Registration of '*Babile-1*', '*Babile-2*', and '*Babile-3*' Groundnut Varieties

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Abstract: In Ethiopia, groundnut (*Arachis hypogaea* L.) is the second most important lowland oilseed crops of warm climate next to sesame. However, the production of the crop is constrained by several biotic and abiotic factors of which lack of improved varieties is among the major constraints. Therefore, the national groundnut project coordinated by Haramaya University has been striving to develop varieties with high yield and oil contents. Therefore, 29 groundnut accessions and one standard check (*Roba*) were subjected to yield trials from 2011 to 2013 (years). After the yield trial at five locations (Werer, Miesso, Pawe, Asossa and Babile) for three years (2011-2013), the genotypes with the accession codes of ICGV-98412, ICGV-98404 and ICGV-94100 were identified and proposed as new varieties with the local names *Babile-1, Babile-2* and *Babile-3*, respectively, to be cultivated in Ethiopia. The three genotypes were introduced from International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), India. Babile-1 and Babile-2 out yielded the standard check variety *Roba* by 33 and 12%, respectively. The seed color of these varieties is red tan. Hundred seed weights of *Baile-1* and *Babile-2* were 78.07 and 79.5g, respectively, which were significantly higher by about 13.47 and 13.71%, respectively, than check variety *Roba* with 57.95g hundred seed weight. *Babile-3* out yielded the standard check variety *Roba* by 26%. The three varieties were also found to be resistant to major diseases such as leaf spots and showed stability for yield over locations and seasons. Therefore, the three varieties, *Babile-1, Babile-2* and *Babile*-3 were approved by the National Variety Releasing Committee of the country in 2016 to be cultivated in the lowland agroecolgy.

Keywords: *Arachishypogaea* L., Genotypes; Oil content; Standard check variety; Yield

1. Introduction

Groundnut (*Arachishypogaea* L.) was first introduced to Eritrea and then to Hararghe in early 1920s by Italian explorers (Yebio, 1984). Nowadays groundnut is well disseminated in the warm lowlands of the country and is the second important lowland oilseed crops of the warm climate. The crop is produced mainly by smallholder farmers and plays a significant role in Ethiopian economy. It provides raw material for the food oil factory; it has high energy content; and it is also a main source of cash income. Major groundnut producing areas in Ethiopia are Babile, Gursum, Beles, Didessa, Gambella, and Pawe, Gamu Gofa, Illubabor, Gojam, Wello and Wellega are identified as potential production areas (Danel, 2009). Moreover, there are pockets of areas of groundnut production in Gambella, Harari, and Dire Dawa regions. It is also grown under irrigation in middle Awash and Gode. The national average seed yield and area coverage of groundnut were 1.6 t ha^{-1} and 64,649.3 hectares**,** respectively (CSA, 2015).

Groundnuts are becoming increasingly important in Ethiopian agriculture and domestic demand has been on the rise. However, the production of the crop is constrained by several biotic and abiotic factors, which include critical moisture stress especially during flowering, lack of improved varieties and appropriate production and post-harvest practices, and diseases affecting both above-and underground parts of the plant (Fredu *et al*., 2015). Although the national average seed yield of 1.6 t ha^{-1} (CSA, 2015) is by far higher than 1.49 and 0.98 t ha^{-1} of the world and African countries average productivity of the crop, respectively (FAOSTAT, 2010), it is low compared to the attainable yield of 6 t ha^{-1}of unshelled groundnut seed yield at research centers (Dandenna *et al*., 2010). Therefore, the national groundnut project coordinated by Haramaya University has been striving to develop varieties with high yield, disease resistance, high seed oil content and other desirable agronomic traits to increase the production and productivity of the crop in the country. Several groundnut genotypes introduced from International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) were evaluated for yield and other desirable agronomic traits aiming to identify genotypes that have better yield than the existing varieties and cultivars cultivated in the country. Yield trials were conducted using 29 genotypes at Werer, Miesso, Pawe, Asossa and Babile for three years (2011-2013). The results showed that genotypes with the accession codes of ICGV-98412, ICGV-98404 and ICGV-94100 were superior to the standard check variety Roba (ICG-273). The standard check variety *Roba* (ICG-273) was released in 1989

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ISSN 1993-8195 (Online), ISSN 1992-0407 (Print)

by Werer Agriculture Research Center (MoANR, 2016). Thus, the three new varieties were verified and approved by National Variety Release Committee of the country as new varieties with local names*Babile-1, Babile-2* and *Babile-3*, respectively, to be cultivated in lowlands of Ethiopia.

2. Agronomic and Morphological Characteristics

Babile-1 has upright growth habit, whereas *Babile-2* has spreading growth habit and both have sequential branching form; they mature in 131-132 days whereas the standard check matures in 136 days. In addition, they have red tan seed color. *Babile-1* and *Baile-2* had 78.07 and 79.5g hundred seed weight, respectively (Table 1). *Babile-1* and *Babile-2* are high yielding, large seeded, medium maturing and Spanish type groundnut varieties. Leaf spot is one of the major threats in the groundnut production. Leaf spot incidence was scored on a 1-9 field scale (Faujdar and Oswalt, 1992), and both *Babile-1* and *Babile-2* showed moderate resistance to the aforementioned disease throughout the study periods in the study areas. *Babile-3* showed slightly better performance than the check variety, *Roba*, to the leaf spot interaction and it is categorized as moderately resistant to leaf spot in the tested locations over seasons. Leaf spots are the most widespread diseases of groundnut that result in severe yield losses in Ethiopia (Solomon and Amare, 2015).

All the three new varieties (*Babile-1, Babile-2* and *Babile-3*) are recommended for production in Ethiopia in the altitude range of 750 to 1650 meters above sea level. The varieties were evaluated without application of fertilizers. The description of the varieties is presented in Table 1 as it was registered in variety registry book (MoANR, 2016).

Table 1. Agronomic and morphological characters of three new groundnut varieties.

Characteristics	*Babile-1*	*Babile-2*	*Babile-3*
Adaption area	Werer, Miesso, Assosa, Pawe and Babile	Same	Same
Altitude (meters above sea level)	750-1650	750-1650	750-1650
Rainfall (mm)	569 - 1100	569 - 1100	569 – 1100
Planting date	At the beginning of the summer for rain fed areas, mid-May for Babile	Same	Same
Seeding rate (kg/ha)	60-110	60-110	60-110
Spacing (cm): between plants	10	10	10
between rows	60	60	60
Days to flowering	48	52	59
Days to maturity	131	132	142
Shelling percentage	67.83	62.2	66.07
Growth habit	Spanish bunch with sequential branching	Same	Same
100 seed weight	78.07	79.5	53.65
Seed color	Tan	Tan	Tan
Flower color	Yellow	Yellow	Yellow
reaction to leaf spot (1-9 scale)	2.7	2.7	2.67
Oil content (%)	49.32	51.13	51
Seed yield (t/ha): Research field	2.4	2.02	2.43
Farmers' field	1.9	1.8	1.65
Year of release	2016	2016	2016
Breeder/ Maintainer	Haramaya University	Same	Same

3. Seed Yield

The three varieties, *Babile-1, Baile-2,* and *Baile-3* had significantly higher average seed yields of 2.42, 2.03 and 2.43t ha^{-1}, respectively, than the average seed yield of the standard check variety *Roba* (1.81 and 1.93 t ha^{-1} in the 1st and 2nd sets of experiments, respectively) (Table 2). *Babile-1, Baile-2* and *Baile-3* exhibited seed advantages of 33, 12 and 26%, respectively, over the standard check variety *Roba*. The yield advantages of the three new varieties are reasonably high to increase the yield of groundnut in the country.

Table 2. Mean seed yield of groundnut varieties at five locations over three years (2011 to 2013).

First set experiment					Second set experiment			
Location	Year	*Babile-1*	*Babile-2*	*Roba*	Location	Year	*Babile-3*	*Roba*
Assosa	2012	2.66	1.85	1.54	Pawe	2012	1.91	1.23
	2013	2.55	2.64	2.2		2013	1.69	2.11
Babile	2012	1.28	1.32	1.1	Babile	2012	2.65	1.86
	2013	1.32	0.61	0.49		2013	1.89	1.7
Pawe	2013	1.33	1.02	1.16	Assosa	2013	1.58	0.7
Werer	2011	3.85	3.03	3.23	Werer	2011	1.37	0.61
	2012	5.05	5.48	5		2012	5.2	2.89
	2013	3.9	2.74	2.3		2013	5.65	2.8
Miesso	2011	1.68	1.64	1.19	Miesso	2011	1.95	3.95
	2012	1.09	0.6	0.7		2012	1.52	1.9
	2013	1.88	1.44	1.05		2013	1.63	1.46
Mean (t ha^{-1})		2.42	2.03	1.81	Mean (t ha^{-1})		2.43	1.93
Yield advantage (%)		33	12		Yield advantage (%)		26	

4. Yield Stability

Additive Main Effects and Multiplicative Interaction (AMMI) (Zobel *et al*., 1988) model analysis of variance was conducted for 11 (*Babil-1* and *Babile-2*) and 12 (*Babile-3*) environments considering each location and one season as one environment. The result indicated that the mean squares for genotype and environment were significant while the mean square for genotype x environment interaction (GEI) was nonsignificant for the experiment conducted at 11 (*Babil-1* and *Babile-2*) environments (Table 3). This implies that the varieties were stable and widely adaptable. The nonsignificant effect of GEI on yields of varieties indicated absence of crossover GEI and consistent yield ranks of varieties over environments since the presence of significant effect of GEI showed the differential yield ranks of varieties due to the presence of crossover GEI (Kang, 2002).

In the case of analysis of variance from AMMI model for 12 (*Babile-3*) environments, the mean squares for genotype, environment and genotype x environment interaction (GEI) were highly significant ($P < 0.01$) (Table 2). This indicated the differential yield ranks of varieties due to the presence of crossover GEI (Kang, 2002). In such case, evaluation of varieties over environments for mean yield and stability is necessary to select varieties that perform well consistently in all environments or to identify specific varieties for each environment (Gauch, 2006).

Table 3. Analysis of variance (ANOVA) from AMMI model for seed yields of genotypes at 11 (*Babile-1*and *Babile-2*) and 12 (*Babile-3*) environments.

Source	ANOVA for 11(*Babile-1and Baile-2*) environments			ANOVA for 11 (*Baile-3*) environments		
	df	SS	MS	df	SS	MS
Total	479	832.4	1.738	575	2375.6	4.13
Treatments	159	736	4.629	191	2294.1	12.01
Genotypes	15	10.6	0.708*	15	22.8	1.52**
Environments	9	689.8	76.646**	11	2023.1	183.91**
Block	20	7.2	0.358	24	6.7	0.28
Interactions	135	35.5	0.263	165	248.2	1.5**
IPCA 1	23	11.4	0.495	25	124.6	4.99
IPCA 2	21	7.2	0.341	23	50.6	2.2
Residuals	91	17	0.187	117	72.9	0.62
Error	300	89.3	0.298	360	74.8	0.21

*Notes: *and * *, significant at P < 0.05 and P < 0.01, respectively; df = degree of freedom; SS= total sum square; MS= mean square; Interactions= genotype by environment interaction; IPCA 1 and IPCA 2, interaction principal component axis one and two, respectively.*

Stability parameters of Eberhart and Russell (1966) model i.e. regression coefficient (b_i) and deviation from linear regression (S^2di) were computed for mean seed yield. The result from this model revealed that *Babile-3* had high seed yield mean values, low regression coefficient (0.633) and significant deviation from the regression slope (Table 4). This suggested that the variety and the tested genotypes were sensitive to changed environments but responsive to environments as observed from coefficient determination (R^2) being >0.5 for all genotypes. According to the Eberhart and Russell (1966), regression coefficient (b_i) approximating unity along with deviation from regression (S^2di) near zero indicated the average stability of genotypes. Accordingly, *Babile-3* showed unpredicted yield performance due to its significant deviation from the regression slope. However, the stability alone has not practical utility as far as the varieties have low mean over environments (Dabholkar, 1998). On the other hand, high mean yield of the variety could not be the only criterion for selection unless its high performance is established over a wide range of environments since a variety with high mean performance across environments is an advantage for farmers to obtain larger harvest due to large genotypic effect and small genotype x environment interaction (Flis *et al.*, 2015). The average yield of genotypes were 2.43 t ha^{-1} in which *Babile-3* had mean seed yields of above or equal to average yield of genotypes at seven environments (Table 2) and suggested to be recommended as variety more preferable environments (locations) where the variety performed best.

Table 4. Stability parameters from Eberhart and Russells' (1966) model for mean seed yields of genotypes at 12 (*Babile-3*) environments.

Genotype	Mean	b_i	S^2di	R^2
ICGV-94100 (*Babile 3*)	2.412333	0.6333	1.4678	0.5789
ICGV-94105	2.09975	0.7032	0.5127	0.8146
ICGV-96242	2.34525	1.3192	0.0111	0.9895
ICGV-96245	2.39025	1.3076	0.2286	0.9665
ICGV-97150	1.886333	1.0118	0.266	0.9392
ICGV-97153	2.10625	1.095	0.0797	0.9745
ICGV-97157	2.189083	1.0562	-0.0548	0.9945
ICGV-97160	1.978583	1.3172	0.2446	0.9654
ICGV-97163	2.18075	1.0557	0.2855	0.9409
ICGV-97164	2.021083	0.9525	-0.0055	0.9834
ICGV-97165	2.20675	1.2085	0.2904	0.9537
ICGV-98369	1.94775	0.9804	0.447	0.9055
ICGV-98370	2.016	0.9724	0.1266	0.9593
ICGV-98371	2.12025	0.7829	0.0062	0.9722
ICVG-97156	1.710333	1.1539	-0.0493	0.9947
Roba	1.93	0.4502	0.1464	0.8221

Notes: b_i= regression coefficient; S^2di = deviation from linear regression; and R^2 = coefficient of determination.

5. Other Attributes

The two varieties *Babile-1* and *Babile-2* were early maturing than the check variety *Roba.* The shelling percentage of *Babile-1* was greater than that of the standard check Rob variety while *Babile-2* had 0.3% lower shelling percentage than that of *Roba* variety (Table 5).The seed oil contents of the three released varieties, *Babile-1, Babile-2* and *Babile-3* were found to be 2.13, 3.94, and 3.67% higher than the seed oil content of the standard check variety *Roba,* respectively (Table 6).

Table 5. Maturity, shelling percentage, and hundred seed weight of three groundnut varieties.

No	Genotype	Days to flowering	Days to maturity	Shelling percentage	100 seed weight(g)
1	*Babile-1*	48	131	67.83	78.07
2	*Babile-2*	51	132	66.2	79.50
3	*Roba* (check variety)	56	136	66.51	57.95

Table 6. Seed oil content of four varieties of groundnut evaluated at 11 and 12 environments.

No.	Variety	Oil content (%)
1	*Babile-1*	49.32
2	*Babile-2*	51.13
3	*Babile-3*	51
4	*Roba* (check variety)*	47.19
5	*Roba* (check variety)**	47.33

*Note: * = At 11 Environments; ** = At 12 Environments*

6. Conclusion

The results of this study have demonstrated that the released varieties *Babile-1, Babile-2,* and *Babile-3* are superior to the commercial (standard check) *Roba* variety in terms of seed yield and seed oil content. The results have also revealed that the three varieties are relatively stable over locations and seasons, and have other desirable traits like resistance to leaf spot disease. The high seed production potential of the varieties implies that increased production and productivity of the crop by smallholder farmers in the country at large. In conclusion, the newly released varieties *Babile-1*, *Babile-2*, and *Babile-3* could be cultivated profitably and sustainably in the lowlands of Ethiopia, leading enhanced income of smallholder farmers.

7. Acknowledgments

The authors are grateful to the Ethiopian Institute of Agricultural Research for providing the fund required to do the research. The authors thank also the Office of the Vice-President for Research Affairs of Haramaya University for its unreserved support in facilitating the research activities. The authors acknowledge Werer Agricultural Research Center, Pawe Agricultural research center, Asossa Agricultural Research Center, and Haramaya University staff for contributing to the success of this work.

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