Photo credit: Sieglinde Snapp/Michigan State University

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Doubled-up legumes technology

Intercropping two grain legumes. Exploiting the opportunity presented by complementary growth habits and plant architecture. The most successful doubled-up legumes combination involves pigeon pea intercropped with groundnut in additive design.

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Description of the technology

The **'doubled-up' legumes** system is based on intercropping of grain legumes, with pigeon pea (*Cajanus cajan*) as one component – increasing the total legume yield per unit area.

It provides a **diversification strategy for smallholders**. Crop diversification on small farms is strongly constrained by limited land, as farmers allocate a large proportion of the farm to the staple crop, usually a cereal. Doubling-up legumes fulfills multiple objectives, including: (i) integrating more grain legumes when land is limiting, (ii) rehabilitating fields with poor soil fertility, and (iii) extending ground cover in cropped lands as pigeon pea can be in the field for 6–8 months, depending on the variety used. The technology has been piloted with Malawian smallholders on 0.5–2 ha of land.

Intercropping two grain legumes exploits their complementary growth habits and plant architecture. The most successful doubled-up legumes system is pigeon pea with groundnut (*Arachis hypogaea*). Both crops are planted at their normal monocrop densities (additive) or one or both crops planted at a lower density (partial substitutive), depending on level of water stress in a site.

Groundnut and pigeon pea are planted at the same time. Pigeon pea grows very slowly during the first 3 months, only starting rapid growth as the groundnut approaches maturity. After groundnut harvest, pigeon pea grows as a sole crop.

Groundnut is often considered as the main crop in the intercrop, and so is planted at its ordinarily 'sole cropping' density. Pigeon pea is then planted at 50–100% of its sole cropping density. In marginal areas, substitutive intercropping minimizes competition for nutrients and water between the two crops.

Key messages

This legume–legume intercrop 'doubles' farmers' grain yields, with up to

40% MORE GRAIN PER UNIT AREA

A farmer growing **0.3 ha doubled-up system** will produce **180 kg pigeon pea**, which is equivalent to about

30% of the PROTEIN REQUIREMENT of a family of six

The doubled-up legumes intercrop was officially 'released' by the Government of Malawi because of documented benefits in

SOIL FERTILITY improvement and improved

HUMAN NUTRITION outcomes

Conditions that favor uptake

Agro-ecological conditions: Both groundnut and pigeon pea grow best in deep well-drained soils. Pigeon pea requires a 6–8 month warm growing period, conditions that are often not met at altitudes of over 1400 masl. This then requires selection of appropriate varieties of groundnut suited to these environments. Higher altitude environments result in prolonged growth duration that unfortunately introduces more intense crop–livestock conflicts as more labor is required to control livestock during the period after the main harvest. In cooler environments where common bean (*Phaseolus vulgaris*) can be grown, maize (*Zea mays*) and common bean is the dominant intercropping system preferred by farmers due to the more stable and higher market price for common bean. In Malawi, over 80% of pigeon pea is grown in the low-lying districts of Balaka, Blantyre and Machinga.

Access to inputs and markets: The technology does best where there are effective agro-input systems (seeds, fertilizer), supported by agro-dealer networks and market access for pigeon pea and the associated grain legumes.

Livestock presence: Presence of livestock may favor the interest in pigeon pea because of the fodder it provides; however, the extra labor needed to restrict livestock is a disincentive.

Alignment with household resource endowments

Variations of this technology can be implemented by households with almost any level of resource endowments. Although productivity does depend on the use of agro-inputs, farmers who have poor access to mineral fertilizers can still benefit from diversification and the nutrient subsidy from biological nitrogen fixation (BNF). Large farms often opt for rotational systems based on the production of sole pigeon pea for a ready export market.

While households with livestock may be interested because of the fodder potential of the legumes, there is often crop–livestock conflict. Non-livestock owners want to preserve the crops for grain (i.e. during the period after the main harvest). Livestock owners are then forced to herd their livestock for an extra 2 months (requiring more labor) when they would rather have their goats access the pigeon pea in the fields and gain more weight.

Necessary ingredients for implementation

Appropriate varieties: Use varieties that respond to farmers' needs. Shorter-duration pigeon pea varieties that mature within 2 months after the main harvest (maize, soybean, groundnut) reduce the labor burden related to extra time required to herd livestock to protect the pigeon pea.

Pest and disease management: Arthropods that feed on young shoots, flowers, pods, and seeds (e.g. jassids, aphids, mites) are the most important pests of pigeon pea. Pigeon pea pest management research has focused mainly on chemical control (e.g. dimethoate), with modern varieties requiring 2–3 sprays. However, the palatability of these landraces with elevated polyphenol content are more resistant to pests, requiring little to no pesticides. However, the palatability of these landraces needs to be improved for competitiveness on the market.

Soil amendments: Groundnut and pigeon pea both normally nodulate well with indigenous rhizobia, so usually require no inoculation. The system performs better if established in a field that has previously been fertilized with phosphorus, as both groundnut and pigeon pea use residual P efficiently. This has worked well for resource-limited smallholders in Malawi who rotate grain legumes with maize,

Different growth habits and maturity times for groundnut and pigeon pea enable smallholders to diversify their crop production. *Photo credit:* Sieglinde Snapp/Michigan State University.

which is generally fertilized with about 10 kg P/ha. After a few cycles, the rotation system self-reinforces, as nitrogen-rich legume residues improve the soil N economy. While rarely implemented, application of 200 kg gypsum (calcium sulfate dihydrate) per hectare enhances groundnut pod development.

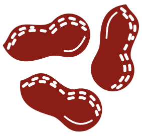
Agronomic practices: Bunch-type groundnut may be grown at a greater density than runner type (Table 1), and therefore yield more pods.

Adaptation possibilities

Other grain legumes: Cowpea (*Vigna unguiculata*) and soybean (*Gycine max*) can also be intercropped with pigeon pea. However, careful selection of compatible varieties of soybean or cowpea is necessary to get the best yield. In fertile lands, soybean is a better alternative than the more leafy cowpea varieties because, at the time of harvest, the latter often weakens pigeon pea plants leaving them little time to recover and consequently resulting in lower pigeon pea yields.

Use of agro-inputs: Agro-input use should be adjusted to the existing soil fertility; P is commonly lacking in most soils in sub-Saharan Africa, so some input of P will likely be required.

Table 1. Plant population to optimize performance of the doubled-up system for different environments

	Crop growth characteristics	Row spacing (cm)	In-row spacing (cm)
	Groundnut bunch type	75	8–10
	Groundnut runner type	75	10–12
	Pigeon pea (wetter environments)	75	90 (2–3 plants per station)
	Pigeon pea (drier environments)	75	90 (1 plant per station)

Where was the technology validated?

The information presented is derived from large-scale testing in the central districts of Malawi (Dedza and Ntcheu); in 2017, the doubled-up legumes technology was officially 'released' by the Government of Malawi as a technology that can be mainstreamed across the country for soil fertility improvement and improved human nutrition outcomes.

Potential benefits to users

Food security: The doubled-up system does not increase cropland under legumes; rather, the system can be implemented on the farm proportion that is usually allocated to groundnut. Improved soil fertility and better maize production reinforce food security.

Access to protein: Farming families that integrate pigeon pea with groundnut have potentially 20% more access to crop-based protein. For example, with a pigeon pea grain yield of 600 kg/ha, a farmer growing 0.3 ha doubled-up system will produce 180 kg pigeon pea in addition to their usual crops. This will supply about 40 kg of protein – about 30% of the protein requirement of a family of six. This system is only surpassed by cropping systems that integrate the inherently protein-rich soybean.

Soil fertility and BNF: This system has 'double' legume grain and 'double' soil fertility benefits from BNF. On-farm research across several sites in central and northern Malawi established that the technology gave consistently greater soil N benefits (at least 20%) than monocrop legumes, with 60–170 kg N/ha from BNF. When the pigeon pea component is not damaged by livestock, land productivity is increased by up to 40% (i.e. the intercrop yield from 1 ha is equivalent to the yield of the two sole crops on a total of 1.4 ha).

Soil carbon: The groundnut–pigeon pea doubled-up system has a root biomass of about 0.5–1 t/ha annually, greater than root biomass additions in maize-dominated systems that only add about 0.4 t/ha. The N-rich crop residues also support diverse and much more abundant soil fauna populations.

Associated crops: Maize grown in rotation with doubled-up legumes needs only 50% of the recommended N fertilizer to produce yields comparable to full fertilizer usage without doubled-up legumes.

Livestock productivity: While positive impacts on livestock productivity could be envisaged, specific data is lacking.

Things to worry about

Considered through the Sustainable Intensification Assessment Framework, the doubled-up legume technology may have the following direct and indirect consequences across the five critical sustainability domains of productivity, economic, environment, the human condition, and social aspects.

Livestock damage: The pigeon pea cycle continues well into the 'off-season' when livestock control is not mandatory. This exposes pigeon pea to livestock damage, which has been the largest setback to adoption of the doubled-up system. In some communities, local chiefs have established by-laws that ensure control of livestock for a further 2 months after the main harvest to enable pigeon pea to reach maturity.

Increased labor: Increased labor by women and children to control goats after the main harvest for an extra 2–4 months, depending on pigeon pea maturity duration.

Price fluctuations: Market access can be risky due to fluctuating grain legume prices. For example, much of Malawi's pigeon pea was exported to India until temporary suspension of the trade agreement in 2017: excess pigeon pea flooded the Malawian market, and the local price collapsed by more than 50% within a season.

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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**