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The Evaluation of Genetic Potential and Adaptability of Bambara Groundnut Genotypes (Vigna subterranea (L.) Verdc.) Under Libyan Climatic Conditions

***Mohamed Milad Mohamed Draweel[1], Amar Omran Alshmam [2]**
[1,2]Department of Crop Science, Faculty of Agriculture,
Tripoli University, Libya.
*Corresponding Author: Email mo.draweel@uot.edu.ly

Abstract
A field experiment was conducted in the Al-Shaafeen / city of Maslata area in the coastal strip area, east of Tripoli - Libya, during the dry season, in the period from April - November 2023. The objective of the experiment was an evaluation of the genetic potential and adaptability of Bambara groundnut genotypes under Libyan Climatic Conditions. Two genotypes were tested (BBL 1.1 from Indonesia, and Tvsu 86 from Thailand). A completely randomized design was used for this experiment with three replications.
The genotype BBL 1.1 showed clear superiority over the genotype Tvsu 86 in the average plant height, number of leaflets per plant, number of leaves per plant, number of branches per plant, number of pods per plant, number of seeds per plant, fresh weight of pods per plant, dry weight of pods per plant, weight of seeds per plant, Weight of 100 seeds, and Total weight of seeds and was the fastest in maturing. Despite its delay in flowering, in addition, the genotype BBL 1.1 possessed inherently high yield potential and showed a grain yield of 321.6 kg/ha compared with genotype Tvsu 86 a grain yield of 24.7 kg/ha. The genotype BBL 1.1 was more adapted to the Libyan climatic conditions and excelled in its performance in field growth, which shows that this genotype maintains stable performance under various conditions.
Keywords: Bambara groundnut, Genetic Potential, Adaptability, Climatic Conditions.

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تقييم الإمكانات الوراثية والقدرة على التكيف للأنماط الجينية للبامبارا (*Vigna subterranea* L. Verdc.) تحت الظروف المناخية الليبية

*محمد ميلاد دراويل[1] , عمار عمران الشمام[2]

[2,1] قسم علوم المحاصيل , كلية الزراعة , جامعة طرابلس , ليبيا

*mo.draweel@uot.edu.ly

الملخص

أجريت تجربة حقلية بمنطقة الشعافيين/ مدينة مسلاتة بمنطقة الشريط الساحلي شرق طرابلس – ليبيا خلال موسم الجفاف في الفترة من أبريل – نوفمبر 2023. وكان الهدف من التجربة تقييم الإمكانات الوراثية والقدرة على التكيف للأنماط الجينية للبامبارا تحت الظروف المناخية الليبية. تم اختبار اثنين من الأنماط الجينية (BBL 1.1 من إندونيسيا، و Tvsu 86 من تايلاند)، واستخدام التصميم العشوائي الكامل لهذه التجربة بثلاث مكررات. أظهر التركيب الوراثي BBL 1.1 تفوق واضح على التركيب الوراثي Tvsu 86 في متوسط ارتفاع النبات، عدد الوريقات للنبات، عدد الأوراق للنبات، عدد الأفرع للنبات، عدد القرون للنبات، عدد البذور للنبات، الوزن الطازج للقرون للنبات الواحد، الوزن الجاف للقرون للنبات الواحد، وزن البذور للنبات الواحد، وزن 100 بذرة، والوزن الكلي للبذور وكان الأسرع في النضج. على الرغم من تأخره في الإزهار، بالإضافة إلى ذلك، فإن النمط الوراثي BBL 1.1 يمتلك إمكانات إنتاجية عالية بطبيعته وأظهر محصول حبوب قدره 321.6 كجم/هكتار مقارنة مع النمط الوراثي Tvsu 86 الذي بلغ محصوله من الحبوب 24.7 كجم/هكتار. وكان النمط الجيني BBL 1.1 أكثر تكيفاً مع الظروف المناخية الليبية وتميز في أدائه في النمو الحقلي، مما يدل على أن هذا النمط الجيني يحافظ على أداء مستقر في مختلف الظروف.

الكلمات المفتاحية: البامبارا، الإمكانات الوراثية، القدرة على التكيف، الظروف المناخية.

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INTRODUCTION

Bambara groundnut is a legume crop that originated in Africa and is an important food source for rural households, commonly referred to as a poor man's crop an important legume has the potential to improve nutrition and boost food security, which makes it a good complement to cereal-based diets, where the seeds contain nearly 63% of carbohydrates, 19% protein, 6.5% fats, 10.43% water, and 3.03% ash (*Hidayah et al.*, 2012; Rodrigues *et al.*, 2011). The Bambara groundnut belongs to the family Leguminosae, subfamily Papilionoideae, and genus Vigna (Fatokun *et al.*, 1993). Both wild and cultivated species have 2n=2x=22 number of chromosomes (Forni-Martins, 1986). Bambara is also an annual herbaceous plant bearing clustered leaves arising from creeping stems that grow close to the ground. The growth habit of the crop may be clustered (erect), semi-clustered, or spreading. It is naturally self-pollinating(Basu *et al.*, 2007a). The leaves are trifoliate, forming a cluster arising from branched stems that are either purple or green colour and are borne on a long, erect, and glabrous petiole, thickened at the base. Stem branching begins early, about one week after germination. Up to 20 or more branches may be borne on a single plant, depending on the genotype (Abejide *et al.*, 2018). The plant has a well-developed taproot system, with abundant lateral roots that grow geo-tropically (Massawe *et al.*, 2002). The roots form nodules for nitrogen fixation, in association with suitable rhizobia especially strains of Bradyrhizobium (Linnemann *et al.*, 1993). The flowers are typically papilionaceous and are borne in a raceme on long, hairy peduncles that arise from the nodes on the stem. It forms pods and seeds on or just below the soil surface (Basu *et al.*, 2007b). The shape of the pod is either small (1.5 cm long), round, or slightly oval-shaped and wrinkled containing mostly one or sometimes two seeds, but pods with three seeds have been reported in the Congo (Goli *et al.*, 1988). In Africa, the seed of Bambara groundnut is consumed in several ways, and at different stages of maturation, as a vegetable or snack. The young fresh seeds may be boiled and eaten as a snack like boiled peanuts, as well as Bambara groundnut, is used for bread making and to produce legume milk, and dried seeds can be roasted and eaten as

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confectionery(Majola *et al.*, 2021). The seed is regarded as a balanced food because when compared to most food legumes, it is rich in iron and its protein contains high levels of lysine and methionine (Adu-Dapaah *et al.*, 2004; Massawe *et al.*, 2005). The crop is now widely distributed and grown in Northern Australia, in Asia especially India, Indonesia, Malaysia, the Philippines , Thailand, New Caledonia, and in South America, particularly in Brazil (Rassel, 1960; Suwanprasert *et al.*, 2006). Therefore this research will look at an evaluation of the genetic potential and adaptability of Bambara groundnut genotypes under Libyan Climatic Conditions.

MATERIALS AND METHODS

A field experiment was conducted in the Al-Shaafeen / city of Maslata area, which is approximately 235 m above sea level in the coastal strip area, which is located approximately 100 km east of Tripoli city in Libya, during the dry season, in the period between April and November 2023. The objective of the experiment was an evaluation of the genetic potential and adaptability of Bambara groundnut genotypes under Libyan Climatic Conditions. Two genotypes were tested (BBL 1.1 from Indonesia, and Tvsu 86 from Thailand). A completely randomized design was used for this experiment with three replications. This experiment was conducted on a plot of land with an area of 4 m (width) x 3 m (length) = 12 m^2, so that each genotype had three lines and each line was considered a replicate. Each line contained eight plants and the distance between the plants was 30 cm, the distance between the lines was 50 cm, and the distance between the genotypes was one meter. The seeds were placed in water for 24 hours before planting, then planted in the soil to a depth of 2-3 cm on Thursday, April 20, 2023. The plots were weeded manually to keep weed pressure low. No fertilizer was added to the experiment, as the experiment was without fertilization, and the experiment was monitored until the harvest period. The experiment was harvested on Monday, November, 20th, 2023 for the genotype (BBL1.1), and on Saturday, November, 25th, 2023 for the genotype (TVSU 86),

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When the plants reached maturity. The Fresh pods were weighed per plant. The pods dried under the sun for two weeks, then they were weighed dry and cracked to extract the seeds and weighed. Other data were recorded, and this experiment was under a system with full irrigation. All results were analyzed using the GenStat 19 statistical program, and a one-way analysis of variance (ANOVA) was performed to evaluate differences in some characteristics of the studied genotypes. The least significant difference (LSD) was used at a significance level of 5%.

Figure 1. The photo for this experiment shows the growth of Bambara groundnut in the Al-Shaafeen field/city of Maslata in Libya.

RESULTS AND DISCUSSION

Assessment of qualitative variation :

There were differences in seed colour between genotype BBL 1.1, and genotype Tvsu 86 after the end of the experiment and harvesting the plants. The seeds of Genotypes BBL1.1 and Tvsu 86 used in this experiment had black colour with white eye colour before planting (Fig. 2). However, after the end experiment and harvesting the plants, drying the pods, and extracting seeds, the seeds changed to reddish-brown with white eye colour for genotype BBL 1.1 and light-brown with white eye colour for genotype Tvsu 86 (Fig. 3). The genotypes differed in the seed colour after the end of the experiment and harvesting of the plants compared to the original seed colour. This was consistent with a study SARI *et al.* (2021) which indicated among Bambara genotypes differences in seed coluor, and seed size. In addition, Khan *et al.* (2021) said there were highly significant differences among the qualitative traits of Bambara genotypes.

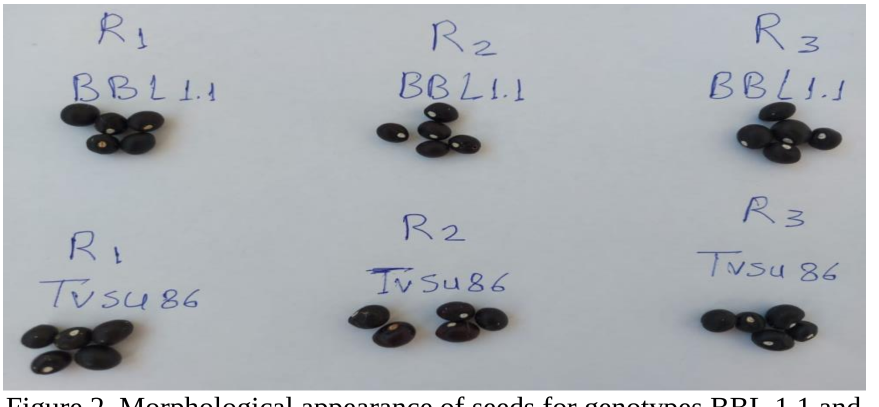

Figure 2. Morphological appearance of seeds for genotypes BBL 1.1 and Tvsu86 before planting.

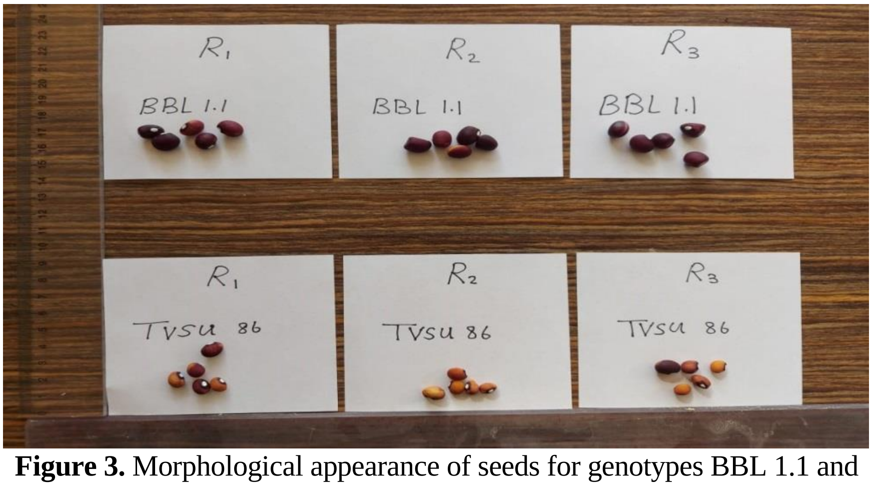

Figure 3. Morphological appearance of seeds for genotypes BBL 1.1 and Tvsu86 after the end experiment and harvesting of the plants.

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Assessment of quantitative variation :

1. Table 1 shows a significant difference between genotype BBL 1.1 and genotype Tvsu 86 in all the studied traits, where the highest average plant height, number of leaflets per plant, number of leaves per plant, and number of branches per plant were in genotype BBL 1.1 (23.67 cm, 919, 306, and 36.67 respectively) while the lowest average was in genotype Tvsu 86 (19 cm, 517, 172, and 28.33 respectively). These results are consistent with a study by Ntundu *et al.* (2006) and Zenabou *et al.* (2014) in Tanzania that reported significant differences among quantitative traits of Bambara groundnut landraces including petiole length, plant spread, plant height, seed length, seed width, among others. Another study by Draweel *et al.* (2020) and Draweel *et al.* (2021) in Indonesia reported significant differences among Bambara groundnut genotypes in hypocotyl length, root length, number of leaflets, number of leaves, Fresh weight of the seedling, and dry matter of the seedling.

Table 1. The mean comparison of physiological traits of two Bambara groundnut genotypes.

No	Genotypes	PH (cm)	NLTP	NLP	NBP
1	BBL 1.1	23.67	919	306	36.67
2	Tvsu 86	19	517	172	28.33

Note: (PH) plant height (cm), (NLTP) number of leaflets per plant, (NLP) number of leaves per plant, and (NBP) number of branches per plant.

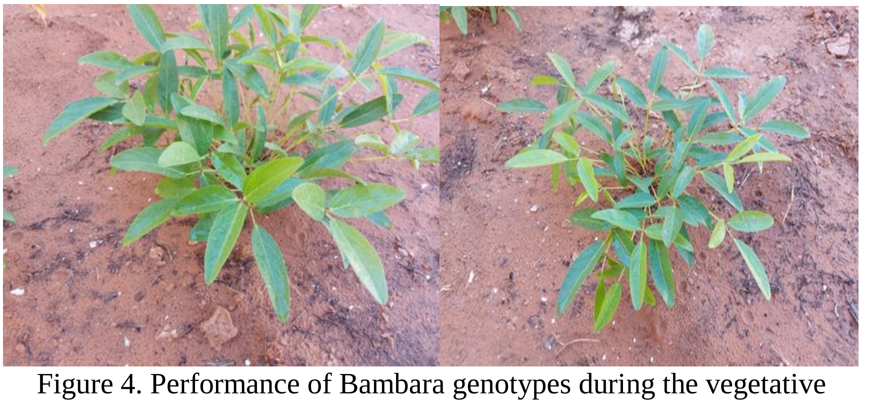

Figure 4. Performance of Bambara genotypes during the vegetative growth stage in the Al-Shaafeen field/city of Maslata in Libya.

2. Table 2 shows a significant difference between genotype BBL 1.1 and genotype Tvsu 86 in all the studied traits, where the highest average number of days to 50% flowering was in genotype BBL 1.1 at 145.67 (late flowering) while the lowest average was in genotype Tvsu 86 at 141.67 (Early flowering), whereas the highest average number of days to 50% maturity was in genotype Tvsu 86 at 220.33 (late maturity), whilst the lowest average was in genotype BBL 1.1 at 215 (early maturity). The highest average of the number of pods, and seeds per plant was in genotype BBL 1.1 (122.2, and 139.2 respectively), while the lowest average was in genotype Tvsu 86 (23.3, and 21 respectively).

Table 2. The mean comparison of vegetative traits of two Bambara groundnut genotypes.

No	Genotypes	NF50%	NM50%	NPP	NSP
1	BBL1.1	145.67	215	122.2	139.2
2	Tvsu 86	141.67	220.33	23.3	21

Note: (NF50%) number of days to 50% flowering, (NM50%) number of days to 50% maturity, (NPP) number of pods per plant, and (NSP) number of seeds per plant.

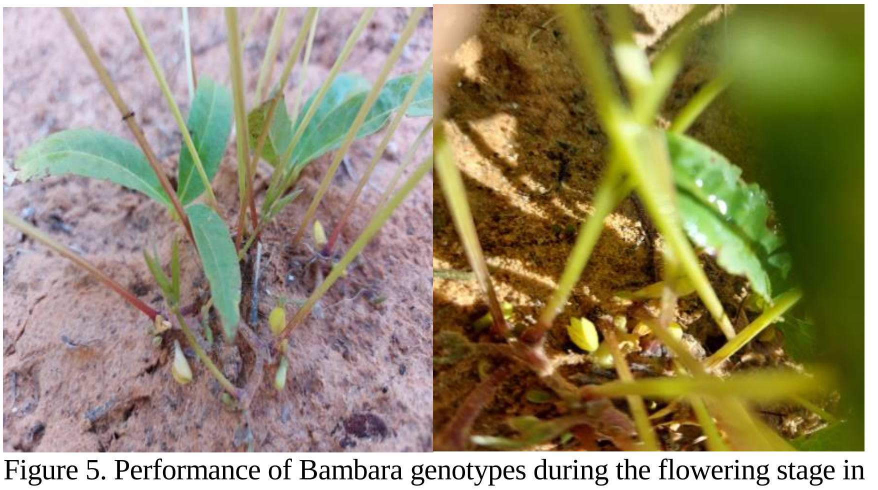

Figure 5. Performance of Bambara genotypes during the flowering stage in the Al-Shaafeen field/city of Maslata in Libya.

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Figure 6. High pods load in individual plants of Bambara groundnut genotypes in the Al-Shaafeen field/city of Maslata in Libya.

The difference among the genotypes in the flowering date and maturity is natural because of the difference between them in their response to environmental conditions and the extent of their adaptation and performance, as well as, due to the genetic structure of genotypes, all these may influence the performance of plants and this is consistent with the study Shegro *et al.* (2013) which indicated that plants show certain changes in yield-related traits and showed that cultivar and environment may influence performance.

3. Table 3 shows a significant difference between genotype BBL 1.1 and genotype Tvsu 86 in all the studied traits. The highest average fresh weight of pods per plant, dry weight of pods per plant, the weight of seeds per plant, Weight of 100 seeds, and Total weight of seeds were in genotype BBL 1.1 (178 (g), 66.96 (g), 48.24 (g), 52.29 (g), and 321.6 (Kg/ha) respectively), while the lowest average was in genotype Tvsu 86 (21.2 (g), 6.35 (g), 3.71 (g), 28.78 (g), and 24.7 (Kg/ha) respectively).

Table 3. The mean comparison of 5 yield-related traits of two Bambara groundnut genotypes.

No	Genotypes	FWPP (g)	DWPP (g)	WSP (g)	W100 S (g)	TWS (Kg/ha)
1	BBL 1.1	178	66.96	48.24	52.29	321.6
2	Tvsu 86	21.2	6.35	3.71	28.78	24.7

Note: (FWPP) Fresh weight of pods per plant (g), (DWPP) Dry weight of pods per plant (g), (WSP) weight of seeds per plant (g), (W100S) Weight of 100 seeds (g), and (TWS) Total weight of seeds (Kg/ha).

The genotype showed BBL 1.1 clear superiority over the genotype Tvsu 86 in the average plant height (cm), number of leaflets per plant, number of leaves per plant, number of branches per plant, number of pods per plant, number of seeds per plant, fresh weight of pods per plant, dry weight of pods per plant, weight of seeds per plant, Weight of 100 seeds, and Total weight of seeds and was the fastest in maturing. Despite its delay in flowering.

Figure 7. The shape of seeds in two genotypes of Bambara groundnut produced in the Al-Shaafeen field/city of Maslata in Libya.

This indicates that the genotype BBL 1.1 was more adapted to the Libyan climatic conditions and that this genotype excels in its performance in field growth, which shows that this genotype maintains stable performance under various conditions. this is consistent with studies (Heller *et al.*, 1997; Siise *et al.*, 2013) which showed crop of Bambara tolerates drought, has high nutritional variability, can adapt to adverse environmental conditions, and is resistant to pests and diseases prevailing during growth period of the crop.

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CONCLUSION

The genotypes differed in their adaptation to the climatic conditions prevailing in the region in which they were planted and the BBL 1.1 genotype showed clear superiority over the genotype Tvsu 86 in the average plant height (cm), number of leaflets per plant, number of leaves per plant, number of branches per plant, number of pods per plant, number of seeds per plant, fresh weight of pods per plant, dry weight of pods per plant, weight of seeds per plant, Weight of 100 seeds, and Total weight of seeds and was the fastest in maturing. Despite its delay in flowering, in addition, the genotype BBL 1.1 possessed inherently high yield potential and showed a grain yield of 321.6 kg/ha compared with genotype Tvsu 86 a grain yield of 24.7 kg/ha. This indicates that the genotype BBL 1.1 was more adapted to the Libyan climatic conditions and that this genotype excels in its performance in field growth, which shows that this genotype maintains stable performance under various conditions.

Recommendations

Bambara groundnut is an important African indigenous legume with high nutritional value, drought tolerance characteristics, and N-fixation properties. This combination makes it a possible multi-use crop in marginal areas of agricultural production with great potential to contribute to food and nutritional security in Africa and should be included in feeding regimes, especially in malnourished areas.
Finally, from the results of this study, we recommended the following :

- Cultivation of genotypes BBL 1.1 and Tvsu 86 in other areas and under different climatic conditions.
- It is important to conduct several experiments, tests, and measurements to determine the most appropriate date for planting these genotypes.
- recommend intensification of research on Bambara genotypes the research for new varieties of Bambara and the determination of the agricultural practices that maximize the productivity of these varieties.

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