Journal of Developments in Sustainable Agriculture 5: 191-202 (2010)

Farmers Experience and Practice of No-tillage System: Towards the Adoption of Conservation Agricultural Production in Atwima-Nwabiagya District of Ashanti Region, Ghana

Patrick Akowuah*

Graduate School of Life and Environmental Sciences, University of Tsukuba,
Tsukuba, Ibaraki 305-8572, Japan

Slash-and-burn farming in the Atwima-Nwabiagya district of Ghana has contributed to more fragile farmland and low soil fertility, resulting in very low crop yields. No-tillage is an agricultural practice whereby a crop is established without any prior tillage or burning of the land, and it was introduced to Ghanaian farmers by the Ministry of Food and Agriculture in 1995. In this study, factors affecting the promotion, adoption, and impacts of no-tillage farming were assessed. Questionnaires were administered to 50 farmers categorized as: adopter (practicing no-tillage farming), deserter (abandoned the practice), or never (never practiced no-tillage). Slash-and-burn farmers used 16 man-days/ha for land preparation, whereas no-tillage farmers required 14 man-days/ha for land preparation. In-crop weed control required 12 man-days for slash-and-burn farming and 8 man-days under no-tillage. Slash-and-burn farmers employed 18 man-days/ha for harvesting maize, whereas no-tillage farmers used 24 man-days/ha. No-tillage farmers listed the following benefits of using this system: increased yield (18% of respondents), reduced labor (17%), conserved soil moisture (16%), improved soil nutrients (15%), increased farm size (13%), reduced soil erosion (11%), and reduced production costs (10%). Information on no-tillage practices was diffused by farmer-to-farmer information transfer. Most farmers practiced a mixed cropping system instead of a crop rotation system, and male farmers were seen to be more innovative and likely to adopt new technologies than their female counterparts. The reported challenges associated with no-tillage included poor society recognition of no-tillage practices, difficulties in planting through residues and application of herbicide, and pest invasion. The lack of no-tillage planters makes it rather difficult for large-scale farmers to switch from conventional farming to no-tillage. More effort is needed to investigate multipurpose conservation farming approaches suitable for fruit and crop production. Agricultural engineers and other experts must collaborate to develop suitable conservation agricultural tools and equipment for small-scale farmers to enhance agriculture production.

Key words: Atwima-Nwabiagya, conservation, farmer-to-farmer information transfer, land, no-tillage, slash-and-burn farming

Introduction

Land is a key resource for Ghana's wealth, with cropland representing about 64% of the country's natural resources. The agricultural sector, currently with an average annual growth rate of 6%, contributes more than 35% to the gross domestic product, employs 45% of the native population (about 60% of the labor force), accounts for 75% of the export earnings, and helps to meet more than 90% of the food needs of the country (GSS, 2000). Within the agricultural sector, the livestock subsector, which mainly relies on permanent natural pastures, contributes about 8% to the agricultural gross domestic product. The industrial and service sectors, which depend on the agricultural sector for raw materials, account for about 12% and 28% of the gross domestic product, respectively. The country's rural

Received: October 1, 2010, Accepted: November 1, 2010

* Corresponding author: Ministry of Food and Agriculture, P.O. Box KS.3820, Kumasi, Ashanti Region, Ghana.
E-mail: akowua963@yahoo.com

households, mostly small-scale farmers, represent 63% of the total population and depend directly on land resources for their livelihood (MOFA, 2009).

The need to feed the country's increasing population has caused Ghanaian farmers to clear forests to create more farmland for crop production. Deforestation through agriculture, logging of trees, and bush fires has critical effects on the environment. When used appropriately, fire can be a useful agent for regenerating pastureland and clearing cropland. However, agricultural burning can also have harmful effects on forests and wildlife, as habitat is destroyed, smoke pollutes the air, and soil fauna are destroyed, thus making farmland more fragile and of marginal quality.

Such land degradation in Ghana continues to adversely affect the productive capacity of the land and undermines the contribution of agriculture to economic growth. The country's Ministry of Food and Agriculture (MOFA, 2008) estimated that 69% of the land area of Ghana is affected by moderate to severe soil degradation manifested mainly through erosion. A conservative estimate of the cost of degradation, based solely on water erosion, gave an average of 2% and range of 1.1% to 2.4% of gross domestic product or 2.9% to 6.3% of agricultural gross domestic product. These figures, which could be higher when the costs of other factors affecting land degradation are taken into account, limit the capacity of Ghana to fulfill its potential growth. Declining yields as a result of land degradation made it necessary for the government of Ghana to search for technologies that would increase production. Research institutes, mainly the Crops Research Institute of Ghana, the Soil Research Institute, and other non-governmental organizations, responded to the government's call by testing technologies such as glyphosate-based no-tillage farming and cover cropping, managing soil erosion, and promoting minimum tillage across the country (Table 1).

Conservation agricultural projects established in Ghana left pockets of land conservation technologies in the catchment areas of the projects, but most farmers are not practicing these technologies. Currently, the conservation agriculture projects are no longer active in Ghana. Although some people in the country have experience and knowledge of conservation agriculture, there has been no concerted effort to promote these technologies.

Over 60% of the Ghanaian population lives in rural areas, and these areas also host the bulk of the country's poor. The rural poor in Ghana are highly dependent on natural resources, including land, for their livelihoods. One of the multi-market models developed by the International Food Policy Research Institute has shown that rural poverty reduction will not be achieved if nothing is done to reduce the trend of land degradation (MOFA, 2008).

Table 1. Summary of major agriculture conservation-related projects implemented in Ghana

Name of project	Sponsors	Implementation partners	Focus	Operational area	Date
Savannah Resource Management Project	Danida	Ministry of Lands and Forestry	Developing land management system	Northern, Ashanti, Upper, Brong-Ahafo	1992
Land and Water Management Project	International Development Agency (Danida)	Ministry of Food and Agriculture	Management of soil erosion, fertility	Ashanti and Brong-Ahafo regions	1995–2003
No-till Programme	Monsanto & Sasakawa Global 2000	Crops Research Institute	Glyphosate-based no-tillage farming	National	1992–2005
Cover Crop Programme	IITA and Crops Research Institute	Crops Research Institute	Adaptive trials of cover crops	Ashanti and Brong-Ahafo regions	1996

Source: Ashburner *et al.* (2007).

Arable Crop Production

Areas planted in different crops have increased only marginally since 2000. The overall percentage increase in cultivated area between 2000 and 2006 was about 14.5%, an average of 2.1% per year. The major staple food crops grown in Ghana are maize, rice, cassava, yam, cocoyam, and plantain (Table 2). Recent studies of the components of agricultural growth suggest that the growth has been mainly due to land area expansion as opposed to yield increases; in general, the yields of most arable crops are about 60% of achievable yields (MOFA, 2008). Achievable yield is an optimum production harvest previously obtained through farmers' own practices. A major reason for the inability to reach achievable yields is low soil nutrients, which is partly due to little fertilizer use by the farmers. The average food crop producer is resource poor and uses little or no fertilizer, poor yielding varieties, and no irrigation-based cultivation.

Table 2. Major crop performance in the Ashanti region, Ghana (2008)

Commodities	Production ('000 mt)	Yield (t/ha)	Achievable yield (t/ha)
Maize	180,589	1.25	2.5
Rice (milled)	10,015	1.08	3.5
Cassava	1,205	10.2	28.0
Yam	388,532	10.5	20.0
Cocoyam	518,920	6.45	8.0
Plantain	915,477	9.1	10.0

Source: MOFA (2008).

Slash-and-Burn and No-Tillage Maize Production

In the slash-and-burn system (Fig. 1), natural vegetation is slashed with a cutlass (a short slashing sword, with a slightly curved blade sharpened on the cutting edge), and plant residue is left on the soil surface for 14 to 21 days before burning. Maize seeds are planted 3 to 4 days after the residues have been burned. Planting is done manually with a cutlass or a dibbler. In-crop weed control is performed twice or more, mostly with a cutlass, at 3 and 6 weeks after planting. Fertilizer may be applied depending on whether the farmer can afford to do so. Maize cobs are harvested manually with a cutlass after 120 days, when the cobs have matured.

In the no-tillage farming system (Fig. 2), land is prepared by spraying glyphosate herbicide on the actively growing weeds or vegetation, and the plant residue is left on the soil surface without burning. After 7 to 10 days, maize seeds are planted directly through the soil surface residue with a cutlass or dibbler. Application of fertilizer is usually done at 2 weeks after planting depending on the choice of the farmer. The plants residue is left on the soil surface throughout 120 days growing period of the maize crop until harvest.

Fig. 1. Slash-and-burn land preparation.

Fig. 2. No-tillage land preparation.

Concept of No-Tillage

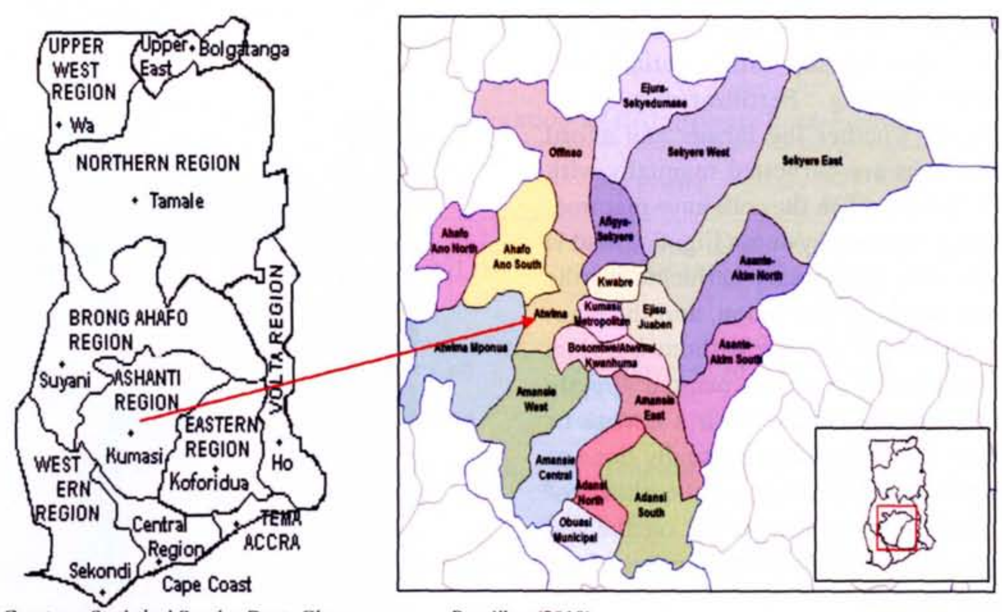
No-tillage is known by various other names, including zero tillage and direct seeding (Olaf *et al.,* 2008). Landers and Saturino (2002) reported that soil surface residues maximize soil fauna and flora activity, which ensures aeration, rainfall infiltration, nutrient recycling, and root penetration. Yield increases and greater nutrient availability translate into lower fertilizer use per unit of production. No-tillage was shown to reverse soil degradation, allow an expansion of agriculture into marginal areas, boost farmers' profitability, and increase the sustainability of the agriculture system in South America. This farming system results in soil and water conservation as well as conservation of the environment as a whole and higher yield and profit for farmers. Derpsch (2005) reported that no-tillage technology is simple for those who have an innovative spirit and who engage in a lifelong process of learning, whereas it may be too complex for those who give up when the first problems appear and for those accustomed with traditional agriculture. No-tillage is applicable to virtually all types of crops, including annual, horticultural, and tree crops. It is a holistic approach to farming and includes integrated disease and pest management.

Conservation agriculture aims to achieve sustainable and profitable agriculture and improved livelihoods of farmers through the application of three principles: minimal soil disturbance, permanent soil cover, and crop rotation. Studies have shown that conservation agriculture technologies reverse soil degradation and increase the sustainability of the agricultural system (Ekboir *et al.,* 2002). Conservation agriculture holds tremendous potential for all sizes of farms and agro-ecological systems, but its adoption is perhaps most urgently required by smallholder farmers (FAO, 2006). The Ministry of Food and Agriculture in Ghana recognizes the need to promote sustainable land management and food security, and this study is consistent with these objectives.

The Study Area

The study was carried out in the Atwima-Nwabiagya district, one of the 27 political and administrative districts in the Ashanti region of Ghana (Fig. 3). The district lies approximately at latitude 6°75′N and between longitude 1°45′ and 2°00′W, and covers an estimated area of 294.84 km^2. According to the 2000 census, the total population of the district was 129,375, with a population density of 439 persons/km^2 (ANDA, 2006).

The Atwima-Nwabiagya district falls within the wet semi-equatorial zone, with a mean monthly temperature between 23 and 33℃ (ANDA, 2006).



Courtesy: Statistical Service Dept.-Ghana, Rarelibra (2010)

Fig. 3. (a) Map of Ghana; (b) map of the Ashanti region showing the Atwima-Nwabiagya district.

Rainfall is bimodal, with peak rainy seasons from March to July and again from September to November, after a short dry spell in August, with annual precipitation between 1000 and 1200 mm. The vegetation in the district is predominantly semi-deciduous, and it has been greatly disturbed by human activities. Formerly the district had forests with valuable tree species and other forest products.

The Atwima-Nwabiagya district was selected for the study because of the area's intense land degradation through slash-and-burn farming and pressure on the use of arable land. The proximity of the Atwima-Nwabiagya district to the Kumasi metropolis, the capital of the Ashanti region, has attracted spillover of the Kumasi population into the district. Because much of the arable land has been converted to developments of residential buildings, much pressure is put on the remaining farmland, resulting in the reduction of individual farm size and increased unemployment in the district (Fig. 4). Farmers in the Atwima-Nwabiagya district have taken advantage of potential markets in the metropolis and intensified land degradation mainly by raising livestock, slash-and-burn farming, arbitrary use of insecticides on crops, timber cutting, wood collection, and uncontrolled use of fire and bush fires. Arable land has become expensive to rent, so most of the youth cannot afford the initial capital to go into farming. Farmers have continually utilized the same pieces of land year after year without fallow periods, resulting in low soil fertility. The exploitation of the arable land has contributed to lower agricultural productivity in the Atwima-Nwabiagya district, and these factors are outlined in Figure 4.

Farming Systems in the Target Area

Soil characteristics in the study area vary from well drained with high organic matter content to poorly drained with low organic matter content (Zschekel *et al.,* 1997). The predominant farming system in the district is shifting cultivation. This involves clearing the existing vegetation, followed by burning of the residue and cropping for a period of 2–3 years. The land is then abandoned for varying periods in order for it to regenerate naturally over time. With the increase in human population, however, the sizes of arable land plots per household have decreased, making it impossible for farmers to practice the fallow system. Agriculture is predominantly on a smallholder basis, with 90% of farm holdings ranging between 0.5 and 2 ha (ANDA, 2006). Farmers use traditional farming methods, and the hoe and cutlass are the main farming tools. Maize and cassava are the major staple crops, complemented by plantain and cocoyam. Maize is consumed daily in different forms, and it plays a critical role in food security, accounting for 50–60% of the cereal production. On average, 40% of the maize produced goes toward household

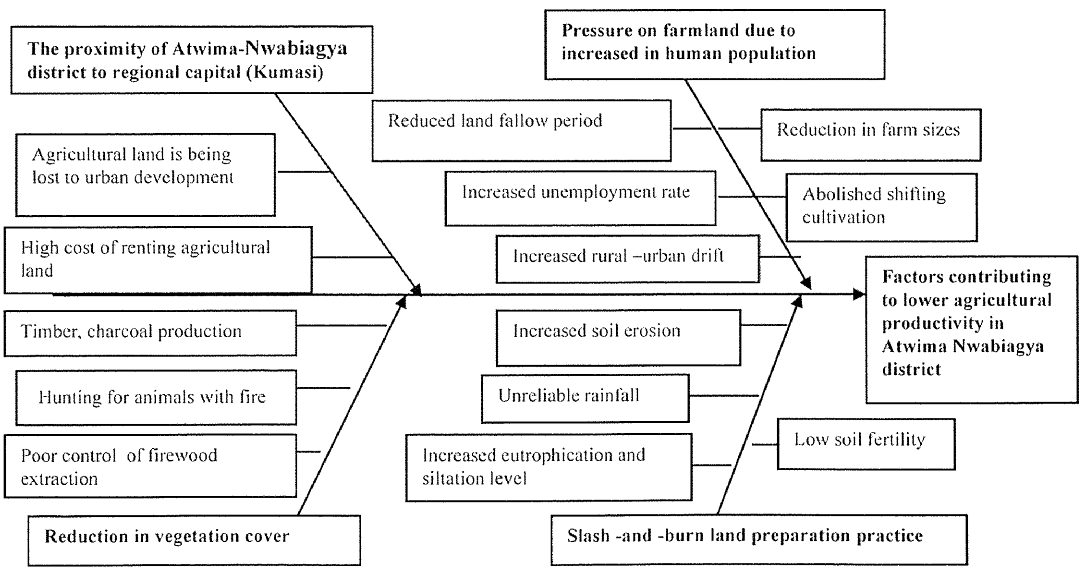


Fig. 4. Factors contributing to lower agricultural productivity in the Atwima-Nwabiagya district.

consumption and 60% is sold for household income.

Slash-and-burn farming is not only labor intensive but also causes rapid soil degradation and results in poor crop yield (Boa-Amponsem, 2000). The slash-and-burn farming practice in the target area has contributed to poor soil fertility and more fragile farmland, resulting in low crop yields in the Atwima-Nwabiagya district and its surrounding areas. The majority of farmers continue to slash the existing vegetation with cutlasses, leave the residue to dry for 7 to 10 days, and then burn it. Farmers then gather the debris (stems and branches of the trees) and burn it again to obtain a clearer land surface before planting. The purpose of this study is to explore the opportunities for a locally adapted framework for promoting conservation agriculture technology practices that replace slash-and-burn farming, maintain soil water and fertility, improve crop yield, and reduce production costs to small-scale farmers in the target area. The specific objectives are to determine factors affecting the adoption of no-tillage practice and to identify and promote land conservation technologies to improve maize yield in the target area.

Materials and Methods

A survey was carried out in five communities (Wioso, Seidi, Nkawie, Fufuo, and Agogo) in the Atwima-Nwabiagya district in the Ashanti region of Ghana from December 2009 to January 2010. Farmers were randomly selected and categorized into three groups: farmers practicing no-tillage (adopters), those who have practiced no-tillage but abandoned the practice (deserters), and those who have never practiced no-tillage (never). Interviews were conducted using questionnaires administered to 50 farmers (28 adopters, 10 deserters, and 12 never) to obtain information on the background of the farmers, their practice of no-tillage, and impacts of no-tillage practices in the target area. The questionnaires were self-administered, and each interview lasted for 30–40 min, depending on the category of farmer. Data obtained were analyzed using Bonferroni post hoc comparisons in two-way ANOVA, using the software Graphpad Prism version 5 for Windows (www.graphpad.com).

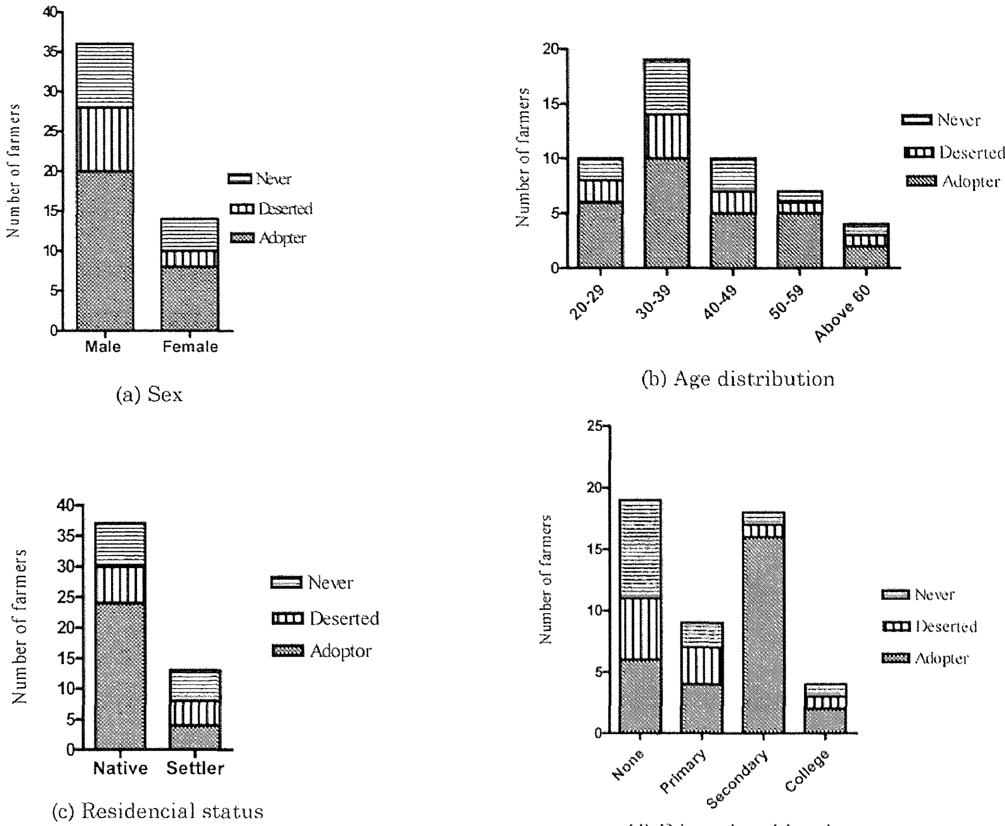
Results and Discussion

Male farmers dominated all three groups (Fig. 5a). Twenty of the 28 adopters (71%), 8 of the 10 deserters (80%), and 8 of the 12 farmers in the never group (67%) were males. Major decisions on no-tillage farm activities were made by both men and women in a household. About 50% of the female farmers concluded that no-tillage technology was good but mentioned that mounting herbicide sprayers on their backs was uncomfortable. According to some of the women, the sprayer straps run across the breast area, making them difficult to manipulate. Women played an important role in selecting the type of crop to be planted in each season, because women are the family members who frequent market centers and have more information about the supply and demand for specific crops.

Among the five age groups of farmers (20–29, 30–39, 40–49, 50–59, >60 years), the 30- to 39-year group was conspicuously larger than the others within all three categories of farmers (Fig. 5b). The 30- to 39-year group constituted 36% of adopters, 40% of deserters, and 42% of the never group. Adopter farmers were relatively higher among all the categories of farmers' age group particularly with 30–39, the reason may be that, farmers in the 30- to 39-year group formed the majority of farmers population. The average life expectancy in Ghana is 55 years, and farmers above 50 years are relatively weak for farm work. This situation may have compelled most farmers between 20 and 39 years to adopt no-tillage practice, which would save time prior to harvest and allow them to earn additional income by providing farm labor services.

Among the three categories of farmers, native (indigenous) farmers were the most prevalent, accounting for 86% of adopters, 60% of deserters, and 58% of the never group (Fig. 5c). Most native farmers were allodial owners of the farmland and were able to farm for more years on the same plot, unlike settler farmers who usually rent a piece of land or contract as share-croppers with the land owners. Settler farmers lose their farmland after the first or second cropping year, which deters settler farmers from practicing no-tillage. Indeed, only 14% of adopters were settler farmers.

Sixteen (57%) of the adopters had completed secondary school (senior high school); 22% of adopters had no formal education, whereas 50% of deserters and 58% of the never group had no formal education (Fig. 5d). Most of the adopter farmers with a



(a) Sex

(b) Age distribution

(c) Residencial status

(d) Educational level

Fig. 5. Frequency histograms of the number of farmers in each group by: (a) sex, (b) age, (c) residential status, and (d) education level.

secondary education were unable to continue their education to the professional level, whereas most farmers who had graduated from college were school teachers in the communities and their major source of income was not derived from farming work.

Income Sources for Farmers

Agriculture was identified as the main source of income by 79% of adopters, 90% of deserters, and 83% of the never group (Table 3). Non-agriculture sources of income were derived mainly from petty trading and masonry and carpentry work.

The most important crops were maize (average yield, 1.2 t/ha), cassava (9 t/ha), plantain (7 t/ha), ginger (no data), and rice (1.05 t/ha [milled]). No-tillage adoption seems to be more closely linked to maize production than to other crops, although some farmers intercropped cassava and plantain 30 days after sowing maize. Farmers were not able to give quantitative information for their income mainly due to a lack of record keeping. Crops were mainly sold fresh, with the exception of maize, which was stored for a maximum period of 6 months before being sold. Generally, the price of maize increases with the length of storage, until just before the next maize harvest, when the price falls.

Table 3. Main income sources for the adopter, deserter, and never groups

Income source	Adopter	Deserter	Never
Agriculture	22 (79)	9 (90)	10 (83)
Nonagriculture	6 (21)	1 (10)	2 (17)
Total	28 (100)	10 (100)	12 (100)

Numbers in parentheses are percentage of farmers in each category.

Number of Years before Changes Were Noted in No-Tillage Fields

Adopters and deserter farmers were asked how long it was before they noticed changes in their fields as a result of practicing no-tillage. Eighteen percent of adopters and 40% of deserters observed no-tillage impacts in the first year, whereas 78% of adopters and 30% of deserters said it took 2 years to notice advantages from no-tillage farming (Table 4). Cumulatively, 24% of both adopters and deserters reported that it took 1 year to notice the benefits of no-tillage, such as soil water conservation and less weed emergence due to the presence of mulch on the soil surface, whereas 66% of the 38 farmers noticed benefits including soil nutrients improvement within 2 years. Farmers who noticed the benefits from no-tillage within the first and second years practiced no-tillage continuously on the same piece of land, whereas those farmers who practiced no-tillage alternatively noticed an impact after 3 or more years.

Most of the farmers practiced the no-tillage system for maize production, although a few farmers intercropped maize with cassava and/or plantain. The cassava and plantain plants remain growing on the land after maize harvest. Cassava matures after 15 months, while the plantain crop continues to grow for 8 to 9 years. Farmers cultivate the land after 9 years, when the plantain crop yield diminishes.

Table 4. Number of years before farmers noticed the impacts of no-tillage

Year	Adopter	Deserter	Total
One	5 (18)	4 (40)	9 (24)
Two	22 (78)	3 (30)	25 (66)
Three	1 (4)	2 (20)	3 (8)
Four	0 (0)	1 (10)	1 (2)
Total	28 (100)	10 (100)	38 (100)

Numbers in parentheses are percentage of farmers in each category.

Table 5. Sources of no-tillage information to the farmers

Sources of information	Adopter	Deserter	Never
Other farmers	9 (32)	4 (40)	4 (33)
Relatives	5 (18)	1 (10)	2 (18)
Herbicide seller	4 (14)	1 (10)	1 (8)
Extension service	8 (29)	3 (30)	4 (33)
Radio program	2 (7)	1 (10)	1 (8)
Total	28 (100)	10 (100)	12 (100)

Numbers in parentheses are percentage of farmers in each category.

Sources of No-Tillage Information for the Farmers

The farmers mentioned five sources of information on no-tillage technology: other farmers, relatives, herbicide sellers, agricultural extension officers, and radio programs (Table 5). Thirty-two percent of adopters, 40% of deserters, and 33% of the never group mentioned other farmers as their main source of information, whereas 29% of adopters, 39% of deserters, and 33% of the never group mentioned agricultural extension officers as their main source of information.

According to Feder and Slade (1985), farmer-to-farmer technology diffusion builds upon farmers' traditional transfer methods, and farmers appear to prefer fellow farmers as their primary sources of information even when they have alternative sources. The proportion of deserters who received information from other farmers was far greater than the proportions for other sources of information; this could be as a result of regular interactions among farmers in the communities, especially in their regular meeting places such as funeral grounds, farm roads, and church places. Farmers who never practiced no-tillage had access to no-tillage information but were less innovative. Herbicide dealers—private agro-input sellers who retailed seeds, pesticides, fertilizers, and other agricultural inputs and equipment—often advised customers on the use of herbicides for weed control. According to the district director of agriculture, the Atwima-Nwabiagya district has 1: 1500 ratio of agricultural extension officers to farmers, making it very difficult for the officers to provide agricultural information to more farmers. Radio programs were the least cited source of no-tillage information in the study area (Table 5). The national Ghana Broadcasting Corporation broadcasts an hour of programs each week on modern agricultural practices. However, the majorities of small-scale farmers either do not have access to a radio or do not often listen to radio programs.

Land Management Practices Known to the Farmers

Among the various land management practices, the use of compost was the practice most often mentioned by the adopters (Table 6). What they referred to as "compost" was the soil surface plant residue or mulch that decomposed into the soil after some period of crop growth. Among all groups of farmers, crop rotation was the prevailing land management technology known, with 32% of adopters, 40% of deserters, and 33% of the never group mentioning this practice. Although some farmers (mostly deserters and the never group) claimed to practice crop rotation, further clarification during the interview revealed that the practice was actually intercropping, not crop rotation.

Although most of the farmers were aware of the importance of using animal manure as a fertilizer, they found it too cumbersome to transport large amounts to their fields. The average distance from a farmer's house to a farm site is 3 km, usually along a footpath. Generally, all groups of farmers had received basic information on the various conservation land management practices. In this study, however, "adoption" was limited to no-tillage technology. The distinction between conservation agriculture and no-tillage is important. No- tillage alone, while attractive in the near term, may prove unsustainable in the longer term (Hellin *et al.,* 2007).

Table 6. Land management practices known to farmers

Land management	Adopter	Deserter	Never
Cover cropping	1 (4)	1 (10)	2 (18)
Contour planting	1 (4)	1 (10)	1 (8)
Crop rotation	9 (32)	4 (40)	4 (33)
Use of compost	12 (43)	2 (20)	1 (8)
Use of manure	5 (17)	2 (20)	4 (33)
Total	28 (100)	10 (100)	12 (100)

Numbers in parentheses are percentage of farmers in each category.

Average Man-Days per Hectare in Slash-and-Burn versus No-Tillage Maize Production

The average man-days per hectare for maize production varied depending on the type of activities employed. According to the survey, slash-and-burn farmers used 16 man-days/ha for land preparation, whereas no-tillage farmers required 14 man-days/ha for land preparation, which was significantly less (Fig. 6). In-crop weed control for slash-and-burn farming required 12 man-days/ha compared to 8 man-days/ha for no-tillage farming. Slash-and-burn farmers employed 18 man-days/ha for harvesting maize, whereas no-tillage farmers required 24 man-days/ha for maize harvest.

Land preparation under slash-and-burn farming was done by physical clearing of vegetation with a cutlass, which is much more arduous work than using a knapsack sprayer to control weeds. Due to the presence of plant residues on the soil surface as a result of herbicide use, the growth of secondary weeds was inhibited. Hence, no-tillage farmers required fewer man-days to weed their farms. Landers and Saturino (2002) reported that soil surface residues maximize soil fauna and flora activity, thus ensuring aeration, rainfall infiltration, nutrient recycling, root penetration, and yield increases; in addition, greater nutrient availability translates into lower fertilizer use per unit of production and higher profit. The additional man-days required for harvesting maize under the no-tillage system may be attributed to the increased crop yield (average maize yield is 1.0 t/ha for slash-and-burn and 1.5 t/ha for no-tillage farming).

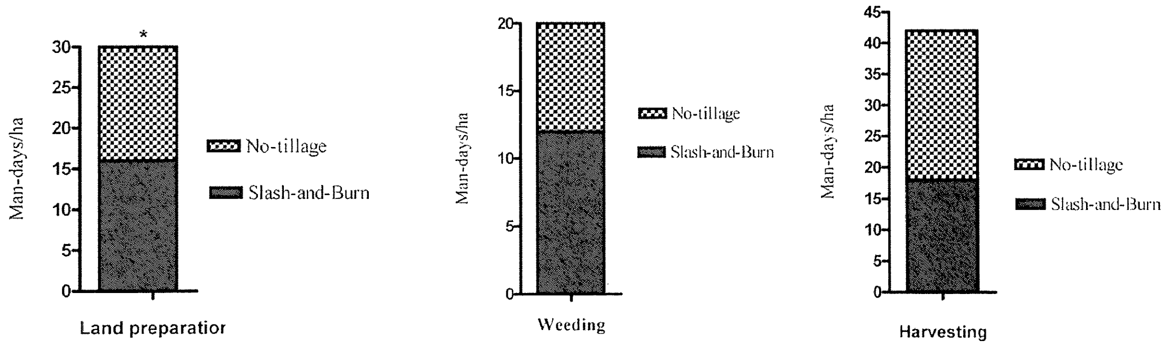


Fig. 6. Average man-days per hectare for land preparation, weeding and harvesting in Slash- and-Burn versus No-tillage maize production.

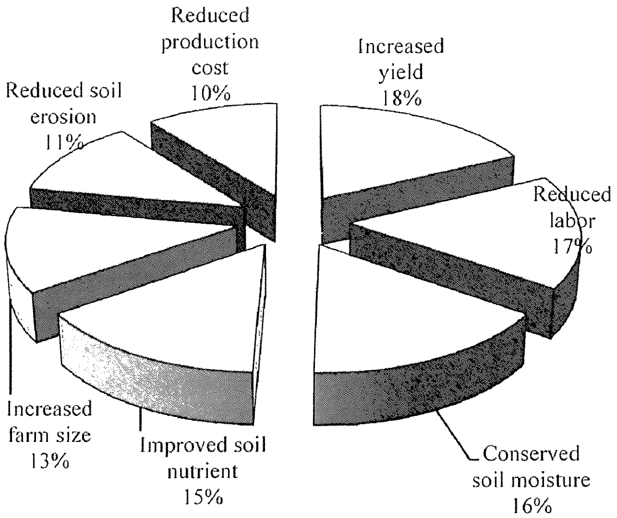


Fig. 7. Proportion of adopter and deserter farmers who agreed with specific benefits of no-tillage farming.

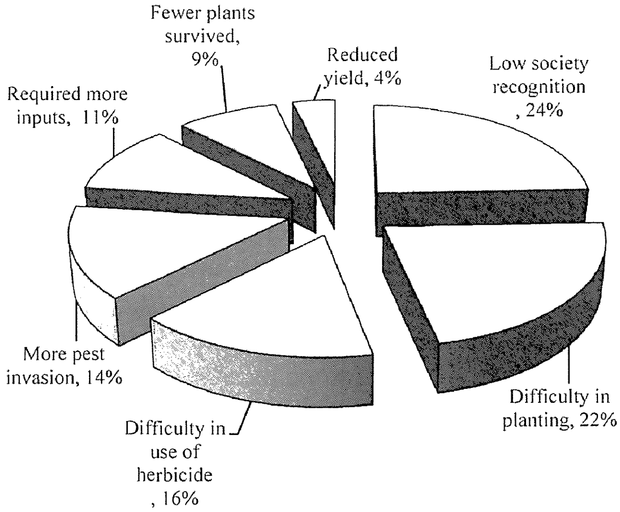


Fig. 8. Proportion of adopter and deserter farmers who agreed with specific problems of no-tillage farming.

Impact of No-Tillage among Farmers

During the interviews, adopter and deserter farmers were asked whether they agreed with various statements about no-tillage farming, which were reported by other studies as benefits derived from practicing no-tillage (Fig. 7). Farmers who testified to the reduction of labor in no-tillage farming agree with statements that the physical clearing of vegetation takes more hours than the use of a knapsack sprayer to control weeds (Fig. 6). In addition, the presence of soil surface cover reduces sunlight intensity beneath the residue, such that less weed emergence requires less labor for weed control.

The increased crop yield noted by 18% of the farmers confirmed the need for more labor for harvesting (Fig. 6). The soil moisture conservation and soil nutrient improvement noted by 16% and 15% of the farmers, respectively, might have contributed to the crop yield increase. The presence of soil surface cover also reduces the speed of surface run-off during rainfall and as a result reduces the rate of soil erosion, as mentioned by 11% of the farmers (Fig. 7). Reduction in production costs could reflect the fact that when decomposed plant residue is added into the soil it reduces fertilizer use per unit of production, as reported by Landers and Saturino (2002). Ten percent of the farmers mentioned increased farm size as a benefit of no-tillage farming.

Problems with No-Tillage According to Adopters and Deserters

Farmers were asked to give their opinion on statements regarding the disadvantages of no-tillage technology, including "low society recognition to no-tillage users," "planting through soil surface residues is difficult," "herbicide application is difficult," "more pest invasion," "requires more inputs," "fewer plants established," and "reduced yield" (Fig. 8). The farmers showed the strongest agreement with statements regarding low society recognition (24%) and difficulty in planting a no-tillage field (22%). Traditionally, a clean prepared field is equated with hard work of the farmer, such that a soil surface covered with stubble or no-tillage land preparation is seen to reflect laziness on the part of the farmer. In addition, the presence of a lot of soil surface residue in a no-tillage field delays planting, especially with traditional tools such as dibblers and machetes. Eleven percent of farmers noted that no-tillage required more inputs. Wall and Ekboir (2002) reported that, while there is an initial increase in herbicide use during the adoption phase of no-tillage, overall herbicide usage decreases once all aspects of the system are being practiced. Female farmers complained that the technique for spraying herbicide was difficult and not suitable, whereas male farmers reported ease of use. According to most of the women, mounting a 15-L knapsack sprayer tank on their back with sprayer straps running across their chest was uncomfortable and difficult to manipulate. Some farmers concluded that the presence of soil surface residues in some instances prevent good plant establishment and harbor insects that damage seedlings, thus resulting in reduced yield, as reported by 4% of the adopters and deserters (Fig. 8).

Conclusion

Since 1990, the Ministry of Food and Agriculture has made efforts to promote beneficial land and soil management practices. According to our survey, farmers believe that no-tillage farming has advantages, such as less labor, conserved soil moisture, reduced soil erosion, increased soil nutrients, reduced production costs, and increased yield. No-tillage adoption continues to lag in Ghana due to low society recognition of no-tillage practices, difficulties in planting through residues, and pest invasion, among other reasons. About 75% of the farmers in the study area continue to practice slash-and-burn farming, which has negative impacts on the soil. In contrast, Ando *et al.* (2010) implemented a program of clearing and spot-burning in Zambia and reported that in the first year of farming spot-burning resulted in higher nitrogen and potassium levels in the soil in proportion to the quantity of burnt residues, which consequently increased yield. In cases of very thick residue cover on the soil surface, modification of no-tillage practices such as spot-burning could be useful to ease planting.

The survey revealed that farmers in the study area have little information about land management practices. Information regarding no-tillage practices was mainly limited to the use of herbicides for land preparation. Greater effort is needed to introduce and promote multipurpose conservation farming approaches, as illustrated in Figure 9, which depicts causes and effects of the proposed integrated approach for promoting sustainable agriculture in the Atwima-Nwabiagya district. Land management training for agricultural extension officers and farmers is required to improve their knowledge base. The ratio of extension officers to farmers (1: 1500) makes it difficult for the officers to reach any more farmers. Therefore, the formation of farmer groups is crucial for better promoting land conservation technologies through farmer-to-farmer information transfer.

The intervention of traditional authorities and government agencies is necessary to enforce restrictions on slash-and-burn farming, *indiscriminate*

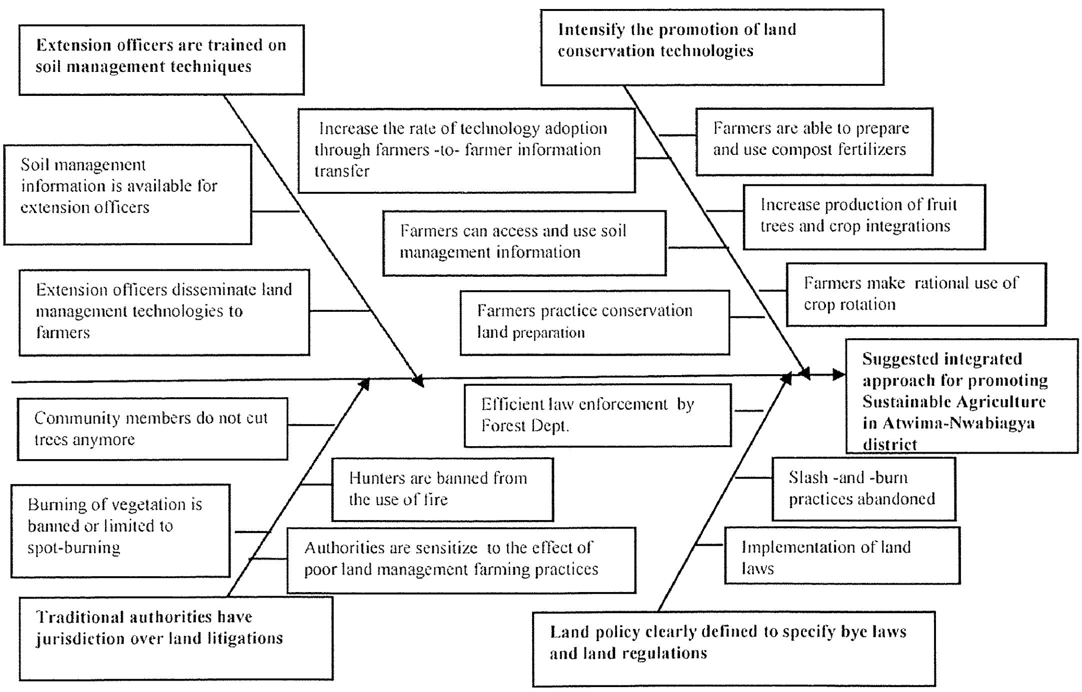


Fig. 9. Proposed integrated approach for promoting sustainable agriculture in the Atwima-Nwabiagya district.

burning, and illegal timber harvesting in Ghana. No-tillage practices alone are insufficient to achieve conservation agriculture. Much more effort is needed to investigate multipurpose conservation farming approaches suitable for fruit and crop production. Agricultural engineers and other experts must collaborate to develop suitable conservation agricultural tools and equipment for small scale-farmers.

Acknowledgements

I am most grateful to my supervisor Prof. Hiroshi Gemma (University of Tsukuba) for his continuous guidance, review, and helpful suggestions throughout my research work. I am also indebted to Prof. Tomohiro Takigawa and Prof. Hisayoshi Hayashi (University of Tsukuba) for their helpful suggestions and contributions to this manuscript. I am grateful to the Japan International Cooperation Agency (JICA) and Japan International Cooperation Center (JICE) for their support of my studies, and I thank all the JICA and JICE staff, including Mrs. Naoko Sakuma, Ms. Yukimi Nakata, Mrs. Sachiyo Akiyama, and Mr. Eishi Aizawa, for their various contributions during my study in Japan. I also extend my sincere thanks to Mr. John Solomon Maninang (my tutor) and Mrs. Kimiko Shinoda of the University of Tsukuba.

I also thank the Ministry of Food and Agriculture of Ghana, particularly my regional director, Mr. George Badu-Yeboah, who nominated me to pursue this program. I thank Mr. Kofi Boa for his contributions and suggestions to the design of the survey questionnaire and the Atwima-Nwabiagya district agricultural extension agents for their help with data collection in the field. I extend my final thanks to the almighty God for making it possible for me to complete this work.

References

Ando, K., Shinjo, H., Miura, R., Takenaka, S., Kuramitsu, H. and Funakkawa, S., 2010. Changes in soil nutrients and maize growth by clearing and burning in a semiarid woodland, eastern Zambia Res. Trop. Agric. Ext.1. pp. 13-14.

Ashburner, J.S., Boahen, P., Dartey, B.A. and Dogbe, G.D., 2007. Conservation Agriculture as Practiced in Ghana. African Conservation Tillage Network, Food and Agriculture Organization of the United Nations, Nairobi.

Atwima-Nwabiagya District Assembly (ANDA), 2006. District Medium Term Development Plan for Atwima-Nwabiagya District Assembly. Ashanti, Ghana.

Boa-Amponsem, F., 2000. No-till Annual Report. Crops Research Institute, Kumasi, Ghana.

Derpsch, R., 2005. The extent of conservation agriculture adoption worldwide: Implications and impact. Proceedings of Third World Congress on Conservation Agriculture, Nairobi, Kenya, 3-7 October 2005.

Ekboir, J., Boa, K. and Denkyi, A.A., 2002. Impact of No-till Technologies in Ghana. Economics Program Paper 02-01. International Maize and Wheat Improvement Center, Me xico D.F.

Feder, G. and Slade, R, 1985. The role of public policy in the diffusion of improved agricultural technology. Am. J. Agric. Econ. 67, 4233-4238.

Food and Agriculture Organization of the United Nations (FAO), 2006. Conservation Agriculture. http: //www.fao.org/ag/ca, accessed November 2010.

Ghana Statistical Services (GSS), 2000. Ghana Housing and Population Census. Accra, Ghana.

Hellin, J., Erenstein, O. and Kosina, P., 2007. U-impact pathway for diagnosis and impact assessment of crop improvement. J. Agric. Sci. 145, 195-206.

Landers, J. and Saturino, H.M., 2002. The environment and zero-tillage. In: Goddard, T., Zoebisch, M.A., Gan, Y.T., Ellis, W., Watson, A., Sombatpaint, S. (Eds.), No-Till Farming Systems. Special Publication No. 3, World Association of Soil and Water Conservation, Bangkok, pp. 253-274.

Ministry of Food and Agriculture (MOFA), 2008. Agriculture Sustainable Land Management Strategy and Action Plan (2009-2015). Agricultural Information Services, Ghana, pp. 5-6.

Ministry of Food and Agriculture (MOFA), 2009. Food and Agriculture Sector Development Policy FASDEP II: Strategic Environmental Assessment and Advisory. Agricultural Information Services, DFID, Ghana.

Olaf, E., Ken, S., Wall, P., Dixon J. and Hellin, J., 2008. Adopting no-tillage agriculture to the conditions of smallholder maize and wheat farmers in the tropics and sub-tropics. In: Goddard, T., Zoebisch, M.A., Gan, Y.T., Ellis, W., Watson, A., Sombatpaint, S. (Eds.), No-Till Farming Systems. Special Publication No.3, World Association of Soil and Water Conservation, Bangkok, pp. 165-223.

Rarelibra, 2010. Map of the districts of the Ashanti region of Ghana. MapInfo Professional v7.5. http: //commons.wikimedia.org/wiki/File: Ashanti_districts.png, accessed 7 June 2010.

Wall, P. and Ekboir, J., 2002. Conservation of Agriculture for Small Farmers: Challenges and Possibilities. Crop Science Society of America, Indianapolis, pp. 10-14.

Zschekel, W., Afful, F. and Agyeman, A., 1997. Baseline Survey on Farming Systems in the Brong-Ahafo Region. German Development Cooperation (GTZ), Sedimentary Farming System Project (SFSP) and Ministry of Food and Agriculture, Ghana.