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Economic Analysis of Balanced Nutrient Management Technologies for Maize Production in Kaduna State, Nigeria

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Abstract: The overall goal of Balanced Nutrient Management Systems (BNMS) a collaborative project between International Institute of Tropical Agriculture (IITA) and Katholieke Universiteit Leuven (K.U. Leuven) is to curb the vicious cycle of plant nutrient depletion in maize-based farming systems in the moist savanna and humid forest zone of West Africa. This is through integrated nutrient management systems geared to land use practices which are economically viable, ecologically sound and socially acceptable. In Kaduna state of Nigeria (Northern Guinea Savannah), three improved maize-based technologies were tested in a series of farmer-managed field trials since 2000. The first technology was a continuous maize treatment characterized by high fertilizer rates (Sasakawa Global 2000 (SG 2000)). In the second technology, half of the fertilizer quantity was replaced with organic manure (BNMS-manure). The third technology was a soybean-maize rotation treatment in which the fertilizer rates to the maize was reduced by a half (BNMS-soybean/maize). The broad objective of the study was to conduct economic analysis of the three introduced BNMS maize-based technologies along with the farmers' own practice of maize production. The specific objectives of the study were to: determine the costs and returns to the BNMS technologies and farmers' practice and to examine the farmers' perception of the BNMS technologies. The tools used for the analysis of the data were: partial budget analysis to determine the costs and returns to the introduced BNMS technologies and farmers' practice and the scoring technique to examine the farmers' perception of the BNMS technologies. Findings from the partial budget analysis showed that, BNMS-soybean/maize was the best in both the demonstration and adaptation trials by having the highest gross margins of ₦18,462 and ₦19,785, respectively, with the inorganic fertilizer cost constituting over 50% of the total production cost. The farmers gave overall best perception to both the BNM-soybean/maize and the BNMS-manure technologies.

Key words: Maize, banlaced nutrients, organic matter fertilizer, economic analysis, Nigeria

INTRODUCTION

The balanced nutrient management technologies for maize production used the combined application of Organic Matter (OM) and fertilizer to arrest soil nutrient depletion in sub-Sahara Africa. For many years, Sasakawa-Global 2000 (SG2000) in collaboration with the state Agricultural Development Projects (ADPs) in northern Nigeria, has been promoting a maize package among farmers consisting of the use of hybrid seeds, proper plant density and fertilizer application practice and the use of fertilizer rates that are quite high for the region (136 kg N, 20 kg P and 37 kg K ha^{-1}). The SG2000, the Institute for Agricultural Research (IAR), Zaria and IITA agreed to compare this package with a practice in which part of the fertilizer quantity is replaced by animal manure. In addition, it was agreed to also include a maize-soybean rotation, again with reduced fertilizer rate to the maize. Farmer-managed demonstration trials were initiated in 2000 in northern Nigeria in collaboration with IAR and SG 2000. In 2002, 28 farmers in nine villages in the NGS benchmark area of Kaduna State established demonstration trials. In 2003, two additional farmers joined. The objectives of this trial were to (i) demonstrate the three packages for maize-based systems to farmers and extension workers (ii) assess labour input, management practice and farmers' feedback (iii) assess adoption/adaptation of the three packages for maize-based systems and (iv) solicit for opinion of farmers and extension workers during the field days (IITA and Leuven, 2003).

Manyong *et al.* (2002) posited that high fertilizer application rates (136 kg N, 20 kg P and 37 kg K ha^{-1}) in the Nigeria's major cereal areas prompted concern about

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the sustainability of the system. It has been argued that the failure to understand the process of agricultural change may result in the misinterpretation of technological patterns and environmental variables as well as the rules of labour and resource sharing. They concluded by stressing the need for more knowledge in this area.

In recent years, the focus of soil fertility research has been shifted towards the combined application of organic matter and fertilizer as a way of arresting the ongoing soil fertility decline in northern guinea savannah of Nigeria (Vanlauwe *et al.*, 2001). The organic sources can reduce the dependency on costly chemical fertilizers by providing nutrients that are either prevented from being lost (recycling) or are truly added to the system (biological N-fixation). When applied repeatedly, the organic manure leads to build-up of soil organic matter, thus providing a capital of nutrients that are slowly released and at the same time increasing the soils buffering capacity for water cat-ions and acidity (Iwuafor *et al.*, 2002).

MATERIALS AND METHODS

Study area and sampling procedure: The study was conducted in three of the four extension zones of Kaduna state ADP namely: Maigana, Lere and Birnin Gwari. They are located in the Northern Guinea Savannah (NGS). Kaduna State covers about 46,016 square kilometers and representing about 5% of the total land area of Nigeria which has been put to be 923,768 square kilometers. It lies between latitudes 11°32 and 09°02 N and longitudes 08°50 and 06°15 E (Kaduna State, 1996). Rainfall is heaviest in the south and east and decreases northwards. The rainy season varies from March to October with the wettest parts being in the southern part. Kaduna (the state capital) falls within the wetter areas with an average monthly rainfall of 361 mm while Ikara in the drier north has an average of 146 mm over the past 5 years. The duration of rainy days varies from about 65 in Ikara to about 165 in Kaduna. The pattern of temperature and rainfall determine the types of crops, planning of farm operations, food and animal production and assessment of drought and erosion hazards on different parts of the state. After the wet season when the bulk of the food crops are grown, there follows the dry harmattan season during which the days are cool and the nights chilly. This period last from around November to February and coincide with the harvest season (Kaduna State, 1996).

The research trials from which this study were done were located in eight villages in three out of the four extension zones of Kaduna state ADP (Fig. 1). There were three villages in the Maigana zone, three in the Lere zone and two in the Brinin Gwari zone. All the villages were located in the NGS benchmark or very close to it. The zones and villages were as follows:

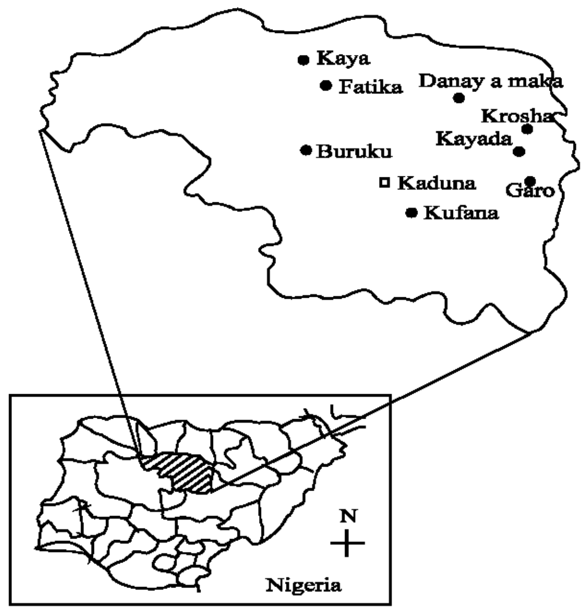

Fig. 1: Kaduna state showing the eight project/study villages

- Maigana zone: Kaya, Danayamaka and Fatika.
- Lere zone: Krosha, Kayarda and Kadiri Garun
- Birnin Gwari zone: Kufana and Buruku.

The participating villages were selected in consultation with the extension services of IAR and SG 2000. There were two types of trials: demonstration and adaptation trials. In 2003, eight villages were involved in the demonstration trials and four in the adaptation trials.

Data analysis: Partial budget analysis was used in the study to determine the costs and returns to the tested Balanced Nutrient Management Systems Technologies and farmers' practice. Scoring technique was used to examine the farmers' perception of the BNMS technologies.

Gross margin as a tool of analysis is essential where partial budgeting is conducted and fixed cost is not included in the analysis. Gross margin represents the most relevant economic indicator which can be used to draw the attention of the farmer to the problems of his farm and offer possible solutions to them. The gross margin analysis is specified as follows:

$$GM = GR\text{-}TVC$$

Where;
GM = Gross Margin (₦ ha^{-1})
GR = Gross Return (₦ ha^{-1})
TVC = Total Variable Cost (₦ ha^{-1})

In calculating the Gross Return (GR), the crop yields (quantity) were scaled down by 5% because it was assumed that the trials had tremendous inputs from visiting scientists which may exaggerate actual yield.

Marginal analysis gives a method for comparing the variable costs with the net benefits (gross margin). This comparison is important to farmers because they are interested in seeing the increase in costs required to obtain a given increase in net benefits.

Before performing the marginal analysis, an initial examination of the costs and benefits of each treatment, called dominance analysis (Boughton *et al*., 1990), has to be done. This may serve to eliminate some of the treatments from consideration and thereby simplify the analysis. A dominance analysis is carried out by first listing the treatments in order of increasing variable costs. Any treatment that has net benefits that are less than or equal to those of a treatment with lower variable costs is dominated. No farmer will choose a treatment in comparison with another treatment, if that treatment has higher variable cost but lower net benefit.

Using the scoring technique the participating farmers were asked to assess each improved technology against eight criteria on a five point scale as follows: (0) completely disagree, (1) disagree, (2) indifferent, (3) agree and (4) completely agree. A satisfactory score on a particular criterion was considered if the rating was greater or equal to 3. A score greater than 50% of the total mark attainable (32 points) corresponded to an overall positive appreciation of the technology.

RESULTS AND DISCUSSION

Gross margin: The gross margin per hectare from the demonstration trials were as follows: BNMS-soybean (₦41335), BNMS-soybean/maize (₦18,462), SG 2000 (₦6,834), BNMS-manure (₦5,513) and the farmer's maize (₦-256) as shown in Table 1.

BNMS-soybean/maize with the highest gross margin of ₦18,462 came out as the best of the introduced maize technologies in the demonstration trials in 2003. The SG2000, BNMS-manure and the farmers own maize followed respectively in order of performance. The BNMS-manure though superior to SG 2000 in terms of gross return, has the highest variable cost of ₦42,759 per hectare thereby making it to have low gross margin. The cost of fertilizer represented the bulk of the variable cost which accounted for more than 50% of the total variable cost.

Among the four maize based treatments in the adaptation trials (Table 2), BNMS-soybean/maize treatment confirmed its supremacy as the best with a gross margin of ₦19,785, followed by SG 2000 (gross margin of ₦19,615), Farmers practice (gross margin of ₦3,730) and BNMS-maize manure (gross margin of- ₦7,807). The poor performance of the BNMS-manure in the adaptation trials compared to the demonstration trials was partly due to the high cost of the over-applied manure. Two of the six farmers' in the SG2000 recorded extremely good yields (of over four tons ha^{-1}).

Dominance analysis: Results of the dominance analysis showed that BNMS-soybean/maize was superior to all the other three technologies in the demonstration trials because it has the least variable cost and the highest gross margin. The SG 2000 technology was also superior to the BNMS-manure (Table 3).

BNMS-paid manure was inferior to all the other treatments in the adaptation trials. A marginal analysis was required to make a final recommendation on the remaining three systems (Table 4).

Marginal rates of returns to each technology: Results from the dominance analysis in the demonstration trials using paid manure showed that the BNMS-soybean/maize should be recommended because it proved superior to the other systems. Removing the BNMS-soybean/maize out of the analysis showed that SG 2000 treatment dominated the BNMS-manure treatment. Therefore a marginal analysis was further conducted leaving out the dominated BNMS-manure treatment.

Table 1: Gross margin analysis for the demonstration trials

	Farmers practice	SG 2000	BNMS-manure	BNMS-soybean/maize	BNMS-soybean
Adjusted yield (kg ha^{-1})	2005.20	2503.05	2814.66	3008.11	1512.73
Farm gate price (₦ kg^{-1})	17.15	17.15	17.15	17.15	39.95
Gross return (₦ ha^{-1})	34389.19	42927.31	48271.42	51589.04	58920.83
Total variable cost(₦ ha^{-1})	34644.81	36093.45	42758.82	33126.71	17585.95
Gross margin (₦ ha^{-1})	-255.62	6833.86	5512.59	18462.33	41334.88

Table 2: Gross margin analysis for the adaptation trials

	Farmers practice	SG 2000	BNMS-manure	BNMS-soybean/maize	BNMS-soybean
Adjusted yield (kg ha^{-1})	2194.83	3135.28	2806.93	3240.93	1590.00
Farm gate price (₦ kg^{-1})	18.82	18.82	18.82	18.82	38.95
Gross return (₦ ha^{-1})	41306.71	59005.97	52826.50	60994.34	61930.44
Total variable cost (₦ ha^{-1})	41306.71	59005.97	52826.50	60994.34	61930.44
Gross margin (₦ ha^{-1})	3730.15	19614.51	-7807.35	19784.59	41999.46

Table 3: Dominance analysis for demonstration trials

Treatments	Total variable cost (₦ ha^{-1})	Gross margin (₦ ha^{-1})
BNMS-soybean/maize	33127	18462
Farmers practice	34645	-256D
SG 2000	36093	6834D
BNMS-manure	42759	5513D

Note: D = Dominated

Table 4: Dominance analysis for adaptation trials

Treatments	Total variable cost (₦ ha^{-1})	Gross margin (₦ ha^{-1})
Farmers practice	37577	3730
SG 2000	39391	19615
BNMS-soybean/maize	41210	19785
BNMS-manure	60634	-7807

DD = Dominated

The marginal rate (MRR) of changing from farmers' practice to BNMS-maize/soybean is 1233%. This means for every N1 invested in changing from Farmers' practice to BNMS-soybean/maize, an additional 11.33 was gained.

MRR: Farmers' practice-BNMS-soybean/maize = Gross margin BNMS-maize soybean-Gross margin Farmers' practice/ Total variable cost BNMS-maize soybean Total variable cost Farmers' practice×100.

$$= \frac{₦18462 - (-256)}{(₦33127 - N34645)}$$

$$= \frac{₦18718}{₦1518}$$

= 12.33 or 1233%.

Changing from farmers' practice to SG2000 gives a marginal rate of return of 490% (a gain of ₦3.90 on every ₦1 invested in fertilizer and its procurement).

Results from the marginal rate of return in the adaptation trials showed the following:

Farmers' practice to BNMS-free manure 190%
For every ₦1 invested in changing N0.90 is gained.
Farmers' practice to SG 2000 .... 876%
For every ₦1 invested in purchasing and applying more fertilizer ₦7.76 is gained.

Farmers' practice to BNMS-soybean/maize 442%
For every ₦1 invested in the change ₦3.42 is gained.

Farmers' perception: During the mid-season interviews, the general response from the demonstration farmers was that the introduced technologies were superior to the farmers' practice in terms of crop yield. The problem of the high cost of inorganic fertilizers in the season made the SG 2000 maize practice to be less appealing to the farmers. This perception was confirmed at the end of the season (Table 5) when none of the farmers agreed with the statement that the fertilizer input in the SG2000 technology was affordable. It is significant to note that 95% of the farmers indicated that they would use the soybean/maize and maize-manure technologies again, while only 50% of the farmers would use the SG2000 system again. A similar contrast was found on the auto-diffusion (automatic diffusion of the technologies). While both the maize-manure and soybean/maize technologies received an overall good appreciation by all farmers, some weaknesses of the maize-manure technology clearly came out. Many felt that it does not suppress weeds (whereas the soybean/maize rotation does) and a few felt that the manure input is not available and affordable. Most farmers indicated that the maize-manure technology suppresses *Striga hermontica*, unlike the SG2000 system. It is possible because maize grows faster under organic manure and since fast growth suppresses weed, the striga may have no effect on the crop even where they are present.

Table 5: Overall appreciation of the technology in the demonstration trials (% score)

Criterion	SG 2000 (n = 20)	BNMS-manure (n = 20)	BNMS-maize/ soybean (n = 20)
Yield of maize ha^{-1}	75	90	90
Soil fertility: Current season	20	95	100
Soil fertility: Next season	15	95	100
Suppression of weeds	20	35	90
Suppression of striga	5	80	85
Diffusion to others	50	95	95
Own use in future	50	95	95
Affordability of inputs	0	75	95
Input concerned is	(fertilizer)	(manure)	(soybean seed)

n = number of farmers who participated in the scoring

The BNMS-soybean/maize rotation was perceived to be a very good technology because of the high price the soybean grains commanded throughout the season together with less cost of input that go with its cultivation.

The adaptation farmers like the demonstration farmers during the mid-season interviews, acknowledged the superiority of the three introduced technologies to farmers' practice in terms of crop yield. The high cost of inorganic fertilizers during the 2003 cropping season made the SG 2000 maize practice to be less appealing to the adaptation farmers. This perception was confirmed at the end of the season (Table 6) when none of the farmers agreed with the statement that the fertilizer input in the SG2000 technology was affordable. All the farmers in the adaptation trials indicated that they would use the soybean/maize and maize-manure technologies again, while only 33% of the farmers would use the SG2000 system.

Perception on auto diffusion of the introduced technologies was exactly like that of usage. All the farmers agreed that they will tell their family members, friends and neighbours about both the BNMS-maize/soybean and BNMS-manure technologies, while 33% will tell about SG 2000 technology. This was in spite of the obvious inability of the BNMS-manure practice to suppress weeds.

About 83 and 73% (In Table 6, 17 and 27%) of the farmers respectively said that SG 2000 and BNMS-manure

Table 6: Overall appreciation of the technology in the adaptation trials (% score)

Criterion	SG2000 (n = 5)	BNMS-manure (n = 23)	BNMS-maize/ soybean (n = 29)
Yield of maize ha^{-1}	50	96	100
Soil fertility: Current season	0	95	96
Soil fertility: Next season	0	91	92
Suppression of weeds	17	27	83
Suppression of striga	29	77	92
Diffusion to others	33	100	100
Own use in future	33	100	100
Affordability of inputs	0	36	72
Input concerned is	(fertilizer)	(manure)	(soybean seed)

n = number of farmers who participated in the scoring

practices suppresses weeds) of the farmers felt that SG 2000 and BNMS practices respectively does not suppress weeds, while 83% felt BNMS-maize/soybean practice suppress weeds. That the availability and affordability of inorganic fertilizer and manure got very low appreciation (zero and 36%) by the adaptation farmers should be of great concern to the change organization (BNMS).

CONCLUSIONS

BNMS-soybean technology came out as the best treatment in terms of gross margin due to the high price of the soybean grains at harvest (₦40 kg^{-1}) and its low attendant input. Among the four maize based treatments, BNMS-soybean/maize treatment came out as the best with the highest gross margin of ₦18,462 and dominated all the three other treatments in the paid manure trials.

Inorganic fertilizer costs accounted for more than 50% of the total variable cost of inputs used for maize production because of its very high prices during the 2003 maize cropping season. Majority of the demonstration farmers perceive the yield of maize in the introduced technologies as satisfactory.

A very high percentage of the farmers perceive both the BNMS-soybean and the BNMS-manure to have positive short and long term desirable effect on soil fertility. The farmers believed that the nitrifying effect of the previous crop of soybean and the organic manure added value to the soil in both the long-run and the short-run. Ninety and 85% of the farmers believe that BNMS-soybean suppress weeds and striga growth respectively. This means that growing soybean on the plot of land and applying organic manure reduce the striga and weeds prevalence.

Auto-diffusion of both the BNMS-soybean/maize and the BNMS-manure technologies was observed among the farmers. There was an overall acceptance of both the BNMS-soybean/maize and BNMS-manure technologies and a near rejection of the SG 2000 technology. About 64% of the adaptation farmers disagreed with the notion that manure is available and affordable while none agreed that fertilizer is available and affordable.

In conclusion, the three introduced maize technologies proved to be better in terms of yield than the farmers' practice of maize cultivation. The combined information from the farmers' perception in the demonstration and the adaptation trials illustrates clearly the positive interest of farmers in both the BNMS-soybean/maize treatment and BNMS-manure treatment over SG 2000 treatment. Furthermore, the farmers' perception indicates the most important constraints and weaknesses of each treatment, from the farmers' point of view.

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