COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH

SOIL RESEARCH INSTITUTE

(CSIR - SRI)

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LIST OF ACRONYMS

ANOVA	-	Analysis of Variance
CEC	-	Cation Exchange Capacity
CSIR	-	Council for Scientific and Industrial Research
CSIR-CRI	-	CSIR – Crops Research Institute
CSIR-FORIG	-	CSIR Forestry Research Institute of Ghana
CSIR-SARI	-	CSIR – Savanna Agricultural Research Institute
CSIR-SRI	-	CSIR – Soil Research Institute
EDIF	-	Export Development and Investment Fund
FAO	-	Food and Agricultural Organisation
IFDC	-	International Centre for Soil fertility and Agricultural Development
INM	-	Integrated Nutrient Management
JIRCAS	-	Japan International Research Centre for Agricultural Sciences
KNUST	-	Kwame Nkrumah University of Science and Technology
MoFA	-	Ministry of Food and Agriculture, Ghana
NUE	-	Nutrient Use Efficiency
PRA	-	Participatory Rural Appraisal
QUEFTS	-	Quantitative Evaluation of the Fertility of Tropical Soils
RSC	-	Residual Sodium Carbonate
RTIMP	-	Root and Tubers Improvement and Marketing Programme
TDS	-	Total Dissolved Solids
SAR	-	Sodium Absorption Ratio
SSP	-	Soluble Sodium Percentage
UDS	-	University of Development Studies

EXECUTIVE SUMMARY

The CSIR-Soil Research Institute continued to focus its Research and Development (R&D) effort on the generation of information and technologies for the sustainable management of Ghana's soil resources as captured under the following four main research programmes in 2014:

The **Soil Fertility Management Programme** conducted studies on general cropland productivity enhancement practices for the production of various crops in collaboration with the other partner institutions. The study on Minimising rice smut diseases in Ashanti region through integrated soil fertility management was undertaken to minimize the incidence of rice smut diseases in Ashanti region through integrated soil fertility management. Specifically, this study identified rice varieties that are resistant to rice the smut diseases as well as developed effective and economically suitable cultural practices that reduced or prevented rice smut diseases. Another study was undertaken to identify the Efficacy of Zytonic Soil Conditioner on two Ghanaian Soils using Sweet Pepper and Maize as test crops. The study concluded that the impact of Zytonic on improving the properties of sandy-loam *Oyarifa series* was greater than that of a clay-loam *Akuse series.* Similarly, another study evaluated the Efficacy of Greenfain WP3 on Six Soil Types within the Accra Plains using Maize and Cowpea as Test Crops. The study assessed the water holding capacity of soils with and without Greenfain WP3 as well as assessed crop (Maize and Cowpea) growth and yield response to Greenfain WP3. A study on the Growth Response of Maize cultivated on Sediment from the Odaw River, Ghana was undertaken to determine the growth of maize on dredged sediment from the Odaw River and on soils from farmers' field. The Optimizing Fertilizer Recommendation in Africa (OFRA) study was conducted to help improve the capacity of National Research Institutions in developing fertilizer recommendations for efficient and profitable fertilizer use in 13 sub-Saharan African countries within the framework of Integrated Soil Fertility Management practices under smallholder farming by the end of March 2016". A study on Promoting Enabling Soil Health Policy Environment in Ghana was undertaken to improve soil and cropland productivity in Ghana through the implementation of conducive soil health policies to contribute to poverty alleviation and food security. Some of the study's key achievements over the years include the development and production of Ghana Fertilizer Policy Framework document; development and production of Regulations Guiding the Implementation of Part III of the Plants and Fertilizer Act 803 of 2010; sensitization of stakeholders along fertilizer value chain on the regulations guiding the implementation of the Plants and Fertilizer act.

The **Environmental Management and Climate Change Programme** undertook a study to Estimate the Potential Evapotranspiration at Botanga Irrigation Scheme in the Northern Region of Ghana This study also examined the influence of potential evapotranspiration on crop water requirement for irrigation for rice, tomato and pepper. The study concluded that under conditions of limited water availability the planting of pepper becomes more favourable than tomatoes and rice since the irrigation water requirement is low. Another study on Promoting a Value Chain Approach to Climate Change Adaptation in Agriculture (PROVACCA) was undertaken to contribute to the reduction of climate-induced risks to the achievement of food security and income generation for the rural communities in Ghana. It sought to promote innovations to address two main environmental challenges of cassava waste management, and energy demand for cassava processing. The main components of the study included the following: Awareness raising on climate change and capacity to address impacts along the cassava value chain; Support adaptation of cassava production to climate change; Promote innovative adaptation solutions along the agriculture value chain.

The **Laboratory analytical services programme** continued to receive for analyses soil, water, plants and fertilizer samples from research institutions as well as from private commercial farms, governmental and non-governmental organizations. The laboratories also provided on-the-job training on standard laboratory practices for graduate and undergraduate students from both local and international institutions. In all almost 6291 samples were analyzed during the period.

Total receipts of Ghana Government funds for the year was GH Cedis 10 3 million constituting about 50% of the approved budget whilst the Institute's research commercialization activities yielded GHC165,832.84 mainly from the laboratory analytical services and also from the land evaluation consultancy services.

The Institute's staff strength stood at 284, made up of 29 Senior Members, 87 Senior and Technical Staff and supported by 168 Junior Staff.

Major constraints

Inadequate funding as well as delays in the release of approved funds continued to be the major constraints faced by the institute. Some of the important equipment being used in the laboratories remain obsolete and must be replaced urgently.

1.0 INTRODUCTION

The CSIR-Soil Research Institute continued to pursue its mandate of generating scientific information and technologies for effective planning, utilization and management of the soil resources of Ghana for sustainable agriculture, industry and environment. Research activities that were undertaken in 2014 were categorized under the following institutional research programmes:

- Land Evaluation Programme
- Soil Fertility Management Programme
- Soil and Water Management Programme
- Environmental Management and Climate Change Programme
- Laboratory Analytical Services Programme

The research and development (R&D) effort of the institute were undertaken with the aim of achieving the following research objectives:

- Develop knowledge for efficient management of the soil resources of Ghana.
- Strengthen the Institute's delivery capacity for increased agricultural production.
- Establish and strengthen linkages with local and international organizations.
- Develop and promote sound and safe environmental practices.
- Commercialize soil resources research findings and services.

In line with the above objectives, R&D effort yielded the production of numerous scientific publications in renowned peer reviewed scientific journals. The Institute's scientists also participated in several conferences, workshops, field demonstrations, exhibitions and fairs to promote sustainable soil resources management technologies.

2.0 RESEARCH PROGRAMMES

2.1 SOIL CLASSIFICATION AND LAND EVALUATION PROGRAMME

2.1.1Study Title: **Soil and Land Suitability Assessment for Agricultural Project at Babator, near Bamboi, Northern Region, Ghana**

***Research Team*:** E. Boateng, P. M. Gyekye Jnr., J. Oppong and E. Akuffo
***Source of funding*:** Africa Agricultural Development Company (AgDevCo)
***Duration of Project*:** 8 months

Introduction

This Soils and Land Suitability Assessment forms part of the feasibility studies for the establishment of an irrigation scheme at Babator, Bamboi District. The soil surveys and land suitability studies were undertaken by the Soil Research Institute on behalf of the Africa Agricultural Development Company (AgDevCo); a company incorporated in the United Kingdom, whose main objective is to promote the establishment of commercial viable irrigation schemes in selected African countries. In this case, the client's intention is to acquire a parcel of land (approximately 10,000 ha) at Babator, assemble all the basic information necessary to implement irrigation agriculture and develop it for ultimate management by local commercial famers.

Objectives

The study aimed at undertaking a detailed soil survey and land suitability assessment at a proposed commercial farm block near Babator, Northern Region, Ghana, for large scale irrigated agriculture. The objectives were:

- to identify the different soils occurring in the target development block and to classify them into individual soil types of soil series;
- to group individual soil types into mapping units;
- to assess the suitability of the soils for the cultivation of irrigated rice and other crops, such as maize, soya and/or other grains or pulses;
- to demarcate areas that are either suitable or unsuitable for the production of the

selected crops; and

- to estimate the amount of suitable arable and irrigable land area for selected crops.

Methodology

Field soil examination was carried out according to the grid method, guided by findings of previous soil surveys by Adu (1965) and Soils Incorporated (2013). The soil association map produced by SRI together with the soil map produced at the reconnaissance level by Soils Incorporated Pvt. Ltd. served as soil baseline information. GPS recordings of soil observations were used to map the soil. The observations were made along transects at intervals of 400 m, and two baselines running parallel at 3 km interval between them from the western boundary to hit the river on the eastern boundary, (generated using ESRI ArcGIS software). At each augur point, soils were identified by their series names on the basis of baseline information on the land, which included parent material of the soil, presence of surface materials, color, texture, structure, presence of concretions, stones or gravel content, drainage class, root density and position of soil on the toposequence. The double ring infiltrometer was used to determine the infiltration rates of the soils near the area where profile pits were dug. It was only at Pit 1 where a layer of iron pan made infiltration very slow and therefore the auger hole method was used.

Soil samples were collected from the 15 soil pits as well as from auger sampling sites for laboratory analysis. The samples were air-dried, crushed and sieved to retain the <2mm material for analysis for the following parameters: Soil pH and Electrical conductivity, Total Nitrogen, Organic Carbon, available Phosphorus (P) and Potassium (K), Total Phosphorus (P), Exchangeable Basic Cations i.e., Potassium, Calcium, Sodium and Magnesium, Exchangeable acidity (Al+H), Sulphur, Manganese, Zinc and Copper, Soil Texture, Effective CEC, Al saturation, Soil Organic Matter.

A suitability assessment for irrigation was carried out based on FAO Guidelines of land evaluation for irrigated agriculture, an FAO soils bulletin No.55. A land evaluation was also carried out based on the FAO methodology for land evaluation as presented in Land evaluation Part III.

Results

Soils of the Study site

Soils of the area were grouped into moderately well to well drained upland soils and imperfectly to poorly drained flat valley bottom soils. Soils developed over voltaian rocks, mainly shale and sandstones are grouped into the *Kpelesawgu-Damongo* complex and those developed over sandstone and Volta alluvium also grouped into *Siare-Nterso* complex (Adu, 1995).

Within the selected site, the soils developed over shale were identified as *Lima* or *Volta series* which occupy the low lying, flat and valley bottoms. *Lima series* was further subdivided into *Lima 1*, *Lima 2*, *Lima 3* based on profile characteristics and texture. These are areas which tends to be inundated every year during the rainy season as a result of the medium to heavy textured (silty loam/silty clay loam) nature of the soils. The soils are moderately deep to deep, imperfect to poorly-drained as exhibited by their grayish color and frequent distinct mottles.

The *Siare-Nterso* complex which forms the flat upland soils is derived from sandstone/alluvial deposition from the Black Volta. Membership of this soil complex consists of *Kunkwa*, *Sirru*, *Lapliki*, *Siare*, *Dagare*, *Nterso* and *Zaw series*. Except for *Kunkwa series* which is sandy and is excessively well drained, these are moderately well to well drained soils and are medium to coarse grained sandy loams and sandy clay loams. The soils are moderately deep to very deep (1.5-1.8 m) except *Nterso* and *Zaw*, which are shallow and may encounter ironstone conglomerates and packed quartz gravel at shallow depths.

Briefly, the soils associated with the landscape, as presented in Figure 1, are categorized as follows:

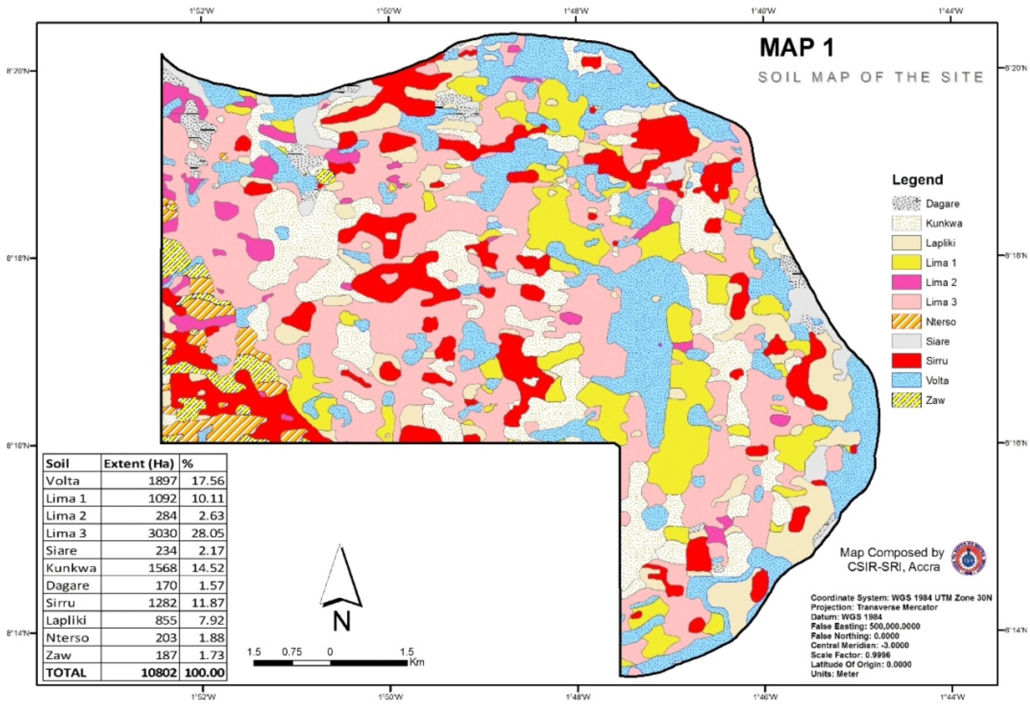
A - The lowland soils are made up of the following:

Lima 1 series (EutricPlanosols)(normal Lima) - light textured top-soils up to max 40 cm depth, over medium to heavy textured sub-soils of ⩾90 cm in depth.

Lima 2 series (EutricPlanosols)- Soils with pisolites and iron concretions within 30 cm and below.

Lima 3 series (EutricPlanosols)- Light textured sub-soils of up to a depth of ⩾70 cm.

Volta Series (EutricGleysol) - Light to medium top-soils over medium to heavy textured sub-soils with depth ⩾90 cm.



Soil	Extent (Ha)	%
Volta	1897	17.56
Lima 1	1092	10.11
Lima 2	284	2.63
Lima 3	3030	28.05
Siare	234	2.17
Kunkwa	1568	14.52
Dagare	170	1.57
Sirru	1282	11.87
Lapliki	855	7.92
Nterso	203	1.88
Zaw	187	1.73
TOTAL	10802	100.00

Figure 1. Soils of the study sites

Siare series **(EutricFluvisol)** - The topsoil consists of about 8cm of medium textured soils, overlying about 40 cm of medium to heavy textured soils. Below 50 cm to about 130 cm, the texture is medium.

B - The middle to lower slopes soils are made up of the following:

Kunkwa series **(DystricFluvisol) -** The soils are deep (>150 cm), and is made up of light textured soils throughout the profile.

The upper to middle slope soils are made up of the following:

Dagare series **(DystricFluvisol**) - The soil is medium textured throughout profile up to about 150 cm depths.

Sirru series **(ChromicLuvisol)** - Consisting of a medium to heavy textured top-soils to a depth of about 30 cm. which overlies light to medium textured sub-soils up to a depth of about 150 cm.

Lapliki series **(HaplicLuvisols) -** Similar to *Sirru series*, the soils are deep and has a light or heavy textured top-soils of about 25 cm depth. This overlies a light to medium textured sub-soils up to a depth of about 180 cm.

C - The upper slope soils are made up of the following:

Nterso series (DystricLeptosol) - It has light textured top-soils of about 24 to 50 cm depth with very few quarts pebbles. Below 50 cm depth occurs packed rounded pebbles (>80%) light to heavy textured sub-soils.

Zaw series (DystricLeptosol) - These are very shallow soils whose surface and sub soils are characterized by presence of ironpan and cobblestones. It is located on the edge of the terrace and at a lower level of *Nterso series*.

Soil Fertility Status

The pH is slightly acidic within the top soil but acidity increases down the profile to strongly acidic. Electrical conductivity ranges from 0.12-0.50 ds/m. Exchangeable sodium percentage also ranges from 3.3-9.4 percent. This indicates that the soils are non-saline and non-sodic. Total nitrogen levels (%) range from 0.01-0.05 whereas organic carbon (%) levels range from 0.1-0.54. Both nitrogen and organic matter levels are therefore very low in all horizons. Available P levels ranges from 1.05-1.26 mg/kg whereas Available Phosphorus (P) and Potassium (K) levels are below the minimum thresholds of 20 mg/kg and 40 mg/kg respectively.

Available K ranges from 16.6-22.5 mg/kg and are therefore inferred as very low. Effective CEC ranges from 1.0-4.8 cmol(+)/kg. Effective CEC is therefore very low. CEC at pH 7 were also very low. Copper and Zinc concentrations are very low (< 2 mg/kg) in all the top soils (0-50 cm) taken from the auger. Manganese and Sulphur concentrations are moderate ranging from 2-43 mg/kg and 159-225 mg/kg respectively.

Suitability of soils for selected crops

Table 1 below shows the soil suitability mapping units with the associated LUTs for the selected crops after improvement to some of the limitations. Irrigated rice is highly suitable on *Lima 1, Volta* and *Siare series*, not suitable on *Nterso, Kunkwa* and *Zaw,* and marginally to non-suitable on *Dagare, Lapliki,* and *Sirru series.* The rest of the selected crops are either highly suitable or moderately suitable on these series: *Lima 2, Lima 3* and *Kunkwa series* are suitable for sugarcane, soybean, maize, millet, sun flower and vegetables, whiles *Dagare*, *Lapliki* and *Sirru series* are high to moderately suitable for cowpea, maize, millet and pigeon pea. *Ntersoseries* is marginally suitable whiles *Zaw series* is permanently not suitable.

Table 1. Summary of soil groups with the associated LUTs

MAPPING UNIT	SOIL SERIES	CROPS	COVERAGE (HA.)	%
1	Lima 1*, Volta, Siare	Irrigated rice	2979	27.6
2	Lima 2, Lima 3, Kunkwa	Sugarcane, soyabean, maize, millet, sun flower and vegetables (green pepper, tomatoes etc.)	5417	50.2
3	Dagare, Lapliki, Sirru	Cowpea, maize, millet &pigeaon pea	2077	19.2
4	Nterso	Cowpea &soyabean (minimum to zero tillage)	131	1.0
5	Zaw	Unsuitable for agriculture	198	2.0
TOTAL			**10802**	**100.0**

* Normal Lima

The extent of land suitable for the selected crops is based on mapping units as presented in Table 1. The table has been derived from landscape and soil requirements of the individual crops. From the table, and as also presented in Figure 2, about 27.6% of the land is suitable for rice cultivation both during the dry season or normal rainy period. Approximately 69.4 % of the land is also suitable for the other selected crops. About 1% is suitable with minimum or zero tillage whiles 2% of the area is unsuitable for cultivation of any of the selected crops.

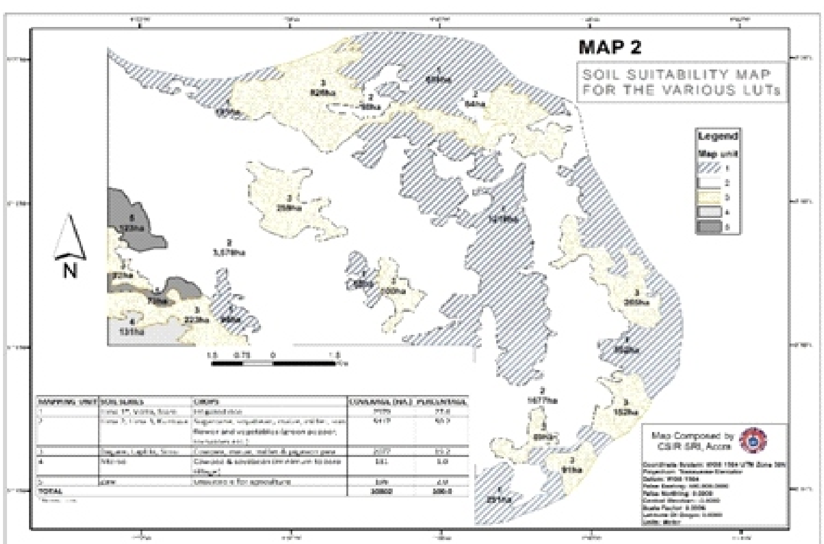


Figure 2

Conclusions and Recommendations

Summary of the soil edaphic characteristics of the selected project area shows that from the description and interpretation of the soil physical and chemical parameters, it could be inferred that the soils are generally deep to very deep with the exception of *Lima 2* and *Nterso series* which were found to be shallow and *Zaw series* which was found to be very shallow. The nutrient level of the soils could also be inferred to be low. Texture was generally medium to high except in *Kunkwa series* and *Lima 3 series* which had light textured soil throughout soil profile.

For irrigation purpose, it is better to apply larger volume of water to the coarse textured Lima soils for shorter duration and at more regular intervals as they reach saturation and steady state infiltration faster, at less than 3 hours of continuous wetting. The *Lima series* will, therefore, be more suitable for dry season vegetable cultivation under furrow irrigation. For the *Volta series* however, it takes much longer wetting period of more than 4 hours to attain saturation and steady state infiltration and in addition, its fine textured nature will allow it to pond surface water over a longer period. The *Volta series* will be more suitable for irrigated rice cultivation. In terms of irrigation, it is not advisable to adopt surface irrigation for soils with higher infiltration rates such as *Nterso, Sirru* and *Lapliki*. However, if such irrigation method is to be used for tomato cultivation, the furrows have to be short and large stream size needed to attain better uniform distribution of water and better irrigation efficiency. It is, therefore, recommended that sprinkler irrigation supplying water at short durations to only wet the root zone is more suitable for the upland soils.

Depending on the crops to be adopted, a strict fertilizer formulation and application structure must be adhered to.

References

Adu, S. V. (1965) Soils of the Navrongo-Bawku Area, Upper Region, Ghana. CSIR-Soil Research Institute Memoir No. 5, Kwadaso-Kumasi

Adu, S. V. (1995) Soils of the Bole-Bamboi Area, Northern Region, Ghana. CSIR-Soil Research

Soils Incorporated Pvt. Ltd. (2013) Reconnaissance Soils Survey of the proposed Bamboi Irrigation Project Site.

2.1.2 Study Title: **Soil and Land Suitability Assessment for Irrigated Rice Project, Adidome-Kpedzeglo area, Volta Region, Ghana**

Research Team: E. Boateng, P. M. Gyekye jnr., B.T. Kabutey
Source of funding: Radikal Overseas Pvt. Ltd.
Duration of Project: 2 month
Project Cost: $21,792.00
Year: 2013

Introduction

This Soils and Land suitability Assessment forms part of the feasibility study contracted to the Soil Research Institute by Radikal Overseas Pvt. Ltd; a company incorporated in India. The intention of the client was to acquire a parcel of land (approximately 20,000 ha) at Adidome, and assemble all the basic information to implement the cultivation of irrigated rice. The overall goal of the soil survey was to assess the suitability of the soils for agriculture on 41,000 hectares of land, and to select approximately 20,000 hectares of this land that would be suitable for irrigated rice production.

Objectives

The objectives of the study were:

1. To identify and characterize the different soil types occurring in the area
2. To determine the general fertility status of the soils.
3. To map out areas suitable for rice production under irrigation
4. Provide recommendations for fertility management for achieving higher sustained rice yield.

Methodology

The field survey relied on information provided by the existing studies (Asiamah, 1995). The soil association maps produced by the reports were geo-referenced and were clipped with the boundary of the area to serve as baseline information.

Soil identification and characterization were carried out along all accessible routes in two pick-up vehicles, on the site (41,000 ha approximately). At every 1 km or less, the survey team stopped and identified soil type with an auger. Short transects were also made perpendicularly from the main route towards the river to establish the toposequence of the soil, which were identified by their series names. Six of the auger borings were sampled at different depths and prepared for laboratory analysis. In addition six profile pits representing the most extensive soils were dug and described according to 'Field book for describing and sampling soils' (NSSC, 2002), after which samples were taken at each genetic horizon for laboratory analysis. In all, about sixty samples were taken for laboratory analysis.

A hand held GPS was used to record the coordinates (latitude and longitude) and the altitude. The GPS points were transferred unto the base map which was then overlain on an ASTER DEM. On the basis of additional information obtained from the field the soil boundaries were redrawn (interpolated) and a soil series map was produced at a scale of 1:5,000, which aided the selection of about 20,000 ha of land as good for the cultivation of irrigated rice.

For the assessment of the fertility status of the soils, some chemical and physical properties were determined on 60 samples. Laboratory analyses were carried out on air-dried, crushed and sieved fine earth fraction of (<2 mm soil) samples.

Results

Soils of the Study site

The findings of the soils in the study area, as presented in Figure 2, are as follows:

Agawtaw series **(Calci-stagnicSolonetz FAO, 1990)**

This includes imperfectly to poorly grey soils with sand or sandy loam topsoil overlying a compact (hardpan) layer which grades down into a calcareous clay substratum overlying wet gneiss. It is developed over gentle middle and lower slopes.

Pejeglo series **(StagnicSolonetz FAO, 1990)**

This series has deep, imperfectly drained very dark brown to very dark grey brown sandy clay loam to clay loam topsoil (0-44 cm), overlying subsoil made up of greyish brown sandy clay having few calcium carbonate nodules and manganese dioxide concretions.

Motawme series **(EutricGleysol, FAO 1990)**

This comprises grey, heavy, alluvial clays developed along the valley. It appears to be more extensive than *Tondo series* and is easily differentiated from it at the surface by the lack of gilgai micro-relief and surface cracking.

***Makuvi series* (DystricVertisols, FAO 1990)**

This series includes black clays occurring patchily amongst *Agawtaw* soils. They occur on all topographical sites except valley bottoms. There may be about 3 cm of black sandy loam or very dark grey sandy clay at the surface. This layer is plastic when wet, but dries very hard and cracks vertically from the surface. Below about 45-60 cm, the clay becomes olive-grey to live-brown in colour and calcium carbonate concretions appear and

***Tondo series* (EutricVertisol, FAO 1990)**

These series includes very heavy, black, cracking clays occurring in irregular patches along the depressions. The soils are characterized by pronounced gilgai micro-relief - the ground-surface consisting of mounds and hollows, the mounds up to 60 cm high and 1.5-6 cm or more in diameter.

***Chiwi series* (EutricGleysols, FAO 1990)**

This series occurs extensively on lower slopes to bottoms in association with *Ziwai series*, more especially in Ziwai consociation. It comprises imperfectly drained soils with 26-75cm of grey-brown sand overlying olive-brown, mottled, gravelly, sandy clay containing calcium carbonate concretions.

***Ziwai series* (DystricPlanosols, FAO 1990)**

This is the most extensive individual soils series occurring on the area surveyed. It occurs extensively on gently undulating to gently rolling upland topography and comprises pale brown sands overlying rather impervious, mottled, gravely clay resting on weathering acidic gneiss.

***Zebe series* (Dystric Planosols, FAO 1990)**

This series is closely similar to *Ziwai series*, but is generally finer in texture, shows a more gradual change from sand to clay down the profile, is more yellowish in colour and occurs on rather flatter topography. Soils of this series occur patchily amongst *Ziwai series*, especially Ziwai-Zebe complex, and all transitional stages between the two soils are found. It is rare possible to draw a firm boundary between them in the field.

Fertility Status and matching of growth and production requirements for irrigated rice against soil resources data

Table 1 indicates that the soils of the site are deep and have almost neutral pH values, whilst

Organic Carbon (OC) values are low. Electrical conductivity (EC) and Exchangeable sodium percentage (ESP) values are both low in the top soils. This implies that the soils are non-saline and non-sodic. The texture of the top soils ranges from sandy loam to sandy clay loam whilst the subsoil texture ranges from sandy clay loam, sandy loam, clay loam or clay. Cation exchange capacity (CEC) ranges from low to moderate.

Table 1: Soils and their major chemical characteristics (0-50cm)

Soil unit	Depth (cm)	CEC at pH 7 (Cmol(+)/kg)	pH (H_20)(1:2.5)	EC (dS/m)	OC %	*ESP %	Soil Texture	
							0-50cm	>50cm
Agawtaw	>120	13.1	7.3	0.75	1.04	3.9	SL/SCL	SCL/C
Pejeglo	>150	9.8	6.8	0.21	2.1	5.3	SCL/SiL	SL/LS
Motawme	>150	13.1	7.1	0.32	1.01	7.5	SCL	SL/CL/C
Tondo	>170	16.0	7.2	0.23	1.00	2.5	SL	CL/C
Makuvi	>180	9,7	7.4	1.59	0.91	11.0	SCL	C
Chiwi	>150	9.1	6.8	0.59	1.02	13.1	SL/L	SL

Table 2 shows the results of 'matching' growth and production requirements against soil data obtained from the proposed site. The method used was the simple limitation method whereby the final suitability class of the soil for irrigated rice was based on lowest suitability rating for the individual soil characteristics.

Table 3: Summary of soil suitability ratings for selected crops

Crop/Soil	Soil suitability ratings					
	Agawtaw/	Pejeglo	Motawme	Tondo	Makuvi	Chiwi
*Rice (IR)	S2tf	S2tf	S2tf	S2tf	S2tf	S2tf
**Rice (IR)	S2t	S2t	S2t	S2t	S2t	S2t

*Rice (IR) - current suitability

**Rice (IR) - potential suitability after improvement to fertility limitation

From Table 2 above, irrigated rice is moderately suitable on all the soil types with texture and fertility being the major limiting factors. Fertility status could be improved with adequate and right proportions of the necessary fertilizers.

Evaluation of the major soils for irrigated rice production

Evaluation of the soils was limited to valley bottom and flat lands. The upland soils were excluded in this exercise since they have been considered as not suitable for irrigated rice. For this reason chemical and physical analysis was concentrated on soils from the valley bottoms and flat lands. The major soils in the valleys and flat areas are *Agawtaw, Pejeglo, Motawme, Tondo, Makuvi* and *Chiwi series.*

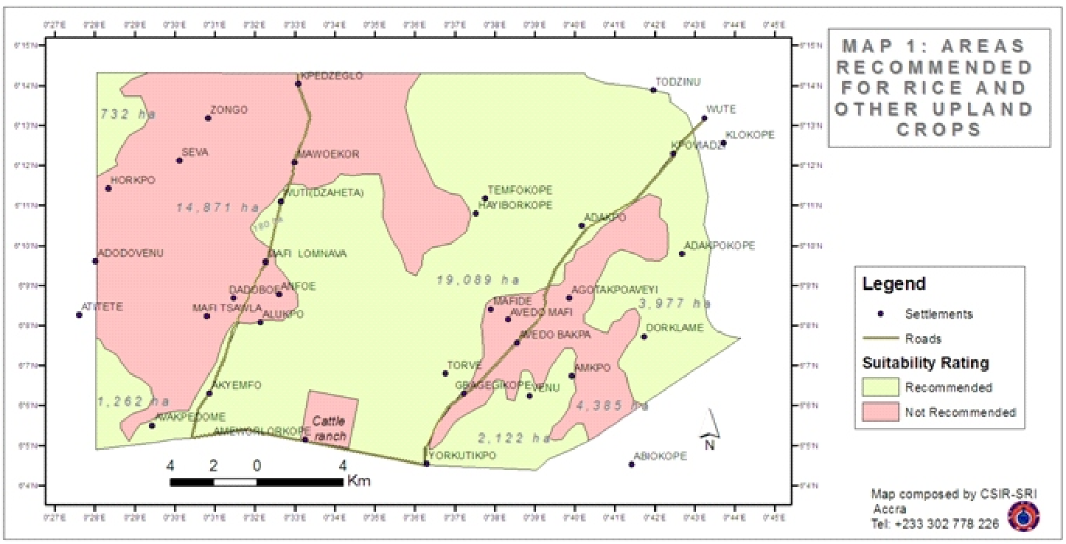


Figure 3

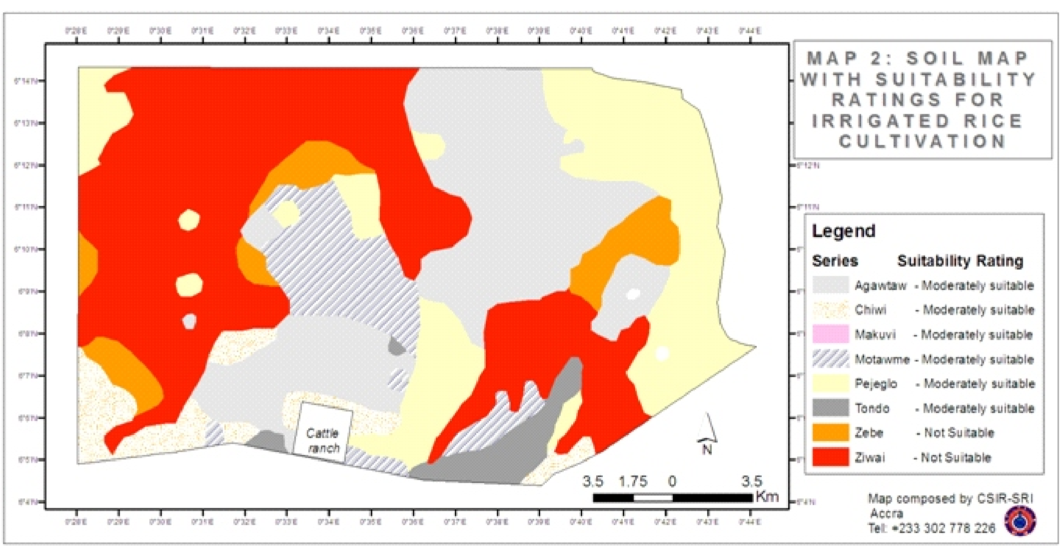


Figure 4

Conclusion and Recommendations

All soil types in the selected area are deep, medium to heavy textured, moderately suitable for irrigated rice production. All the soil types encountered within the selected area are deep and free from gravel. The sandy nature of its top soil will accelerate droughty conditions in the dry season and conversely periods of severe water logging with stagnant conditions in the top soil. One major limitation to crop production is due to the low fertility status of the soils. Available P and K, total nitrogen, organic carbon were very low in almost all the soils.

To enhance soil productivity, it will be necessary to apply both organic and inorganic fertilizer as well as practice crop rotation. Since the area is noted for cattle rearing, cow dung could be a source of organic manure. In addition, green manuring and composting could also serve as organic source for improvement of the soil fertility and physical status. Deep ploughing is recommended on *Agawtaw* and *Pejeglo series* to break the pan layer just beneath the A-horizon. For full characterization of soil types and precise soil map, a detailed soil investigation (Grid soil mapping) is highly recommended. This will also involve determination of infiltration rates and hydraulic conductivity of the different soil series to enable an assessment of the permeability and percolation losses during irrigation.

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2.1.3 Study Title: **Assessing cassava production at Kabilkpe, Northern region**

Research Team: B. O Antwi, and E. Asamoah
Collaborating Institutions: Premium Foods Ltd
Source of Funding: Premium Foods Ltd.
Duration of Project: 2013

Introduction

Premium Foods Ltd (PFL) proposes to undertake a corporate social responsibility project with some communities in Northern Ghana. The selected communities are in a partnership with the company in mutually agreed terms of remuneration. Some sites have been proposed by the chiefs of Kabilpe and Busunu for cassava production. The objective was to present a pre-feasibility study of the proposed sites for cassava and cowpea production.

Method

The team, together, with some natives observed the proposed sites. At various observation points, geo-referenced augerholes were used to identify the textural classes of the soils with depth. Since the sites were dry for six months of the year, soil property predictions were made of the suitability of the soils for cassava and cowpea production based on soil moisture availability. Long term monthly weather data for nearby weather station (Tamale) was studied. Based on the observations, analysis of alternatives of the system was undertaken.

Results

The investigations revealed that, the climatic condition is unimodal and marginally suitable for cassava. Hydrogeological rating shows that about 50% of investigated sites can support cassava production under well-managed conditions. Unsuitable soils have shallow depths to iron pan formations. The soils were sandy to fine sandy loams that required supplementary irrigation. Depth of soils ranges from 30 to over 80 cm. Field slopes ranged from 1 to 3% in most places. The soils are moderately well-drained with ironstone gravel concretions underlain by iron pans at various depths (Table1).

Table 1 Hydrogeological rating of Lingbinkura site for cassava production

Point	Northing(30P)	Eastern	Elevation (m)	Description	Suitability
1	673586	977912	119	Iron pan at soil surface	X
2	673597	977955	113	Fine sand to silty clay loam with 70% gravel to 50 cm	xx
3	673765	977946	118	Fine sand to sandy loam (60 cm)	xx
4	673930	977913	119	Fine sandy clay to sandy loam (100 cm), poor internal drainage	xxx
5	674264	978015	118	Fine sandy loam, iron concretions (70 cm), poor internal drainage	xxx
6	674955	978245	116	Fine sandy loam, with stiff clay at 70cm, poor internal drainage	xxx
7	675249	978275	111	Fine sand with iron pans (30 cm)	X
8	675822	978206	111	sandy soil (30cm), concretions (30 -80 cm)	X
9	676202	978024	115	Fine sandy soil (100 cm); good internal drainage	xxx
10	676713	977827	113	Fine sandy loam (30-95 cm), Gravel at depths >95 cm Good internal drainage	xxx
11	676890	977793	110	Loam over gravel at shallow depth (30 cm)	X
12	677224	977633	108	Iron pan on surface	X
13	677417	977564	99	Flat land covered by iron pan	X

NB: Not suitable (x); moderately suitable (xx); Suitable (xxx)

Analysis of alternatives indicates that relay cropping incur profit losses than sole cropping. Percent reduction in profit obtained through relay cropping of cassava and cowpea ranges from 66 % from soils > 80 cm depth to 104 % on soils with depth 40 cm. However, the % reduction in profit reduced to 10 - 26 % in the second year. Similarly, percent reduction in profit compared to planting sole cowpea ranged from 84% to 101 % for the first year. In the second year, percent reduction in profit compared to sole cowpea ranged from 13 % to 27 %. These differences are attributed to first year land preparation cost and land area reductions from inter relay cropping. However, discounting the benefits from relays in terms of nitrogen fixation by cowpea in the second year, the profit reduction in the relays was only due to land area reduction.

Conclusion

These sites can be used for cassava production using the ridging or bund-forming system. However, there is the need to delineate the soils based on soil depth to categorize them for planning purposes. Where cassava cannot survive, cowpeas may do well. It is recommended that the land can be used for profitable cassava/cowpea production under irrigation.

2.1.4 Study Title: **Soil type selection to meet water requirements for cassava production**

Research Team: B. O Antwi, and E. Asamoah
Collaborating Institutions:
Source of Funding:
Duration of Project: 2013

Introduction

Cassava is one of the major crops promoted to alleviate poverty and hunger in the Ghana. However, under weather variability and climate change issues, cassava production reduces in yield and quality. The study was to address yield reduction of cassava from soil moisture stress perspective.

Method

Participatory approach was used. Workshops and field discussions were held with cassava farmers from the Semi-deciduous ecological zone, Forest-Savanna-Transition, and the Savanna zone of Ghana to address soil-related issue in water stress to cassava production. The process identified soils suitable for cassava production based on textural class and soil depth. The USDA model was used to determine water soil water retention of the suitable soils.

Results

Table 1. Available water capacities of some Ghanaian soils

Soil series	Texture	Available moist. (mm/60cm)
Damango	Sand	<40
Bediesi, Amantin, Ejura, Temang, Nta	Loamy sand	48 - 58
Lima, Channalili, Kokofu	Sandy loam	60 - 72
Oda, Kungwani	Silty clay loam	100 - 105
Pimpimso, Kumasi, Asuansi	Sandy clay loam	90 - 100

The results from participatory discussions indicated that cassava production is an issue of time. Late planting needs to be avoided to reduce moisture stress at critical periods on the crop. This is critical when there is long duration of water deficit at one month after planting and 4-7 months after planting. Table 1 shows soil types on which farmers plant cassava and estimates of the available water capacities within the rooting zone. The results show that in terms of available soil water, silty clay loams and sandy clay loams are able to retain and release more soil moisture for the crop. It was recommended that long term climatic data was necessary to study weekly to monthly rainy days to guide planting of the crop under rainfed conditions. Organic matter may be incorporated into the soil to improve water holding capacity.

2.2. SOIL FERTILITY MANAGEMENT PROGRAMME

2.2.1 Study Title: **Assessing the efficacy of Imidacloprid 20% SL as an insecticide against aphids in cultivated okra plants in a tropical ecosystem: a case study of Mamponteng – Kumasi, Ghana for the 2011 and 2012 cropping period.**

Research Team: E. Amoakwah and Frimpong-Manso Judith
Collaborating Institutions: Department of Chemistry, School of Physical Sciences, University of Cape Coast, Cape Coast – Ghana

Introduction

Okra, *Abelmoschus esculentus* is mainly grown for its young immature pods which are consumed as a vegetable. Okra is a vegetable widely grown in Ghana. In the African context, okra has been called as —a perfect villager's vegetable because of its robust nature, dietary fibers and distinct seed protein balanced in both lysine and tryptophan amino acids it provides to diet (NAP, 2006). Okra is also rich in minerals, carbohydrate fibre, protein, fat, and phenols (Arapitsas, 2008). These properties, along with the high content of carbohydrates, proteins, glycol-protein, and other dietary elements enhance the importance of this foodstuff in the human diet (Arapitsas, 2008).

In Ghana, the plant is attacked by aphids (*Aphis gossypii* Glover) that have the tendency to hamper the growth of the crop (okra) and subsequently reduces yield (Obeng-Ofori and Sackey, 2003). A field experiment was conducted to find the biological efficacy of imidacloprid 20 % SL on aphids in okra.

Materials and Methods

Experimental design:

Okra seeds were hand-sown with intra-row spacing of 0.50 m and inter-row spacing of 0.80 m. Plots were separated by 2 m wide border margin and blocks by 3 m. Plot sizes were 25 m^2 and each plot consisted of 6 lines of 5 m. Nitrogen and phosphorus fertilizers were applied in the form of Diammonium phosphate (DAP) and ammonium nitrate respectively. DAP was applied at the time of planting at the rate of 120 kg/ha.

Ammonium nitrate was applied 21 days after planting at the rate of 60kg/ha as a top dresser. A Randomized complete Block Design with 4 treatments and 4 replications was used. The treatments considered for the field experiment were 3 doses of imidacloprid 20% SL (25g, 50g and 75g active ingredient per ha) and an untreated plot serving as the control.

Data sampling:

The number of aphids present on 25 randomly chosen plants per plot was counted in-situ on a biweekly basis. Counting of aphids on the plants (okra) was done in the morning between 8 and 9 am. The selected plants were subsequently visualized, and quantification of the damages on the leaves was done by scoring the percentage of defoliation. Fresh fruits were harvested from all the plants in the plots at weekly intervals for four consecutive weeks before lignification.

Results and Discussion

Infestations started from 30 to 33 days after planting in 2011 and 2012 planting years respectively. In both seasons, plants in the untreated plots recorded the highest mean number of aphids whereas those in the Imidacloprid-treated plots had the lowest mean count.

Aphid population was observed to be significantly (P > 0.05) lower in the treated plants than the untreated plants in both years irrespective of imidacloprid 20% SL doses. The imidacloprid treatments induced an average reduction of aphids' population on treated plots.

(A) (B)

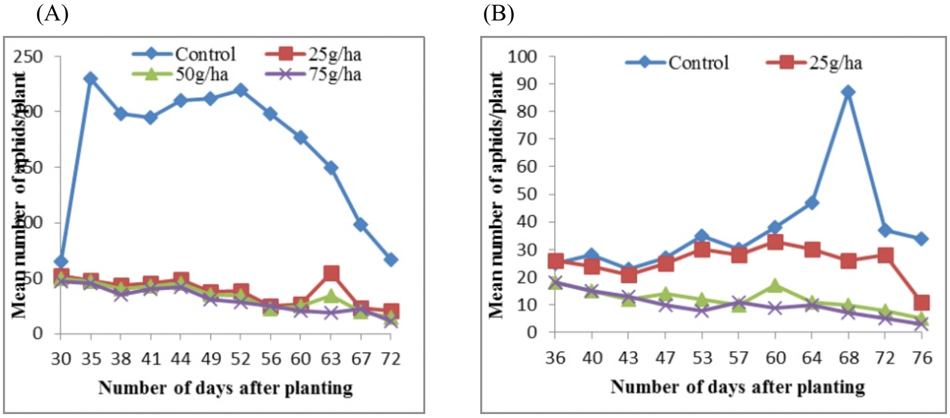

Figure 5. Temporal variation of mean number of aphids on okra treated with increasing doses of imidacloprid 20% SL in 2011 (A) and 2012 (B).

The significantly lower yield observed in the untreated plot may be attributed to the heavy infestation of aphids, resulting in the growth of sooty mould on the leaves of okra, which reduces the photosynthetic ability of the leaves, with a consequent lower reduction in the yield (Obeng-Ofori and Sackey, 2003) (Figure1). This present study shows that imidacloprid-treated plots had relatively more yield than the control (Table 1), which conforms to the findings of Bhargava *et al*. (2001) who observed that the use of imidacloprid results in better yields in okra production due to its effectiveness in controlling aphids.

Table 1. Effects of increasing doses of imidacloprid 20% SL treatments on okra fruit yield

Treatment	Fresh fruit yield	
	2011	2012
Untreated control	0.46 a ± 0.30	0.46 a ± 0.53
25g/ha	1.58 b ± 0.82	1.33 b ± 0.21
50g/ha	1.59 b ± 0.20	1.59 b ± 0.54
75g/ha	1.58 b ± 0.82	1.68 c ± 0.77
	P>5%	

*The data in the table are means of 4 replications

[a] rows that have common superscripts are not significantly different

Conclusion

The significant difference observed in the imidacloprid-treated plots as compared to the untreated (control) plot suggests that, infestation of aphids can result in higher yield reduction. Imidacloprid 20% SL was effective against aphids in okra plants. Effective control of aphids in okra plants is achieved when treatment is started at the early onset of aphids' infestation. The results show that efficacy of the insecticide is found to have a positive correlation with the rate of nutrient application.

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2.2.2 Study Title: **Relationships between Potassium Forms and selected Physico-Chemical properties of some Ghanaian soils along a Toposequence**

Research Team: E. Amoakwah

Collaborating Institutions: Department of Soil Science, School of Agriculture, University of Cape Coast, Ghana

Source of Funding: UCC

Duration of Project: 2013

Introduction

Potassium (K), which is a major constituent in all living cells is required in large amounts by plants, animals and humans (Hamdallah, 2004) because it plays a critical role in plant nutrition and physiology. Uptake of K by many plants is frequently greater than of nitrogen and phosphorus. This macronutrient is extracted in large quantities by intensive cropping systems (Panaullah et al., 2006). There is a general assumption that most tropical soils contain adequate amounts of K to sustain crop growth most probably due to the dominance of K bearing minerals such as illite etc, but the increase in intensity of cropping, leaching and introduction of high yielding varieties in various cropping systems (Moshen, 2007) have resulted in considerable drain of soil K reserves and crops are becoming responsive to K fertilization (Bukhsh *et al*., 2012). In some soils the exchangeable K, which is held onto the soil colloidal surface may be released for plant uptake when the labile K pool is exhausted, but Bhaskarachary (2011) noted that the release of exchangeable K is not fast enough to meet the requirement of rapidly growing crops.

Due to the paucity of information regarding K behaviour in agro-environments, many Ghanaian farmers do not apply K fertilizers even under continuous cropping systems and the few who do, apply K fertilizers in quantities that render crop production unsustainable (Yawson *et al*. 2006).

The objective of the study was to determine the distribution of K forms in some soils along a toposequence and examine the relationships existing between the K forms and selected physicochemical properties of the soils.

Materials and Methods

The soils (0-20 cm) used for the study were collected along a toposequence at the University of Cape Coast Research and Teaching farm in the coastal savanna agroecological zone of Ghana. The soils are the *Edina, Atabadzi, Benya, Udu* and *Kakum* series, which form the Edina Catena. The soils were all developed on sandstones, shales and conglomerates and are classified as Haplic Acrisol (FAO, 1977). In each of the five series, five soil samples were randomly collected and thoroughly mixed to form the composite sample. The samples were bagged and labeled accordingly. The soil samples were air-dried for 48 hours, crushed and passed through a 2 mm mesh sieve. The fine earth fractions (< 2mm) were used for laboratory analyses. All physic-chemical properties of the soil series were carried out by following the standard laboratory protocols.

Data analyses were performed with the SPSS 11.0 statistical package (Windows Microsoft, 2006). Differences between the means of the different K forms measured in the same soil series, and differences between specific K forms measured in the different soil series were compared using Tukey's least significant difference (LSD) test.

Results and discussion

The concentrations of total K in the soils ranged from 0.64 to 2.37 (cmol (+) kg^{-1}) with *Kakum* series showing the lowest ($P < 0.05$) value. Water soluble K and exchangeable K concentrations in the soils ranged from 0.05 to 0.25 c mol (+) kg^{-1}, and 0.26 to 0.89 cmol (+) kg^{-1}, respectively, with the *Kakum* series again showing the lowest values ($P < 0.05$) for both K forms. The *Edina* series, occurring at the summit of the catena, showed the highest concentrations of both water soluble and exchangeable K. In the study non-exchangeable K concentrations measured in the soils varied between 0.20 and 1.25 cmol (+) kg^{-1} (Table 1). The study showed that exchangeable K constituted the highest proportion of the total K measured in the soils, while the proportion of water soluble K in the total K measured was the lowest.

Table 1 Levels of the various forms of potassium in the studied soils

Soil series	Total K (cmol(+)kg^{-1})	Water Soluble K (cmol(+)kg^{-1})	% of Total K	Exch. K (cmol(+)kg^{-1})	% of Total K	Non-Exch. K	% of Total K	% K Saturation	Available K (cmol(+) kg^{-1})
Edina	1.26 (0.01) a	0.23 (0.01) a	18.46 (0.02)	0.83 (0.03) a	65.44 (0.03)	0.20 (0.01) a	16.10 (0.01)	11.9 (0.01)	1.06 (0.00) a
Atabadzi	2.30 (0.03) b	0.18 (0.03) b	7.99 (0.00)	0.89 (0.03) a	38.61 (0.04)	1.23 (0.03) b	53.41 (0.02)	15.8 (0.02)	1.07 (0.00) a
Benya	2.37 (0.01) c	0.24 (0.00) c	10.12 (0.02)	0.88 (0.01) b	37.27 (0.02)	1.25 (0.03) c	52.60 (0.03)	13.7 (0.03)	1.12 (0.01) b
Udu	0.90 (0.03) d	0.11 (0.03) d	11.93 (0.02)	0.48 (0.03) b	53.16 (0.02)	0.31 (0.00) d	34.19 (0.01)	5.5 (0.00)	0.59 (0.00) c
Kakum	0.64 (0.01) e	0.05 (0.01) d	7.83 (0.01)	0.26 (0.00) c	40.86 (0.00)	0.33 (0.00) d	51.31 (0.01)	2.7 (0.01)	0.31 (0.03) d

Means in the same rows with different letters are significantly different at $P < 0.05$ by LSD. Values in parenthesis represent ± 1 standard error.

All the K forms positively correlated ($P < 0.05$) with organic carbon. Soluble and exchangeable K forms positively correlated with organic matter, with correlation coefficients (r) of 0.567and 0.701 for water soluble K and exchangeable K respectively. This observation may be attributed to the fact that, tropical soils are often characterized by variable charge systems (i.e. pH dependent charges), indicative that the creation of charges on tropical soil colloids depends on soil pH. Thus, the charge generated could either be positive or negative depending on the pH of the soil. Soil colloids acquires their charges either by dissociation of H^+ from or onto the active functional group (Van Ranst, 2006) and as the pH of the soil increases, the H^+ ions on the functional groups of organic matter dissociate, resulting in the creation of negative charges on the organic matter. The negative charges created therefore have affinity for K^+ ions, hence the positive correlation between organic carbon and the K forms observed.

Negative correlation was observed between the K forms and Al^{3+}, with correlation coefficients of -0.740, -0.957, -0.965, and -0.973, for total K, water soluble K, exchangeable K, and available K, respectively. At low pH, Al^{3+} becomes preponderant in the soil solution and therefore saturates the exchange complex. The positive charges created under high Al^{3+} and low pH conditions are likely to repel the positively charged K^+ ions, and under intensive rainfall, there is the tendency that the K^+ ions in solution will be lost of through leaching. This conclusion is further confirmed by the observation that the water soluble K, exchangeable K and available K concentrations significantly ($P < 0.05$) correlated positively with soil pH. Additionally, the study demonstrated that water soluble K and exchangeable K significantly ($P < 0.05$) correlated positively with cation exchange capacity (CEC) (r = 0.945 and 0.915 respectively) and percentage base saturation (%BS) (r = 0.806 and 0.664 respectively). However water soluble K and exchangeable K significantly ($P < 0.05$) correlated negatively with the effective cation exchange capacity (ECEC) (r = -0.843, and -0.968 respectively). Furthermore, water soluble K and exchangeable K significantly ($P < 0.05$) correlated negatively with moisture content (r = -0.787, and -0.827 respectively).

Conclusion

The study showed that the exchangeable and non-exchangeable K constituted over 75% of the total K in the soils. However, the non-exchangeable K pool in the soil can serve as K reserves, which can slowly release available K to satisfy crops requirements when the soluble and exchangeable K pools becomes depleted. The study also demonstrated that the water soluble and exchangeable K concentrations in the soils were positively influenced by increasing organic carbon content and percentage base saturation, whiles low soil pH and high exchangeable acidity negatively affected K availability in the soils.

Percentage K saturation values found in the soils also were high, but the overall low CEC values measured in the soil suggest that the soils are not adequately supplied with available K. It can therefore be concluded that potash fertilization would be required for sustainable crop production in the soils studied.

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2.2.3 Study Title: Effect of cover crops relay on maize yield and soil N at different agro-ecological zones of Ghana

Research Team: R.N. Issaka, M.M. Buri, E.O. Adjei

Collaborating Institutions: JIRCAS, CSIR-SARI

Source of Funding: JIRCAS

Duration of Project: 2010-2015

Introduction

The study has been strategically located at Kwadaso, Ejura, Nyankpala and Manga to represent the Forest, Forest-Savanna Transition, Guinea Savanna, Sudan Savanna ecological zones of Ghana. The main objective of this study is to develop cropping systems and soil fertility management techniques based on conservation agriculture suitable for each agro-ecological regions in Ghana.

Materials and methods:

Experimental Design:

Randomized Complete Block Design arranged in a split plot with four replications.

Main plot Treatment: Tillage

- Minimum Tillage (MT)
- Full Tillage (FT)

Sub plot: Cover crop

A: Mucuna (no fertilizer)

B: Pigeon pea (no fertilizer)

C: Cow pea (no fertilizer)

D: Continuous Maize cropping (no fertilizer)

E: Continuous Maize cropping (60-40-40 kg N-P_2O_5-K_2O/ha)

*At Kwadaso all the plots were fertilized

Plot size: 4.8 m x 4.0 m

Maize variety *Obatampa* was used for all the 4 study sites with plant spacing of 80 cm x 40 cm

Mucuna and cowpea were planted when maize was about four weeks old. Mucuna and cowpea were planted in-between maize rows and at intra-row spacing of 20 cm. Pigeon pea was planted 2 weeks after planting maize and on the same row as maize (thinned to 1 plant/hill at 4 weeks after planting)

The various study sites and their geographical positions are presented in Table 1 and Figure 1.

Table 1. Location and agro-ecological zones of the various sites

Location	Agro-ecology	Elevation	Latitude (N)	Altitude (W)
Manga	Sudan savanna	211m	N 10°57' 54.8"	W 0°15' 14.0"
Nyanpala	Guinea savanna	188m	N 9°23' 21,7"	W 1°0' 28.6"
Ejura	Transitional zone	221m	N 7°24' 14.1"	W 1°20' 42.1"
Kwadaso	Forest zone	262m	N 6°40' 35.9"	W 1°40' 0.6"

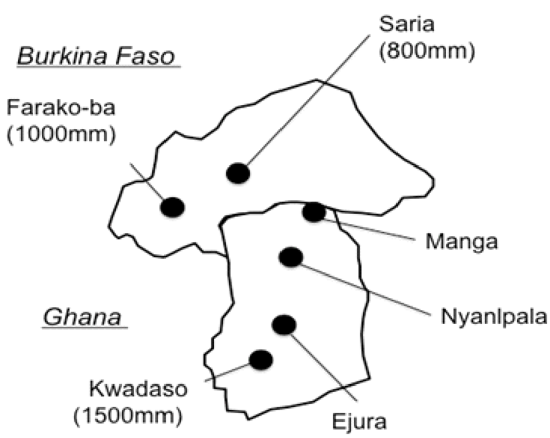
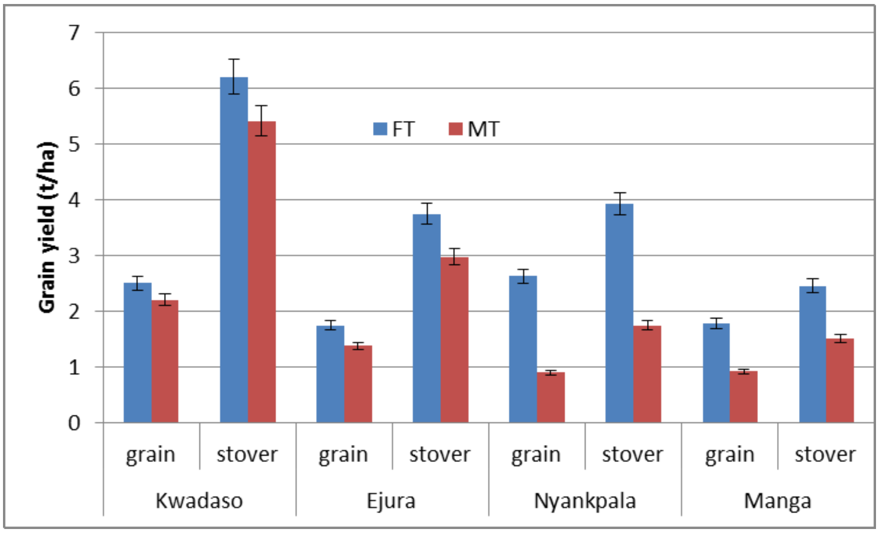


Figure 1. Study sites in Ghana and Burkina Faso.

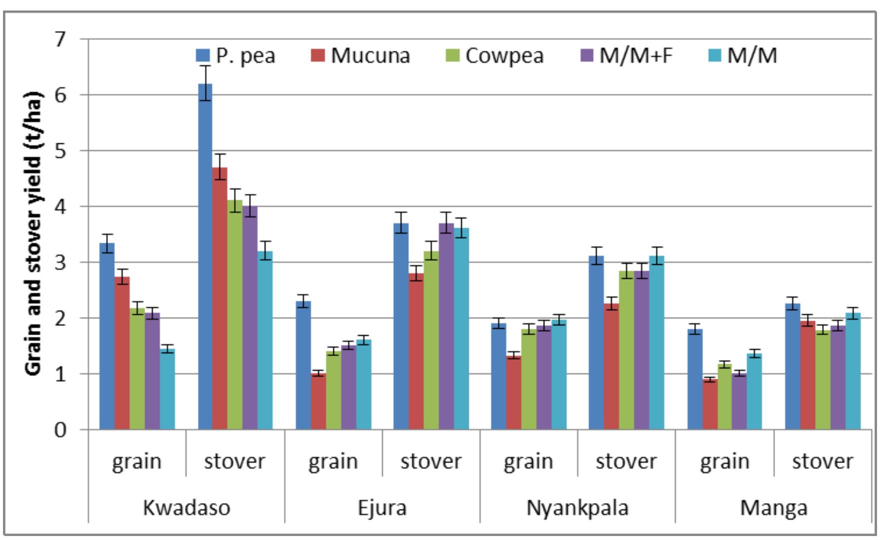
Results



FT:- full tillage. MT:- minimum tillage

Figure 2. Effect of tillage practices on grain yield at the four sites

Except at Kwadaso where grain yield for FT and MT were similar, yield was generally higher under FT than MT at Ejura, Nyankpala and Manga (Figure 2). Lack of adequate plant cover (on the soil) and serious weed problems are major reasons why MT gave lower yields than FT.



P. pea:-pigeon pea. M/M+F:- maize-maize +fertilizer. M/M:-maize-maize

Figure 3. Effect cropping systems on grain yield at the four sites

Intercropping maize with pigeon pea gave significantly higher grain yield at Kwadaso, Ejura and Manga (Figure 3). Maize- mucuna intercrop was only good at Kwadaso but almost the worse combination at all the other three sites.

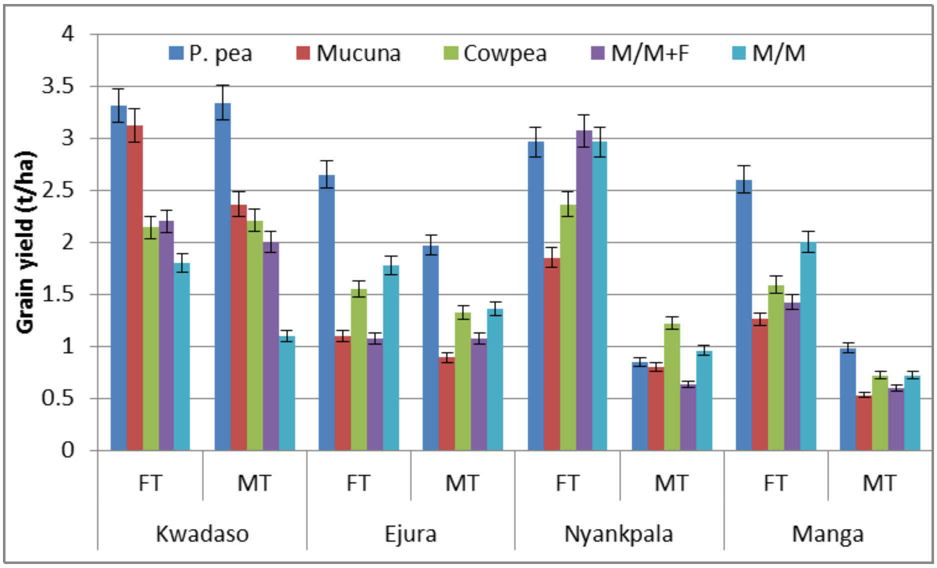


Figure 4. Interaction of tillage practice and cropping system on grain yield at the four sites.

At Kwadaso interaction between tillage practice and cropping system gave comparable results (Figure 4). At Kwadaso maize-pigeon pea under both FT and MT and maize-mucuna under FT were most promising. At Ejura maize-pigeon pea under both FT and MT were also promising. At Nyankpala and Manga grain yield was significantly higher for all the intercrops under FT. Lack of enough plant residue to cover the soil surface and inadequate weed control are major reasons for the low yields obtained under minimum tillage especially at Nyankpala and Manga.

The study will be repeated in 2014. Promising results are being demonstrated at Ejura and will be demonstrated at Nyankpala and Manga this year.

2.2.4 Study Title: **Effects of soaking rice seedlings in phosphorus solution on rice growth and grain yield**

Research Team: R.N. Issaka and M.M. Buri
Collaborating Institutions: JIRCAS,
Source of Funding: JIRCAS
Duration of Project: 2013-2014

Introduction

Low soil phosphorus level restrict root development and hence plant growth. Minimum supply of this mineral on soils with low phosphorus levels may enhance root development. The main objective of this study is to evaluate the effects of soaking rice seedlings in phosphorus solution before planting on rice productivity.

Materials and Methods:

The trial was conducted on station at the CSIR-Soil Research Institute. Three weeks old rice seedlings (*Sikamo*-local name) were used. For treatments A5, B5, C5 and D5 seedlings were soaked in water containing 5% TSP for 30 minutes. Treatment details are presented in Table 1. Rice growth was monitored till harvest. Grain yield and biomass were determined.

Table 1. Treatments

Code	Description
T1	Non-soaked seedlings
T2	Non-soaked seedlings + NK
T3	Seedlings soaked in 1% TSP
T4	Seedlings soaked in 5% TSP
T5	Seedlings soaked in 1% TSP + NK
T6	Seedlings soaked in 5% TSP + NK
T7	Seedlings soaked in 1% TSP + NK + 135 kg P_2O_5 /ha as BFRP
T8	Seedlings soaked in 5% TSP + NK + 135 kg P_2O_5 /ha as BFRP
T9	Seedlings soaked in 1% TSP + NK +135 kg P_2O_5 /ha as TSP
T10	Seedlings soaked in 5% TSP + NK +135 kg P_2O_5 /ha as TSP

NK:- 30 kg N/ha + 20kg K_2O/ha. BFRP:- Burkina Faso Rock phosphate. TSP:-Triple superphosphate. Seedligs were soaked for 30mins.

Table 2. Effect of treatment on yield components and grain yield

Treatment	No. stand/m^2	No. of panicles/plant	No. of panicles/m^2	Stover yield (t/ha)	Grain yield (t/ha)
T1	19.0	5.2	233.6	4.5	3.7
T2	16.6	5.6	213.0	4.5	4.3
T3	17.4	5.6	226.2	5.3	3.8
T4	17.2	6.1	240.6	6.1	4.8
T5	18.8	4.6	208.8	4.6	4.1
T6	20.4	4.8	235.8	6.0	4.4
T7	17.2	5.2	217.4	5.1	4.4
T8	14.6	5.9	196.2	4.7	4.3
T9	18.4	4.9	218.0	4.4	4.3
T10	18.0	4.9	210.8	5.1	4.3
SE	2.11	0.74	28.21	0.94	0.52

Yield components and grain yield as affected by treatments are presented in Table 2. Grain yield was significantly higher for T4, T6 and T7 than T1 and T3. The differences between soaking seedlings in 1% or 5% TSP solution was seen in the yield difference between T3 (1%) and T4 (5%). While the number of panicles/plant were similar for T3 and T4 grain yield was significantly higher for T4. Probably grain weight under T4 was higher than T3.

The trial will be repeated this year.

2.2.5 Study Title: **Improvement of soil fertility with use of indigenous resources in rice systems of Sub Saharan Africa**

Research Team: R.N. Issaka, M.M. Buri and E.O Adjei.
Collaborating Institutions: JIRCAS,
Source of Funding: JIRCAS
Duration of Project: 2010-2014

Introduction

The use of locally available fertilizing materials in rice production is gradually becoming common. These materials are relatively cheaper and have the potential to improve rice production. The main focus of this study is to evaluate the effects of indigenous fertilizing materials on rice yield on-farm

Materials and Methods

Study treatments included Control (only N and K applied), Burkina Faso Rock Phosphate (135 kg P_2O_5/ha), Poultry manure (2.0 t/ha),Triple supper phosphate (135 kg P_2O_5/ha) and Biochar from saw dust (2.0 t/ha) . All treatments received 90 N/kg/ha and 60 K_2O/kg/ha. Nine farmers were selected for this study. On each farmer's field the experimental design was a RCBD with 3 replications. Selected sites included Barniekrom A, Nsutem, Biemso No. 1 (A and B), Agogo (A and B), Afari, Anikruma and Essienkyem. Materials were broadcast and incorporated into the soil with a hoe. Rice was planted at 20 x 20 cm. These treatments were selected from previous on-station trials

Results

Table 1. Effect of organic materials on rice growth and yield

Source of Organic Materials	Plant height (cm)	No. of stand/m^2	Number of panicles/plant	No. of panicles/m^2	Stover yield(t/ha)	Grain yield(t/ha)
Control	120ab	24.1ab	2.0d	144e	24.1ab	3.1d
RP	119ab	23.7bc	2.0d	142e	23.7bc	3.9c
PM	121a	23.8bc	3.0a	189ab	23.8bc	5.3a
PM+RP	120ab	24.1ab	3.0a	191a	24.1ab	5.4a
TSP	119ab	23.9abc	2.8b	180c	23.9bc	5.0b
CHSD	120ab	24.4a	2.8b	184bc	24.4a	5.0b
CHSD+RP	118b	23.6c	2.6c	171d	23.6c	4.9b
P-rich CHSD	119ab	23.9abc	2.6c	172d	23.9abc	4.9b

RP: rock phosphate (135 kg P_2O_5/ha). PM: poultry manure (2.0 t/ha). TSP: triple supper phosphate (135 kg P_2O_5/ha). CHSD: char from saw dust (2.0 t/ha). All treatments received 90-60 kgN:K_2O/ha

Table 1 shows the effect of the various treatments and their combinations on yield components and grain yield. When only NK was applied number of panicles/plt and number of panicles/m^2 were significantly less than those for the other treatments. This resulted in lower grain yield for NK treatments compared to the other treatments. Application of only NK may result in less P availability and yield may be affected. For treatment RP+NK yield components and grain yield was significantly higher than NK but less than the other treatments. Probably not much of the P was released for crop uptake even though enough was released for grain yield to be better than only NK. PM+NK, PM+RP+NK and TSP+NK gave similar and significantly higher grain yield than the other treatments.

The trial will be repeated in 2014.

2.2.6 Study Title: **Soil fertility status of selected citrus orchards in the Eastern and Central regions of Ghana and their management with available soil amendments**

Research Team: Allotey, D. F. K., B. Ason, P. M. Gyekye Jr. and E. A. Akuffo
Collaborating Institutions: MOFA Market Oriented Agriculture Programme,
Source of Funding: MOFA Market Oriented Agriculture Programme,
Duration of Project: 2013

Introduction

This study was initiated to evaluate the soil fertility status of selected orchards in the Eastern and Central regions of Ghana and how best to improve upon their current soil fertility status through the applications of different organic soil amendments and 15-15-15 inorganic fertilizers alone or in combination with each other.

Materials and Methods

Soil (0 – 20 and 20 – 60 cm depths) and leaf samples were taken during the initial stages of the study and their nutrient contents assessed. Leaf and organic manure samples were also taken and together with the soils were analyzed at the Soil Research Institute's Accra Centre Laboratory. Selected organic amendments available around each demonstration farm were obtained and applied after the initial soil sampling. Soils and reasonably matured leaf samples were taken from selected farmers' fields as Initial (profile) soil, leaf and organic manure samples between 15^{th} and 22^{nd} June 2012 in the Eastern and Central regions respectively. Mid-term soil sampling was on 15^{th} January 2013 and harvest sampling was on 15^{th} February 2013. The organic amendments used were poultry manure (PM), cocoa pod husk (CPH), empty palm fruit bunch (EPB) and saw dust (SD). These were applied alone or in various combinations to 10 – 12 healthy trees of the same age depending on the tree population of each site. An absolute control (i.e. neither inorganic nor organic amendment applied) was also added as one of the treatments.

The following were the detailed treatments applied per site and replicated two (2) times in a Randomized Complete Block Design. (1) Poultry Manure (PM): 300 - 360 kg/plot. (2) Cocoa Pod Husk (CPH): 300 - 360 kg/plot (3) Empty Fruit Bunch (EFB): 240 – 320kg. (4) NPK 15:15:15 alone: 2.00 – 2.40 kg. (5) Saw Dust (SD) – 450 – 540 kg.

Half of these rates were also included at some of the locations.

Results

Results obtained from the initial soil and climate investigations indicated that Climatic conditions (rainfall and temperature) of the two regions are suitable for citrus production. Soil texture was mainly clay loam in the Eastern and Central regions. However, their high sand contents of 44.0 to 46.39 percent should be a matter of concerned for nutrient losses through leaching and erosion (Table 1). The EC within the two depths sampled of the two regions were below 4 dS/m and were therefore rated as non-saline. Mean top soil pH was slightly acidic (5.8) in the Eastern region but strongly acidic in the Central (4.7) region. Mean sub soil pH was strongly acidic (< 5.0) for all regions. Mean total nitrogen, available P and K contents within the two depths of the two regions were low. Organic carbon/matter contents were medium. Mean total exchangeable bases (TEB), exchangeable acidity, effective cation exchange capacity (ECEC) were low in these soils, whereas, their base saturation levels (%BS) were high (Table 2). Leaf analytical results showed deficient N, Fe and Zn but high P, K Na and Mg levels for most of the sites in the two regions (Table 3).

Mid-term- and harvest samples from the organic and inorganic managed trials revealed an improvement in pH due to organic soil amendment application over the control. N-P-K inorganic fertilizer application however decreased soil pH although this trend was not consistent with all sites. Organic soil amendment application either alone or in combination with each other and N-P- K, generally, enhanced soil nutrient levels but trends between sites were erratic.

Leaf nitrogen, phosphorus and potassium were improved to the optimum by the 15-15-15 N-P-K fertilizer over all other treatments. Poultry manure improved leaf nitrogen and potassium contents while cocoa pod husk mainly improved potassium. All were significantly (P = %) higher than the control. Leaf nitrogen, phosphorus and potassium were also enhanced by the combined treatments over the control (Table 3)

Enhancements due to inorganic fertilizer and the organic manure across locations were in the order: Akroso< North Abirem < Nkawkaw < Kade and Old Ebu = Ajumako <Manso < Dehia < Fosu in the eastern and central respectively. Leaf N, P, K were generally lower at harvest than mid-sampling. This can be attributed to uptake by the crop.

Secondary and micro nutrient were observed to be deficient at all locations irrespective of the treatments imposed.

Table 1: Physical properties of soils of selected citrus farms in the 2 major citrus growing regions.

Region	%Sand	%Silt	%Clay	Texture
Eastern	44.00b	25.58a	30.42b	Clay Loam
Central	46.39a	20.51b	33.10a	Clay Loam

Similar alphabets are not significantly different by Duncan's Multiple Range Test (P < 5%)

Table 2: Initial chemical properties of soils of selected citrus farms in the 3 major citrus growing regions.

Region	Depth (cm)	pH	EC (dS/m)	Total N (%)	Avail. P (mg/kg)	Avail. K (mg/kg)	% OC	**% OM**
Eastern	0 – 20	5.80a	0.52b	0.085a	40.89a	7.89a	1.7	2.92a
	20 – 60	4.86A	0.56B	0.072A	37.40A	6.44A	1.58	2.72A
Central	0 – 20	4.73a	1.87a	0.076b	28.12b	5.87b	1.63	2.80a
	20 – 60	3.95B	1.84A	0.063B	22.60B	5.56B	1.63	2.80A

Similar alphabets are not significantly different by Duncan's Multiple Range Test (P < 5%). Alphabets in small and capitals are mean comparison for 0 – 20 and 20 – 60 cm respectively.

Table 3: Leaf nutrient content of selected citrus farms in the 3 major citrus growing regions.

Regions	N (%)	P (%)	K (%)	Na (%)	Ca (%)	Mg (%)	Fe (mg/kg)	Zn (mg/kg)
Eastern	1.01a	0.11b	4.50a	0.34b	2.82b	0.95a	22.00c	14.25a
Central	0.72b	0.27a	2.61b	0.66a	3.27a	0.53b	27.20a	14.88a

Similar alphabets are not significantly different by Duncan's Multiple Range Test (P < 5%).

Table 4: Chemical composition of the organic soil amendments applied.

Region	Organic manure	%N	P (mg/kg)	K (mg/kg)	Ca (mg/kg)	Mg (mg/kg)	%OC	C/N	Fe (mg/kg)	Zn (mg/kg)
Eastern	EPFB	0.36b	112.00b	11.40b	2.83ab	1.79b	10.4b	28.89b	3.77a	0.18
	PM	2.11a	214.3a	3.86c	3.37a	6.97a	12.10ab	5.73d	2.66b	0.34
	CPH	0.49b	77.10c	15.01a	3.62a	1.85b	5.92c	12.04c	1.37c	0.15
	SD	0.23b	45.44c	12.84b	3.25a	1.47ab	13.72a	59.57a	2.12b	0.17
Central	EPFB	0.28b	98.56	10.49	2.21c	1.48ab	8.63c	30.74b	2.38b	0.15
	PM	1.86a	167.15	3.36	2.96ab	6.13a	8.71c	4.69d	0.80c	0.29
	CPH	0.45b	63.99	12.61	2.82ab	1.443c	4.60d	10.21c	1.14c	0.11

Table 5: Chemical properties of soil at Nkawkaw as influenced by selected organic soil amendments and 15-15-15(N-P-K).

Soil Sampling Periods	Treatments	Depth (cm)	pH(H_20) (1:2.5)	EC (dS/m)	TN (%)	P_2O_5 (mg/kg)	K_2O (mg/kg)	OC (%)	OM (%)	C/N
Mid-sampling	Control	0-20	4.33	0.45	0.06	3.53	10.86	0.17	0.29	3.05
	NPK(15-15-15)	0-20	4.23	0.65	2.32	9.90	72.02	0.16	0.28	0.07
	PM.	0-20	6.47	1.99	1.25	13.48	133.80	1.36	2.33	1.08
	CPH	0-20	4.29	0.93	0.11	4.29	44.35	1.50	2.58	13.77
	SD	0-20	4.28	0.71	0.11	9.50	14.36	1.12	1.92	10.54
	SD + NPK	0-20	4.13	0.76	0.13	6.89	15.18	1.46	2.50	11.63
	CPH + PM	0-20	4.67	1.40	0.20	4.60	149.35	1.13	1.94	5.72
	CPH+NPK	0-20	4.12	1.14	0.23	5.23	54.11	1.83	3.15	16.80
Harvest	Control	0-20	4.16	0.44	0.05	3.43	10.53	0.16	0.28	2.92
	NPK(15-15-15)	0-20	4.15	0.62	2.25	9.60	69.86	0.16	0.27	0.07
	PM.	0-20	7.96	2.44	1.16	13.07	129.79	1.31	2.26	1.33
	CPH	0-20	4.27	1.15	0.09	4.16	43.02	1.46	2.50	16.94
	Sawdust,	0-20	4.09	0.88	0.08	9.22	13.93	1.08	1.86	12.97
	Sawdust + NPK	0-20	4.00	0.94	0.12	6.68	14.72	1.41	2.43	14.30
	CPH + PM	0-20	4.74	1.22	0.10	4.47	144.87	1.09	1.88	7.03
	CPH+NPK	0-20	4.05	1.1	0.19	5.08	52.48	1.78	3.05	14.79

2.2.7 Study Title: **Soil health policy action node: Promoting enabling soil health policy environment in Ghana**

Research Team coordinator: Francis M. Tetteh,
Collaborating Institutions: MoFA
Source of Funding: AGRA

Introduction

Increased population pressure, land degradation, declining soil fertility and limited use of mineral fertilizer in Ghana have led to low crop yields and food insecurity. Improving soil health is therefore the key to increasing crop yields and improving food security. Ghana government initiated some policy reforms in the agricultural sector with a view to improving agricultural production such as withdrawal of fertilizer subsidy and market liberalization. In 2008, however, the government re-introduced fertilizer subsidies to promote fertilizer use and improve crop productivity of smallholder farmers.

Goal: The goal of the project is to improve soil and crop productivity in Ghana to contribute to poverty alleviation and food security through the implementation of conducive soil health policies.

Project Activities:

- Support the development of a policy strategy to promote the use of integrated soil health technologies.
- Facilitate the development and implementation of regulations to guide the implementation of the Plants and Fertilizer Act 803 of 2010.
- Support the implementation of the input support program.
- Review fertilizer price build-up regularly to provide evidence for advocating government to intervene to minimize price hikes.

Expected Project Outputs:

- National fertilizer policy strategy document
- Codified national Fertilizer Regulations
- Detailed record of trained MoFA staff on subsidy implementation
- Report on fertilizer costs build up between port and farm gate in the breadbasket region established
- Fertilizer regulations developed, disseminated and implemented.

Some of the project achievements include:

i) Fertilizer policy strategy framework for Ghana drafted,

ii) Regulations to guide the implementation of the fertilizer law contained in Part III of the Ghana Plants and Fertilizer Act 803 of 2010 developed and passed as an act of parliament.

iii) Detailed record of trained MoFA staff on subsidy implementation and

iv) Fertilizer cost buildup between port and farm gate in the breadbasket region established

v) Fertilizer regulations are being printed for dissemination and implementation.

vi) AEAs, farmers and policy makers educated and sensitized on fertilizer policy through nationwide workshops.

Other project activities which are ongoing include facilitation of the development of Integrated Soil Fertility Management (ISFM) framework for Ghana as well as fertilizer subsidy impact study. By the end of the fourth year the project will facilitate the production of regulation manuals to guide quality standards and enforcement. Also, handouts, factsheets and brochures will be produced to educate and sensitize stakeholders on the regulations. About 39 fertilizer importing companies, 136 distributors and 1295 fertilizer retailers have come out for registration as a result of the sensitization.

2.3 ENVIRONMENTAL MANAGEMENT AND CLIMATE CHANGE PROGRAMME

2.3.1 Study Title: **Rainfall Distribution and Net Irrigation Requirement of Crops at Botanga Irrigation Scheme in the Northern Region of Ghana**

Research Team: A. Sadick, K. A. Nketia, E. Asamoah, J. Asaana, R. Amfo-Otu, J. Ayer

Duration of Project: 2013

Introduction

Water is necessary for agricultural production. The growing world population requires increased food production, while less water resources are available for agriculture (World Bank, 2003). This alarming situation can only be resolved if water is managed more efficiently, so that crop yield per unit of water consumption increases (World Bank, 2003).
Long term rainfall probability analysis can provide a basis on which to plan cropping pattern and agronomic practices for more than 80% of cultivated land, which remain under rain fed agriculture. For planning an irrigation water supply system, the irrigation water requirement during different month of the crop growing period is a function of the rainfall deficit in those months. Thus, rainfall deficit information for different areas and periods can greatly help in determining optimum water release from reservoir/source in accordance with demand. The rainfall data is essential for planning and designing irrigation and surface drainage system, budgeting water use for optimum crop yield, selecting area for profitable rain fed farming and developing possible means for utilization of excess rainwater (Magali et al., 2003; Robart, 2003;Adeniran et al., 2010).

Objectives:

The objective of this study is to estimate the variations in rainfall distribution and net irrigation requirements of some selected crops at Botanga irrigation scheme in the northern region of Ghana.

Materials and Methods

Location

Botanga irrigation scheme is located in the Northern Region of Ghana, in the Tolon Kumbungu district, it lies between latitude 9° 30" and 9° 35"N and longitude 1° 20"and 1° 04"W (GIDA, 2011).

The cropping area is divided into two, upland and lowland. The upland is free draining soil and plots are designed for furrow irrigation. The upland area is for vegetables production and the lowland for rice production because of the nature of the soil that is heavily textured and irrigated by flooding (Abdul-Ganiyu et al., 2012)

In this study twenty (20) years meteorological data of Northern region(1983-2002) where the study area is located were collected from the Ghana Meteorological Agency (GMet) for the computation of rainfall probability analysis, reference and potential evapotranspiration and net irrigation requirements of rice, tomato and pepper.

Probability analysis of Rainfall data were analyzed using the formula by Weibull (1939) and Handa and Sreenath (1983).The methodology for the calculation of crop evapotranspiration was adopted from Richard G. Allen et al. (1994) which were developed in the FAO bulletin number 56 in 2002.

Results and Discussion

The maximum and minimum annual rainfall occurred in 1991 and 1992. The maximum and minimum monthly rainfall occurred in the months of August and November in 1992 and 2002. Rainfall was evenly distributed in 1999 showing that rainfall distribution in 1999 was suitable for crop cultivation.

The variability of rainfall was measured by the percentage of coefficient of variance (C.V) for different month (Table 1). This varied from 37.7 to 437. For monthly rainfall the highest C.V was observed in January showing the peak of dry season, and the lowest C.V was also observed in September showing the peak of rainfall during the years of study. The rainfall in August has frequency of 2 for more than 300mm, 7 for 200 to 300mm, 8 for 100 to 200mm, 2 for 50-100mm and 1 for 50mm and below. This rainfall could be used for sowing.

Table 1. Mean monthly rainfall and its frequency distribution

Month	>300mm	200 -300mm	100 -200mm	50 -100mm	<50mm	TRM	Prob. R	Mean	CV (%)
Jan	-	-	-	1	1	2	0.1	3	437
Feb	-	-	-	1	6	7	0.35	10	213
Mar	-	-	-	3	14	17	0.85	29	76
April	-	1	2	8	9	20	1.0	72	63
May	1	1	11	6	1	20	1.0	127	52
June	-	4	11	5	-	20	1.0	152	40
July	2	2	12	4	-	20	1.0	167	49
Aug	2	7	8	2	1	20	1.0	185	46.49
Sept	2	7	10	1	-	20	1.0	213	37.70
Oct	-	-	10	4	6	20	1.0	94	63.27
Nov	-	-	-	-	10	10	0.5	8	145.77
Dec	-	-	-	-	5	5	0.25	3	266.67

TRM = Total rainy month, Prob. R = Probability of rainfall and CV = Coefficient of variance

The results obtained when FAO-Penman Monteith method was used to estimate reference evapotranspiration showed that ET_o varied from a minimum value of 4.49mm/day in September to the highest value of 4.94mm/day in April. Adams *et al.*, 2014 reported that ET_o values in the Upper East Region of Ghana are generally higher than those in the Northern Region.

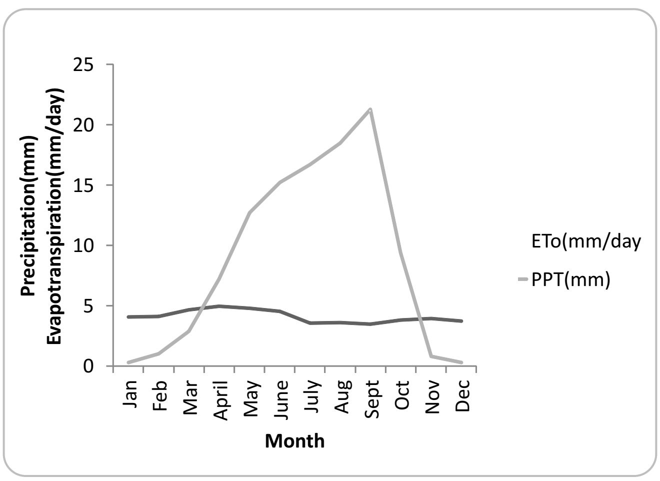


Fig. 1: Hydrological balance of ETo and precipitation at Botanga

The water balance analysis for Botanga irrigation scheme is presented in figure 1. It showed from the results that from January to March and November to December ETo were higher than precipitation. This implies that irrigation was necessary to grow crops during these periods of non-availability of sufficient amount of precipitation and high atmospheric evaporative demand by crops (Shirazi et al., 2011). Also from April to October; precipitation was much higher than ETo. There was abundant supply of precipitation during these periods and might cause sudden flood which in turn damage the root zone of crops.

Also crop water requirement for rice varied from 1.4 to 396.5mm/dec giving a total of 893.8mm/season. Abdul-Ganiyu et al., 2012 also reported that the crop water requirement of rice was 785.8mm/season at Botanga irrigation scheme. The actual irrigation requirement was 599.6mm/season, the difference of 294.2mm could be losses due to runoff and percolation. The result also showed that water requirement of rice was higher than tomato followed by pepper. (Table 2)

Laboratory analysis of the soil at the irrigation area revealed that upland soils where vegetables are cultivated are sandy loam and the lowland soils where rice is cultivated are clayed soils. FAO, 1985 reported that rice grows well in clayed soil but can be cultivated in sandy loam with high water table.

Table 2. Scheme Irrigation Requirements

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Precipitation deficit												
1. Rice	503	118.1	133.5	101.4	36.4	0	0	0	0	0	0	1.4
2. Tomato	130.2	114.7	77.9	0	0	0	0	0	0	0	62.4	89.9
3. Sweet Peppers	116.4	102.7	40.1	0	0	0	0	0	0	0	51.3	78.6
Net scheme irr.req.												
in mm/day	5.8	2.7	1.9	0.9	0.3	0	0	0	0	0	0.8	1.1
in mm/month	180.5	74.6	59.4	26.4	9.5	0	0	0	0	0	23.1	34.4
in l/s/h	0.67	0.31	0.22	0.1	0.04	0	0	0	0	0	0.09	0.13
Irrigated area	66	66	66	26	26	0	0	0	0	0	40	66
(% of total area)												
Irr.req. for actual area (l/s/h)	1.02	0.47	0.34	0.39	0.14	0	0	0	0	0	0.22	0.19

Net Irrigation Requirement of rice, tomato and pepper

The estimation of actual irrigation requirement of Botanga irrigation scheme was computed. The net irrigation requirement of the scheme was 407.7mm/year.

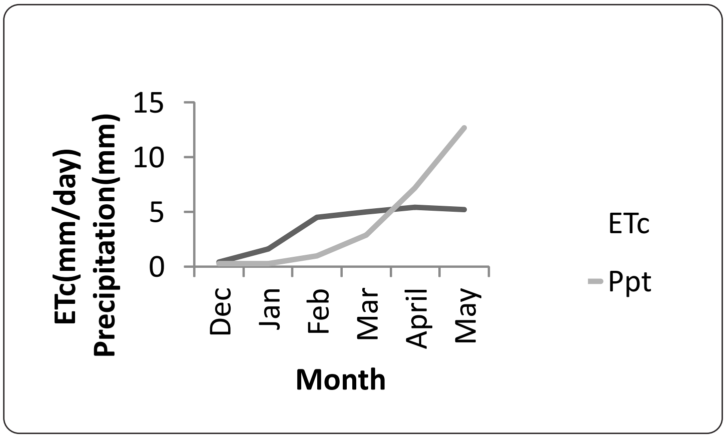


Figure. 2: Net irrigation requirement of rice

Figure 11 showed that irrigation water was required by rice from December to March since ETc was higher than precipitation. After this period no irrigation water was necessary since there was surplus water. Tomato and pepper needed considerable less amount of irrigation water than rice throughout the growing season.

No irrigation water was required from November to December and equal amount of precipitation and irrigation between December and January. Control and drainage measures should be adopted after January to protect the root zone of the tomato and pepper as a result of excessive precipitation.

Conclusion

The highest potential evapotranspiration occurred in April and lowest in September which is the peaks of dry and rainy season. The variability of rainfall was also estimated to confirm the peaks of rainfall and dry season. Rice has the highest crop water requirement and net irrigation requirement than tomato and pepper. Irrigation water was required by rice in the first-four months of the growing period. The results obtained from the study can be used as a guide by farmers in selecting period of cultivation and water requirement for the crops.

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2.3.2 Study Title: **Water Requirements of selected crops at Tono Irrigation Area, Navrongo**

Research Team: A. Sadick, G. W. Quansah, R. N. Issaka, E. A. Asamoah, K. A. Nketia, R. Amfo-otu

Duration of Project: 2013

Introduction

In Ghana, there are few irrigation projects to support farming activities for improved food production to ensure food security. There are many areas with great potentials to benefit from dams to enhance agricultural activities in the country. However, not much studies have been conducted on the water usage and it implication on soil fertility and agricultural production. Tono dam is the largest reservoir in the Upper East Region of Ghana that provides water for irrigation of various crops.

Objective

The objective of this study was to determine crop water requirements of paddy rice, tomato, soya bean, maize, pepper and groundnut.

Materials and Methods

Location

The study area lies in the guinea savannah ecological zone of Ghana and is located in the Upper East Region and lying between latitude 10 ° 45'N and longitude 1° W. It has a potential area of about 3840ha with a developed area of about 3450ha. The study area comprises eight (8) command areas, namely Bonia, Gaani, Korania, Wuru, Yigania, Yigwania, and Chuchuliga zone A and B.

Estimation of water requirement

Climatic parameters that contribute to calculations of irrigation requirements are maximum and minimum temperatures, maximum and minimum air humidity, Sunshine hours, solar radiation and rainfall. These parameters have been found during a campaign of data collection in Tono and Navrongo weather stations. The crops that are common in the study area and considered in this paper are paddy rice, tomato, soya bean, maize, pepper and groundnut.

The software that was used for computation was CROPWAT published and made available by FAO through the internet and the supporting document in the bulletin number 56 in 2002. CROPWAT computes reference crop evapotranspiration, crop water requirement, irrigation water requirement, and irrigation scheduling and yield reduction due to water shortage of a given region, but this analysis was limited toreference crop evapotranspiration, crop water requirement, irrigation water requirement, net irrigation water requirement and scheme irrigation water requirement.

Results and Discussion

Soil properties

Sixteen (16) soil series were identified in the study area, the soils in the area are predominantly coarse textured, ranging generally from sandy loam in the suface horizon to silt and clay in the subsurface horizon, with *Wenchi* series consisting of hard iron pan at the bottom(30+cm depth). FAO (1998) reported that sandy loam, loamy and sandy soils are relatively shallow and free-draining, particularly suitable for upland crops, and clay soils are deep but poorly drained and suitable for deep rooted crops like cotton. The soil pH generally ranges from 7.4 in the surface horizon to 5.8 in the subsurface horizon showing that the soil is predominantly acidic.The Cation Exchange Capacity was generally low from 0.87 to 15.1meq/100g, which means that the soils available have low potential for retaining plant nutrients.

Table 1. Reference Crop Evapotranspiration

Country : Ghana — Meteorological Station: Tono
Coordinates: Lat. 10^{o} 5'N Lon. 1^{o}W — Altitude : 172m

Month	Max. T (^{o} C)	Min. T (^{o} C)	Humidity (%)	Wind (km/day)	Sunshine Hours	Radiation ($MJ/m^2/day$)	ET_o (mm/day)
January	38.5	16.7	33	145	9.1	20.6	5.75
February	41.4	18.9	31	145	9.2	22.1	6.40
March	42.7	21.3	43	113	9.0	23.0	6.27
April	42.0	21.2	52	141	8.3	22.3	6.47
May	40.2	21.7	62	149	8.3	21.9	6.12
June	36.7	20.1	68	161	8.2	21.3	5.53
July	35.0	20.6	72	113	5.9	18.0	4.43
August	33.4	20.2	77	129	6.6	19.4	4.46
September	35.5	19.9	74	133	7.8	21.2	4.94
October	37.9	20.6	63	141	9.0	22.0	5.58
November	39.6	17.0	50	129	9.1	20.8	5.52
December	38.8	17.2	34	129	9.1	20.0	5.43
Year	**38.5**	**19.6**	**55**	**136**	**8.3**	**21.1**	**5.58**

ET_o = Reference crop Evapotranspiration computed using FAO Penman-Monteith Method

Reference crop evapotranspiration

The results obtained when a 11-year period was used with the FAO-Penman Monteith method to estimate the reference crop evapotranspiration (ET_o) for the study area showed that ET_o varied from a minimum value of 4.43mm/day in July to the highest value of 6.47mm/day in April (Table 1). The results showed that ET_o was lowest during the peak of the rainy season to the highest during the peak of the dry season.

Table 2 . Evapotranspiration and Irrigation Requirement for Paddy Rice

Station: Tono　　Date of transplant: 4 Nov. 2008

Month	Decade	Stage	Kc Coeff	ETc mm/day	ETc mm/dec	Eff rain mm/dec	Irr. Req. mm/dec	Irr. Req mm/day
Sep	1	N	1.2	0.57	4	32.4	0	0
Sep	2	N/L	1.11	3.86	38.6	44.7	117.6	11.76
Sep	3	N/L	1.06	5.49	54.9	31	267.8	26.78
Oct	1	Init	1.09	5.85	58.5	10.5	245.2	24.52
Oct	2	Init	1.1	6.14	61.4	0	61.4	6.14
Oct	3	Dev	1.11	6.2	68.2	0.2	67.9	6.17
Nov	1	Dev	1.16	6.43	64.3	1.6	62.6	6.26
Nov	2	Dev	1.21	6.65	66.5	0.7	65.8	6.58
Nov	3	Mid	1.23	6.77	67.7	0.5	67.3	6.73
Dec	1	Mid	1.23	6.74	67.4	0.1	67.3	6.73
Dec	2	Mid	1.23	6.71	67.1	0	67.1	6.71
Dec	3	Mid	1.23	6.84	75.2	0	75.2	6.84
Jan	1	Late	1.21	6.84	68.4	0	68.4	6.84
Jan	2	Late	1.16	6.7	67	0	67	6.70
Jan	3	Late	1.11	6.65	73.1	0.1	73	6.64
					902.3	122	1373.6	135.40

where N= Nursery, N/L= Nursery/Land preparation, Init= Initial stage, Development stage, Mid= Mid-Season stage, Late= Late season stage, IR= Irrigation Requirement (mm/day), IR= Irrigation Requirement (mm/dec), K_c= Crop Coefficient, ET_c= Crop Evapotranspiration (mm/day), ET_c= Crop Evapotranspiration (mm/dec).

Crop water requirement

The results showed that for paddy rice, crop evapotranspiration (ET_c) and crop water requirement varied from 0.57 to 6.84mm/day and 0.0 to 26.78mm/day respectively (Table 2). For tomato, crop evapotranspiration and crop water requirement ranged from 3.22 to 7.01mm/day and 2.16 to 7.00mm/day respectively (Table 3). For soya bean crop evapotranspiration and crop water requirement ranged from 2.15 to 6.52mm/day and 2.15 to 6.45mm/day respectively. For maize crop evapotranspiration and crop water requirement ranged from 1.61 to 6.88mm/day and 1.00 to 6.88mm/day respectively. For pepper crop evapotranspiration and crop water requirement ranged from 3.22 to 6.22mm/day and 1.9 to 6.22mm/day respectively. Finally for groundnut crop evapotranspiration and crop water requirement ranged from 2.15 to 6.77mm/day and 2.15 to 6.77mm/day respectively.

Table 3. Scheme Irrigation Requirements

Crop	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec
Rice	6.2	0	0	0	0	0	0	365.5	237.1	193.7	201.5	198.1
Tomato	159.7	0	0	0	0	0	0	0	0	120	185.5	200.6
Soya bean	0	0	0	0	0	0	0	0	5.7	184.8	167.5	2.9
Maize	14.4	0	0	0	0	0	0	0	0	145.8	202.9	161.9
Pepper	49.1	0	0	0	0	0	0	0	0	116.6	173	181.2
Groundnut	205.5	79.2	0	0	0	0	0	0	0	48.7	109.6	196.5
NSIR1	1.6	0.1	0	0	0	0	0	5.4	3.6	5.1	6.3	5.8
NSIR2	49.2	4	0	0	0	0	0	168.1	109.4	156.6	188	180.2
NSIR3	0.18	0.02	0	0	0	0	0	0.63	0.42	0.58	0.73	0.67
IA	94	5	0	0	0	0	0	46	52	100	100	100
NWR	0.2	0.33	0	0	0	0	0	1.36	0.81	0.58	0.73	0.67

where NSIR1= Net Scheme Irrigation Requirement (mm/day), NSIR2= Net Scheme Irrigation Requirement (mm/month), NSIR3= Net Scheme Irrigation Requirement (l/s/hr), IA= % of total area that is actually irrigated, NWR= Net Water Requirement for Actual Irrigated Area (l/s/hr),

Scheme irrigation requirement

The actual irrigation requirement of Tono irrigation project was estimated. The net irrigation water requirement was 855.5mm/year. This was estimated by summing the net scheme irrigation requirement (NSIR2) from January to December. By using an irrigation application efficiency of 48%, the gross water requirement of 1782mm/year would be 17820m^3/ha/year. Hence the developed land area of 3450ha will require 61MCM. The reservoir capacity is 442MCM and this capacity can satisfactorily irrigate the entire command areas.

Conclusion

The study shows that the reservoir can sufficiently supply the water required for irrigation in the command areas used at present and also in the entire land area. The results obtained from the study can be used as a guide by farmers for selecting the amount and frequency of irrigation water for the crops studied under consideration.

Recommendations

Efficient and effective canal management mechanisms in terms of canals and laterals calibration should be continued to prevent possible crop water stress. Irrigation engineers and management should pay attention to crop water requirements of the various crops at the command areas. Irrigation requirement should be monitored periodically to ensure higher productivity.

2.3.3 Study Title: **Assessment of Irrigation water quality of Tono dam in Navrongo, Ghana**

Research Team: A. Sadick, G. W. Quansah, R. N. Issaka, S. Bagna, R. Amfo-Otu

Collaborating Institutions:

Duration of Project: 2013

Introduction

The quality of irrigation water available to farmers and other irrigators has considerable impact on what plant can be successfully grown, the productivity of these plants, water infiltration and other soil physical conditions. Water quality concerns have often been neglected to the background because good water quality supplies have been plentiful and readily available (Shamsad and Islam, 2005; Islam *et al.,* 1999). Notwithstanding, considerable changes and disparities have been observed in many countries. Intensive use of nearly all good quality supplies means that new irrigation projects, and old projects seeking new or supplemental supplies, must rely on lower quality and less desirable sources (Cuena, 1989).

Objective

The objective of this study was to assess the water quality levels of Tono irrigation water based on some selected water quality parameters

Materials and Methods

Location and climate

The project lies in the guinea savannah ecological zone of Ghana and is located in the Upper East Region and lying between latitude 10 ^{o} 45$'$N and longitude 1^{o} W. It has a potential area of about 3840ha with a developed area of about 3450ha. The project area comprises eight (8) command areas, namely Bonia, Gaani, Korania, Wuru, Yigania, Yigwania, and Chuchuliga zone A and B.

Water sampling and analysis

A total of thirty (34) water samples were collected from the dam, main canal, and laterals of all the command areas. This was done during cropping period of the peak dry season. Each sample was a composite of 10 sub-samples. The bottles used for sampling (voltic bottles) were cleaned with hydrochloric acid (HCl) and rinsed repeatedly with deionized water as suggested by De (1989). The bottles were kept air tight and labeled properly for identification. Stoppering of the bottles was done quickly to avoid aeration during sampling.

Electrical conductivity (EC), pH and temperature of the samples were measured on the spot using portable EC-meter, pH-meter and thermometer, respectively. Total dissolved solids (TDS) were estimated by the method described by Todd (1980).

The samples collected from the study area were carefully transported to CSIR-Soil Research Institute's laboratory, Ghana and kept in a refrigerator for analysis. Na^{+} and K^{+} were determined by flame photometry (Jackson, 1967); Ca^{2+}, Mg^{2+}, Cu^{2+}, Zn, Mn and Fe by Atomic Absorption Spectrophotometer (AAS) (Jackson, 1967; Page *et al.,* 1982); Cl^{-} , HCO_3^{-} , CO_3^{2-} ,SO_4^{2-} , NO_3^{-} and PO_4^{-}, titration method (Jackson, 1967); the Sodium Adsorption Ratio (SAR), the Soluble Sodium Percentage(SSP), the Residual Sodium Carbonate(RSC) and Kelly's ratio were determined by the methods described by Richards (1954), Todd (1980), Eaton (1950) and Kelly (1953) respectively. The results from the main canal and command areas were compared with that of the dam (reservoir).

Results and Discussion

The average temperature of the irrigation water samples at the time of sampling at the study area was 25 °C ranging from 24 to 25 °C. The average EC value was 125.8 μs/cm also ranging from 124.1 to 129.1 μs/cm. This according to Wilcox (1955) falls within the irrigation water classification stand 'excellent to good'. In terms of the 'degree of restriction on use' the irrigation water of the study area is suitable for irrigation purpose as it falls under category 'none' (UCCC, 1974). The primary effect of high EC water on crop productivity is the inability of the plant to compete with the ions in the soil solution of water. The higher the EC, the less water is available to the plants, even though the soil may appear wet, leading to low productivity.

As EC and TDS values of irrigation water are interrelated, both values are indicative of saline water in the absence of non-ionic dissolved constituent (Michael, 1992). The TDS values ranged from 79.4 to 82.6mg/*l*. This indicates that the values are suitable for irrigation purpose. The only area which showed slightly increase in TDS was 'Gaani' which has TDS value of 82.6mg/l at one of the laterals (UCCC, 1974).

Although plant growth is primarily limited by the salinity level of the irrigation water, the application of water with sodium imbalance can further reduce yield under certain soil texture condition (Matthess, 1982). Irrigation water with high sodium (Na^+) can bring about a displacement of exchangeable cations Ca^{2+} and Mg^{2+} from the clay minerals of the soil, followed by the replacement of the cations by sodium. A situation called Sodium Adsorption Ratio (SAR), causes swelling and dispersion of soil clay, surface crusting, pore plugging, obstructs infiltration and may increase runoff (Matthess, 1982). The values of SAR of the water samples from the study area ranged from 0.35 to 0.50 with an average value of 0.42. According to Richards (1954), for salinity classification all the irrigation water samples fell under low sodium hazard (S_1) and low salinity hazard (C_1). This was given by US salinity laboratory (Richards, 1954).

The normal pH range for irrigation water according to UCCC (1974) is 6.5-8.5. High pH above 8.5 is often caused by high bicarbonate and carbonate concentrations. This often cause calcium and magnesium ions to form insoluble minerals leaving sodium as the dominant ion in solution. This alkaline water could intensify the impact of high SAR water. The pH values of the irrigation water ranged from 7.0 to 7.7 with an average value of 7.3 which according to DOE (1997) and UCCC (1974) is within the permissible limit for irrigated agriculture.

The Soluble Sodium Percentage (SSP) values were found to vary from 25.51 to 33.76% with an average value of 28.95 %, depending upon locations. Base on the classification after Todd (1960) for SSP, all the 34 irrigation water samples fell under 'Good' class. The areas which showed slight increase in SSP were Gaani, Bonia and Yigania.

The highest Residual Sodium Carbonate (RSC) value of the irrigation water was 0.39 which was sampled from Bonia location. The average value of RSC of the water sample was 0.24. Based on Eaton (1950), all the 34 samples fell under 'Excellent' class.
The Kelly's ratio of collected irrigation water samples from the study area ranged from 0.24 to 0.38 with an average value of 0.30, which showed all values were under acceptable range and suitable for irrigation purposes (Kelly, 1953).

Chloride (Cl^-) and Sulphate (SO_4^{2-}) contents of the 34 irrigation water samples of the study area varied from 0.010 to 0.122 meq/*l* with an average value of 0.052meq/*l* and 0.04meq/*l* respectively. The water sample of lateral at Gaani showed the highest value of Cl^-. Higher Cl^- concentration at Gaani might be due to the impact of settlement and anthropogenic effect (Islam *et al.*, 1999). It is evident that the values of Cl^- and SO_4^{2-} of the study area were within the recommended limit (BWPCB, 1976; WHO, 1984; Ayers and Westcot, 1985) and suitable for irrigation (Marschner, 1989; UCCC, 1974).

Agricultural activities which could introduce nutrients in the dam and its canals would eventually lead to eutrophication of the dam. Nitrate and phosphate concentrations ranged from 0.02 to 0.05meq/*l* and 0.007 to 0.024meq/*l*. These are low and acceptable according to Marschner, (1989) and UCCC, (1974).Toxicity of the water may be determined from the Fe, Cu, Zn and Mn levels; these are low and have no effect on the quality of irrigation water and the productivity of the crop cultivated

The results also show that the range of bicarbonate (HCO_3^-) of irrigation water samples of the study area was between 1.15 and 1.21 meq/*l* with an average value of 1.19 meq/*l*. The water in the irrigation dam was suitable for irrigation which is in the agreement with the findings of Ayers and Westcot (1985). The values of water samples of the study area fell into 'none to slight' of degree of restrictions on use (UCCC, 1974).

Conclusion

Different physio-chemical properties of irrigation water of Tono irrigation dam were compared with the international water quality standards set for irrigation. Electrical conductivity (EC), pH, total dissolved solids (TDS), iron (Fe), and chloride (Cl^-) fall in the class of 'excellent to good' and category 'none' in terms of the degree of restriction on use. Tono irrigation dam had no salinity problem and on the basis of SAR, SSP and RSC values, no permeability problem was found to exist in the area.

On the basis of agricultural activities which could introduce nutrients into the reservoir, canals and laterals which would eventually lead to eutrophication, nitrate and phosphate values are low and acceptable. Efficient and effective dam management mechanisms should be continued to prevent possible eutrophication. Management should pay attention to frequent water quality monitoring to enhance farmers' confidence in the quality of water for irrigation in their farms. Plant water requirement for higher productivity should be studied to complement management strategies.

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2.3.4 Study Title:	**Climate change, drivers and vulnerabilities in agriculture – climate change education for cassava producers**
Research Team:	B. O Antwi,
Collaborating Institutions:	MOFA
Source of Funding:	Promoting Value Chain Approach to Climate Change Adaptation (PROVACCA)
Duration of Project:	2013

Introduction

One week district stakeholders' workshop was organized at Damango and Akomadan to educate farmers on climate change issues from 15th July to 20th July, 2013. The workshop was sponsored by PROVACCA (Promoting Value Chain Approach to Climate Change Adaptation) in agriculture in Ghana. The approach adopted was participatory. Though they were meant for farmers, school children, the District Assembly, NGOs also attended.

Fig 1. A farmer at Ejura, Ghana

Fig 2. Household discussions on climate, Western Region, Ghana change

Figure 1 and Figure 2 were used to explain the effect of climate change on agriculture and household income.

Materials and Methods

The approach explained weather, climate, drivers of the weather variability and climate change, effect of climate change on agriculture and the roles in farming practices to reduce the effect. Weather was explained as the atmospheric conditions at a given point in time. The atmospheric conditions used were wind, temperature, cloudiness, rainfall and pressure. Climate was taken as stable weather conditions measured over several decades or longer.

Results

It was explained that small changes in average temperature of the planet translate to large and potentially dangerous shifts in weather. The effect of the increase in temperature are changes in rainfall, resulting in more floods, droughts, or intense rain, as well as more frequent and severe heat waves. The need to take weather variability and consequent climate change activities serious was explained using African systems. Agriculture and agro-ecological systems are prominent in the economies of African countries. They use less capital and technology. The countries are expected to be especially vulnerable because they are already too hot. Further warming is expected to reduce crop productivity. The conclusion was to make efficient use of water management practices to reduce weather variability effect on agricultural production.

2.4 LABORATORY ANALYTICAL SERVICES PROGRAMME

SRI Research Team: **F. M. Tetteh, G. W. Quansah, Sadick Adams, Emmanuel Amoakwah and Anthony Abutiate**

Source of Funding: SRI Clients

Duration of Project: 2013

Introduction

The main activities of the Analytical Services Division are twofold: Research and laboratory analytical and diagnostic services. In research, scientists conducted several research activities which have been reported in this report. In the laboratory, soil, plant, water and fertilizer samples were received from projects, private farmers and companies which were analyzed.

Major Activities

Laboratory physico-chemical analysis

The total number of samples received in 2013 was 7725 and the breakdown is as follows:

Soil	–	6248
Plant	–	1266
Water	–	198
Fertilizer	–	13

There was a significant increase in the total number of samples analyzed in 2013 compared to the previous years; this was about twice the numbers. In addition, the laboratory at the Accra Centre received and analyzed over 877 soil and plant samples

Soil Analysis

Routine analyses of Soil pH, Organic Matter, Total Nitrogen, Exchangeable base (Ca, Mg, K and Na), Exchangeable Acidity (Al + H), Available Phosphorus and Potassium, Particle size distribution (Sand, Silt and Clay) were done.

Micro-Nutrients analyses of Zinc (Zn), Manganese (Mn), Iron (Fe), Copper (Cu), Cadmium (Cd), Lead (Pb) and Arsenic (As) were done.

Water Analysis

pH, electrical conductivity (EC),phosphate (P-PO4), nitrate ($N-NO_3^-$), ammonium ($N-NH_4^+$), sodium (Na), potassium (K), calcium (Ca), magnesium (Mg), chloride (Cl), alkalinity, hardness, total dissolved solids (TDS) and sodium adsorption ratio (SAR).

Plant Analysis

Macro-nutrients: Nitrogen (N), Phosphorus (P), Potassium (K), Calcium (Ca), Magnesium (Mg) and Carbon (C).

Micro-nutrients: Zinc (Zn), Manganese (Mn), Iron (Fe), Copper (Cu), Cadmium (Cd), Lead (Pb) and Arsenic (As).

Fertilizer Analysis

Nitrogen, Phosphorus, Potassium, Calcium and Magnesium.

Facilities and equipment

The equipment in working condition in the laboratory are as follows:

Flame photometer, Spectrophotometer, Kjeldahl digestion and distillation apparatus, Distilled water plant, Reciprocal shakers, pH meters, Conductivity meters, Balances, Furnace, Ovens, Atomic Absorption Spectrophotometer, InfraRed Spectrophotometer (Chemistry) etc. The Laboratory at the Soil Research Centre in Accra received four (4) new equipment namely pH meter, conductivity meter, spectrophotometer a desktop computer from the Centre's income generation activities. However, the problem of the Atomic Absorption Spectro-photometer and Kjeldahl apparatus are yet to be resolved. Furthermore, the old distill water plant needs to be replaced since it is gradually getting to the end of its life-span.

Clients

Private Institutions and Commercial Farms including Ghana Manganese Co. Ltd, Goldfields Ghana Ltd, AngloGold Ashanti, Persus Mines, Bogoso Mines, GTZ, BOPP, TOPP, etc benefitted from the services.

Research / Universities / Government and Non-Governmental Agencies including Crops Research Institute (CRI), Forestry Research Institute of Ghana (FORIG), Savanna Agricultural Research Institute (SARI), Oil Palm Research Institute (OPRI), Kwame

Nkrumah University of Science and Technology (KNUST), University of Cape Coast (UCC), University of Development Studies (UDS), University College of Education of Winneba (UCEW), Ministry of Food and Agriculture (MoFA), Millennium Village Project (MVP), Cecar Africa Farmer Associations and other Private Farms sent samples for analysis.

Recommendation

Repair works at the Main Laboratory (Fixing of sinks and fume chambers etc.) need to be completed. Assorted glassware and reagents to be acquired.

New equipment are required to replace the old ones and also to meet the current services being requested for by our clients particularly, the mining companies i.e. pH and conductivity meters, Kjeldahl digestion and distillation apparatus, Flamephotometer, Computer and accessories.

3.0 COMMERCIAL AND INFORMATION DIVISION

Introduction

The Commercial and Information Division (CID) of CSIR-SRI comprises of the Commercial, Data Management, Library and Publications units.

Activities undertaken by the various units.

a. Commercial unit

The commercial activities of the institute include:

1. Laboratory Analytical Services
2. Consultancy Services
3. Sale of Maps, Reports & Memoirs
4. Sale of Farm Produce
5. Conference Hall Hiring Services
6. Hiring of Transport Services

The total IGF realized at the end of 2013 is depicted in the table below. The activities that gave the most revenue were:

- Ø Laboratory analytical services
- Ø Consultancy services
- Ø Land evaluation / soil survey

Internally Generated Funds, 2013

No.	Commercial activities	Gross amount (GH₵)	Expenses (GH₵)	Net (GH₵)
1.	Land evaluation / Soil Survey	150,755.77	126,409.50	24,346.27
2.	Laboratory analytical services (soil / plant / water analysis)	92,675.50	52,548.63	40,126.87
3.	Consultancy services	136,795.92	98,526.58	38,269.34
4.	Sale of maps and memoirs	2011.00	35.00	1976.00
5.	Sale of farm produce	6,940.00	3,395.00	3,545.00
6.	Hiring of conference hall	900.00	105.00	795.00
7.	Hiring of transport	3,225.00	927.50	2,297.50
	TOTAL	**393,303.19**	**281,947.21**	**111,355.98**

b. Data Management Unit

The data management unit managed the local area network of the institute , supervised the servicing of computers by Inter – Speed Systems.

c. Library unit

The library received quite a number of books, magazines, newsletters, journals, brochures, catalogues, and annual reports from partner institutions. Apart from the SRI staff who patronized the library, students from Kwadaso Agric College, KNUST, as well as other tertiary institutions visited the institute's library for research purposes.

d. Publications unit

The publication unit responded to a number of enquiries concerning the soils of Ghana, the vegetation, land use and related subjects from local stakeholders and international collaborators.

4.0 ADMINISTRATION AND FINANCE

The Institute was managed by an eight-member Management Board chaired by Oheneba Adusei Poku, Akyempimhene, Kumasi as well as a 15 member Internal Management Committee chaired by the Director (Appendix 5). The Institute's staff strength stood at 294, made up of 33 senior members, 85 senior staff and 176 junior staff (Appendix 3).

Total receipts of Ghana Government funds for the year was GH Cedis 4.7 million constituting about 55% of the approved budget. The amount was spent as per the table below;

Type of expenditure	**Expenditure (GHC)**
1. Personnel Emoluments	4 706 378.68
2. Administrative Activities	-
3. Service Activities	-
4. Investment Activities	-
TOTAL	4 706 378.68

Appendix 1

PUBLICATIONS PRODUCED IN 2012

Refereed Journals Papers

Amoakwah E., Van Slycken S., Tack F.M.G., Essumang, D. (2013). Assessing the Extraction Efficiency of $CaCl_2$ and Rhizon Extraction Methods after the Application of Organic Matter and $CaCl_2$ as Soil Amendments to Enhance the Mobility of Cd and Zn*. **J Environ Anal Toxicol*** 3: 167. doi:10.4172/2161-0525.1000167

Amoakwah E., **Frimpong-Manso J.**, Essumang D. K. (2013). Assessing the Efficacy of Imidacloprid 20% SL as an Insecticide against Aphids in Cultivated Okra Plants in a Tropical Ecosystem: A Case Study of Mamponteng – Kumasi, Ghana for the 2011 and 2012 Cropping Period. ***ARPN Journal of Science and Technology***, VOL. 3, NO. 4., 390-395.

Amoakwah, E., Ampofo-Asiama, J., Van Slycken, S., David K. Essumang (2013). A Comparison of the Solubilizing Potential of Some Aminopolycarboxylic Acids, Hortrilon® and Fetrilon® for Use in Phytoextraction; ***Open Journal of Soil Science*** 3, 182-190. doi:10.4236/ojss.2013.34021.

Amoakwah, E. and Frimpong, K. A. (2013). Relationships between potassium forms and selected physico-chemical properties of some Ghanaian soils along a toposequence; ***ARPN Journal of Engineering and Applied Sciences***, VOL. 8, NO. 7, 525-533.

S. Adjei-Nsiah and **R. N. Issaka**, 2013: Farmer's Agronomic and Social Evaluation of Productivity, Yield and Cooking Quality of Four Cassava Varieties. American Journal of Experimental Agriculture 3(1): 165-174.

Adams S., **R. N. Issaka,** G. W. Quansah, R. Amfo-Otu, S. Bagna. 2013. Assessment of irrigation water quality of Tono Dam in Navrongo, Ghana. J. Bio. Env. Sci. 4(3), 187-195.

Adams S., G.W.Quansah1, R.N.Issaka, E.A.Asamoah, K.A.Nketia, R.Amfo-Otu. 2013. Water requirements of some selected crops in Tono irrigation area. J. Bio. Env. Sci. 4(3), 246-257.

Allotey D.F.K, K. Ofosu-Budu, F. Essuman, B. Ason, R.N. Issaka, E.Monney, C.K. Sackey, and P.M. Gyekye Jr. 2013. Soil fertility status of selected citrus orchards in the Eastern, Central and Volta Regions of Ghana. International Journal of Soil Science and Agronomy (.accepted on 31st December 2013)

Conference Papers

Amoakwah E. 2013. Climate change, food production and agricultural sustainability in Africa. Paper presented at the World Food Prize Awards panel meeting from 16th – 19th October, 2013, Des Moines, Iowa, U.S.A.

Issaka, R. N., Buri, M. M., Nakamura, S., Tobita, S. Essien. A. Sources, Availability and Application of Organic Materials in Lowland Rice Production Systems in the Forest one of Ghana. Paper presented at an International workshop on: Improvement of Soil Fertility with Use of Indigenous Resources in Rice Systems in Ghana. Tamale, Ghana. October 2013.

Issaka, R. N., Buri, M. M., Nakamura, S., Tobita, S. Essien. Poultry Manure Based Composting With Rice-Straw and Saw Dust for Lowland Rice Production in the Forest Zone of Ghana. Paper presented at an International workshop on: Improvement of Soil Fertility with Use of Indigenous Resources in Rice Systems in Ghana. Tamale, Ghana. October 2013.

Buri M. M. and Issaka R. N. Present status of soil fertility in lowland rice fields of Ghana and recommended management practices. Paper presented at an International workshop on: Improvement of Soil Fertility with Use of Indigenous Resources in Rice Systems in Ghana. Tamale, Ghana. October 2013.

Satoshi Nakamura, Roland N Issaka, Israel K Dzomeku, Monrawee Fukuda, Moro M Buri, Vincent K Avornyo, and Satoshi Tobita. Implication of direct application and residual effects of phosphate rock in lowland rice system of Ghana. Paper presented at an International workshop on: Improvement of Soil Fertility with Use of Indigenous Resources in Rice Systems in Ghana. Tamale, Ghana. October 2013.

Technical Reports

Buri M. M. (2012): Mid-term Review Report on 'Sawah', Market Access and Rice Technologies for Inland valleys (SMART- IV) Project (2012). CSIR-SRI/CR/BMM/2012/01

Antwi, B.O., and W.A. Adjare. Irrigation Feasibility report for Houtman Oil Palm (Draft Report)

Antwi, B.O., and W.A. Adjare. Rehabilitation of Dede Forest Reserve with Irrigated Paulonia; Tech (CSIR-SRI/CR/BOA/2012/04) October, 2012

Appendix 2

Workshops and Conferences:

Mr. Emmanuel Amoakwa	Attended the International conference on Water, Food, Energy and Innovation for a Sustainable World, organized by the Alliance of Crop, Soil, and Environmental Science Societies American Society of Agronomy, Crop Science Society of America, Soil Science Society of America. Date: 3rd–6th November, 2013. Tampa, Florida, U.S.A.
Mr. Emmanuel Amoakwa	Participated in the International training workshop on Soil Health: impact of tillage, carbon, soil quality and biodiversity. From 28th – 30th October, 2013. Michigan, U.S.A.
Mr. Emmanuel Amoakwa	Attended the World Food Prize Awards panel meeting and presented a scientific paper titled "climate change, food production and agricultural sustainability in Africa" from 16th – 19th October, 2013 , Des Moines, Iowa, U.S.A.
Mr. Emmanuel Amoakwa	Participated in the First World Irrigation Forum and 64th International Executive Council meeting, from 29th September – 5th October, 2013, at Mardin, Turkey.
Mr. Eric O. Adjei	Participated in training workshop on addressing climate change in development assistance from 23 Sept. – 11 Oct. 2013, Copenhagen, Denmark
Dr. Roland N. Issaka and Eric O. Adjei	Participated in an International Workshop Improvement of Soil Fertility with Use of Indigenous Resources in Rice Systems in Ghana. Tamale. Ghana. Oct. 15th and 16th 2013
Dr. Roland N. Issaka	Attended an International workshop for the Award Holders of the RS -DFID Africa Network Grants. Darkar. Senegal. 27 and 28 October 2013
Mr. Enoch Boateng	Attended a Workshop by AGRA on Soil Health Consortium, West Africa from 10th to 12th December, 2013 hosted by IITA in Ibadan, Nigeria.

Dr. B. O. Antwi

Appendix 3 STAFF MATTERS

STAFF STRENGTH

STAFF RANKING	KUMASI	ACCRA	TOTAL
Senior Members	26	6	32
Senior Staff	71	14	85
Junior Staff	161	13	174
T O T A L	258	33	291

DIVISIONS/SECTIONS MANPOWER POSITION

NO.	DIVISION	SENIOR MEMBERS	TECHNICIANS SENIOR/JUNIOR	ADMIN/ SUPPORT.	GRAND TOTAL
1.	Soil Microbiology	4	2	6	12
2.	Soil Chemistry/Mineralogy	3	5	7	15
3.	Soil Genesis & Land Evaluation	3	4		7
4.	Soil Fertility & Nutrition Div.	6	10	40	56
5.	Soil & Water Management	4	1	10	15
6.	Commercial Information	4		8	12
7.	Administration	2		14	16
	SECTIONS				
8.	Accounts & Stores			17	17
9.	Security & Watchmen			21	21
10.	SMR & Extension Farm		2	23	25
11.	Transport & Civil Workshop		1	15	16
12.	Station Maintenance		1	31	32
13.	Cartography		7	1	8
14.	Canteen			6	6
	1. KUMASI	26	33	199	258
	2. ACCRA	6	14	13	33
	GRAND TOTAL	32	47	212	291

NEW APPOINTMENTS:

Senior staff

NO.	NAME	POSITION
	Richard Baffour	Accounting Assistant
	Juliet Adomah Amoako (Mrs.)	Accounting Assistant
	Kofi Agyen	Accounting Assistant
	Mary Bannoah Acquaah	Senior Administrative Assistant

Junior staff

NO.	NAME	POSITION
	Francis Adjei Kusi	Senior Security Assistant Gd. I
	Kennedy Adomako	Senior Security Assistant Gd. I
	Nana Konadu Ntsiful (Miss.)	Accounts Clerk Gd. I
	Enoch Danquah	Labourer

TRANSFERS

NO.	NAME	TRANSFERRED FROM	NEW INSTITUTION
1.	Mrs. Celestine Essel	CSIR -SARI	CSIR -SRI, Accra
2.	David Ebo Ampah	CSIR -SRI, Accra	CSIR -WRI

RETIREMENT

Senior members

NO.	NAME	DATE OF 1ST APPT.	POSITION HELD	DATE RETIRED	YEARS SERVED
1.	James K. Senayah	29/11/85	Senior Res. Scientist	01/05/2013	28 yrs

Senior staff

NO.	NAME	DATE OF 1ST APPT.	POSITION HELD	DATE RETIRED	YEARS SERVED
1.	E. Prempeh Kessie	02/01/75	Chief T. Officer	23/08/13	38
2.	Kwaw A. Forson	02/01/75	Chief T. Officer	10/07/13	38
3.	Ampofo Kusi	0/08/85	Sen. Sec. Officer	24/10/13	28
4.	Faustina Achiaa	01/05/82	Prin. Admin. Asst	30/09/13	31
5.	Gilbert O. Danso	01/06/91	Sen. Sec. Officer	22/12/13	22

Junior Staff

NO.	NAME	DATE OF 1ST APPT.	POSITION HELD	DATE RETIRED	YEARS SERVED
1.	Jefferson J. Oppong	01/08/90	Foreman	15/11/13	23
2.	Erasmus Manu	01/07/80	Overseer	07/07/13	33
3.	Joe Roy Mawuli	13/05/83	Overseer	16/03/13	30
4.	John Kwaku Worae	01/06/78	Overseer	01/07/13	35
5.	Atta Kwasi	01/10/82	Overseer	21/08/13	31
6.	Awudu Wala	16/11/76	Superv. Headman	21/07/13	37
7.	Grace Obeng	01/10/79	Superv. Headman	01/07/13	34
8.	Hamidu Busanga	06/11/73	Superv. Headman	01/07/13	40

PROMOTIONS

Senior staff

NO.	NAME	GRADE PROMTED TO	EFFECTIVE DATE
1.	Francis Kusi Adjei	Principal Works Superintendent	01/01/2013
2.	Regina A. Atsu	Principal Technical Officer	01/01/2013
3.	Isaac Owusu Ansah	Principal Technical Officer	01/01/2013
4.	Alex Owusu	Senior Draughtsman	01/01/2013
5.	Peter Osei	Senior Draughtsman	01/01/2013
6.	Alex Y.S. Amrago	Senior Draughtsman	01/01/2013
7.	John Atsu	Principal Technical Officer	01/01/2013

Junior staff

NO.	NAME	GRADE PROMTED TO	EFFECTIVE DATE
1.	Anim Boafo	Technical Officer	01/01/2013
2.	Bernard Tetteh Kabutey	Technical Officer	01/01/2013
3.	Kwasi Appiah	Technical Officer	01/01/2013
4.	Jefferson Joseph Oppong	Works Superintendent	01/01/2013
5.	Alex Amakah	Traffic Supervisor	01/01/2013
6.	Victoria Mensa Stephens	Stores Superintendent	01/01/2013
7.	Regina Aryeeley Armah	Senior Clerk	01/01/2013

STUDY LEAVE

NO.	NAME	POSITION HELD	PROGRAMME OF STUDIES	INSTITUTION OR SCHOOL	DURATION
1.	Ephraim Sekyi Annan	Research Scientist	PhD in Land Use and Degradation	University of Bonn, Germany	4 years 2013 - 2016
2.	Sampson Adjei	Research Scientist	PhD Soil Science	University of Ghana, Legon	4 years 2010 - 2014
3.	Patrick Ofori	Research Scientist	PhD Soil Science	KNUST	4 years 2010 - 2014
4.	J. Frimpong Manso	Technologist	MSc Soil Science	The Netherlands	2 years 2011 – 2013
5.	Doreen Ofeibea Kwabi Sarpong	Principal Admin . Assistant	MBA Human Res. Management	KNUST	2years 2013 - 2015
6.	Kwabena A . Nketiah	Technologist	M.Sc. Soil Science	University of Ghana, Legon	2years 2012 - 2014
7.	Isaac Owusu Ansah	Senior Technical Assistant	B.Sc. Agric. Science	University of Cape Coast	4years 2009-2013
8.	Kwabena Andoh Payin	Technologist	B.Sc. Lab. Tech.	University of Cape Coast	4years 2009-2013
9.	Stephen Wiredu	Technical Officer	Diploma. in Gen. Agriculture	Kwadaso Agric. College, Kumasi	2 years 2011-2013
10.	Dorothy Aponye	Overseer	Certificate in Gen. Agriculture	Kwadaso Agric. College, Kumasi	2years 2011-2013
11.	Thomas Afreh	Overseer	Certificate in Gen. Agriculture	Ejura Agric. College	2years 2012-2013
12.	Peter Ofori	Overseer	Certificate in Gen. Agriculture	Ejura Agric. College	2years 2012-2013

DEATH

Mr. Kwabena Grushie, a Supervising Headman, passed away during the year. May his soul rest in peace.

List of Visitors to the Institute

NO.	NAME	COUNTRY/ORGANIZATION
1.	Dr. Joe Oteng-Adjei	Minister, MESTI
2.	Dr. M.M. Alfa	Deputy Minister, MESTI
3.	Dr. Hide Omae	Okinawa, Japan
4.	Dr. Sotoshi Tobita	Tsukuha, Japan
5.	Qurash Noordia	AGRA, Nairobi
6.	Money Tekyi-Ansah	AGRA, Accra
7.	Dr. Waruyuki Dan	Tsukuha, Japan
8.	Dr. F. Nyagumu	Tsukuha, Japan

List of Students on Industrial Attachments

NO.	**NAME**	**INSTITUTION**
1.	Charis Owusu Dubing	UDS
2.	John Fordjour Sarpong	KNUST
3.	Nundeen Arimiyaw	University of Ghana
4.	Ernest Osei Kodem	Koforidua Polytechnic
5.	Pamela Boateng	Takoradi Polytechnic
6.	Emmanuel Kwabila Kpodo	KNUST
7.	Akwasi Yeboah Asiamah	Koforidua Polytechnic
8.	Alice Adu Bema	O/CG
9.	Kusi Yeboah Amponsem	UCC
10.	Richard Boateng	UCC
11.	Lawrence K. Opoku	UCC
12.	Sheila Ntiwaa	UDS
13.	Cecilia Kumah Afriyie	Christian Service University College
14.	Theophilus Opoku Abrefa	Kumasi Polytechnic
15.	Gifty Donkor	Kumasi Polytechnic
16.	Kwabena Atrams Asare	Kumasi Polytechnic
17.	Ebenezer Adusei	KNUST
18.	Brenda Kankam Allotey	Garden City University College
19.	Nadia Yeboah Amoateng	Garden City University College
20.	Desmond Adjei Owusu	University of Ghana
21.	Paaga Miki Dame	UDS
22.	Eunice Antwi	KNUST
23.	Ophelia Narh	KNUST
24.	Botah Oppong Agyarea	KNUST
25.	Awal Shuaib Adil	KNUST

NO.	NAME	INSTITUTION
25.	Awal Shuaib Adil	KNUST
NO.	**NAME**	**INSTITUTION**
26.	Enyonam Adzo Agbenoheri	KNUST
27.	Cynthia Nyamekye	KNUST
28.	Mawusi Collins	KNUST
29.	Ishmael Owusu Anane	KNUST
30.	Joshua Fudzagbo	KNUST
31.	Emmanuel Owusu Tenkorang	KNUST
32.	Mawuli Amegah	KNUST
33.	Adjoa Dwamena Intiful	University of Ghana
34.	Linda Owusu Ansah	Koforidua Polytechnic
35.	Seth Mensah Bonsu	KNUST
36.	Oscar Ata Frimpong	Pan African Christian University College
37.	Alex Osei Assibey	Central University College
38.	Margaret Ofosua Ohawu	Agric College

List of National Service Personnel

NO.	NAME	INSTITUTION	DATE
1.	Rita Adjei	Garden City Univ. College	12/09/2013
2.	Bright Osei Badu	KNUST	25/09/2013
3.	Alexander Owusu Ansah Senisi	KNUST	26/09/2013
4.	Barbara Asimenyiwaa Annan	KNUST	26/09/2013
5.	Joseph Appiah	UDS, Tamale	4/10/2013
6.	Eunice Amponsem	Univ. of Mines & Tech, Tarkwa	4/10/2013
7.	Edward Ayim Asante	UCC	7/10/2013
8.	Frederick Danso	UCC	9/10/2013
9.	Kate Sarpong	Christian Service Univ. College	16/10/2013
10.	Michelle Jacklin Ofori Asamoah	Univ. of Ghana	16/10/2013
11.	Bright Opoku Manu	OhawuAgricultural College	11/10/2013
12.	Benjamin Opoku Duah	KNUST	11/10/2013

Appendix 4

MEMBERSHIP OF MANAGEMENT BOARD, 2011

1. Oheneba Adusei Poku	-	Chairman, Akempimhene, Kumasi
2. Dr. (Mrs.) R.E.M. Entsuah-Mensah	-	Member, Deputy Director-General, CSIR Head Office, Accra.
3. Mrs. L. Bedu Addo-Mensah	-	Member, Area Manager, Agricultural Development Bank, Kumasi
4. Mr. T.F. Asare	-	Member, Asare Farms Limited, Kumasi
5. Mr. George Owusu Afriyie	-	Member, Manager, Pacific Savings & Loans Limited, Kumasi.
6. Dr. Hans Adu-Dapaa	-	Member, Director, CSIR- Crops Research Institute, Kumasi
7. Dr. J. O. Fening	-	Member, Director, CSIR-Soil Research Institute, Kwadaso-Kumasi
8. Mrs. Hectoria Tsaku-Harker	-	Secretary, Administrative Officer, CSIR-SRI, Kwadaso-Kumasi

Appendix 5.

MEMBERS OF THE INTERNAL MANAGEMENT COMMITTEE

1.	Dr. J.O. Fening	-	Director/Chairman
2.	Mr. E. Boateng	-	Deputy Director/Head, Soil Research Centre, Accra
3.	Dr. M.M. Buri	-	Head, Soil Fertility Division
4.	Dr. F.M. Tetteh	-	Head, Laboratory Analytical services Division
5.	Dr. B.O. Antwi	-	Head, Soil and Water management Division
6.	Mr. E. Yeboah	-	Head, Soil Microbiology Division
7.	Mr. J.K. Senayah	-	Head, Soil Genesis, Survey and Class. Div.
8.	Mrs. H. Tsaku-Harker	-	Head of Administration
9.	Mr. P. Poku Achampong	-	Head, Commercial and Information Division
10.	Mr. K. Yiadom	-	Head, Accounts and Stores Section
11.	Mr. S.B. Atiemo	-	Security and Station Maintenance Section
12.	Mr. James Oppong	-	RSA Representative
13.	Mr. Edward Kissi	-	SSA Representative
14.	Mr. E. Prempeh-Kessie	-	TUC Representative
15.	Mr. S.J. Obeng	-	Secretary