SASHA Sweetpotato Action for Security and Health in Africa

# **Rice-sweetpotato rotation system:** Improving rice yields and profitability while providing sweetpotato planting material and food in irrigated rice schemes in northern Uganda

AUG 2018

**After three seasons, the overall results for the sweetpotato-rice rotation show that average root yields in the rotation treatment were significantly higher (average yield= 28 t $ha^{-1}$) than in the control (average yield= 19.8 t $ha^{-1}$). Paddy yield of rice grown after sweetpotato was also significantly higher than the control (p=0.001) where rice followed rice. The rice yield gain due to the rotation ranged from 35% to 8% above the control. This shows that yields of rice and sweetpotato can be enhanced by rotating rice and sweetpotato as opposed to continuous mono-cropping of either crop. Results also show that the revenue to cost ratio[1] for both rotation and mono-cropping is greater than 1 (i.e., 2.15 for rotation and 1.72 for mono-cropping) which indicates that both approaches are generating revenue more than the cost of production, but the rotation generates more revenue compared to mono-cropping, higher by 0.43. The rotation ensures: a) profitable utilization of land because sweetpotato roots and vines can be sold for income; b) farmers can have sweetpotato cuttings to plant at the beginning of the upland growing season, and c) fields are easier to manage for the next rice crop, thereby reducing costs of land preparation.**

CIP INTERNATIONAL POTATO CENTER A CGIAR RESEARCH CENTER

NaCRRI NATIONAL CROPS RESOURCES RESEARCH INSTITUTE

BioCROPS QUALITY PRODUCTS THROUGH BIO-INNOVATIONS

CGIAR RESEARCH PROGRAM ON Roots, Tubers and Bananas

**Fig 1.** Seed entrepreneurs Nyeko Ponsiano (left) and Robinson Caogura (right) show off Kabode roots and vines after harvesting the rice-sweetpotato rotation experiment in Agoro rice scheme (Credit G. Kyalo)

## What is the problem?

In northern Uganda, rice farmers in the irrigation schemes and rainfed lowland production systems plant rice once a year during the first season. The land is then left fallow until the next year's planting season. During the fallow period, the fields are used for grazing animals resulting in hard pans which make land preparation for next season of rice production tedious.

At the same time the prolonged dry season, from December to March, affects availability of quality sweetpotato planting material, as most plants dry out. As a result, farmers plant late, leading to poor yields and sometimes extended hunger periods due to delayed availability of food. Farmers are forced to purchase vines for planting from as far as east and central Uganda, 550-700 km away, during the first season of the year.

Partners:

- National Crops Resources Research Institute (NaCRRI), Uganda
- BioCrops (U) Ltd.
- Tute Laco Laco farmer Group- Agoro
- Agoro Self-help irrigation scheme management

[1] Revenue to cost ratio estimated from dividing total revenue by total production costs.

These challenges also created an opportunity as some of the rice growing areas are in irrigation schemes or low-lying valley bottoms, which are suitable for sweetpotato vine and root production during the fallow period. However, rice-sweetpotato rotation is not a common practice among rice farmers in Uganda, and its benefits have not been properly researched and documented.

## What did we want to achieve?

Research on the sweetpotato-rice rotation aimed to:

(i) investigate the influence of sweetpotato-rice seed crop rotation on the purity of the rice seed[2] and pest and disease prevalence;
(ii) assess the influence of crop rotation on rice seed and sweetpotato vine and root yield;
(iii) evaluate the cost-benefit of the different rotation options (sweetpotato-rice, rice-rice, sweetpotato-sweetpotato) to provide basic "seed" (cuttings) in a timely manner to decentralized multipliers in the sweetpotato seed value chain and introduce seed of newly released rice varieties to farmers in and around the scheme.

## Where are we working and with whom?

The Agoro Irrigation Scheme is in Lamwo district in northern Uganda. The International Potato Center (CIP) is working with the Cereals Program of the National Crops Resources Research Institute (NaCRRI) of the National Agricultural Research Organization (NARO), the Tute Laco Laco farmer group of Agoro and the Agoro Self-help Irrigation scheme management.

## How have we made it happen?

We set up rice-sweetpotato seed rotation validation trials from December 2015 through October 2017 (Table 1). The trials aimed at testing the rice-sweetpotato-rice, sweetpotato-rice–sweetpotato, rice-rice-rice, and sweetpotato-sweetpotato-sweetpotato treatments using Randomised Complete Block Design (RCBD) with four replicates. Disease-free ("clean") sweetpotato cuttings of three varieties: Ejumula (orange-fleshed), NASPOT 10 O (also known as Kabode, orange-fleshed) and NASPOT 11 (cream-fleshed) were sourced from BioCrops Uganda Ltd. Three rice varieties (New WITA 9, Komboka and Agoro) from NaCRRI were used for the study. The crop was gravity-flow irrigated twice a week for 30-60 minutes during dry periods. The rotation crop was planted immediately after each harvest. Data were collected on incidence and severity of diseases, pest infestation, plant vigour, sweetpotato root and vine weight at harvest, number of productive tillers for rice, rice grain yield and rice biomass dry weight at harvest. Financial data on cost of inputs, labour wages, outputs and market prices were also collected to assess the revenue to cost ratios of the sweetpotato-rice rotation compared to mono-cropping each crop.

## What have we achieved?

Overall results for the sweetpotato-rice rotation show that rotating sweetpotato with rice had a significant effect on sweetpotato root yield but not vine yield. Average root yields in the rotation treatment were significantly higher (average yield= 28 t ha$^{-1}$) than in the control (average yield= 19.8 t ha$^{-1}$) (Fig 2). The variety Ejumula yielded significantly higher (average yield= 29.4 t ha$^{-1}$) compared to the other two sweetpotato varieties (data not shown). The higher yields in the rotation

**Table 1:** Rice (R) - Sweetpotato (SP) rotation cycles 2015-2017

| Season | Month-Yr Planted | Month-Yr harvested | Rotation | | | | Planting Cycle |
|---|---|---|---|---|---|---|---|
| | | | Block 1 | Block 2 | Block 3 | Block 4 | |
| 2nd 2015 | Dec-15 | May-16 | SP | R | R | SP | 1 |
| 1st 2016 | 20-May-16 | 24-Oct-16 | R | SP | R | SP | 2 |
| 2nd 2016 | 2-Nov-16 | 15-Apr-17 | SP | R | R | SP | 3 |
| 1st 2017 | 17-May-17 | 27-Oct-17 | R | SP | R | SP | 4 |

[2] If there is no break crop, volunteer rice seed from the previous crop will mix into the current crop.

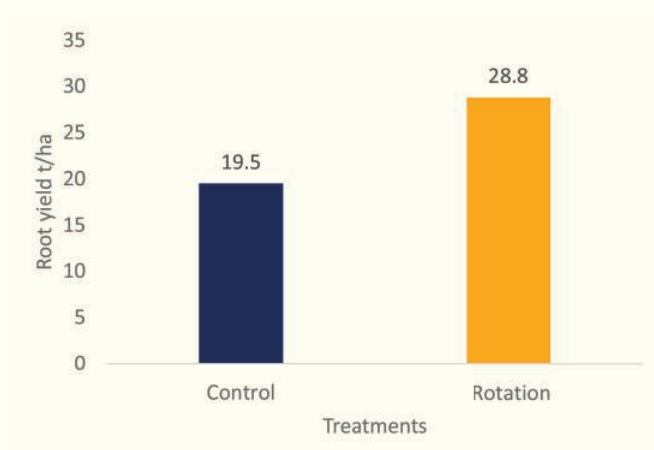


**Fig 2.** Sweetpotato root yield in rotation with rice over three seasons

experiment may have been due to the residual left from fertilizers applied to rice in the previous season. Vine yields were not significantly different across treatments and varieties but significantly different across seasons (Fig 3). This could be because of weather variations across seasons as 2016B experienced a prolonged drought compared to the rest of the seasons.

The incidence of *Alternaria blight* was low and not significantly different across treatments and varieties. *Alternaria blight* is more prevalent in high altitudes, hence it is not a major problem in the Agoro rice scheme where the experiment was set up. The incidence of sweet potato virus disease (SPVD) was not significantly different across treatments, but it differed significantly across seasons. It is worth noting that the original clean planting material sourced from Biocrops were recycled over four seasons. As a result, the incidence of SPVD kept building from season 1 to season 4. However, the highest incidence reported in season 4 was an average score of 3.7 out of a maximum score of 9 (severe virus), which is still low. Generally, northern Uganda is considered a low SPVD pressure zone, hence the slow buildup of SPVD over a period of four seasons. Nevertheless, the continuous buildup of the disease still implies that planting material must be replaced with clean material after about three seasons of recycling. Weevil infestation was generally low and not significant across treatments and varieties, but significant across seasons.


**Fig 3.** Sweetpotato biomass yield after 3 rotations by variety with rice in the Agoro rice scheme, Northern Uganda

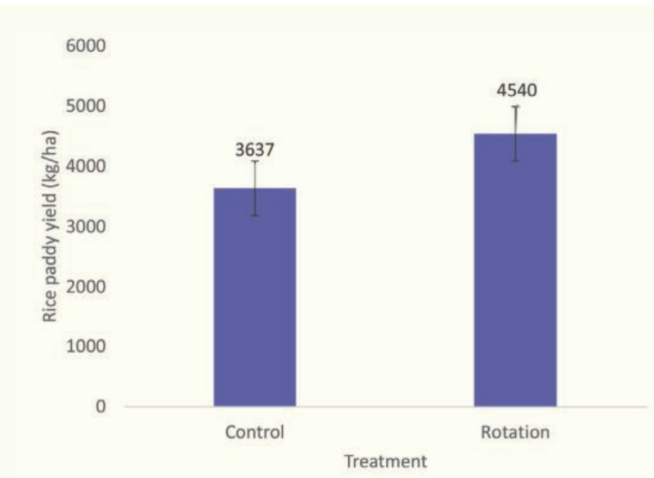


**Fig 4:** Paddy rice yield (kg/ha) for three rice varieties in rotation with sweetpotato over 3 seasons

Paddy yield of rice grown after sweetpotato was significantly higher than the control (P=0.001) where rice followed rice (Fig 4). There was also a significant difference (P <.001) in yield performance between the three rice varieties. The highest yield gain due to the rotation was recorded in WITA-9 at 35% above the control, followed by Komboka at 29%, then Agoro at only 8% above the control. This shows that the yield of rice can also be enhanced by rotating rice and sweetpotato as opposed to continuous rice mono-cropping, but choice of variety matters.

Results from the economic analysis found a statistically significant and positive difference in the mean revenue to cost ratio between rotation and control. Results show that the revenue to cost ratio for both rotation and mono-cropping is greater than 1 (i.e., 2.15 for rotation and

1.72 for mono-cropping) which indicates that both approaches are generating revenue more than the cost of production, but the rotation (treatment) generates more revenue compared to mono-cropping (control), higher by 0.43. The ratio for the two crops varied by season and variety (Fig 5). The overall impact on the ratio using rotation is significant and positive for both sweetpotato and rice. This indicates that sweetpotato and rice can be rotated with each other to improve revenue to cost.

One reason for the higher revenue to cost ratio in the rotation is due to reduced labour cost for land preparation when rice is planted after rotating with sweetpotato. Hung et al. (2005) attributed the higher yields in rotation to a higher nitrogen fertilizer-use efficiency of rice (29%) following sweetpotato as compared to a low nitrogen fertilizer use efficiency of (19%) for rice following another rice crop. The decomposition of sweetpotato residues post-harvest could also increase soil nitrogen content and potentially improve the soil physical properties which could benefit the following rice crop. However, dry season planting requires good management for control of sweetpotato weevil.

Four tons of rice foundation seed of Komboka, Wita 9 and Agoro was produced (Fig 6) and shared by participating farmers from the local community of Agoro.

The results of the sweetpotato-rice rotation study were shared at a seminar organized by the Cereals Program of NaCRRI and was attended by major players in the rice and sweetpotato industry. Sweetpotato-rice rotation is a promising technology which is already being taken up by farmers around the Agoro rice scheme. The rotation ensures: a) profitable utilization of land because sweetpotato roots and vines can be sold for income; b) farmers can have vines to plant at the beginning of the planting season, and c) fields are easy to manage for the next rice crop thereby reducing costs of land preparation.

**Fig 6.** Photo Simon Alibu and Ekobu Moses (NacRRI) record data in the rice plots of the Rice-sweetpotato rotation experiment (Credit J. Ekebu)

## What next?

The sweetpotato-rice rotation has demonstrated improved yields for both rice and sweetpotato, and improved availability of sweetpotato planting material for the upland growing season. It is therefore ready to be scaled out to other irrigation schemes in Uganda and other countries in Africa. We are seeking collaboration and scaling out of the rice-sweetpotato rotation technology.

We are developing fact sheets about sweetpotato-rice rotation systems that will be disseminated to wider audiences soon.

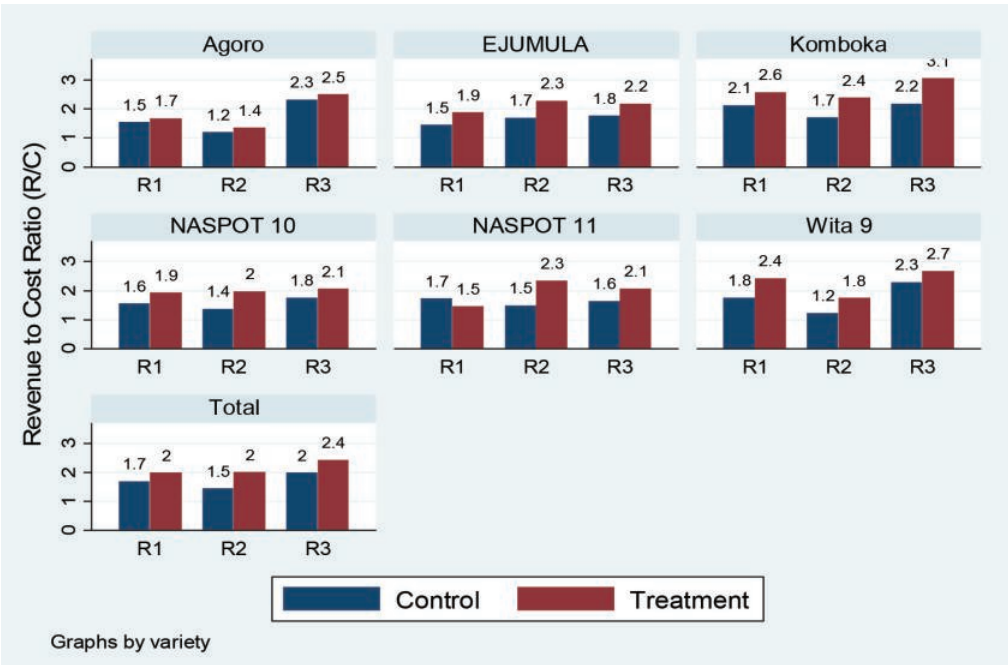


**Fig 5.** Revenue to cost ratio of three sweetpotato (Ejumula, NASPOT 10 O, NASPOT 11) and 3 rice varieties (Agoro, Komboka, Wita) and overall revenue to cost ratio from both crops over three seasons comparing rotation (Treatment) to mono-cropping (Control) in the Agoro Rice scheme.

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