

Regular Article

Leaf and fruit characteristics of Shea (*Vitellaria paradoxa*) in Northern Ghana

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Leaf and fruit parameters of *Vitellaria paradoxa* populations in north-south gradient of the shea belt in the transitional and Guinea Savanna zones of Ghana were compared during the fruiting season between April to July, 2011. Thirty five trees which were at least 50 m apart and with diameter at breast height of at least 20 cm were randomly selected from each of the three locations namely Paga, Nyankpala, Kawampe for the studies. Leaf morphological traits studied include laminar width, petiole and laminar lengths. Fruit parameters measured include fruit and kernel widths, lengths, weights and pulp weight. Results showed variability for most of the characters determined. The leaves in Paga had shorter petioles as compared to those of Nyankpala and Kawampe. The Nyankpala *V. paradoxa* has the smallest laminar width whilst Kawampe has longest leaf laminar as compared to the rest. Values for fruit and kernel parameters were highest for samples from Paga, followed by Kawampe and were significantly higher than those from Nyankpala. There were significant positive relationships between fresh fruit weight and both fresh kernel weight ($P < 0.001$; $R^2 = 0.6925$) and dry kernel weight ($P < 0.001$; $R^2 = 0.6532$) for data pooled from all the three locations, however, the slopes and intercepts varied between locations ($P < 0.001$). The result from the study provides opportunities and prospects for selection and breeding for *V. paradoxa* tree improvement in Ghana.

Vitellaria paradoxa L. is one of the most prevalent tree crops in northern Ghana. The tree is native to Africa and occurs across the Sahel region from Senegal to Nigeria and further east in Sudan and Uganda (Maranz *et al.*, 2004). Shea is an important multipurpose tree, which plays important ecological and socio-economic role, and it is the principal source of income for local population in the Sahel region. For instance, where there are few alternative employment avenues and where agriculture is often difficult and yields

are unpredictable, the shea nuts and other products from the tree provide an important part of the family income. Adaptation of the shea tree to extreme weather conditions makes it a potential species for commercial plantations in arid environments. Fruit production starts after eight to 15 years of plant growth, and reaches maximum production after 30 years. Late March to August is the fruit harvesting period for shea, with some variation between climatic regions.

According to Bojović and Stojanović (2006), leaf is the most important part of photosynthetic apparatus and it has the main role of producing organic matter in plants. Leaf characteristics as well as chloroplasts pigments content, leaf area and dry matter weight have the greatest influence on yield of cultivated plants. Plants meet their nutritional requirements in three ways: (1) nutrient storage, (2) uptake of inorganic nutrients from the soil through the root system, and (3) synthesis of carbohydrate through leaves (Xie and Luo, 2003). Many factors, such as genetic and environmental, affect plant growth and development. Plants are able to modify their growth, development and physiology according to their environment. Ozturk and Serdar (2011) indicated that environmental conditions, such as light and temperature, are the most important factors on plant growth and development. Therefore, the ability of plants to do this plays a key role in determining their tolerance to stress and their maintaining efficient growth (Murchie and Horton, 1997; Walters *et al.*, 2003). Temperature has a considerable influence throughout the development of a plant (Koorneef *et al.*, 2002), stimulating developmental processes such as plant growth, seed dormancy and release, germination and vernalization (Heggie and Halliday, 2005). The distribution, size and orientation of leaves in space determines the pattern of light interception within the canopy, controlling such processes as leaf development, leaf energy balance and water use, and photosynthesis. Light is not only an energy source for photosynthesis but also a stimulus that regulates numerous developmental processes, from seed germination to the onset of flowering Ozturk and Serdar (2011). Light intensity, quality and duration are also critical factors affecting the early survival and growth of tree seedlings, because of their importance in determining the morphological and anatomical structure of plants (Christie, 2007).

Seasonal duration of leafing, flowering and fruiting mainly determine phenological behaviour in tropical trees. These phenological events are not mutually independent in woody species, and flowering may be partly or wholly dependent on leafing activity (van Schaik *et al.*, 1993). Nevertheless, tree species with similar leaf phenology often differ in the timing of their flowering and fruiting (Seghieri *et al.*, 1995).

Reich (1995) reported that global climate change may force variation in timing, duration and synchronization of morphological and phenological events in tropical trees. These trees are expected to respond variously to changes in rainfall and temperature because they differ widely with respect to adaptations to seasonal drought and cues for bud break of vegetative and flower buds (Singh and Kushwaha, 2005). Several studies have also shown significant variation (advanced or delayed) in onset dates of flowering and fruiting responses (Chapman *et al.*, 2005) in tree species as a result of climate change. Earlier literature on shea fruit characterization in Ghana has suggested high variation in fruit size and shape (Bayor and Nyarko, 2003) and the classification of similar morphological traits in tree crops has been found useful for selection and breeding purposes (Samal *et al.*, 2003; Arunachalm *et al.*, Taarmalli *et al.*, 2006). The need for functional types has been emphasized to evaluate and predict the nature of vegetation responses to future global change (Box, 1996).

However, the knowledge of interrelationship between fruits traits and leaf structure in indigenous tropical plants will be an enormous potential of ecological and climatic indicators through time (Wing and Greenwood, 1993; Givnish, 2003; Royer *et al.*, 2005; Sack and Frole, 2006). The objective of the study was to compare the fruit and leaf morphology in three locations along the north-south gradient of shea distribution in

Ghana for selection and future improvement of the shea tree.

MATERIALS AND METHOD

The study was carried out during the fruiting season in April- July, 2011 in parklands of three different locations along the north-south gradient of shea distribution in Ghana namely, Paga, Nyankpala and Kawampe.

Paga is north eastern part of Ghana which is within the Kasena-Nankana District in the Upper East region of Ghana. It is located in the Sudan Savanna vegetative zone and on the latitude and longitude of 10°57.225 N and 01°04.720 W respectively.

Nyankpala is located between latitude 09° 25.925 N and longitude 01° 00,420 W. The area is in the Tolon-Kumbungu District of the Northern Region of Ghana. The Agro-ecological zone of the area is Guinea Savanna. Kawampe is located between latitude 08° 25.630 N and longitude 01° 33,550 W. The area is in the Kintampo North District of the Brong Ahafo Region of Ghana. The area falls within the transitional belt of the Northern Savanna and the Southern Forest

Thirty five trees which were at least 50 m apart with diameter at breast height (dbh) ≥ 20 cm were randomly selected from each of the three locations for the studies. For leaf morphological traits, 20 leaves were sampled

per tree and the following parameters were measured; petiole length, laminar length and width. On the same trees, 20 fresh ripe fruits were harvested and randomly collected and weighed. The pulps of collected fruits were removed manually on the same day and the kernel washed with tap water. The fresh (wet) kernel weight was taken after the kernel was surface dried with tissue paper. The pulp weight was calculated as a difference between the fresh fruit weight and wet kernel weight. The Kernels were then dried for three days in an oven at 60°C after which the dried weight was taken. Analysis of variance was used to determine the variation among locations for all parameters measured except the relationship between fresh fruit weight and the kernel weights where regression analysis was adopted using Genstat-Release 8.1 statistical package.

RESULTS

The result of the leaf parameters taken are presented in (Figure 1. The leaves in Paga had shorter petiole as compared to those of Nyankpala and Kawampe. The Nyankpala shea has the smallest laminar width whilst that of Kawampe has longer leaf laminar as compared to the rest.

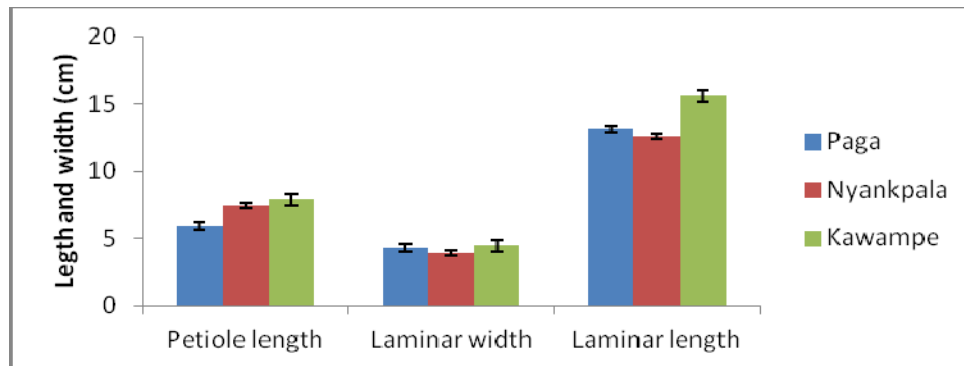


Figure 1: Leaf parameters of shea trees in three different locations in Ghana. Bar= 2 Standard Error of the Difference (SED)

Table 1 shows the fruit length, width and pulp weight of shea trees from the three

locations. Shea fruits from Paga were longest, widest and heaviest while those from

Nyankpala had the least of all the fruit parameters. There was a similar pattern for the kernel parameters taken (Table 2) as shea kenels from Paga were the longest, widest

and heaviest in term of both fresh and dry weights. Again, Kernels from Nyankpala had the least of all the kernel parameters measured.

Table 1: Fruit parameters of Shea in three different climatic locations in northern Ghana

Locations	Fruit length (cm)	Fruit width (cm)	Fresh fruit weight (g)	Pulp weight (g)
Paga	3.146	2.536	20.20	12.04
Nyankpala	2.331	2.059	11.65	6.06
Kawampe	2.655	2.244	16.94	9.82
F probability	<.001	<.001	<.001	<.001
Replication	35	35	35	35
Df	68	68	68	68
S. e. d.	0.0931	0.0862	0.997	0.734

Table 2: Kernel parameters of Shea in three different climatic locations in northern Ghana

Locations	Kernel length (cm)	Kernel width (cm)	Fresh kernel weight (g)	Dry Kernel weight (g)
Paga	2.473	1.649	8.15	7.04
Nyankpala	1.957	1.480	5.59	4.14
Kawampe	2.355	1.615	7.12	5.33
F probability	<.001	<.001	<.001	<.001
Replication	35	35	35	35
Df	68	68	68	68
S. e. d	0.0779	0.0429	0.385	0.345

There were no relationships ($P > 0.5$) between any of the leaf parameters and fruit weights. However, as shown in Figure 2, there were significant positive relationships between fresh fruit weight and both fresh kernel weight ($P < 0.001$; $R^2 = 0.6925$) and dry kernel weight ($P < 0.001$; $R^2 = 0.6532$) for data pooled from all the three locations. However, the slopes and intercepts varied between

locations ($P < 0.05$, Figure 3). Hence the fresh kernel weight associated with a fresh fruit weight of 10, for example, ranges from 4.7-5.4 depending on the location.

DISCUSSIONS

Analysis of ten morphological traits of leaves and fruits showed significant diversity between shea populations of the three

locations. Results indicated that fruits collected from Paga followed by Kawampe (Table 1 and 2) had the highest fresh fruit and kernel (fresh/dry) weights as well as the longest petiole and lamina lengths. This also implied genetic diversity of plants from the three locations as reflected in their morphological diversity which supports the fact that the three climatic locations consist of varied shea types. However, it is of importance to note that morphological traits of fruits are the major criteria used by farmers in establishing differences and selecting tree accessions. In the different parkland zones, factors influencing farmers variety of choice and determining the level of diversity that is maintained may include social, cultural, economic, abiotic and biotic factors. The difference may also be due to environmental mutation as observed by Martin (1976) who attributed the substantial morphological

variation between the various tree accessions to pollination, sexual recombination and mutation followed by intensive selection by isolated human communities in diverse environments. Trees from Paga performed well in almost all the parameters measured probably because the short petiole of the leaves allow them to be positioned at angles that allow maximum interception of sunlight for photosynthesis. Moreover, the different soil characteristics may be contributing factor. Though, Kawampe recorded the highest rainfall regimes, the soil is mostly sandy while that of Nyankpala is mostly clayey (Abubakari *et al.*, 2012) There is therefore the likelihood that during the heavy rains, leaching of important elements may occur in Kawampe soils while water logging and run off conditions may be more pronounced in Nyankpala as compared to Paga.

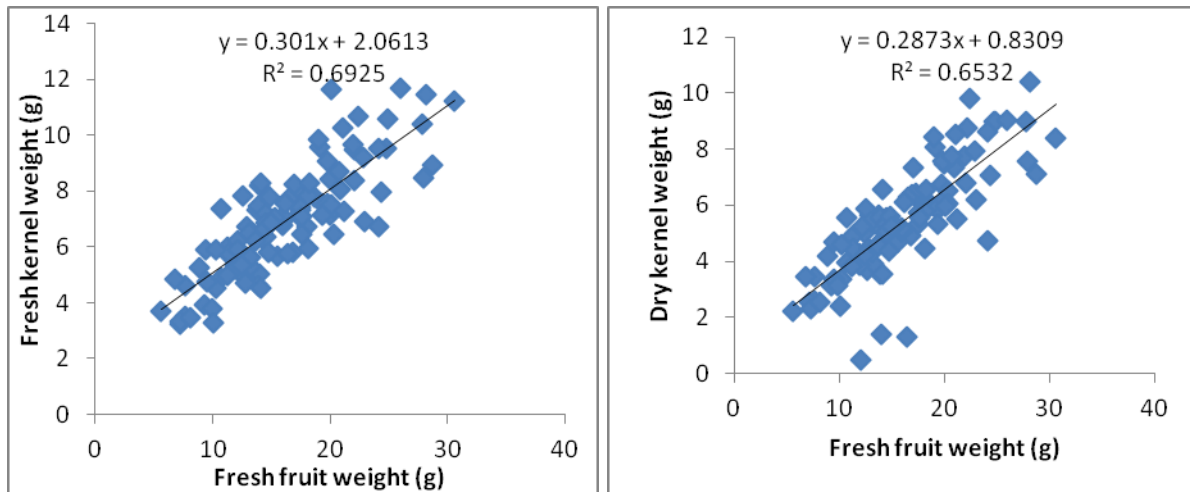


Figure 2: Linear regressions for fresh fruit weight and (a) Fresh kernel weight (b) dry kernel for three different ecological locations

Comparison between the regressions of the four lines gave an indication that, in order to predict the fresh or kernel weight from the fresh fruit weight, it was necessary to develop a regression equation for each location. The differences of the regression lines for the four locations also gave credence to the fact that shea tree from the three locations differed in fruit weight. According to Asudil *et al.* (2010),

knowledge of regressions and correlations among characters is useful in designing an effective breeding programme for any crop. There are several reasons for adopting phenotypic (indirect) selection, because sometimes the main character is expressed late or measurement of the phenotypic character is much easier than for the genotypic (direct) character. Ocampo *et al.*

(2006) observed strong correlations between traits related to fruit characteristics, which indicated the presence of diverse variable arrangements at the individual genotype level that establishes adequate chances of

identifying desirable trait combinations in specific population. In the case of the shea, the relatively high positive regression coefficient means that the trees with bigger fruits can be selected to obtain bigger kernels.

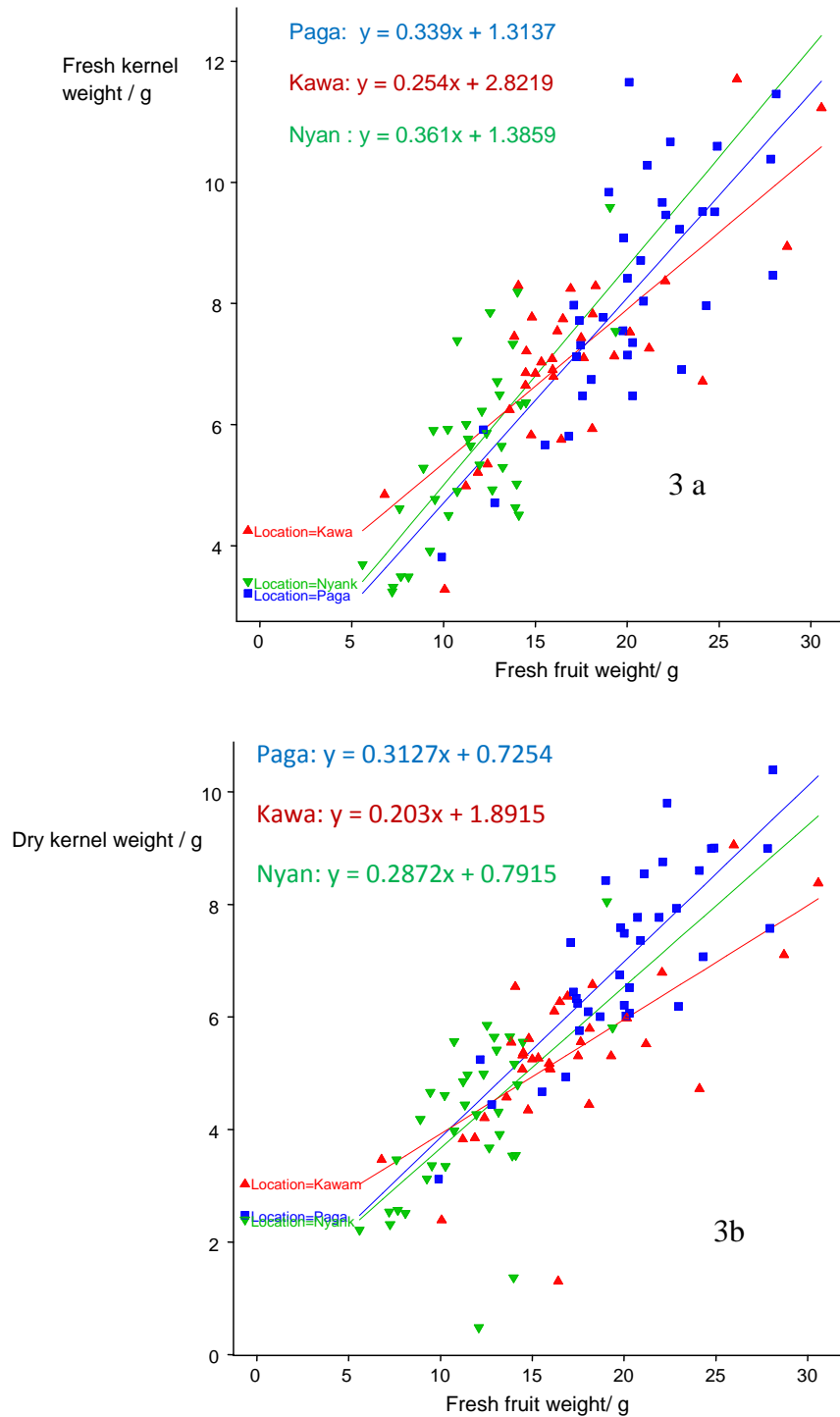


Figure 3: Linear regression for fruit weight and a) fresh kernel b) dry kernel weights of shea from three locations in Ghana.

An analysis of the current study is not only pointing to phenotypic variation among the shea population, but also, the characteristics such as fresh fruit and kernel weight can be useful as genetic markers for classifying the accessions and can be employed in achieving shea breeding objectives. This variation in morphological characters revealed considerable amount of diversity among accessions studied that can be used in selecting diverse parents in breeding programme.

The result of this study presents opportunities and prospects for genetic improvement of traits needed for adaptation to various conditions through selection of desirable genotypes. This would be important in addressing the demand of the farmer, and other stakeholders of shea tree.

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