

GENETIC DIVERSITY BASED ON GROWTH VARIABLES OF THREE BAMBARA GROUNDNUT LANDRACES (*Vigna subterranea* (L.) VERDCOURT)

ES. Redjeki, S. Maulidiah, Suhaili, R. Jumadi, R. Agustina, W. Lailiyah, S. Budi.
 Bambara Groundnut Research Centre (BGRC)
 Agricultural Faculty, the University of Muhammadiyah Gresik
 Corresponding author: endah.siredjeki@umg.ac.id

ABSTRACT

Bambara groundnut has competitive nutritional value such as 49–63.5% carbohydrate, 15–25% protein, and 4.5–7.4% fat. There is not available yet a superior variety. Bambara Groundnut Research Centre has been working intensively to select the candidates of superior variety. Three of bambara groundnut pure lines of BGRC seed collection, including Gresik (Gresik), GHC (Gresik) and S19-3 (Namibia) assessed based on their growth traits, including germination rate, number of leaves, plant height (cm), length of petiole (cm), length of internode (cm), growth type, 1st flowering (das) and 50% of flowering (das) in the Gresik field 5 m above sea level, with Random Complete Block Design experiment, three replicates. Analysis of means (ANOM) calculated to test differences between landraces in particular traits. Heritability of three pure lines calculated based on Mean Square Estimated of Analysis of Variance (ANOVA), as well as coefficient correlation, using Minitab 18. The result showed that S19-3 as an introduced landrace from Namibia has traits similarity to the two landraces, namely GHC and Gresik except days to 50% flowering time. Analysis of means shows that S19-3 has days to 50% flowering early compare to the others. The trait of 50% flowering time (dap) also shows a high heritability (0.58). First flowering time has a significant correlation with 50% flowering time in positive direction.

Key words: *bambara groundnut*, *heritability*, *early flowering*, *S19-3*

INTRODUCTION

To support food security in Indonesia, BGRC (Bambara Groundnut Research Centre) which belongs to Agricultural Faculty, the University of Muhammadiyah Gresik assess three pure lines of its seed collections, namely Gresik, GHC (Gresik), and S19-3 (from Namibia). The bambara groundnut Indonesia came from Southern Africa (E.S. Redjeki *et al.*, 2020). The crop is famous as completed food with nutritional contains 49–63.5% carbohydrate, 15–25% protein, and 4.5–7.4% fat (Abejide *et al.*, 2018). Even though many advantages of bambara groundnut uses and nutritional contains, this crop is still minor and underutilized

legumes. Whereas, Mayes *et al.* (2019a) concluded that this legume will take an important role to climate change.

Most of bambara groundnut in Indonesia shows low yield, less than 1 ton/ha (Redjeki, 2007). In Africa, Madamba (1995) reported that bambara groundnut produced 4 ton/ha in a suitable environment, and only 0.3 ton/ha in the marginal land. Therefore, this research conducted to find suitable trait for selection among bambara groundnut landraces to prepare a super variety.

METHOD

This research conducted in the field from July to October 2019. The location is

5 meter above sea level, with grumusol as soil type. Random Complete Block Design experiment applied for three pure lines, namely Gresik (G_1), GHC (G_2), S19-3 (G_3) landraces, and repeated three times. There are nine plots with $1 \times 4 \text{ m}^2$ square per plot. Planting distance is used $50 \times 25 \text{ cm}$, one plant per hole. Growth variables measure from three days after seed germination until the whole seeds germinated for germination rate observed. Plant height, leaves number, length of petiole and internode, first and 50% flowering time counted referring to PGRI *et al.*, (2000). Data collected and analyzed by using Minitab 18 software (Minitab, LLC., 2019) for analysis of variance (ANOVA), ANOM (Analysis of Means) and correlation test. Heritability

measured based on Mean Square Estimated (Poespodarsono, 1988).

Statistical Analysis

Data collected from seven variables were analyzed using Minitab 18 package to distinguish three pure lines similarity through Analysis of Means (ANOM). Mean Square Estimated (Table 1) counted from analysis of variance to find genotype variation (σ^2_G) and phenotype variation (σ^2_P). Finally, broad sense heritability (H^2) calculated based on Allard (1992) formula, it is comparison between genotype variation (σ^2_G) and phenotype variation (σ^2_P).

Table 1. Mean Square Estimated (Hallauer and Miranda, 1988; Poespodarsono, 1988)

Source of Variation	df	Mean Square (MS)	MS estimated
Replicates	r-1		
Genotype	a-1	MS_G	$\sigma^2_E + r \sigma^2_G$
Error	(r-1) (a-1)	MS_E	σ^2_E

r = replicates; a = genotype number

$$MS_E = \sigma^2_E$$

$$MS_G = \sigma^2_E + r \sigma^2_G = MS_E + r \sigma^2_G$$

$$\sigma^2_G = (MS_G - MS_E) / r$$

$$\sigma^2_P = \sigma^2_G + \sigma^2_E$$

Broad Sense Heritability (H^2)

According to Allard (1992), $H^2 = \sigma^2_G / \sigma^2_P$

σ^2_P = phenotype variance

σ^2_G = genotype variance

Furthermore, Stansfield (1991) classify heritability score as follow:

$0,0 < H^2 < 0,2$ = low

$0,2 < H^2 < 0,5$ = medium

$H^2 > 0,5$ = high

Correlation Test

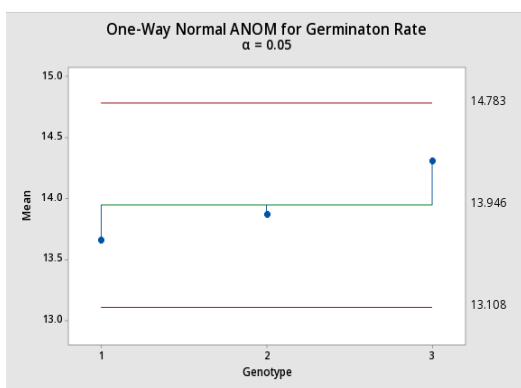
$$r = \frac{n(\sum xy) \cdot (\sum x)(\sum y)}{\sqrt{(n \sum x^2 - (\sum x)^2) (n \sum y^2 - (\sum y)^2)}}$$

This analysis was done using Minitab 18 package.

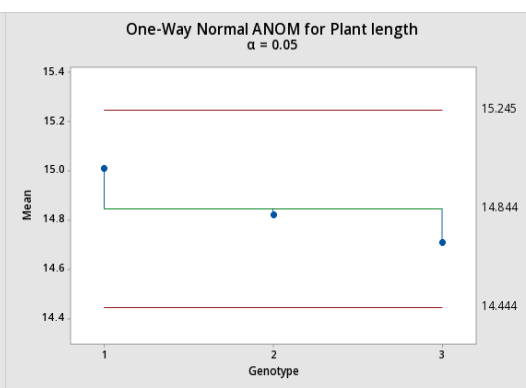
RESULT AND DISCUSSION

Analysis of Means is a complementary curve to Analysis of Variance that investigations the similarity of population means. The graph shows each factor level mean, the overall mean, and the result limits. If a point drops outside the decision limits, then indication exists that the factor level mean characterized by that point is significantly different from the overall mean (Minitab, 2019).

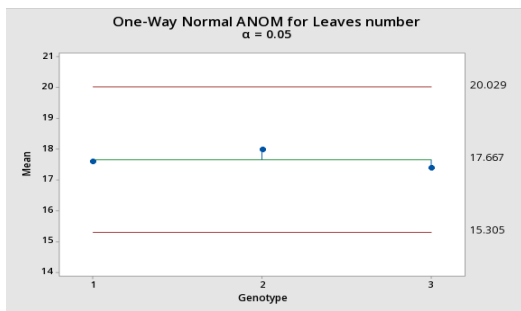
Seven traits assessed from three bambara groundnut pure lines shows that there are no significant differences of six traits, including germination rate, plant height, leaves number, length of internode and petiole as well as days to 1st flowering time (Figure 1a, b, c, d, e, f). That means Gresik, GHC and S19-3 pure lines show similarity to the six traits observed. Furthermore, S19-3 (G₃) shows days to 50% flowering time significantly earlier than the others (Figure 1g).



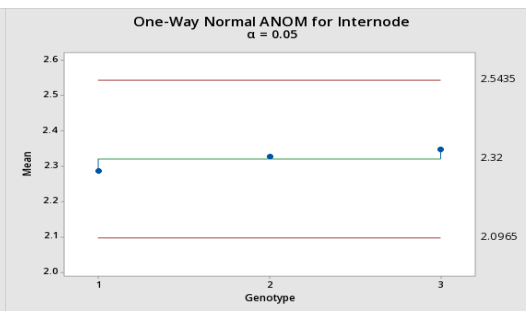
(a)



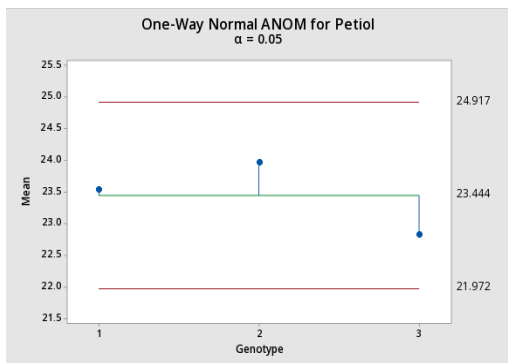
(b)



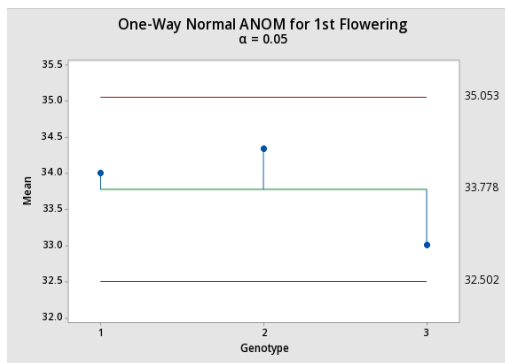
(c)



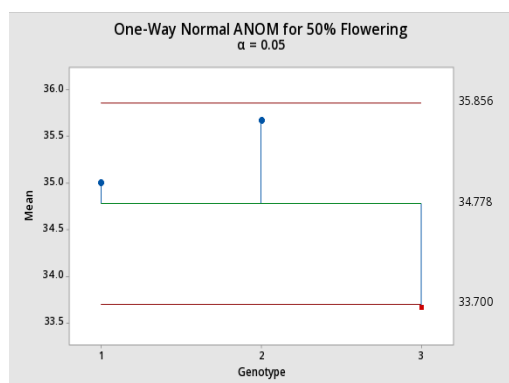
(d)



(e)



(f)



(g)

Figure 1 Analysis of Means (ANOM) (a) germination rates (b) plant height (c) leaves number (d) internode length (e) Petiole length (f) days to 1st Flowering time and (g) days to 50% flowering time.

S19-3 is an introduced landrace from Namibia in Africa. E.S.Redjeki *et al.*(2013a) reported that S19-3 has been well adapted in Indonesia agroekologies. Most of African landraces have early 50% flowering in Indonesia climate. Previous research conducted in three location for two years in Gresik, Malang and Bojonegoro in East Java showed that S19-3 which has the same colour as Gresik landrace placed in to the three top suitable landraces in Indonesia (E.S. Redjeki, 2013b). This information should be important for breeding program so that S19-3 selected as parent for hibridization to gain a superior variety.

The broad-sense heritability is the ratio of total genetic variance to total phenotypic variance, $H^2 = \sigma^2_G / \sigma^2_P$ (Allard, 1992). Hallauer and Miranda (1988) also

Poespodarsono (1988) reported that heritability can be predicted by Mean Square Estimated (MSE). Table 2 shows Mean Square of Analysis of variance (ANOVA). Whereas, Table 3 placed genotype, environment, and phenotype variance based on MSE (Table 1). Broad sense heritability (H^2) calculated after all. According to Stansfield (1991) classify heritability score as low ($0,0 < H^2 < 0,2$), medium ($0,2 < H^2 < 0,5$) and high ($H^2 > 0,5$). Therefore, only 50% flowering time shows a high heritability (0.58). That means 50% flowering time can be used to determine bambara groundnut traits. S19-3 from Namibia belongs to early maturity crops, its harvesting time is 110 days after planting (dap), while Gresik is 150 dap (Mayes, *et al.*, 2019b).

Table 2. Mean Square of ANOVA for *growth rate, plant height, leaves number, petiole length, internode length, 1st flowering and 50% flowering*

Source of Variation /Trait observed	Genotype	Block	Error
Degree of Freedom	2	2	4
Growth Rate	0.09	0.33	0.46
Plant height (cm)	0.05	0.06	0.10
Leaves Number	1.96	0.28	3.02
Petiole length	1.17	0.98	0.97
Internode length	0.05	0.00	0.01
1 st Flowering%	1.44	1.44	0.44
50% flowering	3.11	0.40	0.61

Table 3. Broad Sense Heritability (H^2)

Traits Observed	$\sigma^2\epsilon$	σ^2g	σ^2p	$H^2 = \sigma^2g / \sigma^2p$
Germination Rate	0.46	-0.121	0.33	-0.36 (low)
Plant height (8 wap)*	0.10	-0.019	0.09	-0.22 (low)
leaf number (8 wap)	3.02	-0.353	2.67	-0.13 (low)
Petiole length (cm)	0.97	0.0687	1.04	0.07 (low)
Internode length (cm)	0.01	0.0115	0.02	0.48 (moderate)
1 st flowering (dap)	0.44	0.3333	0.78	0.43 (moderate)
50% flowering (dap)**	0.61	0.8333	1.44	0.58 (high)

*wap = week after planting. **dap = day after planting

Heritability score for different characters displayed at Table 2. Among seven quantitative traits, high heritability (> 0.50) has been found for days to 50% flowering (0.58). High heritability at days to 50% flowering (0.58) means that 58% of the variability in the trait is due to genetic differences among population. Moderate heritability (0.20 to 0.50) has been observed for days to 1st flowering (0.43) and internode length (0.48). Low heritability has been showed for germination rate (-0.38), plant height (0.22) and leaf number (-0.13). Moderate to low heritability means that phenotypic variance (σ^2p) affected by

environment variance ($\sigma^2\epsilon$). Therefore, selection activity will be effective when genetic variance (σ^2g) higher than environment variance ($\sigma^2\epsilon$). In this research, days to 50% flowering will be a considered trait for selection.

Correlation coefficient for seven traits display on the Table 4. Significant correlation happens when P-value < 0.05 . Table 4 shows significant correlation in positive direction happen between days to 1st flowering and days to 50% flowering. It means when days to first flowering early, days to 50% flowering early as well.

Table 4. Coefficient correlation seven traits of three pure lines

Pairwise Pearson Correlations

Sample 1	Sample 2	N	Correlation	95% CI for ρ	P-Value
Petiol	Internode	9	0.607	(-0.095, 0.906)	0.083
Plant length	Internode	9	-0.192	(-0.759, 0.541)	0.621
Leaves number	Internode	9	0.222	(-0.519, 0.772)	0.566
Germination Rate	Internode	9	0.513	(-0.230, 0.878)	0.158
1 st Flowering	Internode	9	0.283	(-0.469, 0.797)	0.461
50% Flowering	Internode	9	0.184	(-0.547, 0.756)	0.635
Plant length	Petiol	9	0.169	(-0.558, 0.749)	0.664
Leaves number	Petiol	9	0.549	(-0.181, 0.889)	0.126
Germination Rate	Petiol	9	-0.071	(-0.702, 0.623)	0.857
1 st Flowering	Petiol	9	0.266	(-0.484, 0.790)	0.490
50% Flowering	Petiol	9	0.451	(-0.304, 0.858)	0.223
Leaves number	Plant length	9	-0.447	(-0.857, 0.309)	0.228
Germination Rate	Plant length	9	0.212	(-0.526, 0.768)	0.583
1 st Flowering	Plant length	9	-0.071	(-0.702, 0.622)	0.856
50% Flowering	Plant length	9	0.246	(-0.500, 0.782)	0.523
Germination Rate	Leaves number	9	-0.526	(-0.882, 0.212)	0.145
1 st Flowering	Leaves number	9	0.066	(-0.626, 0.699)	0.867
50% Flowering	Leaves number	9	0.154	(-0.568, 0.742)	0.693
1 st Flowering	Germination Rate	9	0.047	(-0.637, 0.690)	0.905
50% Flowering	Germination Rate	9	0.010	(-0.658, 0.670)	0.979
50% Flowering	1 st Flowering	9	0.772	(0.220, 0.949)	0.015

Table 5. Growth types, leaf shape, leaf colour and banner flower of Gresik, S19-3 and GHC pure lines

Genotype	Growth Type	Leaf shape	Leaf colour	Banner flower
Gresik (G ₁)	bunch	lancet	green	pigmented
S19-3 (G ₂)	bunch	oval	green	unclear
GHC (G ₃)	bunch	ellipse	green	unclear

Referring to descriptor of bambara groundnut (IPGRI *et al.*, 2000), growth type of bambara groundnut is a comparison between petiole and internode length, namely bunch type, if $P/I > 9$; semi bunch type, if $P/I = 7 - 9$; and spreading type (open), if $P/I < 7$. Table 4 shows that the three pure lines in the same growth type, it is bunch type. Bunch type of bambara groundnut is an ideotype. This type is suitable for large-scale mechanized farming (Karikari, *et al.*, 1997).

CONCLUSION

Genetic diversity of three pure lines bambara groundnut shows a high heritability at days to 50% flowering trait. This trait can be effective for selection in breeding program. Days to 50% flowering correlated significantly to 1st flowering in positive direction.

RECOMMENDATION

S19-3 (Namibia) has early flowering trait, well adapted in Indonesia agroecology, as well as similar to Gresik landraces in term of phenotype. This S19-3 pure line can be a superior variety candidate. Therefore, depth evaluation is needed for S19-3 before registering to the Ministry of Agriculture in Jakarta, Indonesia.

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