IS PRECISION AGRICULTURE FEASIBLE IN COCOA PRODUCTION IN GHANA? : THE CASE OF "COCOA HIGH TECHNOLOGY PROGRAMME" IN THE EASTERN REGION OF GHANA

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ABSTRACT

Ghana is the second largest producer of cocoa in the world supplying 25% of the world's cocoa, thus cocoa production contributes significantly to the economy of Ghana. The average national annual yield (350 kg/ha) in Ghana is very small compared to 800 kg/ha in Côte d'Ivoire, and 1700 kg/ha in Malaysia. This has been attributed to low adoption and inappropriate application of innovations by cocoa farmers. Despite the fact that Cocoa Research Institute of Ghana (CRIG) had conducted various on-farm research resulting in yields averaging about 13,000kg/ha in 1991, the innovations had not been fully extended to the estimated 500,000 cocoa farmers in Ghana. In 2003, the government of Ghana introduced the Cocoa High Technology Programme (CHTP) with the aim of improving the fertility of the soil by applying a newly developed fertilizer and other technologies to existing cocoa farms to increase the productivity of the farms. A survey of 200 cocoa farmers, who had adopted the technology in the Eastern Region of Ghana in 2006, was conducted with the aim of estimating how effective cocoa farmers had applied the main components of the CHTP. The results showed that none of the farmers did soil testing before fertiliser application. Although almost all (99.5%) the farmers applied the fertiliser, they did not use the prescribed ring-method of application that ensures that each cocoa tree has optimal amount of nutrient needed. Barely half (42%) of the farmers applied it on the recommended time. Main reasons given for the farmers' inability to use the precision that came with the CHTP include lack of awareness of the need to perform soil testing, late distribution of fertilizers to farmers and inadequate training of farmers on the precise methods of applying the technologies. The aforesaid constraints, among others, militated against the achievement of the target set by the programme. Several recommendations were made which could make precision agriculture feasible in the cocoa industry in Ghana and other cocoa producing countries.

Keywords: Cocoa Innovations, Precision Agriculture, Cocoa High Technology Programme (CHTP), Feasibility, Eastern Region, Ghana.

INTRODUCTION

Agriculture is the most dominant sector in Ghana's economy contributing about 36.7 % to the GDP (including fishing and forestry), and employing about 60% of the labour force (ISSER, 2005). Cocoa (*Theobroma cacao*, L.) is a major export crop with over one hundred years of history in Ghana. Cocoa is the dominant tree crop in Ghana, accounting for 30% of Ghana's export earnings (ICCO, annual report 2006), and employs 24% of labour force (FASDEP, 2002). Cocoa accounts for 55% of the total household income among cocoa farmers in Ghana (IITA, 2002). Until the mid-1960s, Ghana used to be the World's largest producer of cocoa, with the production hitting a peak of 560,000 metric tonnes. West Africa produces 70 percent of the world's cocoa, with Côte d'Ivoire and Ghana supplying 40 and 25 percent of global consumption respectively (Dizolele, 2005).

The average national annual yield of cocoa in Ghana is 350 kilograms per hectare (kg/ha) and is less than what is produced in Côte d'Ivoire (800 kg/ha) and Malaysia (1700 kg/ha) (Appiah, 2004a). The relatively low yield/ha of cocoa in Ghana has been attributed to a number of reasons including high incidence of pest and diseases (such as capsids, swollen shoot virus disease (CSSVD), and black pod disease), decline in soil fertility and inconsistency in rainfall pattern. Also, a greater number of farmers are still using primitive technologies in this even though new technologies to improve yield and productivity are available. The British Government in Gold Coast (now Ghana), in1938, established the West Africa Cocoa Research Institute (WACRI) now the Cocoa Research Institute of Ghana (CRIG) with the mandate to research into problems affecting production and utilization of cocoa in West Africa. Some of the achievements of CRIG are the control of capsids, characterization of cocoa swollen shoot disease as caused by a virus, discovery of mealy bugs as vectors of the virus and the control of the disease by eradication, and development of early bearing and high yielding hybrids (Appiah, 2004a).

According to Appiah, Ofori-Frimpong, Afrifa, and Asante (1997) and Appiah (2004b), on-farm fertiliser verification trials began in the Ashanti Region of Ghana in 1991/92 cocoa season and ended in 1994/95 season. The result of the on-farm verification trials showed that 25% of the total number of fertilised plots had yields exceeding 1000kg/ha at the end of first year, and at the end of fourth year, it increased to 75%. Twenty five percent (25%) of the farm had 2000kg/ha at the end of the fourth year. The result, therefore, revealed significant responses of cocoa to fertiliser application on experimental farms averaged 13000kg/ha and this was higher than the national average of 350kg/ha. It was seen that if the results from the trials are extrapolated on the national scale, the national production could be doubled within a four year period (Appiah et al., 1997)

Despite above findings, fertilizer used in cocoa farms by cocoa farmers in Ghana was still abysmal. The Government of Ghana in 2003 introduced the Cocoa High Technology Programme (CHTP) with the emphasis of promoting the use of fertilizer by cocoa farmers. This was because even though cocoa production in Ghana has increased over the years, the increase has not been attributed to increase in yield per area but was due to expansion of existing farms and development of new farms in the forest area. This, to a large extent, has resulted in deforestation.

The ‘High Technology’ of cocoa production is defined as “the sustainable cocoa production by which the farmer increases and maintains productivity, through soil fertility maintenance at levels that are economically viable, ecologically sound and culturally acceptable using efficient management of resources” (COCOBOD, 2002, p. iv). The five (5) main components of the CHTP are (1) Cultural maintenance of farm, (2) Application of fertiliser, (3) Spraying of fungicide, (4) Spraying of insecticide, and (5).Harvesting, fermentation and drying technologies. Even though farmers were applying some of the technologies except the fertilizer application, this programme was the first time a package was introduced to holistically address the problem of low yield and productivity of cocoa in Ghana. Inputs in the form of fertilizer, insecticides, and pesticides were given to cocoa farmers on credit, to be repaid by using part of their yield after harvesting whiles Agricultural Extension Agents (AEAs) of Ministry of Food and Agriculture (MoFA),Ghana (a public extension organization in Ghana) trained the farmers on the use of various components of the program.

In precision agriculture, farmers need to perform annual planning, data collection, and analyzing steps to complete the precision agriculture cycle namely,

- Before Planting - perform soil testing, then data analysis to determine spatial variations in soil conditions that call for a variety of treatments or planting methods.
- In the Growing Season - begin by planting with variable seeding rates across the field, and use variable rate application (VRA) of fertilizers as determined by soil test data. Crop scouting is done to search for problems such as weeds, pests, or diseases. Findings determine whether further VRA of chemical treatments or other actions are warranted.
- During the Harvest - as the crop is harvested, a yield monitor in the combine logs geo-referenced yield data to be analyzed and mapped across the field. Variable yield results across the field can help the farmer discover if his management methods have been successful, and determine how to proceed in the next season

Even though the CHTP does not adopt totally the concept (Site-Specific)and method and tools in Precision agriculture which include Lab Testing of soils, programmed planting, Crop Scouting, Variable Rate Chemical Application, (VRA) and Yield Monitors, there were aspect that demonstrated the concept and methods in precision agriculture. The CHTP expected farmers to

- carry on soil testing before application of fertilizer
- use ring method of application of the fertiliser as well as specific rate of application of fertilizers and other pesticides.

The aim of this study was to assess the extent to which farmers complied with these aspects of precision agriculture in the CHTP. The intent is to provide suggestions that will inform decision on Ghana’s movement towards precision agriculture especially in the cocoa industry.

MATERIALS AND METHODS

This paper is a part of a scholarly research conducted on the impact of the CHTP on livelihood of farmers in Ghana (Bosompem, 2006). Correlational survey was used to examine cocoa farmers in the Eastern Region of Ghana, who have adopted the CHTP. Four (4) districts (Birim South, East Akim, Fanteakwah and Birim North) were randomly selected from the nine (9) main cocoa growing districts which undertook the CHTP in the Eastern Region of Ghana in 2003. Content - validated structured interview scheduled was used for the study developed to access the components of the CHTP the farmer adopted, their perceived effectiveness of the components and Background characteristics of the farmers. A five-point Likert-type scale which measured the perceived effectiveness (from very effective to very ineffective) of CHTP (with 17 items) when pre-tested to help determine its reliability yielded Cronbach's alpha co-efficients of 0.87 indicating the subscale was reliable (Pallant, 2001).

Stratified random sample was used to select 200 farmers who had participated in the programme for at least three (3) years since its inception in 2003 from the four (4) districts based on the number of farmers who adopted the programme in each district. Therefore, 68, 53, 38, 41 farmers were chosen from Birim South (N=2500), East Akim (N=1939), Fanteakwah (N=1399), Birim North Districts (N=7356) respectively totalling 200 farmers. Data was collected between March and Mid- May 2006. With the help of Statistical Product and Service Solutions (version 12.0), measures of central tendencies and dispersions, frequencies and percentage distributions, independent and dependent sample t-tests, were used to analyse the data.

RESULTS

Perceived effectiveness of Components of the Cocoa High Technology Programme (CHTP)

The 'cultural maintenance component' of the programme generally prepares the cocoa trees and cocoa farms so that cocoa trees would make maximum use of the fertilizer when applied.

The results of the study revealed that at least over 82% of the respondents undertook each of the various sub-components of the cultural maintenance component of the CHTP, which included weeding of farm before fertiliser application, removal of basal chupons, overhead canopies, mistletoes and dead husks; removal of all cola, ceiba and oil palm trees from the cocoa farms and reducing the number of trees per acre (Table 1). For the digging of trenches in waterlogged areas, only fifteen (15) out of the 200 farmers, representing 7.5% of the respondents, said that their farms were susceptible to water logging and therefore dug trenches to drain the excess water during the rainy seasons.

Table 1. Frequency and mean perceived effectiveness of Cultural Maintenance component of **CHTP**

	Yes		Perceived Effectiveness	
Cultural Maintenance	f	%	$\overline{X}$	SD
Weeding of the cocoa farm before fertilizer application.	194	97.0	3.83	0.81
Removal of Basal Chupons, Overhead Canopies, and Mistletoes.	194	97.0	3.80	0.81
Removal of dead husks (Pod and Cherelles).	189	94.5	3.72	0.80
Removal of all Cola, Ceiba and Oil Palm trees.	173	86.5	3.86	0.79
Leaving of about 8 trees per acre of the farm.	165	82.5	3.76	0.79
Digging of trenches (gutters) in the farm for drainage.	15*	7.5	4.53	0.74
Weighted Mean ($\overline{X}$ w)			3.79	0.78

n=200. * Not Applicable. Scale: 5=Very Effective; 4=Effective; 3=Moderately Effective; 2=Ineffective 1=Very Ineffective.
Source: Field Survey Data, 2006.

Generally, farmers perceived each of the sub-components to be ‘effective’, with means ranging from 3.7 to 3.9. High percentage of respondent been able to apply this component may be as a result of the relatively easy of applying this component as in other material-based technologies (Swanson, 1998).

The application of recommended fertilizer is the main ‘trust’ of the CHTP. The active ingredient is [NPK O-22-18 + 9CaO + 7S + 6MgO (s)] and the rate of application is 300-400 grams/tree/year and it is applied 70-100 cm around each cocoa tree trunk. Application of the fertilizer follows immediately after cultural maintenance of the farm.

Table 2 showed that all but one respondent applied the fertilizer. However, almost all the farmers (99%) used the broadcasting method in applying the fertilizer. This they attributed to the relatively cheaper cost of labour in broadcasting method of application compared to that of the ring method which is most preferred. None of the farmers did a soil test which was part of the original plan of on-farm verification trial that led to the development of the CHTP. They said they were not aware of the need to perform soil testing and did not know where to perform the test. Farmers perceived the various sub-components as well as the ‘whole’ fertilizer component of the programme to be ‘effective’ in increasing their cocoa yields. It is also worthy to note that though only one respondent used the ring method of application, he perceived it to be very effective ($\overline{X}$ = 5) hence the need to emphasis the use of ring method of application.

Table 2. Frequency Distribution and Mean Perceived Effectiveness of the Fertilizer Application Component of the CHTP

Application of Fertilizer	Yes		Perceived Effectiveness	
	f	%	$\bar{X}$	SD
Soil testing before fertilizer application	0	0	-	-
Application of the recommended fertilizer.	199	99.5	3.74	0.87
Ring method of application	1	0.5	5.00	-
Broadcasting method of application	198	99.0	3.83	0.85
Application of the fertilizer at the beginning of the rainy seasons	83	41.7	3.78	1.08
Weighted Mean ($\bar{X}$ w)			3.76	0.83

n=200. Scale: 5=Very Effective; 4=Effective; 3=Moderately Effective; 2=Ineffective 1=Very Ineffective.

Source: Field Survey Data, 2006.

The fungicides used included Nordox and Rindomil. These are sprayed after fertilizer application and when trees start bearing flowers and smaller pods in order to control the black pod disease, the predominant fungal disease in cocoa. Table 3 indicated that majority (87%) used the recommended application rate. However, about 28 (approximately 16%) out of the 176 farmers, who used the fungicides did not use knapsack sprayer which is the recommended sprayer but the motolised sprayer which may results in flower and pod drop and consequently affect the yield.

Table 3. Mean Perceived Effectiveness of the Fungicide Application component of the CHTP

Application of Fungicide	Yes		Perceived Effectiveness	
	n	%	$\bar{X}$	SD
Spraying of fungicides	176	88.0	3.63	0.91
Application rate of 6 sachets of fungicides per acre	174	87.0	3.57	0.89
Use of Knapsack sprayer for spraying	148	84.1	3.47	0.80
Weighted Mean ($\bar{X}$ w)	-		3.61	0.86

n=200. Scale: 5=Very Effective; 4=Effective; 3=Moderately Effective; 2=Ineffective 1=Very Ineffective.

Source: Field Survey Data, 2000

Table 3 also shows that the various sub-components as well as the fungicide component as a ‘whole’ were perceived to be ‘effective’ in controlling the black pod disease and consequently increasing their yields. The results confirm that of McGregor (1981), who found out that Ridomil and Nordox, the recommended fungicides for controlling black pod under the CHTP, gave a substantial and significant reduction in numbers of infections arising from zoospores and significantly reduced percentage black pod on the field.

Table 4. Mean Perceived Effectiveness of the Insecticide Application Component of the CHTP

Application of Insecticides	Yes		Perceived Effectiveness	
	n	%	$\bar{X}$	SD
Spraying of Insecticides.	193	96.5	3.87	0.79
Spraying 2 tankfulls of mixture per acre(60 mls/acrea)	181	93.8	3.80	0.79
Use of a motorised mist blower.	171	88.6	3.77	0.75
Weighted Mean ($\bar{X}$ w)			3.85	0.78

n=200. 5=Very Effective; 4=Effective; 3=Moderately Effective; 2=Ineffective 1=Very Ineffective.

Source: Field Survey Data, 2006.

Pods and cocoa trees are sprayed to treat the capsids insects. The most recommended insecticide is the Confidor, a systemic insecticide. The results from the study revealed that the majority (approximately 95%) of the respondents sprayed the insecticides at the recommended rate on their farms (Table 4). Though 19 farmers misapplied the insecticides and used it on vegetables, it is noteworthy that the insecticide (confidor) is systemic and, therefore, the potential hazards this may cause to consumers of these vegetables should not be underestimated. Pidwirny (2002), reported that many human illnesses (e.g. cancer, mutations and congenital defects) and deaths have occurred as a result of pesticide contamination. He estimated that over the past 50 years there have been 20,000 deaths per year as a result of insecticide contamination including vegetables and food contaminated with pesticides

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Table 5. Mean Perceived Effectiveness of the Harvesting, Fermentation, and Drying Component of the CHTP

Harvesting, Fermentation and Drying of Cocoa beans	Yes		Perceived Effectiveness	
	n	%	$\bar{X}$	SD
Harvesting of pods every 3 - weeks when the pods begin to ripe.	183	91.5	3.85	0.79
Fermentation for 6-7 days.	175	87.5	3.98	0.75
Sun-drying of beans.	200	100	4.22	0.69
Weighted Mean ($\bar{X}$ w)			4.04	0.66

n=200. Scale: 5=Very Effective; 4=Effective; 3=Moderately Effective; 2=Ineffective; 1=Very Ineffective.

Source: Field Survey Data, 2006

Harvesting of the ripe cocoa pods at the right time, proper fermentation and drying practices enhance the quality of the cocoa beans. Heap fermentation of cocoa beans is widely used by farmers in Ghana and it is also the recommended method of fermentation by the CHTP. Table 5 revealed that about 91% of the respondents harvested their cocoa pods at three (3) weeks intervals once the pods started ripening. The majority (87.7 %) of the farmers also fermented their cocoa beans for the recommended 6-7 days. This shows that the programme resulted in desirable changes in cocoa farmers' attitude toward the recommended period of fermentation because, Takrama (2006) observed that though the recommended fermentation period is 6-7 days after opening and turning of the beans in heap at 48 and 96 hours interval, most farmers still use 3-5 days fermentation period despite knowing of the appropriate recommendation.

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Impact of the CHTP on yield of cocoa farmer

Table 6 provides the effect of the CHTP on yield of cocoa farmer and some background characteristics that affect the can affect impact of the CHTP on yields. Although male ($\bar{X}$ =798.9 kg/ha) respondents had mean yield of approximately 127 kg/ha more than their female ($\bar{X}$ =672.3 kg/ha) counterparts, there were no significant difference (sig=.161) at 0.05 alpha level. Hence, though not significant male are likely do more physical work than females especially were physical work are more involved in cocoa technology and in most cases when farmers own labour are involved. Also respondents with formal education ($\bar{X}$ =785.9kg/ha) had mean yield of 65 kg/ha more than those with no formal education ($\bar{X}$ =720.9 kg/ha) though the difference is not significant (sig= .512) at 0.05 alpha level

Table 6. Effect of the CHTP on yield of cocoa farmer, and some Background Characteristics

Characteristics		n	Mean yield (kg/ha)	SD	MD (kg/ha	t	Sig.
Sex	Male	141	798.9	560.6	126.6	1.41	.161*
	Female	45	672.3	393.6			
Educational Background	No formal Education	39	720.9	567.9	65.1	.66	.512*
	Formal education	148	785.9	517.1			
Yield before		186	448.9	354.3	319.6	11.3	.00**
Yield after		186	768.5	526.9			
		n	$\overline{X}$	SD	Mode	Min	Max
Age (years)		178	56.3	14.2	48,60	24	109
Experience (years)		195	24.2	13.0	20	3	70

n=200 $p< 0.05$ *=independent-sample t-test, **=dependent sample t-test
Source: Field Survey Data, 2006

Though majority had formal education (80%), the level of education was relatively low since about 70% out of the 80% had basic education. This has implication on training and education of farmers on cocoa technology since their level of education affects ability to receive, decode, and understand information and to a larger extent , determines the type of tasks they can undertake in any project, and therefore the type and level of participation (Byrness and Byrness, 1978). Therefore, task like calibration of instruments, measurements of insecticides, fungicides and fertilizer and their rate of application may be affected

Table 6 also shows that there was a significant (sig=0.00) increase (about 72%) of farmers yield before ($\overline{X}$ =448.9 kg/ha) and three (3) years after ($\overline{X}$ =768.5 kg/ha) implementation of CHTP at 0.05 alpha level. This is a considerable increase compare to Ghana national average of 350 kg/ha even though it was not up to the targeted CHTP yield of not less than 1500kg/ha (Appiah,2004a). Major constraints that militated against the achievement of the targeted yield was attributed to (1) late distribution of the input credit especially fertilizers to beneficiary farmers hence farmers inability to apply it on time,(2) inadequate training of farmers by AEAS for effective application of the technology and (3) inadequate equipment and tools (sprayers) used in applying the CHTP.

The mean age (56 years) of respondents shows that cocoa farmers in the region are old and aging. Majority of farmers in Ghana are over 50 years reported La-Anyane (1985) and Dankwa (2002). This affected production since the health of individuals normally declines with old age and this can affect the work a farmer can do in his/her farm and consequently his/her production. However, their rich experience as cocoa farmers (mean=24 years) may help in the adoption of a technology since considerable amount of experience may facilitate adoption of cocoa technologies.

CONCLUSIONS AND RECOMMENDATIONS

The study shows that farmers in the study area are aging have considerable years of experience as cocoa farmers and about 80% of the respondents had some form of formal education but the level of education was relatively low. This therefore affected, to some extent, the precise implementation of some of the component of the technology especially knowledge-based ones. This may affect future adoption and sustainability of technologies especially knowledge-based cocoa technologies. Majority of the respondents (at least 80%) implemented the cultural maintenance component and perceived it to be effective in helping them realized their yields. Though almost all (99.5) % applied the recommended fertilizer, none performed soil testing before the application of the fertilizer because the farmers were neither aware of the need to do soil testing nor the place to do the testing. Only one (1) farmer used the ring method of application, the most preferred method of application. These, to a large extent, affected the achievement of target of not less than 1300-1500kg/ha set by CHTP. The attitude of the farmers on the right application of these aspects of the programme has implication to the feasibility of Precision Agriculture in the cocoa industries in Ghana. Majority of the farmers applied the fungicides (at least 84%) and insecticides (at least 89 %) and components of the programme to control black pods and Capsids respectfully which are major disease and pest respectfully in cocoa production in Ghana. Few farmers who were not able to apply these components attributed it to their inability to acquire tools (sprayers) user in the application of these chemicals. Majority of the farmers applied the harvesting, fermentation and drying component of the programme more than the other four (4) components apparently because of it relative easy of application.

Though the yield significantly improved (ie about 72%) from 449 kg/ha to 769kg/ha, the targeted CHTP yield of not less than 1300-1500kg/ha was not achieved. This was attributed to late arrival and application of the inputs especially the fertiliser, inadequate tools for applying the technology, and inadequate knowledge and skills due to inadequate training on the application of the technology.

It is therefore recommended that to improve farmers ability to adopt precision agriculture in Ghana especially in the cocoa industry, there should be a critical look into the following suggestions:

1. Reinforcing training and education of cocoa farmers. Since farmers level of educations is relatively low, their capacities need to be built to a level where they could comprehend the knowledge, skills and the application of the technology. This can be achieved true non-formal education since most cocoa farmers are adults. Also, technologies that are knowledge-based and required high precision of it application must target farmers with high educational level especially those in tertiary education. Since all the five (5) public universities in Ghana graduate a total of about a thousand first degree holders in agriculture (mostly BSc. in Agriculture), some of these students

could be trained and be provided with necessary incentives to take up the technologies involved in precision agriculture. Moreover, the concept, tools and methodologies in precision agriculture should be introduced in the curricula of the Senior High Schools and tertiary institutions (especially the universities and polytechnics) that offer agriculture and it related programmes. This may generate interest of students towards precision agriculture.

2. The government should also strengthen the Research-Extension-Farmers linkages and this will go a long way to reinforce the training and education of farmers who are the ultimate implementers of the technology. If the Research-Extension-Farmer linkage becomes stronger, farmers, especially, would be aware of all the aspects of the innovations and be able to locate and consult researchers for appropriate advice when necessary.
3. Researching into methodologies and tools needed in precision agriculture. Since Ghana has a strong research institution (Cocoa Research Institute of Ghana) which is renowned in research into cocoa technologies, it can be resourced with appropriate tools and technical know-how to look into the concepts, the methodologies and equipment that would be needed in precision agriculture in cocoa industry. The outcome of their research could provide the bases to develop appropriate tools to be used, taken into consideration the soil and other climatic factors in Ghana. These tools should be made readily available to farmers on time for smooth implementation of the innovations.
4. Reinforcing the need of irrigation in cocoa production. Since all farmers in the cocoa industry depend on rain-fed agriculture, they are unable to apply technologies when its application depends on the availability of moisture in the soil, example fertiliser application which is one the bedrocks of precision agriculture. Therefore, irrigation would provide farmers opportunity to apply such technologies when the rain fails especially at this era of emerging issues of climate change.

Indeed precision agriculture in the cocoa industry in Ghana is not a mirage. if these recommendations are considered, precision agriculture would be feasible in Ghana not only in the cocoa industry but could be extended to other crops. Also it will serve as a bedrock for other cocoa growing countries to emulate.

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