VARIATION IN FRUIT TRAITS OF PAWPAW UNDER DIFFERENT RATES OF POULTRY MANURE

***[1]Olajide, K., [1]Ogundare, S. K. and [2]Baiyeri K. P.**

[1]College of Agriculture, Division of Agricultural Colleges, Ahmadu Bello University, Zaria, Nigeria

[2]Department of Crop Science, University of Nigeria, Nsukka

Correspondence: okolawole40@yahoo.com

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ABSTRACT

Twelve pawpaw (*Carica papaya* L.) accessions were evaluated at Nsukka (Latitude 6°51′28″ N Longitude 7°23′44″ E at an elevation of 423 m above sea level), Nigeria, under three poultry manure (PM) rates (0, 5 and 10 t ha^{-1}) in order to study the effect of the manure variation on fruit traits. The experiment was a split plot laid out in randomised complete block design replicated thrice. Main plot treatment was poultry manure rates and sub-plot treatment was the 12 accessions of pawpaw. Data on percent number of fruited plants, number of fruits harvested, true-to-type fruit pulp colour and fruit shape were collected. The effect of accession showed that Cnd-Cl-Ro significantly ($p \leq 0.05$) produced the highest number of fruited plants (80.0%). Number of fruits harvested was highest in accessions Ijm-Cl-Ro and Ijm-Sp-Ly (6.8). Accession Ijm-Sp-Ly had highest fruits with similar pulp colour and fruit shape (53.3%) to the initial. Application of 10 t ha^{-1} of PM significantly produced the highest number of fruited plants (60.0%) and fruits harvested (4.4) but did not significantly affect true-to-type fruit pulp colour and shape.

Key words: Pawpaw, accession, true-to-type pulp colour, true-to-type fruit shape, poultry manure

NTRODUCTION

Pawpaw (*Carica papaya* L.) belonging to the Caricaceae family (Samson, 1986; Nakasone and Paull, 1998; Asudi *et al*., 2010) is a medium-sized fruit crop with a potential to produce fruits throughout the year. The fruit superficially resembles a melon pyriform, oval and elongated in shape. Pawpaw ranks fourth as a major tropical fruit after banana, orange and mango. The growth is fast in nature; high yields and diverse range of varieties offer papaya for development of many economically viable products. It is grown in fertile, well-drained soil and may grow up to 10 metres high or more (Crane *et al.,* 2007). Nigeria is among the top global producers with India, Brazil, Indonesia and Mexico (FAOSTAT, 2007).

Pawpaw is a tropical and subtropical food plant gaining popularity worldwide not just for the delicious fruit but also for medicinal properties of the whole plant parts, leaf, fruit, root, bark, peel, seed and pulp (Aravind *et al.,* 2013). Ripe pawpaw is usually consumed raw or processed into drinks, jams and candies while the unripe or green fruit is added into fresh salads (Boshra and Tajul, 2013). Pawpaw also has several industrial uses. Biochemically, its leaves and fruits produce several proteins and alkaloids with important medical and industrial

*Author for correspondence

application. In many parts of the world including Nigeria, green pawpaw fruit is also cooked as vegetable (Ahmed *et al.,* 2002; Matsuura *et al.,* 2004; Organisation for Economic Cooperation and Development (OECD), 2005). The unripe fruit is also valuable as a source of the proteolytic enzyme, papain, which has many economic and industrial applications (Boshra and Tajul, 2013).

Pawpaw is a polygamous crop species. It has male, female and hermaphrodite plants that produce staminate, pistillate and perfect flowers under different seasonal or environmental conditions. The fruit shape is a sex-linked character. Fruits from female flowered trees are usually sweeter and of more round shape than fruits from hermaphrodite trees (De Villiers and Willers, 1995). The skin of unripe fruit is smooth and green. When ripe, the skin turns yellow or orange. The flesh of ripe fruit is yellow, orange or red in colour.

Plant nutrition is a vital determinant of the quality of fruits at harvest (Rice *et al.,* 1994). In agriculture, the main reasons for applying poultry manure includes the organic amendment of the soil and the provision of nutrients to crops (Warren *et al.,* 2006). Animal and green manure is a valuable source of crop nutrients and organic matter, which can improve soil biophysical conditions thereby making the soil more productive and sustainable for food production (Baiyeri and Tenkouano, 2007). The effects of poultry manure on yield of pawpaw was significantly affected by the manure treatments. The application of 30 kg poultry manure per plant resulted in the greatest fruit yield per plant (62.12 kg) (Dagoon, 2000).

Pawpaw displays considerable phenotypic variation for many morphological and horticultural traits (Ocampo *et al.,* 2006). However, despite this considerable phenotypic variation in morphological and horticultural traits, there are no published studies on morphological diversity of papaya accessions in Nsukka. A better knowledge of the morphological and genetic diversity of pawpaw accessions is, therefore, desirable. The objective of this study was to evaluate the morphological diversity in fruit traits in 12 accessions of pawpaw under three poultry manure rates.

MATERIALS AND METHODS

Experimental site: Field experiment was conducted between January 2013 and March 2015 at the Department of Crop Science Teaching and Research Farm, Faculty of Agriculture, University of Nigeria, Nsukka (Latitude 6° 51′28″ N and Longitude 7° 23′44″ E at an elevation of 423 m above sea level). Nsukka is characterised by lowland humid tropical conditions with bimodal annual rainfall distribution that ranges from 1155 mm to 1955 mm with a shift in the second peak of rainfall from September to October, a mean annual temperature of 29º C and a relative humidity that ranges from 69% to 79% (Uguru *et al.,* 2011).

Collection of papaya germplasm: Pawpaw seeds used for the experiment were collected between January and February 2013. Extraction of seeds was done from pawpaw fruits obtained from locally available pawpaw varieties from three Local Government Areas (LGA), namely, Ijumu LGA (Iyamoye), Yagba West LGA (Okoloke) of Kogi State, and Nsukka LGA (Owerre Obukpa) of Enugu State. The twelve accessions of pawpaw planted were made up of different fruit shapes (Clavate or spheroid) and fruit pulp colours (Light yellow, bright yellow, deep yellow to orange or reddish orange) as shown in Table 1.

Experimental design and field layout: The experiment was a split-plot laid out in a randomised complete block design (RCBD) using a single row plot of five plants replicated three times. The main plot treatment was three levels of poultry manure (0, 5 and 10 t ha^{-1}) and the sub-plot treatment was the 12 accessions of pawpaw. The pawpaw accessions were named according to the shape of fruits, colour of fruit pulp and collection centres (Table 1). The plants were spaced 1.5 m × 2.0 m (intra × inter-row). An alleyway of 3.0 m separated each block.

Data collection: Data on per cent number of fruited plants, number of fruits harvested, true-to-type fruit pulp colour and fruit shape were collected.

Statistical analysis: Data were analysed with GENSTAT Discovery 4 Edition 10 Release 4.23 (GENSTAT 2013), following split-plot in a randomised complete block design procedure. Mean separation to detect the effect of manure and accession was by least significant difference (LSD) at 5% probability level.

RESULTS

The descriptor and acronyms of the pawpaw accessions evaluated in this study are shown in Table 1. About 67 % of the accessions were collected from Kogi State.

Table 1: List of accessions evaluated showing State, Local Government Areas, Specific location of collection, fruit shape, fruit flesh colour and acronyms used

S/N	State	LGA	Specific Location	Fruit Shape	Fruit flesh colour	Acronyms
1	Kogi	Ijumu	Iyamoye "Canada''	Clavate	Reddish orange	Cnd-Cl-Ro
2	Kogi	Ijumu	Iyamoye	Clavate	Reddish orange	Ijm-Cl-Ro
3	Kogi	Ijumu	Iyamoye	Clavate	Deep yellow to orange	Ijm-Cl-Dyo
4	Kogi	Ijumu	Iyamoye	Spheriod	Light yellow	Ijm-Sp-Ly
5	Enugu	Nsukka	Owerre Obukpa	Clavate	Reddish orange	Nsk-Cl-Ro
6	Enugu	Nsukka	Owerre Obukpa	Clavate	Bright yellow	Nsk-Cl-By
7	Enugu	Nsukka	Owerre Obukpa	Spheriod	Reddish orange	Nsk-Sp-Ro
8	Enugu	Nsukka	Owerre Obukpa	Spheriod	Light yellow	Nsk-Sp-Ly
9	Kogi	Yagba West	Okoloke	Clavate	Reddish orange	Yw-Cl-Ro
10	Kogi	Yagba West	Okoloke	Clavate	Bright yellow	Yw-Cl-By
11	Kogi	Yagba West	Okoloke	Spheriod	Reddish orange	Yw-Sp-Ro
12	Kogi	Yagba West	Okoloke	Spheriod	Light yellow	Yw-Sp-Ly

The physical and chemical properties of the experimental site prior to transplanting of seedlings and the manure used (Table 2) revealed that the soil (pH 4.9) was strongly acidic while the poultry manure sample was alkaline with pH 8.8. The soil was characterised texturally as sandy clay loam. The soil was low in essential plant nutrients; however, the poultry manure used was high in pH, organic carbon and organic matter; and other exchangeable minerals.

Table 2: Physical and chemical properties of soil and manure used in the experimental site

Mechanical properties	Soil particle size	Poultry manure
Clay (%)	30	-
Silt (%)	19	-
Fine sand (%)	12	-
Coarse sand (%)	39	-
Textural class	Sandy clay loam	
Chemical properties		
pH in water	4.9	8.8
pH in Kcl	3.7	8.6
Organic carbon (%)	1.03	12.369
Organic matter (%)	1.77	21.324
Total nitrogen (%)	0.084	2.942
Phosphorus (ppm)	2.80	0.953 (%)
Exchangeable base		
Sodium (Na+) cmol/kg	0.73	0.0195 (%)
Calcium (Ca^2+) cmol/kg	2.80	104.00
Potassium (K+) cmol/kg	0.37	0.145 (%)
Magnesium (mg^2+) cmol/kg	0.80	384.00
CEC	14	-
Base saturation (%)	33.57	-
Exchangeable acidity in me/ 100 g soil		
Aluminum (Al3+)	1.40	-
Hydrogen (H+)	0.60	-

Source: Soil Science Laboratory, Faculty of Agriculture, University of Nigeria, Nsukka

Accessions differed significantly ($p \leq 0.05$) on number of plants that fruited, number of fruits harvested, true-to-type fruit pulp colour and fruit shape (Table 3). Accession Cnd-Cl-Ro produced the highest number of plants that fruited (80.0%) while the least was obtained in accession Nsk-Cl-Ro (36.7%). Highest number of fruits harvested (6.8) was obtained in accessions Ijm-Cl-Ro and Ijm-Sp-Ly while accession Nsk-Cl-Ro had the least number of fruits harvested (1.6). Accession Ijm-Sp-Ly produced the highest number of fruits with similar pulp

colour and fruit-shape with 53.3 %. However, the least accession that maintained the initial fruit pulp colour and fruit shape was Yw-Cl-Ro with 21.7 and 0.0%, respectively.

Manure rates significantly ($p \leq 0.05$) influenced number of plants that fruited and number of fruits harvested but showed no significant effect on true-to-type fruit pulp colour and fruit shape (Table 3). Noteworthy is that plants grown with 0 t ha^1 (control) produced no fruit throughout the 2-year experimental period. Application of 10 t ha^{-1} of PM produced higher number of plants that fruited and number of fruits harvested of 60.0% and 4.4 relative to 5 t ha^{-1} of PM that produced 47% and 2.9, respectively.

Table 3: Main effects of accession and poultry manure on number of fruited plants, number of fruits harvested, true-to-type fruit pulp colour and fruit shape

Accession	NPTF (%)	NFH	TTFPC (%)	TTFS (%)
Cnd-Cl-Ro	80.0 (8.9)	4.3 (2.1)	43.5 (6.5)	33.3 (5.6)
Ijm-Cl-Ro	60.0 (7.5)	6.8 (2.6)	40.0 (6.2)	37.4 (6.1)
Ijm-Cl-Dyo	65.7 (7.8)	4.9 (2.2)	34.6 (5.8)	17.5 (4.3)
Ijm-Sp-Ly	43.3 (6.3)	6.8 (2.6)	53.3 (7.3)	53.3 (7.3)
Nsk-Cl-Ro	36.7 (5.8)	1.6 (1.4)	27.1 (5.3)	27.1 (5.3)
Nsk-Cl-By	36.9 (6.0)	1.7 (1.4)	26.5 (5.2)	17.7 (4.3)
Nsk-Sp-Ro	53.3 (7.2)	3.4 (1.9)	40.9 (6.4)	28.3 (5.3)
Nsk-Sp-Ly	44.6 (6.4)	3.4 (1.9)	33.3 (5.7)	20.0 (4.5)
Yw-Cl-Ro	53.3 (7.2)	2.7 (1.6)	21.7 (4.7)	0.0 (0.7)
Yw-Cl-By	66.7 (8.3)	3.9 (2.0)	36.7 (5.9)	26.5 (5.2)
Yw-Sp-Ro	66.4 (8.1)	3.9 (2.0)	34.8 (5.8)	40.0 (6.2)
Yw-Sp-Ly	45.7 (5.8)	2.7 (1.7)	27.1 (5.3)	20.0 (4.5)
LSD (0.05)	1.8	0.4	1.1	1.0
Manure rate (t ha^{-1})				
0	0.0 (0.7)	0.0 (0.7)	0.0 (0.7)	0.0 (0.7)
5	7.2 (4.8)	2.9 (1.8)	35.2 (5.6)	31.5 (5.5)
10	60.0 (5.3)	4.4 (2.1)	32.8 (5.7)	27.3 (5.0)
LSD (0.05)	0.8	0.2	Ns	Ns

0 t ha^1 produced no fruit. NPTF= Number of plants that fruited, NFH= Number of fruits harvested, TTFPC= True-to-type fruit pulp colour, TTFS=True-to-type fruit shape. Values in brackets were square-root transformed and used for ANOVA. Ns= Non-significant.

The interaction effects of accession and poultry manure on number of plants that fruited, number of fruits harvested and true-to-type fruit shape were non-significant ($p \leq 0.05$), but differed significantly in true-to-type fruit pulp colour (Table 4). Accessions Ijm-Cl-Ro and 5 t ha^{-1} of PM, Ijm-Cl-Dyo treated with 10 t ha^{-1} of PM, Ijm- Rd-Yl with 5 t ha^{-1} of PM and Ijm- Rd-Yl grown with 10 t ha^{-1} of PM produced the highest number of fruits with pulp colour similar to the initial pulp colour of 53.3%, respectively, while the least (0.0%) was obtained in accession Nsk-Cl-By that received 10 t ha^{-1} of PM.

Table 4: Interaction effect of accession and poultry manure on number of fruited plants, number of fruits harvested, true-to-type fruit pulp colour and fruit shape

Accession	Manure rate (t ha^{-1})	NPTF (%)	NFH	TTFPC (%)	TTFS (%)
Cnd-Cl-Ro	5	66.7 (8.1)	4.6 (2.2)	40.0 (6.2)	46.7 (6.8)
Cnd-Cl-Ro	10	93.3 (9.7)	4.1 (2.1)	46.7 (6.8)	20.0 (4.5)
Ijm-Cl-Ro	5	27.0 (5.2)	3.9 (2.0)	53.3 (7.3)	40.0 (6.3)
Ijm-Cl-Ro	10	60.0 (7.5)	6.6 (2.7)	26.7 (5.1)	0.0 (0.7)
Ijm-Cl-Dyo	5	60.0 (7.4)	3.0 (1.9)	42.5 (6.7)	20.0 (4.5)
Ijm-Cl-Dyo	10	53.3 (7.3)	6.8 (2.5)	53.3 (7.3)	0.0 (0.7)
Ijm-Sp-Ly	5	33.3 (5.6)	5.4 (2.4)	53.3 (7.3)	53.3 (7.3)
Ijm-Sp-Ly	10	53.3 (7.3)	8.0 (2.9)	53.3 (7.3)	53.3 (7.3)
Nsk-Cl-Ro	5	20.0 (4.5)	1.3 (1.1)	18.3 (4.5)	0.0 (0.7)
Nsk-Cl-Ro	10	53.3 (7.3)	2.7 (1.8)	26.7 (5.1)	20.0 (4.5)
Nsk-Cl-By	5	33.3 (5.6)	1.6 (1.4)	28.7 (5.1)	20.0 (4.5)
Nsk-Cl-By	10	40.0 (6.2)	1.6 (1.3)	0.0 (0.7)	0.0 (0.7)
Nsk-Sp-Ro	5	53.3 (7.3)	2.3 (1.7)	26.7 (5.1)	30.0 (5.4)
Nsk-Sp-Ro	10	53.3 (7.3)	4.6 (2.1)	26.7 (5.1)	26.7 (5.1)
Nsk-Sp-Ly	5	22.5 (4.7)	2.9 (1.9)	18.3 (4.4)	20.0 (4.5)
Nsk-Sp-Ly	10	66.7 (8.0)	3.9 (2.0)	26.7 (5.1)	20.0 (4.5)
Yw-Cl-Ro	5	46.7 (6.7)	1.6 (1.3)	20.9 (4.6)	0.0 (0.7)
Yw-Cl-Ro	10	60.0 (7.5)	3.6 (2.0)	22.5 (4.8)	0.0 (0.7)
Yw-Cl-By	5	73.3 (8.4)	4.1 (2.0)	46.7 (6.8)	30.0 (5.4)
Yw-Cl-By	10	60.0 (7.5)	3.6 (1.9)	26.7 (5.1)	0.0 (0.7)
Yw-Sp-Ro	5	53.3 (7.7)	3.0 (1.8)	38.7 (6.1)	40.0 (6.2)
Yw-Sp-Ro	10	73.3 (8.5)	4.9 (2.3)	30.9 (5.5)	40.0 (6.2)
Yw-Sp-Ly	5	26.7 (4.4)	2.3 (1.5)	20.4 (4.5)	20.0 (4.5)
Yw-Sp-Ly	10	53.3 (7.3)	2.9 (1.8)	39.2 (6.2)	20.0 (4.5)
LSD (0.05)		Ns	Ns	1.9	Ns

0 t ha^{1} produced no fruit. NPTF= Number of plants that fruited, NFH= Number of fruits harvested, TTFPC= True-to-type fruit pulp colour, TTFS=True-to-type fruit shape. Values in brackets were square-root transformed and used for ANOVA. Ns= Non-significan

DISCUSSION

The results revealed that some distinct variability was observed in morphological traits of the accessions evaluated indicating diversity in the qualitative attributes of this germplasm. This suggests the need for selection and also gives room for breeding programme. Pawpaw shows phenotypic variation in morphological and horticultural traits (Champman, 1989). These quality traits are very important in the acceptance of the fruits by the consumers.

Accession Cnd-Cl-Ro produced the highest number of plants that fruited. Accession Ijm-Cl-Ro and Ijm-Sp-Ly had the highest number of fruits harvested. Accession Ijm-Sp-Ly had the highest number of plants that produced fruits similar to the initial pulp colour and shape as observed in this study. The variability observed in this work might be due to the genetic make-up and the ability of these accessions to adapt to Nsukka agro-ecology. Purseglove (1963) and Cooks (1997) had earlier reported that there is a generalisation that the average yield of most crops is higher away from the area of their domestication than within it. Jana *et al.* (2006) and Davamani *et al.* (2013) reported genetic variability in fruit length, fruit yield and number of fruits per plant in papaya from Kenya. Lakshmi (2000) observed genetic variation in fruit shape, fruit pulp colour and fruit yield of papaya varieties evaluated in Vellayani.

The result obtained from analysis of variance revealed that application of 10 t ha^{-1} of PM produced the highest number of plants that fruited and number of fruits harvested. The significant increase in fruit yield due to the application of 10 t ha^{-1} of PM might be connected to the availability of more nutrients which resulted in higher fruit yield. The result is in agreement with the work earlier carried out by Baiyeri *et al.* (2009) who reported that bunch yield and individual fruit size increased when manure was applied at 10 t ha^{-1}. Ndubuaku *et al.* (2015) also reported that 10 t ha^{-1} poultry manure application had the highest values of pod yield in *Moringa oleifera* plant from Nsukka which is in conformity with the result of the present study. Ndubuaku *et al*. (2014) observed that poultry manure increased the nutrient status of the soil and boost crop productivity.

The combined effect of accession and poultry manure on number of plants that fruited, number of fruits harvested and true-to-type fruit pulp colour showed no significant difference ($p > 0.05$) except true-to-type fruit shape. Accessions Ijm-Sp-Ly treated with 5 t $ha^{-1}$of PM and Ijm-Sp-Ly grown under 10 t $ha^{-1}$of PM had the highest number of fruits with initial fruit shape. These observations were probably a reflection of the distinctive genotypic response pattern to the prevailing environmental cues.

CONCLUSION

Accession Ijm-Sp-Ly that produced the highest number of fruits harvested and had the highest number of plants that produced fruits with initial pulp colour and shape is recommended for pawpaw farmers in the study area. Among manure rates used in this experiment, application of 10 t ha^{-1} of PM produced the highest number of plants that fruited and number of fruits harvested and is recommended for farmer's adoption.

REFERENCES

Ahmed, J., Shivhare, U. S. and Sandhu, K. S. (2002). Thermal degradation kinetics of carotenoids and visual colour of papaya puree. *Journal of Food Science*, 67: 2692-2695. DOI:http://dx.doi.org/10.1111/j.1365-2621. 2002.tb08800.x.

Aravind, G., Bhowmik, D., Duraivel, S. and Harish, G. (2013). Traditional and medicinal uses of *Carica papaya. Journal of Medicinal Plants Studies*, 1: 7-15. http://www.plantsjournal.com/.

Asudi, G. O., Ombwara, F. K., Rimberia, F. K., Nyende, A. B., Ateka, E. M., Wamocho, L. S., Shitanda, D. and Onyango, A. (2010). Morphological diversity of Kenyan papaya germplasm. *African Journal of Biotechnology*, 9 (51): 8754-8762.

Baiyeri, K. P. and Tenkouano, A. (2007). Manure placement influenced growth and dry matter yield of a plantain hybrid. *Proceedings of 8th African Crop Science Society Conference, El-Minia, Egypt*, pp. 385-390.

Baiyeri, K. P., Aba, S. C., Faturoti, B. O. and Tenkouano, A. (2009). Effects of poultry manure and bunch pruning management on fruit size, shelf life and pulp colour of 'PITA 24' and 'Mbi-Egome' plantains (Musa sp. AAB group). *Journal of Animal and Plant Sciences*, 3(2): 215 - 226.

Boshra, V. and Tajul, A. B. (2013). Papaya – An innovative raw material for food and pharmaceutical processing industry. *Health Environmental Journal*, 4: 68-75. http://www.hej.kk.usm.my/pdf/HEJVol. 4No.1/Article07.

Chapman, C. (1989). Principles of germplasm evaluation. In: IBPGR training courses: Lecture series. 2. Scientific management of germplasm: characterisation, evaluation and enhancement. Stalker, H.T. and Chapman, C. eds. *International Board for Plant Genetic Resources,* Rome, Italy, pp. 55-63.

Cook, D. G. (1997). Microhabitat use and reproductive success of the California red-legged frog (*Rana aurora draytonii*) and Bullfrog (*Rana catesbeiana*) in an Ephemeral Marsh. Master's Thesis, Sonoma State University, Rohnert Park, California, U.S.A.

Crane, J.H., Balerdi, C.F. and Orfanedes, M.S. (2007). Tropical and subtropical fruit crops for the home landscape: Alternatives to citrus. Horticultural Sciences document hS812. Cytological analyses of *Carica papaya* X C. cauliflora interspecific hybrids. Theoretical.

Dagoon, J. D. (2000). Farm crop production and agroforestry. First Ed. Rex printing company Inc. *Quezon City*, pp. 326-336.

Davamani, J., Balamohan, T.N. and Sudha, R. (2013). Evaluation of papaya (*Carica papaya* L.) hybrids for yield and papain recovery. *Journal of Horticultural Science*, 8(2):165-171.

De Villiers, E. A. and Willers, P. (1995). Papaya pests. In: *Papaya*. Institute for Tropical and Subtropical Crops. Published by the ARC. South Africa.

FAOSTAT (Food and Agriculture Organisation for the United Nations (2007). Statistics online website). The Top 5 Papaya Producing Countries (top5ofanything.com)

GENSTAT. (2013). Genstat 10 Release 4.23 DE, Discovery Edition 4, Lawes Agricultural Trust, Rothamsted Experimental Station, UK.

Jana, B.R., Rai, M., Das, B. and Nath, V. (2006). Genetic variability and association of component characters for fruit yield in papaya *(Carica papaya* L.). *The Orissa Journal of Horticulture*, 34: 22-27.

Lakshmi, U. (2000). Evaluation of papaya (*Carica papaya* L.) varieties for desert purpose. An M.Sc thesis, Department of Horticulture, College of Agriculture, Vellayani.

Matsuura, F. C., Folegatti, M. I. S., Cardoso, R. L. and Ferreira, D. C. (2004). Sensory acceptance of mixed nectar of papaya, passion fruit and acerola. *Science and Agriculture,* 61:604-608.DOI:http://dx.doi.org/10.1590/S0 103-90162004000600007.

Nakasone, H. Y. and Paull R. E. (1998). Papaya. In: *Tropical fruits*. CAB International, Wallingford. Oxon. UK. pp. 239-269.

Ndubuaku, U. M., Nwankwo, V. U. and Baiyeri, K. P. (2014). Influence of poultry manure application on the leaf amino acid profile, growth and yield of moringa (*Moringa oleifera* Lam). *Albanian Journal of Agricultural Science*, 13(1): 42-47.

Ndubuaku, U. M., Ede, A. E., Baiyeri K.P. and Ezeaku, P.I. (2015). Application of poultry manure and the effect on growth and performance of potted Moringa (*Moringa oleifera* Lam) plants raised for urban dwellers' use. *African Journal of Agricultural Science*, 10(36): 3575-3581, 3.

Ocampo, J.P., D'Eeckenbrugge, G.C., Bruyèr, E S., DE Bellaire, L.L. and Ollitrault, P. (2006). Organisation of morphological and genetic diversity of Caribbean and Venezuelan papaya germplasm. *Fruits*, 61: 25-37.

OECD (Organisation for Economic Cooperation and Development) (2005). Consensus document on the biology of papaya (*Carica papaya*). Series on harmonisation of regulatory oversight in biotechnology No. 33, OECD Environment Directorate, Paris.

Purseglove, J. W. (1963). Some problems of origin and distribution of tropical crops. *Genetic Agriculture.* 17: 105 -122.

Rice, R. P., Rice, L. W. and Tindal, H. D. (1994). Fruit and vegetable production in warm climates. Macmillan Press Ltd., Hong Kong. 486 p.

Samson, J. A. (1986). *Tropical fruits* (2nd Ed). Longman Scientific and Technical, New York, pp. 256-269.

Uguru, M. I., Baiyeri, K. P. and Aba, S. C. (2011). Indicators of climate change in the derived savanna niche of Nsukka, South-eastern Nigeria. *Journal of Tropical Agriculture, Food, Environment and Extension,* 10 (1): 17-26.

Warren, J. G., Phillips, S. B., Mullins, G. L., Keahey, D. and Penn, C. J. (2006). Environmental and production consequences of using alum-amended poultry litter as a nutrient source for corn. *Journal of Environment*, Qual., 35: 172-182.