ab	1.89ab	7.12b	5.15c	3.49bc

Values with the same alphabet across the column are not significantly different at P≤0.05 Tukey HSD

Legend: PH=Plant height, NL=Number of leaflets, LL=leaflets length, LW=leaflets width, PLC=pod length, NSP=Number of seeds per pod, PGC=Pod girth in cm, SWG/P=seed weight per plot (g), CHFW=, 100-seed wt g=Hundred seed weight

Analysis of variance of the proximate composition in ten (10) accessions of Mung bean

Table 5 illustrates the average differences in the proximate makeup of 10 Mung bean varieties. Moisture levels varied between 8.56% (TVr-43) and 10.05% (TVr-19). There was a notable difference in protein levels among the varieties, with values ranging from 18.64% (TVr-19) to 24.74% (TVr-43). Fat content also displayed considerable differences, with TVr-100 reflecting the highest measurement at 12.16%, while TVr-49 showed the lowest at 6.69%. The ash content measured between 2.27% (TVr-145) and 4.05% (TVr-46). The highest amount of crude fiber was found in TVr-19 (6.42%), while the lowest was in TVr-100 (3.84%). Carbohydrate levels varied from 49.41% (TVr-43) to 54.26% (TVr-19). These findings underscore the significant differences in proximate composition among the 10 Mung bean varieties, suggesting possibilities for selection in breeding initiatives.

The greatest moisture level was noted in TVr-19 at 10.05, closely followed by TVr-145 at 10.04, then TVr-48 at 9.89, TVr-70 at 9.31, TVr-6 at 9.30, TVr-49 at 9.28, TVr-10 at 9.12, TVr-100 at 8.94, TVr-46 at 8.89, and finally TVr-43 at 8.56. This study disclosed that the protein levels in the Mung bean analyzed ranged between 18.64 and 24.74. The highest amount of protein was seen in TVr-43 at 24.74, while the lowest was found in TVr-19 at 18.64. Likewise, TVr-100 had the highest fat content at 12.16, trailed by TVr-145 at 9.21, TVr-43 at 8.49, TVr-70 at 7.84, with the lowest fat amount appearing in TVr-49 at 6.69. According to Table 5, the three accessions with the most ash content were TVr-46 at 4.05, TVr-19 at 4.00, and TVr-70 at 3.88. In contrast, TVr-145 showed the least ash content at 2.27. Among the varieties analyzed, TVr-19 exhibited the most crude fiber at 6.42, whereas the smallest quantity of crude fiber was observed in TVr-100 at 3.84. The study also indicated that the highest carbohydrate content was in TVr-19 at 54.26, followed by TVr-6 at 51.19, TVr-49 at 51.13, TVr-48 at 50.87, TVr-70 at 50.74, TVr-46 at 50.58, TVr-10 at 50.41, TVr-145 at 50.11, and TVr-43 at 49.41.

Discussion

The study is supported by the variation in a few of the detected features [18], he stated that Mung beans grown in India with well-irrigated soil showed notable diversity in their morphometric traits. Seed weight per plot, 100-seed weight and number of seed per plot was highest for Tvr-100. "This reiterates the findings of [19] who confirmed some Mung bean accessions as high yielding and their suitability for cultivation in agroecological zones in Southwestern Nigeria. [20] also reported that variation observed among the selected accessions is a tool for breeders in the development of new cultivar from genetically different background. [21] had also reported the use of evaluation of qualitative and quantitative traits in the development of new varieties of field pea. The evaluation of Mung bean varieties will help breeders determine which ones need enhancement and which should be eliminated. In a genuine sense of breeding, the eliminated varieties can contribute to developing missing characteristics in superior varieties. Analysis of ten Mung bean varieties indicated that the moisture levels varied between 8.89% and 10.05%, protein content ranged from 18.64% to 24.74%, fat was between 6.64% and 12.16%, ash content fell between 2.27% and 4.05%, crude fiber ranged from 3.84% to 6.42%, and carbohydrate content was between 48.21% and 54.28%. This result corresponds with the report of [22] who worked on the evaluation of nutritional composition of some selected underutilized legumes. Furthermore, the amount of crude fiber present in Tvr-19 is higher in comparison to other widely grown pulses like chickpeas, horse gram, and black gram. Similarly, the ash content of Mung bean accessions under study is more or less equal to the *Vigna unguiculata* [23] and *Phaseolus vulgarisi* [24]. The protein level in TVr-43 exceeded that of the other varieties examined in the research, although it was noted that this high-protein variety did not rank among those with the best yields. This agrees with the findings of [25] that protein content in Mung bean ranges between 20.97-31.32% and that it's about two folds higher that the cereal seeds. [15, 26] reported that essential fatty acids, antioxidants, minerals and proteins of positive health benefits in Mung bean seeds. "[11] documented a variety of micronutrients, proteins, and carbohydrates that are simple to digest, result in reduced gas production, and enhance human health more effectively than proteins and minerals obtained from other pulses. Additionally, mung bean seeds have been noted for their ability to increase feelings of fullness and decrease total calorie consumption, resulting in weight reduction, strengthening the immune system, aiding in weight management, lowering cholesterol levels, encouraging consistent bowel movements, preventing constipation, and enhancing general digestive well-being [27]". "This work also agrees with [13] who also reported the proximate analysis of Mung bean genotypes from four provinces in China for nutritional properties, which could be assessed for better diet".

Table 5 Proximate analysis of 10 accessions of Mung bean

Accessions	Moisture content	Protein	Fat	Ash	Crude fiber	Carbohydrates
TVr-10	9.12g	24.09f	7.47f	3.71e	5.23d	50.41g
TVr-6	9.30e	24.29c	6.89h	3.22f	5.11e	51.19b
TVr-49	9.28f	24.22d	6.69i	3.81d	4.88g	51.13c
TVr-145	10.04b	24.31b	9.21b	2.27j	4.09i	50.11h
TVr-46	8.89i	23.63g	7.61e	4.05a	5.27c	50.58f
TVr-70	9.31d	24.09f	7.84d	3.88c	4.15h	50.74e
TVr-19	10.05a	18.64i	6.64j	4.00b	6.42a	54.26a
TVr-100	8.94h	24.11e	12.16a	2.76h	3.84j	48.21j
TVr-48	9.89c	23.57h	7.23g	2.43i	5.73b	50.87d
TVr-43	8.56j	24.74a	8.49c	3.19g	4.91f	49.41i

Values with the same alphabet across the column are not significantly different at P≤0.05 Tukey HSD

This research highlighted notable differences in the structure and nutritional makeup of the chosen Mung bean varieties, with TVr-100 exhibiting the greatest weight for 100 seeds, while TVr-48 showed the highest seed count per plant. The protein levels were found to vary between 18 and 25%, with Tvr-43 having the peak value of 24.74. Mung beans are a complete food source with significant nutritional advantages. The results showed that an accession could have a high yield but low protein content. Mung beans are positioned as a crucial component of a balanced diet due to their nutritious makeup. Including mung beans in one's diet can greatly improve nutritional security, which is essential for tackling prevalent public health concerns. In order to address the discrepancies in food and nutritional security, future research should examine the high-yielding and protein-rich accessions that have been found.

Author contributions

Conceptualization O. T. O.; data curation and data analysis, O. T. O., E.A; methodology, O. T. O.; writing—original draft, E . A; writing—review and editing O. T. O.

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Declarations

The authors declare that they have no conflict of interest.

Data availability

The information that backs up the results of this study can be obtained by contacting the corresponding author.

References

1. Yi-Shen, Zhu, Shuai, S, FitzGerald, R. Mung bean proteins and peptides: nutritional, functional and bioactive properties. *Food Nutr Res*. 2018;62.
2. Singh RK, Chaudhary BD. *Biometrical Methods in Quantitative Genetic Analysis*. New Delhi-Ludhiana: Kalayani Publishers; 2005. 318 p.
3. Duangmal K, Sangsukiam T. Effect of germination period on changes in mung bean and azuki bean protein and amino acid profiles. *Acta Hortic*. 2015;1088:563-568. doi:10.17660/actahortic.2015.1088.103
4. Ahemad M, Kibret M. Mechanisms and applications of plant growth promoting rhizobacteria: Current perspective. *J King Saud Univ Sci*. 2014;26(1):1-20. doi:10.1016/j.jksus.2013.05.001
5. Hou D, Yousaf L, Xue Y, Hu J, Wu J, Hu X, et al. Mung Bean (Vigna radiata L.): Bioactive Polyphenols, Polysaccharides, Peptides, and Health Benefits. *Nutrients*. 2019;11(6):1238. doi:10.3390/nu11061238
6. Nair RM, Yang RY, Easdown WJ, Thavarajah D, Thavarajah P, Hughes JDA, Keatinge JDH. Biofortification of Mungbean (Vigna radiata) as a Whole Food to Enhance Human Health. *J Sci Food Agric*. 2013;93:1805–1813.
7. Gan RY, Lui W-Y, Wu K, Chan C-L, Dai S-H, Sui Z-Q, et al. Bioactive compounds and bioactivities of germinated edible seeds and sprouts: An updated review. *Trends Food Sci Technol*. 2017;59:1–14. doi:10.1016/j.tifs.2016.11.0115
8. Boye J, Zare F, Pletch A. Pulse proteins: Processing, characterization, functional properties and applications in food and feed. *Food Res Int*. 2010;43:414-431.
9. Saleem MA, Zafar M, Ahsan M, Aslam M. Interrelationships and variability studies for grain yield and its various components in chickpea (Cicer arietinum L.). *J Agric Sci*. 2005;1(3):266-269.
10. Atta YA, Akhter BMJ, Lateef PZ. Genetic variability, association and diversity studies in wheat (Triticum aestivum L.) germplasm. *Pak J Bot*. 2008;40(5):2087-2097.
11. Ramakrishnan M, Yang RY, Easdown WJ, Thavarajah D, Thavarajah P, Hughes JDA, Keatinge D. Biofortification of Mungbean (Vigna radiata) as a whole food to enhance human health. *J Sci Food Agric*. 2013;93(8):1805-13.
12. Cullis C, Kunert KJ. Mungbean: Unlocking the potential of orphan legumes. *J Exp Bot*. 2017;68(8):1895-1903.
13. Wang F, Huang L, Yuan X, Zhang X, Guo L, Xue C, Chen X. Nutritional, phytochemical and antioxidant properties of 24 Mung bean (Vigna radiata L.) genotypes. *Food Prod Process Nutr*. 2021;28(3).
14. Ahmad P, Wani MR, Azooz MM, Tran LP. *Improvement of Crops in the Era of Climatic Changes: Volume 1*. Springer Science & Business Media; 2013.
15. Anwar F, Latif S, Przybylski R, Sultana B, Ashraf M. Chemical composition and antioxidant activity of seeds of different cultivars of Mungbean. *J Food Sci*. 2007. doi:10.1111/j.1750-3841.2007.00462.x
16. NPGRL. National Plant Genetic Resources Laboratory, 2018 for Mung bean Genesys. 2018.
17. SAS Institute Inc. *Statistical Analytical System (SAS)*. Version 9. 2021.

18. Hossain MM, Yesmin S, Islam MZ, Hossain MA, Jahan MA. Physiological attributes of Mungbean (Vigna radiata L.) influenced by different sources of nutrients (NPK) in Madhupur tract region of Bangladesh. *J Sci Technol Environ Inform*. 2021;11(1):736–748. doi:10.18801/jstei.110121.74
19. Akinyosoye ST, Adeola A, Adedayo JA, Paul U. Selection for earliness and seed yield in Mung bean accessions using REML/BLUP. *Pesquisa Agropecuária*. 2021;56(1).
20. Singh A, Singh A, Barb J, Mahama A. Genetic variation and Germplasm Usage. In: *Crop Improvement*. Iowa State University Press; 2023.
21. Azam MG, Sarker U, Hossain MA, Mahabubul A, Islam MR, Hossain N, Alamri S. Phenotypic diversity in qualitative and quantitative traits for selection of high yield potential field pea genotypes. *Sci Rep*. 2024;14.
22. Baiyeri SO, Uguru MI, Ogbonna PE, Samuel-Baiyeri CCA, Okechukwu R, Kumaga FK, et al. Evaluation of the nutritional composition of the seeds of some selected African yam bean *Sphenostylis stenocarpa* Hochst Ex. A. Rich (Harms) accessions. *Agro-Science*. 2018;17(2):37. doi:10.4314/as.v17i2.5
23. Abraham A, Kattoor AJ, Saldeen T, Mehta JL. Vitamin E and its anti cancer effects. *Crit Rev Food Sci Nutr*. 2018;59(17):2831–2838. doi:10.1080/10408398.2018.1474169
24. Adebayo SA, Dzoyem JP, Shai LJ, Eloff JN. The anti-inflammatory and antioxidant activity of 25 plant species used traditionally to treat pain in southern African. *BMC Complement Altern Med*. 2015;15:159. doi:10.1186/s12906-015-0669-5
25. Zhu Y, Sun S, Richard F. Mung bean proteins and peptides: nutritional, functional and bioactive properties. *Food Nutr Res*. 2018;62.
26. Hall C, Hillen C, Garden, Robinson J. Composition, nutritional value, and health benefits of pulses. *Cereal Chem*. 2017;94:11–31.
27. Unilever. Mung beans: The nutritional powerhouse-Unlocking the health benefits of fibre, protein, carbohydrates. [2024]. Available from: https://www.unilever.co.za/brands/health/articles/mung-beans-the-nutritional-powerhouse-unlocking-the-health-benefits-of-fibre-protein-and-more [Accessed Date]