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Full Length Research Paper

Profitability analysis of commercial chemical and biological crop products among farm households in agro-ecological zones of West Africa

A. S. Bamire[1]*, R. Abaidoo[2], M. Jemo[2], T. Abdoulaye[2], A. Yusuf[3] and O. C. Nwoke[4]

[1]Department of Agricltural Economics, Faculty of Agriculture, Obafemi Awolowo University, Ile-Ife, Osun State, Nigeria.
[2]International Institute of Tropical Agriculture (IITA), Oyo Road, Ibadan, Nigeria.
[3]Institute of Agricultural Research, Amadu Bello University, Zaria, Nigeria.
[4]Department of Agronomy, Osun State University, Osogbo, Nigeria.

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This paper evaluates the costs and returns incurred by the use of chemical and biological crop products among households in five selected Compro communities in the derived, Southern Guinea, Northern Guinea, Sudan and Sahel Savanna agro-ecological zones (AEZs) in West Africa. Sixty households were randomly selected in each of the communities to give a total of 300 households. Data were collected on the characteristics of the chemical products, households' socio-economic variables such as age and education, as well as, on farm input and output quantities and prices in the 2009/2010 periods using a pre-tested questionnaire. Data were analyzed with descriptive statistics and budgetary techniques. The Results obtained show a male dominant, fairly literate farming household, with small landholdings (comprising mainly cereal and legume fields) that are predominantly inherited and located far away from the homestead. Inorganic fertilizers, organic manure, improved seeds and pesticides are known as commercial inputs/ products used on farmers' fields, while agrolizer, apron plus and boost extra are the emerging products. The average quantity of inputs applied varied across the zones. The total quantity of inorganic fertilizer applied on the fields was highest in the NGS (924 kg) and lowest in the Sudan (676 kg). However, fertilizer application per hectare by respondents was below recommended dosages across the zones. The emerging chemical inputs (Agrolizer, Boost Extra and Apron Plus) were used only in Compro communities in the derived savanna (DS) and southern guinea savanna (SGS) by a small number of households. The results obtained from budgetary analysis show that gross margin per hectare was highest in the SGS ($ 254) where the emerging inputs were used by 41.7% of the households and lowest in the Sahel ($ 76). Organic fertilizer was used only in small quantities in the AEZs. Total variable costs accounted for more than 30% of revenue generated, and labour and fertilizer accounted for the highest percentage of these costs. The study concludes that promoting the emerging chemical inputs through increased accessibility and farmers' training on their appropriate agronomic use would increase farmers' income generating potentials for sustainable crop production across the AEZs.

Key words: Profitability, crop products, commercial products, budgetary technique, Agro-ecological zones, West Africa.

INTRODUCTION

The widening degradation of cropland with limited availability of additional fertile land has resulted in intensive land use in the Savanna agro-ecological zones (AEZs) of West Africa. This include the derived-, NorthernGuinea-, Sudan-, Southern Guinea-, and Sahel Savanna. In addition, low and inappropriate use of land improvement technologies resulted in yield declines over the years. Under a system of intensive cropping, nutrient availability from organic and natural sources alone are inadequate. Therefore, soil fertility and productivity can only

be maintained through efficient and increasing use of land improving and yield-increasing inputs such as improved seeds, agro-chemicals, agronomic practices (for example, alley cropping and tree planting), organic and inorganic fertilizers (Aduayi, 1985; Lombin et al., 1991; Adebayo, 1997; Awe, 1997; Bamire, 1999; Wetengere, 2010). This raises concerns about the sustainability of agricultural production systems in many developing countries, including Nigeria (Olayemi and Ikpi, 1995; Nwosu, 1995). The accumulation of knowledge on soil management practices and technologies over the past twenty years has made it possible to address the challenges of intensification of major cropping systems in a sustainable and environmentally friendly way through the use of conventional inputs or chemical fertilizer (also referred to as inorganic fertilizer such as NPK and urea) and organic fertilizer which is made up of more natural compounds like compost, manure and peat moss. Organic fertilizers are generally better for plants, mostly because they are completely from nature. Also, many private partners have been commercializing non-conventional industrial biological (such as *Rhizobium*, *Azospirillum*, and *Mycorrhiza*) and chemicals (such as Agrolizer, Boost Extra and Apron Plus) agricultural products which are just emerging with the aim of increasing and sustaining agricultural productivity of a wide range of crops in different AEZs of SSA. For example, Agrolizer is a form of micronutrient foliar fertilizer that can be sprayed on leaves which increases yields of crops such as maize, rice, wheat and soybean. It is an enzymatically digested liquid fertilizer that is particularly suited for spray and injection through simple micro-irrigation systems. Boost Extra usually in a combination of granules and micronutrients can lead to spectacular increases in yields (Ciancio and Mukerji, 2009), and Apron Plus contains a mixture of ingredients which can produce up to 52% of seedling vigour (Badu-Apraku et al., 2005). According to Watson and Preedy (2008), given its relative safety, affordability and low cost, micronutrients offer distinct advantages as potential therapeutic agents for controlling immunodeficiency and infectious disease in undernourished populations. Thus, the application of these products is capable of generally increasing farm income and enhancing sustainable food production (Phillip, 2001).

According to FAO (2007), sustainable agricultural production systems require the appropriate management and use of natural resources to meet people's needs both now and in the future, implying that strategies for increasing agricultural productivity will have to focus on using available nutrient resources more efficiently, effectively, and sustainably than in the past. This can however, be achieved through appropriate application of agricultural inputs with improved agronomic practices within the framework of the Integrated Soil Fertility Management (ISFM) system as applicable in different agro-ecological niches (Manyong et al., 2001). Of particular concern are the management practices that are cost-effective and give relatively higher returns to farmers' investments.

*Corresponding author. E-mail: asbamire@yahoo.co.uk. Tel: +234 803 389 8900.

METHODOLOGY

The study was conducted in five COMPRO project communities in the Savanna agro-ecological zones (AEZs) of West Africa, namely; Derived Savanna (DS), Northern Guinea Savanna (NGS), Sudan, Southern Guinea Savanna (SGS) and Sahel. These are the impact and intensification zones targeted by Soil Health Programme (SHP) for rapid dissemination of ISFM technologies and areas of intense activities for the Program for Africa's Seed Systems (PASS) and AfNet members. Sixty households were randomly selected in each of the communities to give a total of 300 households. Data were collected from farm household heads during the 2009/2010 cropping season using a pre-tested structured questionnaire. Data collected include household characteristics such as age, education level and occupation, sources of income, as well as, input-output quantities and prices of both conventional inputs (such as organic matter and inorganic fertilizers) and non-conventional inputs (such as emerging products – Agrolizer, Boost Extra, *Rhizobium*) used on farmers' fields. Descriptive statistics and budgetary techniques were also used for data analysis. Descriptive statistics was used to describe the study variables using measures of the central tendency like mean and mode, while partial budget approach in budgetary technique was used to analyse and compare the costs and returns of the inputs in the AEZs. The partial budget approach is used for planning changes in activities, activity mixes, or analyzing business enterprises, including the farm business (Horton, 1980). The technique is used to compute the gross margin that could be earned from the use of agricultural products per hectare of land (Olusi, 1990). The gross margin provides a simple way for comparing the profitability of enterprises that have similar requirements for capital and labour. It refers to the gross income earned from an enterprise, regardless of the variable costs incurred (DSE, 2005). For a farm undertaking several different activities, the total gross margin is the sum of the gross margin on each activity. In other words, overhead (fixed) costs are excluded from gross margin computations, as these costs remain constant in the short term regardless of the level of output from the enterprise and often do not affect the choice between different activities on the farm (Abbott and Makaham, 1986). This is particularly the case where a farming business is already established and has all the required machinery and equipment to support a range of enterprises. In this case, farm establishment costs are sunk, and future costs such as depreciation of machinery, permanent paid labour, administration, fixed amount of money charged or paid (for example, insurance rates) and interest on loans, are pre-determined. With overhead costs pre-determined in the short-term, the choice between activities will often only involve more or less variable costs being incurred. The pertinent research question here is "which activity or combination of activities will generate the greatest return (gross margin) for the business given the existing resources, desired lifestyle and agro-ecological condition?" The gross margin is computed as:

$\pi_i = P_i Q_i - TVC_i$ (i = for each AEZ: DS, NGS, SGS, Sudan and Sahel) Where, π_i = gross margin per hectare (US$/ha), P_i is

the price per unit of product output (US$), Q_i = farm output (kg/ha), $P_i Q_i$ is total revenue and TVC_i, total variable costs of production.

RESULTS AND DISCUSSION

Characteristics of emerging chemical and biological products in the AEZs

Two types of products were identified in the AEZs: the conventional inputs such as NPK, urea, TSP/SSP and organic matter that have been in use over the years by the farming households, and the non-conventional chemical products such as Agrolizer, Boost Extra and Apron Plus that are just emerging and used by some farmers. Biological products such as *Rhizobium*, *Azospirillum* and *Mycorrhiza* were not used by any of the households in the AEZs. The different products and their distribution across the AEZs are shown in Table 1.

The conventional inputs have a wider spread and more used by farm households across all the AEZs. NPK had the largest spread and used by the farmers particularly, in the Sudan and SGS, followed by Urea that was used by 55% of each of the respondents in the DS and NGS, but was not used in the SGS, Sudan and the Sahel. Triple superphosphate (TSP) and single superphosphate (SSP) were used only by a small percentage (1.7%) of respondents in the NGS. Though spread across the AEZs, the small percentage of farmers using organic matter claimed that it was used mainly to complement NPK and urea, especially, when they are scarce and costly to obtain. This implies that among the conventional inputs, NPK and urea were most predominantly adopted by farmers in all the AEZs. On the other hand, the non-conventional inputs or emerging chemical products had a smaller coverage in the AEZs and among the farming households. Agrolizer and Apron Plus were each used by a small percentage of households (3.3%) in the DS, while SGS Agrolizer and Boost Extra were each used by a much larger percentage of respondents (41.7%). This implies that only 27 (9%) of the entire sample (n = 300) used these products. This may also be attributed to the location of the producers/ manufacturers of the products (mainly Candel and Cybernetics Nigeria Ltd.) in the two AEZs, which calls for the need for the producers to evolve marketing strategies to create awareness and disseminate the products to other AEZs in West Africa.

All the emerging products were applied to maize as first crop, and only Agrolizer was applied to cassava. This suggests the consideration of crop specificity in the use of these products. Respondents purchased the products from the Agricultural Development Project offices of the Ministry of Agriculture, as well as, the market, suggesting that the Government approves of its importance to improving crop yield and farmers' income.

Demographic and socioeconomic characteristics of respondents

The selected socio-economic characteristics of users of the different agricultural inputs in the AEZs are shown in Table 2. Only 27 (9%) of the whole sample in all AEZs were users of the emerging products. 2 (7.4%) of this number were in the DS and 25 (92.6%) in the SGS. Males dominate the farming households in all the zones, with a mean of 26 years of farming experience. The only female respondent was in the DS, accounting for 1.7% of the entire sample in the zone. Average age of respondents varied between 47 years in the Sahel and about 56 years in Sudan. The age distribution across AEZs shows that all the respondents fall within the active age bracket of between 30 and 60 years (NBS, 2006; Kolawole, 2009; Bamire et al., 2010). This implies that most of the respondents are young and would be interested in trying technological innovations such as the emerging commercial, biological and chemical agricultural products made available to them. Respon-dents in the SGS had more years of formal education than in other AEZs, implying that most households in this zone could easily understand and use information on new technologies. This is capable of enhancing technology adoption and subsequent improvement of livelihood (Feder et al., 1985; Adesina and Zinnah, 1993; APFIC, 2010). Quite a large percentage of respondents (61% in Sudan, 50% in NGS, 51% in Sahel, 34% in SGS, and 33% in DS) had Islamic education, implying that information on new technologies could be effective if communicated through Islamic programmes and approaches. The main source of household income and livelihood was agriculture, involving more than 80% of the respondents who have been farming for over 20 years. A few of them was engaged in secondary occupation such as petty trading, craftsmanship and artisans; though the highest was in the Sudan (27%) and the lowest (7%) was in the Sahel.

Constraints to crop production by households

Households in the project area were mainly involved in cereal-grain legume-based cropping systems. Cereals, particularly, maize and legumes (cowpea, soybean and groundnut) were the main crops grown in all the AEZs. The constraints to production varied across AEZs based on the major crops grown. Inadequate capital/credit ranked as first constraint to cereal production as claimed by about 82% of the households in SGS, 66% in DS, 33% in Sudan, and 10% in Sahel (Table 3). Drought ranked second and was predominant in the Sahel (44%) and NGS (43%), while inadequacy of agricultural inputs ranked third, particularly, with respect to the scarcity of inorganic fertilizer that was reported in the Sahel, Sudan, NGS, and DS. Seventeen percent of the respondents in

Table 1. Products, producers and first crops of application of inputs (% of respondents).

Item		Pooled sample (n = 300)	DS (n = 60)	NGS (n = 60)	SGS (n = 60)	Sudan (n = 60)	Sahel (n = 60)
Conventional inputs							
NPK		86.7	15.0	45.0	81.7	95.0	23.3
Urea		37.2	55.0	55.0	0.0	1.7	0.0
TSP/SSP		0.6	0.0	1.7	0.0	0.0	0.0
Organic matter (manure and compost)		14.7	0.7	8.1	0.6	24.0	10.7
Emerging(non-conventional) products:							
Product	*Content/ formulation*						
Agrolizer	Agrolizer+christerlizer	1.1	3.3	-	-	-	-
	Micro- nutrient	13.9	-	-	41.7	-	-
Boost Extra	Litre and Granule	0.6	-	-	1.7	-	-
	Micro-nutrient	13.3	-	-	40.0	-	-
Apron Plus	Mixture of ingredients	1.1	3.3	-		-	-
	Producer:						
Agrolizer	Candel	6.7	-	-	20.0	-	-
	Cybernetics Nig. Ltd	0.6	-	-	1.8	-	-
	Candel + Cybernetics Nig. Ltd	6.7	-	-	20.0	-	-
Boost Extra	Cybernetics Nig. Ltd	5.8	-	-	17.4	-	-
	Source of purchase:						
Agrolizer	ADP (Ministry of Agriculture)	1.2	-	-	3.5	-	-
Apron Plus	Market	1.1	3.3	-	0.0	-	-
Boost Extra	ADP	3.3	-		10.0	-	-
	Agrochemical shop	6.6	-		19.9	-	-
	ADP + Agrochemical shop	2.8	-		8.4	-	-
	First crop applied:						
Agrolizer	Cassava	0.6	1.7	-	0.0	-	-
	Maize	1.1	0.0	-	3.3	-	-
Apron Plus	Maize	0.6	1.7	-	0.0	-	-
Boost Extra	Maize	12.8	0.0	-	38.3	-	-

NGS also reported striga infestation as a big challenge to crop production. Other constraints faced by respondents in their production activities include: pests and diseases in the NGS and limited improved planting material in the SGS. This implies that government and developmental agencies should strive to address the problem of inadequate capital/ credit by supporting micro-finance institutions in providing production credit to the farmers, as well as, provide easy access to agricultural inputs through effective and efficient extension service delivery systems, as supported by An (2008). Farmers' use of drought tolerant crop varieties should also be promoted in the NGS and Sahel in order to address the problem of

Table 2. Household socio-economic characteristics of users of chemical and biological products in the AEZs.

Item	Pooled sample (n =300)	Agro-ecological zone				
		DS (n = 60)	NGS (n = 60)	SGS (n = 60)	Sudan (n = 60)	Sahel (n = 60)
Gender (%): Male	98.0	90	100	100	100	100
Mean age (years)	51.0	52.0	49.3	50.2	56.4	47
Marital status (%)	95.5	83.3	98.3	98.3	98.2	99.2
Mean farming experience (years)	26.0	28	28	22	30	22
Level of education (%):						
No formal education	15.2	33.7	1.7	6.8	0	33.7
Primary education	12.4	15.8	25.0	6.8	8.5	5.8
Secondary education	8.6	9.5	5.0	15.3	8.5	4.8
Higher education	12.9	5.3	8.3	32.2	18.6	0
Adult literacy	5.2	3.2	10.0	5.1	3.4	4.3
Islamic education	45.8	32.6	50.0	33.9	61.0	51.4
Sources of revenue (%):						
Primary (agriculture)	84.2	83.3	85	86.7	83	93
Secondary (e.g. trading, craftsmanship, labour)	15.8	16.7	15	13.3	27	7

Table 3. Constraints to cereal production in the AEZs (% of respondents).

Constraint	Pooled sample (n = 300)	Agroecological zone				
		DS (n = 60)	NGS (n = 60)	SGS (n = 60)	Sudan (n = 60)	Sahel (n = 60)
Limited land	2.7	0.0	0.0	2.0	3.0	3.0
Inadequate capital/credit	64.8	66.3	3.0	82.2	33.0	10.0
Labor scarcity	4.0	6.9	0.0	2.0	3.0	0.0
Low soil fertility	16.7	5.0	0.0	2.0	30.0	13.0
Drought	32.0	2.0	43.0	0.0	7.0	44.0
Pest and diseases	13.0	14.9	17.0	2.0	3.0	2.0
Scarcity of improved planting material	6.0	0.0	3.0	9.9	2.0	3.0
Inadequacy of agricultural inputs	20.7	5.0	17.0	0.0	17.0	23.0
Striga infestation	5.7	0.0	17.0	0.0	0.0	0.0
No response	1.3	0.0	0.0	0.0	2.0	2.0
Total respondents (n)	100.0	60	60	60	60	0.0

drought and enhance sustainable cereal production in these areas. In legume fields, respondents major production challenge was the inadequacy of capital and credit particularly, in the SGS as indicated by 74% of the respondents, 41.6% in Sudan and DS (11.9%), while drought was most challenging in the Sahel (50%) and NGS (45%) (Table 4). Other constraints in legume fields are pests and diseases, and inadequate provision of improved planting materials. This implies that any attempt made towards addressing the specific constraints associated with each AEZ will increase legume production in general. It is of particular importance to note that addressing constraints identified in the DS and SGS (where emerging products are currently being used by farmers) is capable of increasing farmers' production in the area and further promote the use of the emerging chemical and biological products in other areas.

Households' farm inputs and outputs in the AEZs

The quantities and prices of inputs and outputs on respondents' farms are shown in Table 5. Farm areas varied between 563 and 797 ha, with the SGS having the largest area followed by DS, and Sudan the smallest. This may suggest that households in the SGS and DS have more land to farm, and with the increased use of yield enhancing products, food production will definitely increase. Also, the average distance of fields in minutes to farmers' homestead was longer in the SGS and DS, implying higher transportation cost for getting inputs into and outputs out of farms in these zones. Total crop output was highest in the SGS (2362 kg), followed by NGS (2141 kg), DS (2114 kg), Sudan (2109 kg), and lowest (2101 kg) in the Sahel. Average prices of raw produce ranged from $ 5.7 per bag of 50 kg in the Sahel to $ 20.2 in the NGS. Information on producer prices were obtained through radio in NGS and Sudan by 50 and 35% of the respondents, respectively; agricultural extension agents in the Sudan (52%); neighbours in NGS (40%), SGS (78%) and Sudan (67%); markets in the DS (48%) and NGS (98%) as well as, 85% in SGS and Sudan. Other sources (such as farmer-farmer interractions and farmers' associations) were used though by few households. The total quantity of inorganic fertilizer applied on the fields was highest in the NGS (924 kg) and lowest in the Sudan (676 kg). The variations in fertilizer use across AEZs may be ascribed to the soil types in the zones. However, fertilizer application per hectare by respondents varied and was below recommended dosages across the zones, supporting the findings of Nwosu (1995) and OSSADEP (1996). The use of inorganic fertilizer was complemented with the application of organic matter in form of compost/manure. The Sudan recorded the highest quantity (943 kg) of organic matter use, while the DS had the lowest (877 kg). The use of organic matter on farm fields was attributed to the unavailability and high cost of inorganic fertilizers in the zones. Within the period of the study, farmers in the Sudan mainly applied organic fertilizer in legume fields, those in the SGS applied NPK, while NPK and organic fertilizer were applied in the NGS. Information on fertilizer use were sourced through television in the SGS, radio in the DS, NGS, SGS and Sudan, and agricultural extension agents in the DS, SGS, and Sudan. Non-governmental organizations (NGOs), agro-dealers and local government secretariats were also important sources of information on fertilizers. More of improved seeds (mainly open pollinated maize varieties) were used by households in the NGS (793 kg) followed by, Sudan (625 kg), SGS (276 kg), and the smallest in the DS (160 kg). The high use of improved seeds in the NGS may be due to the large number of seed producers located in this zone (Kamara et al., 2006). Across 97 was cultivated as main cereal in the DS and Sudan, hybrid maize; Oba super 1 in NGS and Oba super 2 in SGS. A larger quantity of pesticides (659 L) was applied in the Sahel than those in Sudan (623 L) and NGS (476 L). Only small quantities were applied in the DS and SGS. Table 6 shows the different types of pesticides used across the AEZs.

Pesticides applied included insecticides, herbicides, fungicides and nematicides. Formulations such as Best, Atrazine, Paraforce, Gramoxone and Fitcosate were applied in the DS; Herbicides such as Force Up and Gramoxone, and Insecticides such as Karat, Agricott, Atrazine and Upper Cott were common in the NGS. Farmers in the SGS used pesticides such as Cyperforce, Decis, Monoforce, Oark Ash, Sarosate, Sharper Plus, Sulfouex, Transmitte, Upper Cott and VP Root. In Sudan, Cyper Diforce, Cyper-One, and Round-Up were predominant, while only few people used fungicides and insecticides in the Sahel. The pesticides were usually applied after planting in the DS, pre- and post-planting in NGS, and mainly before planting in the SGS. The boom and hand spray method was used in pesticide application across all the zones. Except in the Sudan, second pesticides were applied by farmers in other AEZs: Vestalin in the DS, Karat and Upper cott in the NGS, and Round Up in the SGS. Information on pesticides were sourced mainly across the AEZs through radio in the NGS; agricultural extension agents in the DS, SGS and Sudan; neighbours in the SGS; markets in the NGS, SGS and Sudan; and agro-dealers in the NGS and SGS. The television is the most important source of information for pesticides in the SGS where households sought for information only once in a year. Information through radio, neighbours, markets and agro-dealers were important sources at least once in a month in the NGS; whileagricultural extension agents were the main sources in the DS, SGS and Sudan.

Gross margin analysis of farmers' use of agricultural chemical inputs

The results of gross margin analysis on households' use of different chemical inputs in each of the AEZs are

Table 4. Constraints to legume production in the AEZs (% of respondents).

Constraint	Pooled sample (n = 300)	Agroecological zone				
		DS (n = 60)	NGS (n = 60)	SGS (n = 60)	Sudan (n = 60)	Sahel (n = 60)
Inadequate land	6.0	0.0	2.0	2.0	2.0	12.1
High price for rented land	0.7	0.0	0.0	0.0	2.0	0.0
Inadequate capital/credit	47.8	11.9	5.0	74.3	41.6	10.6
Lack of labor	1.7	0.0	0.0	3.0	2.0	0.0
Low soil fertility	1.3	2.0	0.0	2.0	0.0	0.0
Drought	34.2	0.0	44.6	0.0	7.9	50.0
Pests or diseases	18.5	9.9	16.8	2.0	26.7	0.0
Inadequate provision of improved planting material	18.5	2.0	16.8	16.8	7.9	12.1
Inadequacy of inorganic inputs	9.0	0.0	7.9	0.0	6.9	12.1
Inadequacy of organic input	0.7	0.0	2.0	0.0	0.0	0.0
Flooding	0.7	0.0	2.0	0.0	0.0	0.0
No response	27.8	74.3	3.0	0.0	3.0	3.0

Table 5. Inputs and outputs in respondents' farms by AEZs.

Item	Pooled sample (n = 300)	Agroecological zone				
		DS (n = 60)	NGS (n = 60)	SGS (n = 60)	Sudan (n = 60)	Sahel (n = 60)
Area (ha) of crop-livestock field	675	699.6	674.7	796.6	563.4	642.7
Average walking distance of field (in minutes)	680	703	671	803	573	650
Total production in previous season (kg)	2186.3	2114.4	2140.6	2362.1	2109.9	2100.7
Average price of raw produce sold ($)	18.6	19.6	20.2	18.3	17.2	5.7*
Quantity of fertilizer (kg)	823	816	924	848	676	851
Qty of organic matter (kg)	898	877	914	880	943	874
Quantity of 1st seed (kg)	482	160	693	276	625	658.0
Qty of first pesticides (liters)	407	64	476	11	623	659

1US$ = 150 NGN (₦); *1US$ = 458.095CFA.

Table 6. Types of pesticides applied on farms in the AEZs (% of respondents).

Pesticide type	Pooled sample (n =300)	Agro-ecological zone				
		DS (n = 60)	NGS (n = 60)	SGS (n = 60)	Sudan (n = 60)	Sahel (n = 60)
Atrazine	24.5	71.7	1.7	0.0	0.0	0.0
Best Action	2.2	1.7	0.0	5.0	0.0	0.0
Cyperforce	1.1	0.0	0.0	1.7	1.7	0.0
Decis	5.0	0.0	0.0	10.0	5.0	0.0
Force up (herbicide)	6.1	3.3	0.0	10.0	5.0	0.0
Glycel	0.6	0.0	0.0	1.7	0.0	0.0
Round up	20.5	0.0	15.0	33.3	13.3	0.0
VP root	0.6	0.0	0.0	1.7	0.0	0.0
Karat	3.9	1.7	1.7	5.0	3.3	0.0
Mulsate	0.6	0.0	0.0	1.7	0.0	0.0
Sarosate	1.1	0.0	0.0	3.3	0.0	0.0
Sharper plus	2.2	0.0	0.0	6.7	0.0	0.0
Transmitte	0.6	0.0	0.0	1.7	0.0	0.0
Upper cott	4.5	0.0	1.7	11.7	0.0	0.0
Agricott	0.6	0.0	1.7	0.0	0.0	0.0
Oarkash	0.6	0.0	0.0	1.7	0.0	0.0
Cyperone	0.6	0.0	0.0	0.0	1.7	0.0
Fitscosate	1.1	3.3	0.0	0.0	0.0	0.0
Paraforce	6.7	6.7	13.3	0.0	0.0	0.0
Monoforce	3.9	0.0	8.3	3.3	0.0	0.0
Sulfouex	0.6	0.0	0.0	1.7	0.0	0.0
Gramozone	2.8	5.0	0.0	0.0	0.0	3.3
Vestalin	1.1	3.3	0.0	0.0	0.0	0.0
None	75.6	3.3	56.7	0.0	70.0	96.7

shown in Table 7. Respondents in all the AEZs used a combination of chemical inputs in their farm production activities. However, only those in the DS and SGS used some of the emerging non-conventional commercial products, though by a small percentage of respondents. In the SGS, $ 6.3 was spent per ha on these products, while only $ 0.6 was spent per hectare of land in the DS. All respondents in the AEZs had a net return to their farm investments in both conventional and non-conventional chemical inputs. Total revenue was highest in the SGS ($ 432.8), followed by NGS ($ 422.3), DS ($ 413.8), Sudan ($ 376.7) and lowest in the Sahel ($ 121.8).

However, gross margin per hectare was highest in the SGS ($ 254.2), and then the NGS ($ 252.2), DS ($ 250), Sudan ($ 248.7) and lowest in the Sahel ($ 75.8). This suggests that the use of the emerging chemical inputs play a significant role in enhancing crop productivity in the SGS (where the products were used) than in other AEZs. In addition, in spite of the small amount expended on the emerging products in the DS, the difference in gross margin relative to the NGS was marginal. However, there were variations in the items of TVC that produced the gross margin estimates. For instance, while organic matter was not used by households in the DS, it was used in other AEZs and particularly, in the NGS and Sudan where $ 7.9 and 9.1 respectively were incurred per hectare of land. Respondents incurred the highest costs first on labour and inorganic fertilizer except in the Sahel where a relatively higher figure was obtained for fertilizer than labour. Thus, labour accounted for the highest cost of TVC in the DS (51.6%), NGS (50.3%), SGS (49.4%), Sudan (47.2), and the Sahel (42.2%). This implies that policy efforts targeted at developing and providing appropriate labour-saving devices and cheaper technologies such as the emerging chemical products and simple micro-irrigation systems to farmers will reduce the labour requirements for farm operations, reduce TVC and increase farm income. The second highest component of TVC was inorganic fertilizer, accounting for 43.5% in Sahel, Sudan (38.7%), NGS (35.4%), SGS (33.9%) and in the DS (33.8%). This implies that the appropriate use of fertilizer in the right quantity, and at the right time and place will reduce TVC and increase farm income. This could be achieved through resource mobilization and promotion of group action by cooperatives and farmer/ commodity groups.

Seed cost was less than 10% of TVC in all the AEZs. However, provision of adequate and good quality seeds to farmers through mobilization and motivation of the organized private sector to actively participate in the

Table 7. Gross margin ($/ha) from use of chemical and biological inputs in the AEZs.

Item	Pooled (n =300)	DS (n = 60)	NGS (n = 60)	SGS (n = 60)	Sudan (n = 60)	Sahel* (n = 60)
Total revenue ($/ha)	355.4	413.8	422.3	432.8	376.7	121.8
Costs ($/ha):						
Inorganic fertilizer	49.2	55.4	60.2	60.6	49.6	20
Organic matter	5.2	0.0	7.9	3.2	9.1	2.8
Pesticide	5.1	14.4	4.2	4.7	2.0	0
Labour	68.1	84.5	85.6	88.2	60.4	19.4
Seed	9.3	8.9	12.2	15.6	6.9	3.8
Other emerging inputs	1.4	0.6	0	6.3	0.0	0
Total variable cost	138.2	163.9	170.1	178.6	128.0	46
GM ($/ha)	217.2	250.0	252.2	254.2	248.7	75.8
Labour % TVC	49.3	51.6	50.3	49.4	47.2	42.2
Fertilizer % TVC	35.6	33.8	35.4	33.9	38.7	43.5
Seed % TVC	6.7	5.4	7.3	8.7	5.4	5.0

1US$ = 150 NGN (₦); *1US$ = 458.095CFA; Data analysis, 2011.

production of seed and seedlings, as well as, support out-growers mobilization will further reduce seed costs and enhance crop productivity. This will create opportunities for the adoption of new technologies like the emerging products in the AEZs. It is also important to note that the total variable cost accounted for more than 30% of revenue generated in all the AEZs, suggesting the need to look into the appropriateness of the cost structure of farms, particularly, on the items of labour and fertilizer.

In general, all the chemical products (both conventional inputs-organic matter, NPK, urea; and non-conventional emerging inputs-Agrolizer, Boost Extra and Apron Plus) used by the households enhanced crop productivity and improved their farm income. The additional use of the emerging chemical products however, further enhanced the income generating potentials of users, particularly, with respect to the SGS where a relatively higher amount of expenditure was committed to these products. The relatively high gross margin per hectare from the use of emerging chemical products in the SGS therefore calls for the need to encourage its use among other farming households within and out of the Compro project locations.

Conclusion and recommendations

Household revenues and livelihood were derived basically from agriculture, with crop production accounting for more than 80% of activities across the AEZs, while relatively young males dominate the farming households with the capability for trying technological innovations available to them. Both conventional and non-conventional inputs were used in households' farms. The conventional inputs are those chemical products already known and used by farming households across the zones such as inorganic fertilizers (for example, NPK, Urea and TSP/SSP), organic fertilizers (organic matter – compost and manure), improved seeds, and pesticides. Non-conventional inputs are also chemical products such as Agrolizer, Boost Extra and Apron Plus that are least known by most households and are presently emerging and used by some households. None of the households used the biological chemical inputs. There were variations in the use of the chemical inputs across the AEZs as a result of differences in climatic factors and soil type. In general, the total quantity of fertilizer applied on farmers' fields was below recommended dosages, and this was attributed to high cost of the material arising from its scarcity, distance to purchase locations where available, and high transportation costs. Thus, households applied organic fertilizers to complement inorganic fertilizer use. A larger percentage of households used improved seeds in the NGS probably due to the high number of seed producers located in this zone.

The positive yield and gross returns per hectare to farm production in all the AEZs suggest that households derive additional income from the use of both conventional and non-conventional agricultural chemical inputs on their farms. The relatively higher gross margin per hectare ($ 254.2) in the SGS in particular (where emerging chemical products were used by households than in other zones) further showed that the use of the emerging products is capable of increasing the revenue base of the farming households. However, the high percentage of TVC accounted for by labour and fertilizer in all the AEZs suggests the need to train farmers on the appropriate management and efficient use of resources on their farms for sustainable crop production. Lack of capital, drought and low soil fertility were identified as major constraints to cereal and legume production across the AEZs. This implies that any attempt made by government and developmental agencies towards addressing these constraints will enhance crop production in general.

Interventions recommended for consideration include the establishment of agricultural credit institutions in the zones; promoting farmers' use of drought tolerant crop varieties, and promoting the use of soil improvement technologies through farmer training in the zones. In addition, there is a need to intensify the promotion of emerging commercial products across all AEZs through awareness creation and effective extension delivery systems in order to enhance the income generating potentials of the farming households for food security and poverty reduction.

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