International Journal of

Agricultural Research

ISSN 1816-4897

Academic
Journals Inc.

www.academicjournals.com

International Journal of Agricultural Research 3 (3): 211-218, 2008
ISSN 1816-4897

Agronomy and Processing Attributes of Some Cassava (*Manihot esculenta*, Crantz) Genotypes as Affected by Location and Age at Harvest in Ghana

[1]E. Baafi and [2]O. Safo-Kantanka
[1]CSIR-Crops Research Institute, P.O. Box 3785, Kumasi, Ghana
[2]Department of Crop and Soil Sciences,
Kwame Nkrumah University of Science and Technology, Kumasi, Ghana

Abstract: The influence of age on tuber yield, dry matter content, cooking quality and flour, gari and starch yield were studied on 4 cassava accessions (DMA-002, WCH-037, NKZ-009 and NKZ-015) at six selected locations in the Forest and the Transition ecozones of Ghana in 2004/2005. The aim was to determine the effect of age, variety and location on agronomic and processing characteristics of cassava genotypes at the Forest and the Transition ecozones of Ghana. Data were collected for the tuber yield, dry matter content, cooking quality, flour, gari and starch yields. Planting was done at 1×1 m with each genotype occupying half of an acre to facilitate continuous harvesting and for large tuber samples of 25 kg to be processed into flour, gari and starch. Harvesting which began at 12 months after planting was continued monthly until 15 months of age. Tuber yield of the genotypes was generally higher in the Transition than the Forest. In addition, DMA-002 and WCH-037 produced the higher tuber yield than the NKZ-lines in the Transition belt but not in the Forest ecozone. Genotypes did not only vary in dry matter content at the two ecozones but also the age at harvest. Cooking quality of the DMA-002 and WCH-037 was better than the NKZ-lines. Obtained results revealed that the optimum age for root tuber yield did not coincide with that of the flour, gari and starch. Similar observation was made between the starch, flour and gari.

Key words: Cassava, dry matter, cooking quality, flour, gari, starch, agronomy

INTRODUCTION

Root and tuber crops are the most important food crops for man after cereals and grain legumes and cassava (*Manihot esculenta*, Crantz) because of its potential for high dry matter production per day stands out among the root and tuber crops (Srinivas and Anantharuman, 2000). Cassava (*Manihot esculenta*, Crantz) is the only non-native root crop that has achieved the status of a major staple in Africa (Tewe, 1992). It is the main starch staple of many people in Africa (Manu-Aduening *et al*., 2006). It can produce relatively higher yield in infertile soils and tolerates long periods of drought, making it particularly important for poor rural households farming. It can be harvested anytime from 8 to 24 months after planting and can be left in the ground as a safeguard against unexpected food shortages which gives it advantage over cereals. The leaves are rich in protein (23%), appreciable amounts of vitamins and minerals and are a source of vegetables in some areas such as Tanzania and The Congo (Swaminathan, 1991; Balagoplan *et al*., 1998). At least $3 billion is earned by Nigeria through the export of cassava and related products (FAO, 2004). In Ghana, cassava currently contributes over 16% of the total Agricultural Gross Domestic Product (AGDP). In Ghana, a mean

Corresponding Author: E. Baafi, CSIR-Crops Research Institute, P.O. Box 3785, Kumasi, Ghana

per capita production of 465 kg annum^{-1} provides about 20% of calories in the diet, far ahead of any other single crop or animal source (FAOSTAT, 2005). It has therefore, been described as the last line of food security in Ghana (Arku-Kelly, 2001).

In Ghana, the tuber is used in various indigenous preparations including fufu and ampesi. It is also a major source of feed for livestock. Cassava flour and starch have potential usage in the food, plywood, paperboard, textiles, pharmaceutical, petroleum and brewery industries. Cassava's contribution of 16% to the total Agricultural Gross Domestic Product (AGDP), which was higher than any other crop including cocoa (Safo-Kantanka, 2004), is an evidence of the enormous contribution it makes to Ghana's economy. Cassava utilization is affected by variety, age at harvest and the prevailing environmental conditions at growth and harvest. Even though some effort have been made to develop and release superior cassava genotypes to boost cassava production and utilization, studies on the effect of these factors especially their interactions are lacking in Ghana.

The objective of this study was to determine the effect of age, variety and location on agronomic and processing characteristics of cassava genotypes at the Forest and the Transition ecozones of Ghana.

MATERIALS AND METHODS

This study was carried out at the Forest; (Mampong, Dormaa-Ahenkro and Kumasi) and Transition (Techiman, Kwame-Danso and Kintampo) ecozones of Ghana between 2004 and 2005. The genotypes used were NKZ-009, NKZ-015, DMA-002 and WCH-037. They were selected from germplasm collection of the Nkoranza, Dormaa-Ahenkro, Wenchi and the Asunafo districts of the Brong Ahafo region of Ghana. Planting spacing was at 1×1 m. At each location, the genotypes were planted in large blocks of about half an acre per genotype. This ensured that there was enough material for the monthly harvest and also provided enough material for processing. Harvesting began at 12 months and continued monthly until 15 months of age. Twenty five kilogram of tubers was used for the flour, gari and starch from each variety for each location. Processing into the flour, gari and starch was carried out by a group of cassava processors trained by Women In Agricultural Development (WIAD) at Ashanti Mampong. Rainfall data recorded over the period were obtained from the office of the Meteorological Services Department, Kumasi. Soil analysis was done at the Crop and Soil Sciences Department of Faculty of Agriculture, KNUST. Data collected were tuber yield, dry matter content, cooking quality, flour, gari and starch yields.

RESULTS AND DISCUSSION

Tuber yield was recorded higher in the Transition belt than the Forest belt (Fig. 1 and 2). In the Forest belt, tuber yield increased from 12 months up to 14th month and then declined (Fig. 1) while in the Transition ecozone it declined from a peak at 12 months (Fig. 2). At both locations, the NKZ-lines appeared to have performed differently from the other two lines. In the Forest ecozones, the NKZ-lines yielded higher than the DMA-002 and WCH-037 lines (Fig. 1), but the reverse was true in the Transition ecozone (Fig. 2). These differences in tuber yield in the two ecozones may be related to the maturity of the varieties. The DMA-002 and WCH-037 appeared to mature earlier than the NKZ-lines. Therefore, since the rainfall amounts were generally higher and better distributed in the Transition ecozone (Table 1), these two early maturing varieties yielded better than the NKZ-lines. The late maturing NKZ-lines took advantage of the late distribution of rainfall in the Forest belt thus yielding higher than the DMA-002 and WCH-037.

In addition to differences in rainfall, differences in soil properties may have contributed to the variation in the tuber yield (Table 2). The Forest ecozone had higher organic matter content and C/N

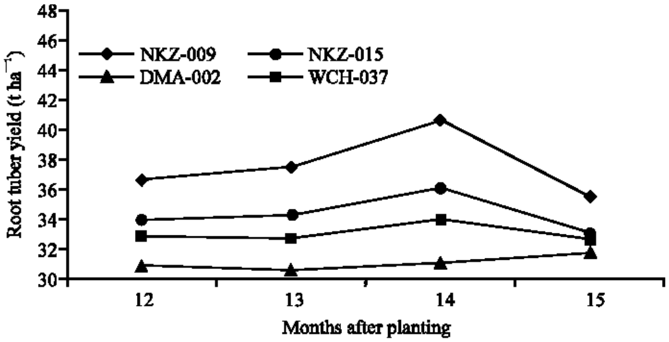

Fig. 1: Tuber yield of the cassava genotypes at different harvest dates in the Forest ecozone

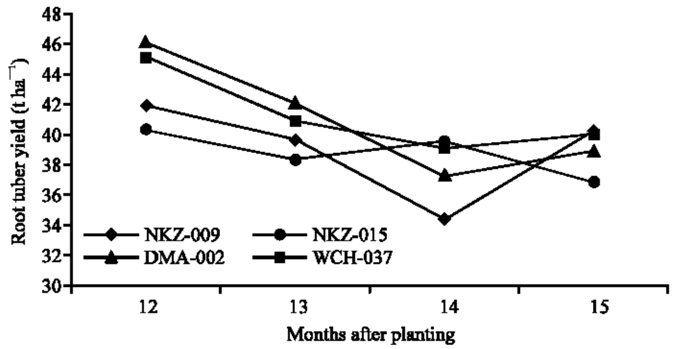

Fig. 2: Tuber yield of the cassava genotypes at different harvest dates in the Transition ecozone

Table 1: Cumulative rainfall (mm) for the locations (Sourced from the Meteorological Services Department, Kumasi)

Age at harvest (months)	Locations+ Forest DMA	MAP	KSI	Transition TEC	KSO	KIN
12	1132.80	1716.30	1630.20	1542.90	1591.10	1723.60
13	1274.60	1820.90	1819.00	1667.60	1661.90	1780.50
14	1409.20	2010.50	2073.60	2113.30	1891.00	2035.30
15	1452.90	2018.20	2168.90	2188.10	1989.30	2111.20
Total	5269.50	7565.92	7691.72	7511.92	7133.32	7650.60

+: DMA: Dormaa-Ahenkro, MAP: Mampong, KSI: Kumasi, TEC: Techiman, KSO: Kwame-Danso and KIN: Kintampo

ratio than the Transition belt even though rainfall amount was low compared with the Transition ecozone. These conditions generally provide good growing conditions for longer period of time for accumulation of photosynthate into higher tuber yield with time. This could have contributed to the higher yield of the late maturing NKZ-lines in the Forest ecozone. These could indicate Genotype x environment interaction on the yield of the varieties and agrees with Dixon and Nukenine (2000).

Dry matter content varied with the ecozones and age at harvest (Fig. 3, 4). Dry matter generally peaked at 12 and 13 months, respectively in the Forest (Fig. 3) and the Transition ecozones (Fig. 4). Exceptions were the DMA-002 in the Forest (13 months) and 15 months in the Transition ecozone. Dixon and Nukenine (2000) also reported variation in dry matter content of cassava genotypes in multilocation trials.

Cooking quality of DMA-002 and WCH-037 was better than the NKZ-lines (Table 3, 4). The differences may be attributed to the differences in dry matter content which was higher for the DMA-

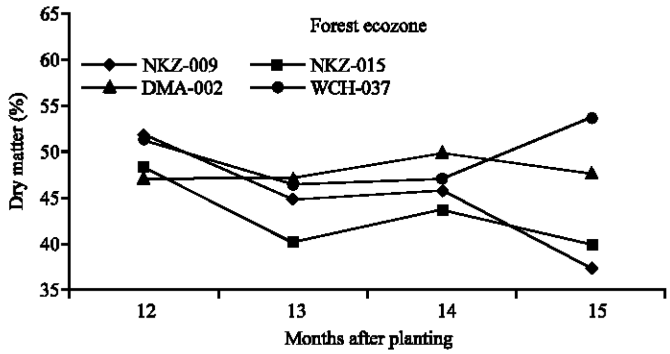

Fig. 3: Dry matter content of the cassava genotypes at different harvest dates in the Forest ecozone

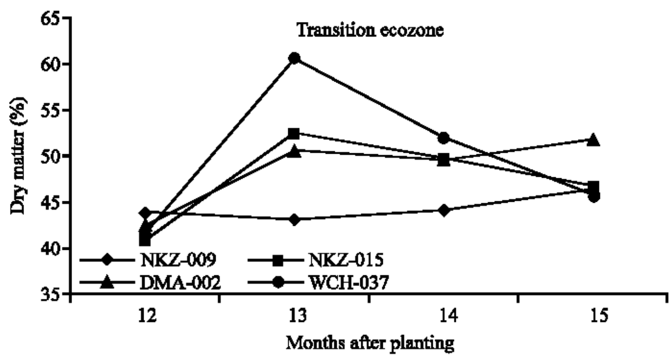

Fig. 4: Dry matter content of the cassava genotypes at different harvest dates in the Transition ecozone

Table 2: Soil properties of the experimental sites (obtained from the Department of Crop and Soil Sciences, Kwame Nkrumah University of Science and Technology, Kumasi

Location	OM (%)[a]	C/N	pH	ECEC	BS	AvP	Textural classification
0-20 cm depth							
Forest							
DMA	2.43	19.15	6.14	3.74	78.07	12.00	Sandy clay
Loam							
MAP	1.60	8.16	6.20	8.53	64.83	41.00	Sandy loam
KSI	0.57	4.65	5.40	7.80	64.10	10.00	Sandy loam
Transition							
TEC	0.57	7.67	5.53	6.54	63.30	20.25	Sandy
KSO	0.38	7.86	6.49	10.44	78.93	14.00	Sandy loam
KIN	1.46	8.58	6.27	7.63	58.06	40.00	Sandy loam
20-60 cm depth							
Forest							
DMA	1.03	4.69	6.29	5.76	51.39	6.00	Sandy clay loam
MAP	0.74	4.34	6.12	7.85	69.43	66.00	Sandy loam
KSI	0.77	6.34	5.20	7.15	58.04	18.00	Sandy loam
Transition							
TEC	0.38	5.12	5.53	6.55	63.51	70.00	Sandy
KSO	0.12	1.63	5.75	6.39	49.92	12.00	Sandy loam
KIN	1.26	12.81	6.43	5.17	61.31	55.00	Sandy loam

[a]: OM: Organic Matter; C/N: Carbon/Nitrogen ratio; ECEC: Exchangeable Cation Exchange Capacity; BS: Base Saturation; Av. P: Available Phosphorus

Table 3: Cooking quality scores of the genotypes at different ages of harvesting

Months after planting (map)	Genotypes NKZ-009	NKZ-015	DMA-002	WCH-037
12	2.00[a]	2.00	3.00	3.00
13	2.00	3.00	3.00	3.00
14	3.00	3.00	3.00	3.00
15	3.00	3.00	3.00	3.00
SED[+]	0.41	0.35	0.00	0.00

[a]: Cooking quality score: 1 = poor; 2 = good; 3 = very good; 4 = excellent. [+]: SED: Standard error of the difference

Table 4: Mean cooking quality scores of the varieties across locations

Location	Variety NKZ-009	NKZ-015	DMA-002	WCH-037
Forest				
Mampong	4.00	4.00	4.00	4.00
Dormaa-Ahenkro	4.00	3.00	4.00	4.00
Kumasi	1.00	2.00	2.00	4.00
SED[+]	0.54	0.41	0.41	0.38
Transition				
Kwame-Danso	1.00	2.00	2.00	2.00
Kintampo	1.00	2.00	1.00	2.00
Techiman	2.00	2.00	3.00	3.00
SED[+]	0.61	0.53	0.65	0.44

[+]: SED: Standard error of the difference

002 and WCH-037 than the NKZ-lines. This agrees to the observation of Safo-Kantanka and Asare (1993) that there is a positive correlation between dry matter content and cooking quality of cassava. Similar observations were made by Safo-Kantanka and Owusu-Nipa (1992). The excellent cooking quality of all the genotypes at Mampong and the poor cooking quality of some of the genotypes at Kintampo and the fact that some of the varieties for example, WCH-037 exhibit greater stability than others indicates a possible effect of location on cooking quality (Table 4). This also confirms Safo-Kantanka and Acquistucci (1996) report that cooking quality of cassava fresh tubers depends on environment.

Flour, Gari and Starch Yield

NKZ-009 and WCH-037 gave the lowest and highest flour yields in the Forest ecozone occurring at 12 and 15 months after planting (Fig. 5). In the Transition ecozone, the lowest and the highest values were produced at 13 and 12 months after planting by NKZ-009 and WCH-037 (Fig. 6). Gari yield for the varieties increased from 12 to 15 months after planting in the Forest ecozone except NKZ-009 and NKZ-015 which decreased slightly at 15 and 13 months respectively (Fig. 7). Gari yield of the NKZ-lines were however lower than DMA-002 and WCH-037. In the Transition (Fig. 8), gari yield of all the varieties peaked at 13 months, then decease generally from 13 to 15 months with the exception of NKZ-015 and WCH-037. Starch yield in the Forest ecozone for all the varieties except NKZ-009 increased from 12 to 13 months and thereafter decline steadily to the 15th month (Fig. 9). In the Transition belt, all the varieties generally decrease from 13 months to 15 months except NKZ-015 (Fig. 10).

The yield obtained for flour, gari and starch may be lower than the potential yield of the genotypes. This is because Safo-Kantanka *et al*. (2003) estimated the yield of the flour, gari and starch using local commercial method as 50% or more, less efficient compared with laboratory methods of extraction. This may be the reason why dry matter content of the varieties appears not reflecting in the flour, gari and starch yields. This therefore, demands an urgent improvement upon the local

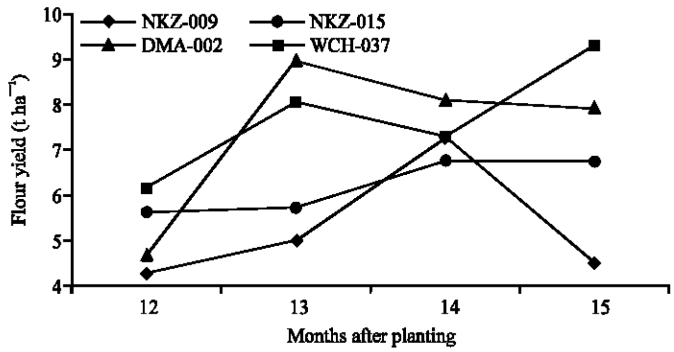

Fig. 5: Flour yield of the cassava genotypes at different harvest dates in the Forest ecozone

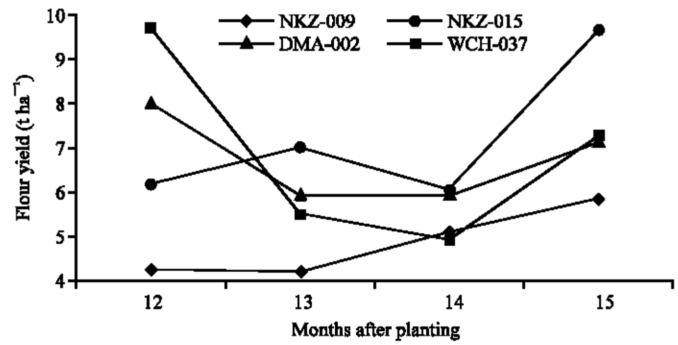

Fig. 6: Flour yield of the cassava genotypes at different harvest dates in the Transition ecozone

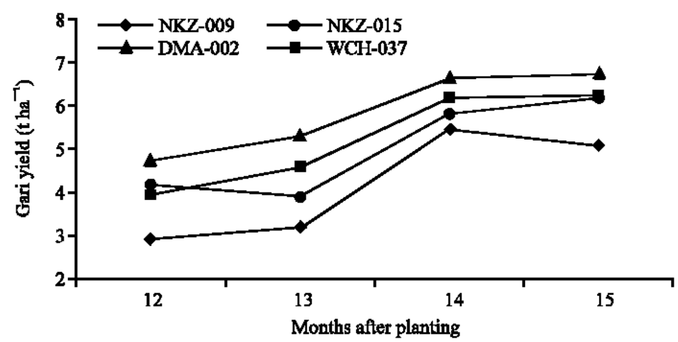

Fig. 7: Gari yield of the cassava genotypes at different harvest dates in the Forest ecozone

commercial method of processing cassava into flour, gari and starch to cut down losses. In spite of the above, the results generally revealed that the optimum age for root tuber yield did not coincide with that of the flour, gari and starch. Similar observation was made between the flour, gari and the starch. Wholey and Booth (1979) made similar observations in their study on cassava starch and reported that the age at which cassava should be harvested to obtain maximum fresh tuber yield may not necessary be the same as that to obtain maximum starch yield. Thus, considering the current commercial potential of cassava in revamping the economy of Ghana, the optimum age at harvest to realise potential yield of starch, flour and gari need to be given the necessary research attention at various cassava producing areas.

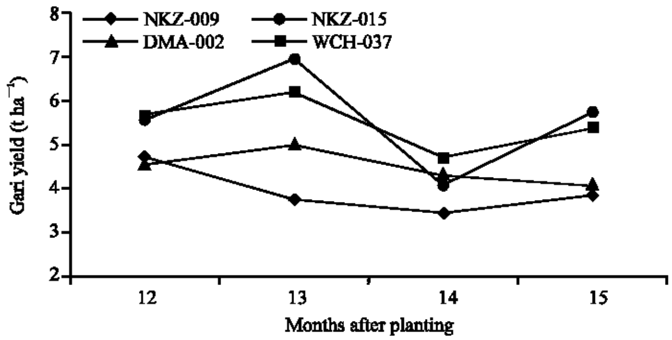

Fig. 8: Gari yield of the cassava genotypes at different harvest dates in the Transition ecozone

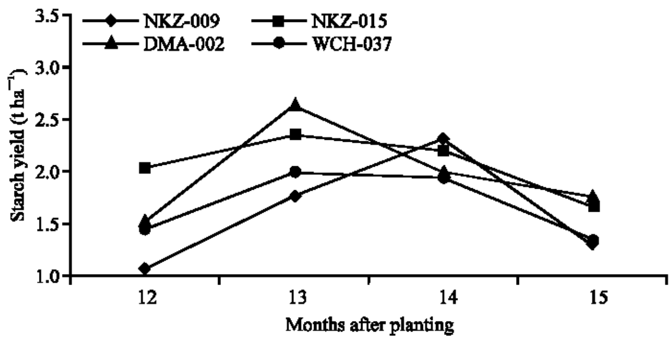

Fig. 9: Starch yield of the cassava genotypes at different harvest dates in the Forest ecozone

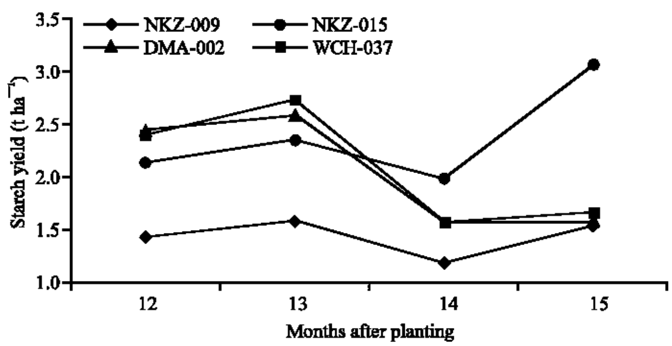

Fig. 10: Starch yield of the cassava genotypes at different harvest dates in the Transition ecozone

CONCLUSION

The variation in the performance of the genotypes across age at harvest and environment indicates the significant influence of variety, date of harvesting and the prevailing growing conditions on the agronomic traits and processing attributes of cassava. Hence, evaluation and selection of cassava genotypes for specific domestic and industrial application may be complicated when differences in those factors are large.

REFERENCES

Arku-Kelly, S., 2001. Cassava our crop II. Daily Graphic, Jan. 2, No. 148104, pp: 7

Balagoplan, C., G. Padmaja, S.K. Nanda and S.N. Moorthy, 1998. Cassava in Food, Feed and Industry. CRC Press, Boca Ration, Florida. USA., pp: 113-127.

Dixon, A.G. and O. Nukenine, 2000. Genotype × environment interaction and optimum resource allocation for yield and components of cassava. African Crop Sci. J., 8: 1-10.

FAO, 2004. Cassava Processing and Utilization. http://www.globalcassavastrategy.net/Al/brazil/b0000e06.htm

FAOSTAT, 2005. http://faostat.fao.org.

Manu-Aduening, J.A., R.I. Lamboll, Ampong Mensah, J.N. Lamptey, E. Moses, A.A. Dankyi and R.W. Gibson, 2006. Development of superior cassava cultivars in Ghana by farmers and scientists: The process adopted, outcomes and contributions and changed roles of different stakeholders. Euphytica, DOI: 10.1007/s10681-006-9091-x C_ Springer 2006.

Safo-Kantanka, O. and J. Owusu-Nipa, 1992. Cassava varietal screening for cooking quality: Relationship between dry matter, starch content, mealiness and certain microscopic observations of the raw and cooked tuber. J. Sci. Food Agric., 60: 99-104.

Safo-Kantanka, O. and E. Asare, 1993. Factors affecting properties of cassava. Proceedings of the 2nd National Workshop on Root and Tuber Crops and Plantain. Kumasi, pp: 107-118.

Safo-Kantanka, O. and R. Acquistucci, 1996. The physico-chemical properties of cassava starch in relation to the texture of the cooked root. Ghanal J. Agric. Sci., pp: 28-29, 69-80.

Safo-Kantanka, O., E.Y. Boampong, E. Baafi and K. Osei-Sarpong, 2003. Final evaluation report on four casava genotypes proposed for release. Presented To The National Variety Release Committee of Ghana.

Safo-Kantanka, O., 2004. Cassava can replace cocoa in Ghana I and II. Daily Graphic, May 11-12. No. 149123 and 149124, pp: 9.

Srinivas, T. and M. Anantharuman, 2000. Status of cassava production, processing and marketing in Andhra Pradesh. Central Tuber Crops Research Institute. Sreekariyam, Thiruvanntha Puram-695017 Kerada, India, pp: 7.

Swaminathan, M., 1991. Essentials of food and nutrition, Vol. 2, BAPPCO, India.

Tewe, O.O., 1992. Why cassava? In: Tropical Root and Tuber Crops Bulletin, 6: 2.

Wholey, D.W. and R.H. Booth, 1979. Influence of variety and planting density on starch accumulation in cassava roots. J. Sci. Food Agric., 30: 165-170.