Modelling of Yam Production for Effective Policy Formulation

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Abstract. Efforts to increase agricultural production in sub-Saharan Africa had focused on raising land productivity through accelerated genetic improvement and labour productivity through mechanisation. It is now an accepted fact that these efforts cannot yield high dividends in the face of harmful policies. The objective of this paper is to formulate effective policies to sustain yam production in the world largest yam producing country. The authors applied quantitative techniques to model trends of yam in Nigeria over a period of 40 years from 1961 to 2000. A double Fourier function model was applied to yam production while an exponential model was used to model yam yields. Results from the two analyses identified a two amplitude cyclic period of 55 years for yam production and a rate of decline for yam yields in the new yam growing area in the savanna (1.27%) higher than that experienced in the traditional yam growing area in the forest (0.97%). Technological changes are mandatory to avoid the cyclic period to reach its lowest level of production within the next 15 years. However, different policy interventions would be required because there are two distinctive intensification areas within the country. Changes in consumers' behaviours are also suggested to speed up the adoption of new technologies at the farm level and sustain a market oriented yam economy in Nigeria. There is an urgent need for disaggregated yam data for a sound formulation of effective agricultural policies for yams.

Introduction

Sub-Saharan Africa is still struggling to adequately feed its increasing population to food security and poverty reduction levels. Albeit, agriculture remains the dominant economic sector providing employment for over 60% of the active population (ADB, 2001). Increasing and improving agricultural productivity are expected to have large pay-off and result in positive impact on the overall economy.

Strategies to increase agricultural production had focused on raising land productivity by rapid genetic improvement and labour productivity through mechanization. These efforts have yielded few dividends in the face of harmful policies (Idachaba, 2000). It is now accepted that deep changes to African Agriculture will not significantly occur without a conducive policy environment.

Agricultural policies are important because they shape the prices of inputs and outputs, which can influence incentives for the adoption of new technologies, market conditions, diversification of economic enterprises, and intensification of crop and livestock production (IITA, 2000). Policies, availability of productive technologies and good infrastructure constitute the angles of a critical triangle that is needed to lead to agricultural development (Figure 1). However the design of acceptable and transferable agricultural policies is facing several constraints. First, the role of research systems (both national and international) in agricultural policy analysis is neither documented nor clearly understood (Idachaba, 2000). Second, policy recommendations must be based on sound empirical data. This is not usually possible because suitable data are either unavailable or most data sources are questionable by potential users (Kormawa et al., 2001). Third, most policy studies in the past were targeting the macro-level issues and had often overlooked what is happening at the micro-level in the farms. Fourth, lack of robust methods in policy analysis often resulted in resulted in recommendations that do not suit the needs of a large majority of small-scale producers.

The objective of this paper is to develop policy recommendations to help sustain the production of yam, a major crop in Nigeria (Manyong et al., 2001); that produces 70% of the 38 million tonnes of world production of yam in 2001 (FAO, 2001). Studies indicate that yam production past through an expansion phase that seems to be at a plateau (Fig. 2) and has started declining in some parts of the yam belt (Manyong et al., 1996; Olaniyan et al., 2001).

The paper is addressing two questions:

1) Is yam production irreversibly declining in the Nigeria?
2) Why is that that yam production is declining?

After the introduction the next section describes the materials and methods. Then follows another section on results and discussion. The last part of the paper is on policy recommendations.

Materials and Methods

Empirical data are from FAO (2001) that provides time series information on area harvested, yam production, and yam yields over a period of 40 years from 1961 to 2000. In principle FAO data are supplied by each country member and are published at the country level. However, it is almost impossible to reconcile data from FAO and those available within a country such as Nigeria. Within Nigeria it is a common fact to find differences in yam data from different sources and it is also impossible to obtain reliable time series data to conduct a trend analysis over a long period as it is the case in the present paper. Therefore the authors relied on FAO data despite the above limitations.

For data analysis the national-level data were submitted to a Double Fourier function, a trigonometric function for periodic variation as follows [GENSTAT 5, 1994]:

$$y_i = a + b \sin[2p(t_i\text{-}h)/w] + g \sin[4p(t_i\text{-}f)/w] + e_i$$

This trigonometric function was selected because it fits the plot of empirical data where two amplitudes are highlighted in Figure 2. Two parameters are important in a double Fourier function: the amplitudes and the period. The amplitudes (b and g) give the maximum value of the periodically varying quantity. The period (w) indicates the duration of a complete cycle. The expression t_i represents the time; h and f correspond to the time when the whole expression is equal to zero; a is the intercept and y_i is the production in a given year i.

The Double Fourier function was applied to both yam production and area harvested to yam. However this model was inappropriate to analyze yam yields because the scatter plots inferred that two subsets of data with a different pattern should be considered (Groups 1 and 2 in Figure 3). Therefore an exponential function is critical to deal with such a situation [GENSTAT 5, 1994].

The estimated model is : $y_i = A + (B + C*t_i)*R^{ti}$

The rate of decline (R) is the key parameter to be estimated, y_i is the production of year i, t_i is a parameter of time, C is the scale parameter of time, and A and B are constants.

Results and Discussion

Results for Yam Production. Estimates from the Double Fourier function appear in Table 1 for yam production. Results for area were very similar to those of yam production; therefore they are not reported here.

The model gave a good fitness to the data because the R square is very high and the standard error of coefficients is small. The model predicts a production periodic cycle of 55 years. That is, yam production is expected to begin a new period after every 55 years. The current data is on a period of 40 years from 1961 to 2000. Therefore, yam production will reach its lower level in 15 years if the current production trends are maintained.

The average productions for the two amplitudes were 8.16 million Mt for the high amplitude and 6.3 million Mt for the low amplitude. Patterns from Figure 2 show that the production cycle for yam production moved from low amplitude in the early 1970s to its high amplitude in the 1990s and is now falling down. Within less than 15 years yam production in Nigeria would drop by about 3 times if the current production practices were not changed to reverse back the current trends.

Results for Yam Yield. Results from the exponential model appear in Table 2 for Groups 1 and 2. The model is validated because the R-square is high. Parameter estimates on the rate of change confirm the declining trends in yam yields for both groups.

The rate of decline for Group 2 (1.27%) is higher than that of Group 1 (0.97%). The latter represents a region where the decline in yam yield started before the period under analysis of 40 years and is still going on but at a slower rate. This region probably

Table 1. Model estimates of amplitudes and period on yam production in Nigeria

Parameter	Unit	Coefficient	Standard Error
ω^{est}	Year	55.22	2.24
β^{est}	Million Mt	8.16	0.40
γ^{est}	Million Mt	6.3	0.45

(R^2 = 96.9%)

Table 2. Model estimates for yam yields in Nigeria

Parameter	Group 1	Group 2
R (%)	0.98	1.27
B	297288	-527
C	9024	18.6
A	-224975	79620

(R^2 = 91.5%)

corresponds to the forest ecology where yam was primarily cultivated. A well-known cultural event at the harvest of new yams or yams festivals is a tradition of the forest zone in Nigeria. Agricultural practices such as the use of staking materials to facilitate the exposure of leaves to solar radiation and planting of yams in big mounds to reduce below-ground competition between yam tubers and roots of wild trees found their origin in the cultivation of yams in the forest (Orkwor et al. 1998). The geographic location in the forest zone of the unique agricultural research institute working on yams in Nigeria (that is National Root Crops Research Institute or NRCRI) is an additional evidence of the (past) importance of yam in that ecology. Recently research findings showed evidence that yam cultivation has expanded into the savanna that has become the (new) major yam growing area in West Africa (Manyong et al. 1996).

Group 2 corresponds probably to this savanna ecology where yam yields were still increasing in the first part of the period under analysis. The decline in yields is a recent event (Fig. 3). Firstly increases in yam yields occurred during the expansion phase of the crop into virgin new lands with no or low pest infestation. Second as that expansion phase was reaching to an end in the savanna, fallow periods reduced, the frequency increased of yam cultivation in the same piece of land, the probability rose up of host plant encounter (Manyong and Oyewole 1997); all these lead to a higher rate of decline in yields.

This explanation is supported by results reported by Olaniyan et al. (2001) who found that yam was expanding in about 11% only of the 1300 Agricultural Development Programs (ADP) cells (1 cell = 6 to 8 villages) that made up the middle belt, the major yam area of the savanna zone in Nigeria. In contrast cassava was expanding in 43% of cells. In fact at the time of that study yam decline was already perceptible in the eastern part of the middle belt and the above expansion was found only in the western part of that belt where land was still abundant. Another reason that could explain a higher rate of decline in yam yields for the savanna is in its low carrying capacity under the current production practices compared to that of the forest. The low potential for biomass production in the savanna would lead to lower replenishment of soil nutrients exported through the harvest of yams and lower productivity in subsequent cropping seasons.

Policy Implications

It is obvious from the results presented in the section above that yam production under the current extensive agricultural practices of expanding into new lands Nigeria enjoyed for several years has reached to the end. These past patterns need to be reversed to satisfy a growing demand by yam consumers and the country has no choice but to intensify the crop production. Research institutes (both IITA and NRCRI) have made a significant progress in yam breeding and new improved varieties are readily available for a wide diffusion. The main issue is on how to quickly saturate rural areas with these new varieties while official extension services are weak and the impact remains site specific from the interventions by non-governmental organizations. The private sector is not likely to invest in the seed sector for a vegetative propagated crop such as yam. The public sector must play a major role in promoting new varieties.

A package of external inputs is also required to sustain intensive yam production systems. Already farmers in the eastern part of the middle belt apply inorganic fertilizers (if available) to yam fields. The issue here is a lack of recommended fertilizer formula for yam. There is a need for research institutes to design economical doses of fertilizer and other soil management practices.

Changes in the consumers' behaviours for yam products are also suggested. Buyers of yams in the market prefer tubers of a large size though the final consumed product (yam chips, yam flour, or yam paste) is size neutral. At the farm level production of large size tubers requires big mounds that are labour consuming to construct. This practice results in a high cost of production. That practice does not motivate farmers to adopt new techniques (such as the minisett technique) for a fast production of small seed yam. A high proportion of harvest (up to 30%) needs to be kept as seed and lack of healthy planting materials are major constraints in yam production. Yam buyers would modify their market attitude if the lower cost of production from the adoption of new technologies were translated into lower consumers prices and yam products of a better quality. Little is known about the processing of yams compared to other root and tuber crops. Post-harvest technologies are unavoidable to accompany the adoption of new varieties and to strengthen a market-oriented yam economy in Africa.

This paper also highlighted the need to design (policy) interventions different for two sets of intensification areas in the savanna and forest.

Lack of disaggregated panel data within Nigeria (and elsewhere in Africa) is a major limitation to the modelling of yam production for effective policy formulation. For example in the present paper the model for yields identified two groups of data, which the authors assimilated to savanna and forest. However that model does not tell precisely what the corresponding regions are nor about the year the decline rate is being measured. Only disaggregated data would make it possible to validate the findings from this paper. Therefore, there is a need for the production of statistics on crops (all the crops not only yam) on a yearly basis from the smallest administrative unit (Local Government Area) through the ADP Zone, State, and Federation. Only one institution in Nigeria should be made responsible for the production of agricultural statistics, which is not the case for the present time.

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