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DOYIWÉ

Kersting's groundnut [*Macrotyloma geocarpum* (Harms) Maréchal & Baudet]

A versatile & underutilized grain legume for subhumid zones.

Recommended practices for farmers

September 2020

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Forewords

Legume crops, with their high protein contents and ability to improve soil fertility, have great potential to contribute toward food security in Africa. Orphan crops have greater potential because of their resilience and contribution to food diversification. Kersting's groundnut is an orphan legume crop which area of distribution is limited to West Africa. Beside the high protein content, Kersting's groundnut has appreciable levels of essential minerals and vitamins. This added to its palatability and physical appearance of dishes prepared out of its grains, gives to the crop a high market value. However, its cultivation is hindered by numerous challenges and the trend of its cultivation is downward. Wide adoption of adequate agronomic practices while growing Kersting's groundnut would make a step forward to enhanced production and productivity. Such adoption can only be fostered when awareness is sufficiently created, with supporting and guide documents availed. The purpose of this production guide is to avail tested tools, create awareness of best agronomic practices that promote productivity and discuss relevant options and challenges that are associated with the production of Kersting's groundnut. It is a compilation of field experiences and information gathered through surveys and literature.

It is a well-illustrated toolbox for farmers, researchers and else who might want to engage in Kersting's groundnut production.

I wish you a fruitful use of this toolbox.

- Prof. Brice SINSIN -

KERSTING'S GROUNDNUT PRODUCTION

Recommended practices for farmers

Introduction

Kersting's groundnut [*Macrotyloma geocarpum* (Harms) Maréchal & Baudet] is a neglected and underutilized legume crop endemic to West Africa. It is a geocarpic, shrubby plant native to Central Benin and Northern Togo. Nowadays it is cultivated widely in Benin, in the South, Centre and part of the North, widely in Burkina Faso, in the north of Togo, in the North of Ghana and some parts of Nigeria. Some accessions have been found in Cameroon and Côte d'Ivoire, but no data exists regarding its cultivation in those countries. The crop is grown for its edible seeds, the leaves and vines are used as forage and for medicinal purposes. The seeds are boiled, seasoned to make a soup, which can be eaten with bread or "*gari*", or used as dressing for rice. The seeds can also be processed into a cake locally nammed "*ata*" in Benin. Kersting's groundnut has got many local names in Benin, the Fon and Mahi ethnic groups call it "*Doyi*" and "*Doyiwé*" which refer to the landrace with white/cream grains; the Idatcha ethnic groups call it "*Atchaka*"; "*Iwadiananssara*" for the Coura/Nagots ethnic groups; the Kotokolis call it "*Yovo-Sohnan*"; "*Yovodoungouni*" for the Dendis; "*Yovosoonan*" for Lokpas; "*Yovoagatchéi*" for Nanis; "*Issanganndani*" for Ditamari and "*Anansarassouyi*" for Bariba ethnic groups.

Kersting's groundnut plants in the field

The plant is bushy in spread form with many branches, up to 24, and plant height varying from 20-30 cm. The fruits are pods developed under ground, with each pod containing one or two seeds, and rarely three. The pods are elliptical or elongated, with 7-20 mm length and 5-9 mm width (Chodaton et al., 2020). The seed coat colors are diverse; white/cream with no color at the hilum, black, light and dark brown and mosaic (brown with black dots or striae). The hilum color is either white, black reddish, in diverse shapes such as triangular, butterfly or irregular. Seed with white/cream coat color is the most appreciated, used and commercialized in Benin.

This guide focuses on agronomical practices for better production and productivity of kersting's groundnut grain. The local name doyiwé which is the most famous generic name used in Benin to designates the species, will be the most used in this document.

How to Grow Doyiwé

Growing Doyiwé is fairly straight forward, with management practices similar to groundnut.

Variety Selection and Seed Sources

The cream seed color accessions are the most liked in Benin markets. Although the black seeded varieties have been reported having good ability to process local cake "*ata*", it is hardly marketable, especially in urban areas.

To date, seeds of doyiwé are sourced either from local market, agro-dealers (at village level) or farmers' own stocks. In general, there is no difference between seed (planting materials) and grain (intended for consumption) during production, harvest and post-harvest handlings. Yet, in most case, when saved for the next planting season, seeds receive special treatments and care. They are further dried and treated with locally sourced insect repellents extracted from plants such as dry hot pepper (Capsicum frutescens), zests of orange (Citrus sinensis), leaves and oil of neem tree (Azadirachta indica). Some inert matters have also proved efficient *viz* sand, wood ash or lamp kerosene. Though not a common practice, there are chemicals (aluminum phosphide tablets: sofagrain, topstoxin, cotton and horticultural crops protection pesticides: CYP&DIM: Cyprodinil and 3,3′-Diindolylmethane, Lambda Super 2.5 EC, naphthalene balls etc.) used to preserve grains of doyiwé in storage. This is reportedly required to control insect's proliferation (*Callosobruchus maculatus*) and maintain the germination capacity of the seeds.

Kersting's groundnut landraces differing in seed coat and hilum color

Land Selection

Site selection is a key step, as doyiwé is at its optimum when grown on fallows bearing quackgrass (*Imperata cylindrica*), napier grass (*Pennisetum purpureum*), panicgrass (*Panicum maximum* Jacq) and (*Megathyrsus maximus*), etc. are the most preferred.

Grasslands, land selection and field marking for doyiwé production at Djidja, Glazoué and Kétou

Soils

The crop does not stand swamped, wet or poorly drained soils. Deep, sandy and well-drained ferrallitic or ferruginous tropical soils are preferable. Doyiwé can thrive on loamy soils but makes difficult the cropping operations, including ploughing, ridging and more importantly during harvesting, and this may cause high yield loss. Optimum tolerable pH ranges from 5.5 to 6.5; doyiwé will not grow well or fix nitrogen in acidic infertile soils.

Climatic conditions

Doyiwé tolerates a wide range of temperature 18°–34ºC. Average annual rainfall in the production areas fluctuates between 900-1300mm. However, the crop can stand lower rainfall below 600mm (Achigan Dako & Vodouhè, 2006). There should be minimum soil moisture toward maturity; wet soil at maturity accelerates rotting of pods or proliferation of myriads, which bores in the pods, leading to increased crop loss.

Rotation

Growing different crops on the same land in a recurring sequence is an agronomic practice known as crop rotation. Crop rotation has been practiced in agriculture for decades and has many advantages. Crop rotation enables variation of substrates to the soil microorganisms and exploration of various soil layers, as roots of different types of crops explore specific soil depths, thus enabling optimum use of soil nutrients. Rotation helps to recycle nutrients in lower layer, functioning as biological pumps. Various types of crops excrete various root exudates, that enables attract different types of soil

microorganisms. Crop rotation helps to control the development of weeds, pests and diseases. Continuous cropping results in pests and diseases build-up. Overall, crop rotation promotes food diversity for human and animal nutrition, reduces risks of pests and weed infestations, improve activities of soil microorganisms, improves water and nutrient distribution in the soil. Rotation with legume crops improves amount of nitrogen in the soils, as leguminous can develop symbiotic plant structures known as nodules. Nodules are houses for symbiosis between plant and soil bacteria known as rhizobia. When sufficient amount of phosphorus is available, such association results in biological nitrogen fixation, thus improving amounts of nitrogen in the soil. Some plant species have capability to form symbiosis with mycorrhizae, to promote phosphorus availability in the soil.

Doyiwé is a soil fertility-enhancing crop, as it fixes nitrogen (Mohammed et al., 2018) and can improve yield in subsequent cereals. In general, doyiwé is on top of rotation list followed by cereals (maize, sorghum, …) or tubers (cassava, potatoes,…). Cotton may be grown after doyiwé.

Intercropping

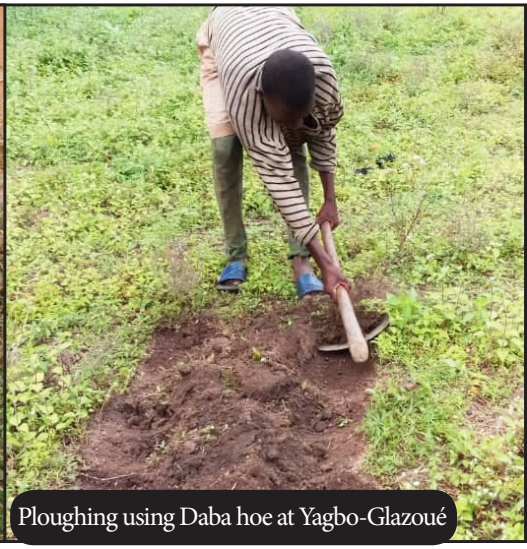
Not many farmers have reported using doyiwé in intercropping, and no research has investigated to inform on any advantages or disadvantages. However, given that the crop has specific requirements for types of land and modes of land preparation, given the cares and labor required to grow doyiwé, its intercropping with less demanding crops is likely to be less advantageous.

Land Preparation

Land should be prepared early, before the rains start, so that sowing can take place at onset of the rains. When a proper grass fallow is found, it is advised not to slash grasses and perform ploughing by cutting grasses at the root systems and deep turning the soil to burry all grasses and residues. This operation should be done two to three weeks before sowing, using hand hoe, tractors or ox plough to enable decomposition of the organic matters.

Just before sowing, ridges should be made to ensure organic matters are completely buried and provide uniform seedbed with sufficient planting depth and spacing. Recommended spacing are 75-80 cm between two planting lines, with 30-40 cm depth to ensure water drainage and promote easy harvesting. Good seedbed depth facilitates pegging and pod formation. Pegging is when an extension (peg) grown post flowering forces into the soil to develop fruits (pods).

Daba: Type of hoe used for ploughing to sow Doyiwé



Ploughing using Daba hoe at Yagbo-Glazoué

At their base, ridges should be wide enough to enable well incorporate all grasses and organic matters and promote fast decomposition. A width of 40-50 cm is recommended at the base of each ridge. Enough soil should be added to the top of the ridges to provide good soil-to-seed contact after sowing.

Legend

- Between rows spacing 75-80 cm
- Plant-to-plant spacing 15-30 cm
- Ridge base width 40-50 cm
- Ridge depth 30-40 cm

Fine seedbed for doyiwé production (Sékou)

Seed selection

When sourced from local markets or farmers' own stocks, seeds of doyiwé should not have been stored for more than 12 months. Seeds should be well dried and kept in a dry environment in hermetic storage containers. Prior to sowing, seeds should be sorted to remove inert matters, broken seeds, diseased seeds, and seeds of other crops. To achieve uniform maturation and facilitate harvesting, varietal purity has to be maintained by planting seeds of different cultivars separately. Proper seed dressing with fungicides is advisable to prevent poor germination and seedling wilt caused by fungal attacks at early growth stage, and improve plant stand in the field.

Time of planting

Planting should be done when rains are well established but should be scheduled such a way to ensure that maturity occurs in dry season. Wet soil at maturity lead pods to rot and seed sprouting in the field. In Benin, to cope with climate variabilities, doyiwé planting can be done from July to September depending on the production zones. As such, early planting is done in July, usually during third and fourth weeks. Medium planting periods fall within the two first third of August, while late planting can be done beyond 20th of August up to early (first third) September (this was done successfully in Djidja and Kétou).

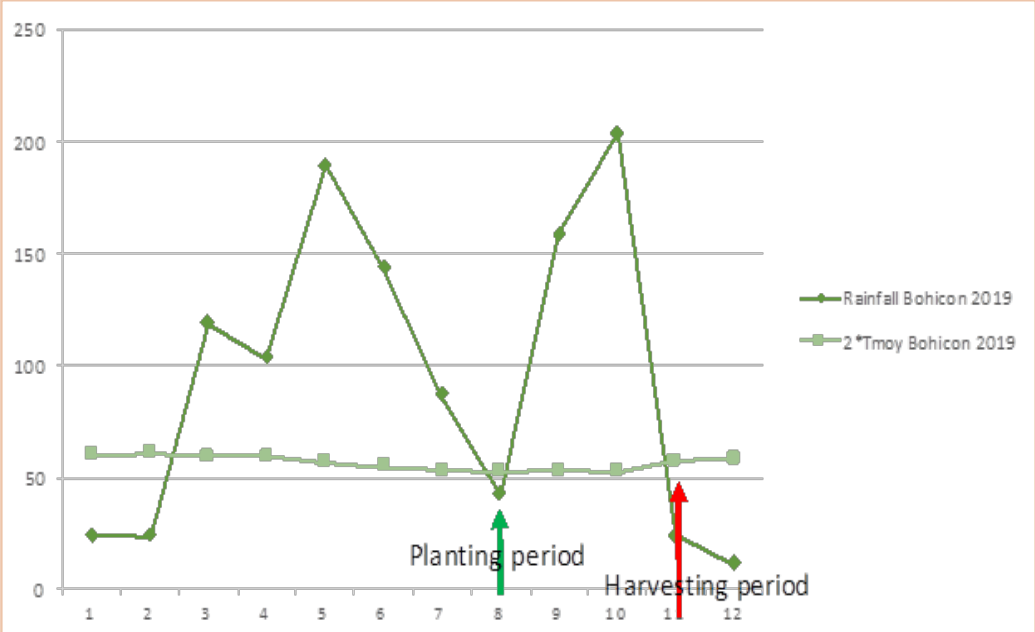


Diagram showing planting and harvesting periods for Doyiwé in Benin

Sowing

Sow seeds of doyiwé in rows following a line in the middle of the top of ridge and at the right spacing. Row planting eases weeding, spraying, disease & pest identification, estimation of plant population/ yield per unit area; uses less seed/easy to determine seed rate, and eases supervision and harvesting. Seeds are sown at 5 cm depth in average, deeper planting slows down germination and plants take longer to emerge, especially when seed vigor is low. This causes emergence of substandard plants that fail to grow. Substandard plants of doyiwé may stay stunted for months, fail to flower nor produce pods. Shallow planting results in poor germination, as some of the seeds are exposed and susceptible to birds and rodents attacks. In addition, when seed stay uncovered in less moist soil it may fail to germinate. Avoid sowing in waterlogged soils, as seeds rot after imbibing too much water.

Research team sowing doyiwé in the field at Sékou

Plant density/Spacing

Kersting's groundnut spacing depends on mass germination rate of the seed-lot. The recommended space between rows is 75-80cm to allow ridges have wide base and a within row spacing of 15-30 cm depending on canopy spread of the variety under cultivation. Generally, plant density ranges between 60000 to 120000 plants/ha. While larger planting results in lower yield per unit area, planting closer together results in few pods per plant. However, it has been reported in groundnut that closer planting ensures short pod filling, resulting in pods of a similar age and stage of development, thus making it easier to decide when to harvest (Okello et al., 2010). This needs to be investigated in kersting's groundnut to accurately set times for harvesting.

Weed management

Weeds are plant enemies that can cause total failure of the crop, as they compete with plants for space, light, moisture and soil nutrients. Therefore, weed control is very crucial to ensure successful cultivation of doyiwé. Effective weed control translates into good crop stand, growth and higher yields. In doyiwé cropping, weeds can be controlled using hand hoe, machines or chemicals. While hand weeding is the most careful, environment-friendly and preserve plants and plants organs, it may not be the most effective, as it is tedious and time consuming. Crop may suffer from poor and late weeding in situations where there is a lack of labor for hand weeding. Thus, it becomes less effective when larger acreage is under cultivation. A combination of those three means is recommended to control weeds in doyiwé cropping. The choice may depend on

the types of weed and level of infestation. For instance, in the case of weed infestation caused by graminoids sedges (*Cyperus spp*), it might be useful to process manual weeding using hands, knife or machete. Careful and deep removal of sedges' root systems reduces drastically the power of the weed, and when this operation is done 3-4 times, it suppresses completely that weed species from the field. This may begin during land preparation by deep digging the sedges before harrowing.

In general, 2-3 weeding is recommended for doyiwé. The first should be done about 3 weeks after sowing. It is delicate to perform first weeding in doyiwé just 2 weeks after sowing, as most plants at that stage do not have the trifoliate leaves that enables distinguish them from other plants and weeds. The first weeding must be done before flowering and the second when deemed necessary, generally during pegging. While weeding during pegging, avoid soil disturbance near the plants operate in the middle rows between ridges. Hand pulling may be more adequate at that stage to avoid damaging pegs. Earthing up may be done when deemed necessary, not to keep initiated pods outside the ground where they will never develop into actual pods, keeping initial pods of doyiwé outside ground prevent the plant from pod filling. A third weeding may be done towards physiological maturity when deemed necessary. This may have the advantage of avoiding mature crops to stay in the bush, which promotes high rodents' attack who eat-up the pods. Also, weeds can disrupt harvesting operations stripping pods from vines. Weeds are reservoirs of pests and diseases; at harvesting when doyiwé crop is dug up, it is advisable to let plants drying in the fields for easy handpicking of the pods. Leaving the plants to dry in the bush may

result in heavy crop loss as birds and rodent activities on the pods will be maximum. Moreover, weeds can cause grades lowering of the products, as weed fragments and fruits that may colonize the harvest will be classified as foreign contamination materials. Pre- and post-emergence herbicides may be used to lower weeds activity on the crop.

Before and after weeding (Adakplamè-Kétou)

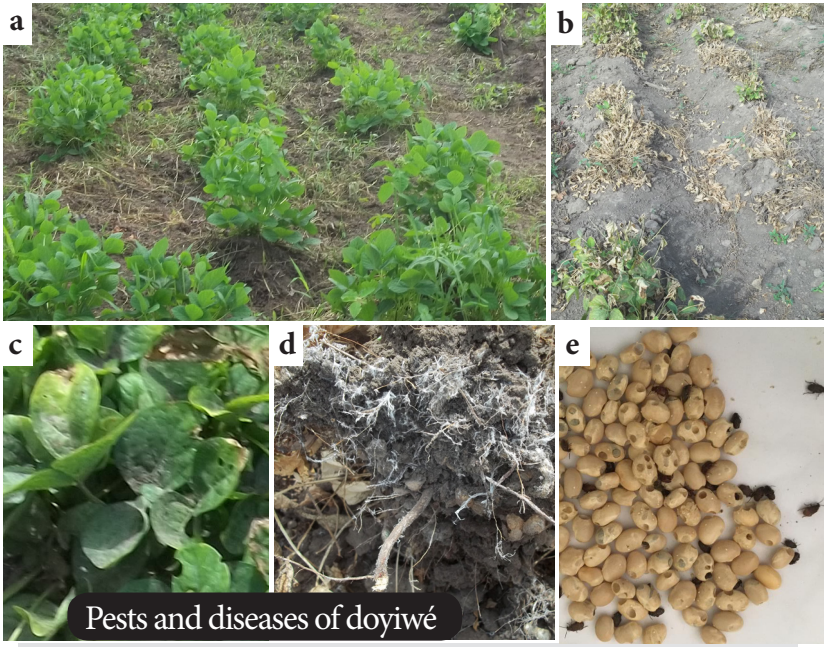
Fertilizer requirements

Doyiwé thrives well in soils with low fertility. Residual fertilization is preferred to direct fertilization. If a grass fallow precedes doyiwé cropping, there is no need for additional fertilization. In the event where grass fallow is not available and doyiwé should be grown after other crops in a low fertile soil, a basic fertilizer application may help increase yields. It is recommended to apply basic dressing fertilizer prior to sowing. Best practice is to determine nutrients profile of the soil through testing samples. This informs whether and how much fertilizer or lime is required. Blind basic fertilization may

be applied when no data is available from soil test. The following may be applied: NPK (16-16-16) at rate of 100kg per hectare (Kouelo et al., 2020.

Major pests and diseases of doyiwé

Doyiwé is exposed to pests and diseases that cause yield loss and total failure in some cases. Majorly, fungal and viral diseases and some pests have been reported (Agoyi et al., 2019). Fungal diseases are wilt disease caused by *Pythium* spp, white mold disease caused by *Oidium* spp and rust disease (Fig.7). *Pythium* attack is the most common and damaging field disease in doyiwé cropping. It causes plants to wilt and most plant end up dying, some plant may regenerate. However, these regenerated plants often fail to reach maturity, as they require more time than the actual crop of which maturity coincides with dry season. In other words, in rainfed cropping of doyiwé, regenerated plants dry up during the dry season. Doyiwé crop can be attacked by viruses, that cause yield reduction through reduced photosynthesis, as leaf area reduces when leaves shrink. Grasshoppers and caterpillars can also feed on the leaves, when these are severe, they can cause reduction in yield. When crop matures and soil still highly wet, millipedes attack and perforate fresh pods, this also can cause significant reduction in yield. In storage, the grain of doyiwé is particularly liable to bruchid attack. The bruchid species *Callosobruchus maculatus* (Edah et al., 2020) has been identified as major storage pest in kersting's groundnut.

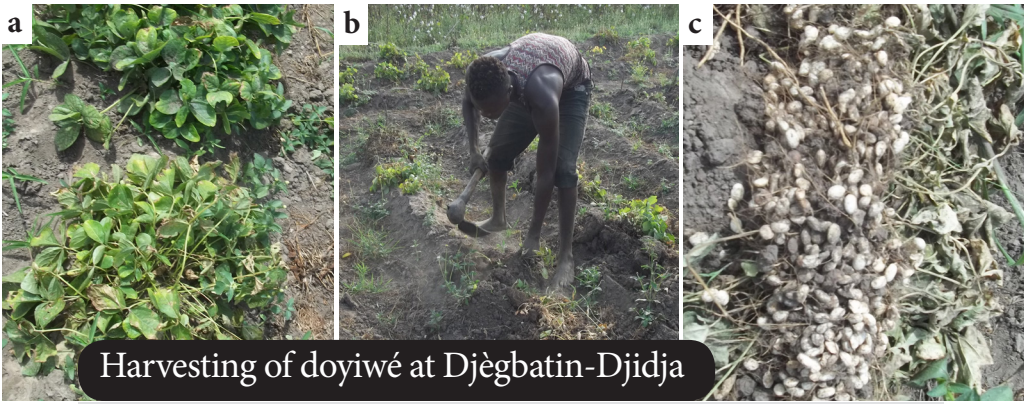


Legend: a) Healthy doyiwé field; b)Doyiwé crop affected by fungi; c) diseased doyiwé plant infected by pseudomonas spp (bacteria); d) Root system of doyiwé colonized by fungi mycelium; e) Doyiwé grain attacked by *Callosobruchus maculatus.*

Harvest and Storage

Harvesting from the field

Doyiwé is adequately harvested in dry season. To avoid pod loss during harvesting, plants are carefully dug-up using hoes, and then spread on top of the ridges to allow pods to dry up and get easy to detach. Two to three days after plants removal, once pod moisture is deemed adequately reduced and pods are easily detachable, plants are gathered and pods carefully removed by handpicking. This operation should be done with maximum care, as pods are very small, hence liable to be massively lost, and this would lead to yield reduction.



Harvesting of doyiwé at Djègbatin-Djidja

Legend: a) Doyiwé at harvest maturity; b) Digging-up of doyiwé plants using hoes; c) Freshly harvested doyiwé pods.

Pods drying in the field at Djègbatin-Djidja

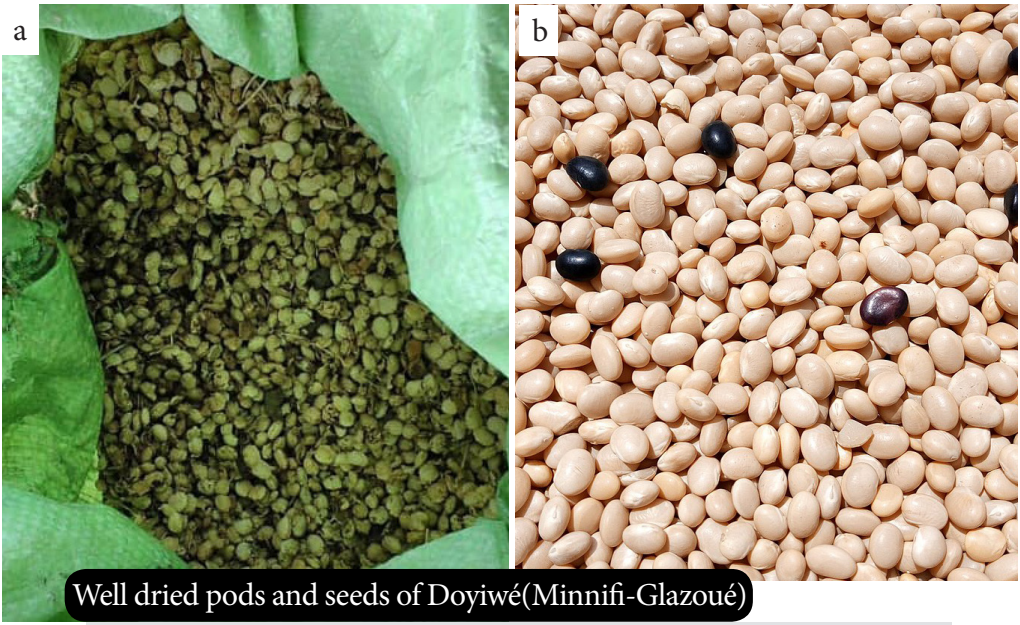
Pod drying, threshing, seed drying and storage

Seeds and grains of doyiwé cannot be well kept if not properly dried. In addition to pod moisture reduction in the field, pods should be properly dried before threshing. This is important, as it eases threshing, but also helps keep seed integrity during threshing. After all pods have been carefully detached from plants root system, they are spread on a dry surface for drying. This operation can be done using makeshift carpets, made out of jute sacks, old tents, or even used clothes. Farmers often use top of rough or slab to dry pods and seeds. During highly insolated periods, three to five days of open-air drying before threshing are enough.

Once pods are deemed well dried, flat pod packages are made in jute sacks. The sacks are beaten with stick (not too heavy sticks, nor using too much energy, to avoid breaking the seeds). This operation seeks to release seeds from the shell and can be repeated as much as needed. Non-shelled pods are returned in the sack to be beaten

again, until almost all seeds are released. The tinniest pods that fail to shell through that process are manually shelled. Threshing can also be done beating pods in a wood mortar. The mixture (seeds and empty pods) is transferred on the makeshift carpets, which is returned under sunshine for drying over, before being transferred onto trays or flat basins for winnowing. Winnowing operation enables removing empty pods and debris (which fly away as they become lighter). Thereafter, seeds are hand sorted; inert and foreign matters and broken seeds are removed.

Clean seeds may be dried one more time, or if deemed sufficiently dry can be stored in hermetic containers, put in a moisture-free environment. There are various types of storage containers for doyiwé; these include clay-pots or jars, plastic jerry cans, calabash, bottles, etc. Seeds can also be mixed with pre-heated soil before storing in hermetic jerry cans.



Well dried pods and seeds of Doyiwé(Minnifi-Glazoué)

Legend: a) dried pods in jute bag for threshing; b) threshed and sorted grains of doyiwé

Threshing and winnowing operations at Tokégon-Djidja

Storage containers for doyiwé seeds

Hermetic storage of Doyiwé grains in plastic bottle in the Laboratory of Applied Ecology and jerry cans, in farmers' households at Agounan and Glazoué.

Closed, but non-hermetic storage of Doyiwé grains in calabashes and jars in farmers' households at Agounan, Glazoué and Kétou.

Doyiwé grains kept at open air in plastic bucket in the central market of Djidja.

Utilizations, commercialization, production cost and profitability

Doyiwé is mainly produced for commercialization in the urban markets. Only a small share of the production is kept for home consumption. The varieties with cream seed coat and hilum is the most liked. The varieties with black or brown seed coat or coloured hilum are mostly used for home consumption. Doyiwé is used to prepare various meals such as: "*Doyi Bòbò*" (grains of Doyiwé boiled, seasonned with condiments and cooking oil, which is eaten with gari), " *Doyiwé soup*" (boiled grains soaked in tomato and/or onion soup, can be garnished with meat, sausages, and vegetables such as carrots, cabbage, french beans, etc.), "*adowè*" (boiled grains matched and seasonned, that is eaten as a sandwich), "*Doyità*" (fried cakes made out of grains of Doyiwé).

Doyiwé is the most expensive grain legume in Sub-Saharan Africa. In Bénin, its price varies according to the area and when it is being solde, but also vary from year to year. In general, women in the market use a measuring bowl known as "*Tohoungodo*" to sell Doyiwé. One full tohoungodo of Doyiwé grain weight 0.986kg in average. In the farms, one tohoungodo full of Doyiwé grain is generally solde between 1000 and 1200 XOF (≈ 2 à 2,5 USD). On Benin' urban markets, the price

Tohoungodo: Measuring bowl used to sell Doyiwé in the local markets of Benin

fluctuate between 1500 and 2000 XOF (≈ 3 à 4 USD) and can rise as high as 2500 (≈ 5 USD) with the planting season approaching. This price experienced a special upsurge in November 2017, whereby one tohoungodo of Doyiwé grain costed up to 3500 FCFA, around 7 USD.

The table below presents an estimation (on an indicative basis) of expenses and potential returns of its cultivation on one hectare.

N°	Items/activities	Estimations
1	**Land preparation, sowing and field maintenance**	
	Fallow slushing, harrowing and ploughing	60000
	Seeds (20 Kilogrammes)	40000
	Fertilizer	30000
	Sowing and fertilizer application	15000
	Weeding 1	15000
	Weeding and earthing up 1	20000
	Weeding and earthing up 2	20000
T1	**Total 1**	**200000**
2	**Harvesting**	
	Digging-up of plants	20000
	Pod detachment	10000
T2	**Total 2**	**30000**
3	**Threshing**	
	Stick beating of pods	15000
	Winnowing and seed sorting	15000
T3	**Total 3**	**30000**
	Total	**260000**
Production cost: for a yield of 700 kg per hectare, the estimated production cost is 371,5 FCFA/Kg		
Profit : Assuming sale is done at farm gate for 1000 FCFA per kg, the farmer will fetch a gross margin amounting 440000 FCFA per hectare, corresponding to 170% of the production cost.		

Conclusion and recommendations

Kersting's groundnut, Doyiwé, is an anual grain legume that is easy to cultivate. In Bénin, Doyiwé is mainly grown in the short rainy season, July to November, in the departments of Collines, Zou and Plateau. Its production is optimal on fallows grown of quackgrass, napier grass, panicgrass, etc. Land preparation to grow Doyiwé consists in deep ploughing with 'daba'. When grown on fallows, Doyiwé does not require chemical fertilization. Harvesting of Doyiwé should be in dry season to reduce pod rotting and re-germination. This brings in difficult harvesting, as plants have to be dug-up using hoes. Owing to the small size of pods and seeds, pod detachment, threshing and winnowing should be done with maximum attention to reduce yields loss. Doyiwé production is profitable, the cultivation of Doyiwé on one hectare can generate over 170% gross margin with respect to production cost.

To date, none of the activities in the production chain, from sowing to threshing and winnowing is mechanized, thus limiting the ability to grown wider acreage. It is therefore recommended that researchers pay more attention to mechanization of Doyiwé cropping activities. Besides, due to its profitability and nutritional quality that offer possibilities for its exportation, governments an policy makers should pay more attention to that crop, to enable it better contributes to the improvement of farmers' incomes and growth of countries' Gross Domestic Product (GDP).

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