



**ACDI/VOCA  
Farmer-to-Farmer Program**

**Commercial Soybean Production in  
Ghana – A Consolidated FtF Report For:**

**Caltech Ventures Ltd. #629013 A &  
Kobbiman Farms #596046 D**

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## **List of Acronyms**

ACDI/VOCA	Agricultural Cooperative Development International/ Volunteers in Overseas Cooperative Assistance
CARE	Cooperative for Assistance and Relief Everywhere
CIAT	Center International Agriculture Tropics
CLUSA	National Cooperative League USA (National Cooperative Business Association)
CNFA	Citizens Network for Foreign Assistance, (CNFA, Inc.)
DED	Deutschen Entwicklungsdienstes (German Development Service – Peace Corps)
FtF	Farmer to Farmer Program
IARC	International Agricultural Research Center
ICRISAT	International Crops Research Institute for Semi-Arid Tropics
IITA	International Institute for Tropical Agriculture
IRRI	International Rice Research Institute
KIP	Kpong Irrigation Project
NGO	Non-Government Organization
REAP	Rural Enterprise & Agribusiness Project
SME	Small and Medium Enterprise
SOW	Scope of Work
TRI	Tractor Round-Up International
TSBF	Tropical Soil Biology and Fertility Program
USAID	United States Agency for International Development
WARDA	West Africa Rice Development Association (Africa Rice Center)

## Acknowledgement

I wish to acknowledge the donation of one package of NITRASTIK, Rhizobium bacteria by:

EMD Crop BioSciences  
13100 W Lisbon Road, Suite 600  
Brookfield, WI 53005-2509

In addition I would like to acknowledge Robert Todd, the agent who arranged for the donation, as well as Francis Leier, EMD Crop BioSciences International Business Development Manager, who followed up on some inquiries and would be the contact person for anyone wishing to import inoculant from the USA. [Francis.leier@emdcropbioscience.com](mailto:Francis.leier@emdcropbioscience.com).

The inoculant was divided between the two host farms and became a major contribution of the FtF program. Hopefully, it will lead to soybeans being able to fix nitrogen and contribute to enhancing soil fertility as desired by both host farms.

## Executive Summary

This was a combined farmer – to – farmer consultancy involving two commercial soybean farmers in two locations in Ghana, both with potential out grower programs. These were Caltech Ventures, Ltd in Ho, Volta Region and Kobbiman Farms around Nkoranza, in Brong Ahafo Region. In both cases soybeans were a secondary crop, with cassava for processing into flour and dough which will eventually shift fermentation to beverage ethanol the main crop for Caltech, and export quality mangos the primary crop for Kobbiman Farms. In both cases the interest in soybeans was more for its potential to enhance soil fertility for the main crops, then production of soybean itself.

The consultancy focused on several issues:

1. Soybeans should be promoted with emphasis on the potential to provide a well-balanced source of vegetable protein for industrial processing into animal feed. They should not be promoted as an oil crop, as most of the use will most likely be full fat and provide no oil. Any oil that is provided should be viewed as strictly a by-product.
2. Similarly soybeans should not be promoted for their nitrogen fixation and soil fertility enhancement potential without clearly linking this to the need for the rhizobium bacteria specific for soybeans.
3. Soybeans is usually considered a temperate crop and can be a challenging crop to produce in the tropics, particularly the low elevation humid tropics that include the two host commercial farms, as well as most of Ghana.
4. The challenges include the problem of seed viability and the ability of the seed to remain viable at ambient temperatures across the warm dry off season, as shown by the marginal 65% germination for fresh certified seed at Kobbiman.
5. This concern might best be addressed by the commercial farms undertaking limited evaluation of selected potential lines, and multiply and preserving seed internally and not rely on expensive commercial certified seed. It has to be recognized that the government seed certification program could be sufficiently underfunded to prevent it from implementing the international standard for seed certification and certification might be mostly on the honor system, and may not be noticeable better than market seed. This is consistent with over 90% of the seed planted in the world, particularly for self-pollinated crops like soybean that will not have any noticeable genetic decline for generations.
6. The rhizobium species needed to fix nitrogen is specific to soybeans and thus soybeans have to be inoculated for effective nitrogen fixation, the primary reason both Caltech and Kobbiman are interested in soybean production. This can result in a major logistic problem that has historically been insurmountable in the developing countries,

particularly when smallholders are involved. A donated package of inoculant was brought and divided between the two hosts.

7. The need to inoculate soybeans in order to fix nitrogen is contrary to other legumes in the tropics that all cross inoculate and can be produced and fix nitrogen automatically.
8. Mechanization is concern mostly from the continued need for maintenance and adjustments that with the mix-match of tractors and equipment becomes a daily hassle highlighted by some highly innovative improvising. This is good in the short term but eventually takes its toll on the equipment and the quality of field work.
9. It might be worth considering out-sourcing the use of tractors to avoid the maintenance hassle and also minimize the cowboy operators.
10. There is a need to smooth out as much of the ridges and mounds in the fields so that planters, sprayers and harvesting equipment can operate efficiently and effectively. Failure to do so could ultimately result in incomplete stands of crops lowering yields; non-precise spraying of herbicides, that could damage crops or fail to control the weeds; and too much foreign material in grain, that could result in discounts of 10 to 15% the value of the crop.
11. There is a major concern for the basic organization of the out grower programs, that really needs some major adjustments to take into consideration how previous out grower program have worked or not worked, the adjustment that had to be made to make them operate.
12. The biggest concern is to have business model that is equitable for both the nucleus farm and out growers, and keeps the overhead costs to a competitive minimum. This can become a particularly serious problem with the repayment of production credits, that many previous out grower programs were forced to drop from their programs.
13. Caltech's interest in producing biofuels and lubricants should be carefully followed up on, but perhaps shift from soybean oil to palm oil for fuel and castor oil for lubricants.
14. Finally a limited follow-up on a personal initiative to provide reconditioned used tractors to smallholder communities in Africa under the name Tractor Roundup International.

# Commercial Soybean Production in Ghana – A Consolidated FtF Report For:

## Caltech Ventures Ltd. #629013 A & Kobbiman Farms #596046 D

R.L. Tinsley

### Introduction



*Fig. 1. Map of Ghana Showing Approximate Locations of Caltech Ventures and Kobbiman Farms.*

This is a combined report for two Farmer-to-Farmer assignments looking at soybean production in Ghana undertaken by two commercial farmers both planning to work with smallholder out growers. In both cases the soybeans are a secondary crop with the main crop being either cassava or mango. The consolidated assignment ran for five weeks beginning on 12 June 2010 and ending on 17 July 2010. This allowed approximately 2.5 weeks with Caltech Ventures outside of Ho in Volta Region adjacent to the border with Togo, and two weeks with Kobbiman Farms outside Nkoranza, in Brong Ahafo Region north of Kumasi (Fig. 1.). The timing was consistent with mostly the land preparation with limited sowing of the soybeans. The timing restricted the ability to address several of the concerns mentioned in the SOW,

particularly the post-harvest handling of soybeans. The basic descriptions of the farms

are:

#### Caltech Ventures Ltd.

Caltech Ventures Ltd. is a 2500 ha farm outside of Ho. Its primary crop is cassava which they intend to process into beverage ethanol, as a replacement for imported ethanol (Fig. 2).

Apparently the distilled beverages such as gin and brandy in Ghana are mostly imported ethanol to which the appropriate flavoring is added, rather than a true distilled beverage with natural



Fig. 2. Sign Board for Caltech Ventures

flavoring. The managing director and owner, Chris Quarshie, is one of the primary importers of beverage ethanol. Since the fermentation and distilling equipment is not ready, Caltech is currently processing cassava into flour and fermented dough. There interest in soybeans is to rotate it with the cassava. The plans are for three consecutive years of annually harvested cassava followed by a year of soybeans. The expectation is to take advantage of soybeans nitrogen fixation potential to improve the soil Nitrogen for the benefit of the cassava. The soybeans would then to be used in the poultry feed industry, after extruded the oil that can be recovered from physical extrusion. This would leave the cake with 10% oil. The oil recovered would then be used for making bio-diesel to run the farm. This idea for large commercial farms, particularly in the tropics, to produce their own fuel and lubricants is well worth considering but may need to be carefully reviewed as discussed at the end of this report.

There is also some interest in developing commercial animal enterprises based on poultry, pigs, and fish ponds using the soybean meal for protein, cassava processing tailing or residual cassava from the fermentation operation for energy, blended into a reasonable if not ideal feed. The venture into animal production is well worth considering, but might require an animal nutrition FtF volunteer to fully evaluate, particularly the inclusion of cassava tailing from flour and dough processing as well as the residue from ethanol production, as there nutrient content may be difficult to estimate from available data on the Internet, and require some direct analysis.

The farm along with all processing facilities is managed by Ben Bentil, an agronomist by training. He is assisted by several managers for farm operations, maintenance, and processing. While new to soybean production, he has attended several training programs and has become well versed on the basic soybean management techniques, which he is implementing, perhaps more precisely than necessary or desired. He should have little difficulty making the necessary adjustments from the ideal recommendations to the economic optimal needed for commercially successful soybean production.

### **Kobbiman Farms**

Kobbiman Farms is a group of four farms totally nearly 1000 ac (400 ha) around the town of Nkoranza, in Brong Ahafo region north of Kumasi. The primary crop is high quality mangos (Fig. 3) ultimately intended for weekly shipment of at least one 40 foot refrigerated truck to Accra, for transshipment via either air or sea to Europe or other locations. The mango variety has been carefully selected for its potential to endure a week or more of refrigerated shipping after

maturing on the tree and retain full favor. The farm is still being developed and the mango trees



*Fig. 3. Main Mango Export Crop For Kobbiman Farms*

in many sections remain small prior to or just beginning to become productive, and well before being fully productive. During this period the canopy is open and available for sub-cropping. This was initially maize, but the maize was actually shading the mangos (Fig. 4). Thus there was a need to find a short crop for growing with the mangos while they were developing. This resulted to his interest in soybeans, both because they are shorter statured than maize, as well as, the prospects for nitrogen fixation to enhance the soil fertility for the benefit of the mangos. The

expectation being that once the mangos are in full production the soybeans will be phased out and full attention given the mango production.

The farms are owned and managed by Kwabena Adjei-Mensah, who also serves as a local sub-chief, and thus gets involved in extensive civil duties. His civic involvement provides him the title Nana, by which most people respectfully refer to him. He directly manages the entire farm alone, assisted by a labor force of field workers and equipment operators, plus some out sourcing for mechanical and other services not readily available on the farm. He has also taken some training courses in soybean production which he again is implementing as best he can and perhaps more precisely then necessary or desirable, but as with Caltech will quickly rationalize that to the economic optimal possible with the resources and time available. He has consulting assistance from a crops officer posted to the Agriculture Research Center in Kumasi.



*Fig. 4. First Year Mango Plant Overgrown by Annual Maize Crop*

## **Soybeans**

Soybeans are a perhaps the most widely grown legume grain crop in the world. It is also the most promoted and provides one of the best sources of vegetable protein, as well as, when properly inoculated with the specific species of rhizobium, at least the potential to fix more nitrogen than other grain legumes. However, it is classified as primarily a sub-tropical or temperate crop, where the off seasons temperatures are cool or cold. It is not considered a tropical crop, and can

be challenging to produce in the tropics particularly the low elevation humid tropics, which includes most of Ghana, and for smallholder producers living in that environment.

### **High Protein Industrial Feed Crop**

Soybeans also need to be considered almost exclusively an industrial animal feed crop and not effectively anything else including being an oil crop. As a feed crop soybeans are an excellent source of vegetable protein with a near ideal balance between the amino acids desired for both animal and human nutrition. It is second only to fishmeal for the protein balance, and without the undesired fishy taste that fish meal can leave even in the final consumer product when used for more than 10% of the feed ration. Yes, it is true that there are potential direct consumption uses for soybeans as tofu, soymilk and other products, but these are cumbersome to take advantage of, particularly as cottage enterprises in smallholder villages when not an established part of the diet, even more so if the established diet already contains substantial vegetable protein from such sources as cowpeas, beans, groundnuts, etc. All of these legumes are already well established in the farming systems and diet of rural Africa including Ghana, and can be considerably easier to cultivate in Ghana's low elevation humid tropics than soybeans. Soybeans will not soften on cooking like other beans often directly consumed beans further hindering their potential acceptance for direct consumption.

More often the human consumption is via commercial blends with maize or other grains, and often included to increase the protein content of relief rations to what is basically a captive desperate audience, where unfortunately peoples' dietary needs have to be considered more from most economic perspective of providing an essential nutritional balance of protein, energy and supplemental minerals and vitamins, then the esthetic appearance or social preferences. Yes, it is treating people similar to livestock, but for refugees trying to survive that cannot easily be avoided. The typical blend would be 80% maize flour and 20% full fat soybeans. Soybeans are also often included in baby formula. One problem with the consumption of soybeans either directly or for animal feed is soybeans contain a trypsin inhibitor and have to be heat treated to deactivate this. This can normally be done by cooking the beans at some point in the processing or even physically extruding the beans. The friction in the extruding process will generate enough heat, even if extruded full fat, to render the beans safe for consumption.

The need to primarily market soybeans as a processed industrial crop with only limited opportunity to convert to a home consumption crop increases the marketing risk. Thus, if for some reason an expected marketing channel such as via an out grower program or private trader, fails to materialize as expected or the expected price suddenly drops, farmers could be left with a crop they will have to dump on the market for whatever it will bring from potentially scrupulous traders resulting in substantial financial loss. This will quickly result in a reluctance to produce soybeans in the future.

## Not an Oil Crop

In addition soybeans should not be considered as primarily an oil crop, and its promotion as such is deceptive, particularly in Africa where most processed soybeans are full fat, as noted in both Malawi and Kenya<sup>1</sup>. Yes, soybeans contain vegetable oil and reasonable good quality (Table 1). However, they only contain about 20%. Since when oil is physically extruded there will be 10% oil left in the cake, the oil recovery of soybeans is 10% or only 50% of the available oil. Thus a ton of soybeans when extruded in any efficient oil extruder will yield 100 lit of oil and 900 kgs of cake, with the cake having more economic value, most likely even on a per kilogram basis, let alone having nine times as much material to market. At this recovery rate processing soybean oil would not be an effective cottage industry for smallholder communities. Much better to use groundnuts or sunflowers where, with a 40% oil content, it is possible to recover over 75% of the oil with simple physical extruding and still allow 10% in the cake. Such oil processing from groundnut has been promoted by various NGOs as a potential income generating cottage industry in smallholder communities. Even after being extruded the oil still needs to be filtered and pasteurized to increase physical appearance and enhance the limited shelf life.

**Table 1. The fat composition in different vegetable and animal oils**

Type of Oil	Cholesterol, mg/10 ml	Saturated Fat, %	Poly-unsaturated Fat, %	Mono-unsaturated Fat, %
<b>Vegetable Oil</b>				
Soybean	0	15	61	24
Sunflower	0	11	69	20
Corn	0	14	61	25
Olive	0	14	9	77
Rice bran	0	18	45	34
Groundnut	0	18	34	48
Cottonseed	0	27	54	19
Palm	0	52	9	39
Coconut	0	92	2	6
<b>Animal Oil</b>				
Lard	13	41	12	47
Beef Tallow	15	52	4	44
Butterfat	36	66	4	30

It is possible to recover the remaining 10% oil but this requires the more difficult, dangerous, and expensive hexane dissolution process. It involves dissolving the oil in hexane, a highly volatile and explosive hydrocarbon, and then distilling the hexane off to leave the oil and recover the hexane for reuse. There appear to be very few hexane dissolution retorts

available in Africa. The only one encountered by this consultant was BIDCO's in Kenya, and they acquired it when they bought a processing facility from Unilever rather than being purchased directly. The oil processors in Malawi have discussed acquiring a joint hexane processing capacity for over 20 years without actually acquiring one. Thus, with the limited amount of oil readily available, virtually all soybean processing is full fat, producing no oil, even as a by-product. The exception would be if the final product as restrictions on the fat content to the extent full-fat soybeans could not be used. This may be the case of some poultry feed

<sup>1</sup> <http://amar.colostate.edu/~rtinsley/SoybeanKenya.pdf>

formulations, but it appears even poultry feed can be formulated with whole fat soybeans, particularly if quickly utilized<sup>2</sup>.

Even in developed countries like the USA, soybean oil is almost strictly a by-product of the feed processing business and never or very rarely a primary product. They defat soybeans to reduce the possibility of the blended feeds becoming rancid and reducing the shelf life. Then they often meter it back in to increase the energy component of the feed. As a by-product the soybean oil is sold on the open market for whatever price it will get. In the health conscious USA with obesity the main concern, and even though the saturated – unsaturated ratio is only marginally less healthy than competing oils, soybean oil is basically the trash oil of the vegetable oil industry with a large portion being dumped into the biodiesel fuel manufacture for lack of a better market. If one visits a USA supermarket and look at the vegetable oils, safflower, sunflower, corn (maize), and canola (rapeseed) oils are all promoted and identified on the bottle, but the soybean oil is only listed as generic vegetable oil with a 7% reduction in price (Fig. 5).



*Fig. 5. Different Vegetable Oil Displayed in USA Supermarket, with Soybean Oil Generically Listed as Only Vegetable Oil.*

However, soybean oil is nutritionally considerable better quality for its saturated/unsaturated ratio than palm or coconut oil, the common oils produced in the tropics with the highest per hectare oil yields. However, in developing country societies that could be more energy deficient, particularly in rural smallholder communities, fat will more likely be consumed for urgently needed energy, the saturated vs. unsaturated fat ratio may not be as important as in developed countries where fat is more likely to be retained by the body for lack of demand for energy<sup>3</sup>.

In Ghana the demand for soybeans is mostly from the feed industry largely for a rapidly expanding commercial poultry industry. There is little need for supplemental feed for range feed cattle or goats, and commercial scale pig and fish farming is only now being developed. The current demand is specifying soybean cake or the extruded soybean with 10% oil removed and 10% remaining. Rather this demand continues will depend on the prospects of using whole fat soybean in poultry feed as is being done in other countries. How much of the current feed demand is being met with national production and how much is being imported could not be determined during this consultancy.

<sup>2</sup> Meal Quality Poultry Science Department at CAES UGA.mht

<sup>3</sup> <http://tamar.colostate.edu/~rtinsley/CalorieEnergyBalance.htm>

# Challenges to Soybean Production in the Tropics

## Introduction

While soybeans can be a challenging crop to produce, particularly in the low elevation humid tropics, there are numerous manual and guidebooks available on the internet. Often they have been produced by well known international organizations including several of the IARCs working in conjunction with specific countries like Nigeria. These international organizations include USAID, IITA and ICRISAT<sup>4</sup>. However, as with all manuals and guidebooks, they provide the precise ideal recommendations for getting the maximum yield. It is then left to the individual farmers, either large commercial or smallholder, to fine tune the recommendation. This is usually a downwardly adjust to the economic optimal level of inputs and quality of field work, and further adjust this to the normally limited resources farmers have available to manage the land. This would include the tractors available, the implements for use with the tractors and the manual labor that can be mustered. This all goes into converting the precise scientific recommendations to the “art of profitable farming” that provides the most returns on investment and highest profit.

It is highly interesting that none of these manuals address the key issue of specific rhizobium needed for soybeans to fix nitrogen, while still promoting them for their potential contribution to soil fertility. Likewise none mention any problems of seed viability. Instead they promote the use of nitrogen fertilizer that stops any nitrogen fixation, and use of fresh certified seed each year, even for a self-pollinated crop that will retain its genetic purity for many generations of retained seed.

## Seed Viability

One major concern is with warm ambient temperatures during the dry off season the seed viability or germination can deteriorate very quickly and thus not bridge the dry off season like other crops will. In Thailand the seed viability of soybeans can decline to unacceptable low levels as quickly as six weeks after harvest<sup>5</sup> and in Nigeria, even with treatments to extend the viability, three months appears the outer limit. In the Rift Valley of Kenya, the viability was estimated to be approximately two months. Success in growing soybeans in the lowland tropics can become contingent on a logistic supply of fresh seed, either propagated in an area under irrigation during the dry season or transported into an area from other areas where it could be grown in the off season or are sufficiently high elevation to be cool enough for the seeds to retain their viability. Countries like Thailand, which produces only 1/6<sup>th</sup> the certified seed needed for soybeans, and Indonesia appear to have overcome this problem with some informal private

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<sup>4</sup> <http://www.icrisat.org/tropicallegumesII/pdfs/Soybean.pdf>; [http://www.ics-nigeria.info/publications\\_files/soybean\\_01b.pdf](http://www.ics-nigeria.info/publications_files/soybean_01b.pdf); [http://www.fao.org/sd/erp/toolkit/BOOKS/soybean\\_illustr\\_guidebook.pdf](http://www.fao.org/sd/erp/toolkit/BOOKS/soybean_illustr_guidebook.pdf)

<sup>5</sup> Personal communication Nisa Meese, Former AIT Doctorate Student & Officer Thai Ministry of Agriculture Seed Division.

sector initiatives getting viable seed to smallholders. The details on how this works is not readily available.

The alternative is to restrict soybean production in the tropics to elevations above 1600 m. At these elevations the temperatures in the off season are sufficiently cool for seeds to retain their viability at ambient temperatures across the dry seasons. This is the case in Malawi where soybeans have become well established in the last 20 years, but above the Rift Valley Escarpment avoiding the lakeshore areas or the lower Shire Valley. This is also the case in Nigeria where the soybean cultivation is concentrated around Jos, again at a higher elevation.



*Fig. 6. Caltech's Soybean Seed in the Governments Cold Storage Facility in Ho*

The success of large scale soybean production in tropical countries like Brazil and Argentina would be related to the larger more commercial farmers that can afford and justify both the capital costs and operating costs for large cold storage facilities. Something smallholders would not have access to, even as part of an out grower program. A problem maybe that while the cold storage will retain the viability over the course of a dry season, once removed to the warm ambient temperatures for transport to outreach program the soybeans viability would deteriorate quickly. This was noticed by IRRI in the Philippines in the late 1970s when soybeans were removed from cold storage in Loa Banos with good germination, but a week later after distributing the seed to the outreach sites in Iloilo, Central Philippines, the germination had dropped to unacceptable levels. In Ghana the Ministry of Agriculture has a seed cold storage facility in each region that they provide at a nominal, subsidized cost to farmers. However, it does not have near the capacity to accommodate all the seed needs for all crops. The use is mostly by the larger farmers in the area, with limited access for smallholders, accept possible through an out grower program. Caltech Ventures was able to store soybean seeds in the government facility in Ho (Fig. 6).

How critical the soybean seed viability problem is in Ghana will need to be sorted out on almost an individual basis. It most likely will be more of a problem for Caltech than Kobbiman, simply because of the differences in altitude. However, one soybean scientist mentioned that with the dryer climate in the north, this was not a serious problem. Kobbiman farms also reported to have retained seed for seven months and it still had good germination. If that is correct than it may be more a problem to keep in the back of the mind, than a major concern. However, when Kobbiman changed variety to get one that was more shatter resistant, a quick “rag doll” germination test on the over 200 bags of fresh certified seed showed a germination of only 66%. This is marginal and will require a higher than expected planting rate and consume much of the

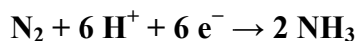
reserve seed. There could also be considerable differences between varieties and a major criterion for variety selection. A criterion that may be overlooked by the variety developers who usually assume farmers will obtain certified seed each season. Even IARCs could overlook this criterion.

## Nitrogen Fixation



*Fig. 7. Nodules Attached To The Root Of Soybean That House The Nitrogen Fixing Bacteria.*

Soybeans like all legumes have the potential to fix atmosphere nitrogen for the benefit of the crop. However, nitrogen fixation is not a gift. The actual fixation is done by a particular type of bacteria - rhizobium infecting nodules, usually attached to the roots of the legume (Fig. 7). The chemistry of nitrogen fixation is actually a high energy consuming process as the chemical equation requires a substantial six electrons or valance changes for the N<sub>2</sub> in the atmosphere to become a plant usable NH<sub>3</sub> as shown in the following chemical equation.



The only source for this energy is the photosynthetic accumulation by the plant. It has been estimated that it takes 10 kg of photosynthetic accumulation to fix one kilo of NH<sub>3</sub>. This has to come from the dry matter accumulation and the bean yield. Thus it is always possible to obtain higher yields of a legume crops by using chemical fertilizers then relying on nitrogen fixation. However, when a legume receives Nitrogen fertilizer, the nodules will stop wasting energy on nitrogen fixation and enjoy the free supply. In doing so the rhizobium converts from a symbiotic to a parasitic relationship, consuming energy but providing nothing in return. This can be clearly seen by the interior color of the nodules being green instead of red. In addition, having spent all that energy to fix nitrogen the legume is not going to give it up readily. Thus, legumes will hoard the fixed N until they mature, die and decompose. Only then will the fixed nitrogen be released to the soil and available to other crops such as cassava or mangos. However, even then the nitrogen is still in the organic form and will still have to be mineralized to the ionic form before becoming fully available to other plants. Often this will be the following cropping season.

Even so legumes can fix an appreciable amount of atmospheric nitrogen (Table 2). However, most of the time the values will be in the lower range of what is shown rather than the upper range. The different rates could represent the available of nitrogen in the soil, and the plants desire not to waste energy fixing nitrogen it does not need as mentioned above. Also, while soybeans are listed as one of the most effective N-fixing grain legumes, this is most likely based on the soybean specific rhizobium and not a promiscuous inoculation. How effective the

**Table 2. Nitrogen Fixation by Different Grain Legumes**

Species	Range of N fixed/yr (kg/ha)
Soybean	49 – 450
Common Bean	3 – 57
Groundnut	27 – 206
Black gram	119 – 140
Pigeon pea	4 – 200

Sources: Wani & Lee (1992), Peoples & Grasswell (1992)

promiscuous soybeans are at fixing nitrogen compared to other legumes is a question for IITA and CIAT-TSBF programs to look at and report. Also, it must be appreciated that the nitrogen which is part of the protein content of the harvested soybeans has to come from this fixed nitrogen and substantially depletes that remaining in the soil for mineralization and uptake by future crops. For example, if a soybean crop fixes some 200 kg/ha of Nitrogen and produces a yield of 1500 kg/ha of soybeans.

At 40% protein this will be approximately 600 kg/ha of protein that will contain some 100 kg of nitrogen that will be removed with crop and reduce net increase in soil nitrogen to only 100 kgs.

As mentioned above, soybeans have a specific rhizobium for effective inoculation that will allow for nitrogen fixation. A fact that appears usually overlooked by those promoting soybeans for its potential for improving soil fertility as well as the guidebooks on best management practices for soybean production, and makes those responsible potentially liable for the failure of soybeans to contribute to soil fertility. Both Caltech Ventures and Kobbiman farms primary reason for producing soybeans is for the potential soil fertility increase to benefit their main crop of cassava and mangos. While groundnuts, cowpeas, common beans, leguminous weeds, etc. will all cross inoculate so they will normally become nodulated and fix nitrogen with rhizobium readily available in most soils, **soybeans will not**. This limitation in soybeans ability to improve soil fertility needs to be carefully acknowledged when promoting soybean production for its nitrogen fixing potential. They have to be inoculated with the specific rhizobium (*Rhizobium japonica*) in order to fix nitrogen. In developed countries including the major soybean producers of Latin American, inoculating soybeans has become a relatively inexpensive and routine process.

However, in developing countries like Ghana it has become a major logistical struggle, particularly when working with smallholder communities or smallholder out growers. Many host governments, through either their ministries of agriculture or agriculture university systems, have tried to produce soybean inoculate as part of some income generation initiative. Typically it would be a moist formula that required refrigeration. This can become an insurmountable problem when transported and held in remote smallholder communities off the electric grid. The result is that most soybean in the tropics are produced without the desired specific inoculate, do not fix nitrogen, and might best be described as “*soygrain*” crops rather than soybean crops. In this case it is essential to provide some nitrogen fertilizer to obtain suitable yields. The rate would be about 50 kg N/ha. It was mentioned that there may be some dry inoculant in Northern Ghana of British or European origin, but this could not be verified.

As inferred above, IITA has spent over 20 years trying to develop soybean varieties that will be promiscuous and inoculate with the rhizobium usually native to the soils in the tropics. This has been met with some limited success, as now they do have soybean varieties that will cross

inoculate with native rhizobium but how effective they are at fixing Nitrogen could be a question. Normally the red color in the nodule, which indicates active nitrogen fixation, is often a weak pink in the promiscuous lines, indicating only limited fixation, instead of the anticipated darker red.

Since both Caltech Ventures and Kobbiman Farms interest in soybeans is primarily to enhance the soil fertility to benefit their main crops, if the nitrogen fixation is not automatic as promoted they might consider and quickly shift to other legumes such as groundnuts, cowpeas, common beans, etc. Kobbiman Farms is currently producing small quantities of cowpeas, perhaps mostly for the caretaking labor staff. These are well nodulated and fixing Nitrogen. Kobbiman might also consider a prostrate cover forage style legume to go under the mangos as a permanent means of adding biological fixed nitrogen to the soil, similar to what is demonstrated for under plantains in Uganda (Fig. 8).



*Fig. 8. Legume Cover Crop Under Plantains in Demonstration in Uganda.*

### **Inoculating Soybeans**



*Fig 9. Sample of Inoculants Provided for Demonstration During FtF Assignment*

Once inoculants are available, the actual process of inoculating the soybean seeds is a simple process. With the inoculant provided for demonstration with this consultancy the seed treatment was simple (Fig. 9). Following a combination of instructions obtained off the internet from the supplier's website and an Iran website, 50 kgs of seed was spread on a cloth in the shade, sprinkle with 600 g of inoculate plus a liter and half of water, making certain the water has no chlorine added as part of a domestic water treatment<sup>6</sup>. When completely mixed so the seeds were clearly tinted black, the seeds are briefly dried in the shade and planted the same day (Fig. 10). Once the seeds have been inoculated it is critical to keep them in the shade to prevent the bacteria from getting too hot and dying. These rates could be prorated to any amount of seed needing to be inoculated. This would include packing a few grams of inoculant in small sealable plastic bags for distribution to out growers, along with instructions on how to proceed. Also, once a field has been inoculated the rhizobium can remain viable and able to inoculate future crops of soybeans for up to five years of none soybean

<sup>6</sup> [http://www.emdcropbioscience.com/products/product\\_detail.cfm?PROD\\_ID=28;](http://www.emdcropbioscience.com/products/product_detail.cfm?PROD_ID=28;)  
<http://www.asiabiototechnology.org/fa/En/p9.html>

production. This is sufficient to bridge the four years of cassava in Caltech's suggested crop rotation.



*Fig. 10. Inoculated Soybean (Right) With Clear Black Tint.*

Also it is possible that once rhizobium has been well established in the soil, the soil can then be used to inoculate more soybeans to expand the inoculated area. As an initial effort it might be desired to take a well inoculated field remove some soil from 10 to 15 cm below the surface, as representing the area of maximum rhizobium activity. Take this soil sieve it through a relatively fine sieve, than use the resulting soil in the same manner as the commercial inoculate.

### **Soybean Variety Evaluation**

**Varietal Differences:** While there does not appear to be any major quality difference in the beans attributed to different varieties, there are differences in morphology and physiology that would make variety selection a concern from the production aspects, if not from the processing. Virtually all soybean varieties result in beans with relatively narrow differences in protein, 40%, or oil 20%. This is a narrower range of varietal differences in grain qualities then found in many crops such as rice. Thus for processors all soybeans are the same. However, the morphological and physiological differences can be important to the production. These characteristic would include maturity with early maturity being particularly important for late planting and potential to run out of rains, uniformity of maturity if mechanized harvesting is anticipated, shade tolerance for intercropping into cassava or mangos, height, growth habit, shattering of mature pods, seed viability, etc. In addition, there will be some differences in yield potential. Kobbiman experienced some considerable loses of soybeans from shattering during a previous years' soybean production on the main farm, and decide to use a single variety based on shattering resistance, that may require machine threshing instead of the normal manual threshing usually done by smallholders. It is expected that mechanical threshing can be done with a maize sheller that appear common throughout the area either for direct connection to the PTO of a tractor or small independent engine.

While during a varietal screening process there could be considerable differences in yield, among the top four or five lines this will jump around from year to year in a totally unpredictable manner as shown for rice in Madibira, Tanzania (Table 3). Thus across a nucleus farm and out grower program it would be desirable to have three or four clearly defined varieties being produced in near equal acreage each year. One reason for having multiple varieties is that most

**Table 3. Two Year Yield Comparison of Rice Lines**

Variety	Yield (t/ha) & Ranking ( )					
	1999		2000		Average	Difference (2000 – 1999)
Line 85	7.19	(3)	8.71	(1)	7.95 (1)	1.52
Subarimati	6.33	(5)	8.12	(2)	7.22 (2)	1.79
NARO TAC	6.40	(4)	7.27	(4)	6.84 (3)	0.87
PSBRc 28	8.64	(1)	4.73	(6)	6.60 (4)	-3.73
IET 1444	7.72	(2)	5.11	(5)	6.41 (5)	-2.61
Line 88	4.98	(6)	7.71	(3)	6.35 (6)	1.37

modern varieties are developed with resistance to various diseases, particularly bacterial and virus diseases, for which varietal resistance to the disease and the insects that vector the disease is the only control method. Since these pathogens are continuously mutating to breakdown the

resistance, the use of multiple varieties reduces the likelihood that a sudden breakdown in resistance will be catastrophic to the entire crop. This also means there is a continuous low level need to review potential varieties.

**Varietal Development & Seed Certification:** Similar to most African countries, most likely the Ghana national program for soybean variety development does not have the financial resources to carry out an effective variety improvement program alone. This was certainly the case for rice in October 2009, where the research station near Akusa had not received any new material from either IRRI or WARDA in over 10 years<sup>7</sup>. Thus, most of the soybean variety development work is deferred to collaborative programs with one of the International Agriculture Research Centers (IARC). For soybeans and cassava this would be International Institute for Tropical Agriculture (IITA) headquarter in Ibadan, Nigeria. However, they have an outreach program in Ghana, working in collaboration with the national program at one of the major research centers. In all likelihood all the actual breeding and variety evaluation of exchanged lines will be done by the IITA outreach senior scientific staff assisted by the host officers.

Once a variety has been developed or agreed upon it will be turned over to the Ghana ministry for formal release, multiplication, and distribution. However, again it is unlikely that the government has the resources to do a complete three visit inspection plus germination tests on all farms contracted to produce certified seed and individual field as stipulated in the international standards for seed inspection. Thus, the seed certification effort is mostly on the honor system, perhaps with some small gratuities exchanged. This could be why the seed purchased by Kobbiman farms was listed as having 85% germination but only tested at 66%. Thus it is unlikely the quality of the “certified” seed is substantially different from retained or market seed available at about half the price of certified seed. However, that put the seed in the company of about 95% of all seed successfully used across the world. This is really not a problem. Since soybeans are self-pollinated there is little if any deterioration in the seed genetic quality with successive generations. In reality, for self-pollinated crops rarely is there justification for the extra costs of obtaining certified seed, except when introducing a new variety. In Malawi retained soybean seed has been used for over 10 generations until the variety identity has been

<sup>7</sup> <http://amar.colostate.edu/~rtinsley/KIP-Report.pdf>

lost. Similar the informal distribution of soybean seeds in Thailand has lost the variety identity. In Colorado certified seed is use on less than 30% of the wheat crop, with the rest planted with retained seed. It only requires some care in handling the seed between successive generations. This would not hold true for hybrid seed of maize or sunflower, where using retained seed will quickly start to segregate with considerable yield loss. Thus when using hybrid seed it is essential to get fresh certified seed each season.

Even then despite the heavy promotion of the government offices and seed industry, with their clear vested interest, it can be difficult to demonstrate a potential statically significant yield benefit to certified seed. Again, Madibira, Tanzania provides a comparison between project distributed seed and locally distributed seed. There were no differences, with the locally distributed seed actually out yielding the project seed (Table 4)

**Self-Maintaining Seed:** The implication of this for large commercial companies producing soybeans is that they should mostly undertake their own limited final variety evaluation and seed multiplication for both the nucleus farm and any out grower units. This would imply every three or four years going directly to the IITA representatives in country to see what their leading soybean lines under development are, and get a couple hundred grams for each line. Normally,

*Table 4. Yield Comparison of Project and Farmers' Seed for 3 Varieties*

Subarimati		Zambia		IR 54	
Source	Yield (t/ha)	Source	Yield (t/ha)	Source	Yield (t/ha)
Project	1.72	Project	0.61	Project	1.44
Farmer 1	2.24	Farmer 4	1.11	Farmer 7	0.97
Farmer 2	2.01	Farmer 5	1.01	Farmer 8	1.68
Farmer 3	1.56	Farmer 6	0.42	Farmer 9	2.28
Ave.	1.89	Ave.	0.79	Ave.	1.59
Std. Dev	0.57	Std. Dev	0.57	Std. Dev	0.80

they will be happy to provide this small amount of seed. It might be necessary to agree to use it for a verification trial and report the results back to IITA. This could then be grown out in the corner of a field at the nucleus farm to see how appropriate they are. It is not necessary to travel to Ibadan, Nigeria as the country representative will be in close contact with the headquarters and have the same

preferred material available. Similarly, it is not necessary to make the visit more frequently as the primary lines only change slowly and are always tested for several years. It is desired to check the selection criteria to make certain it is what is needed or if something is overlooked. The shade tolerance needed for intercropping with cassava or the sub-canopy of mangos would be one selection criteria that might be overlooked as would be seed viability. For those farms also interested in cassava production, it would be possible to collect selected cassava cutting at the same time.

In addition more genetic material from other tropical countries such as Brazil could be included. Discard what you don't like and multiply what you like, but maintain the varietal identity. If the inoculants efforts are successful and the fields become viable sources of the specific rhizobium for Soybeans, then in dealing with IITA it would be best to avoid the promiscuous lines they are

promoting as you would not want the soybeans being inoculated with the native rhizobium as it does not appear to be that effective in fixing nitrogen. However, if the inoculants effort does not work, then strong consideration should be given to the promiscuous lines as the best hope in getting some nitrogen fixation with soybeans. Hopefully, in the next few years it will be possible to get high yielding, promiscuous lines that can fix large amounts of nitrogen without the logistic problems of acquiring inoculant and inoculating the seeds.

Once some desirable varieties are identified it will be necessary to maintain them through the dry off season. The best way to do this might be to simply grow an irrigated seed crop during the dry season. Both Caltech Ventures and Kobbiman Farms have access to perennial stream with sufficient flow to irrigate the necessary area for seed production sufficient to serve the needs of both the nucleus farm and the associated out growers. It should only take between 10 and 15 hactares.

### **Mechanization**



*Fig. 11. Lifting Cassava Roots & Leaving Extensive amounts of vegetation that needs to be controlled in converting from cassava to soybeans*

opening new land as with Kobbiman Farms or preparing land coming out of cassava that has not been weeded for several months. The lack of weeding reflects the limited response to weeding on well-established cassava fields. However, it does result in extensive vegetative growth to control (Fig. 11). This can take a month or more with multiple passes to get all the vegetation fully cut up, incorporated into the soil, and decomposed sufficient to allow planting of soybeans or replanting cassava.

In the case of Caltech, the transport was mostly to bring lifted cassava in for processing in what was their standard operating unit, a tractor pulled trailer holding an estimated 2.5 t of cassava. Both lifting and peeling was done manually on piece meal compensation based on four, mostly women, workers doing either the lifting or peeling of 2.5 tons of cassava per day. Typically a diligent crew could complete this in about five hours so that by two or two-thirty in the afternoon

most of the work was completed the task and gone home, with enough daylight left to do some



*Fig. 12. Manually Peeling Cassava for Processing: A Task Needing Mechanization*

personal cultivation. They receive less than US\$2/person/ unit of work. The peeling is particularly arduous and wasteful, with up to 25% being discarded with the tailing. Caltech is highly interested in mechanizing this but despite several attempts so far has not been successful (Fig. 12).

The tractors were an appropriate size being a mixture of 60 to 80 hp units that can pull three or four bottom disc plows, but of mixed origin. This naturally made for a spare parts logistical problem. The newer tractors were mostly FarmTrac's. These are Ford knock-offs

manufactured in India. They appeared not to be as durable as the Massey-Ferguson, which has been the tractor work horse for Africa for many years. Thus they were suffering from frequent breakdowns preventing anyone from fielding their full complement of available tractors. This could severely impact on the ability for the nucleus farm to provide contract tillage to out growers as envisioned in the orally promoted out grower agreements, since the nucleus farms must give highest priority to their basic farm operations. Also Kobbiman had some new John Deere's from the USA.

The government of Ghana is encouraging farm tractors and has a program for importing them and distributing the costs over several years. They also have annual contracts with specific manufacturers to import tractors.



*Fig. 13. Poorly Designed and Constructed Chinese Seeder that Needed Complete Overhaul to be Field Worthy.*

There were some really serious problems with Chinese manufactured implements. They were just not well designed or manufactured. The construction was weak, the planting plates improperly aligned, no covers on the hoppers, exposed chains, etc. (Fig. 13.) The seeders were virtually impossible to field without being completely overhauled. Caltech also had a Chinese combine but they had not tried it, and are concerned it will be of the same quality as the

planters. Considerable time was wasted attempting to get these Chinese implements functioning, but without success. Caltech took a whole day to deliver one to a government mechanization repair center near Akusa to see if they could get it working. They reported back

claiming the planter plates were installed backward. Kobbiman actually had the dealer's mechanics come out from Accra, and basically fully reconstruct the seeders to make them robust enough to operate.

**Maintenance:** Equipment maintenance was a continuing problem. Caltech had a full time staff of mechanics serving both the farm equipment and cassava processing machinery. There appears to be qualified diesel mechanics as well as general equipment mechanics available. These can be either directly hired by the commercial farm as is the case for Caltech, available on call within the community for Kobbiman, or arranged through the tractor and equipment dealers, even when sent from Accra as Kobbiman did. This can be supplemented by specialized mechanics from



*Fig. 14. Large Cassava Press Fabricated from Scratch by Caltech Mechanics.*

government programs that can legally provide consulting services and receive gratuities for the services provided which Caltech does when necessary. Since budget restrictions may limit their official duties, this is actually a good use of their time and keeps them in close touch with the farming needs. In addition there are sufficiently well qualified mechanics to innovate and fabricate special equipment for use on the farm. An example would be Caltech mechanics fabricating a large cassava press needed to complete a large order for cassava dough (Fig. 14).

However, the problem is that too many loose parts, such as connecting pins or locking pins for 3-point hitches, and even counter weights and radiator caps appear to disappear. It is hard to determine how much of this is accidental or perhaps pilferage by employees and operators, but in most countries these items rarely disappear. Also, the genuine parts are not readily available for the mixture of equipment. The result was the continuous need to improvise the maintenance and operations. It really became a daily time consuming hassle just to keep the equipment operational. The continuous need to improvise repairs is great for the short term and very innovative, but does eventually take its toll on the equipment, the quality of the field work, etc. An example is that without counter weights it is impossible to add weights to the harrows, and they then cannot penetrate the soil sufficiently to chop and incorporate vegetation. The continuous improvising has resulted in the mindset on improvising rather than even attempt to find the real part

**Outsourcing Tractors:** The continued hassle to keep tractors operational might make it worth considering out-sourcing most of the tractor use along with the disc plow and harrow equipment that most tractor owner and operators have. More specialized equipment like planters, sprayers and harvester would have to remain with the nucleus farm. This would than transfer most of the

tractor maintenance to the contracted outsourcers, who would be expected to report each day with an operational tractor. The nucleus farm could maintain a list of tractor owner/operators in the areas with a primary on-call contract to give the nucleus farm priority each day. This would also mean the tractors would most likely be owner-operated, and thus much of the “cowboy” driving could be eliminated. It might also mean that fewer loose items would disappear. The use of outsourced tractors could be more valuable for the out grower program, particularly for Caltech, that really does not have enough tractors for the nucleus farm, let alone assist the out grower effort. There appear a reasonable and growing number of tractors available for cash hire. It might take up to three days for the tractor to become available after payment, but that normally is acceptable, particularly for the smallholders on an out-grower program.

**Operator Skills:** While tractors seem like a simple basic piece of equipment, they are really quite complex and require diligent highly conscientious drivers, who are willing to acquire the skills needed to make certain all the adjustments are optimized. There is no place for “cowboy” operators trying to see how fast they can perform a task without concern for the quality of the final operation. “Cowboy” drivers not only cause extra wear and tear on the tractors and implements, but also result in poorer quality work, including damage to existing crops like mangos or cassava. Such drivers should be quietly let go. At Kobbiman the senior mechanic, who came up from Accra to work on the Turkish boom sprayer, indicated there was a tractor operator training program available in Ghana. Such training programs should be taken full advantage of, but only for the consciousness operators.



*Fig. 15. Improvising Using a Large Knife to Adjust a High Pressure Diesel Fuel Injector.*

**Tools:** There appears a problem with company owned hand tools. By some miracle of miracles on dark, moonless rainy nights, in tune to the clash and rumble of thunder, hands tools seem to grow legs and dance off the job, right past the security guards, never to be seen again. This results in the continuous need to replace hand tools and use of improper tools when precision is required. For example, using the tip of a large knife as a screwdriver when adjusting a high pressure fuel injector (Fig. 15), or using a pipe wrench to tighten nuts on a harrow that have worked loose. The use of the wrong tool, similar to use of improper connections, is ok I the short term, but slowly takes its toll on the equipment in terms of rounded nuts, and miss aligned screw heads, that cannot be precisely adjusted.

One solution to this would be to have mechanics provide their own tools, and provide them a tool allowance to

maintain and replace their tools. It was estimated that a full complement of mechanics hand tools would cost about US\$400 in the local market in Ho. This might include along with their estimated cost in the USA in US\$<sup>8</sup>:

• a full set of open end/box wrenches,	US \$35
• 3/8 socket wrenches with ratchet and short and long extensions bars,	35
• ½ inch socket wrenches with ratchet and short and long extensions bars	45
• set of screwdrivers, both flat and Philips,	10
• a set of Allen wrenches,	10
• 15 cm crescent wrenches,	10
• 30 cm crescent wrenches,	15
• 40 cm pipe wrench,	15
• set of pliers, (regular jaws, needle nose, vise grip & channel lock),	30
• diagonal cutters,	10
• hack saw,	5
• 4 m tape measure,	5
• 15 cm calipers,	15
• Ball peen hammer,	5
• Punch and chisel set,	10
• set of Files,	15
• Lockable tool box,	20
<b>Total</b>	<b>US\$ 290</b>

The difference between the US\$ 290 USA estimate and the US\$ 400 for Ghana would most likely be the import tax on the tools. Initially the farm could purchase these for the mechanics, possibly arrange for a wholesale price, but require the mechanics to pay for them from a salary deduction. Meanwhile the toolbox is retained on location in a locker. Once fully paid for the mechanics can take the tools home at night or over the weekend to do whatever outside work can be arranged. The prospects for doing outside work can provide substantial motivation to quickly pay off the tools. It is essential that all tools be marked with the mechanics initials so they do not get confused between mechanics. This is more of a problem for Caltech with a permanent mechanical staff, than with Kobbiman that contracts out much of the servicing. The tool allowance could easily be considerably cheaper than the continued need to replace lost hand tools. However, once provided there would be no reason not to expect all repairs to be done with the proper tool, and use of improper tools be severely penalized.

It was noted that visiting mechanics usually came with at least a rudimentary tool kit, but usually kept them wrapped in a plastic shopping bag instead of a more secure lockable tool box.

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<sup>8</sup> Information provided by Norman Illsley based on prices at Harbor Freight Tools, Fort Collins, CO

# Crop Management

## Overview

The art of farming for all farmers, large commercial and smallholder alike is the art of compromising and optimizing what is desired, to what there are the resources and time available to complete. The research and extension effort, even with the budget restrictions of developing countries, is very capable of making very precise statements of what should be done for *maximum* yields, but no farmer, large or small, nucleus or out-grower can ever completely comply. Nor is it really desirable and economic to do so. Farmers continuously need to fine tune the scientific recommendations to what is the economic optimal level of management, and then adjust to the resources and time available, based on maximizing the total returns from all farm enterprises and fields. This usually means reducing the management on one enterprise or field to allow better management on another. This is really something that can only be done on an individual basis, and both Caltech and Kobbiman are more than capable of fairly quickly making these adjustments, and learning from past experience.

## Land Preparation

The land preparation is done almost exclusive with disc plows followed by a harrowing to breakup any clods, etc. This does a reasonable good job of preparing a traditional seed bed for soybeans or other annual crops. However, there remains a need to use a grader or scraper to smooth out some of the ridges that will interfere with the use of planter, boom sprayers, combines, etc. When in the field these implements have a rigid three or four meter width, and cannot operate effectively solidly attached to the three point hitch when being rolled from side to side or pitched up and down by ridges and mounds in the field. Thus there is an urgent need to smooth out any ridges or mounds. If not planters will occasional be tossed in the air, or the cutting head of a combine dig into the soil, and boom sprayers spray from different heights above the soil. Having a harvester or combine dig into the soil will quickly dull or otherwise damage the cutting bar as well as allow large amount of soil to contaminate the grain which will eventually have to be cleaned or have the value of the grain discounted. This smoothing does not have to be full precision leveling or grading required for surface irrigation, just enough for the equipment to move uniformly over the fields.

There is a legitimate concern that scrapping off some of the high ridges will result in exposing some subsoil. This is possible, but cannot be avoided if other equipment is to be utilized. For cassava most of the ridges that need leveling are a result of cassava cultivation and the ridging up along the rows of cassava. In this case leveling them should basically be putting the soil back from where it came. In mangos the trees are planted on permanent ridges that will be more difficult or impossible to smooth without damaging the mangos, and may require other actions.

The implement of choice for this type of soil movement is actually a land plane, but these are not readily available. The idea is the same as a carpenter's plane or jointer, have the cutting edge in the middle of the longest rigid structure as practical. When properly attached to a three point hitch, the rigid section of a landplane can go from the rear wheels of the plane to the front wheels of the tractor a total that can approach 20 m. If a land plane is not available the next best would be a road grader which is available at Caltech but not Kobbiman. For Kobbiman the only thing available is a scraper fitted directly to the three point hitch. This will make the task considerable more challenging unless equipped with laser equipment, which does not appear readily available in Ghana. In either case it is going to require a skilled operator to get this done. The skill is really one that can only be acquired on the job.

There is some thought that a harrow will accomplish this. That will be difficult as a harrow is really designed to stir the soil, break small clods in place, but not really displace soil. A close look at the design of a harrow would show that the first set of discs will move the soil slightly in one direction, only for the next set to move it in the opposite direction, for a net zero soil movement (Fig. 16). This land smoothing should be done over a three or four year period. Doing



*Fig. 16. Close up of Harrow to illustrate how the two rows of disc counteract to minimize soil movement.*

a little each year as time allows. The problem is that the moved soil will compact during a growing period and emerge as a depression, smaller than before but again in need to be smooth out. After three or four years the fields should be smooth enough to for planters and combines to move freely without digging into the soil or being lifted out of the soil, and boom sprayers provide uniform applications of chemicals.

Also, as fields are development and continuously used for annual cropping as many of the out-grower field may be, the need for both discs plowing and harrowing may need to be reexamined. If there is only crop residues and not a lot of vegetation to control, it might be possible to skip the disc plowing and only use the harrow, or it may be possible to shift to simple chisel plows or tine tillers. Throughout much of the Middle East these are the only implement used for land preparation. This is all on contract to individual owner/operators most of whom are no longer farmers but full time contract tractor operators. As such they can have as many as 220 workdays a year just on land preparation, excluding other activities such as nighttime threshing or transport.

### **Herbicides Applications**

After land preparation the intention is to use pre-emersion herbicides prior to planting. The recommendations are for a mixture that includes a generic version of Roundup, a systemic non-specific herbicide. This may need some careful consideration, particularly on the outreach

program. The problem is herbicides require some highly accurate applications in order to control the weeds without doing damage to the soybean or companion crops such as mango or cassava, and result in herbicide burn. Normally, herbicides are applied with a boom sprayer attached to a tractor. However, this still requires smooth ground or the boom will bounce to various levels above the ground instead of a uniform level. In an observation at Kobbiman farm, the boom height above the ground varied from 30 to 70 cm. (Fig. 17). The higher elevation would also



*Fig. 17. Boom Sprayer Applying Herbicides for Soybeans Under Mangos. Be Careful!*

increase the potential for drift to contract the mango, even with some light winds, while the lower heights would result in incomplete coverage of the ground and limited overlap. The need for some large ridging to assure good drainage for the mangos makes a smooth surface very difficult. One possibility would be to consider trailing sprayers rather than attached, when next acquiring mechanical spraying equipment. This will be more difficult to turn around, but will follow the irregularities in the surface considerable better.

For the out grower effort it might be better to avoid herbicides. Unless the nucleus farm can provide the mechanical tractor based boom spraying, the out growers will most likely be left to work with back pack sprayers and simple wand applicators. While there are boom sprayers for use with back pack sprayers, they have never been very well received. Thus the out growers might be left with backpack sprayers and simple wand applicators. This will be very difficult to provide the accurate application needed to effectively control weeds without causing herbicide burn to the soybeans or companion crops.

## **Sowing**

After land preparation and herbicide applications, if done, the planting needs to be mechanized in order to get the recommended 5 cm interrow spacing. However, this is where flexibility needs to be applied. The five centimeters within row spacing is extremely precise, and almost impossible to accurately obtain. Nor is it really necessary, unless it is desired to compensate for limited germination as with the tested 65% at Kobbiman. The critical issue is to get fairly rapid canopy closure to assure maximum interception of solar radiation. This can usually be obtained with a 10 cm within row spacing and have only minor perhaps non-significant drop in yields, certainly not cost effective. With the recommended interrow spacing only 5 cm, it will be difficult to manually plant and thus the desire for mechanical planting (Fig. 18). This can usually be done with some of the old available Italian grain drills, by using only one row in three to get close to the intended 60 cm between row spacing. These grain drills were acquired by the government

some 10 years ago, but rarely used and spent most of the time in unprotected storage. Both Caltech and Kobbiman had obtained access to units. When it is necessary to manually plant, don't be too rigid on the 5 cm interrow spacing, most likely it will creep up to 10 cm. That will get the job reasonable done and perhaps represent the optimal spacing for the resources available.

### Other Crop Husbandry Activities

The timing of the FtF visit was such that no other activities could be readily observed for soybeans.

However, it is expected that there would be some hand weeding particularly for the out growers where the more limited areas would allow for manual weeding, particularly if herbicides were not used. Also, after harvest there may be a concern for the quality of the grain due to the amount of trash and foreign material that tends to get mixed in. The acceptable standard is for only one percent foreign matter. With the traditional winnowing by allowing the wind to remove foreign material by pouring the grain from a height of about two meters usually will not get the material sufficiently clean to the one percent acceptable standard.



*Fig.18. Manual Planting Soybeans on Caltech and Trying for 5 cm Spacing.*



*Fig. 19. Communal Threshing/Winnowing Floor Near KIP in Akusa That Often Blows Chaff from Pile to Pile and Makes it Very Difficult to Obtain 1% Foreign Matter Standard.*

More likely traditional winnowing will move the light foreign material from one farmer's pile to the next as it slowly works its way downwind and off the threshing/winnowing floor (Fig 19). Also, if the land is not smooth, mechanical harvesting will unintentionally pick up some dirt and other field debris. This all has to be removed either before it is marketed or by the processor. When left to the processor, the processor has little choice but to discount the value of the grain by an estimate of both the amount of foreign material and the costs for removing it. This could be as much as 10 to 15% of the value of the grain<sup>9</sup>. It is possible to mechanically clean the grain with simple manual

winnowing machines, already fabricated and available in Ghana and used for rice in the Kpong Irrigation Project near Akusa. This would be more suitable for the out growers than the nucleus farms (Fig. 20).

<sup>9</sup> <http://amar.colostate.edu/~rtinsley/CleanBag.htm>

## Out Grower Programs

### Historic Overview

One of the efforts of the development community in working with commercial enterprises, either agribusiness processors or large commercial nucleus farms, while maintaining a primary interest in promoting poverty alleviation for smallholder producers, is the use of out grower programs. The idea is excellent and needs to be effectively pursued. However, it needs to be pursued from a business efficiency perspective, and make certain the programs do not become a financial burden on the agro-business processor or the nucleus farm. If they do become a financial burden to the commercial enterprise, they will simply and rightfully lose interest and the program collapses. Unlike an NGO facilitating a value chain project with a donor provided budget that can cover or subsidize the administrative and other overhead costs, during the initial startup of the value chain and do not need to show immediate financial solvency, a nucleus farm or commercial processor managing an out grower program has to at least break even from the beginning and charge the out grower farmers for any overhead and operational costs incurred. This would most likely take the form of a deduction on what the farmers will receive for their soybeans or other products. The nucleus farm or commercial processors cannot be expected to operate a charity for the out growers.

Unfortunately, the development effort's approach may best be describes by the adaption of the 1859 words of Omar Khayyam in *The Rabaiyat*:

*The Moving Finger writes; and, having writ, Moves on: nor all thy Piety nor Wit Shall lure it back to Cancel half a Line, Nor all thy Tears wash out a Word of it, [Nor Observes the Carnage in its Wake].*

The development effort appears to have conceptualize the out grower programs, and then kept moving forward, without looking back to see just how sustainable the programs were, particularly after the donor funding and external facilitation end. For out grower programs it appears that the basic design for was developed more from the social science perspective than the business perspective, and has remained unchanged for over a decade, despite limited sustainable success without continued external support and facilitation, and no post funding reviews to see what become of the efforts after donor assistance ends. One of the basic problems is the reliance on farmer organizations, desired for empowering the farmers, to undertake business support services. These farmer organizations follow the same imposed rubber stamp organization structure for over two decades. Each has a chairman and vice chairman, never



*Fig. 20. Simple Manually Operated Winnowing Machine that Could Help Reduce Foreign Material in Soybean and Increase Value by 10% or More.*

consolidated or opting for a president and vice president plus a secretary and treasurer, again never consolidated. However, when farmers' organizations provide business support services, it usually is administratively cumbersome and usually are non-competitive compared to competing private traders, etc.

Typically a cooperative business enterprise will have a 30 to 35% sustainable administrative overhead cost, although some of this could be transportation and other operating costs,<sup>10</sup> but because of limited reporting this is difficult to accurately determine. The sustainable overhead costs are those costs incurred in running a business without any external subsidies or facilitation. Typically it would be the costs of the locally hired staff, and exclude any expatriate staffing and associated cost for maintaining expatriate staff. Unfortunately, donor pressure to only show "success stories" virtually mandates skewing information to emphasize social benefit and results in the overhead costs frequently being excluded from the reporting process and often attributed as a financial benefit to the beneficiaries in what could be some deceptive reporting<sup>11</sup>. The 30% overhead costs usually are greater than the discount obtained for bulk ordering of inputs or bonus for bulking produce into higher volumes, and renders some socially desired business models noncompetitive in comparison to the indigenous private traders particularly the village based family enterprises<sup>12</sup>. This skewing of information may be good to appease donors but it does little good for the smallholder beneficiaries, and effectively hinders any program conceptual development that might lead to more effective programs. Perhaps the best example of this comes from the Farmapine Cooperative, headquartered in Nsawam, Ghana about 35 km northwest of Accra, in which a year after a highly promotional article was written in Choices Magazine the cooperative collapsed in bankruptcy<sup>13</sup>.

Both Caltech and Kobbiman have been encouraged and agreed to develop out grower programs for soybeans. Caltech also has an out grower program for cassava. In both cases the business model promoted is lopsided in favor of the smallholders and could result in substantial overhead costs even exceeding the typical cooperative overhead costs, mentioned above. In both cases the expectation created was that of the nucleus farm subsidizing a major portion of the production costs for the smallholder out growers, or at least providing production loans to cover the costs as well as providing the inputs and equipment to do so. This is where other out grower programs have experienced serious difficulties and had to drastically retreat. Something the development community should be well aware of made appropriate adjustments in the conceptual organization of present and future out grower efforts.

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<sup>10</sup> *Personal communication for Central Growers Association, Kitwe, Zambia, but repeatedly reinforced with limited data available.*

<sup>11</sup> <http://lamar.colostate.edu/~rtinsley/DeceptiveReporting.htm>

<sup>12</sup> <http://lamar.colostate.edu/~rtinsley/CompetitiveAdvantage.htm>

<sup>13</sup> <http://www.choicesmagazine.org/2005-1/grabbag/2005-1-16.pdf>

## Case Studies

There are four examples in Zambia of out grower programs starting with the above promoted and imposed model for Ghana and its emphasis on providing complete support services and extending production credits. All four had to substantially back away from the expected support or completely abandon the program. They are:

**AgroFlora:** AgroFlora was a cut flower and specialty vegetable processing company for air freighting produce to Europe. This is an extremely sensitive business as the air freight had to be booked and paid for in advance, and either was used or lost. Thus, if they were unable to fill the space, they were losing money, and if they had excess produce it had to be discarded, with a loss of money to someone, perhaps a smallholder out grower. In addition baby corn had a one day window of opportunity between being immature and overripe. The quality of the baby corn could not be determined until de-husked in the packing house. This is well after the smallholder out growers have relinquished control of their crop and have no alternative but to accept the quality decisions of the packing house. They tried to use a small holder grower program, but eventually were forced to focus the out grower effort away from their core business, and into goods that were less perishable such as coffee. However, AgroFlora went bankrupt and out of business between 2001, when first visited, and 2005 went second visited. The bankruptcy was not attributed to the out grower effort, but it mostly likely was a contributing factor. AgroFlora is the primary example behind the webpage discussing on how high value does not necessarily result in high profits. It could result in high discards!!<sup>14</sup>

**Amanita:** is a general commodity processor making animal feed and extracting vegetable oil including soybean oil. It attempted an out grower program in accordance to the standard business model discussed above, but had problems with the production loan repayments, and completely gave up. It believes that it still obtains considerable commodities from smallholder communities, but does so via the normal marketing channels. This would include some Lebanese traders operating from towns in areas dominated by smallholder producers.

**Cheetah:** Is a major provider of paprika, used worldwide as the primary red food coloring. Paprika is considerable less perishable than specialty vegetables but still considered a high value crop, with some potential for value added at the farm or village level. They developed a smallholder out grower program, and continued it at least through 2005. However, they very quickly backed out of the production loan provision and provide only the seed to assure the farmers grew their preferred variety. Also, they proceeded with a rather cumbersome procurement system that ultimately had to offer a lower price than offered to larger farmers, and then added some extra charges, for transport and overhead not all of which were fully transparent<sup>15</sup>. The latter was disguised by recording one kilo less than what the bags weighted

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<sup>14</sup> <http://amar.colostate.edu/~rtinsley/HighValued.htm>

<sup>15</sup> <http://amar.colostate.edu/~rtinsley/Cheetah.htm>

(Fig. 21). This all provided opportunity to side sell to pirate traders, who most likely ultimately sold to Cheetah. Finally they obtained the revolving services of a DED (German Peace Corps) volunteer to help manage the out grower scheme. This effectively subsidized the overhead costs. The field visit to a Cheetah buying operation with the small family operated kiosk including a seven ton lorry parked in front only 50 meters away provided the conceptual insight that these out grower programs needed to be managed through village based family enterprises<sup>16</sup>.



*Fig. 21. Cheetah Buyer Weighing Bags of Paprika in Smallholder Community*

**Dunavant:** Is the Zambia cotton company with monopoly control on cotton production and processing. They have perhaps the most effective out grower program, but they did this by



*Fig. 22 One of Dunavant's Buying Points Located in Smallholder Community to Purchase Cotton From Farmers and Forward to Processor*

basically duplicating the marketing channel of the private traders as it was described to me nearly 20 years earlier in Malawi. They simply contracted with a local person to set up a buying point, and when they had accumulated enough bales of cotton to fill a truck they call in to have a truck come out and pick it up (Fig. 22). Again they very quickly backed away from the production loan aspects and only provided seed. Since they had a monopoly on cotton and purchased seed cotton instead of ginned cotton, they had full control on the operations.

**Tea Estates in Tanzania:** In addition to the above examples from Zambia, in Tanzania it was noted that both Unilever Brook Bond Tea plantation and the locally owned Mfinga Tea Estate were both planning to have all future expansion done via out grower programs. This was to get around some 200+% labor fringe benefits and overlook possible family child labor usages since children have more nimble fingers for picking tea. Again they have no plans to get in the production credit effort, just providing the planting material.

These examples of out grower programs indicate that the commercial operations have to be very careful to keep the overhead cost to a competitive minimum. If not the out grower program will become an excessive financial burden to the commercial enterprise and they will simply and

<sup>16</sup> <http://amar.colostate.edu/~rtinsley/Reconciliation.htm>

rightfully withdraw. A major concern would be the provision and repayment of production credit. A review of how the informal credit system works could indicate the “games” smallholders tend to play to delay or avoid repayments that may justify the extensive usury quoted interest rates, as well as some of the discounts for expedient payments<sup>17</sup>. If the nucleus farm tries to manage the loan repayments for the central farm, the running around requirements with the associated transportation costs as well as time and effort of the out grower coordinator could substantially increase the administrative overhead that has to be recovered by some means. Most likely by discounting what the smallholder out growers received for their soybeans. This happened in Madibira, Tanzania in which the project extended land preparation credit for an in-kind repayment in rice at harvest. The cost for the cooperative coordinator to run around and collect the repayments as sacks of rice, one sack at a time because that was all he could strap to his motorcycle, exceeded the value of the rice collected and forced the project the following year to abandon providing production credits in subsequent years.

It should be noted that without production credit the smallholder out growers were still interested and able to produce both paprika and cotton in Zambia and rice in Tanzania. The same may also apply to Ghana where in the Kpong Irrigation Project (KIP) only 10% of the farmers were able to obtain institutional credit. This all may be an indication that while smallholders are poor, and do not have cash on hand, they may be hoarding their monetizeable assets in kind as long as possible as part of an overall financial management strategy, but are willing to monetize what is needed to produce a high value, value chain crop if the prospects of good return are there<sup>18</sup>. Thus the commercial enterprise primary concern needs to make certain that a good efficient market channel is available to the out growers with appropriate rewards.

The development community might want to take a closer look at its fixation with institutional credit and see if it is really as big a concern to the beneficiaries as to the donor, and perhaps they are overlooking bigger concerns of the smallholder, such as drudgery relief.

### **Host Commercial Farms’ Soybean Out Grower Initiative**

Both commercial soybean farms were still in the initial process of implementing out grower programs with neighboring smallholder farmers for soybean production and marketing. In addition Caltech has an operational cassava out grower program. In both cases the person assisting in organizing and registering the farmers implied the nucleus farm would be providing full technical support and services, including land preparation, chemical weed control, mechanical planting, certified seed, herbicides, etc. With that level of expectation the question might well be asked “what would be the smallholder input other than providing access to the land”. This basically looks like “estate mode” management for smallholders that was discredited over 100 years ago by the British in the massive Gezira Irrigation Scheme outside Khartoum,

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<sup>17</sup> <http://amar.colostate.edu/~rtinsley/InformalCredit.htm>

<sup>18</sup> <http://amar.colostate.edu/~rtinsley/FinancialStrategy.htm>

Sudan developed primarily for cotton production. In both Ghana cases the commercial farm hired a full time person to manage the out grower program. This generates overhead costs that will have to be recovered in some manner for the out grower program to be financially competitive. Most likely it can only be recovered by discounting what the nucleus farm and afford to pay the out growers for the soybeans or other crops. This has to be viewed as proper business practices. How else can it be done? Commercial farms are not charitable NGOs that have development donor funds to cover any overhead or other expenses needed to effectively operate an out grower program.

**Caltech Ventures:** While Caltech is implementing a soybean out grower program, the cassava out grower program is established and operating. Since Caltech main enterprise is cassava processing the cassava out grower program is more important. However, since they are planning to make direct use of the soybeans, the soybean out grower program is also justified, but still the cassava out grower program has the best prospects of being sustainable. This is because the marketing volume used by Caltech for the main farm is similar to what individual out grower can market. That is a tractor pulled trailer with an estimated 2.5 tons of cassava. Thus the coordination will be a simple phone call between an individual out grower and the Caltech out grower coordinator. Administratively this is very simple and can be effective. However, similar to the out grower programs in Zambia, they are experiencing problem with production loan repayments and are considering taking some out growers to court. That is both hard and expensive on everyone. Caltech does need to insist on specifying the variety being produced as they need to assure the variety with the highest starch content for the processing into flour, dough or fermentation to ethanol.

The soybean out grower effort is just getting started, but could become more complex, as there most likely will be some bulking requirement within the smallholder community before it can be delivered to Caltech. If not the administrative cumbersome procurement procedures of Cheetah will be needed, resulting in additional overhead costs. The reason is that soybeans are less perishable than lifted cassava, and once harvested the out growers could be hoarding their assets in kind as long as possible before monetizing them. This is actually a reasonable financial management strategy that avoids sticky finger temptations from family members dipping into the proverbial “cookie jar”. Sticky fingers appear to be a greater financial risk than post-harvest losses<sup>19</sup>.

In working with both the cassava and soybean out growers the expectations of the out growers appears is for complete support. This would include land preparation with Caltech tractors, etc. For Caltech this is really not feasible as with the amount of maintenance required their tractors are overextended just working the nucleus farms. Thus this type of support will most likely have to be out sourced. However, the commercial rate in Ho was quoted at 50 GHC/ac (110 GHC/ha),

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<sup>19</sup> <http://lamar.colostate.edu/~rtinsley/FinancialStrategy.htm>

which was considerable higher than in Akusa or Nkoranza where the rate was only 30 GHC/ac (70 GHC/ha).

**Kobbiman Farms:** Kobbiman is just organizing its soybean out grower program (Fig. 23). Since mangos are the primary business, it is less clear how important a soybean out grower program will be to Kobbiman in the long term. He does not have any real need for soybeans, and will simply pass them through to a feed processor, along with those he produces. In the future he could have need for an out grower program for export mango. The experiment with soybeans out growers will than become the model for how to organize or perhaps not organize an out grower program for Mangos.



*Fig. 23. Organizing a Soybean Out Grower Program of Kobbiman Farms. Nana is in the center Facing the Camera.*

One of the initial problems Kobbiman is facing is the person registering the out growers unfortunately conveyed the impression that the nucleus farm was going to virtually grow the soybeans for them, gratis. This was reinforced by one out grower asking if Nana was an NGO, with clear and disturbing undercurrent that if it was an NGO than no need to consider repayment etc. as seriously as if working with more typical business entity. Such misrepresentation caused much concern and it had to be clearly stated that any services provided would be on a credit basis. If individual out growers retain this expectation it could be difficult to recover the production credits. In this case Kobbiman was expecting to commit its tractors and other machinery to providing the contract services for land preparation, herbicide applications, certified seed, mechanical planting, and ultimately threshing. He had actually taken out a development loan to finance the cost including the purchase of certified seed and herbicides. This represents considerable capital commitment to support the out grower program for which he should be commended. However, if the loan repayments become a problem as with Caltech and Zambia, he could quickly lose interest for future years.

**Central Coordination:** Both Caltech Ventures and Kobbiman Farms plan to coordinate the out grower program directly from the nucleus farm with a single full time coordinator. If, as normally appears to happen with smallholder credit, the out growers play games to delay or avoid repayment, the amount of running around these coordinators will have to do could escalate, and with that the administrative overhead costs for managing the program and then the nucleus farms interest in discontinuing the program, rather than continuing it.

**Overhead Costs:** Much of the concerns discussed above center around the overhead costs, or at least the sustainable overhead costs that will be incurred by the nucleus farm or its representative

and will have to be deducted from what the out growers can receive. This would exclude any initial external facilitation costs needed to get the program initiated. Unfortunately, administrative overhead costs are frequently under estimated and underappreciated. Such cost would have to include:

- The cost for the out grower coordinator, salary and any fringe,
- Administrative activities such as maintaining individual accounts, etc.
- Office equipment and supplies for running the programs including computers and printers,
- Communication costs, mostly cost for cell phones, etc.
- Transportation costs of the marketing the soybeans or other produce, including any surcharges for off tarmac travel,
- Transportation costs for the coordinator to go between nucleus farm and out-grower communities,
- Transit costs including fuel, accommodations, and per diem when tractors and operators are required to remain in the more remote out grower villages for several days to do basic land preparation.
- Monetizing any in-kind loan repayments,
- Interest on any development or other loans, and
- Any pilferage, spillage or other loses in goods, either inputs or produce.

Since overhead costs tend to be discounted or severely underestimated, all of these overhead costs will need to be transparently shown to the out-growers so they can fully appreciate any discounts they have to accept for their goods.

### **Suggestions for Organizing Out Growers**

If the development community is going to promote out growers and it is important for them to do so, then it will be essential to take very careful account of the costs of doing business in terms of the overhead costs being incurred and do so in real terms from statically sound imperial data, rather than conceptual social ideology. To minimize the overhead costs it might be wise to look at how the competing private traders operate – the evil exploitive ones. They are very profit minded with a business model that was developed and persist over time, because it is profitable in the overall developing country economic environment. Furthermore, in most cases, their profits are more associated with keeping costs down than any excessive charges they can make for goods and services. This in what might best be described as a suppressed economic environment, that severely limits what traders can charge for services provided and makes profit margins razor thin<sup>20</sup>. After all they are part of a production and marketing system that can deliver goods to the consumer at a fraction the USA costs, while the transport fuel costs are in excess of

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<sup>20</sup> <http://lamar.colostate.edu/~rtinsley/FinancialSuppressed.htm>

the USA prices. This represents a high degree of business efficiency. This holds true for Ghana as well as most developing countries<sup>21</sup>.

The key to promoting out growers particularly for nonperishable crops like soybeans could be to follow the example of Dunavant, the cotton monopoly in Zambia. They had the least problems by basically duplicating the private traders' model of establishing buying points in areas. Thus the most effective means of promoting out growers would be to work with the established family enterprises already supporting the smallholders. These are the small shops that have always supplied the smallholders with inputs and marketed their products (Fig. 24). They are often maligned and vilified, but usually without and supporting data which really constitutes slander.



*Fig. 24. An Agro-Dealer Near Akusa, Ghana. Such Dealers Are In Most Town and Could Serve As The Coordinator for An Out Grower Program.*

as the individual entrepreneurs they are without trying to push them into being communal farmers.

They can usually out compete the 30% overhead cost of farmer cooperatives etc. to provide the best financial return to smallholder in terms of costs of inputs and price for produce. Thus identifying an agro-dealer within each smallholder out grower community who would do virtually all the out grower coordination, and do so as an integral part of the already established business effort and thus no costs to the nucleus farm or commercial processor. They are already in the business of supporting smallholders, and working with smallholder as individual instead of collectively. That is respecting the smallholders

This also means the shop owner already knows most of the perspective out growers, has dealt with them in the past, knows how credit worthy they are. Also, they are in reasonable close contact on nearly daily basis just interacting around the community, and be more difficult for a delinquent out grower to avoid. Coordinating an out grower program, as an additional activity, should be relatively easy for them. They could be empowered to identify the smallholders for involvement, funnel the necessary inputs to them, and purchase the crop from them. This would be part of their established practices and other commodities they would be working with. The commercial enterprise be it nucleus farm or processor could assist the agro-dealer coordinating the out grower program with financial support. This could be direct as a seasonal loan or perhaps assisting them to obtain SME loans from any microfinance NGOs operating in the area such as Kiva.

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<sup>21</sup> <http://amar.colostate.edu/~rtinsley/ConsummerPriceComparison.htm>

The importance of working with multi-commodities reflecting all the non-perishable cereal and bean crops produced by the farmers should not be overlooked. This distributes the labor over several commodities and assures fuller overall employment, then if an enterprise was restricted to one commodity. This will be even more critical if farmers are holding assets in kind and monetizing them over several months after harvest<sup>22</sup>. If only working with a single commodity, the staff could spend a lot of time idle waiting for business to arrive. The nucleus farm could provide some financial and logistic support to designated agro-dealers, particularly in terms of commodity purchasing float or input credits. The agro-dealer could also extend credit but according to established informal credit procedures. It is acknowledge that this endorses a quoted usury 100% seasonal interest rate, but it may actually represent the high cost of managing the informal loans, and reflect the games that smallholders tend to play with credit programs. Such games have to be factor into the quoted interest rates, and discounted for good repayments<sup>23</sup>. Also, such agro-dealers may be the most logical person to have the mechanical winnowing machine (Fig. 20), that could be used to clean the soybeans and other grains for an initial value added of perhaps 10 to 15%<sup>24</sup>.

This concept is very much modeled after the USAID funded CARE administered REAP (Rural Enterprise & Agribusiness Project) in Zambia in the late 1990 and early 2000. It is also consistent with the effort to promoted agro-dealers lead by CNFA in both East and West Africa.

**Production Practices:** Also, in organizing smallholder out growers the basic agronomic production practices encouraged for use in the nucleus farms may best be modified to reflect the overall economic and operational environment of smallholder relative to large commercial farms. For example if the smallholder have fields that have been extensively cultivated in the past and have mostly crop stubble on them, the need for both disc plowing and harrowing can be reduced to just harrowing. This has to be a field by field decision. In contrast if the out growers are taking advantage of the out grower program to expand the area they are cultivating by bringing new land under development the plowing and harrowing may have to be expanded to include some land grading or smoothing. Likewise it might be best not to provide out growers with herbicides and encourage them to continue the practice of hand weeding, or at least make in optional. This would minimize the value of any production loan being extended and having to be repaid with all the hassles that typical occur with loan repayments.

### **Report All Business Parameters**

Finally, since out grower programs involve business activities it is necessary to clearly report all the basic business parameter essential to determine the potential to be sustainable even after any external assistance or facilitation ends, even if they are embarrassing. That is the only way to

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<sup>22</sup> <http://lamar.colostate.edu/~rtinsley/FinancialStrategy.htm>

<sup>23</sup> <http://lamar.colostate.edu/~rtinsley/InformalCredit.htm>

<sup>24</sup> <http://lamar.colostate.edu/~rtinsley/CleanBag.htm>

fully evaluate the success and avoid continuing to advocate ideas that have only limited success, as appears to have happened with the out grower programs for at least a decade. It is also the only way for programs to evolve to more effectively assist the smallholder beneficiaries. Some of the fundamental business parameters that are often overlooked would include:

1. The basic cost of doing business comparison between the out grower program and the alternatives. Does the sustainable overhead cost exceed the negotiated advantage for bulk purchase or high volume marketing? Are there elements in the competition that could be adopted to provide better returns to the members?
2. What is the sustainable overhead costs for operating an out grower program? That is the cost to operate it with no outside funding or facilitation. This also needs to extend all the way to the farm gate, as too often the reporting has stopped at the farmer organization. This excludes the overhead cost or worse proclaims it a financial benefit to the beneficiaries, which is basically dishonest.
3. What is the percent of the beneficiary pool actively participating in the program? How will this impact the prospects for the program to meet the Millennium Development Goals?
4. How much side selling are the out growers doing? Is this related to the use of credit clubs? Isn't the most astute business decision for a smallholder when involved with a credit club to consign only enough to meet loan obligations and side sell the rest? If not does he risk having his crop confiscated to pay off a neighbor's loan? Consigning only what is estimated to cover outstanding credit was initially mentioned by interviews with senior host country personnel of CLUSA in Zambia along with the estimate of 60+% side-selling<sup>25</sup>. That level of side-selling does not make for a successful project.

### **Tractor Round-Up International (TRI)**

Tractor Round-Up International (TRI) is personal initiative of mine that I very much appreciated ACDI/VOCA allowing me some time to follow-up with possible contacts in Ghana. TRI is currently in the preliminary feasibility stage. The idea is to address what I consider the most critical oversight of the past 40 year effort to assist smallholder producers. That is the calorie energy balance in terms of the number of calories smallholders have access to in their diet, usually 2000 calories or less, relative to the number they may be expected to exert in collaborating with a development projects, as much as 5000 calories for a full diligent 10 hour day<sup>26</sup>. The only solution I know is to reduce the basic drudgery, particularly for land

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<sup>25</sup> <http://amar.colostate.edu/~rtinsley/SMC-RLT-Report.pdf>

<sup>26</sup> <http://amar.colostate.edu/~rtinsley/CalorieEnergyBalance.htm>

preparation, by increasing the smallholders' access to contract mechanization. Thus what I am considering is in the USA round up used 65 to 80 hp as a charity tax write-off, add whatever spares are needed to recondition the tractors and bring them back to a 7000 to 10,000 hr service life, ship them to countries like Ghana, have them reconditioned by a vocational training organization like Don Basco, and sold to individuals in smallholder communities<sup>27</sup>. Hopefully, the final price will be around US\$12,000, with \$8,000 being returned to the USA for sustaining the project.

The follow-up I did while on ACIDI/VOCA FtF assignment was during the initial trip to Ho divert to a beach resort near Accra to meet with Andy Nomato, who owns a mechanization unit in Akusa and has hosted previous FtF volunteers, to discuss the concept in general. Also, between assignments coming back to near Accra to meet with Fr. Jose Valiplackel, the person in charge of Don Basco's vocational mechanical training program to see the possibility of Don Basco doing the reconditioning and sales to individuals able to work with smallholder. He seemed very interested, but needed to refer it to his superiors. Don Basco is a well-established Catholic Charity throughout much of Africa. They specialize in vocational training of youth similar to Boys' Town in Nebraska.

In addition while meeting with the out growers groups made some inquires as to the availability of tractors for hire. They indicated they were available but it might take up to three days for them to be scheduled. This I consider acceptable. As expected the farmers complained about the price which ranged from 30 to 50 Ghc per acre. However, this really needs to be evaluated from the tractor owner/operators perspective in terms of the expenses being incurred, opportunity to make a reasonable living including alternatives to land preparation such as transport, threshing, etc. and any other conditions like having five acres available in an area, so a tractor minimizes the amount of time getting to and from smallholder fields, during any given day.

This looks like an area the development community is overlooking, that could easily result in mechanization of smallholder agriculture in Africa, following the example of Asia, where the conversion from water buffalo to rice based power tillers has gone virtually unnoticed by the development community, but most like has done as much if not more to assure the success of the green revolution in for rice in Asia as IRRI's development of high yielding varieties and related technologies. It may actually be too late for the development community of make a major impact on mechanizing Africa. Also, it might be too late for TRI to be effective in Ghana as there may already be a program that is based from Europe and thus has better access to Massy Ferguson, the much preferred tractor for Africa.

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<sup>27</sup> <http://amar.colostate.edu/~rtinsley/UsedTractors.htm>

## Bio-Diesel & Bio-Lubricants

In this day of green technologies the idea of a large nuclear farm growing and processing its own fuel and possible lubricants is well worth considering and appropriate if the economics are positive and the tax structure on imported oil is conducive. Caltech is interested in the prospects for bio fuels and has suggested soybean oil be used. This is their primary initial reason for producing soybeans In Ghana, as with most developing countries, taxes on imports are the administratively easiest means of revenue collection. Thus, when oil has to be imported it can be heavily taxed to the extent that fuel prices are substantially higher than in the USA, closer to the fuel costs in Europe. For Ghana the estimated comparative diesel fuel prices are Ghana \$0.77 vs. USA \$0.69/lit or a 13% difference<sup>28</sup>. How much of that represents taxes cannot be determined, but this could result in it being economically advantageous for a large farm to quietly manufacture biodiesel for its own use, more so than in the USA.

However, the question is if soybean oil is the most appropriate in the tropics or should other sources of vegetable oil be considered. For Caltech Venture the fuel consumption is estimated to be some 13,000 lit of diesel per month or 156,000 lit/yr. This would provide all energy needs including possible using a diesel generator to operate the electric motors in the cassava processing plant. The 156,000 lit/yr. is approximately the smallest amount for which a commercial biodiesel plant may be economically feasible<sup>29</sup>.

To get this amount from extruded soybeans that typically yield some 446 lit/ha of oil with about 50% recovery, leaving 10% oil in the cake, would provide 223 lit/ha of recovered oil. If as estimated the conversion from vegetable oil to bio-diesel is 1:1 it would take  $156,000/223 = 700$  ha of soybeans to produce enough oil for Caltech's bio-diesel needs. In comparison it appears palm oil is the oil of choice for large scale bio-diesel in Africa, with Cameroon making a serious effort to develop a biodiesel program around palm oil. Palm oil produces some 5950 lit/ha oil and if the same 1:1 ratio of oil to bio-diesel would only require some 26 ha plus what is needed to compensate for oil left in the cake, which with 15% protein can be easily used for animal feed. In addition, the empty bunch after removing the kernels actually contains enough energy that when incinerated in a highly efficient incinerator/generator will power the palm oil extraction process with some surplus as noted in Thailand a few years ago for large palm oil processing plants. The empty bunch might also be used as a fuel for cassava drying. Some of the oil palm production might blend itself to an out grower program as it seems oil palm is frequently used as a shade tree in many of the villages and homesteads surrounding Caltech.

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<sup>28</sup> <http://amar.colostate.edu/~rtinsley/ConsummerPriceComparison.htm#ghana>

<sup>29</sup> Ryan Lafferty, *Blue Sun Biodiesel*

Also, if considering bio-oil it might be worth considering producing some castor oil that is already growing wild on the farm. It appears to be the lubricant of choice for racing engines. Castor oil has an estimated production of some 1413 lit/ha. However, the cake is toxic to animals and would have to be used only for organic fertilizer. With a little refining this could take care of the lubricant needs and most like be expelled from the same expeller as used for soybeans or palm oil, with some possible adjustments to the setting.

However, there is a need for careful economic analysis as bio-diesel appears just outside the economic profit margins in the US and is mostly used by public sector organizations such as municipalities interested in demonstrating and promoting a green image and not concerned with the economic bottom line.

There was additional discussion on bio-gas generation and use. This is something that many a well-intentioned NGO has promoted, but with only limited acceptance. It is really a slow process. Its use is really mostly by waste treatment plants that have anaerobic digesters that recover part of the energy they need to manage the waste treatment plant. Rather Caltech has enough biological waste to justify a bio-gas plant of this scale is questionable. Thus the recommendation is to proceed with caution.

Just some things one needs to consider in the bio-oil and other green industries business.

### **Summary, Conclusions & Recommendations**

Since soybeans are primarily a temperate crop they can be a challenge to produce in the tropics, particularly the low elevation humid tropics that encompass most of Ghana. The biggest challenge in the low elevation tropics is the warm off season temperatures that can substantially reduce the seed viability and reduce the germination to unacceptable low levels. This was noticed at Kobbiman where fresh “certified seed” informally tested at 65% instead of the listed 80<sup>+</sup>%. Also, while soybeans are a leguminous crop with the potential to fix atmospheric nitrogen for the benefit of the plant, the rhizobium that actually fixes the nitrogen is specific to soybeans. Thus while other legumes either established in the farming system of Ghana or even leguminous weeds can be simply be planted and effectively nodulate on native rhizobium, **soybeans will not**. They have to be inoculated. This requires an additional and substantial logistical requirement involving moving environmentally sensitive live bacteria that often is insurmountable. Finally, soybeans are frequently promoted as primarily an oil crop. This is misleading as few farmers or processors are handling soybeans for the limited oil that can be physically extracted, and in Africa most of the soybeans are processed full fat. It would be better to promote soybeans as a high quality source of vegetable protein mostly for the feed industry, which in Ghana is mostly poultry, with a little pigs and fish production. It could be used for cattle and goat supplement, but not in large amount as these animals are mostly range feed without supplements.

With the exception of the challenges noted above the production of soybeans is fairly straight forward. There are several manual produced by well recognized international organizations for producing soybeans in the tropics. All provide similar procedures that are based on the research/extension recommended for maximum yield. Interestingly these manual do not mention or address the issues of seed viability or specific rhizobium. Instead they endorse the expensive use of certified seed as well as apply nitrogen fertilizer. Thus, as with any agronomic production manual all the detailed recommendations need to be fine-tuned to the economic optimal, which represent the most profitable level on inputs, and fit the operational resources and time available. Both host farms are fully familiar with the recommended practices and very capable of making these adjustments over the next few years.

There was considerable concern with the role of mechanization. Both host farms are and have to be fully mechanized, but this is though a mixture of equipment that became a major daily hassle for maintenance that usually prevents fielding the full complement of available tractors. While this leads to considerable and inventive short term improvising, it ultimately reduces the life of the equipment and the quality of the field work being performed. There were some major concerns with some of the Chinese implements available. They were just poorly constructed and could not be utilized without being substantially rebuilt. There is also a need to smooth out some of the mounds and ridges in the field where possible. This may not impact so much on the land preparation but will on the use of planters, sprayer and harvesting equipment, as these implements usually have four meter or more rigid extension that extends past the wheels and if bounced around too much will either dig into the soil, or be raised to high above the soil to be effective. Such land smoothing may not be possible for mangos where the ridges are needed to assure the mangos remain well drained.

Both host farms were developing out-grower programs for involving smallholders in surrounding communities in soybean production. This is being organized in same manner that is has for at least a decade and needs substantial revision to incorporate some of the problems other have had in implementing them, particularly the level of involvement of the nucleus farm and subsidies expected of them, as well as the expectation of production credit repayments, something Caltech is already having problems with for their cassava out grower program. If this is to be sustainable it will have to look at alternatives to the basic business model, and develop a more equitable basic agreement between nucleus farm and out-growers. This may mean looking at managing the out growers via the indigenous village based family enterprises that already handle most of the input and marketing needs of the smallholders, and usually provide the smallholder farmers with the best financial benefits in terms of lowest cost for input and best price for produce.

Finally, interest was expressed by Caltech in developing a biodiesel capacity based on soybean oil. This idea of larger farms producing their own fuel and possible lubricants is well worth considering and most likely has better prospects then in more temperate areas. However, it needs to consider if soybean oil should be the base or perhaps basing it on oil palm for diesel fuel and

castor oil for lubricants. The FtF effort also allowed me to follow up on my own initiative looking at the feasibility of rounding up old used tractor in the USA for shipment to countries like Ghana, have them reconstructed by vocational training organizations like Don Basco, and sold to individuals in smallholder communities. They could then be used for contracting to smallholders for basic land preparation, etc., and reduce the extensive drudgery associated with land preparation, and likelihood of smallholder being expected to exert more calories than they have access to, or reduce their workday to only a few hours.

### **Specific Recommendations**

**Development Community:** The development community would best reflect on the word of William Shakespeare in Hamlet:

*This above all: to thine own self be true, And it must follow, as the night the day,  
Thou canst not then be false to any man. – William Shakespeare*

The development community needs to be true not only to itself but to the smallholder beneficiaries and make certain the commitment is to the beneficiaries and not overwhelming to the mechanism by which they are expected to be assisted. In so doing the development community should be very careful in:

- Promoting soybeans as an oil crop when most likely it will be mostly used full fat and produce no oil or the oil will be mostly a by-product of the animal feed processing, with the animal feed being considerable more valuable than the oil. It can properly be promoted as a well-balanced industrial protein crop for the feed industry, with some applications for direct consumption and oil as a byproduct.
- Promoting soybeans for its potential to fix nitrogen and improve soil fertility, without making it clear that soybeans require a specific rhizobium and needs to be inoculated to effectively fix nitrogen, and this is an exception to most other legumes both crops and weeds grown in the tropics that cross inoculate with the rhizobium already in the soil.
- Take a very close look at the out grower business model being promoted and imposed on the nucleus farm and out growers alike to make certain it reflects past experienced and provides an equitable approach to all parties. Be very careful not to imply the nucleus farm is subsidizing the costs or even displacing the out growers.
- When projects are involved in business activities make certain any reports accurately include the basic business parameters that will reflect in the potential for long term sustainability and this analysis needs to extend to the farm and not stop at the cooperative or farmer organization, as appears to be the normal reporting.
- Take a very close look at where the development community's commitment lies. Make certain the commitment is first, last, and foremost with the smallholder producer and not

the mechanism by which he is expected to be assisted, that may represent a socially ideal but horrendous business model.

**Host Commercial Farms:** The host commercials should consider some of the following recommendations:

- Avoid using certified seed except to change varieties. There rarely is enough quality difference to justify the extra costs. Instead commercial farms should undertake to evaluate a few potential varieties and multiply seed internally for both the main farm and any out growers. However, be careful of viability over the dry season. If possible and necessary multiply seed during the dry season under irrigation. This should represent considerable saving in input costs. As a self-pollinated crop, soybeans can be retained and planted for many generations without any noticeable loss in genetic quality.
- Inoculate the seeds with the rhizobium specific for soybeans as soybeans will not inoculate or fix nitrogen without the specific rhizobium. This is in marked contrast to other legumes commonly found in the tropic including crops, trees and weeds. For best result obtain imported dry rhizobium from the USA, Europe, South Africa, or other major soybean producing area.
- With the land preparation slowly smooth out the ridges and mounds where possible with the equipment already available. This may take two or three years and may not be possible when planting soybeans under mangos as the ridges are needed for the mangos. But it will be necessary for effectively operate planters, sprayers, and harvesting equipment in the fields.
- Consider outsourcing some, if not most, of the tractor use to avoid the daily hassle on maintenance and operations, and perhaps reduce the cowboy driving. This could be particularly desirable for the out grower effort. There appears to be a reasonable number of tractors in the area that can be rented on a daily basis.
- Consider having directly hired mechanics provide their own tools, but assist them in getting the initial tool box and provide them a tool allowance. This could be cheaper than the continued need to replace tool that continually seem to quietly disappear, and the slow damage done by not using the correct tool.
- Show flexibility in implementing the precise recommendations to develop the economic optimal that provide the highest profit margin.
- Show additional flexibility in adjusting the agronomic practices to the out growers, allowing individual out growers to right to determine what assistance they need and what they would prefer to forego. This is particularly true if the inputs and equipment costs are to be included in a production loan the out grower will be expected to repay.
- Be very careful in implementing an out grower program to make certain it provides a competitive advantage for both the nucleus farm and out growers and does not result in excessive overhead costs.

- Be very transparent in determining the overhead costs and any discounts on the purchase price of soybeans or other commodities needed to cover these costs so the out growers understand and appreciate the role of the nucleus farm and cost being incurred for their benefit.
- This would include being particularly cautious with any production loans and the repayment of them with due consideration to the repayment games that might and usually are played.
- Consider having the out grower effort coordinated by agro-dealers already in business in the different out grower communities. Provide them the financial support needed to implement the out grower effort or assist the agro-dealers obtain loans from NGOs involved with micro-finance.
- Take a good look at the prospects of producing your own biofuel and lubricants.

## Appendix

### Activity Log for FtF Assignments in Ghana June – July 2010

R.L. Tinsley

- Saturday, 12 June      Departed Fort Collins for Accra, Ghana
- Sunday, 13 June      Arrived in Accra, had evening meeting with Mary Adutwumwaa to discuss grain quality and processing.
- Monday, 14 June      Brief orientation at ACDI/VOCA office and proceeded to Ho accompanied by Frank, with interim stop to meet with Andrew Nomafo who owns the mechanization unit near KIP for discussion on mechanization as it would relate to soybean assignment as well as TRI (Tractor Round-up International) my proposed project on reconditioning used tractors from the USA for Africa. Upon arrival at Ho settled into guest house and meet with Caltech Ventures personnel.
- Tuesday, 15 June      Had introduction to Caltech with observation of their cassava processing mostly into flour. This included orientation with supervisory staff and review of proposed schedule. The dough is a moist process consisting of grinding, 50% dewatering and packaging. This would then mildly ferment during time. Also, took tour of the farm which was mostly cassava with limited acreage of freshly sown soybeans. We looked at some of the equipment available and noted Chinese made planter with problems getting the desired plate settings.
- Wednesday, 16 June      Mostly, spent around headquarters to discuss variety and seed problems as Ben tied up dealing with the daily concerns of a manager. Did take a closer look at the Rhizobium I brought and decided on how to apply according to a couple articles down loaded from the internet. We were supposed to visit cold storage unit. This is a government owned facility that is available at very nominal cost well below the actual operating costs. Did meet a mechanic from mechanization unit that was able to diagnose and correct the problems with the Chinese planter.
- Thursday, 17 June      Mostly, visiting with Ben when not tied up on usual managerial brush fires. Took a close look at how to manage the inoculate based on the

website information from the company plus an article from Iran. Then I concentrated on discussions of land preparation and other mechanization issues including need for TRI for out grower program, as Caltech did not have sufficient tractors to fully support the out grower program. Got the estimated price of 50 Ghc per ac compared with 30 to 35 for Andy's program. Meet with Chris the owner and General Manager and had continued discussion with him. He tends to spend most of his time in Accra but does come up for two days each week.

- Friday, 18 June Experimented with the inoculate, first trying plain dry mixing as suggested on the company website but decided the adding water according to the Iran formula. This worked as the seeds had distinct darker color showing the inoculate sticking to the seeds. These seeds were then planted and inspected to see if too much material was rubbed off during handling. It looked good just need some rain to germinate.
- Saturday, 19 June Meet with the out growers at the farm. Interesting discussion but it is the same as with other out growers scheme indicating a need to review the whole process. Again it is the problems of credit and side selling. The need is to negotiate what would be a reasonable price for a trailer of cassava based on the production costs and reasonable profit for the producers. However, did note a trailer coming in as we left that was less than full indicating a desire for the out grower to cut down on what was being marketed.
- Sunday, 20 June Day off spent in the guest house preparing notes etc.
- Monday, 21 June Big problem with dying of soybean seedlings. It appears to be herbicide burn, from applying a mixture of herbicides designed for pineapple that appear to succeed with cassava. Check the environmental stats on half-life and it persistent in the soil. Also they may have boasted the concentration above recommendation.
- Tuesday, 22 June Big effort to inoculate and plant large area to soybeans, checked to see if germination of trial inoculation planting. They were well germinated, surprising since there had been no rains. Continued following problem with Chinese seeder and construction of large cassava press.

- Wednesday, 23 June Side trip to deliver the planter to government mechanization service unit. This was near Akusa, where my first assignment was, and we proceeded to visit the area including Andy's mechanization project, the winnower, the project mechanization unit to look at the new small combine that replaced a couple large combines that were completely unsuitable for the small farm environment of KIP. It was from Thailand, but larger than what I had expected. At the same time contained storage hopper instead of bagger. Finally, we visited a drying floor to see extent of mud in grain that needs to be removed. Ben bought some rice that his wife later rejected for too many stone, etc.
- Thursday, 24 June Spent day at farm working including long visit with Chris the General Manager. Discussion was largely on out grower concerns, and ethanol manufacture for the beverage industry. Claimed he needed soybean cake for the poultry industry instead of whole fat. Internet check indicated potential to use whole fat soybeans in poultry feed. Also, looked at inoculated soybeans but did not look at root, too young. Farm busy fabricating large cassava dough press. The evening was spent with Chris at hotel overlooking the city. Beautiful view.
- Friday, 25 June Ben had an accident at home and was unable to come to the farm. Spent the day at the farm writing and looking around mostly on my own. Did visit the soybean fields with Chris before he returned to Accra, checked for nodulation, but there was none as yet. I did observe the lifting of cassava and the amount of vegetation that needed to be controlled before planting soybeans or more cassava.
- Saturday, 26 June Ben still laid up so on my own at the farm. They did get the cassava press working and got some good photos of it. Rest of the day remained in farm office working on report etc. Back at apartment did some internet search for project needs. Most people preoccupied with the World Cup match between Ghana and the USA. Tried to root for USA but all Africa was behind Ghana.
- Sunday, 27 June Day of rest around the apartment, doing some personal writing, etc.
- Monday, 28 June Return to the farm to check on soybean nodulation and continued general discussion on the farm operations.

Tuesday, 29 June      Remained in guest house with case of gout and unable to effectively mover around. Did continue work on report.

Wednesday, 30 June    Had final briefing in guest house attended by Chris, Ben, Kofe and three from local ACDI/VOCA local project.

Thursday, 1 July        Departed for second assignment but with diversion to meet with Fr. Jose Valiplackel the head of Don Basco's mechanics vocational training program on possibility of Don Basco receiving, reconditioning and selling used tractors. Concept well received. Continued on to Kumasi.

Friday, 2 July          Proceed to next assignment. Had orientation briefing and visited some of the farms. Main crop is mango with expectation to under sow developing trees with soybeans as means of getting Nitrogen. He was not aware that this would require specific rhizobium. Someone is misrepresenting soybeans and it nitrogen fixing prospects.

Saturday, 3 July        Remained in house as host had to go to Kumise for Funeral. Worked on some writing, etc.

Sunday, 4 July          Made field visit to the last farm, then later in afternoon meet with out-growers. Very contentious meeting, as someone had promised the out growers that the nucleus farm was providing everything. The whole thing almost collapsed.

Monday, 5 July         Accompanied Nana for visit to next town and meeting with finance project in the morning, then in the afternoon went for second out growers meeting. This went considerable better

Tuesday, 6 July        Nana tied up in city chief consul, introduced to the senior chief in the morning. Afternoon meet at home with out-growers. Nana tied up with banker so had chance to do small group interview. It looks like they are expecting Nana to do some initial land development as part of soybean out grower effort after which they will be able to manage the land for future cultivation. They did claim tractors were available, but it might take 3 day from when you made payment until tractors would be available. Cost on Cdes 30/ac. Same as Andy charged.

Wednesday, 7 July	Nana tied up with Funeral arrangement for deceased relative, so stayed around house mostly waiting in yard. We made forth visit to out growers after a farm visit. Farm visit showed they had tried to use the scraper to get some smoothing of some of the fresh developed land, scheduled for soybean. The meeting was in a school, and went similar to other except for delay in getting it organized.
Thursday, 8 July	Made farm visit to observe harrowing land between Mango trees for sowing of soybeans. Returned at lunch and Nana tied up all afternoon with litigation
Friday, 9 July	Again went to farm toured the mango operation and observed crew loading harrow for transport to next farm, return for lunch
Saturday, 10 July	Mostly on field visit to get Indian tractor repaired. The tractor had a bad steering bearing that may have led to larger problem with the entire steering mechanism now needing to be replaced.
Sunday, 11 July	Mostly day off around the house working on report, but did make a grand tour of the farms except could not reach the most distant farm as too much rain resulted in impassable stream.
Monday, 12 July	Crew arrived to work with boom sprayer and get it ready for herbicide applications.
Tuesday, 13 July	Final field day to test both seeders and boom sprayer for herbicide, still had problem with uneven ground and spray bouncing with drift into Mangos
Wednesday, 14 July	Heavy rain resulted in need for Nana to make final field visit that delayed departure for Accra until 2:30 with arrival after 8:00
Thursday, 15 July	Debriefing to ACIDI/VOCA, work from hotel on report
Friday, 16 July	Mostly worked from hotel on report
Saturday, 17 July	Departed for USA early morning arriving home at midnight

End of Activity Log