Genetics/ Original Article

Selection for earliness and seed yield in Mung bean accessions using REML/BLUP

Abstract – The objective of this work was to select early maturing and high yielding mung bean (*Vigna radiata*) genotypes for savanna and rainforest conditions in Nigeria. Twenty mung bean genotypes were evaluated, in 2019 and 2020, in the following agroecological zones of Southwestern Nigeria: Rainforest, Derived Savanna, and Southern Guinea Savanna, totaling six environments. The experiment was carried out in a randomized complete block design with three replicates. The restricted maximum likelihood (REML)/best linear unbiased prediction (BLUP) mixed model was used. The magnitude of the phenotypic coefficient of variation was higher than that of the genotypic coefficient of variation for all agronomic characters measured. A high heritability estimate was recorded for first flowering (87%), followed by pod length (85%), number of seeds per pod (79%), and 50% flowering (55%). However, a low heritability was observed for seed yield per hectare (23%). The selective accuracy was 0.5 for yield, which is considered moderate, and ranged from 0.7 to 0.9 for the other characters. A yield of 1,472.93 kg ha^{-1} was obtained across the six environments. Nine promising genotypes (TVr-45, TVr-98, TVr-64, TVr-102, TVr-86, TVr-106, TVr-9, TVr-95, and TVr-33) were identified. Therefore, these genotypes are suitable and adapted for cultivation in the agroecological zones of Southwestern Nigeria.

Index terms: *Vigna radiata*, genetic gain, heritability, selective accuracy.

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Seleção para precocidade e rendimento de sementes em acessos de feijão-mungo com uso de REML/BLUP

Resumo – O objetivo deste trabalho foi selecionar genótipos de feijão-mungo (*Vigna radiata*) de maturação precoce e alto rendimento para condições de savana e mata na Nigéria. Vinte genótipos de feijão-mungo foram avaliados, em 2019 e 2020, nas seguintes zonas agroecológicas do sudoeste da Nigéria: floresta tropical, savana derivada e savana do sul da Guiné, o que totalizou seis ambientes. O experimento foi realizado em delineamento de blocos ao acaso, com três repetições. Utilizou-se o modelo misto de máxima verossimilhança restrita (REML)/melhor predição linear não enviesada (BLUP). A magnitude do coeficiente de variação fenotípico foi maior do que a do coeficiente de variação genotípico para todos os caracteres agronômicos mensurados. Registrou-se elevada estimativa de herdabilidade para primeira floração (87%), seguida por comprimento da vagem (85%), número de sementes por vagem (79%) e 50% da floração (55%). No entanto, observou-se baixa herdabilidade para produção de sementes por hectare (23%). A precisão seletiva foi de 0,5 para rendimento, que é considerada moderada, e de 0,7 a 0,9 para os outros caracteres. Obteve-se um rendimento de 1.472,93 kg ha^{-1} nos seis ambientes. Foram identificados nove genótipos promissores (TVr-45, TVr-98, TVr-64, TVr-102, TVr-86, TVr-106, TVr-9, TVr-95 e TVr-33). Portanto, esses genótipos são adequados e adaptados para cultivo nas zonas agroecológicas do sudoeste da Nigéria.

Termos para indexação: *Vigna radiata*, ganho genético, herdabilidade, acurácia seletiva.

Introduction

Mung bean [*Vigna radiata* (L.) R.Wilczek], although still underutilized, is a legume cultivated throughout Asia for its edible seeds and sprouts (Asari et al., 2019). The species likely originated in India (Asari et al., 2019), which is also its largest producer and consumer worldwide. In Africa, Kenya was reported as the largest producer, alongside other countries such as Tanzania, Ethiopia, Mozambique, and Uganda (Nair & Schreinemachers, 2020). The interest of farmers in mung bean is attributed to its short life cycle, ability to be intercropped with other crops especially cereals, low input requirement, and resistance to heat and drought stress (Nair & Schreinemachers, 2020).

One of the main focuses of any crop improvement program in sub-Saharan Africa is earliness of maturity, because it allows for two to three cultivations in a year with a reasonable return on investment (Badu-Apraku et al., 2017). In this context, some mung bean genotypes have been introduced into humid forest agroecosystems of Southeastern Nigeria (Agugo & Muoneke, 2009; Agugo et al., 2010) and into Savanna agroecosystems of Northern Nigeria (Okweche & Avav, 2013). However, the species is not always included in the national statistics of the country (Agbeleye et al., 2020), since its yield is still relatively low there and also in other regions, with values of: 450 kg ha^{-1} in South Asia, 460 kg ha^{-1} in East Africa, 1,081 kg ha^{-1} in East Asia, 1,282 kg ha^{-1} in Southeast Asia, and 1,920 kg ha^{-1} in Central Asia (USDA, 2014; Nair & Schreinemachers, 2020).

The main challenge of plant breeders/geneticists in selecting the best genotype in terms of high yield has been environmental influence and the complexity of genes associated with the trait. Therefore, effective selection methods are required to obtain a high selection gain (Resende, 2002), showing the importance of evaluating and assessing the suitability of available cultivars to an environment or across several environments.

In Nigeria, there is still no known released variety of this crop. The few accessions of mung bean available are kept in the gene banks of some of the agricultural research institutes in the country and cannot be accessed by potential farmers. This shows the need for the selection and improvement of promising mung bean accessions with high yielding potentials for a sustainable cultivation and integration into the cropping system of Nigeria. Another challenge is that the selection of mung bean has been based on phenotypic data of individual performance (Muzibul Alom et al., 2014; Agbolade et al., 2019) rather than on the genetic (breeding) values of the genotypes, which is not an ideal strategy, particularly when heritability is low. Considering this, the mixed model has been used to assess the genetic potentials of genotypes across mega-environments, using restricted maximum likelihood (REML)/best linear unbiased prediction (BLUP) to estimate the genetic values or breeding values of different cultivars (Borges et al., 2010; Slater et al., 2014; Sousa et al., 2019).

The objective of this work was to select early maturing and high yielding mung bean genotypes for savanna and rainforest conditions in Nigeria.

Materials and Methods

Seeds of 20 accessions of mung bean (TVr-9, TVr-20, TVr-21, TVr-22, TVr-25, TVr-27, TVr-33, TVr-45, TVr-50, TVr-61, TVr-64, TVr-70, TVr-71, TVr-73, TVr-78, TVr-86, TVr-95, TVr-98, TVr-102, and TVr-106) were obtained from the Genetic Resources Center of the International Institute of Tropical Agriculture, located in Ibadan, Nigeria.

The experiment was repeated over two cropping seasons, in 2019 and 2020, at the following three research stations of Institute of Agricultural Research and Training, also located in Ibadan, Nigeria: Ibadan (Forest-Savanna agroecology; 7°38'N, 3°84'E, at 160 m above sea level); Ile-Ife (Rainforest, agroecology 8°98'N, 3°94'E, at 280 m above sea level); and Kishi (Southern Guinea Savanna agroecology, 8°98'N, 3°94'E, at 380 m above sea level), totaling six environments. The dominant soils type at the experimental sites were classified as Ferric Luxisols in Kishi and only as Ferric Lixisols in Ibadan and Ile-Ife (Sonneveld, 2005). Nigeria has a tropical climate, with a mean annual rainfall in 2019 and 2020, respectively, of: 93.08 and 77.17 mm in Ibadan, 95.50 and 75.08 mm in Ile-Ife, and 77.25 and 46.83 mm in Kish, which is considered as the driest region. In addition, the three locations had a mean annual temperature of approximately 27°C in 2019 and 20°C in 2020.

The experimental design was a randomized complete block with three replicates at each site. The plot size at each site was 2.0x1.5 m with a spacing of 0.5 m

between rows and 0.5 m within rows. Manual weeding was carried out in the field as found necessary until the crops reached physiological maturity. Field insect pests were controlled using Magic Force (Lambda-cyhalothrin 15% + Dimethoate 300 g L^{-1}) both at the vegetative and reproductive stages.

Data were collected for days to first flowering, days to 50% flowering, days to 70% physiological maturity, number of seeds per pod, pod length, and seed yield (kg ha^{-1}), being subjected to the statistical analysis of mixed models using the statistical package of the R, version 3.6.1, software (R Core Team, 2019). The variance components and heritability of the genotypes across the six environments were estimated with the following statistical model (Sousa et al., 2019): y = Xb + Zg + Wc + ε, where y are the vectors of the observed values; b are the fixed effects of blocks within different environments; g are the random effects of genotypes; c are the random effects of the genotype × environment interaction; ε are the random errors; and X, Z, and W are the incidence matrices for b, g, and c, respectively.

The following genetic parameters were also estimated: phenotypic variance, genotypic coefficient of variation (G$_{CV}$), and phenotypic coefficient of variation (P$_{CV}$), using the respective equations: $(\delta^2 p) = \delta^2 g + \delta^2 e$, G$_{CV}$ = $(\sqrt{\delta^2 g})/X \times 100$, and P$_{CV}$ = $(\sqrt{\delta^2 p})/X \times 100$, where $\delta^2 g$ is the genotypic variance, $\delta^2 p$ is the phenotypic variance, and X is the mean of the trait. The G$_{CV}$ and P$_{CV}$ values were categorized as low when less than 10%, moderate when 10–20%, and high when greater than 20% (Sivasubramanian & Madhavamenon, 1973).

Heritability (h^2) was determined according to Singh & Chaudhary (1985), as:

$$h^2 = \frac{\text{total genetic variance}}{\text{total phenotypic variance}} = \frac{\delta^2 g}{\delta^2 p}$$

REML/BLUP was used to determine genetic effect (g), percentage of genetic gain, and predicted genetic values (g+μ), where μ represents the grand mean of genotypes for yield and other agronomic traits, evaluated across the six environments. The accuracy in the selection of genotypes was calculated as (h^2)$^{0.5}$ (Chiorato et al., 2008; Sousa et al., 2019).

Results and Discussion

For seed yield and the other agronomic traits, the P$_{CV}$ was higher than the G$_{CV}$ (Table 1), which implies the influence of environmental factors. The obtained results are in agreement with the findings of Azam et al. (2018), who reported a higher P$_{CV}$ than G$_{CV}$ for some agronomic traits in 28 mung bean genotypes evaluated in Bangladesh. Similar results were also found for mung bean by Rahim et al. (2010).

The h^2 estimates obtained for days to first flowering, pod length, number of seeds per pod, and days to 50% flowering indicate that selection based on these traits would be more effective because of minimal environmental influence. However, seed yield showed a low h^2 of 23%, which may be explained by a significant portion of phenotypic variance caused by environmental effects, as well as by the control of this trait by complex genes. This suggests that days to first flowering, days to 50% flowering, pod length, and number of seeds per pod are controlled

Table 1. Estimates of genetic parameters for yield and earliness of 20 mung bean (*Vigna radiata*) genotypes evaluated by restricted maximum likelihood across six environments[1] in Southwestern Nigeria in 2019 and 2020.

Parameter	Genotypic variance	Residual variance	Phenotypic variance	G$_{CV}$[2] (%)	P$_{CV}$[3] (%)	Heritability	Selective accuracy
Seed yield	21,875.98	388,355.40	410,231.38	10.04	43.48	0.23	0.5
Days to first flowering	8.68	20.27	11.59	7.05	8.14	0.87	0.9
Days to 50% flowering	8.22	18.94	27.16	6.14	11.16	0.55	0.7
Days to 70% physiological maturity	0.40	26.56	26.96	0.78	6.37	0.12	0.4
Pod length	1.07	0.40	1.47	12.45	14.59	0.85	0.9
Number of seeds per pod	2.38	1.39	3.77	13.14	16.54	0.79	0.9

[1]The Rainforest, Derived Savanna, and Southern Guinea Savanna agroecological zones in two cropping seasons. [2]G$_{CV}$, genotypic coefficient of variation. [3]P$_{CV}$, phenotypic coefficient of variation.

by an additive gene effect, while seed yield is under a nonadditive gene effect. The additive gene effect is the sum of the alleles at the locus that controls the quantitative character of interest (Barroso Neto et al., 2017). Therefore, especially when heritability is low, the use of the BLUP-based selection method provides accurate estimates of genotype performance, which is affected by environmental factors (Slater et al., 2014).

In the present study, the selective accuracy of the measured agronomic traits ranged from 0.4 to 0.9, considering the classification range from 0 to 1.0, where ≥0.9 is very high; ≤0.7 to ≤0.9, high; ≤0.5 to <0.7, moderate; and <0.5, low (Resende & Duarte, 2007). Selective accuracy is associated with the precision of selection based on predicted genetic values, with inferences on genotype means, helping to measure the reliability of genotype ranking. Selective accuracy was high for seed yield per hectare and for 50% days to flowering and very high for days to first flowering, pod length, and number of seeds per pod, which is in agreement with the findings of Pimentel et al. (2014) and Barroso Neto et al. (2017). The obtained results show that, the higher the heritability, the higher the selective accuracy and the genetic gain, which is in alignment with the reports of Viana et al. (2010) and Pinheiro et al. (2013). This shows the effectiveness of the experimental design and the reliability of the selection of promising mung bean genotypes for earliness (flowering and maturity) and yield.

The seed coat of mung bean may be of several colors, such as chocolate, yellow, and green (Figure 1). This is a major trait that affects consumer acceptability, preference, and use patterns from region to region (Adetumbi et al., 2019), since decisions about the quality and presumed taste of a product are based on its appearance (Jaeger et al., 2018). In the present study, one genotype (TVr-71) had a chocolate-colored seed coat, five genotypes (TVr-33, TVr-50, TVr-78, TVr-86, and TVr-95) had a yellow-colored seed coat, and the rest had a green-colored seed coat. Seed coat color and grain size are important characteristics for consumer preference and may influence market value. In Nigeria, most of the available accessions of mung bean have a green-colored seed coat, whereas in Kenya, Tanzania, Indonesia, and Taiwan, dull-green grains are preferred by consumers and farmers (Nair, 2020).

Genotypic variability was also observed for seed yield (Table 2). Nine out of the 20 mung bean genotypes evaluated across the six environments showed predicted genotypic values above the grand mean of 1,472.93 kg ha^{-1} for this trait. TVr-45 presented the highest seed yield, together with the longest pod, with approximately 12 seeds per pod; the highest number of seeds per pod was recorded for TVr-98. It should be noted that the seed yield of 1,472.93 kg ha^{-1} obtained for the 20 mung bean genotypes is higher than those reported by Okweche & Avav (2013), which were of 1,181.67 kg ha^{-1} in early season and 995.60 kg ha^{-1} in late season for cultivars of mung bean assessed in the Southern Guinea Savanna of Nigeria. Similarly, Agugo (2017) found a lower seed yield of 620 kg ha^{-1} in early season and 415 kg ha^{-1} in late season for mung bean genotypes evaluated in a lowland Rainforest in Southeastern Nigeria. Therefore, for the effective selection of chocolate-, yellow-, and green-colored seeds aiming higher genetic gains, the genotypes with higher means and genetic variability should be chosen (Chiorato et al., 2008).

Six high yielding mung bean genotypes (TVr-45, TVr-102, TVr-98, TVr-64, TVr-86, and TVr-33) were identified as having a genetic gain between 6.0 and 14.3%. TVr-45 stood out with the highest genotypic gain of 14.3, 8.2, and 4.0% for seed yield, pod length, and number of seeds per pod, respectively (Table 3). Therefore, those six genotypes are promising due to favorable genes for high yield, which was not negatively affected by environmental variations, and could be selected for an on-farm evaluation for an eventual release to farmers in Nigeria.

Data collected on earliness (flowering and maturity) across the six studied environments showed that TVr-33 and TVr-106 flowered earlier than the rest, at approximately 36 and 37 days after planting (DAP), respectively, and reached 50% flowering at 42 DAP and 70% physiological maturity at 79 and 80 DAP, respectively (Table 4). Therefore, six extra-early maturing mung bean genotypes (TVr-106, TVr-33, TVr-86, TVr-102, TVr-9, and TVr-95) were identified considering their negative values for genetic gain for days to first flowering (-12.8 to -0.2%), days to 50% flowering (-8.9 to -5.0%), and days to 70% physiological maturity (-0.7 to -0.1%). In addition, TVr-33 and TVr-106 presented the highest genetic gain of -12.8 to -10.3%, -8.9 to -8.2%, and -0.38% to -0.71%, respectively, for first flowering, 50% flowering, and 70% physiological maturity (Table 5).
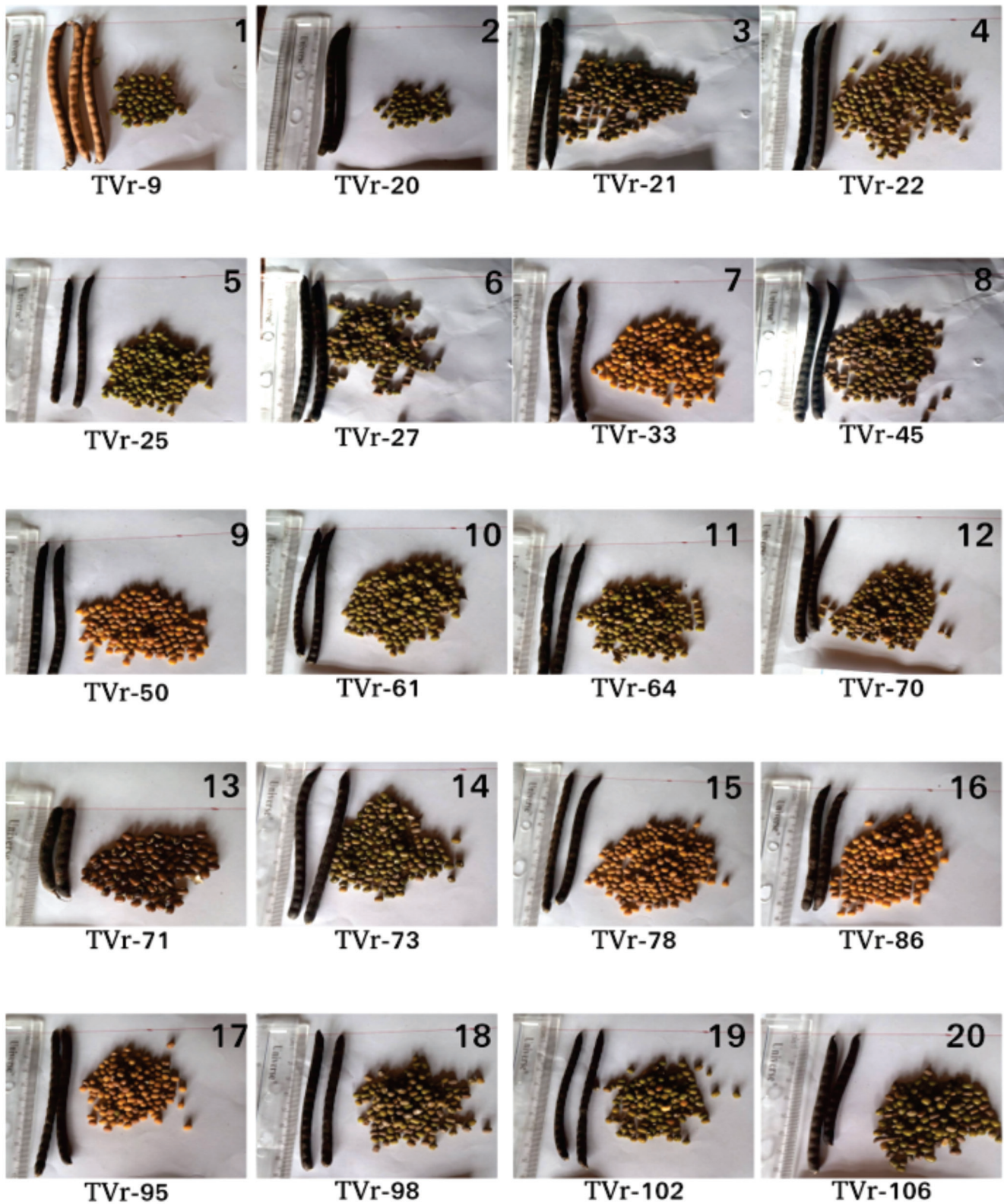
Figure 1. Different pod shapes and seed coat colors of the 20 mung bean (*Vigna radiata*) accessions evaluated across six environments (the Rainforest, Derived Savanna, and Southern Guinea Savanna agroecological zones in two cropping seasons) of Southwestern Nigeria in 2019 and 2020.

Table 2. Mung bean (*Vigna radiata*) seed yield, pod length, and number of seeds per pod evaluated across six environments[1] of Southwestern Nigeria in 2019 and 2020.

Ranking	Seed yield (kg ha⁻¹)		Ranking	Pod length (cm)		Ranking	Number of seeds per pod	
	Genotype	Mean		Genotype	Mean		Genotype	Mean
1	TVr-45	1,891.23	1	TVr-45	9.00	1	TVr-98	12.91
2	TVr-102	1,784.28	2	TVr-78	8.96	2	TVr-95	12.81
3	TVr-98	1,666.08	3	TVr-22	8.91	3	TVr-78	12.77
4	TVr-64	1,660.72	4	TVr-50	8.86	4	TVr-70	12.76
5	TVr-86	1,656.64	5	TVr-95	8.86	5	TVr-102	12.61
6	TVr-33	1,650.19	6	TVr-33	8.82	6	TVr-61	12.61
7	TVr-20	1,545.81	7	TVr-20	8.70	7	TVr-22	12.59
8	TVr-27	1,545.50	8	TVr-86	8.62	8	TVr-20	12.36
9	TVr-21	1,525.91	9	TVr-27	8.54	9	TVr-45	12.34
10	TVr-78	1,458.07	10	TVr-21	8.54	10	TVr-21	12.12
11	TVr-22	1,451.82	11	TVr-98	8.47	11	TVr-86	12.02
12	TVr-70	1,383.02	12	TVr-102	8.42	12	TVr-50	11.92
13	TVr-25	1,377.51	13	TVr-25	8.42	13	TVr-64	11.88
14	TVr-61	1,372.92	14	TVr-73	8.34	14	TVr-25	11.76
15	TVr-73	1,364.95	15	TVr-61	8.32	15	TVr-33	11.76
16	TVr-95	1,347.20	16	TVr-9	8.30	16	TVr-27	11.58
17	TVr-50	1,320.66	17	TVr-64	8.28	17	TVr-73	11.20
18	TVr-71	1,250.50	18	TVr-70	8.00	18	TVr-106	10.92
19	TVr-9	1,119.25	19	TVr-106	7.72	19	TVr-9	10.18
20	TVr-106	1,086.34	20	TVr-71	4.09	20	TVr-71	5.78
General mean		1,472.93			8.31			11.74

[1]The Rainforest, Derived Savanna, and Southern Guinea Savanna agroecological zones in two cropping seasons.

Table 3. Estimates of individual best linear unbiased prediction of genotypic effects (g) and predicted genotypic values (μ+g) for seed yield, pod length, and number of seeds per pod of mung bean (*Vigna radiata*) evaluated across six environments[1] of Southwestern Nigeria in 2019 and 2020.

Ranking	Genotype	Seed yield (kg ha⁻¹)			Genotype	Pod length (cm)			Genotype	Number of seeds per pod		
		Genetic effect	g+μ	%g[2]		Genetic effect	g+μ	%g[2]		Genetic effect	g+μ	%g[2]
1	TVr-45	210.60	1,683.53	14.3	TVr-45	0.68	8.99	8.17	TVr-98	1.13	12.87	9.61
2	TVr-102	156.75	1,629.68	10.64	TVr-78	0.64	8.95	7.70	TVr-95	1.03	12.77	8.75
3	TVr-98	97.24	1,570.17	6.60	TVr-22	0.59	8.90	7.14	TVr-78	1.00	12.74	8.50
4	TVr-64	94.54	1,567.47	6.42	TVr-50	0.54	8.85	6.50	TVr-70	0.98	12.72	8.38
5	TVr-86	92.49	1,565.42	6.28	TVr-95	0.54	8.85	6.50	TVr-102	0.84	12.58	7.18
6	TVr-33	89.24	1,562.17	6.06	TVr-33	0.50	8.81	6.02	TVr-61	0.84	12.58	7.17
7	TVr-20	36.69	1,509.62	2.49	TVr-20	0.39	8.70	4.64	TVr-22	0.82	12.56	7.01
8	TVr-27	36.54	1,509.47	2.48	TVr-86	0.30	8.61	3.64	TVr-20	0.59	12.33	5.05
9	TVr-21	26.67	1,499.60	1.81	TVr-27	0.23	8.54	2.75	TVr-45	0.58	12.32	4.93
10	TVr-78	-7.48	1,465.45	-0.51	TVr-21	0.22	8.53	2.69	TVr-21	0.36	12.10	3.07
11	TVr-22	-10.63	1,462.30	-0.72	TVr-98	0.16	8.47	1.92	TVr-86	0.27	12.01	2.27
12	TVr-70	-45.27	1,427.66	-3.07	TVr-102	0.11	8.42	1.29	TVr-50	0.17	11.91	1.41
13	TVr-25	-48.04	1,424.89	-3.26	TVr-25	0.11	8.42	1.27	TVr-64	0.13	11.87	1.14
14	TVr-61	-50.35	1,422.58	-3.42	TVr-73	0.03	8.34	0.41	TVr-25	0.02	11.76	0.13
15	TVr-73	-54.36	1,418.57	-3.69	TVr-61	0.01	8.32	0.11	TVr-33	0.02	11.76	0.13
16	TVr-95	-63.30	1,409.63	-4.30	TVr-9	-0.01	8.30	-0.11	TVr-27	-0.16	11.58	-1.33
17	TVr-50	-76.66	1,396.27	-5.20	TVr-64	-0.03	8.28	-0.37	TVr-73	-0.53	11.21	-4.52
18	TVr-71	-112.00	1,360.94	-7.60	TVr-70	-0.30	8.01	-3.62	TVr-106	-0.80	10.94	-6.79
19	TVr-9	-178.10	1,294.87	-12.10	TVr-106	-0.58	7.73	-6.93	TVr-9	-1.51	10.23	-12.90
20	TVr-106	-194.60	1,278.30	-13.20	TVr-71	-4.13	4.18	-49.7	TVr-71	-5.77	5.97	-49.20

[1]The Rainforest, Derived Savanna, and Southern Guinea Savanna agroecological zones in two cropping seasons. [2]%g, percentage of genetic gain.

Table 4. Mung bean (*Vigna radiata*) earliness (flowering and maturity) evaluated across six environments[1] of Southwestern Nigeria in 2019 and 2020.

Ranking	Days to first flowering		Ranking	Days to 50% flowering		Ranking	70% physiological maturity	
	Genotype	Mean		Genotype	Mean		Genotype	Mean
1	TVr-106	36.06	1	TVr-33	42.00	1	TVr-106	78.72
2	TVr-33	37.17	2	TVr-106	42.39	2	TVr-9	79.00
3	TVr-70	38.61	3	TVr-9	42.50	3	TVr-33	80.00
4	TVr-86	38.67	4	TVr-102	42.83	4	TVr-102	80.33
5	TVr-71	38.72	5	TVr-71	43.17	5	TVr-98	80.83
6	TVr-102	38.83	6	TVr-70	43.72	6	TVr-70	81.06
7	TVr-9	39.33	7	TVr-86	44.06	7	TVr-86	81.17
8	TVr-95	41.72	8	TVr-95	46.89	8	TVr-95	81.28
9	TVr-78	42.33	9	TVr-78	47.06	9	TVr-50	81.33
10	TVr-27	42.44	10	TVr-50	47.28	10	TVr-20	81.56
11	TVr-98	42.72	11	TVr-98	47.28	11	TVr-22	81.61
12	TVr-21	43.17	12	TVr-45	47.61	12	TVr-61	81.67
13	TVr-50	43.17	13	TVr-27	48.72	13	TVr-78	81.67
14	TVr-64	43.39	14	TVr-64	48.72	14	TVr-64	81.83
15	TVr-45	43.44	15	TVr-22	48.94	15	TVr-21	81.89
16	TVr-22	44.39	16	TVr-21	49.11	16	TVr-25	81.94
17	TVr-20	44.56	17	TVr-20	49.94	17	TVr-45	82.00
18	TVr-73	44.56	18	TVr-73	50.28	18	TVr-71	82.67
19	TVr-61	45.00	19	TVr-61	50.50	19	TVr-73	84.22
20	TVr-25	47.78	20	TVr-25	50.72	20	TVr-27	84.28
General mean		41.8			46.69			81.45

[1]The Rainforest, Derived Savanna, and Southern Guinea Savanna agroecological zones in two cropping seasons.

Table 5. Estimates of individual best linear unbiased prediction of genotypic effects (g) and predicted genotypic values (μ+g) for earliness (flowering and maturity) of mung bean (*Vigna radiata*) evaluated across six environments[1] of Southwestern Nigeria in 2019 and 2020.

Ranking	Days to first flowering			Genotype	Days to 50% flowering			Genotype	Days to 70% physiological maturity		
	Genotype	g+μ	%g[2]		Genetic effect	g+μ	%g[2]		Genetic effect	g+μ	%g[2]
1	TVr-106	36.45	-12.80	TVr-33	-4.15	42.54	-8.90	TVr-106	-0.58	80.87	-0.71
2	TVr-33	37.48	-10.32	TVr-106	-3.81	42.88	-8.16	TVr-9	-0.52	80.93	-0.64
3	TVr-70	38.83	-7.11	TVr-9	-3.71	42.98	-7.95	TVr-33	-0.31	81.14	-0.38
4	TVr-86	38.88	-6.98	TVr-102	-3.42	43.27	-7.32	TVr-102	-0.24	81.21	-0.29
5	TVr-71	38.93	-6.86	TVr-71	-3.12	43.57	-6.68	TVr-98	-0.13	81.32	-0.16
6	TVr-102	39.04	-6.61	TVr-70	-2.63	44.06	-5.63	TVr-70	-0.08	81.37	-0.10
7	TVr-9	39.50	-5.50	TVr-86	-2.33	44.36	-4.99	TVr-86	-0.06	81.39	-0.07
8	TVr-95	41.73	-0.18	TVr-95	0.18	46.87	0.39	TVr-95	-0.04	81.41	-0.05
9	TVr-78	42.29	1.18	TVr-78	0.33	47.02	0.70	TVr-50	-0.03	81.42	-0.03
10	TVr-27	42.40	1.43	TVr-50	0.52	47.21	1.12	TVr-20	0.02	81.47	0.03
11	TVr-98	42.66	2.05	TVr-98	0.52	47.21	1.12	TVr-22	0.03	81.48	0.04
12	TVr-21	43.07	3.04	TVr-45	0.82	47.51	1.76	TVr-61	0.05	81.50	0.06
13	TVr-50	43.07	3.04	TVr-27	1.81	48.50	3.87	TVr-78	0.05	81.50	0.06
14	TVr-64	43.28	3.53	TVr-64	1.81	48.50	3.87	TVr-64	0.08	81.53	0.10
15	TVr-45	43.33	3.66	TVr-22	2.00	48.69	4.29	TVr-21	0.09	81.54	0.11
16	TVr-22	44.21	5.76	TVr-21	2.15	48.84	4.60	TVr-25	0.10	81.55	0.13
17	TVr-20	44.36	6.13	TVr-20	2.89	49.58	6.19	TVr-45	0.12	81.57	0.14
18	TVr-73	44.36	6.13	TVr-73	3.18	49.87	6.82	TVr-71	0.26	81.71	0.32
19	TVr-61	44.78	7.12	TVr-61	3.38	50.07	7.24	TVr-73	0.59	82.04	0.72
20	TVr-25	47.36	13.31	TVr-25	3.58	50.27	7.66	TVr-27	0.60	82.05	0.74

[1]The Rainforest, Derived Savanna, and Southern Guinea Savanna agroecological zones in two cropping seasons. [2]%g, percentage of genetic gain.

For some genotypes, negative values for genetic effect and percentage of genetic gain depict earliness of flowering and maturity.

Conclusions

1. Nine promising mung bean (*Vigna radiata*) genotypes (TVr-45, TVr-98, TVr-64, TVr-102, TVr-86, TVr-106, TVr-9, TVr-95, and TVr-33) are suitable for cultivation in Southwestern Nigeria, among which stand out three high yielding genotypes: TVr-45, TVr-98, and TVr-64.

2. Of the evaluated genotypes, three (TVr-102, TVr-86, and TVr-33) are both high yielding and extra-early maturing, while three (TVr-106, TVr-9, and TVr-95) are only early maturing.

Acknowledgments

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