Ghana – FTF Improved Agronomic Practices for Cassava Production

Final Report by Robert D. Walters

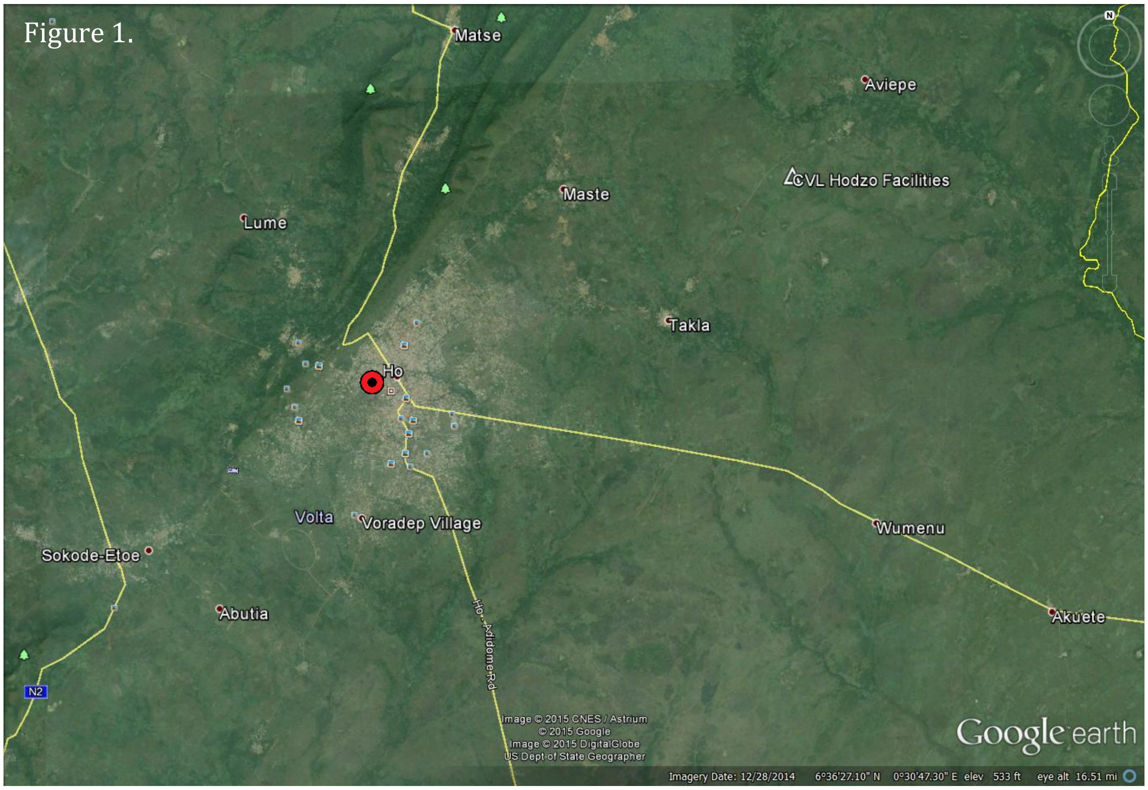
I. EXECUTIVE SUMMARY

1. HQ Assignment number: 0740236-01
2. Assignment Country: Ghana
3. Name of Host Organization(s): Caltech Ventures Ltd.
4. Dates of Assignment: 22 August 2015-08 September 2015
5. Summary of Scope of Work Objectives:
   - Assess the current practices of Caltech's farm and that of their outgrowers and provide recommendations for improvement
   - Based on the result of the assessment, train staff on best practices to boost production
   - Train CVL on how to mechanize their operation
   - Develop a cassava production manual to guide CVL in their farming operations
   - Make suggestions/recommendations on any other professional support that will strengthen the CVL in its operations
6. Recommendation Summary: Caltech Ventures Limited (CVL) must focus attention on improving four critical operations: (1) cassava plant stand and vigor; (2) uniform primary and secondary tillage operations including fallow residue management and ridge alignment in their production blocks; (3) efficient and effective machinery operation prior to deploying post-plant mechanized solutions for weed management and fertilization; and (4) improve plant growth and root yield monitoring for establishing baseline information to assess impacts of agronomic practices on CVL's production system.

I. BODY OF THE REPORT

1. Host organization description:

Caltech Ventures Limited (CVL) is a commercial producer of cassava starch, flour, and starting 2015, ethanol. CVL has 3,000 hectares of farmland in the Volta region near Ho, of which 350 hectares are under cultivation either by CVL directly, or by outgrowers who produce cassava for CVL under agreement in exchange for crop inputs and marketing support. CVL also sources cassava from external suppliers provided that root quality (starch content) meets standards. CVL would like to expand production to 500 hectares in order to provide feedstock for their ethanol plant. Production facilities are located in Hodzo (Figures 1, 2).



(1) shop and equipment shed (2) store rooms (3) farm offices and loading bay (4) cassava primary processing (5) ethanol plant (under construction) (6) cassava drying and milling (7) garage.

Presently CVL's cropping system resembles "shifting" cultivation wherein blocks of land rotate between cassava for 2-4 years depending on the site, and bush fallow for 1-3 years. Some long-rotation land remains in fallow for up to 10 years, which CVL growers refer to as "virgin" land. Fallows are all natural, unmanaged, native herbaceous grasses and broadleaf vines, brush, and small trees. Block areas range anywhere from 2 to 18 hectares.

CVL employs two land preparation systems, herein designated: Pre-Plow-Disk (PPD), and Plow-Disk-Stale (PDS). The difference between the two systems is in timing and frequency of herbicide application: PPD includes a pre-plow application of glyphosate for termination of fallow growth, followed by post-plant application of pendamethalin whereas the PDS system omits the pre-glyphosate, post-pendamethalin treatment and instead uses a single post-plant broadcast application of glyphosate for post-emergent weed control.

The two systems are described following in detail.

Pre-Plow-Disk: (virgin land): D6 bulldozer equipped with a curved shank ripper attachment rips, de-stumps fallow land; followed by (*fb*) broadcast application of glyphosate @ 200 mL per 15 L H_2O (1.3% v/v), total application is 300 liters per hectare for fallow growth termination; *fb* a waiting period of about 4 weeks for glyphosate burn down; *fb* one pass with a 6-disc plow; *fb* two passes with a disc harrow; *fb* ridging if planting is done by hand, or if not, mechanical planting is done flat and cassava sticks are planted horizontally and completely buried; cassava on ridges is planted vertically slanted in both PPD and PDS systems; *fb* a post-plant, manual, over-the-top application of pendamethalin @ 250 mL per 15 L H_2O (1.7% v/v); a boom sprayer is not used because the grower's FarmTrac 5440M tractor tire spacing is not aligned with the ridge and furrow spacing. After a period of about three months, the first weeding is done via hand hoe (cassava is still too small to apply non-selective herbicides like glyphosate); after six months, when the cassava has grown and the lower leaves have dropped, a second, manual, post-directed glyphosate application @ 200 mL mixed in 15 L H_2O (1.3% v/v) is made. This is the final weed control treatment, prior to root harvest about 6 months later. On short fallow land (1-3 years) the D6 and ripping treatments are omitted. Instead, vegetation is surface pressed with the disk harrow, which provides shallow root cutting as well.

(2) Plow-Disk-Stale: D6 treatment as above, *fb* 6-disk plow 1x; after about three weeks disk harrow 2x (the waiting period between disk plow and disk harrow is to provide time for root desiccation, and varies depending on the weather); *fb* ridging; weeds are allowed to grow prior; cassava is planted into stale ridges *fb* manual broadcast application of glyphosate 1.3% v/v; *fb* manual weeding after about 4 months; the need for further weeding depends on the extent of the cassava canopy; additional control, if needed, is done via manual, post directed glyphosate treatment or hand weeding. On short fallow land (1-3 years) the D6 and ripping treatments are omitted as above. Fallow growth termination is also done in a similar manner as above.

Note: Not all land is ripped with the D6; ripping is done to remove large tree roots on virgin land. CVL stated that early on they were clearing land with the D6 pushing vegetation and attached topsoil to the field edges. Fertility in these blocks was affected such that cassava yields declined sharply over 2-3 years cropping. Presently, trees are pushed over, ripped, cut, and dragged to the field edges leaving topsoil and non-woody vegetation intact; fallow growth is terminated with a combination of mechanical and chemical treatments.

Fertilizer is applied at planting regardless of planting method. Not all blocks receive supplemental fertilizer. CVL consults soil reports from as long ago as nine years to as recently as 2012 for deciding which blocks to fertilize. Urea and rock phosphate (RP) are the two principal fertilizer N and P sources. Fertilizer N and P may be applied at planting with the mechanical planter, which is equipped with a hopper, metering mechanism, and fertilizer opener. It is also applied manually at planting at a rate of 15 grams per plant (2:1 w/w mixture of urea and RP, see comment under Agronomics section c below). When manually applied, the fertilizer is spread on the ridge around the cassava stick about 5 cm away.

Pre-plant broadcast weed management is done with CVL's FarmTrac 5440M tractor equipped with a 7.5 m spray boom, 500 L tank and two-stage roller pump assembly. FarmTrac 5440M tire spacing is 152 cm and tire width approximately 40 cm; front axle clearance is approximately 40 cm. Broadcast sprayer rig consists of three, 2.5 m articulated boom sections equipped with Lechler 110-03 flat fan, pressure compensated nozzles on 50 cm centers. This rig can only be used for pre-ridge, pre-plant broadcast herbicide application because the tires are not aligned with 1 m ridge spacing, nor can the tires spacing be adjusted for 1 m ridging. Front and rear axle clearance is insufficient for post-plant herbicide application. CVL growers have expressed interest in equipping their JD 6145 with a wide (10-12 m) swath width spray rig for post-plant herbicide application (see final presentation for details). Otherwise, all post-plant weed management is carried out manually either by hand or backpack sprayer. No other major pests or diseases affect CVL's production.

Cassava is planted either manually or mechanically with a specialized planter imported from Brazil. The mechanical planter consists of two unit planters equipped with double disk openers mounted on parallel linkages *fb* press wheels and disk hillers. One independent, ground driven rubber tire and wheel assembly actuates the planter unit and fertilizer distributor via a series of sprockets, idlers, and roller chains. Fertilizer is metered from a hopper mounted under the two planter seats, and is deposited in the opener slit a little in front of the planted cassava stick. All mechanical planting is done flat (no ridging) with cassava sticks placed in the ground horizontally. The planter is not designed for ridge planting (note: I believe with some tinkering it could be modified to plant on ridges, see comment below). All ridge planting is done manually with cassava stem trimming on-the-go by cutlass, and stick placement at an angle to the ground surface. Inter-row plant spacing is 1 m and the intra-row plant spacing target between 0.80 m – 0.90 m which is optimal for high cassava yields.

Cassava harvest is done either manually by hand in very dry soil or in weed infested land, or mechanically in moist, soft soil with a specialized root plow. Roots are removed from the field by hand and transported by tractor to the main production facility in tag-along trailers equipped with hydraulic tilt mechanisms.

2. **Prioritized list of issues or problems addressed.** Expanding cassava production on a scale envisioned by CVL requires increasing reliance on mechanization and modern agro-technical inputs. Agricultural mechanization is still at a very incipient stage in Ghana, as is true in all West Africa. CVL wants to expand production while improving efficiency and product quality by adopting better agronomic practices and mechanization. However, CVL does not have enough trained staff and consequently, attempts to implement improved agronomic practices and mechanization have not reached their potential. Relevant issues/problems are grouped separately under three headings:

Agronomics

a) **Issue/problem:** Variable cassava plant population stand and vigor.

Recommendations: Caltech farm hands and outgrowers must improve selectivity in preparing planting stakes such that only mature stem material beneath terminal branching is used. Stems above this point have smaller diameter, less carbohydrate and mineral reserves, and generally produce plants with low vigor. Fresh planting material should be trimmed and stacked in the shade and covered with a canopy of branches or other material to reduce moisture loss. Dried stakes should have both ends trimmed to live tissue or failing that, discarded. Cassava stake viability can be determined in the field by scratching the stem periderm tissue down to the cambium layer, which should be bright green. Just before planting, cassava stakes should cut with a sharpened cutlass to about 30 cm in length with 5 to 7 nodes. It was recommended that in-ground stake ends be cut perpendicular to the long axis of the stake; the above-ground portion can be cut obliquely (at an angle) to the stem axis or perpendicular to it, whichever is preferred. Stakes that do not germinate should be replaced with fresh stakes. Replacements should be planted a little away from the original stake that died, especially in all cases where the reason for mortality is unknown.

i. Applicable/relevant: yes
ii. Can be completed within a reasonable amount of time: yes
iii. Cost-effective: yes
iv. Measurable/Allows for follow up: yes
v. Beneficial to environment, if applicable: yes

Action per Recommendation: in-service or OTJ training.

Anticipated Impact: Uniform crop stand with higher yield, better suited for post-plant, under-canopy mechanical and/or chemical weed treatment in future.

b) **Issue/problem:** Cassava plant population density, root yield and quality information incomplete, dated, or unavailable.

Recommendations: Before harvesting, cassava population density, root yield and starch content should be measured bi-annually coinciding with rainy and dry season canopy development, in at least one block for each cassava variety. In future, all production blocks should be monitored to include, with the above, planting date, harvest date, and agronomic inputs, but we realize this level of detail may not be feasible for CVL in the short-term.

vi. Applicable/relevant: yes
vii. Can be completed within a reasonable amount of time: partial
viii. Cost-effective: yes
ix. Measurable/ Allows for follow up: yes
x. Beneficial to environment, if applicable: yes

Action per Recommendation: Better training and software for tracking production information and statistics (see comments in follow-up actions below).

Anticipated Impact: Establish baseline information to assess impact of agronomic practices and future interventions in Caltech's production system (Table 1).

Table 1. Effect of block, variety, and planting method on cassava population density.

Block	Variety	Planting method	Ct/5m[1]	Population mean	Population std. dev.	Population CV (%)
I-1	Caltech	Vertical	7.6	15,200	2,040	13.4
I-4	Caltech	Vertical	7.8	15,600	2, 332	15.0
F	Sika	Vertical	5.0	10,000	2,828	28.3
I-10	Doku	Vertical	6.4	12,800	1,600	12.5
G	Oshewkau	Horizontal	3.8	7,600	1,497	20.0
G	Oshewkau	Horizontal	3.8	7,600	1,960	26.0
G	Oshewkau	Horizontal	4.0	8,000	1,265	16.0

[1] n=5 replicates for each of seven population density estimates.

Source: Walters and Caltech staff, August 2015

c) **Issue/problem: S**oil fertility information incomplete, dated, or unavailable; low and/or unknown nutrient application rates.

Recommendations: Use of compound N-P-K fertilizer instead of urea + rock phosphate (RP) was recommended. CVL mixes urea and rock phosphate in a 2:1 w/w ratio, i.e. 100 kg urea + 50 kg RP. It is impossible to know what is the application rate for either urea nitrogen or RP phosphorus in this mixture because (1) the two materials have different density therefore 15 grams applied to each plant (CVL dose) does not contain fertilizer N and P in 2:1 ratio; and (2) the level of RP solubility is unknown. Ghana SRI soil tests (2012) reported phosphorus levels low or very low in all blocks. Surficial soil pH (0-15 cm deep) was reported as slightly acidic to neutral (mean = 6.73). The predicted solubility of RP under neutral or slightly acidic pH is low therefore it is questionable if the quantity of RP applied is supplying 30 kg/ha phosphorus recommended by SRI. A 2:1:2 compound fertilizer ratio is preferred for cassava however a 1:1:1 ratio is acceptable for boosting phosphorus levels in deficient soils. Application of micronutrients should continue per instructions given by the SRI soil reports. Sulfate salts of Zn, Mn, Cu, or commercial blends (Yara or equivalent) were recommended for micronutrients. Tecamin Raiz root growth "biostimulant" was not recommended as an economical source of plant essential nutrients.

Applicable/relevant: yes

xi. Can be completed within a reasonable amount of time: yes
xii. Cost-effective: yes
xiii. Measurable/ Allows for follow up: yes
xiv. Beneficial to environment, if applicable: yes if used properly

Action per Recommendation: Recommended to CVL beneficiaries.

Anticipated Impact: Improved crop yield and crop quality.

d) **Issue/problem:** Weed competition in cassava plantings.

Recommendations: Presently there are no herbicides labeled for use in cassava. Worldwide, growers are using them anyway but their effect on cassava root growth/quality cannot be foreseen. Therefore, pre-emergence, early-post-emergence, contact, non-systemic, herbicides are recommended for cassava. Systemic herbicides such as glyphosate should only be applied manually for post-plant weed management. The only safe method for mechanized under-canopy application of non-selective, systemic herbicides is with hooded and/or shielded equipment. Control of *Cyperus* spp. (sedges) in cassava can be achieved with an under-canopy, post-directed application of bentazon, or paraquat dichloride. Sethoxydim can be tank mixed with bentazon for enhanced control of grasses. Read and follow all directions on the product label. Better long-term management of weed populations in cassava can be achieved by CVL transitioning away from fallow periods between cassava plantings when perennial broadleaf and grass weeds become established. A cassava-peanut rotation was recommended as one option.

Applicable/relevant: yes

xv. Can be completed within a reasonable amount of time: yes and no
xvi. Cost-effective: yes
xvii. Measurable/ Allows for follow up: yes
xviii. Beneficial to environment, if applicable: there are trade-offs in transitioning away from fallow periods. See final presentation for details.

Action per Recommendation: Recommended to CVL beneficiaries.

Anticipated Impact: Improved crop yield and crop quality; greater productivity per unit land area; diversified products.

Mechanization

a) **Issue/problem:** Inefficient and/or ineffective use of equipment and machinery.

Recommendations: Primary and secondary tillage operations should be aimed at providing uniform mixing of soil and fallow season plant residues. When ridging, traffic patterns should be aligned with uniform spacing between passes, such that deviation from 1 meter ridge-to-ridge (or furrow-to-furrow) spacing is minimized. Otherwise post-plant mechanized weed control is impossible without damaging some cassava rows. For maximum efficiency, tractor operators should match ground speed with the tillage implement. Generally, rotary tillage machines are unsuitable for commercial use due to low ground speeds. Rotary tillers also produce very fine tilth which is not needed by cassava. Converting all cassava blocks to ridge planting was recommended to alleviate high draft, low ground penetration during dry season root digging operations.

Applicable/relevant: yes

xix. Can be completed within a reasonable amount of time: yes
xx. Cost-effective: yes
xxi. Measurable/ Allows for follow up: yes
xxii. Beneficial to environment, if applicable: yes.

Action per Recommendation: In-service and OTJ training. Equipment dealers may also provide assistance.

Anticipated Impact: Lower overhead cost of production; less pollution; more timely completion of field operations; more uniform ridge spacing which is needed for mechanized post-plant weed control and fertilization operations.

b) **Issue/problem:** Reliance on manual labor for post-plant weed management; lack of mechanical weed control options.

Recommendations: A combination of chemical and mechanical weed control is optimal for cassava production. Large commercial plantations, such as CVL, should consider acquiring high-clearance equipment with appropriate wheel spacing for weed control operations, especially post-directed, inter-row, treatments prior to canopy closure. For post-plant chemical weed control, a sprayer boom equipped with drop nozzles for under-canopy, post-directed application of herbicides and liquid fertilizer is preferred. All herbicide application equipment should be calibrated before use and checked periodically to confirm that recommended rates are being applied. Constant ground speed for all herbicide application equipment must be maintained.

Applicable/relevant: yes

xxiii. Can be completed within a reasonable amount of time: no
xxiv. Cost-effective: yes
xxv. Measurable/ Allows for follow up: yes
xxvi. Beneficial to environment, if applicable: yes.

Action per Recommendation: No actions were indicated; recommendations were given as "food for thought" as some of the technology has not been demonstrated in cassava. Use of chemical weed control under all circumstances requires equipment calibration via in-service or OTJ training. Recommended that CVL spray crew mark the location in the

field row with colored survey tape where their backpacks have emptied to avoid skips and gaps in weed control. Avoid contact of glyphosate with cassava leaf tissue.
Anticipated Impact: Lower overhead cost of production; less environment impact; improved weed controls.

Technology Transfer

a) **Issue/problem:** Inadequate knowledge of integrated mechanized farming systems by farm hands, outgrowers, and allied producers.

Recommendations: Mechanized farming requires high level of technical knowledge: operational parameters; equipment service; field operations integration. In addition, improved infrastructure (dealers, equipment, inputs, support) is needed. CVL should implement in-service training for operators, farm hands and outgrowers in best agronomic practices and new technology. Training must be an ongoing process, not just task oriented. Increasing demand for mechanization in Ghana will encourage infrastructure development but the time frame is uncertain. Encourage staff to devise and test agro-technology innovations. Test innovations on a small area before adoption.
Applicable/relevant: yes

xxvii. Can be completed within a reasonable amount of time: yes
xxviii. Cost-effective: yes
xxix. Measurable/ Allows for follow up: yes
xxx. Beneficial to environment, if applicable: yes.

Action per Recommendation: Recommend that CVL field staff examine options for modifying their mechanical cassava planter for planting on ridges. I discussed this option with CVL, but did not have opportunity to see the planter in action due to dry season conditions.

Anticipated Impact: Improved farm hand knowledge and skills set; problem solving that avoids/reduces overhead costs.

3. **Achievement of Expected Products and Results (present and short term):**

Objective 1: Assess the current practices of CVL's farm and that of their outgrowers and provide recommendations for improvement. Product: Final presentation (Power Point). This was aimed at CVL beneficiaries "directly assisted" noted in item 14 below. Note: no outgrowers were contacted due to insufficient time allocated in the assignment.

Objective 2: Based on the results of the assessment, train staff on best practices to boost production. Product: CVL training was mainly one-on-one, unstructured and field based. There was insufficient time for developing structured group training events. The farm assessment activity consumed the entire ten days on site. In future, I suggest that ACDI/VOCA develop all structured group training in advance with both Volunteer and host as such events cannot happen spontaneously in this environment.

Objective 3: Train CVL on how to mechanize their operation. Product: Detailed measurements were taken in CVL's cassava fields showing ridge-to-ridge alignment and its impact on post-plant mechanized weed control and fertilization. Videos showing the wide sweep rolling cultivator for weed control and bed listing in tobacco in North Carolina (tillage land preparation and planting similar to cassava); drop nozzle technology for under-canopy chemical weed control and fertilization; use of high-clearance, limited tire footprint, equipment were proposed as promising (but untested) options for early-season, pre-close canopy mechanized weed control and fertilization in cassava; CVL farm managers and equipment operators were given instruction on optimizing ground speed and tillage tool adjustment for more efficient and effective field operations.

Objective 4: Develop a cassava production manual to guide CVL in their farming operations. Product: Production information was given throughout the final presentation, but no inclusive, written manual was published. I informed ACDI/VOCA personnel in advance of accepting this assignment that a published production manual was impossible given the assignment's brief time frame.

Objective 5: Make suggestions/recommendations on any other professional support that will strengthen CVL in its operations: Strongly recommend further support given to CVL aimed at farm record keeping: operations management; production costs; and productivity/quality indicators like yield, population density, and starch content.

4. **Key Contacts:** N/A.

5. **Beneficiaries: Please list below those who have benefited from your assignments. Please seek guidance from ACDI/VOCA field staff on any questions you may have on definitions.**

Number of Persons Trained (Training defined as: formally structured training activities, usually in a classroom, which do not lead to an academic degree, or a learning activity taking place in a classroom or workshop with learning objectives and outcomes):
Male: 4
Female: 5
[redacted]

Number of Persons Directly Assisted (Persons who received face-to-face or hands-on technical assistance, training or advice from the volunteer. This is also considered program direct

beneficiaries. "Persons Trained" are ALSO counted as "Persons Directly Assisted" and represent a sub-category of "Persons Directly Assisted.")
Male: 4
Female: 0
[redacted]

III. CONFIDENTIAL MEMO TO ACDI/VOCA (This information is NOT shared with the host)

[redacted]

[redacted]

2. **ACDI/VOCA follow-up actions:** We are interested in what you think ACDI/VOCA should do next to assist your host organization(s). Please list what ACDI/VOCA should be made aware of, in the interests of your host organization(s). Include possible challenges as well as future possibilities.

   Please see under Agronomics c Action per Recommendation above. CVL faces many challenges on the road to full mechanization in cassava production. In some cases the technology has not been tested in cassava, in other cases reported but only under "controlled" conditions. Saying that, CVL is, in fact, doing better than they think. We measured 51.2 tons/ha cassava yield in block F Sika (2 year fallow, unfertilized, dry season leaf canopy), and 35.4 tons/ha cassava in block I-10 Doku (1 year fallow, fertilized, rainy season leaf canopy), both figures are well above

18.3 tons/ha average Ghana root yield reported by FAOSTAT (2013). The challenge ahead for CVL is adopting new technologies without regrets (monetary and productivity) or “white elephants” (processing/production equipment). CVL is well positioned to take leadership in commercial cassava flour, starch, and ethanol production in Ghana and beyond. I leave it to CVL to decide what further support is needed to improve their operations.

3. **Promises:** Please list here a summary of follow-up commitments you may have made to the host organization(s) (e.g. providing U.S. contacts, shipping catalogs, books, seeds etc.) Provide CVL with peanut production information for Ghana.

F2F Caltech Field Shots 24 August-04 September 2015

Entrance to Hodzo cassava fields


Cassava root peeling station. Mechanical peelers from China did not perform so back to basics. CVL hopes new equipment works better.


Hodzo ethanol plant under construction


Fermentation tank bases

USAID FROM THE AMERICAN PEOPLE

ACDI VOCA Expanding Opportunities Worldwide

FARMER-TO-FARMER


Hodzo high quality cassava flour (HQCF) milling


Hodzo HQCF wood-fueled dryer


Discussing Caltech operations


Training CVL how to measure cassava plant population density needed to estimate root yield


Field worker teaches green horn the right way to hand-harvest cassava roots


Examining cassava plant growth and vigor with CVL field workers

Field worker marks upper and lower stem preferred for cassava multiplication

Brazilian mechanical cassava planter drive wheel, chain and sprocket assembly. Arrow points to stick feed mechanism.

Disk harrow pressing down fallow growth. Heavy fallow biomass favors soil conservation but interferes with ridge building systems preferred for cassava root production. Rotating cassava with another crop like peanut could help.

Fallow biomass is a prime source of organic matter but too much hinders field operations.

Assessing ridge alignment

Red arrows point up variable cassava growth and plant vigor. Non-uniform plant growth delays canopy closure, encourages weeds, and is incompatible with mechanized weed control.


Aligning tractor lower links prior to attachment


Adjusting top link for improved ridger penetration


Good practice! JD 6145 fluid and filter changes


Brazilian cassava root plow knock-off manufactured in Ghana with locally sourced tube steel, flat stock and rebar.


All CVL post-plant weed control and fertilization is done manually. Mechanizing these operations requires new technology, tight operation integration, and improved agronomic practices.


Last day on the farm. Thank you Caltech!