



UNIVERSITY FOR DEVELOPMENT STUDIES

BOOK OF ABSTRACTS OF PUBLICATIONS

By

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Table of Contents

	Page
FACTORS INFLUENCING TECHNOLOGY ADOPTION BY TRADITIONAL AFRICAN VEGETABLE FARMERS IN NORTHERN GHANA	1
EFFECTS OF TRIPLE SUPER PHOSPHATE AND INOCULANT ON YIELD OF SOYBEAN SEED IN NORTHERN REGION OF GHANA	
A REVIEW OF EXPLORED USES AND STUDY OF NUTRITIONAL POTENTIAL OF TAMARIND (<i>Tamarindus indica</i> L.) IN NORTHERN GHANA	
THE EFFECT OF DECOMPOSED SAWDUST AND RICE HULL AS GROWTH MEDIA ON THE GROWTH AND YIELD OF <i>CORCHORUS OLITORIUS</i>	
CARBON DIOXIDE AND GASEOUS NITROGEN EMISSIONS FROM BIOCHAR-AMENDED SOILS UNDER WASTEWATER IRRIGATED URBAN VEGETABLE PRODUCTION OF BURKINA FASO AND GHANA	
ARTHROPOD COMMUNITIES IN URBAN AGRICULTURAL PRODUCTION SYSTEMS UNDER DIFFERENT IRRIGATION SOURCES IN THE NORTHERN REGION OF GHANA	
COMPARATIVE STUDIES ON THE NUTRIENT COMPOSITION OF SHADE DRIED AND SUN-DRIED LEAVES OF ROSSELLE (<i>HIBISCUS SABDARIFFA</i> L.)	
NUTRIENT FLOWS AND BALANCES IN INTENSIVELY MANAGED VEGETABLE PRODUCTION OF TWO WEST AFRICAN CITIES	
NON-THERMAL INACTIVATION OF POLYPHENOLOXIDASE FROM JERUSALEM ARTICHOKE (<i>HELIANTHUS TUBERUSUS</i> L.)	
VIRTUAL WATER FLOW IN FOOD TRADE SYSTEMS OF TWO WEST AFRICAN CITIES	
EFFECT OF PRE-GERMINATION SEED TREATMENTS ON GERMINATION OF SEEDS AND INITIAL GROWTH OF MANGO (<i>Mangifera indica</i> L)	
THE EFFECT OF SPATIAL THINNING ON THE POTENTIAL DISTRIBUTION OF 10 AFRICAN INDIGENOUS VEGETABLES	

PACKAGING CONTAINERS FOR LONG-DISTANCE TRANSPORT OF SWEETPOTATO [*Ipomoea batatas* (L) LAM] STORAGE ROOTS IN GHANA

PERFORMANCE AND NUTRITIONAL QUALITY OF ROSELLE (*Hibiscus sabdariffa* L.) AND JUTE MALLOW (*Corchorus olitorius* L.) UNDER ORGANIC SOIL AMENDMENTS (COMPOSTS)

STRUCTURAL LANDSCAPE CHANGES IN URBAN AND PERI-URBAN AGRICULTURAL SYSTEMS OF TWO WEST AFRICAN CITIES AND THEIR RELATIONS TO ECOSYSTEM SERVICES PROVIDED BY WOODY PLANT COMMUNITIES

AGRONOMIC EFFECTS OF BIOCHAR AND WASTEWATER IRRIGATION IN URBAN CROP PRODUCTION OF TAMALE, NORTHERN GHANA

HEAVY METALS CONCENTRATIONS AND RISK ASSESSMENT OF ROSELLE (*Hibiscus Sabdariffa* L.) CULTIVATED WITH THREE COMPOST TYPES

SOIL PHYSICAL AND CHEMICAL PROPERTIES AND CROP WATER REQUIREMENT OF SOME SELECTED VEGETABLE CROPS AT CENTRAL EXPERIMENTAL FIELD OF URBAN FOOD PLUS PROJECT IN SANARIGU DISTRICT, TAMALE, GHANA

ASSESSING SOCIOECONOMIC FACTORS INFLUENCING PRODUCTION AND COMMERCIALIZATION OF BAMBARA GROUNDNUT AS AN INDIGENOUS CLIMATE RESILIENT CROP IN NIGERIA

WEED SPECIES STRUCTURAL AND FUNCTIONAL COMPOSITION OF OKRA FIELDS AND FIELD PERIPHERY UNDER DIFFERENT MANAGEMENT INTENSITIES ALONG THE RURAL- URBAN GRADIENT OF TWO WEST AFRICAN CITIES

FOODSHEDS AND CITY REGION FOOD SYSTEMS IN TWO WEST AFRICAN CITIES

PRELIMINARY INVENTORY OF HYMENOPTERAN PARASITIDS ASSOCIATED WITH FRUIT- INFESTING FLIES (DIPTERA: TEPHRITIDAE) IN NORTHERN GHANA

ADOPTION OF BAMBARA GROUNDNUT PRODUCTION AND ITS EFFECTS ON FARMERS' WELFARE IN NORTHERN GHANA

USE PATTERNS AND PERCEPTIONS ABOUT THE ATTRIBUTES OF BAMBARA
GROUNDNUT (*Vigna Subterranea* (L.) VERDC.) IN NORTHERN GHANA

INSECTICIDE APPLICATION IN VEGETABLE PRODUCTION AND THE RISK OF
FOOD POISONING IN NKORANZA MUNICIPALITY, GHANA

IN-SERVICE TRAINING NEEDS OF AGRICULTURAL EXTENSION AGENTS IN
THE MANAGEMENT OF FRUIT-INFESTING FLIES (DIPTERA: TEPHRITIDAE) IN
NORTHERN GHANA

TECHNICAL EFFICIENCY OF BAMBARA GROUNDNUT PRODUCTION IN
NORTHERN GHANA

REVIEW OF THE PEST STATUS, ECONOMIC IMPACT AND MANAGEMENT OF
FRUIT-INFESTING FLIES (DIPTERA: TEPHRITIDAE) IN AFRICA

EFFECT OF COMPOST-BIOCHAR MIXES AND IRRIGATION ON THE GROWTH
AND YIELD OF AMARANTHUS (*AMARANTHUS HYBRIDUS*) UNDER TWO
GROWING TEMPERATURES

SPLIT-PLOT DESIGN: ANALYSIS DOLDRUMS COMPARING GENSTAT, SPSS
AND R

EFFECTIVENESS OF THE EGG PARASITOID *Trichogramma Evanescens*
PREVENTING RICE MOTH FROM INFESTING STORED BAGGED COMMODITIES

PRELIMINARY STUDIES ON THE EFFECT OF SHEA KERNEL SIZE ON SHEA
BUTTER QUALITY

EFFECT OF VITRIFICATION SOLUTION (PVS2) ON VIABILITY AND VIGOUR OF
SEEDS OF AMARANTH (*AMARANTHUS HYBRIDUS*)

ASSESSING THE PERFORMANCE OF SORGHUM VARIETIES IN THE GUINEA
SAVANNA ZONE OF GHANA

FATTY ACID AND TOCOPHEROL PATTERNS OF VARIATION WITHIN THE
NATURAL RANGE OF THE SHEA TREE (*VITELLARIA PARADOXA*)

DIVERSITY OF TREE SPECIES IN CULTIVATED AND FALLOW FIELDS WITHIN
SHEA PARKLANDS OF GHANA

EFFICACY EXTRACT FROM *Hyptis spicigera* LAM. AGAINST CALLOSOBRUCHUS MACULATUS F. (COLEOPTERA: BRUCHIDAE IN KERSTINGS' GROUNDNUT (*MACROTYLOMA GEACARPUM* HARMS)

POTENTIAL OF BIOTECHNOLOGY AND APPLICATION OF GENOMICS TO INDIGENOUS AND TRADITIONAL LEAFY VEGETABLES IN WEST AFRICA

LEAF AND FRUIT CHARACTERISTICS OF SHEA (*Vitellaria paradoxa*) IN NORTHERN GHANA
43 COMPARATIVE STUDIES OF SOIL CHARACTERISTICS IN SHEA PARKLANDS OF GHANA

DETERMINATION OF BIOCHEMICAL COMPOSITION OF SHEA (*Vitellaria paradoxa*) NUT USING NEAR INFRARED SPECTROSCOPY (NIRS) AND GAS CHROMATOGRAPHY

THE EFFECT OF ELECTRICAL CONDUCTIVITY (EC) AND ACIDITY (PH) OF IRRIGATION WATER ON THAT OF VEGETABLE GARDEN SOILS IN THE TAMALE METROPOLIS

BASELINE STUDIES ON THE MARKETING OF AMARANTHUS IN TAMALE

GROWTH AND FRUIT WEIGHT OF CHILLI PEPPER (*Capsicum frutescens*) AS AFFECTED BY SOIL STERILIZATION AND PRICKING OUT

FOSTERING SUSTAINABLE ENGAGEMENT OF THE YOUTH IN THE AGRIFOOD SECTOR: OPPORTUNITIES AND CHALLENGES FOR YOUTH EMPLOYMENT IN GHANA

LABORATORY EVALUATION OF EXTRACTS FROM *HYPTIS SPICIGERA* LAM. AGAINST *Callosobruchus maculatus* F. (COLEOPTERA: BRUCHIDAE) IN KERSTING'S GROUNDNUT (*Macrotyloma geocarpum* HARMS).

PRELIMINARY STUDIES ON THE GROWTH AND YIELD OF HOT PEPPER (*Capsicum frutescens* L.) AS INFLUENCED BY PRICKING OUT AND STARTER SOLUTION

PRELIMINARY STUDIES ON GROWTH AND FRESH WEIGHT OF LETTUCE (*Lactuca sativa*) AS AFFECTED BY CLAY POT IRRIGATION AND SPACING

GROWTH AND YIELD RESPONSE OF CARROT (*Daucus carota* L.) TO DIFFERENT RATES OF SOIL AMENDMENTS AND SPACING

PRELIMINARY EVALUATION OF SOME PLANT PRODUCTS IN THE CONTROL OF FIELD INSECT PEST OF OKRO

EFFECT OF AGRO-ECOLOGICAL ZONE AND STORAGE ENVIRONMENT ON THE QUALITY OF THE PHYSIC NUT (*Jatropha curcas*) SEED

A REVIEW ON THE POSSIBILITY OF FLOWERING AND SEED PRODUCTION OF CABBAGE IN THE TROPICS

SUCROSE AND NITROGEN EFFECTS ON GREENNESS, HEAD PARAMETERS AND FLOWERING OF FOUR LINES OF CABBAGE

COMPARISON OF CELL MEMBRANE THERMOSTABILITY AND CHLOROPHYLL FLUORESCENCE PARAMETERS FOR THE DETERMINATION OF HEAT TOLERANCE IN TEN CABBAGE LINES

INDUCTION OF FLOWERING IN CABBAGE PLANTS BY IN VITRO VERNALIZATION, GIBBERELIC ACID TREATMENT AND RATOONING

INDUCTION AND GENERATION OF FLOWERING IN CABBAGE PLANTS BY SEED VERNALISATION, GIBBERELIC ACID TREATMENT AND RATOONING

PROMOTION OF VIGOUR IN CABBAGE SEED BY OSMOTIC PRIMING PRE-TREATMENT AT BOTH VERNALISATION AND NON-VERNALISATION TEMPERATURES

TOWARDS CABBAGE (*BRASSICA OLERACEA* VAR. *CAPITATA* L.) SEED PRODUCTION IN THE TROPICS

PACKAGING AND HANDLING OF FRESH TOMATO FROM TONO IRRIGATION PROJECT SITE

THE EFFECT OF CONTAINER TYPES, SEED DRESSINGS AND DESICANTS ON THE VIABILITY AND VIGOUR OF ROSELLE (*Hibiscus sabdariffa* L. VAR. SADDARIFFA) SEEDS

EFFECTS OF DIFFERENT SEED TREATMENT METHODS ON THE PERCENT GERMINATION, SEEDLING VIGOR AND BIOMASS PRODUCTION OF GROUNDNUTS IN GHANA

VARIATION IN FRUIT AND SEED CHARACTERISTICS OF THREE POPULATIONS OF SHEA TREES (*VITELLARIA PARADOXA*) IN THE NORTHERN REGION OF GHANA

A SURVEY ON ONION PRODUCTION IN THE BAWKU EAST DISTRICT OF GHANA

COMPARISON OF NEEM PRODUCTS WITH ACTELIC AND DITHANE AS SEED DRESSERS ON THE VIABILITY AND VIGOUR OF STORED SEED MAIZE

FACTORS INFLUENCING TECHNOLOGY ADOPTION BY TRADITIONAL AFRICAN VEGETABLE FARMERS IN NORTHERN GHANA

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The production of traditional African vegetables is an age-old tradition among the people of the northern region of Ghana. However, the knowledge base of traditional African vegetable production remains local due to a lack of research and policy support. Therefore, the adoption of improved technology among traditional vegetable farmers is generally low and impedes efforts to promote widespread cultivation, consumption and even commercialisation. This study aims at clarifying potential factors that determine the adoption of technologies by traditional African vegetable farmers in the northern region of Ghana. One hundred and five (105) respondents in five communities and across two administrative districts in the northern region were selected for an in-depth survey using a combination of quantitative and qualitative data collection methods. In addition, a logit regression was used to determine the effect of various factors on technology adoption by farmers. Among the factors, the educational level of a farmer, access to credit, farm size, experience in farming and access to extension support were found to be important factors affecting the decision of traditional African vegetable farmers to adopt improved technology. The results of this study can help enhance the effectiveness of policy re-orientation towards a more effective commercialisation of traditional African vegetables in Ghana and elsewhere.

Keywords: Traditional African vegetable, farmers; Ghana, rural, technology

EFFECTS OF TRIPLE SUPER PHOSPHATE AND INOCULANT ON YIELD OF SOYBEAN SEED IN NORTHERN REGION OF GHANA

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The research was conducted to establish the effects of triple super phosphate and rhizobia inoculant on yield of soybean (*Glycine Max* (L)) seed quality in the Northern region of Ghana. Multi-locational trials were adopted and three different locations were used. Soybean foundation seeds obtained from Savannah Agriculture Research Institute were subjected to three different treatments on the field. These treatments were TSP + Inoculant, TSP only, Inoculant only and a control plot as a check. Randomize complete block design was used to allocate the treatments to the various plots. Data collected from the field included: number of days from seeding to germination, flowering and pod formation; nodule formation; plant height, number of pods per plant per treatment (Pod load), number of days to maturity, seed weight at harvest per plant per treatment (1000 seed weight) and finally, the yield was determined after harvest. Results revealed that the treatments (TSP + Inoculant, TSP only and Inoculant only) generally enhanced growth, development and yield of soybean seed as compared to the control plots in almost all the locations. The application of rhizobia inoculant contributed significantly to the development of the soybean plant. It aided the fixation of atmospheric nitrogen into the soil which improved its fertility that led to the significant increase in the number of nodules that were formed by the plant. The pod load was very high for all the treated plots. They were fully filled with seeds which were evidence in the yield obtained from the trials. TSP in combination with inoculants gave a very good yield of 2.66 Mt/ha and was significantly higher than all the other treatments. This result is a clear indication of how phosphorus fertilizer and inoculant positively affected the

yield. Seed producers should be encouraged, in addition to good agronomic practices, to apply the recommended dosage of inoculant and TSP to their seeds and soybean fields respectively. This would lead to early maturity and high yields.

Keywords: Soybean seed, Northern region of Ghana, Phosphorus, Inoculant, Yield

A REVIEW OF EXPLORED USES AND STUDY OF NUTRITIONAL POTENTIAL OF TAMARIND (*Tamarindus indica* L.) IN NORTHERN GHANA

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Tamarind (*Tamarindus indica*) is increasingly becoming a commercially important underutilized tree crop worldwide. Due to its multi-purpose use and market demand the tree and its processed products are been traded in many towns and villages. Despite its potential, major setbacks are the lack of knowledge on its uses and nutritional potential within the Ghanaian context. This study reviews and exposes the beneficial potential of tamarind whiles studying with empirical data its nutritional composition for proximate analysis. Indigenous to tropical Africa and naturalized to many regions of the world, the tree is seen in over 50 countries. Within Ghana and other parts of the world, tamarind is distinctively called by different vernacular names either referring to the tree or its product. Almost every part of the tree is used in one way or the other from food including beverage drinks, jams, and curries, to pharmaceutical, textile, timber, fodder, and as a fuel source. It is rich in vitamins, minerals and other proximate elements. Proximate composition of locally sourced fruit pulp showed high levels of fats and oils 51.39% and fibre 15.10% while other parameters like protein, ash,

vitamin C and moisture were similar to test results from other countries. The tamarind plant has undoubtedly great potential based on its benefits, and uses.

Key words: Tamarind, *Tamarindus indica*, Ghana, multipurpose, benefits, nutritional potential, medicinal, proximate composition.

THE EFFECT OF DECOMPOSED SAWDUST AND RICE HULL AS GROWTH MEDIA ON THE GROWTH AND YIELD OF *CORCHORUS OLITORIUS*

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A research was carried out at the Nursery of the Horticulture Department, Faculty of Agriculture, Nyankpala Campus, University for Development Studies (UDS), to evaluate how decomposed sawdust and rice hull affect the growth and yield of *Corchorus olitorius*. Randomized Complete Block Design (RCBD) with three replications was used for the experiment. Sawdust (SD), rice hull (R) that had been heaped for about eight months in Tamale and topsoil (S, used as the control treatment) were collected and utilized as media for the growth of the corchorus plants. *C. olitorius* seeds were sown on the three media and three weeks later they were transplanted into polyethylene bags. Findings of the study indicate that the treatments differed significantly ($p < 0.05$) in the parameters used, and S performed best, which was followed by R. The findings nevertheless show that decomposed sawdust and rice hull can be used as growth media for *Corchorus olitorius*. More investigation should however be done to find out how the duration of decomposition of sawdust and rice hull affects the growth and yield of *C. olitorius*.

Keywords: *Corchorus olitorius*, Decomposed, Growth Media, Optimum Yield, Growth Parameters.

CARBON DIOXIDE AND GASEOUS NITROGEN EMISSIONS FROM BIOCHAR-AMENDED SOILS UNDER WASTEWATER IRRIGATED URBAN VEGETABLE PRODUCTION OF BURKINA FASO AND GHANA

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To quantify carbon (C) and nitrogen (N) losses in soils of West African urban and peri-urban agri culture (UPA), we measured fluxes of CO₂-C, N₂O-N, and NH₃-N from irrigated fields in Ouaga dougou, Burkina Faso, and Tamale, Ghana, under different fertilization and (waste-) water regimes. Compared with the unamended control, application of fertilizers increased average cumulative CO₂-C emissions during eight cropping cycles in Ouagadougou by 103% and during seven cropping cycles in Tamale by 42%. Calculated total emissions measured across all cropping cycles reached 14 t C ha⁻¹ in Ouagadougou, accounting for 73% of the C applied as organic fertilizer over a period of two years at this site, and 9 t C ha⁻¹ in Tamale. Compared with unamended control plots, fertilizer application increased N₂O-N emissions in Ouagadougou during different cropping cycles, ranging from 37 to 360%, while average NH₃-N losses increased by 670%. Fertilizer application had no significant effects on N₂O-N losses in Tamale. While waste water irrigation did not significantly enhance CO₂-C emissions in Ouagadougou, average CO₂-C emissions in Tamale were 71% (1.6 t C ha⁻¹) higher on wastewater plots compared with those of the control (0.9 t C

ha⁻¹). However, no significant effects of wastewater on N₂O-N and NH₃-N emissions were observed at either location. Although biochar did not affect N₂O-N and NH₃-N losses, the addition of biochar could contribute to reducing CO₂-C emissions from urban garden soils. When related to crop production, CO₂-C emissions were higher on control than on fertilized plots, but this was not the case for absolute CO₂-C emissions.

Key words: ammonia volatilization / biochar / carbon dioxide emissions / inorganic N fertilization / urban agriculture / wastewater irrigation.

ARTHROPOD COMMUNITIES IN URBAN AGRICULTURAL PRODUCTION SYSTEMS UNDER DIFFERENT IRRIGATION SOURCES IN THE NORTHERN REGION OF GHANA

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Urban and peri-urban agricultural (UPA) production systems in West African countries do not only mitigate food and financial insecurity, they may also foster biodiversity of arthropods and partly compensate for structural losses of natural environments. However, management practices in UPA systems like irrigation may also contribute to disturbances in arthropod ecology. To fill knowledge gaps in the relationships between UPA management and arthropod populations, we compared arthropods species across different irrigation sources in Tamale. During a 72-h sampling period, 14,226 arthropods were caught with pitfall traps and pan traps from 36 fields. These specimens comprised 13 orders, 103 families, 264 genera, and 329 taxa (243 identified species, 86 unidentified species) and categorized into five feeding guilds (carnivores, decomposers, herbivores, omnivores, and pollinators). Species richness, species accumulation curves, and diversity functions (richness, evenness, and dispersion) were calculated to characterize the arthropod community. Non-metric multidimensional scaling was applied to examine structural similarity of arthropod communities among sites. To account for the effects of soil-related data, we furthermore applied a redundancy analysis. Arthropods grouped according to the irrigation water source, whereby the dipterans were most dominant under wastewater conditions. Here, particularly the eye gnat, *Hippelates pusio*, a disease-causing vector for humans, accounted for the dipterans. The occurrence of three alien ant species suggested community shifts through invasive species, while the occurrence of seven ant species (at least one ant species occurred under each water source) that form mutualistic relationships with aphids highlighted future risks of aphid pest outbreak. Future studies on these taxa should specifically target their ecological and economic effects and potential countermeasures.

Keywords: agrobiodiversity; ecosystem service; feeding guild; insects; NMDS; RDA; species function; Sub-Saharan Africa; urban agriculture.

**COMPARATIVE STUDIES ON THE NUTRIENT COMPOSITION OF SHADE
DRIED AND SUN-DRIED LEAVES OF ROSSELLE
(*Hibiscus sabdariffa* L.)**

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African Journal of Horticultural Science, 16, 29 – 42, 2019.

Hibiscus sabdariffa, a leafy vegetable consumed extensively in Ghana, provides important source of micronutrients and essential amino acids in diets. Although sun-dried vegetables have been used as alternatives to green vegetables, no study has been done to ascertain the nutritional content against that of shade-dried leaves. This study determined nutritional composition of shade-dried and sun-dried leaves of *Hibiscus sabdariffa* ('Bera') to evaluate the various nutrients supplied, and their abilities to meet the recommended dietary allowance (RDA) for various age and physiological groups of people. Sun- and shade-dried leaves of *Hibiscus sabdariffa* were analysed for their nutritional content using standard analytical methods. Mean values of protein, carbohydrates, ash, moisture and fibre for sun-dried leaves were 22.7, 42.2, 10.3, 8.1, 8.54 g/100g respectively, for shade-dried leaves, values were 1.6, 7.0, 1.4, 87.1, 1.6 g/100g respectively. Mean values of calcium, Iron, potassium, magnesium, phosphorus, and zinc were: sun-dried leaves; 411.0, 20.1, 39.3, 36.5, 54, 1.8 mg/100g; shade dried leaves values were: 65.6, 6.2, 5.6, 4.8, 14.1, 1.4 mg/100g. For RDA of nutrients per 100g sample, sun-dried leaves provided protein in the range of 32.0 – 206.4 %, carbohydrates 21.5 – 47.7 % and fibre, 29.4 – 47.6 %. For shade-dried leaves, protein was 2.3 – 14.2 %, carbohydrates 3.3 – 7.3 % and fibre 5.5 – 8.4 %. Percentage RDA of minerals supplied per 100g sample for various age and physiological groups were; sun-dried leaves, Fe (74.6 – 287.6), Mg (8.7 – 48.7), Ca (31.6 – 152.2), P (4.3 – 19.6), K (770.6 – 5614.3), Zn (13.5 – 58.3); shade-dried leaves, Fe (23.9 – 89.0), Mg

(1.1 – 6.4), Ca (5.0 – 24.3), P (1.1 – 5.1), K (110– 801.4), Zn (11.0 - 47.7). The study indicates, sun-drying is a better method of preserving *Hibiscus sabdariffa* leaves. It could be included in diet to improve micronutrient intake which is a major problem in Ghana.

Key words: Recommended Dietary Allowance, Shade-dried leaves, Sun-dried leaves, *Hibiscus sabdariffa*

NUTRIENT FLOWS AND BALANCES IN INTENSIVELY MANAGED VEGETABLE PRODUCTION OF TWO WEST AFRICAN CITIES

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This study reports and analyses nutrient balances in experimental vegetable production systems of the two West African cities of Tamale (Ghana) and Ouagadougou (Burkina Faso) over a two-year period comprising thirteen and eleven crops, respectively. Nutrient-use efficiency was also calculated. In Tamale and Ouagadougou, up to 2% (8 and 80 kg N ha⁻¹) of annually applied fertilizer

nitrogen were leached. While biochar application or wastewater irrigation on fertilized plots did not influence N leaching in both cities, P and K leaching, as determined with ion-absorbing resin cartridges, were reduced on biochar-amended plots in Tamale. Annual nutrient balances amounted to +362 kg N ha⁻¹, +217 kg P ha⁻¹, and -125 kg K ha⁻¹ in Tamale, while Ouagadougou had balances of up to +692 kg N ha⁻¹, +166 kg P ha⁻¹, and -175 kg K ha⁻¹ y⁻¹. Under farmers' practice of fertilization, agronomic nutrient-use efficiencies were generally higher in Tamale than in Ouagadougou, but declined in both cities during the last season. This was the result of the higher nutrient inputs in Ouagadougou compared to Tamale and relatively lower outputs. The high N and P surpluses and K deficits call for adjustments in local fertilization practices to enhance nutrient-use efficiency and prevent risks of eutrophication.

Key words: biochar / horticulture / leaching / nutrient budgeting / volatilization / wastewater irrigation.

NON-THERMAL INACTIVATION OF POLYPHENOLOXIDASE FROM JERUSALEM ARTICHOKE (*Helianthus tuberosus* L.)

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Polyphenoloxidase (PPO) is an enzyme that causes brown-colour in fruits and vegetables, and has been the object for the development of anti-enzymatic browning agents for food industries. In this study, PPO was extracted using the method as described by ÖNez, Karaku, & Pekyardimci, (2008) at 4 °C from Jerusalem artichoke (*Helianthus tuberosus* L.). The PPO was inactivated using

microwave and pulse magnetic field techniques. The kinetics of the non-thermal inactivation process was effectively modelled using Bigelow, Weibull and Hülshager models. Results of this study revealed that, an increase in Tesla enhanced the inactivation of the PPO. Thus, treatment at 4.0-Tesla with 45-pulses were found to reduce the residual-activity of the enzyme to 32.6%. Also, the lowest PPO residual activity ($\leq 30\%$) occurred at high power (180 W – 300 W) for 15, 20, 25 and 30 min. when microwave was employed. With regards to the kinetic models, Hülshager fitted the research data with an $R^2 \geq 0.980$. The application of pulse magnetic field and microwave was able to inactivate PPO from *Helianthus tuberosus* L., and may have a huge potential in the food industry for the control of enzymatic browning, which occurs during fruit and vegetable processing.

Keywords: Non-thermal inactivation, Polyphenoloxidase, Pulse magnetic field, Jerusalem artichoke.

VIRTUAL WATER FLOW IN FOOD TRADE SYSTEMS OF TWO WEST AFRICAN CITIES

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Rapid urban growth in sub-Saharan Africa challenges food supply of cities. As food and other organic matter are transported from production areas to consumption points, water, which has been used for their production, is

transported virtually. This study aimed at determining the magnitude and sources of virtual water flows in food trade of two West African cities, in order to better assess food provisioning risks and water resource use and planning. To this end, flows of unprocessed food from local, regional, national and international sources were systematically recorded at all roads leading to Tamale, Ghana and Ouagadougou, Burkina Faso. The survey was conducted within two years covering the peak (November - December) and lean season (March - April), respectively, for six days in a row. Virtual water flows were computed by multiplying the flow quantities ($t\ yr^{-1}$) by their respective virtual water contents ($m^3\ t^{-1}$). Results showed that virtual water of all food commodities imported to Tamale and Ouagadougou were 514 and 2105 million $m^3\ yr^{-1}$ respectively, out of which 68% and 40% were re-exported to other regions of the country. The data also showed major seasonal variation in virtual water flows across the year. Reflecting their dominating role in local diets, cereals contributed most to the total virtual water inflows in both cities. Southern Ghana is the major net virtual water importer from Tamale through cereals, legumes, vegetables, and livestock. The Northern Region of Ghana, on the other hand, is a net exporter of virtual water in all food groups apart from fruits. In Ouagadougou, large flows of virtual water were imported in cereals, specifically rice from Asian countries, via Ivory Coast.

Keywords: Food flow, Food security, Ouagadougou, Tamale.

EFFECT OF PRE-GERMINATION SEED TREATMENTS ON GERMINATION OF SEEDS AND INITIAL GROWTH OF MANGO (*Mangifera indica* L)

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An experiment was conducted to find out the effects of some pre-germination seed treatments on germination of mango (*Mangifera indica* L.) seeds and initial growth of mango. Seeds obtained from a local mango variety at Nyankpala were sown in polyethylene bags filled with topsoil for the experiment. The four treatments used were; seeds sown without seed coats (SW), seeds without seed coats soaked in cool water of 5°C for 12 hours before sowing (SSC), seeds without seed coats soaked in warm water of 15°C for one minute before sowing (SSW) and seeds with seed coats sown to serve as the control (SC). Randomized Complete Block Design was used and each treatment was replicated three times. The parameters measured were germination percentage, height of seedlings, leaf length of seedlings, number of leaves and stem diameter of seedlings. Data obtained were analysed using Analysis of Variance and the differences were determined by using Tukey-Kramer multiple comparison test. All the treated seeds recorded more than 80% of germination three weeks after sowing, with SSW recording the highest value of 91%. In general, the treated seeds performed significantly ($p < 0.05$) better than the control for the parameters studied. SSW is recommended for adoption since it performed optimally better than the other treatments in terms of number of leaves (7.67), leaf length (14.71 cm), leaf width (4.41 cm), stem diameter (1.82 cm) and plant height 20.86 cm).

Keywords: Mango, seeds, pre-germination treatments, germination percentage, seedling vigour.

THE EFFECT OF SPATIAL THINNING ON THE POTENTIAL DISTRIBUTION OF 10 AFRICAN INDIGENOUS VEGETABLES

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Species distribution modelling is important in conservation planning and many other fields of study. It is however often fraught with bias in the location data

used to develop the models. Spatial thinning is one of the bias correction methods. It has been reported to be superior to the background correction method in modelling experiments. However, the effect of spatial thinning on predicted areas and model assessment characteristics are unreported. We examined the effects of spatial thinning on the potential distribution of 10 African indigenous vegetables (AIV). The aims of our study were to investigate the effect of different spatial thinning distances on (1) the potential predicted areas (present and future 2070) of 10 species of AIV and (2) model evaluation statistics. We applied spatial thinning to the location data using the R package 'spThin' at distances of 0, 10, 20, 40, 60, 80 and 100km. For each species MaxEnt was used to run 10 replicate models with cross-validation and a threshold of 10% training presence. There were between 54 and 564 location data points a species after cleaning of GBIF data and 153-25 after thinning at a spatial resolution of 100km. The area under the curve (AUC) of the receiver operating characteristic, Boyce Index and the true skill statistic (TSS) decreased with increasing spatial thinning distance but sensitivity remained relatively constant. There was consistency in the direction of prediction for eight of the 10 species while spatial thinning influenced the direction of prediction for two species. Future 2070 suitable climatic envelope may be larger than the present for six species, remain the same as present for three species and become smaller for one species. We concluded that while spatial thinning may be useful in correcting for underestimation caused by clustered data, it might also lead to incompleteness in environmental space leading to unexpected results if not done with caution. Although the differences in the extent of suitable climatic envelope may imply reduction of overall biodiversity, no species was under serious threat of complete loss of suitable environment in the future.

Keywords: Area under the curve (AUC), Boyce Index, Sensitivity, Spatial Thinning, Specificity, True Skill Statistic, Vegetables.

PACKAGING CONTAINERS FOR LONG-DISTANCE TRANSPORT OF SWEETPOTATO [*Ipomoea batatas* (L) Lam] STORAGE ROOTS IN GHANA

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Two proposed containers (50 kg-polypropylene sack and 50 kg-wooden crate) were compared with existing packaging containers (100 kg-polypropylene and jute sacks) to transport sweet potato storage roots from major aggregation sites to distant urban market centres. The extent of breaks, bruises and the impacts, incurred by storage roots packaged in the different containers, were assessed. Additionally, at the urban market centres, the visual quality of the transported storage roots was evaluated by both aggregators and consumers. The benefit cost ratio (BCR) for each of packaging options was calculated to ascertain their profitability for sweet potato roots transportation. The existing polypropylene/jute sacks resulted in significant major breakages in both years ($p = 0.028, 0.016$) after transportation for the Afram Plains-Accra route in truck. The donkey-driven carts or tricycles used for the Bawku-Bitou route did not show any significant ($p > 0.05$) influence on the storage roots contained in the existing polypropylene/jute sacks. The average impact recorded at both loading and offloading sites was significantly different (13.4 - 19.3 g vs. 0 - 30.0 g; $p = 0.045$) for all the containers. The proposed 50 kg-wooden crate had a significantly superior (mean rank of 127; $p < 0.0001$) visual quality compared with the other

packages. All the packaging options showed profitability, because they had a BCR > 1.40, except for the 50 kg-wooden Research crate. The 50 kg-polypropylene container delivered better quality roots to urban market centres than the existing packaging containers, and was more profitable than the 50 kg-wooden crates. The 50 kg-polypropylene container is recommended for the transport of sweet potato storage roots in Ghana.

Keywords: Aggregators, Impact, Root quality, Sweet potato, Transport, Urban market

PERFORMANCE AND NUTRITIONAL QUALITY OF ROSELLE (*Hibiscus sabdariffa* L.) AND JUTE MALLOW (*Corchorus olitorius* L.) UNDER ORGANIC SOIL AMENDMENTS (COMPOSTS)

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The aim of the study was to determine the performance and nutritional quality of roselle and jute mallow under organic soil amendments (composts). The experiments were conducted in a Randomised Complete Block Design (RCBD) with four replications. Place and The experiments were conducted at the CSIR – SARI upland field, Changnaayili near Nyankpala in the Northern Region of Ghana during the rainy season (from June to October) in 2014 and 2015. The composts used were Decentralized Company (DeCo) compost, Accra Compost

and Recycling Plant (ACARP) compost and Composted Deep Litter Chicken Manure (CDLCM) applied onto prepared raised beds. The composts were incorporated into the beds at a rate of 10 t /ha two weeks before seedlings of roselle, and jute mallow were transplanted onto the prepared beds. Plant height, numbers of leaves per plant and leaf yield were taken for both vegetables. Protein, moisture and ash contents were also determined by proximate analysis. For both crops, significant differences ($p = 0.05$) in plant height and number of leaves were recorded at 8 weeks after transplanting. Cumulative leaf yield was significantly ($p = 0.05$) different between CDLCM, DeCo, ACARP composts and the control plot. Proximate analysis of leaf samples of the roselle and jute mallow showed that percent moisture and ash content were not affected significantly ($p = 0.05$) by the application of compost. However, percent protein in the roselle varied significantly ($p = 0.05$) with highest (29.2%) in the control followed by ACARP compost (28.6%), CDLCM (27.6%) and DeCo compost (26.4%). **Conclusion:** Application of organic soil amendment resulted in improved agronomic and yield parameters of roselle and jute mallow. However, their application did not have much effect on the nutritional status of both crops except on protein in roselle.

Keywords: Leaf yield; soil amendments; nutritional quality; DeCo compost; ACARP compost

STRUCTURAL LANDSCAPE CHANGES IN URBAN AND PERI-URBAN AGRICULTURAL SYSTEMS OF TWO WEST AFRICAN CITIES AND THEIR RELATIONS TO ECOSYSTEM SERVICES PROVIDED BY WOODY PLANT COMMUNITIES

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High urbanization pressure in Sub-Saharan Africa led to changes in the composition and configuration of rural and peri-urban agricultural production systems and to the establishment of highly market-oriented urban farming systems. Trees and shrubs, as a key component of agroecosystems, provide ecosystem services that support food security and agricultural productivity. However, the relationship between landscape structure, land use intensification, species diversity and functional diversity of woody plant communities particularly within the semi-arid environment of West Africa has received little attention. We combined GIS analyses and field sampling of woody plant communities of 72 agricultural systems located in rural, peri-urban and urban areas of Tamale (Ghana) and Ouagadougou (Burkina Faso). From a landscape perspective, peri-urban systems in Ouagadougou formed a transition or interacting zone between rural and urban systems and were shaped by urban growth dynamics whereas in Tamale peri-urban systems constituted a

simplification of the rural parkland habitats and was mainly determined by agricultural intensification. Woody plant communities showed a high functional richness along the rural-urban gradient and provided a variety of ecosystem services, with food provisioning as main good. A trade-off between two regulating services, bio-control of pests and pollination services, could be observed within urban and in part within peri-urban farming systems. Hence, obtaining a holistic understanding of how landscape structure that is shaped by city growth and agricultural intensification affects ecosystem services is fundamental if West African urban farmers are to be politically supported in their efforts to manage landscapes effectively and to ensure agroecosystem multi-functionality and productivity.

Keywords: Landscape, composition and configuration. Sub-Saharan cities, Species' function, Urban agroecology

AGRONOMIC EFFECTS OF BIOCHAR AND WASTEWATER IRRIGATION IN URBAN CROP PRODUCTION OF TAMALE, NORTHERN GHANA

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Agricultural production needs to increase, particularly in sub-Saharan Africa, many rural people are undernourished, and the urban population is growing rapidly. It is worrisome that on many West African soils with low cation exchange capacity and soil organic carbon content, mineral fertilization is rather inefficient. Under these conditions, wherever available untreated wastewater is used for irrigation despite the potential health risks to producers and consumers. For intensively cultivated soils with high mineralization rates, biochar application has been advocated as a promising management option. However, the agronomic benefits of wastewater reuse in agriculture and its interaction with biochar have received only limited attention. This study therefore investigated the effects of mineral fertilizer application and biochar amendment at two water quality and quantity levels on soil moisture, plant nutrition and biomass production on a Petroplinthic Cambisol over 2 years. Rice husk biochar applied at 20 t ha⁻¹ significantly increased fresh matter yields in the first five cropping cycles by 15%, and by 9% by the end of 2 years. Compared with clean water, wastewater irrigation increased yields 10–20-fold on unfertilized plots during the dry seasons, while a fourfold increment was observed in the wet seasons. This seasonal difference is likely a result of the high sequence of irrigation events during the dry season. In this study, fertigation with wastewater contributed significantly to plant nutrition and nutrient recovery while yield-increasing biochar effects disappeared over time. Soil moisture was enhanced by up to 9% due to biochar amendments under unfertilized conditions.

Keywords: Fertigation, Soil moisture, Urban agriculture, Wastewater

HEAVY METALS CONCENTRATIONS AND RISK ASSESSMENT OF ROSELLE (*Hibiscus sabdariffa* L.) CULTIVATED WITH THREE COMPOST TYPES

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Field experiments were conducted at the research field of the CSIR–SARI near Nyankpala in the Northern region of Ghana during the major growing seasons of 2014 and 2015. The objectives of the study were to determine the effect of three compost types i.e., Accra compost and recycling plant (ACARP) compost; decentralised compost (DeCo) and composted deep litter chicken manure (CDLCM) on heavy metals concentrations in roselle (*Hibiscus sabdariffa* L.) and jute mallow (*Corchorus olitorius* L.) and the health risk of these vegetables to adults and children. The composts were each applied at the rate of 10 t/ha in a randomized complete block design in four replications. The concentrations of Cd and Pb in the leaves of roselle were 0.8 mg/kg and 5.0 mg/kg while in jute mallow, they were 0.7 mg/kg and 6.0 mg/kg, respectively. These concentrations were above the Maximum residue levels (MRLs) of 0.2 mg/kg for Cd and 0.3 mg/kg for Pb in the standards of the European Commission and Codex Alimentarius Commission. The low soil pH might have facilitated the bioavailability of the heavy metals resulting in concentrations that could be harmful to consumers of these vegetables. There is, therefore, the need to amend the soil pH of the study area. An upward adjustment of the pH of the composts used can also help in reducing the bioavailability of heavy metals to roselle and jute mallow cultivated in soils with low pH.

Keywords: Bioavailability, Amendments MRL, Roselle, Jute

SOIL PHYSICAL AND CHEMICAL PROPERTIES AND CROP WATER REQUIREMENT OF SOME SELECTED VEGETABLE CROPS AT CENTRAL EXPERIMENTAL FIELD OF URBAN FOOD PLUS PROJECT IN SANARIGU DISTRICT, TAMALE, GHANA

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This study was carried out to determine the crop water requirement of some selected vegetable crops cultivated at the Central Experimental Site for Urban Food Plus Project. These crops include `Ayoyo` (*Corchorus spp*), Lettuce (*Lactuca sativa*), Cabbage (*Brassica oleracea*), Amaranthus (*Amaranthus candatus*) and Carrot (*Daucus carota*). Crop water requirement for each of the crops was determined by using 30-year climatic data from the Tamale Synoptic station as and input in CROPWAT programme, FAO, version 8, 2014. Using CROPWAT, Reference Evapotranspiration (ET_o) was determined using the FAO Penman Monteith method. For all the crops, daily, decadal and seasonal crop and net irrigation requirements were computed for the various growth stages: initial, development, mid-season and late season. The soil infiltration test was conducted *in situ* while composite soil samples were also collected for laboratory analysis of some soil physico-chemical properties of the experimental site. The study shows that the soil was low in organic matter content, slightly acidic, but not saline and also has low water holding capacity due to its low amount of clay content. The site however, is well drained and is therefore suitable for cultivation of vegetables and upland arable crops. Climate conditions, however demand considerable amount of irrigation to supplement rainfall in the period mid- November to March, when the experiment was taking place. Reference Evapotranspiration (ET_o) varied from 3.9 mm / d in August to 8.9 mm / d in February. Crop evapotranspiration (ET_c) for `ayoyo` varied from 4.03 to 8.81 mm / d, for

cabbage from 4.03 to 9.43 mm / d, for lettuce from 4.03 to 9.19 mm / d, for carrot, 4.03 to 10.53 mm / d, for amaranthus from 4.03 to 9.75 mm / d. Thus, with the calculation of crop water requirement and net irrigation demand for each of the crops cultivated, an appropriate water planning and management can be scheduled to ensure that adequate soil water is maintained by rainfall and/or irrigation, so that it does not limit plant growth and crop yield.

Keywords: Crop, Irrigation, Soil, Water requirements, Vegetables

ASSESSING SOCIOECONOMIC FACTORS INFLUENCING PRODUCTION AND COMMERCIALIZATION OF BAMBARA GROUNDNUT AS AN INDIGENOUS CLIMATE RESILIENT CROP IN NIGERIA

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Climate change is impacting the cropping system, landscape, livelihoods, and nutrition diversity of farming households and communities in Africa. Climate change adaptability and resilience are emerging as important criteria for setting national priorities for promoting indigenous crops to enhance food and nutrition security, especially of resource-poor smallholders. However, many climate resilient indigenous crops have been lost due to inappropriate policies that fail to prioritize climate resilience and nutritional diversity. Bambara groundnut (*Vigna subterranea*) is an indigenous crop in Africa. It is tolerant to drought, poor soils, and short spells of elevated temperatures. It, therefore, offers several advantages over other legumes as a source of nutrition, food security and improved welfare in the face of climate change. The research investigated farmers' perceptions and socioeconomic factors that influenced the cultivation and commercialization of bambara groundnut and the effect of commercialization on smallholder farmers' welfare in two local government areas (LGAs) of Benue State, Nigeria. In all, 300 smallholder farmers were sampled through a multistage sampling technique. The method of analysis involved the estimation of a fractional regression and treatment effect models. We found that older farmers who perceived that bambara groundnut is a climate-resilient and food security crop allocated more of their total farmland to its production. The perception that bambara groundnut is a climate-resilient crop also impacted positively on the commercialization of bambara groundnut. Formal education coupled with the commercialization of bambara groundnut led to increased farmers' welfare. We recommend that more sensitization and education should be given to farmers on the good characteristics of bambara groundnut as a climate-resilient and food security crop while they are also supported to upscale its production for commercialization purposes.

Keywords: Indigenous crop, Bambara groundnut, Commercialization, Climate resilience, Food security and nutrition, Household welfare

WEED SPECIES STRUCTURAL AND FUNCTIONAL COMPOSITION OF OKRA FIELDS AND FIELD PERIPHERY UNDER DIFFERENT MANAGEMENT INTENSITIES ALONG THE RURAL-URBAN GRADIENT OF TWO WEST AFRICAN CITIES

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In urban and peri-urban agricultural production systems of Sub-Saharan African cities, diverse and functional complex weed communities may help to maintain biodiversity and ecosystem services and therefore indirectly support crop performance. However, effects of agricultural intensification and urbanisation on important weed diversity in the West African region had received so far little attention, although in Burkina Faso and Ghana up to 90 per cent of the population depends on agriculture as a main source of income generation. Hence, our research focused on the analysis of changes in weed assemblages' structure and function of okra fields that were cultivated under different management intensities and were embedded into the rural, peri-urban and urban environment of two West African cities: Ouagadougou (Burkina Faso) and Tamale (Ghana). We found a strong relationship between gender and market orientation of okra cultivation. Market orientation of okra farmers was also a major driver in shaping weed species assemblages and led to the development of

a distinct weed assemblage in urban areas that even showed higher diversity in weeds' function. Morphological plant traits (life form, seed properties) were most affected by agricultural practises; distribution pattern of ecological traits (seed dispersal mode, pollination vector) seemed to be influenced additionally by environmental characteristics with less entomophilous but more ornithochorous weed species on okra fields within urban areas. Our results revealed that the management of okra was highly variable and that this variation was influenced by farmers' socioeconomic background leading to changes in soil properties. These in turn may alter the functional diversity of beneficial weed communities beyond changes in species richness by potentially harming the provisioning of ecosystem services such as pest control and pollination.

Keywords: Agricultural intensification, Anthropogenic, Plant traits, Sub-Saharan Africa, Weed biodiversity

FOODSHEDS AND CITY REGION FOOD SYSTEMS IN TWO WEST AFRICAN CITIES

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In response to changing urban food systems, short supply chains have been advocated to meet urban food needs while building more sustainable urban food

systems. Despite an increasing interest in urban food supply and the flows of food from production to consumption, there is a lack of empirical studies and methodologies which systematically analyse the actual proportion and nutritional significance of local and regional food supplied to urban markets. The aim of this empirical study therefore was to compare the geographical sources supplying food to the urban population (“foodsheds”) in Tamale, Ghana and Ouagadougou, Burkina Faso, to record the supplied quantities and to assess the level of interaction between the sources and the respective city. The study was conducted over two years, covering the seasons of abundant and short supply, via traffic surveys on the access roads to the two cities, and in the Tamale markets, resulting altogether in more than 40,000 records of food flow. Results indicated that food sources were highly crop- and season-specific, ranging from one-dimensional to multi-dimensional foodsheds with diverse sources across seasons. Across the commodity-specific foodsheds, city region boundaries were established. Within the proposed city region, a relatively large proportion of smallholders contributed to urban food supply, taking advantage of the proximity to urban markets. While food provided from within the city region offers certain place-based benefits, like the provision of fresh perishable crops, a larger geographical diversity of foodsheds appeared to enhance the resilience of urban food systems, such as against climate related production failures.

Keywords: urban food systems; foodsheds; city region food systems; food flows; urban food supply; spatial analysis; GIS mapping; climate change

PRELIMINARY INVENTORY OF HYMENOPTERAN PARASITIDS ASSOCIATED WITH FRUIT-INFESTING FLIES (DIPTERA: TEPHRITIDAE) IN NORTHERN GHANA

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Baseline studies were conducted to determine the parasitoids associated with fruit flies in the northern savanna ecology of Ghana. Fruit fly puparia obtained from incubation of 17 host fruit species were maintained in rearing cages for the emergence of parasitoid wasps. Four species of braconid parasitoids namely, *Fopius caudatus* (Sz epligeti), *Psytalia cosyrae* (Wilkinson), *Psytalia concolor* (Sz epligeti) and *Diachasmimorpha fullawayi* (Silvestri) were recovered. *F. caudatus* was the most abundant parasitoid (61.0%) reared from most host fruits while *D. fullawayi* was the least abundant (7.7%). The overall mean parasitism rate was 7.1% with the highest record in *Annona senegalensis* Pers., *Sarcocephalus latifolium* S. Bruce and *Icacina senegalensis* Juss. *Ceratitidis cosyra* and *Bactrocera invadens* were the fruit fly species most commonly reared that produced *F. caudatus*, and to a lesser extent, *P. cosyrae*. The peak occurrence of the parasitoids coincided with the peak of the rains and the maturity period of many of the host fruits. This first inventory of tephritid parasitoids in Ghana provides critical baseline data for biological control efforts in the future.

Keywords: Biological control; *Bactrocera* species; *Ceratitidis* species; host plants, braconid parasitoids

ADOPTION OF BAMBARA GROUNDNUT PRODUCTION AND ITS EFFECTS ON FARMERS' WELFARE IN NORTHERN GHANA

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With the growing concerns about the likely implications of climate change, the long-term sustainability of conventional agricultural approaches and biodiversity loss have contributed to a growing interest in the potential of the so-called underutilised crops to address food, nutritional, and income security challenges. In support of their wider use, advocates of underutilised crops associate a number of benefits with them. These include agronomic and nutritional benefits such as drought tolerance and micro-nutrient content and the perceived socio-economic benefits of their wider use. It is widely suggested that the adoption of such crops can generate improved agricultural resilience and support nutrition, food and income security. Simultaneously, the adoption of underutilised crops is seen as a means of conserving biodiversity. However, scientific evidence concerning the use of such crops remains extremely limited. Crucially, little research has been undertaken concerning the contribution of such crops to the welfare of producers. This study investigates the socio-economic factors characterising the production of Bambara groundnut (*Vigna subterranea* (L.) Verdc.) in Northern Ghana and the impact of its production on farmers' welfare. Primary data was collected based on the 2013 farming season, 240 farmers were selected using a multi-stage sampling technique. A treatment effect model, comprising an adoption and a welfare model was estimated. The probability of adopting Bambara groundnut was found to be greater for: unmarried farmers; farmers in larger households; farmers with little or no formal education; and farmers who had no access to credit. The production of Bambara groundnut led to increased household welfare, as measured by the level of household per capita expenditure/consumption. Results suggest that while further research and support for Bambara groundnut production could contribute to addressing high poverty levels in the region, many of the basic assumptions underlying current advocacy of underutilised crops need rigorous empirical verification.

Keywords: Adoption, underutilised crops, Bambara groundnut, Northern Ghana, treatment effect model, welfare.

USE PATTERNS AND PERCEPTIONS ABOUT THE ATTRIBUTES OF BAMBARA GROUNDNUT (*VIGNA SUBTERRANEA (L.) VERDC.*) IN NORTHERN GHANA

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The study aimed to investigate the use patterns and perceptions about the positive and negative attributes of the underutilised legume, Bambara groundnut in northern Ghana. A multi-stage sampling procedure was adopted to select 360 respondents consisting of 240 farmers, 60 consumers and 60 marketers and the responses analysed using descriptive statistics. From the results, positive judgments about the legume included that it: can be processed into many products (1.3); requires a small amount of fertilizer (1.4); is drought-tolerant (1.7); has high protein content/ very nutritious (1.8); tastes better than other legumes (1.8); and more profitable (1.8). However, respondents' disagreements were with respect to the following: Bambara groundnut matures earlier compared with other legumes (2.3); and Bambara groundnut cooks faster than other legumes (2.7). Other challenges identified by the respondents were bloating of the stomach/constipation; irregular markets; and lack of capital and modern inputs for production and marketing. It is recommended that research be intensified around shortening the maturity period and reducing cooking time of the legume while farmers and marketers are supported with credit and modern inputs to scale up production. Lastly, farmers must be taught to take the production of the crop as a business if the crop is to be produced on a wider scale.

Keywords: Bambara groundnut, Perceptions, Use patterns, Northern Ghana

INSECTICIDE APPLICATION IN VEGETABLE PRODUCTION AND THE RISK OF FOOD POISONING IN NKORANZA MUNICIPALITY, GHANA

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The application of insecticides in vegetable production has become an issue of global concern following reports of food poisoning in some countries, including Ghana. The main objective of the study was to determine incidence of insecticide-related food poisoning in vegetable production in the Nkoranza Municipality in the Brong Ahafo region. The study involved a total of 120 respondents, consisting of 40 each of producers, consumers and food vendors/vegetable traders. The commonest chemicals used in controlling insects in the study area were Confidor 2500SL [Imidacloprid (2500g soluble liquid)], Karate 2.5 [Lambda-cyhalothrin (25g emulsifiable concentrate)], Karate 5.0 [Lambda-cyhalothrin (50g emulsifiable concentrate)], Rambo 2.5EC [Deltamethrin (25g emulsifiable concentrate)] and Pawa [Lambda-cyhalothrin]. The period for the last spraying before harvesting the vegetables for the majority of the farmers was 30 minutes to 4 hours. Salt solution and water were the main solutions used in treating vegetables. However, only 7.5% of the consumers reported of illness after eating vegetables. This was confirmed by the health officials. Recommendations by vegetable farmers included: education (43.6%); use of organic insecticide (30.8%); follow instructions (20.5%); and education and follow instructions (5.2%). While the consumers suggested Treatment (54.4%); Education (34.6%); and buying from a hygienic source (9.8%). Given the level of insecticide misapplication in the study area, it is important that education on pesticide usage and regular monitoring is conducted to ensure conformance to recommended application regimes.

Keywords: Food poisoning, Insecticide application, Nkoranza Municipality, Vegetables

IN-SERVICE TRAINING NEEDS OF AGRICULTURAL EXTENSION AGENTS IN THE MANAGEMENT OF FRUIT-INFESTING FLIES (DIPTERA: TEPHRITIDAE) IN NORTHERN GHANA

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Strengthening the capacities of Agricultural Extension Agents (AEAs) for effective innovation dissemination is critical for addressing the fruit fly menace in Ghana. A survey was conducted among 150 AEAs in northern Ghana to assess their knowledge and priority management training needs for fruit fly pests. Based on standard instrument and reliable model, 15 competency aspects of fruit flies were developed and used to measure AEAs' levels of knowledge, importance and level of competence of fruit fly pests. Their in-service training needs were analysed and ranked using mean weighted discrepancy scores (MWDS). AEAs demonstrated good knowledge in six competencies and poor knowledge in five competencies. The top five competency areas of fruit flies in need for further training included; knowledge of the economically important species, their economic impact, life cycle, host plant associations and control strategies. Each of these competency areas recorded a MWDS above 7.00. The professional competence of AEAs needs to be strengthened as a prerequisite to combating the fruit fly menace in the country. Staff capacity development programmes for AEAs should look into how these top five critical educational needs on fruit flies can be addressed in training programmes executed by experts

of the national fruit fly management committee of the Plant Protection and Regulatory Services Directorate of Ghana.

TECHNICAL EFFICIENCY OF BAMBARA GROUNDNUT PRODUCTION IN NORTHERN GHANA

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<http://www.udsijd.org>

Achieving food security under climate change is one of the greatest concerns of governments in developing countries. Due to favourable agronomic characteristics such as drought tolerance and an ability to produce a crop on less fertile soils, a number of underutilised crops, such as bambara groundnut offer potentials to address food insecurity problems in areas impacted by climate change. While efficiency studies have gained popularity in relation to many food crops, very little research has been carried out on the technical efficiency of bambara groundnut production. This study estimated a Translog stochastic frontier to determine the factors that influenced farmers' technical efficiency in the 2013 cropping season in Northern Ghana. It involved 120 farmers selected through a multi-stage sampling technique. Technical efficiency scores ranged from 27% to 97% with a mean of 83%. The significant positive determinants of output and efficiency were farm size, household labour, organic fertilisers as well as education and off-farm activities. The study found that bambara groundnut production can be stepped up by supporting farmers to scale up their farms, form farmer groups, diversify their livelihoods and improve the use of organic fertilizers. Improving opportunities for formal education may also have a positive impact.

Keywords: Bambara groundnut, Northern Ghana, Stochastic Frontier Model, Technical efficiency

**REVIEW OF THE PEST STATUS, ECONOMIC IMPACT AND
MANAGEMENT OF FRUIT-INFESTING FLIES (DIPTERA: TEPHRITIDAE)
IN AFRICA**

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Fruit flies are a major threat to the horticulture industry in Africa owing to their damage incidence and economic losses to fruit and vegetable crops, and their quarantine implications. Numerous studies with different research interests have been conducted on fruit flies throughout the African continent. Despite these studies, there is little knowledge among stakeholders about fruit fly pests in terms of the economically important species, their pest status, economic impact and control strategies. These parameters are prerequisites in designing management tools for addressing the fruit fly problem in the continent. This paper reviews the status of the fruit fly menace in Africa by reporting some of the findings of previous researchers while laying emphasis on what needs to be done.

Keywords: Tephritid fruit flies, pest status, economic losses, management, Africa.

EFFECT OF COMPOST-BIOCHAR MIXES AND IRRIGATION ON THE GROWTH AND YIELD OF AMARANTHUS (*Amaranthus hybridus*) UNDER TWO GROWING TEMPERATURES

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An experiment was carried out to study the sensitivity of amaranthus to different sources of soil nutrients and different amounts of irrigation water at different temperatures. Nitrogen (N) rich materials (compost/poultry manure) and carbon (C) rich material (biochar) used included poultry manure + rice husk biochar (PM+RB), poultry manure + sawdust biochar (PM+SB), rice husk compost + rice husk biochar (RC+RB), sawdust compost + sawdust biochar (SC+SB) mixed at 10 ton ha⁻¹ N rich material to 5 ton ha⁻¹ C rich material. Rice husk compost only, Sawdust compost only (at 10 ton ha⁻¹ for each of RC and SC), NPK (400 kg ha⁻¹) and no amendments as Control were also used. Two irrigation amounts (0.1124 mm and 0.225 mm per pot), were imposed resulting in 12 treatment combinations, in a completely randomized design with 4 replicates. The experiment was repeated under two different temperatures of 37 and 30°C in the glass house and plant house, respectively. Data on growth, yield, water use and nutrient leaching were collected. PM+RB produced the tallest plants (31.67 cm) with 0.1124 mm irrigation at 30°C. PM+SB treated plants had more leaves (17) with 0.1124 mm amount of irrigation water at 37°C. NPK treated plants gave the highest stem girth (5.87 cm) and highest SPAD value (42.5%) with 0.1124 mm amount of irrigation water at 37°C. Leaf area index was highest (43) at 30°C for plants receiving NPK and 0.225 mm amount of irrigation water. NPK treated plants gave the highest fresh biomass of 36.93 g at 30°C but lowest biomass (13.01

g) at 37°C. PM+SB gave the highest fresh biomass weight of 16.7 g at 37°C and highest volume of leachate (123 ml) with 0.225 mm irrigation water at 30°C. At 37°C, SC gave the highest leachate volume (166 ml). The study indicates a good potential for sustaining crop yield with organic materials under increasing temperature and declining water resources that may be associated with changing climate.

Keywords: Amaranthus, compost, biochar, climate change, irrigation frequency

SPLIT-PLOT DESIGN: ANALYSIS DOLDRUMS COMPARING GENSTAT, SPSS AND R

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<http://gjstd.org/index.php/GJSTD>

A modelled split plot experiment involving Completely Randomized Design of the main (whole) plots replicated three times was analysed using three statistical software packages namely Genstat, SPSS and R. The results were compared in terms of accuracy of output and ease of analysis. The data set was also analysed semi-manually to validate the results of the software outputs. Genstat and R produced identical result to the semi-manual analysis indicating they were correct. SPSS however, produced erroneous test results even when the correct linear model was specified. The correct output could however be obtained by specifically instructing SPSS on how to carry out the test. This experiment demonstrates the need for experimenters to be in charge of every aspect of an experiment from design to analysis leaving no part to the whims of statistical software. It also demonstrates that SPSS on its own is incapable of producing the correct result based on the linear model for this experiment. SPSS and Genstat

are menu-driven and may be easier to learn than R which is mostly command based.

EFFECTIVENESS OF THE EGG PARASITOID *TRICHOGRAMMA EVANESCENS* PREVENTING RICE MOTH FROM INFESTING STORED BAGGED COMMODITIES

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Experiments were carried out in the laboratory with the aim of accessing the effectiveness and parasitism by *Trichogramma evanescens* to prevent *Corcyra cephalonica* from infesting rice in paper and jute bags. Eight small jute or paper bags filled with 5 kg of organic rice grains were prepared and the openings sealed. Sentinel egg cards were prepared with thirty fresh eggs of *C. cephalonica* glued onto small pieces of paper cardboard. Eight sentinel egg cards were introduced into a plastic box measuring 60 x 40 x 21 cm, i.e four cards on top surface of the bag and the box bottom, respectively. Approximately 500 adults of *T. evanescens* were released 10-30 cm away from the egg cards. The control boxes contained no parasitoids; there were five replicates for all treatments and controls. Two experimental conditions were tested, i) placing a single *T. evanescens*-release unit with sentinel egg cards placed every 3e4 days without any further replacement of the release unit for three weeks, ii) both new host eggs and *T. evanescens* release units were replaced every 3-4 days. Mean emergence of *C. cephalonica* was significantly ($p > 0.001$) suppressed by the release of *T. evanescens*. There was statistically no significant difference on the number of emerged moths on paper bag compared to jute bag. All sentinel egg patches were

visited by *T. evanescens*. There was no correlation between the distance (10-30 cm) at which the sentinel egg cards were placed away from the *T. evanescens* release point and the number of parasitized *C. cephalonica* eggs. There was no decrease in parasitism over time. The results demonstrate that *T. evanescens* has the potential for host-location ability and parasitism of *C. cephalonica* both on paper and jute bags. This parasitoid could be a promising candidate for the biological control of moth pests in bagged stored products.

Keywords: *Corcyra cephalonica*, Jute, Paper, Bag, *Trichogramma evanescens*, Hymenoptera, Trichogrammatidae

PRELIMINARY STUDIES ON THE EFFECT OF SHEA KERNEL SIZE ON SHEA BUTTER QUALITY

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The study was carried out between March, 2012 and January, 2013 at the University for Development Studies, Nyankpala campus, Ghana. The objectives of the study were to characterize farmer shea nut varieties to determine the physical and chemical characteristics of the shea nut butter and determine appropriate shea nut quality for the domestic market. The shea nuts were characterized as T1 (small nuts), T2 (medium nuts), T3 (big nuts) and T4 (very big nuts). These nuts were arranged in a completely randomized design and replicated three times for shea nut butter extraction and assessed for free fatty acid (FFA), moisture content and sensory quality. The study reveals strong correlation between shea nut size and butter quality with bigger shea nuts recording lower FFA and moisture content hence higher butter quality. There were differences in colour and texture of the shea butter extracted from the

different shea nut sizes. It is recommended that, further research be carried out at different geographical locations to assess the effect of shea nut size on butter quality.

Keywords: Shea kernel, free fatty acid, moisture content, sensory quality

EFFECT OF VITRIFICATION SOLUTION (PVS2) ON VIABILITY AND VIGOUR OF SEEDS OF AMARANTH (*AMARANTHUS HYBRIDUS*)

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An experiment was conducted on the effects of different exposure periods of plant vitrification solution 2 (PVS2) on viability and vigour of seeds of Amaranth (*Amaranthus hybridus*). This was done as a step towards long term cryopreservation of seeds of Amaranth. The seeds of Amaranth, 100 per treatment, were exposed to PVS2 between 0 and 60 min. Data were taken on in vitro germination percentage of the seeds, percentage of moisture removed from the seeds, shoot and root length of the seedlings and their vigour index calculated. The results showed that PVS2 application did not have an adverse effect on germination percentage of the seeds when the exposure time was not more than 45 min. However, the root and shoot lengths as well as the vigour of the seedling were inhibited to a certain extent by the PVS2 application. PVS2 application dehydrated the moisture of the seeds during the exposure. About 34 to 60.7 % of the moisture was removed from the seeds by the PVS2. This work may pave the way for cryopreservation of seeds of Amaranth and similar seeds.

Keywords: Amaranthus, seed, cryopreservation, PVS2, desiccation

ASSESSING THE PERFORMANCE OF SORGHUM VARIETIES IN THE GUINEA SAVANNA ZONE OF GHANA

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Asian Journal of Agriculture and Food Science, 2(1), 64-72, 2014

Two field experiments were conducted at the Faculty of Agriculture Research Farm, University for Development Studies, Nyankpala during the two successive growing seasons of 2011 and 2012 cropping. The objective of the study was to evaluate new hybrids of sorghum (Pannar sorghum) and their level of performance in the Guinea savannah zones of Ghana. The experiment was laid in a randomised complete block design with five treatments for the 2011 seasons and ten treatments for the 2012 season. They were all replicated four times. Parameters measured include plant height, number of leaves, days to 50% flowering, stalk lodging, number of panicles per plot, biomass at harvest, panicle dry weight, 1000 grain weight and grain yield. From the obtained results, Pannar varieties performed better compared to the landrace in terms of growth and yield parameters. From these studies, famers are encouraged to cultivate more of the Pannar 606 and Macia varieties for higher grain production.

Keywords - Sorghum, Pannar, Panicle, Grain yield

FATTY ACID AND TOCOPHEROL PATTERNS OF VARIATION WITHIN THE NATURAL RANGE OF THE SHEA TREE (*Vitellaria paradoxa*)

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Agroforestry systems, 87(5), 1065-1082, 2013. <https://doi.org/10.1007/s10457-013-9621-1>

The shea tree, *Vitellaria paradoxa*, is one of the most economically and culturally important indigenous tree species in the Sudano-Sahelian region. Its seeds contain a vegetable fat, internationally known as shea butter, which is widely used in edible, cosmetic and pharmaceutical sectors. Based on samples from 456 trees distributed in 17 locations across the species natural range from Senegal to Uganda, the fatty acid and tocopherol variation, and its relationship with geographic and climatic variables, was assessed in order to address the pattern and the origin of this variation across the natural range. Significant differences between Western and Eastern regions for oleic, stearic acid, saturated-unsaturated acid ratio and c-tocopherol were identified that it is postulated maybe a result of genetic drift due to the evolutionary history of shea tree populations. Within regions the difference among stands was significant for most constituents; however, the major part of the variation was observed among trees within stand (53-90 %). Relationships with climatic variables were not verified, weakening evidence for clinal variation hypotheses suggested by previous studies.

Keywords: *Vitellaria paradoxa*, Shea butter, Fatty acids, Tocopherols, Variability, Climatic gradient, Natural range

DIVERSITY OF TREE SPECIES IN CULTIVATED AND FALLOW FIELDS WITHIN SHEA PARKLANDS OF GHANA

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Key words: Biodiversity, parklands, species, evenness, richness, quadrats, index

Journal of Biodiversity and Environmental Sciences, 3(2), 1-9, 2013.

Tree species diversity associated with shea in cultivated and fallow fields of shea parklands of Ghana was studied. The study was to assess tree species diversity in relation to land use type across a North – South gradient of shea growing sites in Ghana. The study was conducted in 2011/12 at Paga, Nyankpala and Kawampe. In addition to shea trees, other highly valued tree species are preserved in parkland systems because of their ability to improve soil fertility and increase crop yield in addition to reducing microclimatic extremes as well as wind and water erosion, parkland trees are important sources of income and nutritional security. There is the need to conserve other tree species so as to reduce the over reliance on shea tree as the sole economic tree in many areas of the savanna parkland. Fifty-four (54) quadrats measuring 50 x 50 m (18 in each location) were used as experimental plots. Diversity of higher woody plants was analysed using the Simpson Diversity Index (D). A total of 863 trees were studied. The total density of trees in cultivated and fallow fields was 64 and 355 for Paga, 39 and 130 for Nyankpala, 75 and 200 for Kawampe. Shea densities in all the study locations showed that there were more shea trees in fallow fields (469) than cultivated fields (298). The main species identified in the study were *Diospyros mespiliformis* Hochst, *Annona senegalensis* Pers, *Azadirachta indica* A. Juss, *Terminalia albida* Sc Elliot and *Senna siamea* Lam. The occurrence of these species amounted to 54.8% of all trees. Fallow fields were more species composed (33 species) than cultivated fields (21 species). The results showed differences in diversity based on locations with Paga and Nyankpala showing high species diversity of 0.95 each in cultivated and fallow fields. However, there were no significant differences ($P > 0.05$) in species diversity of all three study locations within cultivated and fallow fields.

**EFFICACY EXTRACT FROM *HYPTIS SPICIGERA* LAM. AGAINST
CALLOSBRUCHUS MACULATUS F. (COLEOPTERA: BRUCHIDAE IN
KERSTINGS' GROUNDNUT (*MACROTYLOMA GEACARPUM* HARMS))**

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Aqueous foliage extracts from *Hyptis spicigera* Lam. at 10 and 20 per cent concentrations were applied at 25, 50 and 100 °C on the seeds of Kersting's groundnut (*Macrotyloma geocarpum* Harms), to evaluate their bioefficacy against the pulse beetle, *Callosobruchus maculatus* F. and the effects on viability of the seeds. The experiment was laid out in a completely randomized design with four replications. Data were collected on the infestation and damage caused by the pest, and on the viability of treated seeds. The results showed that the oviposition, progeny emergence, developmental period, adult longevity of the pest, and damage on the seeds were significantly affected by the extract applied. All the extract treatments were found to offer better protection than the untreated seeds in most of the parameters evaluated. Insecticidal efficacy was found to show a dose- and temperature-dependent response. Extracts at 20 per cent concentration, treated at 50 ° or 100°C, offered protection comparable to that of the synthetic insecticide, Pirimiphosmethyl at 20 g kg⁻¹. Extracts treated at 100°C, however, showed significant reduction in the germination percentage of the seeds. The implications of these findings are discussed with the view to developing more sustainable means of protecting Kersting's groundnut grains from bruchid attack so as to minimise the rampant postharvest losses to the crop in the savanna ecology of Ghana.

POTENTIAL OF BIOTECHNOLOGY AND APPLICATION OF GENOMICS TO INDIGENOUS AND TRADITIONAL LEAFY VEGETABLES IN WEST AFRICA

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Keywords: biotechnology/genomics, Sub-Saharan Africa, indigenous leafy vegetables

The application of biotechnology/genomics has been very useful in many fields. In agriculture, they have been used for the development of new genetic lines, rapid multiplication of improved crop planting materials and the detection and elimination of diseases in useful plants. However, the techniques developed from these important disciplines have not been applied to many indigenous and traditional leafy vegetables (ITLVs) that are sustaining the lives of poor rural people in Sub-Saharan Africa (SSA). This paper examines the importance of ITLVs in West Africa as well as the limitations of popularising them. An attempt is made to throw light on some of the tools of biotechnology/ genomics that have the potential to solve many problems militating against the commercialisation of ITLVs in West Africa.

LEAF AND FRUIT CHARACTERISTICS OF SHEA (*Vitellaria paradoxa*) IN NORTHERN GHANA

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Research in Plant Biology, 2(3): 38-45, 2012

Leaf and fruit parameters of *Vitellaria paradoxa* populations in north-south gradient of the shea belt in the transitional and Guinea Savanna zones of Ghana were compared during the fruiting season between April to July, 2011. Thirty-five trees which were at least 50 m apart and with diameter at breast height of at least 20 cm were randomly selected from each of the three locations namely Paga, Nyankpala, Kawampe for the studies. Leaf morphological traits studied include laminar width, petiole and laminar lengths. Fruit parameters measured include fruit and kernel widths, lengths, weights and pulp weight. Results showed variability for most of the characters determined. The leaves in Paga had shorter petioles as compared to those of Nyankpala and Kawampe. The Nyankpala *V. paradoxa* has the smallest laminar width whilst Kawampe has longest leaf laminar as compared to the rest. Values for fruit and kernel parameters were highest for samples from Paga, followed by Kawampe and were significantly higher than those from Nyankpala. There were significant positive relationships between fresh fruit weight and both fresh kernel weight ($P < 0.001$; $R^2 = 0.6925$) and dry kernel weight ($P < 0.001$; $R^2 = 0.6532$) for data pooled from all the three locations, however, the slopes and intercepts varied between locations ($P < 0.001$). The result from the study provides opportunities and prospects for selection and breeding for *V. paradoxa* tree improvement in Ghana.

COMPARATIVE STUDIES OF SOIL CHARACTERISTICS IN SHEA PARKLANDS OF GHANA

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Journal of Soil Science and Environmental Management, 3(4), 84-90, 2012 DOI: 10.5897/JSSEM11.145

An assessment of soil physical and chemical properties was carried out in Shea parklands of northern Ghana, selected along a North-south climatic gradient in 2011. The study sites were Paga, Nyankpala and Kawampe, which are located in the transitional and Guinea savannah zones of Ghana. For each site, 9 fallows and 9 cultivated fields were used, a total of 18 plots per site. Soil samples were collected at a depth of 0 to 30 cm and analysed for particle size distribution, pH, organic matter (OM), nitrogen (N), phosphorus (P), exchangeable bases, exchange acidity and effective cation exchange capacity (ECEC). The results revealed that the soils were strongly acid to neutral in reaction. The soils at Nyankpala parkland were comparatively more acidic (pH < 6). Generally, the pH values recorded were within the desirable range for plant nutrient availability. Levels of, OM, ECEC, and total exchangeable bases (TEB) were very low, and varied across the parklands, with Nyankpala parkland showing higher levels of OM and ECEC. In spite of the low pH, the soils were highly base saturated (PBS > 80%) and deficiencies of basic cations were uncommon. Land use did not significantly influence the soil chemical properties. However, N values, were significantly higher in old fallows than in respect of new fallows and cultivated fields. Soil particle size distribution especially at Nyankpala was significantly influenced by land use, with fallow lands having more proportion of sand than that of cultivated fields. The extremely low P content (trace - 7.11 mg/Kg) of the soils might be due to P fixation which was commonly reported for soils in northern Ghana. However, if these soils were supplied with N fertilizers,

seedling regeneration would be promoted due to the fact that increasing N levels and decreasing P levels in soil, results in significant increase in seedling dry weight as well as increasing uptake of total shoot N and C.

DETERMINATION OF BIOCHEMICAL COMPOSITION OF SHEA (*Vitellaria paradoxa*) NUT USING NEAR INFRARED SPECTROSCOPY (NIRS) AND GAS CHROMATOGRAPHY

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International Journal of Biology, Pharmacy and Allied Sciences, (2): 84-98, 2012

The shea tree *Vitellaria paradoxa* L. is the most prevalent tree crops in northern Ghana with the shea butter fat as the most important product from the tree. Difference in the shea butter fat quality is mainly attributed to bioclimatic variations in temperature and rainfall. The purpose of this study was to apply near infrared, wet chemistry and gas chromatography to characterize the fat and free fatty acid profiles of shea butter fat from three locations (Paga, Nyankpala and Kawampe) in Ghana. The shea nuts from the tree locations in Ghana conformed to the West Africa shea nuts on the global data base on shea nuts compiled at CIRAD. Samples from Paga recorded the highest moisture content ranging between 5.63 % and 12.04 % (dry matter) with a mean content of 6.83 % and a standard deviation of 1.30 % whilst from Kawampe recorded the lowest moisture content with a mean of 5.23 %. Samples from Kawampe recorded the highest fat content ranging from 47.07 % to 57.39 % (dry matter) with a mean content of 52.69 % and a standard deviation of 2.55 % with samples from Paga recording the lowest fat content with a mean of 48.84 %. Stearic acid content of

the samples was higher than oleic acid content from the three locations with virtually the same ratio of saturated and unsaturated fatty acids. Correlation between wet chemistry values and near infrared spectroscopy (NIRS) predicted values for moisture content (calibration set) with regression of 0.974 indicating the ability of NIRS to differentiate between nuts from different regions. The nature of the dried shea nuts before processing affected the quality of the shea butter fat as moulded samples recorded higher free fatty acids reducing the quality of the shea butter fat. Fatty acid methyl esters (FAME) analyses indicated that the samples from the three locations in Ghana were mostly saturated with stearic and oleic acids and less of palmitic, vaccenic, linoleic and arachidic acids in the fatty acid profiles of shea butter fats.

Keywords: Shea nut butter fat, Fat content, Moisture Content, NIRS, Free Fatty Acid, Gas Chromatography

THE EFFECT OF ELECTRICAL CONDUCTIVITY (EC) AND ACIDITY (PH) OF IRRIGATION WATER ON THAT OF VEGETABLE GARDEN SOILS IN THE TAMALE METROPOLIS

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Horticulture Magazine, 2(1), 20-30, 2012

The study was conducted in the Tamale Metropolis to study the relationship between the ECs of irrigation water and irrigated soil as well as the relationship between the pH of irrigation water and that of soils in eight irrigated vegetable gardens. The gardens were located in Builpela (Site A and Site B), Gumbehini, Lamakara, Sagani, Sakasaka, Zagyuri and Zuju. Seven irrigation water samples and 16 soil samples were taken and analysed in the laboratory. The pH of the soil was determined in water at a soil to water ratio of 1:1 while the EC of the soil was determined by the saturated paste extract method. The EC of the soils

ranged from 0.02 dS/m to 0.20 dS/m and that of the irrigation water ranged from 0.01 dS/m to 0.10 dS/m, that is non-saline. The research revealed that, the ECs of the soils were highly influenced by that of irrigation water. The pH of the soils ranged from 5.68 to 8.36 and that of the irrigation water ranged from 6.36 to 7.48. The pH of the soils was also influenced by the pH of the irrigation water, though the impact was minimal.

BASELINE STUDIES ON THE MARKETING OF AMARANTHUS IN TAMALE

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Horticulture Magazine, 2(1), 34-38, 2012

This paper examined the marketing of amaranthus in terms of handling, access to market information and consumer demand in four major markets in the Tamale metropolis. The study was done in May 2011 by employing a semi structured questionnaire for interviewing 50 randomly sampled respondents. Results from the study showed that females are the retailers of amaranthus. Majority (56%) of the respondents had no formal education and the percentage of respondents with secondary education (28%) was more than those with primary education (16%). Retailers had their daily consignments from 8 areas in and around Tamale with Choggu (36%) and Gumbihini (34%) dominating in supplies of amaranthus to Tamale markets. Retailers (76%) fixed market prices based on farm gate prices agreed on by farmers at the beginning of a production period. 30% of the respondents always washed their consignments before display. Fifty-two (52%) percent of retailers observed that consumers normally prefer smaller bundles while 48% indicated that consumers prefer bigger bundles. Other consumer preferences were for flavour (18.7%), maturity (18%), quality grades (15%) and packaging (19%). A major constraint strongly indicated by all (100%) respondents is the high perishable nature of amaranthus under the high temperature environment that produce are displayed. The full potential of amaranthus as a market commodity will be harnessed when the post-harvest

handling and marketing activities are well organized for the up scaling of the commodity to formal markets (supermarkets) like Quality First.

GROWTH AND FRUIT WEIGHT OF CHILLI PEPPER (*Capsicum frutescens*) AS AFFECTED BY SOIL STERILIZATION AND PRICKING OUT

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International Journal of Agricultural Research, 7(8):398-405, 2012;

DOI:10.3923/ijar.2012.398.405

Pricking out and the sterilization are regarded as very important nursery practices in certain crops but chilli farmers in northern Ghana do not practice them. Information is needed on their effects on the growth and yield of chilli pepper so as to promote these practices in northern Ghana. A field experiment, was conducted at the experimental farm of the University for Development Studies, Nyankpala campus, Ghana to verify the contributions of some simple nursery soil sterilization types, seedling pricking and their interactions to the growth and fruit weight of chilli pepper. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. The treatment combinations were straw burning (to sterilize the nursery bed) with pricking out, straw burning without pricking, solarisation (to sterilize the soil by trapping solar energy) with pricking out, solarisation with no pricking out, no solarisation with pricking out and a control which did not receive any of the treatment. The parameters studied were plant height, number of leaves, number of branches, canopy spread, number of fruits, fresh and dry fruit weight. The results revealed that, pricking out or sterilization affected most of the parameters studied independently. Pricked out plants were taller, produced more branches, produced about twice the number and weight of fruits compared to non-pricked out ones. Soil sterilization especially straw burning enhanced the production if more leaves and higher fresh fruit weight per fruit. It is concluded that plants that were nursed on sterilized soils and later pricked out were better in vegetative

growth and fruit weight than those that were not. Ongoing research is quantifying the reduction in soil pathogen and weed seeds as a result of the nursery bed sterilization types under consideration.

Keywords: Soil sterilization, Solarisation, Pricking out, Competition for growth factors

FOSTERING SUSTAINABLE ENGAGEMENT OF THE YOUTH IN THE AGRIFOOD SECTOR: OPPORTUNITIES AND CHALLENGES FOR YOUTH EMPLOYMENT IN GHANA

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The youth, who form the main active working force, constitute more than 30% of Ghana's population. The Ghana Institute of Horticulturists (GhIH) has over the last decade been working to address some of the main aspirations of the youth, which include improved nutrition, increased income and employment opportunities. This paper discusses the methodologies and results achieved by GhIH, through training young farmers and young professionals for employment in the agrifood sector. GhIH has addressed these issues at both the community and the organisational levels. At the community level, training methodologies have included Farmer Field Schools (FFS), Training of Trainer workshops (ToT) and on-farm demonstrations at five locations in the Upper West Region (UWR) of Ghana. At the organisational level, GhIH builds the capacity of young professionals through networking, conferences, communication, professional

exchanges and youth mentoring. Results of these interventions included stronger farmer associations with 30% of the farmers aged 19-35 (male/female=16.0%/13.2%). Over 80% of farmers have learned and applied Best Management Practices (BMP) that resulted in a two-fold increase in productivity compared to non-project communities. Availability of fresh vegetables increased from 5 months to 9 months in project communities. At least 53% of the farmers reported increases in purchasing power as a result of increasing productivity and income. Thirty-two percent (32%) of male and 36% of female farmers have recognised vegetable production as a critical livelihood support system. The rural-urban migration was reported to have substantially decreased (11% decrease in 2006 and 20% decrease in 2010) over the five years of the project and appears to be evidence of the higher income. At the organisational level, vibrant student groups of GhIH (3 in 2006 and 8 in 2011) have been established and sustained. There have been increased skills among young professionals (who formed more than 60% of members) in project management, scientific writing and communication, and increased engagement between young professionals, student groups and agrifood value chain actors. Participation of female youth is evident in at least 20% female student attendance at Annual General Meetings (AGM) and at least 7% of authorship in three volumes of Ghana Journal Horticultural Science. Through south-south and north-south exchanges, the project has also built the capacity of young professionals (at least 10 members and 35 student executives each year) for sharing best practices and lessons on international agriculture development. Poor agricultural finance and poor integration of small-holder producers into national and regional markets are the main challenges in recruiting young farmers. Other challenges include high interest rates on loans, lack of social security for men and women in the informal sector and weak institutional support for small and medium enterprises. These opportunities and challenges need to be considered in developing a comprehensive policy for sustaining the engagement and employment of youth in the agrifood sector.

LABORATORY EVALUATION OF EXTRACTS FROM HYPTIS SPICIGERA LAM. AGAINST CALLOSOBRUCHUS MACULATUS F. (COLEOPTERA: BRUCHIDAE) IN KERSTING'S GROUNDNUT (MACROTYLOMA GEOCARPUM HARMS).

Badii, K. B., Nyarko, G. and Ayertey, J. N.

Ghana Journal of Agricultural Science, 46: 9 -19, 2011

PRELIMINARY STUDIES ON THE GROWTH AND YIELD OF HOT PEPPER (CAPSICUM FRUTESCENS L) AS INFLUENCED BY PRICKING OUT AND STARTER SOLUTION

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Ghana Journal of Horticulture, 9, 95-103, 2011

An experiment was carried out at the experimental field of the University for Development Studies at Nyankpala between April-November. 2009 to determine the effects of pricking out and starter solution application to seedlings on the growth and yield of hot pepper. The experimental design was 2 x 2 factorial in completely randomized design with three replications. A starter solution (10g NPK, 15: 15: 15, mixed with 15 l of water) was applied to some pricked out and non-pricked out seedlings immediately after planting out (6 weeks after sowing in the field). The treatment combinations were: Pricked-out seedlings which were given starter solution (P_1S_1), pricked out seedlings without starter solution (P_1S_0), non-pricked out seedlings which were given starter solution (P_0S_1) and control plants which were neither pricked out nor received starter solution (P_0S_0). The study revealed that plants that were pricked out and / or received starter solution had better vegetative growth and gave over three times higher yield as compared to the control plants. The results suggest the adoption of pricking out

and the application of starter solution to pepper seedlings as appropriate means of increasing yield and maximizing profit in pepper cultivation.

PRELIMINARY STUDIES ON GROWTH AND FRESH WEIGHT OF LETTUCE (*Lactuca sativa*) AS AFFECTED BY CLAY POT IRRIGATION AND SPACING

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Pakistan Journal of Biological Sciences, 14(14):747-51, 2011.
doi:10.3923/pjbs.2011.747.751

An experiment (Completely Randomized Design) was set up to determine the effects of Clay Pot Sub-surface Irrigation (CPSI) with spacing; 15x15cm, 20x20cm and 30x30cm. Control treatments were Watering can Irrigation (WCI) with the same spacing as above. Treatments were replicated three times given a total of 18 experimental units. Eighteen large enamel basins of 50/20cm (diameter/height) were filled with good topsoil and clay pot buried neck deep in each of the basins. Seedlings were planted in all the eighteen basins. Five Hundred million of wastewater was applied daily to plants in each container having either clay pot or watering can treatment. Plant height increased from 2.50 to 4.25 cm within 6 Weeks after Transplanting (WAT) under CPSI and only increased from 2.14 to 2.99 cm under WCI. The CPSI also supported better leave growing and fresh weight. The fresh weight of lettuce increased almost two fold under 15x15 cm spacing compared 20x20 and 30x30 cm.

Keywords; Clay pot, Surface irrigation, Lettuce planting, Density, Wastewater

GROWTH AND YIELD RESPONSE OF CARROT (*Daucus carota* L.) TO DIFFERENT RATES OF SOIL AMENDMENTS AND SPACING

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Journal of Science and Technology, 31(2)11-20, 2011

A 5 x 2 factorial field experiment in a randomised complete block design with four replications was conducted at the College of Agriculture Education, University of Education, Winneba, Mampong Campus to investigate the growth and yield responses of carrot to different rates of soil amendments and spacing. The five rates of soil amendments were: (i) 10 t/ha chicken manure (ii) 15 t/ha chicken manure (iii) 20 t/ha chicken manure (iv) 300 kg/ha NPK (15-15-15) and (v) Control (no soil amendment). The two spacings were: (i) 30 cm x 5 cm and (ii) 20 cm x 5 cm. The application of 15 t/ha and 20 t/ha decomposed chicken manure improved vegetative growth, increased root yield and gave more income. More plants were however, infected by *Sclerotium rolfsii* by the application of the 20t/ha chicken manure. Soil amendment rates did not suppress nematode populations but the highest root galling index was recorded on the control plants. The wider spacing of 30cm x 5cm promoted vegetative growth and increased root length of carrot but planting at closer spacing of 20cm x 5cm resulted in higher total and marketable yields and also increased income and profit.

Keywords: Soil amendments, spacing, nematode populations, carrot yield

PRELIMINARY EVALUATION OF SOME PLANT PRODUCTS IN THE CONTROL OF FIELD INSECT PEST OF OKRO

Nyarko, G., Badii K. B. and Abiba Musah

Horticulture Magazine, 1: 12-16, 2010.

Research was conducted during the 2008 cropping season to evaluate the effects of fatty soap, fine ash and aqueous extracts from neem seeds in control of major insect pests of okro, *Abelmoschus esculentus* L. The target pest species included *Zonocerus spp*, *Podogrica sjostedti*, *Sylepta derogata* and *Dysdercus supersticiosus*. The results showed that okro plants treated with fine ash or fatty soap performed significantly better than those of the control, in terms of reduction in pest abundance and incidence. Plants treated with neem seed extract had a lower pest load and damage incidence than those treated with fine ash or fatty soap. The difference between the fine ash and fatty soap treatments was, however, not significant. Fruit yield and quality obtained from the fine ash or fatty soap treatment was significantly higher than that of the control. Among the treatments, okro plants sprayed with neem seed extract recorded the highest fruit yield, and this was statistically comparable to that of the synthetic insecticide, Karate. The implications of these findings are discussed as a guide to explore the insecticidal potential of locally available plant products in the management of field insect pests of okro in the savanna ecology of Ghana

I.

EFFECT OF AGRO-ECOLOGICAL ZONE AND STORAGE ENVIRONMENT ON THE QUALITY OF THE PHYSIC NUT (*Jatropha curcas*) SEED

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Ghana Journal of Horticulture, 8, 12-20, 2010

Jatropha curcas seeds were harvested at brown ripe stage from plants growing in the Guinea Savannah (GSZ), Forest (FZ) and Coastal Savannah (CSZ) Zones in Ghana and were assessed for seed quality at harvest, after seed drying and seed storage. The harvested seeds were dried to 8 and 10 % moisture levels and subjected to two storage conditions (cold storage and room storage) from March to August, 2007. The principal aim of the experiment was to evaluate the effect of storage on the quality of *J. curcas* seed. Some of the seed characteristics assessed were: seed kernel to shell ratio, thousand seed weight (TSW), seed oil content, percentage seed germination, seedling dry weight, seed vigour index, and fungi associated with the seed. There were no differences in the seeds from the three zones in terms of seed oil content, percentage seed germination, seedling dry weight and seed kernel to shell ratio at harvest. However, seed from the FZ showed superior performance in absolute terms for most of the parameters measured. After drying, seed from FZ at both 8 and 10 % seed moisture had highest TSW, seed oil content, percentage germination and vigour index. The result further indicated that even though cold storage seemingly preserved *J. curcas* seed better than room storage, it rather promoted fungi survival on the seed. The results suggest that fresh seed of *Jatropha* from any of the three zones could be used for planting with satisfactory germination and seedling establishment.

A REVIEW ON THE POSSIBILITY OF FLOWERING AND SEED PRODUCTION OF CABBAGE IN THE TROPICS

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Ghana Journal of Horticulture, 7, 103-116, 2009

The need to investigate the possibility of producing cabbage seeds in tropical countries like Ghana has become very imperative. The objectives of this review are to highlight the concept of vernalization and some of the other factors that

may enhance flowering and seed production of cabbage in the tropics and to sensitize interested scientists to research into this very important area.

SUCROSE AND NITROGEN EFFECTS ON GREENNESS, HEAD PARAMETERS AND FLOWERING OF FOUR LINES OF CABBAGE

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Ghana Journal of Horticulture, 7, 44-52, 2009

A study was carried out to determine whether increasing the sucrose concentration to seedlings *in vitro* and subsequently increasing N supply to plants in soil can affect head parameters or greenness which may lead to flower induction in cabbage. A further aim was to find out whether there is a relation between SPAD meter values for greenness and total chlorophyll of four cabbage varieties under study. Sterilized cabbage seeds were cultured individually in glass jars with heat sterilized agar medium containing 0 or 3 % sucrose. Plants generated were raised in 23 cm pots and a total of 0 or 7 g N per pot was applied as a top dressing to the plants. In a separate experiment, after greenness had been measured from leaves of each of the four varieties, 1cm leaf discs were cut from the exact points where the measurements of greenness were taken and total chlorophyll determined for each disc. Sucrose and N increased the stem height at flowering independently and the combined effect of 3 % sucrose and 7 g N promoted early flowering of 'HRI 006556' as compared to when treatment was applied alone. Supply of 7 g N caused head splitting of three varieties and reduced the solidity of 'KK Cross '. Variety, sucrose and N affected the SPAD readings. There were significant positive relationships between SPAD meter value for greenness and the total chlorophyll for data pooled from all the four cabbage varieties, however there were variety differences in the relationship that

required the development of a separate regression equation for each variety of cabbage for effective prediction of total chlorophyll from SPAD meter readings.

COMPARISON OF CELL MEMBRANE THERMOSTABILITY AND CHLOROPHYLL FLUORESCENCE PARAMETERS FOR THE DETERMINATION OF HEAT TOLERANCE IN TEN CABBAGE LINES

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Journal of Horticultural Science & Biotechnology, 83 (5) 678–682, 2008

Cell membrane thermostability (CMT) and chlorophyll fluorescence (CF) were determined for ten lines of cabbage in order to select heat-tolerant varieties, to provide an improved method to screen for heat tolerance, and to determine whether there is a relationship between CMT and CF. Chlorophyll fluorescence parameters, especially variable fluorescence (Fv) and the ratio between Fv and maximum fluorescence (Fm), were found to be better than CMT for screening cabbage lines for heat tolerance. Fv values and the Fv/Fm ratio of stressed plants corresponded to high heat damage for the varieties 'HRI 002605', 'HRI 003202', and 'HRI 007827'; and to low heat damage for the varieties 'HRI 013011', 'HRI 005237', and 'HRI 006556'. The latter group may therefore be more tolerant of high temperature stress in the tropics. There were significant relationships ($P < 0.05$) between relative injury (RI), an index of CMT, and two of the CF parameters [minimum fluorescence (Fo) and Fv/Fm] under stress conditions (35° – 40°C). This suggests that parameters measured under stress temperatures are more reliable than those measured under non-stressed conditions when determining heat tolerance.

INDUCTION OF FLOWERING IN CABBAGE PLANTS BY *IN VITRO* VERNALIZATION, GIBBERELIC ACID TREATMENT AND RATOONING

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A study was carried out to determine whether applying cold to plants *in vitro*, or gibberellic acid treatment later to green plants in soil, alone or in combination, can induce flowering in cabbage plants raised from seeds at 20°C. Sterilized seeds of four lines of cabbage were cultured in glass jars and kept in the growth room 25°C for 56 d after which they were cold treated (6°-1 3°C) for another 56 d. The seedlings generated were later transplanted into 15 cm-plastic pots and 250 mg l⁻¹ gibberellic acid (GA) was later applied to the leaves of plants, followed by six further applications at 1-week intervals. Results showed that one line, 'HR1 003202' produced more leaves than the other three lines but the stem girth of the lines was not affected after 8 weeks cold treatment. At 21 d after transplanting, 'HR1003202 ' had the smallest stem girth, shortest leaves and stem and highest leaf number however all lines varied significantly from each other in terms of stem height. For line 'HRI 006556', GA, did not have any effect ($P > 0.05$) on cold treated plants but reduced both the leaf number and number of days at flowering of the control plants. One of the three replicates of line 'HRT 007617 ' flowered when a combination of cold and GA treatments was applied to plants.

**INDUCTION AND GENERATION OF FLOWERING IN CABBAGE
PLANTS BY SEED VERNALISATION, GIBBERELIC ACID
TREATMENT AND RATOONING**

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Experiments were conducted to determine whether applying seed vernalisation or gibberellic acid treatment, alone or in combination, can induce flowering in cabbage plants raised from seeds and ratoons at relatively high temperatures (20° – 25°C), and to determine whether new flowering plants can be generated from flower-induced plants. Seeds of ten varieties of cabbage were imbibed in 302.44 g l⁻¹ polyethylene glycol 6000 and exposed to vernalisation temperatures (2.0° – 4.5°C) for 8 weeks in a refrigerator, while controls were kept at 25°C for 11 d, after which the seeds were sown and plants raised at 20° – 25°C. Ratoon plants were also raised from control and seed-vernalised plants from the previous experiment. Forty five d after transplanting, or 28 d after removing the heads, 250 mg l⁻¹ gibberellic acid (GA₃) was applied to the leaves of plants raised from seed or ratoons respectively, followed by six further applications at 1-week intervals. The combined effects of seed vernalisation and GA₃ induced flowering in cabbage plants of variety 'HRT 009617' developed from seeds or ratoons. None of the treatments had any adverse effect on the percentage germination of subsequent seeds produced from those varieties that flowered. All showed 89%, or higher germination. Cuttings from the reproductive stalks of flowering-induced plants were able to flower at 20°C, without vernalisation.

**PROMOTION OF VIGOUR IN CABBAGE SEED BY OSMOTIC PRIMING
PRE-TREATMENT AT BOTH VERNALISATION AND NON-
VERNALISATION TEMPERATURES**

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Osmotic priming of cabbage seeds with polyethylene glycol (PEG 6000), to prevent germination during a vernalizing treatment, was investigated as part of a study into potential seed production in the tropics. A preliminary attempt to vernalise cabbage seeds had resulted in weak stemmed seedlings, with fungal infections, as a consequence of the non-primed seeds having germinated while still in the fridge at the low temperatures used for vernalisation (0° - 5°C). Two experiments to determine the effect of PEG 6000 on the viability and vigour of cabbage seed at non-vernalisation and vernalisation temperatures were carried out. In the first experiment, seeds of ten varieties of cabbage were imbibed separately in 302.44 g l⁻¹ PEG 6000 in Petri dishes lined with filter papers moistened with PEG solution, or with distilled water as controls. The primed seeds were kept for 2 weeks at 25°C (non-vernalisation temperature) under an 8 h photoperiod, washed in distilled water and sown immediately into 4 cm-square plastic modular trays filled with Levington F2S compost. Priming did not have any significant effect on the proportion of seeds that germinated ($P > 0.05$), but significantly enhanced the coefficient of velocity (CV) at 25°C. In the second experiment, seeds of four varieties of cabbage were primed at 0° - 5°C for 8 weeks prior to sowing in compost. Controls were seeds primed in the same concentration of PEG 6000 and kept at 25°C for 11 d, and seeds sown without priming or vernalisation. Again, priming of cabbage seed with PEG 6000 had no adverse effect on the proportion of seeds that germinated, but promoted the CV (vigour) of seeds kept at vernalisation temperatures (0° - 5°C).

**TOWARDS CABBAGE (*Brassica oleracea var. capitata* L.)
SEED PRODUCTION IN THE TROPICS**

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Some morphological and flowering characteristics of ten cabbage varieties obtained from Warwick–Horticultural Research Institute, UK have been evaluated with the aim of selecting suitable varieties for the study of flowering and seed development in the tropics and to ascertain the viability of cabbage seed produced under high temperatures (20-30°C). Plants raised from seed in peat-based compost in plastic pots were grown in a controlled environment room (CER) at 20°C with 12h photoperiod and 400mmolm⁻²s⁻¹ photosynthetic photon flux and in a glasshouse receiving natural light with a blackout system to give a 12-h photoperiod and maintained between 20 to 30°C. Eight weeks after sowing, two pots of each variety from each environment were transferred to another CER for vernalization at 4 °C for 8 weeks, after which they were returned to their respective controlled environments. Vernalization at 4°C promoted flowering in all varieties, however; varieties 11446, 6556 and 9617 flowered earlier and seeds produced in tropical conditions (20-30°C) were viable and vigorous with most varieties having 80% germination or higher. The varieties varied significantly in terms of number of leaves, height of stem and length of leaves, but canopy shape index did not vary significantly and was approximately one. The taller varieties of cabbage flowered easily, consistently showed higher levels of greenness and had lower incidence of tip-burn and splitting of the heads as compared to the shorter varieties. Varieties 3720, 5237 and 113011 can be considered as early maturing types.

PACKAGING AND HANDLING OF FRESH TOMATO FROM TONO IRRIGATION PROJECT SITE

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Tomato is all important vegetable in the diet of the people of Ghana. Large quantities of fresh tomato are produced at Tono irrigation Project site in the Upper East Region, whilst the major marketing centres are located in the southern parts of the country, quite a distant away from this production centres. To retain produce quality and to reduce risk of handling damage, appropriate packaging is necessary to ensure the produce reaches the consumer in an acceptable quality. The study showed that wooden boxes (crates) which are used, generally for packaging in the fresh tomato trade provided some degree of protection for the produce against bruising. External factors, however were observed to contribute to produce quality deterioration during packaging and handling. The use of boxes as measuring units (volume rather than weight) gives room to manipulation by traders as they try to overfill the boxes. This was identified as a major cause of squashing and bruising of the produce.

THE EFFECT OF CONTAINER TYPES, SEED DRESSINGS AND DESICCANTS ON THE VIABILITY AND VIGOUR OF ROSELLE (*HIBISCUS SABDARIFFA L. VAR. SADDARIFFA*) SEEDS

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An experiment was conducted to investigate the effects of seed dressings (neem leaf powder, tobacco leaf powder, wood ash and control), container types (earthen pots, bottles, polythene sacks, plastic container and gourds) and desiccants (toasted rice and powdered charcoal) on the viability and vigour of roselle (*Hibiscus sabdariffa L. var. sabdariffa*) seeds. The leaves were dried and ground separately into fine powders. These were mixed with the roselle seeds and put into the various containers. The neem leaf powder (NLP) and tobacco leaf powder (TLP) were each applied at the rate of 50% (W/W) and 100% for each wood ash (WA). Also added were the desiccants (10 g charcoal and 10 g toasted rice) to absorb any moisture that might be generated during the respiration of the seeds in the containers. Some seeds were stored in the containers without dressings or desiccants to serve as control. The containers and their contents were stored at room temperature (21-30°C) and relative humidity (40-70%) for a period of one-year after which they were sown to determine viability and vigour. After 14 and 20 days since sowing, the germination percentage and vigour index data were recorded, respectively. NLP and WA did not have any adverse effect on the vigour of treated roselle seeds. The best container for roselle seed storage was plastic containers, followed by bottles and polythene bags in that order. The results showed that charcoal was a better desiccant than toasted rice and the former improved the viability and vigour of seeds stored in gourds and earthen pots.

Keywords: Roselle, seed dressings, desiccants, containers, viability, vigour

EFFECTS OF DIFFERENT SEED TREATMENT METHODS ON THE PERCENT GERMINATION, SEEDLING VIGOR AND BIOMASS PRODUCTION OF GROUNDNUTS IN GHANA

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Low plant stands due to poor seed germination accounts for over 70% of the low production and productivity of crops in Ghana. This led to the conduction of an experiment to ascertain the effects of hot water, diathane M45 (D) and maceration (M) treatment on the viability, vigour and biomass production of three groundnut varieties, Chinese, Manipintar and F-mix. Maceration and D produced significantly higher rate of germination in Chinese and Manipintar than their controls. The three main treatments had no significant effect on the speed of germination of F-mix seeds. Hot water at 50°C level (H50°C), M₁ and D₁ treatments gave significantly higher germination percentage values for Chinese and Manipintar but not for F-mix. M₁ and D₁ treatments gave mean vigour indices significantly higher than their controls for Chinese, Manipintar and F-mix. However, it was only in Chinese where 50°C hot water treatment produced significantly higher vigour index than the 60°C level. 50°C, M₁ and D₁ yielded significantly higher than their controls in Manipintar and F-mix, respectively. Chinese seeds treated with various levels of hot water and D₁ gave biomass yields significantly higher than seeds treated with hot water without diathane. Speed of germination, seedling vigour, germination percent and biomass production were about two or more times better and significantly higher in Chinese and Manipintar than F-mix, irrespective of the treatment levels. Maceration emerged as the best single treatment and could be adopted by farmers to increase germination percentage and plant stand at farm level since it is readily available to the farmers and cheap.

Keywords: Groundnuts, Seed treatment, Percent germination, Seedling vigour, Biomass production

VARIATION IN FRUIT AND SEED CHARACTERISTICS OF THREE POPULATIONS OF SHEA TREES (*VITELLARIA PARADOXA*) IN THE NORTHERN REGION OF GHANA

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In June 2000, a nested sampling procedure was used to collect shea fruits from three locations, involving six sites and 30 individual trees from a radius of about 50km in the Northern Region. Our aims were to estimate parameters of fruit weight (FW), seed weight (SM), seed length (SL), seed width (SW), hilum length (HL), hilum width (HW), percentage pulp (PULP) and the length to width ratio of the seed (LW) in the populations sampled; estimate the variation in these traits, calculate correlations among them and to determine the population structure with respect to these traits. Estimates of these parameters were in close conformity with those reported in the literature. Variance components revealed that while trees were highly heterogeneous at a site, differences between sites and between locations were less pronounced. High Pearson Product Moment correlations between pairs of traits were observed for all pairs of traits except LW and PULP, which correlated poorly with the others indicating the possibility of independence of fruit size traits and percentage pulp. It is recommended that genetic tests be established to enable estimation of genetic parameters and their inheritance patterns.

A SURVEY ON ONION PRODUCTION IN THE BAWKU EAST DISTRICT OF GHANA

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Dry season vegetable cultivation in the northern part of Ghana is important in various respects. It provides employment and income during a period, which would otherwise be spent in idleness among most rural farmers. Dry season vegetable production therefore has the potential of checking the north-south migration as well as contributing to improved nutrition. Dry season vegetable production has to be improved by solving some of the most important problems that hinder productivity to make it more attractive for farmers to engage in it. It is in this respect that a baseline survey was carried out in seven onion-producing communities in the Upper East Region to identify some of the major problems hindering productivity. From the survey, it became apparent that sufficient quality onion seed was a problem. Farmers produce their own seed and even supplement this by buying seed from the market. There are no certified seed growers. It was also evident that there was no standard method of bulb pre-treatment before planting and farmers were uncertain of the optimal "seed-bulb" size. However, the Bawku red cultivars were the most preferred but thrips were a major pest problem. It appears that marketing and storage of bulbs were less problematic. Seed storage, on the other hand, was a problem with about 39% of farmers able to store for only up to six months. It is recommended that the major problems identified should be scientifically studied and solutions worked out and recommendations given to the farmers to boost onion production.

COMPARISON OF NEEM PRODUCTS WITH ACTELIC AND DITHANE AS SEED DRESSERS ON THE VIABILITY AND VIGOUR OF STORED SEED MAIZE

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Samples of seed maize were treated with neem seed powder, neem leaf powder and neem seed oil at 0.5% and 1.0% concentration each. Some of the seeds were also treated with Actellic 25 EC. and Dithane M45 (at the same levels of concentration as used for the neem products) while others were left untreated. The seeds were then stored for nine months in pre-sterilized black polythene bags. After the storage period, germination tests were performed on the treated seeds and the control to determine viability. Vigour index and coefficient of velocity were also determined for each treated seed as a measure of seed vigour. Results showed that neem seed powder, neem seed oil and Actellic depressed the viability and vigour of seed maize. However, Dithane M45 and neem leaf powder had no adverse effect on the quality of seed maize. Therefore, neem leaf powder could be used as seed dresser at 1.0% (W W) concentration.

Keywords: Neem, Viability, Vigour, Seed maize.