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# The effect of mechanization on cassava production in Ogun, Osun, and Kwara States of Nigeria

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**Abstract:** *Use and adoption of mechanization in cassava farming has the potential to increase yield if combined well with good agronomic practices. Promotion of machines in Nigeria has been occurring since the early 1990s, however uptake remains a challenge. This research was aimed at determining the factors that affect cassava yield as well as extent of use of mechanization in cassava production. Both primary and secondary data on cassava mechanization in Nigeria was used. The research focused on beneficiaries of the Cassava Mechanization and Agro-processing Project (CAMAP) led by the African Agricultural Technology Foundation (AATF) which promotes full mechanization for cassava production; i.e. ploughing, harrowing, planting, spraying, and harvesting. The data was analysed using Statistical Package for Social Sciences (SPSS). Multiple regression was used to determine the factors affecting cassava yield. The results showed a significant and positive influence of mechanization and good agronomic practices on the cassava yield. Project beneficiaries who used machines reported yields of 23–33 tonnes/hectare with non-beneficiaries reporting 4–11 tonnes/hectare. This translated into an income increase for farmers using machines for cassava production. This research recommends promotion of mechanization in Nigeria to enhance cassava production.*

**Keywords:** cassava, mechanization, Nigeria, good agronomic practices, production economics

## Introduction

CASSAVA (MANIHOT ESCULENTA CRANTZ) is believed to be one of the world's oldest crops, which originated in Brazil and spread through to the African coast. It is cultivated in tropical and subtropical climates and has a maturity period of 8–24 months depending on the variety. Over the years, cassava was believed to be a 'poor man's' crop; however things have now changed, and cassava is widely cultivated as an industrial crop in Asia, Africa, and Latin America as a great source of starch. In addition to this, cassava has many uses; the root tubers and leaves are used for human consumption and animal feeding (Latif and Müller, 2015). Cassava tubers can also be stored well in the ground for up to 24 months. The tubers are used for several products such as cassava chips, flour, starch, and ethanol for beer production, among others (Howeler et al., 2013).

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Nigeria has the potential to produce cassava and use it to reduce food insecurity and generate much-needed foreign currency. However, because of cassava's labour-intensive nature, long maturity period, and high level of perishability, it is often widely neglected as a possible high value crop, and as a viable solution to rising food insecurity and poverty reduction in sub-Saharan Africa (SSA). Time saving technologies, such as the cassava harvester and stem cutter among others, that can be used to make cassava an 'attractive' crop to farmers have been developed in several countries around the world such as Brazil, Thailand, Indonesia, and China, though their availability and use has not been emphasized in key cassava producing communities and countries in SSA. Governments and donors have also rallied behind increasing cassava production through different projects and initiatives, but these investments have not been sufficient to make a positive impact. However, this is slowly taking a turn as interest continues to build in West African countries (Nweke, 2004). Efforts by non-governmental organizations (NGOs) to intensify cassava production have also increased over the last 10 years.

### *Cassava production in Africa*

Cassava is the second most important crop after maize in SSA. It is consumed by over 200 million people across the continent (Adewale et al., 2016). The top five cassava producing countries in Africa are Nigeria, Ghana, Democratic Republic of the Congo (DRC), Angola, and Mozambique, as shown in Figure 1. Cassava production increased between 2010 and 2014 in Nigeria and Ghana while there was a decline in DRC, Angola, and Mozambique. Nigeria remains the largest cassava producing country in Africa and in the world.

African countries boast of high cassava production because of the vast land area available for agriculture. However, the yields remain low, ranging from 7 to 10 tonnes/ha and 5.9 to 9.7 tonnes/ha in eastern Africa (Hahn and Keyser, 1985; Fermont et al., 2009). These low yields are attributed to a number of reasons which include: poor agronomic practices; use of rudimentary farming tools; pests

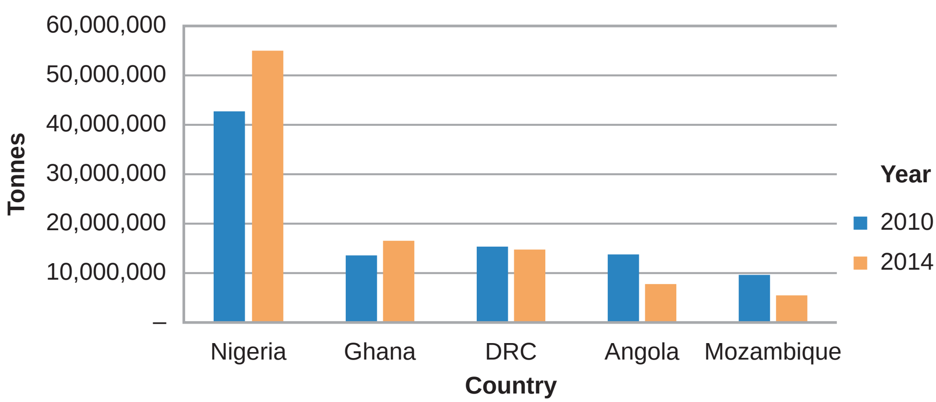


**Figure 1** Change in cassava production in Africa between 2010 and 2014
*Source*: FAOSTAT (2016)

and diseases; and low yielding varieties (Thresh et al., 1994; Nweke et al., 2002). Further to this, cassava is planted manually across Africa proving to be tedious to farmers and less attractive to the youth.

### *Cassava production in Nigeria*

Cassava is widely grown in Nigeria. It is used for preparation of local dishes like *gari, fufu*, high quality cassava flour (HQCF), ethanol, starch, and livestock feed among others. It is the most important tuber crop and source of income for the majority of the farmers in Nigeria (Ugwu, 1996; Tonukari, 2004; Ogundari and Ojo, 2006). Over the years, cassava production in Nigeria has been done manually with only mechanized tilling of the land. Local and international demand for cassava products from Nigeria has been quite high since the early 1990s, although the country has not been able to satisfy the market due to inefficiencies in production.

Traditionally cassava is considered a cheap crop to cultivate and therefore popular among small-scale farmers (Taiwo, 2006). Production is done using basic implements which may prove to be tedious if cultivating more than one hectare of land. In addition to this, the average land holding for smallholder farmers in Nigeria is two hectares, making it hard for farmers to adopt mechanized production as this would incur higher costs. Furthermore, labour is mainly family or communal; therefore cultivating large pieces of land becomes cumbersome. Like many African countries, Nigeria's agricultural activities, including cassava processing, are mainly done by the women and youth who constitute over 75 per cent of the labour force in agriculture. As these activities are tedious, they become unattractive to the youth who would otherwise prefer easier jobs. The amount of time and effort spent on these activities can be reduced if mechanization was introduced.

Another challenge to cassava production is access to capital for smallholder farmers as they have no guarantors (FAO, 2005). With these production challenges, increasing yield per hectare may be a viable solution to increasing cassava production in the country.

### *Trends in cassava mechanization in Nigeria*

Various improved agriculture technologies have evolved over the years since the 1970s. New varieties, machines, processing technologies, fertilizers, and herbicides are some of the technologies that have been improved in an effort to increase agricultural production in Africa. Among these technologies, use of machines in Africa has been the slowest although its potential is given as the highest. Mechanization in agriculture is the use of advanced machines in substitution of crude methods for crop and animal production.

One would assume that Nigeria is able to feed itself because of the vast land area and the large smallholder farmer population of about 70 per cent. However, this is not the case. The vast area of agricultural land is slowly decreasing because of the increase in population. This means that for Nigeria to sustain its population, it would need to increase its agricultural yield per unit area. This can only be achieved through improved technologies coupled with increased access to finance and markets. According to the World Bank (2011) mechanization in Nigeria is still low at 0.7 horsepower (HP) per hectare, which is below the FAO recommended rate of 1.5 HP/ha. Other countries like Vietnam, Thailand, China, and South Korea are currently at 2.2, 4, 8, and 10 HP/ha, respectively. Use of mechanization in Nigeria is therefore low and has potential for growth. Various factors affect the use of machinery in agriculture production. These include the limitations in: knowledge and information on cassava mechanization equipment; availability of tractors and mechanization service providers; financing options for smallholder farmers; information on the advantages and benefits of mechanization; and the fact that 70 per cent of the farmers in Nigeria own small pieces of land (an average of two hectares per family). The latter makes it expensive to mechanize a small piece of land.

Mechanization has been widely recognized as the missing input for Nigerian manual subsistence agriculture. Takeshima et al. (2013) articulated the argument that only 6 per cent of the country's farmers used tractors. With regard to the few farmers who used tractors on their fields, the ratio according to FMARD (2011) is one tractor per 10 hectares of farmland compared with Indonesia which has 24 tractors per 10 hectares. It has also been identified that the market for mechanization is underdeveloped, with uneven supply across locations (Takeshima et al., 2013). Nigeria is known for oil and therefore promotion of mechanization has not been at the top of the agenda for the government. However, since the decline of oil prices, the government has been at the forefront of promoting agriculture as well as procuring tractors on behalf of investors as a way of encouraging mechanization.

In spite of the low level of mechanization observed in the country, there have been several attempts at creating locally based technologies to mechanize various operations in cassava cultivation and processing. Oni and Oyelade (2013) highlighted the various technologies that have been developed by the National Centre for Agricultural Mechanization (NCAM), tracing their development to specific needs in the production and processing operations within the cassava value chain. Oni and Eneh (2004) reported that NCAM's prototype 1-row tractor-mounted planter and harvester developed for cassava production has been concluded and tested with over 80 per cent planting and harvesting efficiency. These prototypes are, however, not commercially available.

Oni and Oyelade (2013) reported that the development of appropriate production and processing equipment for mechanization of cassava has the potential to encourage agricultural development in Nigeria and hence self-sufficiency in food and agro-industrial raw materials. However, they pointed out that though the manufacturing of production and processing equipment for cassava operations is an important aspect of mechanization development in Nigeria, this issue had not been adequately tackled. Cassava production and processing equipment will give the country the opportunity to compete with other countries on the international market.

This research was aimed at examining the use of mechanization equipment technology in cassava production in Kwara, Ogun, and Osun states in Nigeria. Insights from this will provide more information to researchers, entrepreneurs, development organizations, government agencies, and farmers. Specifically, the research objectives were to:

- Identify the socio-economic characteristics of sampled cassava farmers in the research areas.
- Determine the factors influencing use of machines for cassava farming in the research areas.
- Outline the benefits of mechanized cassava farming compared with manual planting.
- Identify factors influencing cassava yield.

## Research area

This research covered Ogun, Osun, and Kwara states where the African Agricultural Technology Foundation (AATF) Cassava Mechanization and Agro-processing Project (CAMAP) is currently being implemented. Kwara State, whose capital is Ilorin, is located in north-central Nigeria. Ogun State whose capital is Abeokuta, is located in south-western Nigeria, while Osun State is an inland state in south-western Nigeria. Cassava is the main staple in Nigeria and these states extensively cultivate cassava as well as process it industrially. At the time of this research, the project had about 500 beneficiary farmers participating in its activities within these areas.

### *Sampling and data collection*

Purposive sampling was used to select farmers for the research. This sampling method was used as the number of beneficiaries of the project was already known and the objective was targeted to project beneficiaries. A total of 161 farmers were selected as the sample size. This was based on the total number of beneficiaries of the project in the three areas. The respondents included 72 beneficiary farmers and 79 non-beneficiaries of the project. However, 10 questionnaires were incomplete and therefore 151 questionnaires were used in the analysis. Secondary data was also collected from literature and reports on mechanization.

### *Data analysis*

Analysis was done using Statistical Package for the Social Sciences (SPSS). A multiple regression analysis was performed on the data to determine the effect of variables on the yield. The harvest per hectare (yield) was denoted by the variable harvq. The formula used was:

$$Y = a + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5 + b_6X_6 + b_7X_7 + b_8X_8 + e$$

where $Y$ = yield per hectare
$X_1$ = respondent's gender
$b_1$ = slope of regression line with respect to $X_1$

$X_2$ = part of a farmer group, cooperative, or association
$b_2$ = slope of regression line with respect to $X_2$
$X_3$ = intercrop cassava with any other crop
$b_3$ = slope of regression line with respect to $X_3$
$X_4$ = rotate cassava with other crops
$b_4$ = slope of regression line with respect to $X_4$
$X_5$ = chemical fertilizers in your cassava fields
$b_5$ = slope of regression line with respect to $X_5$
$X_6$ = practice disease/pest control in your cassava fields
$b_6$ = slope of regression line with respect to $X_6$
$X_7$ = processing of cassava
$b_7$ = slope of regression line with respect to $X_7$
$X_8$ = government assistance for cassava cultivation or processing in any form in the last 3 years
$b_8$ = slope of regression line with respect to $X_8$

### *Data and variables*

Data collected included a set of key variables that were assumed to have a significant influence on the use of cassava farming technologies to improve yields. According to Mvodo et al. (2012), farmers who attended field schools and planted improved varieties had a significant increase in their yield. Other factors that have been documented to affect crop yields are soils, water, climatic conditions, pests, and diseases (Bareja, 2016). However, none of these publications has established if mechanization has an effect on the yield especially for cassava.

Variables that were included in the analysis were: gender, education level of the farmer, cooperative membership, undertaking cassava processing, practice crop rotation, government assistance, practice pest and disease control, practice weed control, visits from extension agents, and application of fertilizer.

These variables would determine the effect of mechanization on the yields of the cassava crop in addition to identifying the socio-economic characteristics of sampled cassava farmers, the use of machines for cassava farming, outlining the benefits of mechanized cassava farming compared with manual planting, and finally identifying factors influencing cassava yield output within the research area.

## Results

### *Descriptive statistics*

Gender disaggregated data was key during data collection; however, the majority of the women responded on behalf of their husbands and were not the heads of the households. From the 72 beneficiaries who responded, 4.2 per cent were female and 94 per cent were males. From the non-beneficiaries, 81 per cent were males and 19 per cent were females. The female respondents represented female-headed households. Table 1 shows the distribution of respondents.

**Table 1** Percentage distribution of respondents

| *Project beneficiary* | *Male (%)* | *Female (%)* |
|---|---|---|
| Yes | 94.4 | 4.2 |
| No | 81.0 | 19.0 |

Most of the farm work in the research area was done by women but the men would be in charge of the income or any field activity conducted in their area. This explained the high male turnout during the interviews.

*Level of education*. The level of education of the farmers did not have any significant influence on the yields. Although it may be assumed that educating a farmer through the formal system may translate to them getting higher yields, it was not evident in this research. Of the respondents, 25 per cent had completed primary education while 35 and 28 per cent completed secondary and tertiary education, respectively. Only 11 per cent of the respondents had no formal education. Gaining knowledge does not guarantee wealth; it is how you use it that determines success. This variable was, however, removed from the final regression analysis to reduce the standard error. Figure 2 shows a graphical representation of education level of the respondents.

*Yield*. In comparison to the 2014 baseline survey done by AATF on cassava farming in Nigeria in the same states, yield had significantly changed from 2 to 24 t/ha to the current 23 to 33 t/ha in this research. At the time of this research, non-project beneficiaries reported yields ranging from 4 to 11 t/ha. Several factors attributed to this difference are described in the following sections.

*Use of chemicals and pesticides*. Use of chemicals to control pests and diseases in cassava is not a common practice in Nigeria. From the research area, 80 per cent of the respondents used chemical fertilizer to improve their yield while the other 20 per cent did not apply any. Weeding was practised by 97 per cent of the

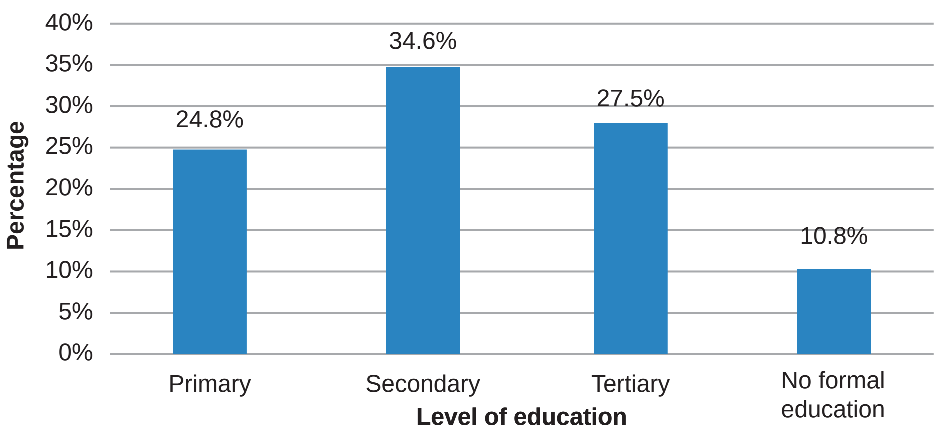


**Figure 2** Education level distribution of respondents

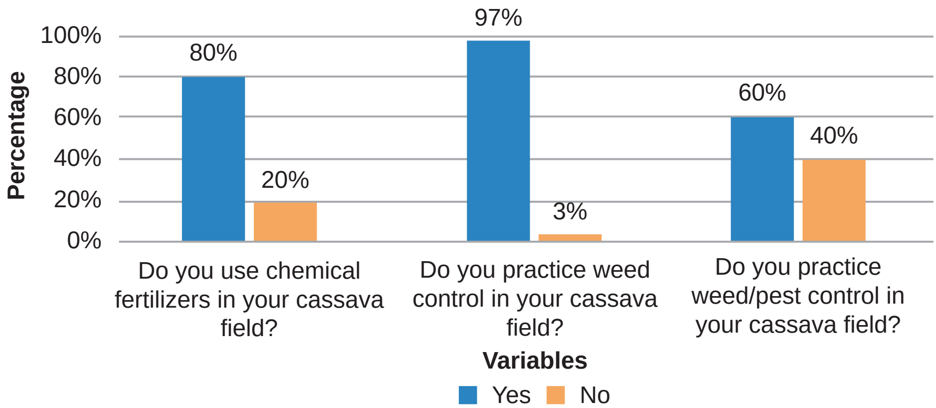


**Figure 3** Proportion (%) of respondents using chemicals and pesticides

respondents on their cassava crop, and 3 per cent did not. Finally, 60 per cent of the respondents used pesticides on their crop while 40 per cent did not. This is illustrated in Figure 3.

In comparison with traditional practice, weeding of cassava crops was not a common practice. Weeds would germinate and compete with cassava in the early stages and eventually reduce the yield from the cassava crop.

*Use of machines in cassava farming in the research areas.* Use of machines for non-beneficiaries was limited to ox plough for tilling the land. CAMAP beneficiaries were using a full set of mechanization for cassava farming; i.e. ploughing, harrowing, planting, weeding, spraying, and harvesting.

### *Statistical findings*

Regression analysis was used to determine the influence of the factors on yield. This research aimed at determining what factors influenced cassava yields as well as the impact of mechanization on cassava yields. Several regression analyses were performed on the data ensuring that the dependent variable Y (yield per hectare) follows a normal distribution. These results are shown in Table 2.

From the results, controlling pests and diseases with pesticides and processing had significant influence on cassava yields. This means that use of pesticides to control diseases and pests had the potential to increase cassava yield. The negative coefficient indicated that a reduction in the use of pesticides will translate to a reduction in the yield. This finding coincides with that of Kawasaki and Lichtenberg (2015) who found that use of pesticides had a direct impact on the yield.

In addition to this, processing of cassava at the household level also had a significant influence on cassava yield. Although processing of cassava is seen as a laborious task by farmers, a research study showed that it has potential to influence farmers to increase cassava yield. This means that farmers involved in cassava processing as a

**Table 2** Regression results

| *Variables* | *Coefficient* | *T-value* | *Significance* |
|---|---|---|---|
| (Constant) | | 1.892 | 0.061 |
| Respondent's gender | 0.037 | 0.476 | 0.635 |
| Membership of farmer group, cooperative, or association | 0.065 | 0.795 | 0.428 |
| Intercropping with any other crop | –0.063 | –0.714 | 0.476 |
| Rotating with other crops | –0.039 | –0.479 | 0.633 |
| Use of chemical fertilizers | 0.039 | 0.447 | 0.656 |
| Disease/pest control | –0.250 | –2.851 | 0.005 |
| Cassava processing | –0.288 | –3.612 | 0.000 |
| Receipt of government assistance for cassava cultivation or processing in any form in the last 3 years | 0.094 | 1.190 | 0.236 |

business would be more inclined to increase their yield per hectare; however, if their focus changes to subsistence (i.e. non-commercial cassava processing) then their yield may also decrease as they would only focus on feeding the household. This finding is in line with de Ponti et al. (2012) who found that yield for commercial farmers was higher than that of non-commercial farmers.

Use of pesticides and undertaking cassava processing have a negative coefficient indicating that reduction of pesticide use and not undertaking processing will lower the yield considerably. Other factors like gender, being a member of a cooperative, intercropping cassava, use of fertilizers, crop rotation, and government assistance had no major influence on cassava yield.

In addition to this, project beneficiaries who used machines to plant their cassava witnessed a tremendous increase in yield from 4–7 t/ha to 27–33 t/ha. Use of machines was not included in the regression but was assessed by the difference between beneficiaries (machine users) and non-beneficiaries (non-machine users).

### *Benefits of mechanized cassava farming compared with manual planting*

According to AATF CAMAP, use of machines and good agronomic practices such as fertilizer application, timely planting, weeding, and spraying herbicides have a wide array of benefits in terms of yield and time spent in the field, income, and efficiency in operations. This systems approach is considered the key to increasing cassava production in Nigeria.

Table 3 shows a comparison between manual and mechanized cassava farming in Nigeria calculated from the research area. It shows a great difference between manual and mechanized cassava farming. The use of a tractor to plough and harrow one hectare took approximately 1.5 hours while the use of manual labour took up to one month to complete the work. This is time consuming and sometimes

**Table 3** Comparison between manual and mechanical cassava production

| *Process* | *Manual/ha* | *Mechanized/ha* |
|---|---|---|
| Ploughing and harrowing (time) | 30 days | 1.5 hours |
| Stem preparation and planting (time) | 8 days | 45 minutes |
| Weeding (time) | 12 days | 30 minutes |
| Harvesting (time) | 45 days | 8 hours |
| Crop vigour | Low | High |
| Yield (t/ha) | 7–9 | 27–45 |

forces the farmer to abandon the work temporarily as they work on less tedious projects. In this case, pre-emergent weeds may spring up during this rest period forcing the farmer to start afresh on land preparation.

Stem preparation includes sorting the good and the bad stems and chopping them into recommended length for planting. The stems are planted at a 45° angle which means only a few nodes are buried in the soil. The chance of germination with this method might be reduced to about 50 per cent if the rains disappear before sprouting begins. In contrast, there is no need to cut the stems into small pieces during mechanical planting, which takes 45 minutes in total including fertilizer application. To do this manually, it would take an average of eight days. The cassava planter cuts the stem into 15 to 20 cm lengths and buries them in the ground horizontally to ensure increased chances of sprouting, which has a direct impact on the yield.

Mechanical weeding of cassava uses a machine known as 'the cultivator' which doubles up in herbicide application and weed uprooting. This machine is more useful when cassava is planted using machines, which is done in straight lines. In 30 minutes, weeding and herbicide application is completed saving the famer more than 11 days to focus on other ventures.

Finally, harvesting a continuous piece of land of one hectare took eight hours to complete using machines and 45 days (equivalent to 1,080 hours) while harvesting manually. Harvesting with machines involves cutting of stems manually to pave the way for the harvester which loosens the soils allowing labourers to collect the tubers by hand and load them into the truck ready for transportation to the processing plant. This combines both manual and mechanical harvesting as some actions are done manually. This approach is less tedious than full manual harvesting of cassava.

From the above description it is evident that there is a significant difference between machine and manual planting. Focusing on the economics of the same, investment in machine planting generates a greater profit margin than manual planting (Table 4).

Economically, one would want to spend less time to reap higher benefits or invest less money for higher returns. This research highlights the benefits of cassava mechanization which translates to higher yield per hectare. Crop vigour and yield are some of the un-tradeable benefits of mechanization.

**Table 4** Gross margins (1 ha) for manual and machine cassava farming

| *Data* | *Margins (naira)* | |
|---|---|---|
| | *Traditional* | *Mechanization* |
| Average price of cassava in the market (naira/tonne) | 22,000 | 22,000 |
| Average quantity of cassava produced (tonnes/ha) | 8 | 30 |
| **Total revenue per ha** | **176,000** | **660,000** |
| Average cost of cassava stems used for planting (naira/ha) | 10,000 | 30,000 |
| Average cost of fertilizer used in planting (naira/ha) | N/A | 28,000 |
| Average cost of agrochemicals used in planting (naira/ha) | 8,000 | 30,000 |
| **Total input costs** | **18,000** | **88,000** |
| **Average cost of operations (naira/ha)** | | |
| 1st ploughing | 22,000 | 14,000 |
| 2nd ploughing | N/A | 14,000 |
| 1st harrowing | N/A | 14,000 |
| Planting | 18,000 | 13,000 |
| Weeding | 22,000 | 10,000 |
| Harvesting | 18,000 | 10,000 |
| Transport cost/km | 80 | 50 |
| Cost for amount produced over 100 km (8 tonnes × 80 naira × 100 km and 30 tonnes × 50 naira × 100 km) | 64,000 | 150,000 |
| **Total operations costs** | **144,000** | **225,000** |
| **Total costs (inputs + operations)** | **162,000** | **313,000** |
| **Net profit (revenue – total costs)** | **14,000** | **347,000** |

Note: US$1 = 359.80 naira

## Discussion

The results indicate that cassava yield is influenced by several factors, however the level of influence for each factor varies. These results are in line with the project's idea that good agronomic practices are likely to increase cassava yields. These agronomic practices, such as weeding and use of herbicides, use of pesticides to control pests and diseases, timely planting of cassava, use of improved planting material, and mechanization, have an impact on cassava yield based on field experience in Nigeria.

Weeds compete with cassava for nutrients causing poor germination and crop stunting. Use of a mix of herbicides post- and pre-emergence is recommended to delay emergence of weeds. Like any other crop, cassava has to be weeded in a timely manner, so as to allow the crop to gain the most at the sprouting/germination stages.

Use of improved varieties to ensure maximum yield is also imperative. This was not captured as a variable because all the respondents in the research area used improved varieties of cassava cuttings as their planting material. Addition of other agronomic practices gives a bonus to the increment in yield. Improved cassava cuttings are mainly pest and disease resistant, therefore guaranteeing the farmer use of reduced pesticide or none at all in some instances.

From the yield analysis and comparing beneficiaries and non-beneficiaries of cassava mechanization, the yield difference was evident. There was a 425 per cent increase in the minimum level of yield and a 200 per cent increase in the maximum yield between the two groups of respondents in this research. This sums to an average increase in yield of 313 per cent. This percentage increase is not fully attributed to mechanization but a combination of mechanization and good agronomic practices.

From this we therefore reject the null hypothesis that none of the factors had a significant influence on cassava yield and accept the alternative that some of the factors had a significant influence on cassava yield. This finding is in line with those of other authors such as Feder et al. (1985), Obasi et al. (2013), and Abdoulaye et al. (2014) that highlight agronomic practices and mechanization as factors that affect cassava yields.

## Conclusion and recommendation

From this research, it is evident that mechanization and good agronomic practices have a significant influence on cassava tuber yield. With this in mind extra effort has to be put into promoting mechanization and good agronomic practices for cassava as it has potential to reduce food insecurity.

However, this recommendation is likely to be limited by the high cost of machinery for smallholder farmers. Project models similar to CAMAP, which provides mechanization services and ownership of these machines through a flexible payment plan, may be implemented. The other option is to link farmers to credit facilities to promote mechanization.

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