Impacts of agricultural mechanization adoption on floodplain sugar-cane (*Saccharrum officinarum* L.) farmers' income in Mubi, N.E. Nigeria

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Abstract: A survey was conducted in order to assess the effectiveness of agricultural mechanization adoption on floodplain sugar-cane farmers' income in four locations, namely: Bahuli, Muchalla, Mijulu and Kirya, all within Mubi area. The survey was conducted during growing season between September, 2006 and May, 2007. Information related to the subject was sourced from target farmers (80) through purposively administered questionnaires. Information sought centered on inventory of practiced technologies, levels of adoption and its economic returns. Data generated during the study were statistically validated using the test-re-test method of reliability test and correlated positively (r=0.80). The data were analyzed and compared using simple bar charts, percentages, chi–square and Likert scaling test types. It was indicated that there was a higher concentration of traditional technologies among the farmers prior to the adoption of modern agricultural mechanization as judged numerically. However, despite the awareness by the extension workers, there were about 5% of farmers who were adamant of the modern technological changes. Also, about 95% of the farmer population experienced drastic rise in farm output and sales income from their sugar-cane produce after the adoption process. Sugar-cane farmers' perception analysis further attested to positive effectiveness of both the modern agricultural mechanization and farm incomes during the study period. The challenge for better prospective outputs further depends on the extent of extension awareness among practicing farmers in the study area.

Keywords: adoption rate, farm input, farmers' perception, traditional technology, modern technology, Nigeria

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1 Introduction

Agricultural mechanization perhaps constitutes the center stage power source for boasting agricultural production. The application of machines in agricultural production minimizes the burdens and drudgery of manual farm labor, and increase farmers' income (Kepner et al., 2003). Farm machineries are collections of implements and devices for applying power on the farm. Some of the essential operations requiring farm machinery application in sugar-cane production are: tillage (such as plough, harrow and ridging), irrigation, plant protection, harvesting and transportation. These items are recognized as the most costly operations in the budget of the farmer (Igbeka, 1986; Havrland and Kapila, 2000).

Agriculture indeed constitutes the most promising vehicle for income drive among peasant farmers globally. In Nigeria, for instance, it provides more than 70% of population with habitation and employment, and contributes about 40% of the gross domestic product (GDP) and 88% of non-oil foreign exchange earning (Ado, 2005). Food demand growth rates of usually

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between 3%-4% are recorded as against the annual production rate of 1% (Imam, 1984; Kwaghe, 2003). This regressive balance has long necessitated relevant authorities to formulate programmes packaged to boost food production through the adoption of appropriate technologies (Havrland et al., 2006). Notable of such programmes were Operation Feed the Nation (OFN), National Accelerated Food Production Programme (NAFPP), Green Revolution Programme (GRP), and National Agricultural and Development Authority (NALDA), amongst others. The Agricultural Development Programme (ADP) appears as the most recent farmer-oriented organ for awareness creation in the Nigerian agricultural sector (Kwaghe, 2003). Olayide (1980) earlier reported that the desire to uplift Nigerian agriculture has suffered decline due to low technological 'know how'. ICAR (2006) also mentioned that regular falls in crop yields are recorded as a result of poor adoption of appropriate technologies for food crop production.

Sugar-cane (*Saccharum officinarum L*), a heavy feeder crop grown for chewing, drinking juice, and raw and centrifugal sugar, constitutes the cheapest source of energy-giving food substance known to man (Onwueme and Sinha, 1999). Annually, crop returns translate into huge economic benefits among farmers, especially when grown on deep, fertile soils under improved management systems (Onwueme and Sinha, 1999).

Mubi area is characterized by patched fertile grounds (floodplains) conducive to profitable sugar-cane production, where only little attention has been devoted to adoption of modern agricultural mechanization known for optimizing crop production in the past. This study was therefore designed to investigate the economic benefits achievable from the adoption of modern agricultural mechanization by sugar-cane farmers in the study area.

1.1 Research objectives

- To assess farming technologies practiced by sugar-cane farmers in Mubi area
- To determine the economic benefits of adopting modern agricultural mechanization on sugar-cane farmers' income in the area
- To recommend the most profitable modern technology for sugar-cane production in the area

2 Materials and methods

2.1 Study area

Mubi is located in the north-eastern part of Adamawa state and situated between latitudes 9°26′ and 10°10′N and longitudes 23°11′ and 13°44′E. It has a land area of 506.40 km^2 with a population size of 759,045 at a density of 160.5 persons per square kilometer (Nwagboso and Uyanga, 1999). Its eastern boundary belts the Nigeria-Cameroon border to the north, Askira-Uba to the west and Hong Local Government Area to the south. The climate of the area is characterized by alternating dry and wet seasons. The rains last from April to October with a mean annual rainfall typically ranging from 700 mm to 1,050 mm, and sometimes ranging between 998 mm and 1,262 mm. The vegetation is of typical Sudan Savannah type, which connotes grassland interposed by shrubs and few trees, mostly Acacia, Eucalyptus and Locust-bean trees, amongst others (Adebayo, 2004). The dominant physical feature in the area is the Mandara Mountains, which run along the Cameroon-Nigeria boarder with a height of up to 1,200 to 1,500 m (Hiol et al., 1996).

2.2 Research questions

What farming technology do the sugar-cane farmers now practice in Mubi area?

What benefits do the farmers derive from adopting modern farm machineries in the study area?

2.3 Field survey

The study was conducted in four sub-locations namely; Bahuli, Muchalla, Mijilu and Kirya, all within Mubi area, between September 2006 and May, 2007. The study used two methods of purposive data collection. First, a farm visit was conducted to view and sample field information through oral interviews from eighty (80) sugar-cane farmers on the impact of modern technologies on their farm incomes. Similarly, a questionnaire was designed and purposively administered to sugar-cane farmers in the study area.

2.4 Data analysis

The data collected was validated using the test-re-test method of reliability test (Dixon-Ogbechi, 2002; Asika, 2008), with a strong correlation ($r=0.80$) between the multi-stage responses to the field questionnaires within the same farmer population. The data were then analyzed using descriptive statistical tools. Also, farmers' perception on the subject was analyzed using the Likert scaling test type (Asika, 2008). The technique analyzes the questionnaire responses based on four grades of effectiveness in the order; 1 = not effective; 2 = less effective; 3 = moderately effective; and 4 = highly effective. The effectiveness test value (*ETV*) is calculated as expressed by (Asika, 2008):

$$ETV = \frac{TNR \times LSG}{TAQ} \quad (1)$$

Where: ETV = Effectiveness test value; LSG = Likert scaling grade; TNR = Total number of responses; TAQ = Total administered questionnaires.

An ETV of 2.5 was considered to be the benchmark below which any adopted technology was termed as not effective during the study period.

The parameter computed based on the field performance of the various implements employed by the farmers before and after the adoption process is the effective field capacity (ha/h) as expressed by Gbadamosi et al., (2004), Abubakar et al., (2009):

$$\text{Effective field capacity, } EFC = A/EOT \quad (2)$$

Where: A = Area covered in hectares, ha; EOT = Effective operation time, h.

3 Results and discussion

Results on the inventory of farming technologies practiced are presented in Table 1.

The results indicated that more farmers used traditional implements than the modern farm implements. This event could have been due to habitual use and accumulation of ancient farm tools by traditional farming systems (Agboola, 1979). The traditional implements used among sugar-cane farmers included the Indian hoes (24%), as the most widely spread, followed by axes (20%) and planting rods (19%). However, ox-drawn ploughs exhibited low percentage (4%) concentration in the locations studied. This was as a result of their low numerical availability in the study areas. Study conducted in the location indicated that Mijilu had the largest concentration (28%) of traditional farm tools in use prior to the adoption process. It was followed by Kirya (26%), Bahuli (24%) and Muchalla (22%) with the least estimates.

Table 1 Inventory of farming technologies practiced in the study area

Farming technologies	Farming locations					
	Bahuli	Muchalla	Mijilu	Kirya	Total	% of Total
Traditional technologies (Farm implement)						
Indian hoe	501	406	351	156	1414	24
Axe	223	340	465	251	1219	20
Cutlass	250	152	263	386	1067	18
Matchet	53	87	300	427	867	15
Planting Rod	330	250	296	230	1106	19
Ox-drawn plough	45	72	65	61	243	4
Total	1402	1307	1680	1511	5900	100
% of Total	24	22	28	26	100	
Modern technologies (Farm machinery/inputs)						
Disc ploughs	14	6	2	4	26	2
Disc Harrows	10	2	3	3	18	1
Herbicides	65	8	43	52	168	10
Pesticides	50	47	40	41	178	11
Water pumps	30	35	35	28	128	7
Knapsack sprayers	256	369	321	321	1169	69
Total	425	467	346	449	1687	100
% of Total	25	28	20	27	100	

A different trend occurred with the adoption of modern technologies, where locations like Mijilu that earlier had the largest (28%) number of traditional tools now recorded the least concentration (20%) of modern technologies, while other locations like Muchalla recorded the most adopted modern technologies at 28%, followed by Kirya (27%) and Bahuli (25%). This leaves Mijilu location farmers as the laggards in the adoption process. Knapsack sprayer adoption rates were recorded at about twice the cumulative rate of other modern technologies in all the locations studied. This was a rather high figure, suggestive of wider applicability of this modern equipment in crop production (Goni, 1983).

The farmers' adoption of modern agricultural mechanization in the study area is presented in Table 2 below. The result indicated that only a few farmers were conservative towards the adoption. For instance, out of the 80 sampled sugar-cane farmers, only 5% of the farmers neglected the adoption of the disc plough for cultivating their sugar-cane farms, while 95% of them adopted the use of the technology for same application. Similar wide adoption margins existed for water pumps, mineral fertilizers and pesticides, with 20%, 15%, and 14% of farmers, respectively, neglecting to adopt the technologies.

Table 2 Results on farmers' adoption of the modern technologies (Farm machinery/inputs)

S/No.	Farm farming inputs	Machinery/ experience (years)	Adoption rate		Percentage adoption	
			Before	After	Before	After
1	Tractors:					
	(i) Disc Ploughs	20	5	95	5	95
	(ii) Disc Harrows	20	6	94	6	94
2	Water pumps	10	20	80	20	80
3	Mineral fertilizers	15	15	85	15	85
4	Pesticides	8	14	76	14	76
5	Herbicides	6	22	78	22	82
6	Sugar-cane (hybrid) sets	12	28	72	28	72

A higher rate of 80%, 85%, and 76% of farmers later adopted the water pump generators, mineral fertilizers and pesticide use respectively. Results on herbicide use indicated that up to 22% of the sugar-cane farmers were late adopters, although a higher number of the farmers (28%) neglected adoption of hybrid sets of sugar-cane for cultivation. However, larger portions of the farmers sampled adopted both herbicides application (78%) and hybrid sets of sugarcane (72%) on their commercial farms. Also, the chi-square analysis accounted the adoption of every technology assessed as highly significant (*P* = 0.05).

Most importantly, Table 3 presents the results of farmer income accruable from the adoption of these modern technologies on their small farms, ranging between 2 to 10 hectares. It was observed that on a general note, the number of farmers that earlier used the traditional technologies declined sharply on realization of increasing income among the early adaptors of the newer agricultural mechanization, since the input impact cannot be assessed until after the user (farmer) applies some of the inputs (Zijp, 1991; Samndi et al., 2007). Prior to the adoption process, about 63% of the farmers earned below $100 from the sales of their sugar-cane products. Trial adoption of the modern facilities further exposed the farmers to generation of relatively higher incomes (Table 3).

Table 3 Distribution of farmer income derived from adoption of modern agricultural mechanization

Farmer income /$	Before adoption process		After adoption process	
	Frequency	Percentage/%	Frequency	Percentage/%
<100	50.0	62.50	0	0
100-500	20.0	25.0	30.0	37.50
500-700	8.0	10.0	35.0	43.75
700-1,000	2.0	2.50	10.0	12.50
>1,000	0	0	5.0	6.25
Total	80.0	100	80.0	100

In the successive harvest, none of the farmers' incomes were recorded at below $100, as compared to their previous income, when up to about 63% often only earned below $100 from their sugar-cane sales. After the adoption process, 37.5% of the farmers generated between $200 and $500 seasonally, while a larger percentage (43.75%) of the farmers earned between $500 and $700 seasonally during the period under study. However, it was observed that only 8% of the farmers realized between $700 and $1,000 and 6% of them generated beyond $1,000 from their sugarcane sales. Generally, the chi-square analysis recorded a significant (*P* = 0.05) rise in farmers' income as a result of the adoption of modern technologies on their farms.

Results on farmers' perceptions on the effectiveness of the adopted technologies on the sugarcane farmers' income are presented in Table 4. It indicates that the use of tractor implements, mineral fertilizers and improved sugar-cane sets were all effectively influential on the economy of sugar-cane producers in the study area. Only a few negations were recorded for water pumps, pesticides and herbicides application on sugar-cane farms. Only Bahuli location indicated negative effectiveness of pesticides, likely due to its less or none application in the location. Both Muchalla and Mijilu locations indicated poor adoption of herbicides for controlling weeds on their sugarcane farms, while Kirya recorded the lowest quantity of water pump generators for their sugarcane irrigation farming practices.

Table 4 Likert scaling test for effectiveness of adopted technologies on sugar-cane production/farmers' income

Adoption	Bahuli		Muchalla		Mijilu		Kirya	
Parameter	ETV	ER	ETV	ER	ETV	ER	ETV	ER
Implement/Input Adoption:								
Tractor Implements	2.694	E	3.997	E	3.05	E	2.940	E
Water Pumps	2.721	E	3.997	E	2.051	E	2.056	NE
Mineral Fertilizers	2.617	E	3.094	E	3.056	NE	2.944	E
Pesticides	1.657	NE	3.333	E	2.889	E	2.667	E
Herbicides	3.475	E	2.033	NE	2.222	E	2.670	E
Sugar-cane (hybrid) sets	2.678	E	3.056	E	2.664	NE	2.786	E
Adoption effectiveness:								
Implement output	2.788	E	2.951	E	2.615	E	2.512	E
Income rise on implement	3.751	E	3.815	E	3.101	E	2.613	E

Note: ETV=effectiveness test value; ER=effective rate; NE=not effective; E=effective.

Ultimately, the generally high adoption benefits evidenced in the locations studied encouraged most sugarcane farmers to expand their farm sizes, as is usual with agricultural technology adoption (Osaji, 1983; Williams, 1989; Tekwa and Abubakar, 2008), which was reflected by the general rise in farm outputs and farmer incomes during the study period (Table 3).

The capacity of field machines in hectare per hour (ha/h), according to Buckingham (1976) and Maduako et al. (2004), is the function of non-operating time due to idle travels such as traveling to the field and turning at the ends. Figure 1 shows the field capacity of traditional farm tools used by the farmers prior to the adoption process, and it was observed that the highest field capacity of 0.4 ha/h was attained from the matchet, followed by the planting rod and cutlass which recorded 0.3 ha/h each, with the lowest capacity of 0.1 ha/h obtained from the axe and mould board plough as similarly observed by Abubakar et al. (2009) in Yola environment. The lower productivity experienced by the farmers before adoption could be attributed to the low field capacities obtained from the traditional tools, since their power source is human or animal effort and the power obtained from man or animal is very low compared to that of a machine. A human can only develop 0.08 kW of power for a few hours due to fatigue, but this, of course, varies with environmental conditions and the type of food intake (Ojha and Michael, 2003). Similarly, it was also observed (Figure 2) that after the adoption of modern technologies, higher field capacity that ranged between 1.1 to 1.5 ha/h was achieved when power tools (tractors) were employed to drive implements such as disc ploughs and harrows. In these cases, man only serves as a controller of the machine, rather than the source of power, and the work can be accomplished within a reasonable time. Also, the use of knapsack sprayers, whereby a farmer can spray chemicals (herbicides or pesticides) at a field capacity of 0.6 ha/h to suppress weeds and pest infestation, had improved their crop yield. The higher crop yield and income observed after the adoption process could be attributed to the higher field capacity attainment from the adopted modern technology. It was also observed that none of the farmers employed cane harvesters to harvest their sugar-cane even after the adoption process. This was as a result of non-availability of the implement in the studied areas.

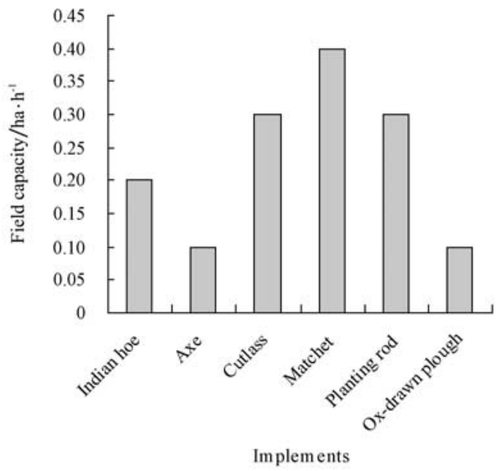

Figure 1 Effective field capacity of various farm tools employed by the farmers before adoption

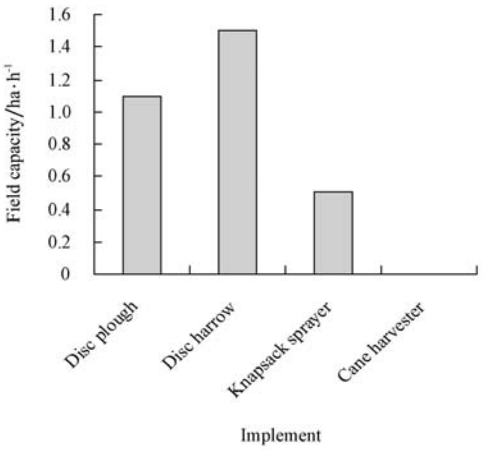

Figure 2 Effective field capacity of various implements employed by the farmers after adoption

4 Conclusions and recommendations

Technology is a system of many inputs (independent variables) and outputs (dependent variables). Six different mechanized technologies were conceived as provided with various operations and inputs: tractor implements, water pumps, mineral fertilizers, pesticides, herbicides and sugar-cane (hybrid) sets. The high inventory of traditional technologies earlier in practice produced lower farm outputs and farmers' incomes compared to the modern technologies that were later adopted. The results indicated that few farmers were conservative towards the adoption process. For instance, out of the 80 sampled sugar-cane farmers, only 5% of the farmers neglected the adoption of disc plough for cultivating their sugar-cane farms, while 95% of them adopted the use of the technology for same application. Similar wide adoption margins existed for water-pumps, mineral fertilizers and pesticides, with 20%, 15%, and 14% of farmers, respectively, neglecting the adoption of the technologies. Seasonal boosts in farmers' income after the adoption process are driving forces for farmers' high recruitments into adoption of modern agricultural mechanization. It suffices to recommend that extension workers be devoted to wider farmer awareness education in order to achieve higher adoption of modern agricultural mechanization, which proved rewarding to the sugar-cane farmers' income profiles in this study. Field trials of recently uncommon technologies could prove profitable on the available sugar-cane farms in Mubi area.

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