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Photo credit: Wills Munthali/ICRISAT.

Sorghum-pigeon pea intercrop (1:2 planting pattern) for enhancing resilience in the semi-arid ecologies of Central Tanzania

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The Problem

Farmers in semi-arid regions of Central Tanzania face critical food shortages emanating from erratic rainfall resulting in crop failure. Over 60% of farmers in the region practice cereal-legume intercropping. Intercropped pigeon pea accounts for 70% of the total pigeon pea area. The local and long-duration varieties for sorghum and pigeon pea in these intercrops and the planting patterns used do not provide sufficient returns on investment. The new varieties available and good agricultural practices are key to ensuring food security in these semi-arid ecologies.

Description of the Technology

Intercropping is the growing of two or more crops on the same piece of land at the same time. There are many forms of intercropping, in patterns and crop combinations. Crops selected for intercropping often have different abilities to use the resources available for growth, leading to better yield advantages than sole crops. Pigeon pea (*Cajanus cajan* L.) and sorghum (*Sorghum bicolor* L. Moench) intercropping is a common practice in the semi-arid regions of Dodoma and Manyara. The alternate planting pattern (one row of medium duration pigeon pea (Ilonga-14-M2) followed by two rows of medium duration sorghum (IESV 23010) fits best in these sub-ecologies with optimal benefits.

Key Messages

Environment: At least **45%** reduction in soil erosion compared to the respective sole crop practice.

Soil health: N fixation by PIGEON PEA up to **88 kg** N/ha per season leading to soil fertility improvement.

Productivity: The **intercrop** had more than **20%** yield advantage per unit area compared to the normal practice.

Economic: **> 50%** gross margins over farmer practice translating to income generation by farmers.

Nutrition:
100 g SORGHUM GRAIN contains 329 Kcal, 11 g PROTEIN; while 100 grams PIGEON PEA dry seeds contain 343 CALORIES, and 21.7 g PROTEIN, 456 µg FOLATES, thus this will give more than

28% of the CALORIES and

58% PROTEIN required by a household family compared to normal practice.

Potential benefits to users

Productivity: Based on our evaluations, intercropping IESV 23010 and Ilonga M2 at an alternate pattern gave Land Equivalent Ratios (LER) > 1.2 (Table 1). The combined yields for these improved varieties gave higher yields than landraces in the intercrops. IESV 23010, a new sorghum variety in the intercrop with pigeon pea, yields up to 4200 kg/ha. It is tolerant to diseases of economic importance such as Gray leaf spot *Cercospora zea-maydis*), rust *Puccinia* spp), anthracnose, downy mildew, powdery mildew, and head smut. Ilonga M2, the newly introduced pigeon pea variety, has a potential yield of up to 2,000 kg/ha, representing a 70% yield advantage over local checks. It is tolerant to fusarium wilt (*Fusarium udum*), a soilborne pathogen. Combining the two varieties in a 1:2 planting pattern gives better returns than the farmers' practice. The sorghum and pigeon pea intercrop can reduce soil erosion by 45 %.

Economic: Intercropping IESV 23010 and Ilonga-14- M2 has >50% gross margin compared to the farmer practice (local sorghum (Lugugu) + long duration pigeon pea), US$462.58 and 241.87 per hectare, respectively (Table 1).

Food and nutrition security: Sorghum and pigeon pea are chief sources of calories in the dryland ecologies of Central Tanzania. Sorghum grains are nutritionally rich, whereby 100 g grain contains 329 Kcal, 10.62 g protein, 3.46 g fat, 72 g carbohydrate, 1.43 g ash, and 6.7 g fiber. When consumed, pigeon pea grain provides a rich source of dietary protein (21.7 g), energy (343 Kcal), micronutrients (calcium, iron, magnesium, phosphorus, and potassium), dietary fiber (15 g), and vitamins. The farming families that grow sorghum and pigeon pea will have more access to crop-based nutrients, having more than 40% energy, 58% protein, and 45% dietary fiber of recommended daily values to a family in a household.

Soil fertility: Ilonga-14-M2 leaf fall, when incorporated in the soil, can add up to 40 kg of nitrogen per hectare. The variety can also mobilize phosphorus from the soil and make it available to subsequent crops, together with other deeply leached nutrients. It meets a good proportion of its N-requirement through biological N-fixation. It is a good crop to be intercropped with any cereal as it provides minimum nutrient competition.

Conditions that favor uptake

Agroecological conditions: The sorghum and pigeon pea intercrop thrives under dry and fragile ecological conditions where producing other crops and most cropping systems is difficult. The intercrop can easily be grown on soils characterized by low nitrogen. Both crops are well adapted to drought and high temperatures. It is well adapted to semi-arid agroecologies (average annual rainfall of 200–700 mm) since it can access water from deep in the soil profile. There is minimal competition for nutrients, especially N, for the two crops as pigeon pea can meet a good amount of its N-requirement through biological Nitrogen fixation and its ability to extract Iron-bound phosphorus.

Table 1. Land Equivalent ratio and gross margins for improved intercrop system vs farmers' practice: 2020–21 season, source: Africa RISING ESA Technical report, Sept 2021.

Treatment	IESV 23010 grain yield (kg/ha)	Ilonga M2 grain yield (kg/ha)	Land Equivalent Ratio (LER)	IESV 23010 Gross Margin (USD/ha)	Ilonga M2 Gross Margin (USD/ha)	Combined GM (Improved vs Farmer practice
Improved: IESV 23010 + Ilonga M2-alternate	1009.26	648	1.27	239.78	222.8	462.58
Pure stands	1376.63	1200		285.79	375.5	
	Local sorghum grain yield (kg/ha)	**Local pigeon pea grain yield (kg/ha)**	**Land Equivalent Ratio (LER)**	**Local sorghum Gross Margin (USD/ha)**	**Local pigeon pea Gross Margin (USD/ha)**	
Farmer practice: Local sorghum + Local pigeon pea	472.22	552	1.4	78.67	163.2	241.87
Pure stands	513.89	963		27.17	141.8	

Plate 1: Pod borer (*Helicoverpa*).

Alignment with household resource endowments

This technology is versatile with minimal resource requirements and thus can be implemented by households with low to high resource endowments. Farm productivity is enhanced by using associated farming inputs. However, poor farmers with limited access to mineral fertilizers can still benefit from this technology from the nutrients achieved via biological nitrogen fixation (BNF). The households would benefit from the crop residue as fodder after harvest, though crop–livestock conflict might occur, particularly between those with and without livestock.

Necessary ingredients for implementation

Land preparation:

- Plow land early, preferably immediately after harvesting. This gives enough time for crop residues to decompose and break the disease cycle.
- Harrow the field if it has big soil clods to facilitate easy planting of the small-size sorghum seeds.

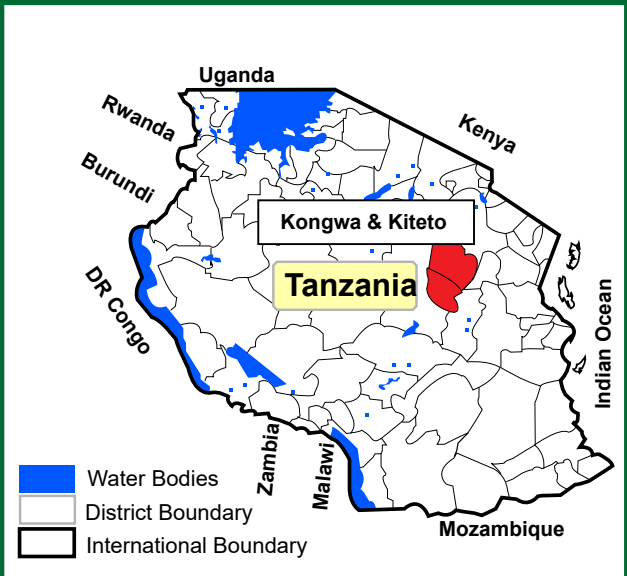
Planting and intercropping:

- Drill seed in furrows or plant in hills following a 1:2 inter-cropping pattern, i.e., 1 row of improved pigeon pea (Ilonga M2) alternated with 2 rows of improved sorghum IESV 23010.
- A seed rate of 7–10 kg/ha (3–4 kg/acre) is recommended for IESV 23010, and dry planting depth should be 5.0 cm, while for moist soils is 2.5–4.0 cm.

Locations where the technology was validated

Studies were conducted in the semi-arid regions of central Tanzania in Dodoma, Manyara, and Iringa. On-station trials were done at the Tanzania Agricultural Research Institute, Hombolo (TARI-Hombolo), with on-farm evaluations undertaken in the districts of Kongwa (Mlali, Moleti, Laikala, and Chitego villages); Kiteto (Njoro and Kiperesa villages) and Iringa (Igula village). Trials were conducted between 2016 and 2020 to assess the adaptability and suitability of the technology to these environments and cropping systems through on-farm testing, participatory variety selection, and demonstration plots.

Kongwa district lies 1120 masl and has an average yearly rainfall of 556 mm and average temperature of 28 °C. Kiteto district lies 1087 masl. It has weather conditions varying from semi-arid to sub-humid, with an average annual precipitation of 682 mm and average temperature of 19.5 °C.



- The intra- and inter-row spacing of sorghum in the intercrop should be 25 cm and 100 cm, respectively; while that for pigeon pea is 50 cm and 100 cm, respectively.

Crop and pest management

- The sorghum crop needs fertilization with NPK fertilizer (20:20:20) at planting at 100 kg/ ha and top-dressing with calcium nitrate at the same rate.
- Where organic manure is available, application of 10 t/ha of organic matter at plowing is recommended or 45 kg NPK/ha in combination with 2 tons of cow manure/ha
- Fertilizer is not applied to the pigeon pea crop since it can extract minerals from deeper soil zones and make its nitrogen through biological N-fixation.
- The first weeding should be done within two to three weeks after emergence. Common insect pests include the shootfly and stem borer; therefore, Marshall or Dipterex insecticide should be used at 3 kg/ha.
- Pests (pod borers (Lepidoptera), pod-sucking bugs (Hemiptera), and seed-feeding pests (Diptera and Hymenoptera) are among the key constraints facing pigeon pea production
- Pesticide application must be done at the peak time (90–100 days after planting) when the pods are developing.
- Two or three systemic pesticide applications (based on the pest load, e.g., a pyrethroid such as cypermethrin) are effective.

Adaptation possibility

Other crops: Sorghum can be intercropped with other legumes such as groundnut adapted in the same agroecology. Similarly, pigeon pea can be intercropped with other cereals such as drought-tolerant maize in the same agroecology.

Things to worry about

Use of fertilizer: Most farmers in dry ecologies do not invest much in inorganic fertilizers due to fear of losses associated with the frequent drought occurrences. As such, sorghum yield will be low since fertilizer is critical for its growth and development.

Livestock damage: Once sorghum is harvested, the pigeon pea is left as the only crop on most farms and is prone to livestock damage as they feed. This would translate to irreversible losses.

Increased labor: Since pigeon pea is left in the field after harvesting sorghum, extra labor is needed to control livestock damage for at least two months.

The Africa Research In Sustainable Intensification for the Next Generation (Africa RISING) program comprises three research-for-development projects supported by the United States Agency for International Development as part of the U.S. government's Feed the Future initiative. Through action research and development partnerships, Africa RISING will create opportunities for smallholder farm households to move out of hunger and poverty through sustainably intensified farming systems that improve food, nutrition, and income security, particularly for women and children, and conserve or enhance the natural resource base. The three projects are led by the International Institute of Tropical Agriculture (in West Africa and East and Southern Africa) and the International Livestock Research Institute (in the Ethiopian Highlands). The International Food Policy Research Institute leads an associated project on monitoring, evaluation, and impact assessment.

Africa RISING website: **https://africa-rising.net**