

Economics of Adopting a Technological Innovation: A Case Study of Drought Tolerant Maize for Africa in Southern Guinea Savanna Zone of Nigeria

Olaoye, I. J.^{1*}; Ayinde, O.E.¹; Takim, F. O.²

¹Department of Agricultural Economics and Farm Management, University of Ilorin, Ilorin, Kwara State, Nigeria.

²Department Agronomy, University of Ilorin, Ilorin, Kwara State, Nigeria

Corresponding Author's email address: olaoyeibukunjames@yahoo.com

Received 18th August, 2018 Accepted 25th October, 2018

Abstract

Adoption of innovation is important in the overall agricultural innovation system. Maize breeders have been promoting the adoption of drought tolerant (DT) maize varieties as a means of ameliorating the negative effects of recurrence of drought in southern guinea savanna (SGS), Nigeria. This study compared the economics of cultivating DT maize variety and local maize variety using a baby on-farm trial approach in Kwara, Niger and Oyo states located in SGS zone of Nigeria. The maize technologies were planted on ridges 0.75m apart and 0.50m within the rows for seeds planted at 2/hill or 0.25m for seeds grown at one seed/hill within 10m x 10m plots and 20m by 20m depending on farmer's choice. Primary data were collected through the use farmers log book and questionnaire which was augmented with an interview schedule. The data collected were analyzed using descriptive statistics, T test and gross margin analysis. The results revealed that the DT maize variety had a higher productivity than the local variety in terms of resources input base. The gross margin of cultivating the DT maize varieties was ₦255,569.61 (\$811.05) compared to ₦94,194.65 (\$298.93)/ha of the local variety which implies that cultivating DT maize variety was more profitable than the local variety (T-test 5.979*** Sig 1%). Thus, adoption of improve seed variety will have a positive influence on farmer's productivity, profitability and conversely improve adaptation to climate change. However, it was recommended that seeds of improved DT maize varieties be made available for the farmers most especially farmers within the drought prone areas.

Keywords: Innovation, Drought Tolerant Maize, Climate change, Productivity, Gross margin

Introduction

Innovation is a global concept and it remains a crucial and fundamental element to sustainable development goal. Achieving substantial growth in agricultural production in order to achieve food security required ideas and technology to enhance productivity. Technological innovation is an important driver for increasing productivity and economic growth (Spielman and Birner, 2008; Olmstead and Rhode, 2008; Eakin *et al.*, 2009). Over the years, particularly in developing nations, the production of food has barely met the demands of the teeming population thereby leading to hunger, food insecurity and poverty. Also, the problems associated with climate change have long been affecting agricultural productivity, most especially in Sub Saharan Africa. Although, farmers have been adapting to the impacts of climate variability since the time past but foretold rate at which climate change, presents a great challenge that will test farmers' ability to adapt and improve them

livelihoods (Adger *et al.*, 2007). Yet, the failure of farmers to improved agricultural practices and adopt new technology has been hindering increase in agricultural productivity in developing countries (Kyle *et al.*, 2015). As a response to this challenge, breeders were tasked with development of Drought Tolerant (DT) maize variety to help farmers cope with the challenge of drought arising from effect of climate change. Although, since the introduction of DT maize variety in Nigeria, there have been limited number of studies on economics of DT maize (Ogunlade *et al.*, 2010; Ayinde *et al.*, 2013), but in the few cases, emphasis have been on gender, preference and constraints to adoption. The recent increase in food and agricultural input prices as well as instability of human attitude made this work necessary. Therefore, this study compared the economics of the DT maize technology and local maize variety in

Southern Guinea Savanna region of Nigeria using an on farm trial approach.

Maize (*Zea mays* L.) is the third most important cereal crop in the world after wheat and rice (FAO, 2011). It is an important staple food and feed crop in Africa and it is a key crop for rural food security in sub-Saharan Africa (FAO, 2007). Maize is a preferred staple food for about 900 million poor people and about one third of all malnourished children (IITA, 2000). The crop has been reported to cover over 143 million hectares of land and worldwide production of 700 million tons of grain (FAO, 2007; Gibbon *et al.*, 2007). Maize is cheaper than other cereal crops such as rice and wheat and more affordable to the vast majority of the population, and therefore occupies a prominent position in the agricultural development agenda of several countries in Africa (FARA, 2009). The importance of maize in Nigeria cannot be overemphasized, with Nigeria producing most of maize grown in sub-Saharan Africa, which accounts for about 43% of calorie intake in the country (FAOSTAT, 2014; NARP, 1994). Maize has consumption quantity of 53.20 g/capital/day (FAOSTAT, 2007). It is an important constituent of livestock feeds, especially in poultry management in Nigeria. Despite the numerous importance and uses of maize among rural household, its productivity still remain low.

Cultivated land expansion has contributed considerably to the growth of agricultural production, but crop yields have been stagnating (FAOSTAT, 2014; Lal, 2010). Thus, there is still a wide gap between demand and supply of maize in Nigeria, plausible due to lack of appropriate maize varieties to cope with the negative impact of climate change factors as well as those arising from effects of biotic and abiotic stress factors. For example, poor soil fertility, lack of nitrogen, and drought stress have been identified as the top three constraints affecting maize yield in Africa (Gibbon *et al.*, 2007). Drought stress in particular has a limiting effect on increase in maize yields in the southern guinea savanna (SGS) of Nigeria and has remained the single most important abiotic stress responsible for reduced maize productivity in arid and semi-arid areas, leading to up to 70% crop loss (Ismaila *et al.*, 2010). In addition, lack of

suitable varieties that perform well under insufficient and erratic distribution of rainfall significantly reduce productivity of maize, with grain yield of 1.3tons/ha, compared to the potential of over 10tons/ha (Gibbon *et al.*, 2007).

However, the introduction of drought tolerant (DT) maize varieties is an adaptive strategy for maize-based farmers to cope with drought stress. Thus, two major initiatives, the Water Efficient Maize for Africa (WEMA) and the Drought Tolerant Maize for Africa (DTMA) have resulted in development and release of appropriate maize hybrids and open pollinated varieties through genetic engineering or breeding (Cavalieri *et al.*, 2011). This is to help African farmers cope with the challenges posed by drought stress. African agriculture is characterized by high levels of vulnerability to climate change in which reoccurrence of drought is one of those variabilities (Hassan and Nhemachena, 2008).

Nevertheless, the persistent occurrence of drought, increase in agro-input and food prices, perpetrated poverty, low productivity and poor adoption of innovation technology in Nigeria, aided the study focus on comparative analysis of DT and local Maize variety in SSG. Thus, the aim of this study was to compare the economics of DT maize technology and local maize variety using on-farm trial approach. Specifically, the study compared the land productivity of the DT maize variety with the local maize variety; profitability of the DT maize variety with the local maize variety, and identified the preference characteristics for maize quality among the farmers used for the on-farm trial experiment.

METHODOLOGY

This research work was conducted in three States in Guinea savannah zone of Nigeria, which were Niger, Kwara and Oyo States. These states were purposively selected. The part of Oyo state used in this study was Kishi and Saki in the southern periphery of the Guinea savannah zone of Nigeria. The Mokwa on-farm stations were used for the Niger state trial plots, while the on-farm trial plots for Kwara were scattered within the southern and central part of the state. This Guinea savannah

zone is located between latitudes 7°3' and 9°12' north of the equator and longitudes 2°47' and 4°23' east of the Greenwich Meridian. Mean annual temperature is about 27°C (Ogunlade *et al.*, 2010). It is the broadest vegetation zone in the country and it occupies almost half of its area. It is located in the middle of the country, extends southwards to southern Nigeria and pushes northward beyond Zaria. It covers an area that has 100 – 150 cm of annual rainfall and where the wet season lasts for 6 - 8 months with occurrence of drought between these periods (Aregheore, 2009). This zone is made up of sands and clays. They are grey to black clays poorly drained and seasonally flooded forming the “fadama”. Soil in this zone is deeply corroded, generally sticky and impervious to water and has low fertility.

This research work was a quasi-experimental study in which three (3) experimental blocks were used in three states of Oyo, Kwara and Niger in the SGS of Nigeria. It was quasi because the treatment was not a true experiment since farmers' decisions were flexible. The three states are part of the drought prone area of the SGS where DT maize project activities are being executed under the auspices of the DTMA project coordinated by IITA in Ibadan, Nigeria.

The three (3) experimental blocks (i.e. Oyo, Kwara and Niger States) had 1, 10, and 7 on-farm Baby-trials respectively as a result the total number of 18 farmers were used for the on-farm trial experiment zone for the 2014 planting season. The on-farm trial plots were 10m x 10m and 20m x 20m depending on farmer's choice for both the DT maize variety and local maize variety (as the control). Hence, on-farm baby trial consists of a DT maize variety plot and a local variety in farmers' fields. Maize seeds were planted at the rate of two seeds/hill with 0.75m between the rows and 0.50m within the rows. Also, pre-emergence type of herbicide “forced up” was used while urea and N.P.K fertilizer were also applied in all the on-farm trial plots to supplement the available soil nutrients.

The trial sites were monitored twice a month for inspection and guidance on crop management practices during the planting period. Data on socio-economic characteristics and maize quality preference of farmers were

collected through a well-structured questionnaire augmented with an interview schedule. The type of input used, quantity of inputs used and quantity of outputs from the on-farm trial plots were obtained from the farmer's log book. Also, the market prices of inputs and outputs were obtained from the local market in each of the states selected. Both descriptive and inferential statistics were used to analyze the data collected. The descriptive statistics includes the mean, frequency count and percentage, while the inferential statistics includes T-test and budgetary analysis.

RESULTS AND DISCUSSION

Socio-economic Characteristic of the Farm Households used for the on – farm Trial

Results on Table 1 revealed that the average age of the respondents was 44 years and majority of the household head were within the age class of 41 – 50 years while none of the respondent was more than 60 years of age as at the time of data collection. This is an indication that all of the farmers used for the on-farm trial experiment are still in the working age class category. All the households head was male probably because male was regarded to be the head of the family except in case of a single mother or widow-headed households. About 70.59% of the household head had secondary school or tertiary school education, while 5.88% of the respondents had informal education. About 41.18% of the farmers' household had between 6 – 10 household sizes, 17.65% had less than 15 members in their household, while about 11.76% of the farmers had more than 15 as their household size. More than half of the respondents had a farm size that is more than 4 hectares of land while a little above one fifth had less than 2 hectares of land. The low accessibility of the farmers to large hectares of land might be as a result of land tenure system as observed to be predominant in the area. Average farming experience of the farmer was 22 years which indicated that most of the farmers used for this on-farm trial experiment might have being in the farming practice since their adolescent age. The result also implied that the respondents have a deep knowledge of maize farming practices.

Table 1: Socio-economic characteristics of the farm households used for the on –farm trial

Characteristics	Frequency	Percentage
Age of the household head		
21 – 30	0	0.00
31 – 40	6	35.29
41 – 50	8	47.06
51 – 60	3	17.65
More than 60	0	0.00
Gender of the household head		
Male	17	100.00
Female	0	0.00
Education of the household head		
Informal	1	5.88
Primary	4	23.53
Secondary	5	29.41
Tertiary	7	41.18
Household size		
1 – 5	5	29.41
6 – 10	7	41.18
11 – 15	3	17.65
More than 15	2	11.76
Farm size		
< 2ha	4	23.53
2-4ha	4	23.53
>4ha	9	52.94
Farming experience		
1 – 10		23.53
11 – 20		29.41
21 – 30		35.29
>30		11.76

Source: Field survey data, 2015

Resources Productivity and Economics of the DT Maize Variety and Farms Local Variety

Table 2 presents the descriptive statistics result of the resource productivity for DT maize variety and local variety. The result indicated that the mean of land productivity for the treatment was greater than the yield of control variety. This implies that DT maize variety

was more productive than the local variety in the study area for the on-farm trial experiment. Also, there was statistically significant difference between DT maize variety and local maize variety in terms of their yield at 1% ($t=7.809$, $Pv=0.000$). This result corresponds to the findings of Ogunlade *et al.*, (2010) that DT maize varieties performed significantly than farmers' seed in terms of their productivity.

Table 2: Descriptive statistics of the land productivity of the DT maize variety and farms local variety

Variable	DTMA Variety		Farmers Local variety	
	Mean	Std Deviation	Mean	Std Deviation
Land Productivity (kg/ha)	3153.25	552.70	1602.11	600.20

Source: Field Survey Data, 2015

 $t=7.809^{***}$ statistically significant at 5% significance level

Profitability of DTMA and Local Maize Varieties

Table 3 shows the results of cost-benefit analysis and the profitability index for both the DT maize variety and local maize variety of the on-farm trial experiment. The result revealed that the gross margin for DT maize variety and local variety was ₦255,569.61 and ₦94,194.65 per hectare and with profitability index of 2.80 and 1.15 respectively. This implies that for every one naira spent on the DT maize variety production will lead to a return of about two hundred and eighty naira while for every one naira spent on local maize variety will lead to some varieties of DT maize have a positive gross margin higher than that of local maize variety.

a return of about one hundred and fifteen naira. However, this result was in consonance with the works of Oladejo and Adetunji, (2012) and Fakayode *et al.*, (2009). In both reports, maize production was found having a higher profitability index. This result was also consistent with other similar studies that have found labour accounting for the largest share of total cost in farm production (Ogundari, 2006; Babatunde *et al.* 2008; Zalkuwiet *et al.*, 2010). More so, the t-test statistics revealed that DT maize variety performed significantly better in terms of the gross margin result than the local maize variety which was also found to be in concordance with the early report of Ogunlade *et al.*, (2010) that

Table 3: Result of the gross margin and profitability index of the DT maize variety and farmer's local variety

Variable	DT Maize varieties	Local Maize Variety
land size(ha)	1	1
Labour input (man-days/ha)	47.66	41.58
Total Output (kg/ha)	3,153.25	1,602.11
Gross revenue (₦/ha)	346,857.5	176,232.1
Labour cost (₦/ha)	56,908.55	51,250.00
Fertilizer cost (₦/ha)	19,357.38	19,116.66
Other input cost (₦/ha)	15,021.96	11,670.79
Total variable cost (₦/ha)	91,287.89	82,037.45
Gross margin (GR –TVC) (₦/ha)	255,569.61	94,194.65
Return to investment (GM/TVC)	2.80	1.15

Source: Field survey data, 2015 T test = 5.979***, P-value 1% df = 16
 Note: Official exchange rate: 1 US dollar = 315.11 Nigerian Naira.

Farmers Preference for Maize Qualities and Characteristics

Table 4 revealed the characteristics used in the preference for maize selection by the farmers for on-farm trial experiment. The farmers identified three characteristics each for the preferred maize variety in addition to the maize being drought tolerant. However, majority of the farmers give preference for yellow coloured maize, which might be as a result of its sweetness and market value. Other characteristics, in decreasing order of

importance, used as preference for selecting maize are big seed, multiple cobs, big cob, cob with full grain, greenish leaf colour, big leaves and tall stalks. Ayinde *et al.* (2013) observed that big cobs with full grains, big seed, yellow coloured seed and multiple cobs were the main reasons for preference of particular maize variety by farmers. It was also in agreement with the work of Obaa *et al.*, 2005 and Julia *et al.*, 2013 that reported that seed colour, size and number of cob per stand were characteristics for maize preference among farmers.

Table 4: Result of farmers' preference for maize qualities and characteristics

Characteristics	Frequency	Percentage
Yellow colour of seed	12	23.53
Cobs with full grains	5	9.80
Big Seed	9	17.65
Big cobs	7	13.73
Big Leaves	1	1.96
Greenish leaf colour	5	9.80
Multiple cobs	9	17.65
Produce multiple cobs	3	5.88
Total	51	100

Source: Field survey data, 2015

* preference variable was a multiple option

Conclusion and Recommendations

Conclusively, given the introduction of the new varieties of DT maize, it was to this extent that we compare the yield and profitability of DT maize variety and Farmers seed variety type using on-farm trial experiment. However, all the DT maize varieties tested performed significantly better than the farmer's seed in terms of their yield, quality and profitability. Finally, it could also be concluded that the most characteristics or qualities for farmers' preference in the selection of maize variety for adoption were colour of the seed, size of the seed and number of cobs per stand. Based on the findings of this study, it is recommended

that farmers should take the advantage of the drought tolerant maize because of its performance in yield and profitability as compared to the local maize variety most especially during the late season planting. DT maize seed should be made available for the farmers in drought prone zone in Nigeria. Plant breeder and researchers should also take into consideration the characteristics and qualities that farmers look for in selecting maize seed for planting in their subsequent hybrid and breeding exercise in order to increase acceptability and adoption of the new maize variety by farmers.

Reference

- Adger W N, Agrawala S, Mirza M, Conde C, O'Brien K, Pulhin J, Pulwarty R, Smit B, Takahashi K (2007). Assessment of adaptation practices, options, constraints and capacity. pp. 717-743. In: Climate Change 2007: Impacts, Adaptation and Vulnerability (Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change), Parry ML, Canziani O. F, Palutikof JP, van der Linden PJ, Hanson CE (Eds.), Cambridge University Press, Cambridge, (UK).
- Ayinde O.E., Abduolaye T., Olaoye G. And J.A. Akangbe (2013): "Gender and Innovation in Agriculture: A Case Study of Farmers' Varietal Preference of Drought Tolerant Maize in Southern Guinea Savannah Region of Nigeria". *Albanian Journal of Agricultural Science*, 12 (4): 617-625
- Babatunde R. O., Fakayode S. B. and Obafemi A. A. (2008): "Fadama maize Production in Nigeria: Case Study from Kwara State". *Research Journal of Agriculture and Biological Sciences*, 4(5): 340-345.
- Bergek, A., Jacobsson, S., Carlsson, B., Lindmark, S., Rickne, A., (2008) Analyzing the functional dynamics of technological innovation systems: A scheme of analysis. *Research Policy*, 37, 407-429.
- Cavalieri, A., L. Cramer, J. Falck-Zepeda, and P. Zambrano. (2011). "Delivering Technologies to Small-scale Farmers: The Case of Drought Tolerant and Water Efficient Maize for Africa". A report submitted to IFPRI's Senior Management Team (SMT) by the

- implementing team Washington, DC: IFPRI.
- Eakin, H., Tompkins, E. L., Nelsons, D. R. and Anderies, J. (2009). Hidden costs and disparate uncertainties: trade-offs in approaches to climate policy. In: Adger, N. W., Lorenzoni, I. & O'Brien, K. L. (eds.) *Adapting to climate change: thresholds, values, governance*. Cambridge: Cambridge University Press.
- Fakayode S. B., Adewumi M. O., Salau S. A. Salau and Afolabi O.A. (2009). "On-Lending Credit Scheme to Crop Farmers in Nigeria: An Appraisal of Ekiti State Agricultural Credit Agency (ESACA) Scheme". *Journal of Agriculture, Biotechnology & Ecology*, 2(3), 286-294.
- FAO (2007). FAO Statistical Databases. <http://faostat.fao.org/default.aspx>. Accessed 14 October, 2007.
- FAO (2011). World Agricultural Production. <http://faostat.fao.org/default.aspx>. Accessed 14 October, 2014.
- FAOSTAT (2007): Food Security Statistics.
- FAOSTAT (2014). <http://Faostat.fao.org>
- FARA, (2009): "Patterns of Change in Maize Production in Africa: Implications for Maize Policy Development Ministerial". *Policy Brief Series Number 3*
- Frederico, Giovanni (2009) *Feeding the World: An Economic History of Agriculture, 1800-2000*, Princeton University Press: Princeton, New Jersey.
- Gibbon, D., Dixon J., and Flores D. (2007). *Beyond Drought Tolerant Maize: Study of Additional Priorities in Maize - Report to Generation Challenge Program*. CIMMYT Impacts, Targeting and Assessment Unit.
- Hassan, R, and C. Nhemachena, (2008). "Determinants of climate adaptation strategies of African farmers: Multinomial Choice Analysis". *African Journal of Agricultural and Resource Economics*, 2 (1), 83-104.
- IITA, (2000): "International Institute of Tropical Agriculture, Ibadan, Oyo State". Annual Report on Maize Production.
- Ismaila U., Gana A. S., Tswanya N. M. and Dogara D. (2010). Cereals production in Nigeria: Problems, constraints and opportunities for betterment. *African Journal of Agricultural Research* 5(12), 1341-1350
- Julia S., Pangirayi T., John D., & I. Makanda (2013). "Farmers' desired traits and selection criteria for maize varieties and their implications for maize breeding: A case study from KwaZulu-Natal Province, South Africa". *Journal of Agriculture and Rural Development in the Tropics and Subtropics*, 114(1) 39-4
- Kyle E., Alain de J., Elisabeth S. and Manzoor H. D. (2015). Technological innovations, downside risk, and the modernization of agriculture. <http://are.berkeley.edu/~esadoulet/papers/RiskModernization2015.pdf>
- Lal, R. (2010): "Enhancing Eco-efficiency in Agro-ecosystems through Soil Carbon Sequestration". *Crop Science* 50 (2): S120-S131.
- National Agricultural Research Project (NARP), (1994): National Agricultural Research Strategy Plan for Nigeria North-West Zone: Draft Report.
- Obaa B., Chanpacho M. & J. G. Agea (2005): "Participatory farmers' evaluation of maize varieties: A case study from Nebbi District, Uganda". *African Crop Science Conference Proceedings*, Vol. 7. pp. 1389-1393
- Ogundari, K. and Ojo, S. O. (2005): *The determinant of technical efficiency in Mixed Crop food production in Nigeria: A stochastic Approach*. Proceeding of the 1st annual

- conference on Development in Agriculture and Biological science. School of Agriculture Nigeria, Pp159-164.
- Ogunlade I., G. Olaoye, D. Tologbonse and O. E. Ayinde (2010): "On-farm Evaluation of Drought Tolerant Maize Varieties and Hybrids in the Southern Guinea savanna Zones of Nigeria"
- Oladejo, J.A. and Adetunji, M.O. (2012). "Economic analysis of maize (zea mays L.) Production in Oyo state of Nigeria". **Agricultural Science Research Journals**, Vol. 2(2) pp. 77 – 83
- Olmstead, A. L. and RhodeP. W. (2008). *Creating Abundance: Biological Innovationand American Agricultural Development*, Cambridge University Press: New York, NY.
- Spielman, D. J., and Birner, R. (2008). "How innovative is your agriculture? Using innovation indicators and benchmarks to strengthen national agricultural innovation systems". *Agriculture and Rural Development Discussion Paper* no. 41. Washington, D.C.: World Bank.
- World Bank (2007): *World Development Report 2008: Agriculture for Development*. Washington, DC: The World Bank.
- Zalkuwi, J. W., Y. Z. Dia and R. Z. Dia (2010). "Analysis of Economic Efficiency of Maize Production in Ganye local Government Area Adamawa state, Nigeria". *Science pub report and Opinion*, 2(7)