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Research Application Summary

Cassava value chain upgrading for secure food, nutrition, income and resilience of smallholder farmers in the Agricultural Semi-Arid Lands of Nakuru County – Preliminary results

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Abstract

Cassava is an important food security crop in Kenya, mainly grown for subsistence and limited commerce in western, eastern and coastal regions. Demand for the crop has grown in non-traditional growing areas of Nakuru County where cassava agribusiness development initiatives have been introduced. However, take off of cassava agribusiness is constrained by introduced varieties' susceptibility to Cassava Brown Streak Disease (CBSD), late maturity, low yields and poor adaptability. Participatory introduction of improved sweet varieties with CBSD tolerance and exposure of communities to broad based utilities of cassava is needed to upgrade the value chain to a commercial status. The current study aims at contributing to improved food, nutrition and income security of Nakuru County small holder cassava farmers through innovations in the cassava value chain. The following objectives are being pursued; 1) farmer participatory screening of cassava varieties to select suitably adapted early maturing sweet varieties for the arid and semi-arid lands (ASALs) of Nakuru County; 2) Improving CBSD resistance in farmer preferred varieties using Marker Assisted Selection techniques; 3) Developing safe high value cassava based food, feed and industrial products for improved food, nutrition and trade/ commerce; and 4) Building capacity of graduate, undergraduate, and TVET students, and farmers in breeding and development, testing and utilization of cassava food and feed products. The project under which these objectives are being persued has in the first year conducted a household baseline survey to determine the status of cassava production, value addition, and utilization in three selected sites (Sub-counties) in the county. A farmer participatory sweet cassava germplasm collection and evaluation in the three sites has been undertaken; the evaluation sites and plantings also acted as demonstration fields where farmer trainings were held. Also three suitable varieties for each of two sites (Subukia and Solai) have been selected for further bulking and distribution to farmers. Five farmers' trainings on cassava production and evaluation have been conducted, with over 216 farmers attending. Two community dialogue sessions on cassava production and the crop's benefits have also been held. Farmer to farmer learning has been initiated with the demonstration host farmers keeping registers of compatriots visiting their sites for learning purposes. In the project, two PhD students have been recruited to conduct studies on cassava product development (Food Science) and to develop improved germplasm with tolerance to CBSD (Plant Breeding). Four (4) M.Sc. students (2 Agribusiness and 2 Community studies) under the TAGDev programme are studying various aspects of the cassava value chain in Migori county where cassava is established crop value chain and one M.Sc student is studying aspects of cassava biochemistry for fermentable starch. 10 TVET students have been recruited to be exposed to cassava agribusiness through trainings in clean seed production and value addition.

Key words: Cassava Brown Streak Virus Disease, Cassava value chain, Egerton University, Kenya, Nakuru County

Résumé

Le manioc est une culture importante pour la sécurité alimentaire au Kenya, principalement cultivée pour la subsistance et le commerce limité dans les régions occidentales, orientales et côtières. La demande pour cette culture a augmenté dans les zones de culture non traditionnelles du comté de Nakuru où des initiatives de développement de l'agrobusiness du manioc ont été introduites. Cependant, l'essort de l'agrobusiness du manioc est limité par la sensibilité des variétés introduites à la maladie des stries brunes du manioc (CBSD), la maturité tardive, les faibles rendements et la faible adaptabilité. L'introduction participative de variétés améliorées tolérantes à la CBSD et l'exposition des communautés à une large gamme d'utilisations du manioc sont nécessaires pour améliorer la chaîne de valeur à un niveau commercial. Cette étude vise à contribuer à l'amélioration de la sécurité alimentaire, nutritionnelle et des revenus des petits exploitants de manioc du comté de Nakuru grâce à des innovations dans la chaîne de valeur du manioc. Les objectifs suivants sont poursuivis : 1) sélection participative des variétés de manioc par les agriculteurs afin de choisir des variétés sucrées à maturation précoce adaptées aux terres arides et semi-arides (ASAL) du comté de Nakuru ; 2) amélioration de la résistance des variétés préférées des agriculteurs à la CBSD en utilisant des techniques de sélection assistée par marqueurs ; 3) Développer des produits alimentaires, fourragers et industriels à base de manioc, sûrs et de grande valeur, pour améliorer l'alimentation, la nutrition et le commerce ; et 4) Renforcer les capacités des étudiants de premier, deuxième et troisième cycle, des étudiants de l'EFTP et des agriculteurs en matière de sélection et de développement, de test et d'utilisation des produits alimentaires et fourragers à base de manioc. Le projet dans le cadre duquel ces objectifs sont poursuivis a, au cours de la première année, mené une enquête de base auprès des ménages pour déterminer l'état de la production, de la valorisation et de l'utilisation du manioc dans trois sites sélectionnés (sous-comtés) du comté. Une collecte et une évaluation du stock génétique du manioc doux, avec la participation des agriculteurs, ont été entreprises sur les trois sites ; les sites d'évaluation et les plantations ont également servi de champs de démonstration où des formations ont été organisées pour les agriculteurs. De plus, trois variétés appropriées pour chacun des deux sites (Subukia et Solai) ont été sélectionnées pour être distribuées aux agriculteurs. Cinq formations agricoles sur la production et l'évaluation du manioc ont été organisées, avec la participation de plus de 216 agriculteurs. Deux sessions de dialogue communautaire sur la production de manioc et les avantages de la culture ont également été organisées. L'apprentissage agriculteur-agriculteur a été initié avec les agriculteurs hôtes tenant des registres de leurs collégues qui visitent leurs sites à des fins d'apprentissage. Dans le cadre du projet, deux doctorants ont été recrutés pour mener des études sur le développement de produits à base de manioc (science alimentaire) et pour développer un stock génétique de manioc amélioré tolérant à la CBSD (sélection végétale). Quatre (4) étudiants en maîtrise (2 en études agroalimentaire et 2 en études communautaires) dans le cadre du programme TAGDev étudient divers aspects de la chaîne de valeur du manioc dans le comté de Migori, où le manioc est une chaîne de valeur végétale établie, et un étudiant en maîtrise étudie les aspects de la biochimie du manioc pour l'amidon fermentable. Dix (10) étudiants de l'EFTP ont été recrutés pour être exposés à l'agrobusiness du manioc par le biais de formations à la production de semences propres et à l'ajout de valeur.

Mots clés : Cassava Brown Streak Virus Disease, Chaîne de valeur du manioc, Université d'Egerton, Kenya, Comté de Nakuru.

Introduction

Cassava is majorly a smallholder crop in the marginal regions of western, coastal and eastern Kenya. It is consumed in fresh and processed form as part of diet in breakfasts, lunches or dinners or as snacks. Production and consumption has, however, declined due to outbreaks of Cassava Mosaic Disease (CMD) and Cassava Brown Streak Diseases (CBSD). The CBSD viruses are spread through planting of infected cuttings and by the main insect vector, the whitefly (*Bemisia*

tabaci) (Maruthi *et al*., 2005). The disease began to spread in Uganda around 2004 (Alicai *et al*. 2007), and has since spread around the Great Lakes Region to affect eastern Uganda, western Kenya, the Lake Zone of Tanzania, Rwanda, Burundi and the DRC (Patil *et al*., 2015). Cassava Brown Streak Disease afflicts virtually all local varieties grown in western Kenya with just a few showing tolerance as low root necrosis. Mean damage to roots has been recorded at over 47% for susceptible varieties and going up to 100% in the most affected types (Masinde *et al*., 2016). Widespread utilization of cassava can relieve demand pressure on cereals in human diets, animal feeds, and some industrial products such as beer as well as enhancing resilience in the face of a changing and variable climate because of its drought tolerance. Development of the food, industrial and adaptation roles of cassava has attracted targeted interventions with the Kenya Government investing in improving production, marketing and regulations to develop the cassava industry. A national policy formulated in 2007 to foster coordinated cassava value chain development (MoA, 2007), however, is yet to be finalized and implemented but the rising demand of cassava for food, industrial products and resilience to climate change is fuelling expansion of cassava growing into non-traditional cassava growing agro-ecological zones. Nakuru County exemplifies such a non-traditional zone where cassava production and agribusiness is being promoted since the area experiences recurrent droughts and frequent maize crop failures.

In 2010-2015, a consortium of three public and private institutions (Mtakatifu Clara, Egerton University and Kenya Agricultural and Livestock Organization (KALRO) partnered to upscale cassava value chain enterprise developments in efforts to contribute to Sustainable Development Goals (SDGs 1-3, 9 and 13) on alleviating poverty and hunger, and enhancing good health and well-being, industry and innovation, and community resilience to climate change. This scaling occurred in the period farmers were searching for alternative adaptable crops to maize which was massively failing from Maize Lethal Necrosis and recurring droughts. Though the introduced cassava varieties (KMEI, Karembo, Mucericeri, Ndolo, I-96, I-94) had good yields of 10 to 20 tons per hactare, their maturity was long (18 to 24 months) yet farmers needed early maturing varieties. In stakeholder forums conducted by the three partner institutions, the barriers to further scaling of cassava agribusiness enterprises in Nakuru County were identified to include: i) long maturity periods of 18-24 months, ii) Cassava diseases -CMD and CBSD, iii) limited access to variety diversity, iv) consumption limited to fresh cassava and limited product diversity, iv) poor market linkages, and v) weak farmer institutions to support cassava value chain upgrading. This current action is building on these previous efforts to tackle the challenges impeding cassava value chain upgrading in Nakuru County. The process will involve acquisition and sharing of technological capabilities to encourage wider utilization of cassava and creation of market linkages that enable improvement of competitiveness and trade in higher value products.

Research Approach and Methodology

This project is conceptualized using the sustainable livelihoods model (Carney, 1999), which gives focus to the full economic effect of activities undertaken at the lowest economic level. It is a people centred approach that takes into account the complexity of the poor peoples' lives to promote a more holistic understanding of how they use the full suite of assets and innovations available to them, and the various structures and processes that influence the presence of these assets and innovations.

This project is anchored in fostering innovations in the cassava value chain through promoting the uptake of more adaptable and resilient varieties. The approach is also aimed at promoting value addition and creation of products and services that can attract youth to undertake cassava based agribusinesses. As a strategy, the project team is training farmers and farmer groups on the different production and processing technologies and also establishing cassava seed farms in selected farmers' fields to bulk the selected variety(ies), based on tolerance to diseases, especially

CBSD, and high yields. Considering that most of the value addition interventions may require capital input, the project is purchasing affordable processing equipment and exposing the farmers and other stakeholders to their use so that farmer groups can be encouraged to acquire them for their product development.

Farmer participatory methods are being adopted as an approach in a bid to spur productivity and transform cassava farming from subsistence to a cash economy through processed products from surplus cassava. This initiative aligns with aspiration 1 of the Africa Union Agenda 2063 for inclusive growth and sustainable development as well aspiration 6 on people driven development relying on the potential of women and youth. Locally, the action is contributing to the Kenya Government's Big4 agenda on Food and Nutrition Security.

Methodology

Baseline survey. The Baseline survey was undertaken through a reconnaissance survey and administration of a household questionnaire. During the reconnaissance survey, key stakeholders (Ministry of Agriculture officials, farmer leaders and Cassava welfare group members) in the project sites were identified and geographic locations for the actual survey mapped. A Household questionnaire was administered at farm level by the project team members and enumerators. A purposive sampling methodology with the aid of farmer leaders in the sites was used to select farmers who grew or had at some time grown cassava. A total of 105 farmers were sampled in the three project sites within Nakuru County. In each of the three Sub-counties (Njoro (Lare)), Lower Subukia (Waseges) and Rongai (Solai)), thirty-five (35) farmer households were selected and interviewed. The questionnaire tool captured information on household characteristics including gender of household heads, level of education of household heads, land tenure, involvement in cassava production, marketing and utilization.

Farmer participatory screening and selection of farmer preferred early maturing and adapted cassava varieties for the ASALs of Nakuru County. Farmer participatory collection of popular sweet cassava varieties grown in the counties of Nakuru, Busia, Migori, Machakos and Makueni counties was conducted. Additional improved cultivars were obtained from KALRO centres in Njoro, Alupe and Katumani. The CBSD resistant landrace, 'Namikonga', was to be obtained from Tanzania. However, having hit snags on plant material exchange with Tanzania, this was replaced by a Kenyan selected landrace named "Tajirika" which is a derivative of "Namikonga". In total, 27 varieties/ land races were collected and evaluated in farmers' fields in three multi-locational trials in Subukia, Rongai and Njoro Sub-counties to select the most adaptable in these Arid and Semi-Arid Lands (ASALs) areas. In each Sub-county, the germplasm was participatorily evaluated with farmers from the localities. An additional trial was located at Mtakatifu Clara Mwangaza in Njoro. Participating farmers were trained on the use of the Fukuda *et al*., (2010) cassava trait descriptors handbook to evaluate the following traits: phenology (time to maturity), root yield, root quality (cyanide content) and disease infections.

Plants were harvested 12-14 months after planting and sensory and biochemical evaluations of roots carried out to test palatability and food safety. Data on yields were collected by lifting three representative stools on each plot. The marketable weight (kg) and number of storage tubers produced per plant was determined. The weights were converted into yields in tons per hectare. Food safety/quality aspects were assessed following the sensory taste method of Fukuda *et al*. (2010) where a score of 1 = sweet and 2 = bitter using three trained tasters and also biochemically through analysis of cyanide content in the fresh root using the alkaline titration method No. 915.03B (AOAC, 1990). Cyanide content was determined from 10 grams of freshly grated cassava samples in triplicates. Dry matter (DM) content was determined using the oven dry matter content method where 2 gram samples of grated cassava were dried in an oven at 65^0C to constant weights then reweighed. The dry matter content was calculated as a percentage using the formula:

$$\% \text{ Dry matter content} = \frac{\text{Weight of dry sample}}{\text{Weight of fresh sample}} \times 100$$

Improvement of CBSD resistance in selected varieties using MAS. The landrace 'Tajirika' is being used in an accelerated breeding programme using marker assisted selection (MAS) to introgress CBSD tolerance into three selected cassava varieties. A crossing block consisting of 20 plants of each of the three targeted varieties and "Tajirika" has been planted in the KALRO field station at Marigat under irrigation. Crosses between "Tajirika" and the three selected varieties will be made to develop 3 F_1 breeding populations. From the initial crosses, SSR markers will be used to identify 100 true F_1 seedlings per population. The F_1 seedlings will be grown and used as explant sources for quick in vitro multiplication of new germplasm.

Development of high value cassava based food, feed and industrial products for improved food, nutrition and household incomes. Attributes essential for processing food, feed and beer products in selected adaptable cassava varieties will be determined through laboratory analyses with food, feed and brewery industry partners. For food and feed products, preliminary analyses have been conducted on the food safety and basic nutritional qualities of all the cassava varieties to select those with high dry matter content for further analyses of starch quality. Varieties with low cyanide and high dry matter and starch content will be selected for use in product development. The products to be developed include fortified cassava based biscuits; prosopis and acacia enriched cassava based animal feed formulations; and cassava based beer.

Capacity building in cassava breeding, food science and agribusiness. In each of the sub-counties, individual cassava farmers and those organized into registered producer groups were engaged. Farmer trainings on cassava production and value chain issues were conducted and visits to the established farmer trial fields made. TVET students at Baraka Agricultural College (BAC) were recruited and briefed on the project. PhD and MSc students are being engaged to carry out research in the various aspects of development in the project.

Knowledge sharing on cassava and cassava based products for value chain upgrading. Two stakeholders' consultative meetings are envisaged where project results will be shared and recommendations for quality standards for cassava based food and feed products developed in this project discussed. The stakeholders will include cassava farmers, traders, County Executive Committee (CEC), Members of Agriculture, Marketing, Trade and Industry players from the cassava growing Counties, Kenya Plant Health Inspectorate Services (KEPHIS), Kenya Agricultural and Livestock Research Organization (KALRO), Horticultural Development Authority (HDA), Kenya Bureau of Standard (KEBS), and the private sector: East African Breweries and animal feeds millers.

Results and Discussion

Farmer and household characteristics. Table 1 presents the disaggregated data by sub-county of the household characteristics. Agriculture is the predominant economic activity in the three Sub-counties. All the sampled households in Njoro reported farming to be their primary occupation. Almost 89% of respondents in Rongai and 90% in Subukia indicated that farming was their main economic activity. A small percentage, 5% of households in Rongai and 3% in Subukia indicated non-farm casual work to be their primary occupation.

From the total number of sampled households, 78% were male-headed and the rest female-headed. The majority of household heads (60%) interviewed had primary level of education while 24% had attained secondary education. Twelve percent (12%) of respondent household heads had no formal education. This finding indicates that while the majority of farmers had basic literacy skills, there is a need to communicate in the local or national language during training in order to reach out to all the farmers.

The average age of the household heads was 60 years, indicating the generally advanced ages of

Kenyan farmers. Households in Rongai had relatively higher numbers (6) of dependents compared to those in Njoro that registered the least number of dependents. On average, households in Njoro and Rongai had 4 and 5 dependents, respectively. This means that households in Rongai and Subukia areas were more likely to suffer from food insecurity than Njoro, owing to their large numbers of dependents.

Table 1. Household head characteristics in three Sub-Counties of Nakuru county

Variable		Njoro	Rongai	Subukia	Chi-Square value
Gender	Male	84.85	74.29	75.00	1.35
	Female	15.15	25.71	25.00	
Education	Illiterate	15.63	11.43	9.38	6.66
	Primary	71.88	54.29	53.13	
	Secondary	9.38	28.57	34.38	
	Post-Secondary	3.13	5.71	3.13	
Occupation	Farming	100.00	88.57	90.63	7.09
	Casual - Farm	0.00	2.86	3.13	
	Casual – Non-farm	0.00	5.71	3.13	
	Formal employment	0.00	2.86	3.13	

Cassava acreage and ranking. The majority of farmers in the project area grew cassava on relatively small plots. Farmers in Njoro Sub-county allocated the smallest size of land to cassava production despite owning larger parcels of land among the three Sub-counties. On average, farmers in Njoro allocate about 0.23 acres of land to cassava production compared to averages of 0.3 and 0.5 acres in Subukia and Rongai Sub-counties, respectively. In terms of production, Rongai farmers harvested an average of six bags of cassava annually, while Njoro and Subukia sub-counties harvested two and three bags respectively.

Overall, cassava was ranked the second most important crop after maize in the three target sites. Approximately 7% of the sampled farmers in the three Sub-counties ranked cassava as the first most important crop, while 14% grew it majorly for subsistence and 86% grew the crop for both subsistence and commercial reasons. This observation indicates that cassava is emerging as an important root crop in Nakuru County.

Table 2. Allocation of land resource to cassava and production levels in three Sub-counties of Nakuru county

Sub-county	Average Land size (Ha)	Output (bags)
Njoro	0.23	2.60
Rongai	0.49	5.92
Subukia	0.31	3.90

Cassava varietal characteristics. The highest ranked desirable cassava variety characteristic was high yield potential followed by early maturity. Other high ranking characteristics included good ugali (Cassava milled food) properties, good milling properties and drought tolerance. Thus selection of high yielding and high dry matter content will therefore be important. Late maturity and susceptibility to pests and diseases were the most undesirable variety characteristics identified by farmers. These undesirable characteristics affirm the project's objective of breeding varieties with improved disease resistance and early maturity.

Cassava production and management. Access to appropriate and clean planting materials is critical for improved cassava productivity. Results obtained from this baseline study showed that a majority (44%) of farmers use cassava planting materials obtained from neighbours while 27% recycle their own cassava propagation material. Nineteen percent (19%) got planting materials distributed by NGOs. On disease management, the Cassava Mosaic and CBSD were identified as the most important diseases by 49% and 10% of the respondants in Njoro and Subukia, respectively. However, the majority of farmers (76%) did not take any disease control measures, while 16% used other alternative disease control measures. Whereas 6% of the farmers controlled diseases using pesticides, about 2% indicated that the cassava varieties they planted were resistant to diseases.

Concerning access to information on disease control and management, farmers indicated obtaining it from different sources. Forty-eight percent, 27%, and 21% of respondents indicated that they received information on disease management and control from fellow farmers, public extension officers, and NGOs, respectively. This observation affirms that farmer-farmer exchanges are an important channel through which agricultural information can be channeled. Hence the need to convey the right and accurate information to the original recipients.

On harvesting methods, 88% of farmers indicated that they practiced piecemeal harvesting as the need for consumption or sale arose. About 7% of farmers indicated that they did a one-off harvest, while a small minority (4%) combined the two harvesting methods depending on the occasion and need. This practice largely depends on the utilization intended for the harvested cassava.

Selling form of cassava. Cassava in the three sub-counties is mostly sold as fresh roots. Approximately 81% of the farmers sold cassava as fresh roots. Farmers selling cassava as fresh roots sold about 78% of the marketed output as fresh roots (Table 3). Milled flour the second most important form in which cassava was sold by farmers. Approximately 7% of farmers sold cassava as milled flour o. An equal number of farmers, about 6% sold cassava as dried whole roots and dried chips, respectively. Overall, about 32% and 20% of the marketed cassava was sold as dried chips and whole roots, respectively. This indicates the low level of cassava value addition and therefore very low product diversity in Nakuru County.

Table 3. Proportion of farmers and selling form of cassava produce in Nakuru County

Form	Farmers (%)	Proportion sold (%)
Whole fresh roots	81.43	78.07
Dried whole roots	5.71	20.00
Dried chips	5.71	32.00
Milled Flour	7.15	42.00

Cassava utilization and value addition. Among utilization modes for cassava, farmers ranked boiling, deep frying and roasting as the three most popular methods of utilization of cassava. At least 83% of the farmers indicated that they boiled cassava for consumption. Deep frying and drying was done by 7% and 1% of farmers, respectively. Other important value addition practices practiced by a minority of farmers included chipping and drying, and milling. These results reveal a capacity gap in cassava utilization and value addition options and calls for efforts towards enhancing the capacities of farmers to diversify products from cassava.

Germplasm screening at Solai site

A total of 27 varieties were evaluated at the Solai site of whivh 21 varieties were ready for harvesting at 12 and 14 months (Table 4). Six varieties (MM96/7680, MM96/2480, MM98/0011, MH98/0185, MM96/0013, and MM98/3567) poorly performed at this site and data were not collected from them. At the time of harvest plants from these varieties had not grown to produce stools that could be harvested. Overall, there were significant variations in the yield potential of the varieties, with yields ranging from 6.9 – 36.47 tons/ha (Table 4). The overall yields for the varieties is low at the Solai site owing to the poor soil conditions and frequent transient droughts which subjected the crop to stress. However, this is still an improvement on the productivity at this site since the farmer's maize crop for the production year failed but the cassava crop yielded up to 36 tons/ha. In terms of ranking by yield the best performing five varieties in this site were Okonyo welo, Nyar AICAD, Obaro dak, Madam and MM99/0072. The first four of these are selections and landraces obtained from Migori County while MM99/0072 is an improved variety from KALRO-Njoro.

Significant variations were also observed in the cyanide assessment both biochemically and with the sensory method. Overall, the biochemical cyanide content was relatively high compared to the safe allowable level of 10mg/100g HCN. The varieties assessed ranged from 18 – 34 mg/100g HCN. However, the sensory evaluation in the field indicated that a majority of the varieties were safe as they scored 1. Despite the high levels of the biochemical cyanide detection compared to the 10mg/100g safe limit, the levels can considerably be brought down by cooking and other forms of processing such as boiling, drying and fermenting.

Dry matter content of cassava genotypes varied from one accession to another, generally ranging between 20% and 40% as previously reported by Barima *et al*., (2000); values above 30% are considered high. The cassava varieties grown in the Solai environment generally produced high levels of dry matter, ranging between 26.58 and 54.95%. The highest DM content was recorded in variety MM99/4884 (54.95%). One of the top varieties for yield (Madam) also had comparably high DM content. Most of the observed values in this study are above those reported by Braima *et al*. (2000). The DM of cassava roots is an important trait for acceptance of cassava by processors and consumers who boil or process the product. Preparation of cassava products such as flour, pulp, starch, chips, pellets etc. depend on DM content. Therefore, selection of cultivars with high DM content is paramount for product development.

Improvement of CBSD resistance in selected varieties using MAS. Cassava Brown Streak Disease remains a challenge in cassava production in the region. In this project, a breeding programme was designed to introgress CBSD tolerance/ resistance into three selected cassava varieties from the three sites. A source of resistance, "Tajirika", was identified at the KALRO-Mtwapa station and has been planted in a crossing block at Marigat research station. Reciprocal crosses will be made between "Tajirika" and the best three selected varieties from the three trial sites.

Table 4. Yield, cyanide content and dry matter content of 21 cassava varieties grown in solai Sub-county

Variety	Mean yield (tons/ha)	Mean HCN concentration (mg/100g)	Mean cyanide score (sensory)	Dry matter content (%)	Maturity period (months)
Mabul	17.88	29.88	1	43.76	12
Oduwo	17.93	24.12	2	50.76	12
MM99/0072	25.68	21.24	1	52.1	14
Masisa	19.00	26.64	1.3	38.2	12
Adhiambo lera	15.62	18.72	1	29.27	12
Migyera	6.90	24.12	1	46.34	12
Olomba	19.10	31.32	2	44.55	>14
Rao Onyoni	19.13	24.48	1	47.43	>14
Nyatanga	19.58	31.68	1	41.6	12
MM99/4884	19.20	32.4	1	54.95	12
MM96/1871	22.17	25.92	1.3	45.75	12
MM99/0067	8.82	32.04	2	37.1	12
Karembo	25.08	37.8	2	54	12
Obaro dak	27.17	29.88	1	42.17	12
Nyar maseno	21.98	34.2	2	26.58	12
Madam	26.50	25.56	1	54.27	10
Selele rabuor	16.02	36	2	40.95	12
Okonyo welo	36.47	29.88	1	43.42	12
KME-1	27.23	16.92	1.3	37.47	>14
Nyar AICAD	29.83	34.2	1	41.41	12
Nyar JICA	20.87	32.76	2	48.87	12

Development of high value cassava based food, feed and industrial products. Cassava is a priority crop in ASALs where child malnutrition is prevalent. In this study, cassava varieties with high yields and dry matter content are being characterized for starch quality with the ultimate aim of using them to develop nutrient fortified biscuits as snacks for children in the target areas. Additionally, farming communities will be trained on preparation of new food products from cassava to expand the utilization of the crop in the project localities. For animal nutrition improvement and to reduce dependence on expensive grains for manufacture of animal feeds, this project is developing a new animal feed formulation with cassava as the energy base to replace cereal grains. Innovation in terms of nutrient fortification in the feed product will be through the incorporation of Prosopis and Acacia pods as protein sources. Production of ethanol for eventual cassava beer making will also be explored in the project in conjunction with an industrial partner, East African Breweries Ltd.

Capacity building

Three farmer training sessions on cassava production were held in the sub-counties. In Njoro sub-county, 47 cassava farmers attended the first training. Additionally, the Mt. Saint Clara Centre received funding from the project to conduct flagging of cassava opportunities sessions with the farmers on a continued basis. In Solai a total of 92 farmers attended the cassava production

training. These farmers have expressed interest in the crop and have continued to visit the three trial sites set up in Rongai sub-county. In the Subukia site 31 farmers attended the first training; an additional training attended by 21 and 17 farmers in Subukia and Rongai, respectively, was held on request by the farmer leaders. An organized and registered farmer cooperative (Subukia Cassava Farmers' Cooperative Society Ltd) has been identified for project upscaling of cassava processing technologies and product marketing.

The project recruited two PhD students to work on food product development and crop improvement, respectively. So far the PhD in food science student is characterizing cassava for food safety and product development quality. Work on assessment of cyanide content in leaves and roots has been undertaken. The plant breeding student has established crossing blocks and is proceeding with crossing work. Four Masters students, two in community studies and two in agribusiness, are in the tail end of writing and defending their thesis on various aspects of the cassava value chain. Ten (10) TVET students were recruited at Baraka Agricultural College (BAC) and briefed on the project. They will be trained on cassava agribusiness and production of food and feed products.

Conclusion

Research. Preliminary assessments through the adaptation trials has revealed great variation in the response of the cassava varieties introduced. At least five varieties appeared suitable for production in the Solai site based on yield, cyanide levels and dry matter content. Master student's research projects on the various aspects of the cassava value chain will further inform on the gender involvement aspect, cassava technologies and the application of various agribusiness models for sustainability of the cassava value chain.

Impact. In this project, a community participatory approach linking research and production with industry is being adopted for strong market linkages and inclusive business growth among women, youth and rural cassava producers. The model aims at creating inter-dependence between production and utilization of raw materials for domestic and targeted industrial uses. The new dimensions of cassava for feed and brewery applications targets opening up of new product demand pathways. East Africa Breweries Limited (EABL), a private brewery, is exploring the possibility of substituting barley with cassava in its brewing, hence increasing sustained demand for cassava. Cassava is also a cheap substitute for cereals in feed production and can add to the sustained demand for cassava. Capacity building in variety development and adaptation, good agricultural and entrepreneurial skills provided to cassava value chain actors will enhance sustainability of cassava enterprises. This project is therefore expected to profit smallholder farmers through employment creation, food and nutrition security and business opportunities.

An array of impacts are expected from the project actions. In the first instance, mainstreaming cassava production through development of well adapted varieties for the proposed areas will contribute to an improved food and nutrition security situation in the areas. Cassava value chain upgrading in the proposed areas through diversification of products will spur small business growth. These business outlets around cassava will in turn bring about increase in farm incomes from cassava based products. Overall, the upgrading of the cassava value chain in Nakuru County will contribute to building a more resilient agricultural value chain through adoption of a drought resilient crop. This will help build resilience to the bigger effects of climatic variations on crop production and food security in the region.

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