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Phenotypic Diversity of Pearl Millet (*Pennisetum glaucum* [L. R. Rr.]) Accessions in Zamfara State, Nigeria

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Abstract
This study was conducted in the Bobo and Tashar Taya areas of Zamfara State, to examine the phenotypic characteristics of pearl millet and identify the varieties with a good physical appearance. Little is known about the phenotypic diversity of pearl millet accessions in the State. Methods used for data collection involved transect walks and in-depth interviews. Sampling involved two phases first, two study villages were sampled secondly, thirty-nine respondents were sampled for semi-structured interview administration. Data on phenotypical traits were collected based on 4 qualitative and 6 quantitative traits, presented in tabular form, and analyzed using simple percentages. The findings revealed that spike shapes vary from cylindrical; spindle, candle, and monkey tail. The entire collection displayed 6 types of seed colours; black 11%, brown 5.5%, whitish 5.5%, grey 28%, light green 28% and brownish 22%. Different spike lengths were observed between a range of 34 and 93 cm long. Spike diameter also varied among the accessions between 2.0 and 3.6 cm. It was discovered that *Maiwa Gajera* MLVBB10 with a grain weight per 1000 of 18.8 g had the highest grain weight of 1000 seeds and the least was *Tarmekuwa* MLVBB9 with 6.9 g/1000. It revealed that the 2 accessions *Dandigali Dogo* MLVBB5 and *Soso* MLVBB11 with the highest total seed per spike of 10416 and 8125 seeds, were collected from Bobo. This study recommended that farmer-based millet crop selection and improvement should be encouraged through initiatives like seed selection, seed exchange, seed fairs, and seed treatment.

Keywords: Accessions, Diversity, Pearl Millet, Phenotypic

Introduction

Pearl millet is a critical resource for combating the food security of poor farmers that form a major part of Nigeria's population (Mukhtar, 2017). Pearl millet grain contains 27% to 32% more protein, a higher concentration of essential amino acids, twice the fat, and higher gross energy than maize (Davis *et al.,* 2003). Pearl millet is a major source of calories and a vital component of food security in semi-arid areas in the developing world (Badau, 2006). Despite the desirable characteristics and importance of pearl millet as a staple cereal with nutritional and medicinal value, it has received inadequate attention from the scientific community, political support, and funding agencies as compared to other major cereals (Abdulhakeem *et al*., 2019). This neglect is largely due to its socio-ecological condition, as it is a crop of poor farmers in marginal agricultural areas (Jukanti *et al*., 2016). Several studies on the traits of pearl millet were conducted elsewhere. For example, Angarawai *et al.* (2016) carried out a study on the morphological characteristics of Maiwa accessions in Adamawa, Taraba, Sokoto-Kebbi, and Bauchi. Mohammed (2005) identified the phenotypic diversity of twelve landraces of pearl millet in semi-arid northeastern Nigeria. Izge and Song (2013) reviewed the problems in pearl millet production and breeding and its prospects in Nigeria. Ojediran *et al*. (2010) also reported some physical properties of Pearl millet (*Pennisetum glaucum*) seeds as a function of moisture content in Barno State.

Little is known about the phenotypic diversity of pearl

millet accessions in Zamfara State. To our knowledge, no work has been reported from Zamfara State on the subject matter. This study will make an inventory of the existing and their phenotypic characteristics in the area. Thus, this study examined the characteristics of pearl millet in Bobo and Tashar Taya villages in the Western zone of Zamfara State, to identify the varieties with good characteristics for sustainable food security and to sustain the livelihood of smallholder farmers in the area.

Materials and Methods

Study Area

The study was conducted in the Bobo and Tashar Taya areas of Zamfara State with coordinates 12°17′17.0″N 006°08′43.2″E and 12°01′11.6″N 005°31′04.3″E respectively. The state is well-known for the production of groundnuts, rice, pearl millet, sorghum, maize, root crops, and vegetables. It has a daily mean temperature of 30°C to 33°C from March to May and has the lowest temperature of 10°C from September to February (Danjuma, 2018). The vegetation types are Sudan Savannah in the North and Southern Guinea Savannah in the South. It is distinguished by the large expanse of grasslands with widely spaced trees of varying heights and diversity (Abdulhakeem, 2019).

Sampling Procedures

Sampling involved two phases. First, 2 study villages were sampled. Secondly, thirty-nine respondents were sampled for semi-structured interview administration. A transect was conducted and an inventoried pearl millet cultivar in each village was collected with the help of a local guide (s) and farmers. Local names of the cultivars were identified through the farmers and classified in indigenous taxonomic terms.

Procedures for Data Collection

Inventoried pearl millet accessions were collected between August through November 2019 and were based on maturity periods as early (50-70 days), moderate (71-110 days), and late (110-140 days) with 4, 6, and 8 accessions, respectively. Qualitative data on phenotypical traits of pearl millet accessions were collected based on 4 qualitative and 6 quantitative traits.

Procedure for Data Analysis

Pearl millet data on phenotypic identification was presented in tabular form, analyzed using simple percentages, and presented in tables.

Results and Discussion

Qualitative Traits Variation of Pearl Millet Accessions

Spike Shapes

The results of qualitative variation of the accessions collected showed heterogeneity in spike shapes. The shapes vary from cylindrical; to spindle, candle, and monkey tail. Among the accessions, the cylindrical shape was the most dominant with a total of 9 accessions (50%), followed by candle 6 accessions (33%) and the least were monkey tail shape and spindle with only 1 accession (5.5%) each refers to table 1. The monkey tail shape comprises *Baragade* MLVTT2 and *Wutsiyar Biri* MLVBB6. The cylindrical shape had the highest percentage of the entire accessions collected based on maturity period, as early, moderate and late with 22%, 37%, and 41%, respectively refer to Table 1. The result of this study conforms to the report of 4 spike shapes across the growing state of (Adamawa, Gombe, Jigawa, Kano, Nasarawa, Niger, Kaduna, Sokoto, Taraba, and Zamfara) Northern Nigeria. Among the accessions collected cylindrical shape was the most dominant with 40% followed by candle shape with 37.14% conical and spindle with 11.43% each (Abdulhakeem *et al*., 2019). This result is in agreement with a previous study which reported that the most dominant two spike shapes were cylindrical (110) and candle (13) accessions with 89.4% and 10.6%, respectively (Asungre, 2014). Similar to the present finding, cylindrical/ candles were reported with the highest number of accessions out of a total of 221 collected from the National GenBank of India (Kumar *et al.*, 2016). A similar result with a higher percentage of cylindrical shape 84% was reported followed by candle and conical with 8% each in the study conducted among the three-pearl millet matured variety groups, the result revealed that cylindrical was dominated with 91.7%, 85.2%, and 93.3% for early, medium and late groups, respectively (Asungre, 2014). In contrast to these results, Singh *et al.* (2016) reported conical shape was the dominant accession and the least was lanceolate with only one accession (H 77/833-2-202). This finding is akin to the study conducted across 51 countries in the world. The report revealed a total of 9 spike shapes among the 21,594 accessions assembled of which candle shape had the highest frequency of 11,132 accessions followed by cylindrical (4,960 accessions) (Upadhyaya *et al.,* 2009).

Seed Colour

The entire collection displayed 6 type of seed colours which includes: black 11%, brown 5.5%, whitish 5.5%, grey 28%, light green 28% and brownish 22% (Table 1). The seed Colour studied revealed that grey, light green, / brownish were dominant among the accessions collected, while whitish accession 5.5% was only found among the accessions collected from Tashar Taya. However, the maximum 6 number of accession seed colours obtained in this study was lower than the total of 10 seed colours earlier reported in Northeastern Nigeria (Muhammad 2005). A similar report of 10 colours was also revealed in a large pearl millet assembled of accessions in India (Upadhyaya *et al.,* 2009). But the present study was slightly higher than the four colours of grey 58%, grey-brown 8%, Ivory 25% and yellow 8% (Gapili, 2019). The result achieved in the present study was akin to that which was reported by Asungre (2014). They classified one hundred and twenty-three accessions collected from 3 Pearl millet production regions of Ghana, into the maturity period and revealed that deep grey constituting 42.3% and grey constituting 38.2% were

dominant seed colours of early matured accessions, followed by grey-brown. Similarly, medium and late maturing groups did not show grey-brown Colour but showed that the dominant color for the medium group was grey. Certain accession colours were very rare as reported that *Mwonjera* was the only darker colour of pearl millet among the ten accessions collected in the study areas of Tharaka province of Kenya. The accession was very rare among the introduced varieties and was associated with memories and traditions (Mucioki *et al.*, 2014). A similar black accession *Chilum* was reported as rare among the accessions collected from Dagaceri in the Semi-arid of Northeastern Nigeria (Mohammed 2005) this view corroborates with other findings which revealed that in Burkina Faso, pearl millet farmers maintain seed purity by selecting pearl millet spikes with uniformity of grain color. This practice appears to favour seed quality and seed vigour and when farmers maintain it for five years, higher seed quality is obtained (Hodgkin *et al.,* 2007).

Seed Shapes

The seed shapes recorded in this study revealed 4 types, including; obovate 16.5%, oblanceolate 22%, globular 56%, and hexagonal 5.5%. The highest seed shape globular was recorded with 10 accessions among the 3-maturity period of early, moderate, and late with 1, 4 and 5 accessions respectively as shown in Table 1. The close agreement of these results was reported in research conducted in the Upper East, Upper West, and Northern regions of Ghana which revealed that the dominant seed shape among the total collections of one hundred and twenty-six accessions was globular with 60% (Asungre 2014). In another finding, obovate accessions were recorded with the lowest seed shape from the 3 states of Jigawa, Katsina, and Zamfara, the result also revealed that hexagonal shapes were all early matured accessions 50% found from Sokoto State. Only 15.39% of oblanceolate accessions were moderately matured while the rest 53.85% and 15.39% of accessions were early and late matured respectively (Abdulhakeem *et al*., 2019). The total number of 4 seed shapes recorded in this research was slightly higher than the 3 seed shapes earlier recorded for obovate 16.0%, hexagonal 24.0%, and globular 60.0%, and the finding revealed that the trend in terms of prominence was similar for individual maturity groups, except for the early group where obovate showed a higher percentage 25.0% than hexagonal 16.7% (Asungre 2014). In a similar vein, this result is in agreement with that of a recent report of 5 seed shape variability (Elliptical, Globular, Hexagonal, Obovate and Oblanceolate) that revealed globular with a percentage of 48.57% as the highest accession, followed by obovate 25.71%. The least elliptical shape 2.86% that was observed at Nasarawa was completely absent in other study locations (Abdulhakeem *et al*., 2019). It was also in agreement with 5 seeds (Upadhyaya *et al.,* 2009). In contrast to this finding, hexagonal seed shape 50% was reported as dominant, followed by globular 43% and obovate 17% (Gapili *et al*., 2019).

Seed Cover

In this study, 2 different seed covers were identified that comprise exposed and covered hairs with 83% and 17% respectively. The predominant seed cover was the exposed type, recorded in fifteen accessions, while only 3 accessions were recorded with hairs in the study locations. The dominant exposed type exhibited 3 different maturity periods, with dominant of late matured with 7 accessions equivalent to 56%. Exposed accessions were found among the two study villages while accessions covered with hairs were only found at Bobo village. These comprise *Dogon Gero Maigashi* (MLVBB4), *Zamfarwa Maigashi* (MLVBB7), and *Wuyan Bajini* (MLVBB8). The result achieved in the present study on types of seed cover was similar to the earlier reported two seed cover types which comprises covered with hairs accessions of *Gargasa, Argun Kundera* and *Tafsir* constituted 12% and exposed accessions with 88% (Muhammad 2005). This result was also comparable with the finding that reported 2 seed cover types, the exposed and the intermediate with thirteen and eleven accessions respectively (Singh *et al.,* 2016). A similar 2 seed cover types were reported with expouse at 67% and intermediate at 33% (Gapili 2019). All the findings were in congruence with the present findings, that the dominant seed cover was exposed type. A recent report also revealed that exposed accessions were the most abundant with a total of sixteen accessions equivalent to 45.71% followed by the intermediate with fifteen accessions 42.86% and the least enclosed type with 4 accessions at 11.11% (Abdulhakeem *et al*, 2019).

Quantitative Variation of Pearl Millet Accessions

Table 2 revealed the quantitative disparity among 6 variables of pearl millet accessions in the study area, in terms of spike length, spike diameter, spike weight, grain weight per 1000 seeds, the weight of seed per spike, and total seeds per spike.

Spike Length

Large phenotypic diversity in the collection has been observed for several characters. Different spike lengths were observed among the accessions in this study, between a range of 34 and 93 cm long (Table 2). The spike lengths were dissimilar from many findings such as a range from 22.67 to 66.25 cm (Abdulhakeem *et al.,* 2019). Pearl millet spike length was usually 15-45 cm long (Vara *et al.,* 2010). The longest and shortest spike lengths of 24.67cm and 15.3cm, respectively were reported in the findings of (Asungre 2014). Spike length was between 6.54 and 13.63 cm, (Animasaun *et al.,* 2017). The present study revealed 2 accessions with the longest spike length of 93cm each which comprise *Zamfarwa Maigashi* (MLVBB7) and *Zango Dogo* (MLVTT1). The longest accessions in this study were shorter compared with other findings like Vara *et al* (2010) and Upadhyaya *et al.,* (2009) which recorded accessions with 150cm, and 134cm lengths respectively. The shortest spike lengths of 34cm recorded of *Dandigali Gajere* (MLVBB12) at Bobo differs from several studies that identified pearl millets

with shorter spike lengths than what was reported in this study. For instance, a finding from Ghana identified 5 accessions (SARMIL 067, SARMILL 044, SARMIL 070, SARMIL 063, and SARMIL 053) having spike lengths of less than 20cm (Asungre 2014). These findings of the lowest spike length were also high with a report that identified fifteen accessions with a short spike length range between 11 and 20cm long (Singh *et al.,* 2016). The shortest spike length recorded across 51 countries in the world was accessions 5 cm long (Upadhyaya *et al.,* 2009). A study conducted in Northeastern Nigeria revealed that farmers in seed selection considered spike structure and length among the major important agronomic traits (Muhammad 2005). In line with this study found that *BONKOK- SHORT* has the shortest panicle length among parental lines (Izge *et al.*, 2007). An earlier report revealed that farmers were found to select their seeds based on spike compactness, seed size, and spike length, for subsequent planting (Ouendeba *et al.* 1996).

Spike Diameter (Thickness/ Girth)

The current study reported that spike diameter (girth/ thickness) varied among the accessions collected, with a range between 2.0 and 3.6 cm. *Dankota* MLVBB2 was considered with the largest spike girth of 3.6 cm. And the least with 2cm of *Tarmekuwa* MLVTT5 was recorded among the accessions of Tashar Taya. Accession with the largest spike thickness was late matured (Table 2). Three accessions possessed the same spike girth of 3.5 cm and were considered the second largest in the study locations encompassing *Maiwa Gajera* MLVTT6, *Wuyan Bajini* MLVBB8, and *Soso* MLVBB11. To corroborate the present results, recent findings revealed that panicle (spike) diameter varied significantly different ($p<0.05$) accession JG-DU-01 had the highest diameter of 3.13 cm while accession NG-ZA-01 had the least panicle diameter of 1.09 cm, found from Zamfara State (Abdulhakeem *et al.*, 2019). Several studies recorded diverse spike girth among accessions with different ranges of values between the lowest and highest like finding reported spike girth from 16 to 30 mm as medium size (Singh *et al.,* 2016). The highest spike diameter of 2.11 cm was found in *IP3132* and the lowest below 2.0cm was recorded among the accessions *NGB00551, NGB00616, NGB00537,* and *NGB00532*, which were all Nigerian accessions (Animasaun *et al.,* 2017). Among a total of 126 accessions collected across the entire Pearl millet production regions of Ghana, Asungre (2014) revealed spike girth ranging from 6.40cm for *SARMIL 002* to 11.93cm for *SARMIL 082*. Research conducted at Sudan Savanna of Nigeria revealed that the largest pearl millet spike girth was observed for *SOSAT-C-88* and pearl millet accessions *ZATIP* and *EX-BARNO* had the least diameter (Bassi & Dugje 2016). Two different studies conducted in India revealed a diverse range of pearl millet spike girth. Kumari *et al.* (2016) revealed a range of spike girth between 1.32 and 3.5 cm while Upadhyaya *et al.* (2009) reported a range from 8 to 58 mm. In contrast to this study, a larger spike girth was reported with the largest girth of 9.5 cm and the lowest of 6.4 cm (Gapili *et al.,* 2019). In most cases, spike shape determines the size of spike girth. It has been discovered that pearl millet with spike shapes of lanceolate, globose, club, and dumbbell has a wider girth. It was also revealed that with an increase in spike girth, there is an increase in some grains per spike, and seed filling accounts for a positive increase in single plant yield (Singh *et al.,* 2018).

Grain Weight per 1000 Seeds

The result of grain weight per 1000 seeds, in the present study, showed heterogeneity among the accessions in the study locations. It revealed that *Maiwa Gajera* MLVBB10 with a grain weight per 1000 of 18.8 g (table 2) had the highest grain weight of 1000 seeds and the least was *Tarmekuwa* MLVBB9 with 6.9 g/1000. The 5 major accessions recorded with the highest weight per 1000 seeds above 10g/1000 were late matured except for *Wuyan Bajini* (MLVBB8), which comprises *Zango Dogo (*MLVTT1) (10.9 g), *Dan-kota (*MLVBB2) (10.5 g), *Dogo Gero (*MLVBB3) (11.3 g), *Maiwa Gajera (*MLVTT6) (15.7) and *Zango Dogo (MLVBB1)* (10.9g). They were among the accessions with larger spike girth, which corroborates the view that in an increase in spike girth, there is an increase in seed density (Singh *et al.,* 2018). It was also revealed that the accession with the longest spike *Zango Dogo* (MLVTT1) was among those with a higher weight per 1000 seeds above 10g. The results obtained in the present study on the weight of 1000 seeds were higher than those documented by other studies. For example, a range value of 4.67 to 12.85 g was obtained by Anuradha *et al,* (2018) and Abdulhakeem *et al*. (2019) similarly reported the highest weight of 1000 seeds was obtained in *JG-BIR-01* with a value of 14.19 g and accession *NG-ZA-02* had the least weight of 1000 seeds with the value of 5.25 g. A similar report revealed that *NGB00616* produced the heaviest grains (10.13 g/1000 grain) and *IP22269* had the lowest weight (8.08 g/1000 grain) (Animasaun *et al.,* 2017). The results are also similar to those reported by other authors (AlSuhaibani 2011; Zerbini & Thomas 2003). An earlier finding reported a total of thirteen accessions with an average 1000- grain weight above 10 g and a range from 8.88 g to 12.21 g (Asungre 2014). A study conducted on the performance of the pearl millet varieties intercrop with legumes revealed that variety *SOSAT-C-88* significantly ($P < 0.05$) produced superior 1000 weight. On the other hand, *LACRI-9702-IC* and *EX-BORNO* produced significantly ($P < 0.05$) the lowest weight (Bassi &Dugje, 2016). A similar report of seed weight per 1000 (g) minimum of 8.6 g and a maximum of 11.0 g was reported among pearl millet landrace from South of Chad (Gapili 2019).

Total Seeds per Spike

The result of this study showed heterogeneity in the total seed per spike among accessions collected in the study area. It revealed that the 2 accessions *Dandigali Dogo* MLVBB5 and *Soso* MLVBB11 with the highest total seed per spike of 10416 and 8125 seeds, were

collected from Bobo. Accessions with the least total seed per spike of fewer than 3000 seeds were identified as late- matured *Maiwa Gajera* MLVBB10 and *Maiwa Gajera* MLVTT6 with total seeds of 2872 and 2102, respectively. Similar to the present finding, Abdulhakeem *et al.* (2019) revealed that NS-YEL-07 had the highest seed per spike and KD-KG-01 was recorded with the least. Also, the earlier finding of Bassi (2016) revealed that *ZATIP* produced a greater number of grains per spike while *LACRI*-9702-IC had the least number of grains than the other varieties.

Conclusion

A total of eighteen accessions were inventoried in the 2 study villages and were categorized into 3 based on maturity period as early, moderate, and late with total accessions of 4, 6, and 8, respectively. Bobo possessed the highest diversity of twelve accessions. The study showed heterogeneity among the accessions in terms of 4 qualitative and 6 quantitative traits. The late matured accession in Tashar Taya comprises Zango *Dogo* (MLVTT1), *Dansalka* (MLVTT3), *Maiwa Gajera* (MLVTT6) other accessions of *Baragade* (MLVTT2) and *Tarmekuwa* (MLVTT5). This study recommended that farmer-based millet crop selection and improvement should be encouraged through initiatives like seed selection community seed banks, seed exchange, seed fairs, and Seed treatment.

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Declaration of conflicting interests

All authors contributed and no conflict of interest

References

Abdulhakeem, A., Ahmed, F.O., Omoniyi, A.M., Kayode. O.I. and Yusuf D.O.A. (2019). Genetic Diversity Studies for Morphological Traits in Pearl Millet (*Pennisetum Glaucum* L.) Landrace of Northern Nigeria. *GSC Biological and Pharmaceutical Sciences,* 7(2): 60-70.

Al-Suhaibani, N.A. (2011). Better forage and Grain Yield Quality of Pearl Millet (*Pennisetum Glaucum* L.) under different Irrigation Water Supplies and Planting Densities. *World Applied Sciences Journal, 15* (8):1136-1143.

Angarawai, I.I., Aladele, S., Dawud, M.A., Turaki, Z.G.S. and Yakub, Y. (2016). Genetic Diversity among Nigeria '*Maiwa* type' of Pearl Millet Germplasm. *Global Journal of Science Frontier Research,* 16(3): 14-20.

Animasaun, A.D., Morakinyo, J.A., Krishnamurthy, R. and Mustapha, O.T. (2017). Genetic Divergence of Nigerian and Indian Pearl Millet Accessions Based on Agronomical and Morphological Traits. *Journal of Agricultural Sciences,* 62(2): 115-131.

Anuradha, N., Satyavathi, C.T., Bharadwaj, C., Sankar, M., Singh, S.P. and Pathy, T.L. (2018). Pearl Millet Genetic Variability for Grain Yield and Micronutrients in the Arid Zone of India. *Journal of Pharmacognosy and Phytochemistry,* 7(1): 875-878.

Asungre, A.P. (2014). Characterization of Pearl Millet *[Pennisetum glaucum, (L), R. Br]* Germplasm in Ghana. A Published MSc Thesis Submitted to the Department of Crop and Soil Sciences**,** Kwame Nkrumah University of Science and Technology, Kumasi.

Badau, M. H. (2006). Microorganisms Associated with Pearl Millet Cultivars at Various Malting. *Internet Journal of Food Safety*, 8:66-72.

Bassi, J.A. and Dugje, I.Y. (2016). Performance of Pearl millet (*Pennisetum glaucum*(L) BR) Varieties Intercrop with Legumes in Sudan Savanna of Nigeria. *Journal of Agricultural and Crop Research,* 4(5): 72-82.

Danjuma, M.N., Muhammad, S. and Karkarna, M.Z. (2018). Farmer's Participation in Agroforestry System in Northwestern Nigeria. *Journal of Environmental Sciences and Technology,* 2(2):257-265.

Davis, A.J., Dale, N.M. and Ferreira F.J. (2003). Pearl Millet as an Alternative Feed Ingredient in Broiler diets. *Journal of Applied Poultry Research,* 12: 137–144.

Hodgkin, T., Rana, R., Tuxill, J., Balma, D., Subedi, A., Mar, I., Kawamura, D., Valdivia, R., Collado, L., Latournerie, L., Sadiki, M., Sawadogo, M., Brown. A. H. D. and Jarvis, D. I. (2007). Seed System and Crop Genetic Diversity in Agro-ecosystem. Published by: Columbia University Press.

Izge, A.U. and Song, I.M. (2013). Pearl Millet Breeding and Production in Nigeria: Problems and Prospects. *Journal of Environmental Issues and Agriculture in Developing Countries,* 5(2):25-33.

Izge, A.U., Kadams, A.M. and Gungula, D.T. (2007). Heterosis and Inheritance of Quantitative Characters in a Diallel Cross of Pearl Millet (*Pennisetum glaucum* L.). *Journal of Agronomy,* 6(2):278-285.

Jukanti, A.K., Gowda, C.L.L., Rai, K.N., Manga, V.K. and Bhatt, R.K. (2016). Crops that feed the World. Pearl Millet (*Pennisetum glaucum* L.): an important Source of Food Security, Nutrition and Health in the Arid and Semi-arid Tropics. *International Journal of Food Sciences,* 8(2):307-329.

Kumar, J., Bag, M, K, Pandey, S., Jha, S.K., Chauhan, S.S., Jha, G.K., Gautam, N.K. and Dutta, M. (2016). Assessment of Phenotypic Diversity in Pearl Millet [*Pennisetum Glaucum* (L.) R. Br.] Germplasm of Indian origin and identification of Trait-specific Germplasm. *Crops and Pasture Science,* 67(12): 1223-1234.

Mucioki, M., Mucioki, S.K. and Johns, T. (2014). Intraspecific Diversity and Seed Management of Pearl Millet (*Pennisetum Glaucum*) In Tharaka, Kenya: A Persistent and Valued Traditional Food Crop. *Economic Botany,* 68(4): 397-409.

Muhammad, S. (2005). *Adaptive Management of Genetic Diversity of Pearl Millet Cultivars under Indigenous Cultivation at Smallholder level in Semi-Arid Northern Nigeria.* a PhD thesis submitted to the School of postgraduate studies, Bayero University, Kano, Nigeria.

Mukhtar, M., Mohamed, Z., Shamsuddin, M.N. and Sharifuddin, J. (2017). Impact of inputs costs on Farm Profitability: An Evaluation of Pearl Millet Production in Northwestern Nigeria. *Journal of Asian Scientific Research,* 7(12):471-482.

Ojediran, J.O., Adamu, M. A. and Jim- George, D. L. (2010). Some Physical Properties of Pearl Millet (*Pennisetum Glaucum*) Seeds as a Function of Moisture Content. *African Journal of General Agriculture,* 6 (1): 39-40.

Ouendeba, B., Hanna, W.W., Ejeta, G. and Santini, J.B. (1996). Forage Yield and Digestibility of African Pearl Millet Landraces in Diallel with the missing cross. *Crop Science,* 36: 1517-1520.

Singh, S., Yadav, Y. P., Yadav, H.P, Vart. D. and Yadav, N. (2016). Morphological Characterization of Pearl Millet Hybrids [*Pennisetum glaucum* (L.) R. Br.] and their Parents. *African Journal of Agricultural Research,* 11(5): 371-378.

Singh, O., Gowthami, R., Singh, K. and Shekhawat, N. (2018). Genetic Divergence Studies in Pearl Millet Germplasm based on Principal Component Analysis. *International Journal of Current Microbiology and Applied Sciences,* 7(6): 522-527.

Upadhyaya. H.D. and Reddy, K.N. (2009). Pearl Millet Germplasm, Collection, Conservation, Characterization and Utilization in Crop Improvement. Genetic Resources; International Crops Research Institute for the Semi-Arid Tropic (ICRISAT), Patencheru, India.

Vara, N., Djinidji, R., Mahamat. A.H. and Serferbe, S. (2019). Ethnobotanical and Agromorphological Assessment of Pearl Millet (*Pennisetum glaucum* (L) R. Rr.) access from South of Chad. *International Journal of Agriculture and Environment and Bioresearch,* 4(6): 391-407.

Zerbini, E. and Thomas, D. (2003). Opportunities for Improvement of Nutritive Values in Sorghum and Pearl Millet Residues in South Asia through Genetic Enhancement. *Field Crop Research*, 84: 3-15.

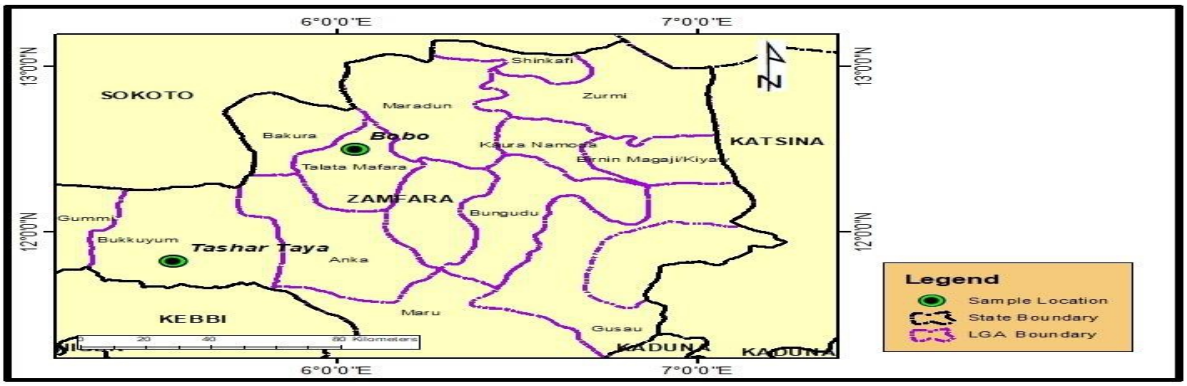

Figure 1: Map of Zamfara State Showing the study locations in Northwestern Nigeria

Table 1: Phenotypic Variations among Pearl Millet Accessions

Traits	Sub Traits	Number of Varieties			
		Tashar Taya	Bobo	Total	%
Spike Shape	Cylindrical	3	6	9	50
	Spindle	0	1	1	5.5
	Candle	2	4	6	33
	Monkey tail	1	1	2	11
Seed Shape	Obovate	2	1	3	16.7
	Oblanceolate	2	2	4	22
	Globular	2	8	10	55.6
	Hexagonal	0	1	1	5.5
Seed Cover	Exposed	6	9	15	83
	Cover with Hairs	0	3	3	17
Seed Color	Black	1	1	2	11
	Brown	0	1	1	5.5
	Whitish	1	0	1	5.5
	Grey	1	4	5	27.8
	Light green	3	2	5	27.8
	Brownish	0	4	4	22

Source: Fieldwork 2019.

Table 2: Quantitative Characteristics of 18 Pearl Millet Accessions

S/No	Millet Accessions	Code	Spike length(cm)	Spike Diameter (cm)	Spike Weight(g)	Weight of seed per spike(g)	Seed Weight 1000(g)	Total seed per spike
1.	*Zango Dogo*	MLVTT1	93	2.5	144	86	10.9	7890
2.	*Baragade*	MLVTT2	68	2.6	98	58	7.7	7533
3.	*Dansalka*	MLVTT3	64	2.3	82	42	8	5250
4.	*Dandigali Gajere*	MLVTT4	38	2.2	54	37	9.2	4022
5.	*Tarmekuwa*	MLVTT5	62	2	70	45	9.1	4945
6.	*Maiwa Gajera*	MLVTT6	38	3.5	49	33	15.7	2102
7.	*Zango Dogo*	MLVBB1	92	2.7	86	41	10.9	3762
8.	*Dankota*	MLVBB2	75	3.6	159	72	10.5	6857
9.	*Dogo Gero Dogon Gero*	MLVBB3	84	2.5	87	43	11.3	3805
10.	*Maigashi*	MLVBB4	64	2.8	86	47	9	5222
11.	*Dandigali Dogo*	MLVBB5	65	3.1	171	100	9.6	10416
12.	*Wutsiyar Biri*	MLVBB6	68	2.3	54	31	8.1	3827
13.	*Zamfarwa Maigashi*	MLVBB7	93	3	134	69	9.8	7041
14.	*Wuyan Bajini*	MLVBB8	58	3.5	102	58	10.6	5472
15.	*Tarmekuwa*	MLVBB9	60	1.8	43	28	6.9	4058
16.	*Maiwa Gajera*	MLVBB10	46	3	96	54	18.8	2872
17.	*Soso*	MLVBB11	37	3.5	122	78	9.6	8125
18.	***Dandigali Gajere***	***MLVBB12***	***34***	***2.7***	***54***	***32***	***9.9***	***3232***

Source: Fieldwork, 2019