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Trends in the development of Cassava Stem Planters

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ABSTRACT

Cassava is now grown throughout the tropical world with annual global production at approximately 276 million tonnes. Nigeria is the largest producer of cassava in the world accounting for 19 % of the global production. Cassava is mainly planted with cut stem at a spacing of 1m x 1m. Manual stake production is tedious and time consuming. The production rate per person is about 5000 stakes per day and about 100000 stakes are required per day for mechanized commercial planting. Some cassava planters have been developed but they have not been commercially available to farmers in Nigeria. There have been attempts made in research on mechanical planting of cassava stems. The prototype-planters from the previous research include cassava planter model PC-2; cassava planter model PMT-3; automatic cassava planter model 3; commercial prototype of model 3; Thailand cassava planter model; NCAM-developed cassava stem planter and a single-row cassava stem planter. However, this critical review has revealed that all the mechanical planters require extra labour for feeding of the stems for cutting and planting of the stakes. Therefore, projection for an improved mechanical planter named single-row cassava stem planter with semi-automatic metering system is recommended for research. This improved planter will eliminate the extra labour required by the existing mechanical planter as well as providing such labour for other farm operations for the present and future demand of cassava products

Keywords : cassava, planting, stem planter, mechanization, review

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I. INTRODUCTION

Cassava (*Manihot esculenta*) is a perennial woody shrub with an edible root, which grows in tropical and subtropical areas of the world, such as Asia, Central, West and Southern Africa (Oni and Eneh, 2004; Shadrack, 2011). It can be planted alone or in association with many other crops like maize, groundnuts, vegetables and rice (Braima *et al.,* 2000). Growing cassava usually requires 75 – 125 persons per hectare from land preparation to harvesting. The storage roots can be harvested 9 – 18 months after harvesting (Braima *et al.,* 2000). The annual global production of cassava is now approximately 276 million tonnes of which Nigeria is accounting for 19 % (Nteranya, 2015). Recently cassava has occupied a prominent place in national non–oil export commodity, especially exports in Sub–Saharan Africa that international demand is far above the supply (Fresco, 1993; Nweke *et al.,* 2002). This increase in cassava export has also negatively affected local supply. In Nigeria, with the demand for cassava for food and industrial uses, mechanization of cassava field operations has become imperative if the huge demand is to be met locally. Mechanization reduces drudgery, thus making farming an attractive enterprise. It therefore, has the potential for national economic growth, food self-sufficiency, industrial growth and employment leading to poverty reduction (Ikejofor and Eke-Okoro, 2012).

Cassava production depends on a supply of quality Stem cuttings. The multiplication rate of planting materials is very low compared to grain crops which are

propagated by seeds (IITA, 2009). Planting of cassava involves stake production operation. Manual stake production using secateur or sharp matchet is tedious and time consuming. The production rate for one person is only about 5000 stakes per day. The normal plant density for cassava is 10,000 stakes per hectare for spacing of 1m x 1m (Eke-Okoro, *et al* 2005). However, about 100,000 cassava stakes are required per day for mechanized commercial planting. Planting is still majorly done manually and is expensive. Though some cassava planters have been developed, but they have not been commercially available to farmers in Nigeria. Even the imported ones from countries like Brazil and Colombia that still require extra labour behind the tractor to manually feed in the stems for cutting into stakes for mechanical planting. Currently, labour shortage arising from rural-urban migration in Nigeria and the present trend for higher demand for cassava for industrial production of starch, bio-ethanol, etc. and the increased export to China and other developed worlds have created the need to improve on the planting technology of cassava so that present labour shortage can be resolved with replacement by an improved mechanical cassava stem planter. This paper is therefore on a critical review of the trends of mechanization in cassava planting and a projection for an improved mechanical cassava stem planter that will eliminate the extra labour required behind the tractor for placement of the cassava stems for mechanical planting as well as providing such labour for other cassava production operations for the present and future demand for cassava products.

Cassava Varieties

According to IFAD and FAO (2005), farmers in Africa grow several cassava varieties. From a survey conducted by researchers from the Collaborative Study on Cassava in Africa (COSCA), over 1000 local cassava varieties in six countries of the study, namely the Congo, Côte d'Ivoire, Ghana, Nigeria, Tanzania and Uganda were identified. The farmers group the local cassava varieties into the bitter and the sweet varieties. The sweet varieties are more popular in Côte d'Ivoire, Ghana and Uganda while the bitter varieties are more common in the Congo, Nigeria and Tanzania. The COSCA farmers reported that the bitter varieties are more resistant to pests, higher yielding and store better in the ground than the sweet varieties. However, as the productivity of the cassava system increases and more cassava is processed as *gari*, the issue of the sweet or the bitter cassava varieties will become irrelevant (IFAD and FAO, 2005; Shadrack, 2011). Several improved varieties of cassava have been recommended and released in Nigeria. The most commonly grown of these are TMS 30572, 4(2)1425, 92/0326 and NR 8082 (Omeh, 2013; IITA, 2015). Earlier studies by Dorp and Rulkens (1993), Agwu (2002), Springer *et al.* (2002) Kimenju *et al.* (2005) and Agwu and Anyaeche (2007) showed that farmers decision to use particular crop cultivars were influenced by a number of reasons, some of which are market-driven or socio-culturally based.

Tillage System for Cassava Production

Field is usually prepared after the land has been cleared, by first ploughing followed by harrowing. Cassava could be planted on the flat, on ridges or on mounds (Ekanayake *et al.,* 1997). Where ridges are preferred, they are constructed using a ridger after primary and secondary tillage and may range from 15-30 cm in height and 75-100 cm in crest to crest distance (between ridges). Ridging could however be done before or after planting and is best suited for areas with drainage problems (International Starch Institute, 2002; Philippine Root Crops Information Service, 2005; Shadrack, 2011). On the light-textured soils, cassava can be grown without or with minimum tillage as long as weeds are controlled; in heavy or compacted soil, cassava responds favourably to tillage and yields tend to increase when grown on ridges. In order to reduce erosion as well as production costs, cassava should be grown with as little tillage as possible as long as high yields can be maintained (Howeler *et al.,* 1993). Research conducted by Ennin *et al.,* (2009) proved that planting cassava on ridges had the advantage of higher cassava root yield coupled with better and easier field management and has the potential for mechanization to further decrease drudgery and increase the scale of production of cassava compared to planting on the flat. When cassava is grown as the first crop in forest land, no further preparation is required than the clearing of the forest growth. When cassava is planted after other crops, it can often be planted without further preparation of the soil, once the preceding crop has been harvested or the soil has been ploughed two or three times until it is free from grass or other plants(FAO, 2013).

Soil Requirements

For ease of mechanized operations, areas with a loam type of soil should be selected, while heavy clays should be avoided. Also field plots should not have slopes of more than 8%, nor should they be laid on low-lying and flood-prone areas. If cassava needs to be planted on slopes then it would be advisable that the plots be laid across the slope or slightly inclined to contours so as to minimize soil erosion in the plots (Sukra *et al.,* 1992). It was reported that cassava can be grown on most soils with soil pH of 5.5 – 6.5, however the best soils are sandy clay loams that are well drained without a fluctuating table. Proper soil management practices, adequate soil and limestone applications at 2-4 t/ha incorporated into the soil 3 to 4 months before planting are necessary for the successful cultivation of cassava (Anthony, 2008).

Agronomic Requirements

Cassava stem cuttings (also referred to as 'stakes') could be planted 1 per hole in a horizontal, vertical or slanting position to a depth of 5-10 cm depending on soil type and condition (International Starch Institute, 2002; Adekunle *et al.,* 2004; Shadrack, 2011). Cassava stem cuttings may be planted at a spacing of 1.2 x 0.8 m (approximately 10,417 plants/ha) or 1m x 1m with cuttings of 2 or 3 nodes depending on the cultivar. Cuttings planted in moist soil under favourable conditions

produce sprouts and adventitious roots within a week. In areas where freezing temperatures are possible, the cuttings are planted as soon as danger of frost is over. Observing the polarity of the cutting is essential in successful establishment of the cutting. The top of the cutting must be placed up with nodes also pointing upwards. Replanting can be done 2 weeks after planting to replace dead stem cuttings or those which could not sprout (International Starch Institute, 2002; Ikejiofor and Okwesa, 2013; Adebayo, *et al.*, 2014). 0.9 x 0.9 m plant spacing is recommended by IITA 2015. Cassava cuttings are also planted 50 cm to 90 cm on the ridge at a 45^{o} angle leaving 2-3 nodes above ground. Cassava is normally planted in May at the beginning of the rainy season. However, earlier plantings in March and April can significantly increase tuber yields (Anthony, *et al.*, 2008). It was reported that cassava is propagated exclusively from cuttings because seed germination is usually less than 50 percent (Moore and Lawrence, 2003).

Cassava Production in Nigeria

Cassava is most widely cultivated in the southern part of the Nigeria in terms of area devoted to it and number of farmers growing it. Since 1990, Nigeria has surpassed Brazil as the world leading producer of cassava with an estimated annual production of 26 million tonnes from an estimated area of 1.7 million hectares of land (Agbetoye, 2004; Agbetoye, *et al.*, 2006). In 2002, it was estimated as 34 million tonnes. %. In 2007, Nigeria produced 46 million tonnes making it the world largest producer (IITA, 2009). Comparing the outputs of various crops in Nigeria, cassava production ranks first followed by yam production at 27 million tonnes in 2002 and at 46 million tonnes in 2007 (IITA, 2014). The trend of cassava production is presented in Figure 1.

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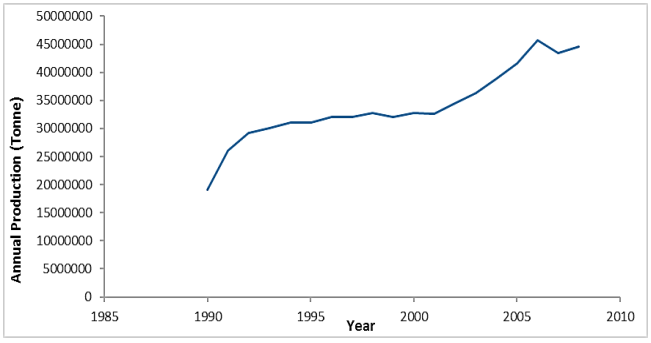
Figure 1: Trend in production of cassava in Nigeria from 1990-2008



Source: Analysed from FAO (2004) and National Bureau of Statistics (2010)

II. EXISTING CASSAVA STEM PLANTER

Cassava Planter Model PC-2(two rows)

According to Ospina *et al.*, 2007, the main technical characteristics of this prototype are; the distance between planting rows was adjustable from 85 to 95 cm; the distance between plants in the row was adjustable from 40 to 100cm; the planter can be pulled with a tractor ranging from 60 to 70 HP with hydraulic lifting system; automatic cutting of the stake was controlled by the tire of the tractor; the capacity for storage of the cassava stems was 1.5 m^3; storage capacity for chemical fertilizer was 150 kg; there was a provision for controlling the planting depth and the planting output was 5 to 7 ha/day with labour requirement of two people for loading the cassava for planting plus the tractor driver.

Cassava Planter Model PMT-3(Three Rows)

According to Ospina *et al.*, 2007, the main technical characteristics of this prototype are; the distance between planting rows was fixed for 1.0 m; the distance between plants in the row was fixed at 90 cm; the planter can be pulled with a tractor ranging from 60 to 70 HP with hydraulic lifting system; automatic cutting of the stake was controlled by jaw system, cutting by pressure on the stem; the capacity for storage of the cassava stems was 1.5 m^3; storage capacity for chemical fertilizer was 150 kg; there was no provision controlling the planting depth and the planting output was 8 to 10 ha/day with labour requirement of three people for loading the cassava for planting plus the tractor driver.

The Odigboh Models

According to Odigboh (1983), the attempt to design a cassava planter dates back to 1971. But it was only in 1977 that a functional model emerged. That prototype was trailed and planted two rows of cuttings at an inclination that can be varied from 45° to 85° to the horizontal, depending on the forward planter speed. The cuttings were spaced 90 cm on small ridges which are 90 cm apart. In addition, the hopper design was too complicated and required that the cuttings be fed individually, one by one, according to the diameter of the cuttings (Odigboh, 1985). The photograph of the single-row model of this ultimate design of an automatic cassava planter is shown in Figure 2. A two-row prototype was completed in 1985. The hopper design was very simple and efficient. The planter performed very satisfactorily at planting speed of 8 km per hour. After so many years of tinkering, Odigbo was in Britain from March to June 1985, to build a commercial field prototype of the planter (Figure 3).

Figure 2: Automatic cassava planter Model III

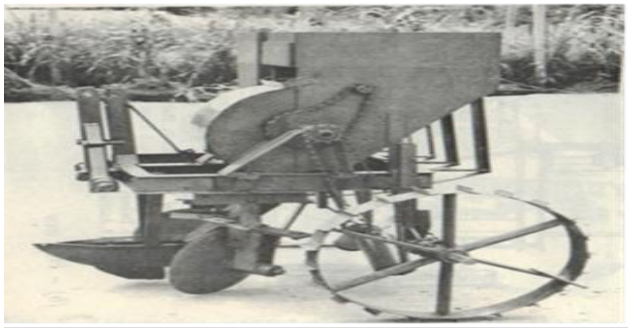
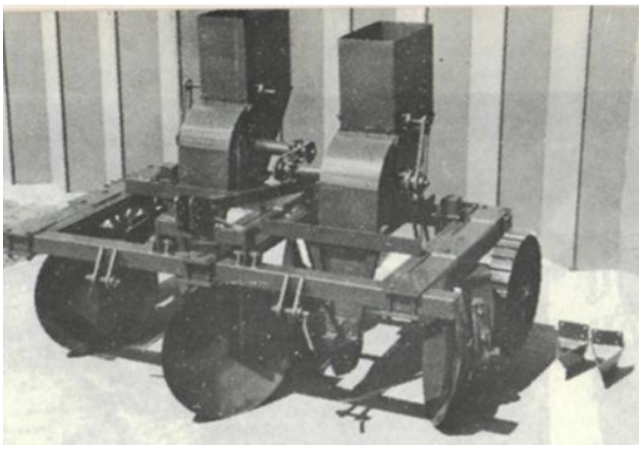


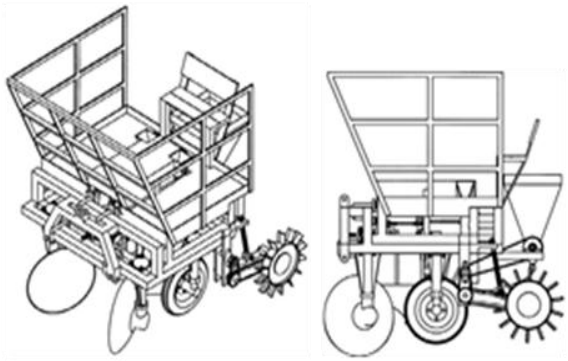
Figure 3: Commercial Prototype of Model III Cassava Planter



Thailand Cassava Planter Model

A cassava planter (Figure 4) suitable for use in local farms was developed. It was designed to plant stakes either on flat beds or in ridges and to apply fertilizer at the same time. The machine consists of the main frame, the cutting unit, the planting unit, the fertilizer unit, the ridger, and the soil levelers. A 57.4 kW tractor was used as a power source with labour requirement of two people for loading the cassava for planting plus the tractor driver. It was observed that the average field capacity and field efficiency were 0.135 ha/h and 65.3%, respectively. The maximum draught requirement of the machine was 1.55 kN. It could plant the stakes at an average inclination of 67° (angle 1, altitude angle of stake in the longitudinal-vertical plane) and 88° (angle2, altitude angle of stake in the lateral-vertical plane) depending on the forward speed (Lungkapin *et al.*, 2009).

Figure 4: Schematic of the cassava planter



(b) Isometric view (c) Right side view

NCAM-developed prototype cassava stem planter

The National Centre for Agricultural Mechanization (NCAM), Nigeria has in recent times made an in-road into the development of a mechanical planter (Figure 5) which is about 75% completed. (Hariharam *et al.*, 2015).

Figure 5: NCAM-developed prototype cassava stem planter

Single Row Cassava Planter

A cassava stem planter was designed, fabricated and tested at Federal University of Technology, Akure, Nigeria. Its major components consist of frame, disc furrow opener, cutting device, operator seat, stem tube, press wheel, stem container and wheel. The power transmission was through belt and pulley arrangement. The stem was manually fed for cutting and planting. The machine was coupled to a 41 kW Massey Ferguson tractor. The field capacity and field efficiency of the planter are 0.28ha/h and 73.1% respectively at a forward speed of 4.24km/h (Oyedeji *et al.*, 2011).

Commercial Cassava Stem Planters

Some mechanical cassava stem planters are already available for mechanization of cassava planting. Some of the mechanical planters (Figure 6) can only be sighted in Nigeria in public institutions like National Centre for Mechanization (NCAM), Ilorin, Nigeria. Federal University of Technology, Akure, Nigeria, International Institute for Tropical Agriculture (IITA), Ibadan, Nigeria and National Root Crops Research Institute, Umudike, Nigeria. All the planters as sighted require extra labour to feed the machine for cutting and planting.

A mechanical planter made in Brazil is in use there and in Mexico. It is a two-row planter using a tractor driver and two men on the machine to feed cuttings from the reserve bins into the rotating planting turntable. In operation, the cuttings fall in succession through a hole into a furrow opened by a simple furrower. A pair of disks throw dirt into the furrow and floats pulled by chains pack the soil over the cuttings. The planter is able to cover about 5 hectares per day. A unit for ridging and planting has been developed by modifying a ridger to work as a ridger-cum-planter and a cultivator to work as a six-row planter after the area has been ridged (FAO, 1977).

Figure 6: Mechanical Cassava Stem Planters

III. FUTURE PROJECTIONS

Based on the critical review on the existing prototype and commercial planters for mechanization of cassava production, it was observed that all the planters requires extra labour behind the planter for manual feeding of the stems for cutting and planting of the stakes. It is therefore projected that a single-row cassava stem planter with semi automatic metering system that will eliminate the extra labour required for the present set of planters. The planter will be able to plant cassava stake varying from 25 mm to 35 mm in diameter; stake length of 250 mm and it will be manually loaded before operation. The machine will be operated by a 31.6 kW tractor.The development of a single-row cassava stem planter will also be a solution to food security problem; drudgery reduction in farming; disinclination of youths to farming as well as providing sufficient biomaterials for future production of biofuel.

IV. FEATURES OF THE PROPOSED PLANTER

The single-row cassava stem planter will consist of the hopper, cam shaft for regulation of the stem cutting, cutting section, the conveyor/metering system, double disc furrow opener, double disc furrow coverer, power transmission system (angle drive), the land wheels and the frame (Figures 7 and 8).

Figure 7: Isometric View of the proposed Planter

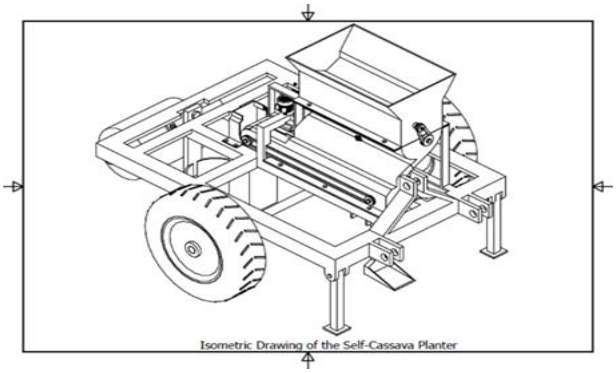
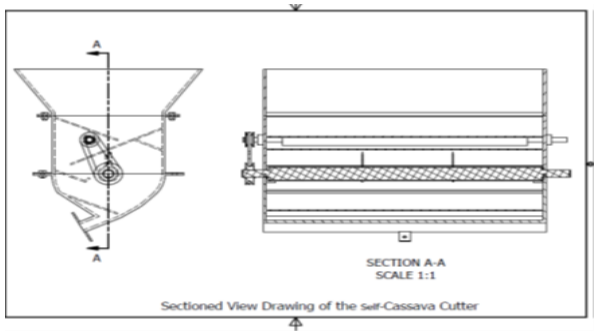


Figure 8: Sectioned View of the Cutting Section



V. CONCLUSIONS

The annual global production of cassava is now approximately 276 million tonnes of which Nigeria is accounting for 19 %. Nigeria produced 46 million tonnes making it the world largest producer. Cassava production is not only important for Nigeria on food security but also on the socio-economic system

Agricultural practice for cassava production includes land preparation, planting, fertilizer application, farm sanitation and weeding, pest and disease control, harvesting and processing. Cassava stakes could be planted 1 per hole in a horizontal, vertical or slanting position to a depth of 5-10 cm depending on soil type and condition.

Mechanical planters in Nigeria can only be sighted in public institutions. the critical review on the existing prototype and commercial planters for mechanization of cassava production has revealed that all the planters require extra labour for manual feeding of the stems for cutting and planting of the stakes. So there is the need for developing a cassava stem planter with automatic metering system that will eliminate the extra labour required for the present set of planters. The development of a single-row cassava stem planter will also be a solution to food security problem; drudgery reduction in farming; disinclination of youths to farming providing sufficient biomaterials for future production of biofuel as well as resolving present labour shortage from the rural-urban migration.

VI. REFERENCES

[1] **Adebayo, B. A., Elifatio, T., Ivor, M., Richardson, O., Roger R., Gbassey, T., Edward, k.** Growing Cassava; A training Manual from Production to Postharvest. IITA, Ibadan, Nigeria, 2014.

[2] **Adekunle, A.A., Dixon, A., Ojurongbe, J., Ilona, P., Muthada, L. Adisa, S.** Growing Cassava Commercially in Nigeria - An Illustrated Guide. USAID, ICS-Nigeria and IITA. 2004.

[3] **Agbetoye, L. A. S, Ademosun, O. C, Ogunlowo, A. S., Olukunle, O.J., Fapetu, O. P. Adesina, A.** Developing Indigenous Machinery for Cassava Processing and Fruit Juice. International Conference on Advances in Engineering and Technology Held 16-19 July 2006 at Entebbe, Uganda. 2006.

[4] **Agbetoye, L. A. S.** The Unsolved Problem of Cassava Harvesting Mechanisation: Why and How? Technical Paper for Presentation at the South-West Zonal Meeting of the Nigerian Institution of Agricultural Engineers held at Rufus Giwa Polytechnic, Owo, Ondo State, Nigeria on 29th January, 2004.

[5] **Agwu A.E.** Cowpea varietal needs of farmers in Bauchi and Gombe states of Nigeria, J. Tropical Agric. Food, Environ. Ext. 2002: 3 (1): 55- 62.

[6] **Agwu, A. E. Anyaeche, C. L.** Adoption of improved cassava varieties in six rural communities in Anambra State, Nigeria. African Journal of Biotechnology 2007: 6 (2): 089-098.

[7] **Anthony, S., Mynie, R. Manmohan, L. V.** A Guide to Growing Cassava Successfully. Root Crop Bulletin. Ministry of Agriculture, Land and Marine Resources Research Division, Centeno. 2008.

[8] **Braima, J., John, U., Ambe, T., Norbert, M., Alfred, D., Rasaq, S. Joseph, K.** Starting a Cassava Farm. International Institute of tropical Agriculture, Cotonou, Republic of Benin. 2000. http://www.cgiar.org/iita.

[9] **Dorp M and Rulkens T.** Farmer Crop Selection Criteria and Gene Bank Collections In Indonesia, In: Boef W, Amanor K, Wellard K, Bebbington A (Eds). Cultivating knowledge: Genetic diversity, farmer experimentation and crop research. London, Intermediate technology publications. 1993: 119-127.

[10] **Ekanayake, I. J., Osiru, D. S. O. and Porto, M. C. M.** Agronomy of Cassava. IITA. Research Guide 60. IITA, Ibadan, Nigeria. 1997.

[11] **Eke-Okoro, O.N., Ekwe, K.C. and Nwosu, K.I.** Cassava Stem and Root Production. A Practical Manual. National Root Crops Research Institute, Umudike. 2005. Pp 39.

[12] **Ennin, S. A., Otoo, E. and Tetteh, F. M.** Ridging, a Mechanized Alternative to Mounding for Yam and Cassava Production. West African Journal of Applied Ecology, 2009: (15) 1-8

[13] **FAO.** Cassava Processing. FAO Corporate Document Repository. 1977.

[14] **FAO.** United Nations Annual *Statistics.* Rome, Italy. 2004.

[15] **IITA.** Opportunities for Cassava in Nigeria: Competitiveness Workshop in Bookanga, International Institute of Tropical Agriculture. (IITA), Ibadan. 2002

[16] **FAO.** Save and Grow Cassava; A Guide to Sustainable Production Intensification. Food and agriculture Organisation of the United Nations, Rome. 2013.

[17] **Fresco, P.** The Dynamics of Cassava in Africa: An Outline of Research Issue, COSCA1993. Working paper no. 9.

[18] **Hariharan, K. V., Pradeep-kumar, S. P., Prasanth, M. Senthil Kumar.** Design and Fabrication of Tapioca Planter. International Journal of Innovative Research in Science, Engineering and Technology 2015.

[19] **Howeler, R. H., Ezumah, H. C. and Midmore, D. J.** Tillage systems for Root and Tuber Tropics. Soil and Tillage research. 1993(27): 211-240.

[20] **IFAD and FAO** A Review of Cassava in Africa with Country Case Studies on Nigeria, Ghana, the United Republic of Tanzania, Uganda and Benin. Proceedings of the validation forum on the global cassava development strategy, Rome. 2005: Vol. 12.

[21] **IITA. Cassava.** International Institute of Tropical Agriculture Headquarters, Ibadan, Nigeria. 2009 http://www.iita.org/cassava.

[22] **IITA.** Nigeria's Cassava Industry; 2014 Statistical Handbook.

[23] **IITA.** Growing Cassava in Nigeria. Commercial Crop Production Guild Series. Publication of International Institute of Tropical Agriculture. 2015. www.iita.org

[24] **Ikejiofor, M. C. Eke-Okoro.** Performance Evaluation of NRCRI Cassava Stem Cutting Machine. International Journal of Scientific and Technology Research 2012:1(8): 175-178.

[25] **Ikejiofor, M. C., Okwesa, C. O.** Design and Development of NRCRI Cassava Stem Cutting Machine. International Journal of Advanced Scientific and Technical Research. 2013:3(1):39-43.

[26] **International Starch Institute Cassava Plantation,** Science Park Aarhus, Denmark. 2002. www.starch.dk/isi/papers/TM29%20Cassava%20Plantation%20EB.

[27] **Kimenju S.C, De Groote H, Karugia J, Mbogoh S, Poland D.** Consumer awareness and Attitudes toward GM foods in Kenya. Afr. J. Biotechnol. 2005: 4 (10): 1066-1075.

[28] **Lungkapin, J., Salokhe, V. M., Kaksirisilp, R.,Nakashima, H.** Design and development of a cassava planter. Transaction of ASABE. 2009: 52 (2): 393-399.

[29] **Moore, L. M. and Lawrence, J. H.,** Plant Guilde-Cassava (Manihot esculenta Crantz). USDA NRCS National Plant Data, Centre, Baton Rouge, Louisana. 2003.

[30] **National Bureau of Statistics.** 2010 Annual Abstract of Statistics. National Bureau of Statistics, Federal Republic of Nigeria. 2010

[31] **Nteranya, S.** Feeding Africa- An Action Plan for African Agricultural transformation; A background paper on Root and Tuber Crops (Cassava, Yam, Potato and Sweet Potato) presented at Abdou Diouf International Conference centre, Dahar, Senegal in October, 2015.

[32] **Nweke, F.I; Spencer D.S; Lyman, J.K.** The Cassava Transformation. Africa's Best- Keep Secret, East Lansing: Michigan State University. 2002.

[33] **Odigboh E.U.** Mechanization of Cassava Production and Processing: A decade of design and development. University of Nigeria Inaugural Lecture,1985. Series No. 8. Tropical Food. Marcel Decker Publisher, Madigun avenue, New York. 1983. Pp 141-200.

[34] **Odigboh, E. U.** Cassava Production, Processing and Utilization. In Chan Jnr, H. T(ed). Handbook of Tropical Food. Marcel Decker Publisher, Madigun avenue, New York. 1983. Pp 141-200.

[35] **Omeh, D.** How to Produce Cassava in Nigeria- The Cultivating Techniques Wealth Result. WealthResult.com.

[36] **Oni, F.C., Eneh, M.C.C.** Strategies for reducing the cost of Production and Processing of Cassava, Paper presented at the facilitation and sensitization workshop for cassava producing States under the Presidential Initiatives on Cassava Production and Export, 8th – 12th November, 2004. Federal Ministry of Agriculture and Rural Development, Abuja.

[37] **Ospina, B., Cadavid, L. F., Garcia, M. Alcalde, Cesar.** Mechanization of Cassava Production in Colombia. Ciat-library.ciat.cgiar.org CIAT Publications › Articles in Proceedings. 2007.

[38] **Oyedeji, O. A., Agbetoye, L. A. S., Adedeji, O. T.** Development and Performance Evaluation of a Cassava Planter. Proceedings of the 11th International Conference and 32nd Annual General Meeting of NIAE held in Ilorin, Nigeria in October, 2011.

[39] **Philippine Root Crops Information Service.** Cassava, VISCA, baybay, Leyte. 2005.

[40] **Shadrack, K. A.** Performance Evaluation of the TEK Mechanical Cassava Harvester in Three Selected Locations in Ghana. M.Sc Thesis submitted to the Department of Agricultural Engineering, Kwame Nkrumah University of Science and Technology, Kumasi Ghana. 2011.

[41] **Springer A, Mattas K, Papastefanou GT, Tsioumanis A.** Comparing Consumer Attitudes towards Genetically Modified Food in Europe. Mimeo. 2002.

[42] **Sukra, A. B., Tengku-Ahmad, T. I., Tan, S. L.** Modified API Cassava Planter. Performance, Owning and Operating Costs. MARDI. 1990 Report No. 144, MARDI Serdang, Malaysia. pp.15

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