

## IITA Research Guide 60

**Agronomy of cassava**

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**Abstract.** Even though cassava is a durable crop, it has certain husbandry requirements and is responsive to favorable crop management practices. Healthy, fresh stem cuttings from mature cassava plants are the best planting materials. Depending on moisture conditions of the soil, farmers plant cassava cuttings vertically, at an angle, or horizontally. Slow initial development of sprouts makes cassava susceptible to weed competition in the first 3-4 months. Therefore, weed control involves cultural, biological, chemical and integrated control. For good growth and yield, cassava requires friable, light textured and well drained soils containing sufficient moisture and a balanced amount of nutrients. Farmers usually intercrop cassava with maize, melon, and other crops. Farmers can harvest cassava from 7 months after planting, however, most cassava varieties attain optimum weight and starch content 18 months after planting. Improved varieties selected for early bulking may be harvested after 6 months and attain maximum yield at 9-12 months.

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# 1 Land preparation

Cassava is an important food crop in sub-Saharan Africa. The crop produces acceptable yields under sub-optimum conditions. Nevertheless, good production requires good land preparation. Land preparation practices depend on

- climate
- soil type
- vegetation
- topography
- degree of mechanization
- availability of labor
- traditional cropping systems

Where farmers grow cassava traditionally as the first crop after clearing the forest, no land preparation is required other than the removal of shrubs and vines, and cutting off branches of large trees to admit sunlight. When the first rains have softened the ground, farmers loosen the soil with a hoe, planting stick, or sharp instrument.

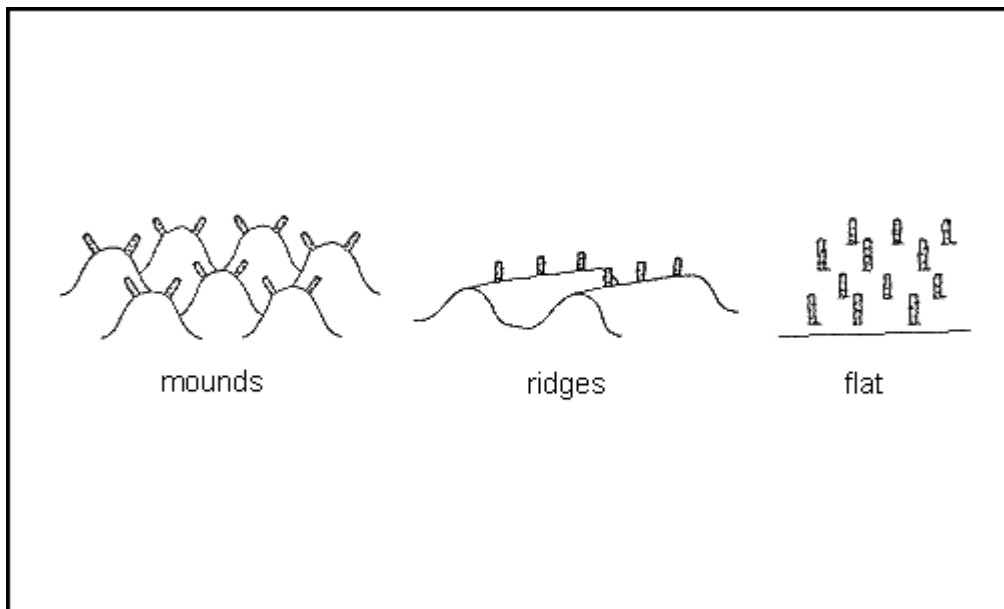
Depending on soil type and drainage, the field may be prepared as mounds, ridges, flat-tilled, or zero-tilled ([Figure 1](#)). Drainage conditions determine the size of the ridges or mounds, and the placement of crops. In wet areas, water-loving crops such as rice may be planted between mounds or ridges. Upland crops such as cassava, maize, and legumes which require good drainage may be planted on the side or top of the mounds or ridges.

Land preparation for planting cassava on upland and in valleys differs ([Figure 2](#)). On upland, farmers plant on flat ground, or mounds and ridges. In valleys, farmers prepare ridges or mounds above ground level to control waterlogging.

Cassava cultivation on mounds is common in West Africa. Farmers gather the soil into heaps. Mounds range from 30 to 60 cm high. They are lower than mounds prepared for yam, but have broader bases. Cassava tuberous roots spread more widely and penetrate less deeply than yam tubers. The space between mounds varies from 60 to 200 cm.

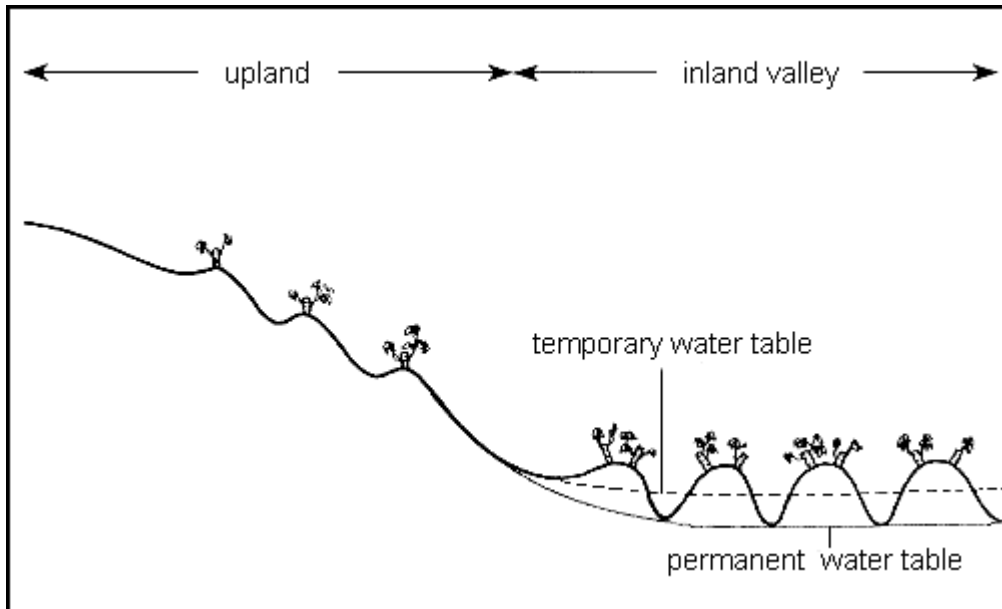
Where mechanization is available, farmers plow and harrow the land down to a depth of 25 cm.

For planting on flat soil, farmers insert cuttings directly into the land. For planting on ridges or furrows, farmers ridge or furrow the land after harrowing.



**Figure 1.** Cassava planted on mounds, ridges or flat soil.

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**Figure 2.** Cassava planted on upland and in valleys.

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## 2 Planting material

Ideally, grow cassava plants from semi-hardwood cuttings. Within 2-3 weeks, adventitious roots develop at the base of the cuttings. Subsequently, roots develop into a fibrous root system. Other roots develop at the base of axillary buds, or at the nodes. Fibrous roots may be up to 200 cm long. Some fibrous roots develop into 'storage roots' or 'tuberous roots', 20-40 days after planting. Tuberous root formation, or root bulking, depends on

- soil conditions
- temperature
- quality of planting material
- variety

Cassava stem cuttings (or stakes) are vulnerable to adverse climatic conditions, pests, and diseases. If exposed to sunlight, cuttings dry and lose viability. Excessive moisture causes sprouting or rotting.

Pathogens and pests are common causes of poor sprouting. Sprouting is better with freshly harvested stem cuttings. Long storage periods emphasize varietal differences in sprouting vigor.

Healthy, fresh stem cuttings from mature plants are best for planting. However, if planting is delayed because of cold weather, drought or excess moisture, farmers need reliable methods to store the stems. Stem cuttings store best in dry, well-ventilated, shaded areas away from direct sunlight.

Storage methods depend on environmental conditions. The simplest method is arranging the stems vertically under a tree, with the oldest part of the stem buried in the soil. The soil should be moist to keep the stems 'alive'. Leaves form on the upper part of the stems. After storage, discard the top and basal parts of the stems, and use the middle part as cuttings.

Under cold conditions (for example, in southern Africa; <15°C), store the stems in underground tunnels. Place stems inside the tunnel on top of a layer of dry straw, and cover them with another layer of straw and soil. Protect the tunnel from water.

The quality of cassava stem cuttings depends on

- age of stem
- thickness
- number of nodes
- health of stems

**Age of stem.** Take stem cuttings from plants which are between 8 and 18 months old. Cuttings from older, more mature parts of the stem give better yield than cuttings from younger parts. Cuttings from green parts are susceptible to pathogens and insects. Also, immature stems cannot be stored for a long time, because they dry rapidly. Stem cuttings from older plants are lignified, and contain only small amounts of nutrients for sprouting. Sprouts are weak.

**Thickness.** Use thick stems. Although any part of the cassava stem can be used

for propagation, do not use thin stems. Thin stems have little nutrients and moisture. Sprouts are weak, and plants produce only few and small tuberous roots.

**Number of nodes.** Use 20-30 cm long cuttings with 5-7 nodes. Nodes are the origins of shoots and roots. You may obtain a plant from a small cutting with only 1 node, but the possibility of sprouting is low. Cuttings with 1-3 nodes do not sprout well because of small amounts of nutrients.

Small cuttings may also lose viability during transport, propagation, and planting. Long cuttings give higher yields than short cuttings, because long cuttings produce more stems and leaves.

**Health of stems.** Select planting material from healthy plants. Examine planting material carefully to prevent transmission of diseases and pests. Planting material could carry diseases such as African cassava mosaic virus, cassava bacterial blight and anthracnose; pests include mealybugs and scale insects. Do not use planting material with disease and pest symptoms.

Cut stems when you are ready for planting. Cut stems with a well-sharpened machete, knife, or saw. Avoid rough handling, otherwise the epidermis and buds may be bruised or damaged. Each wound provides entry for microorganisms.

If feasible, treat cuttings with appropriate pesticides (Table 1). Immerse stems for 5 minutes and dry them in the shade. The use of pesticides is not common among cassava farmers in Africa.

**Presprouting.** Presprouting stem cuttings before planting improves establishment, particularly in the humid and subhumid zones. Other advantages of presprouting are high growth vigor, a full crop stand, reduced weed pressure, and higher yield.

Presprout stem cuttings by placing hardwood or semi-mature stem cuttings in perforated polythene bags without soil. Fill each bag up to two-thirds leaving about one-third for aeration. Tie the bags with a piece of string and place in a shaded area or under a roof. Sprouting occurs in 3-5 days. Some varieties however, require a longer period for sprouting.

**Table 1.** Pesticides for treatment of stem cuttings.

Pesticides	Effective against	Concentration (per liter of water)
Perfekthion	insects	3ml
Benlate	fungi	3g
K-othrine	termites	10g

### 3 Planting

**Orientation of planting.** Plant cassava cuttings vertically, at an angle, or horizontally ([Figure 3](#)).

- Vertical planting: place two-thirds of the cutting in the soil.
- Planting at an angle: place two-thirds of the cutting in the soil, with an angle ranging from slightly above horizontal to about 60°.
- Horizontal planting: place the entire cutting horizontally in the soil at a depth of 5-20 cm; usually 10 cm.

The orientation of the cutting influences growth characteristics. Cuttings planted vertically sprout and develop foliage quicker than cuttings planted at an angle or horizontally.

Vertical planting produces deeper tuberous roots than angled planting, while horizontal planting produces the shallowest tuberous roots. However, tuberous roots from vertical or angled planting are arranged more compactly, and are more difficult to harvest than tuberous roots from horizontal planting.

Most modern mechanical planters are designed for horizontal planting. The planter opens a furrow and drops the cutting horizontally.

Experience in different cassava-growing areas shows that

- in clay soils with sufficient rainfall (1000-2000 mm/year), planting may be horizontal, vertical, or angled, because the moisture is adequate for sprouting
- in sandy soils and under erratic rainfall, plant vertically. A 20-30 cm cutting, planted vertically, reaches 20 cm deep into the soil, and may find enough contact with available moisture

**Planting time.** Plant as early as possible, just before the rains or after the rains begin. Delayed planting leads to reduced yield. When planted early, cuttings sprout, establish well, and receive sufficient moisture; plants withstand diseases and pests later in the season.

**Planting depth.** Regulate planting depth according to prevailing environmental conditions. Shallow planting at low soil moisture results in poor establishment and low yield. Therefore, in dry, sandy soils, plant cassava cuttings deep; in moist and heavy soils, plant shallow.

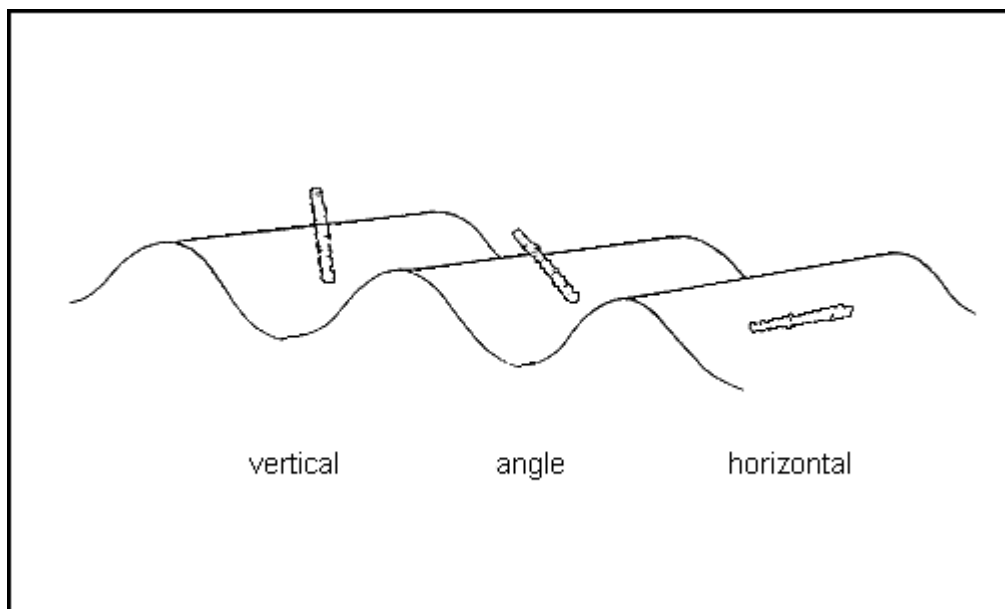
Remember that deep planting makes harvesting difficult and increases production costs. However, deep planting is advisable in areas prone to termite attacks.

**Plant density.** Plant density depends on

- soil and climate
- variety
- soil fertility
- cultural practices
- end use of tuberous roots

Optimum plant density varies from upland to inland valleys and depends on whether cassava is an intercrop or a monocrop. Denser planting is practised in inland valleys with distance between cassava plants ranging from 50 to 100 cm.

In traditional farming, cassava often grows together with yams, maize, groundnut, banana, and melon. The distance between cassava plants in the upland and depending on the type of intercrop ranges from 100 to 400 cm. In a monocrop, space cassava 80-100 cm within and between rows. Although no universal recommendation exists, in Africa, a plant density of 10 000-15 000 plants/ha gives a good crop.



**Figure 3.** Different methods of planting cassava cuttings.

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## 4 Weed management

Slow initial development of sprouts makes cassava susceptible to weed competition in the first 3-4 months. Early-branching varieties develop canopies which reduce weed growth when

- sprouts are vigorous
- crops are weed-free in the first 3-4 months
- plant density is higher than 10 000 plants/ha
- plants are free of diseases and pests
- environment and soil fertility are favorable

Weed competition reduces canopy development and root bulking. Yield reduction varies from 40% in early-branching cultivars, to 70% in late- or non-branching cultivars. When canopies do not provide sufficient cover, weed problems become severe.

Major weeds affecting cassava production are

- grasses such as *Andropogon* spp., *Imperata cylindrica*, *Panicum maximum*, and *Pennisetum* spp.
- broad-leaved weeds such as *Commelina* spp., *Chromolaena odorata*, *Mimosa invisa*, *Smilax kraussiana*, and *Mucuna pruriens*

*Imperata cylindrica* not only competes for resources, but also pierces tuberous roots, and provides entry for rot-causing pathogens.

Five methods of weed management are

- cultural measures
- biological measures
- genetic measures
- chemical measures
- integrated control measures

**Cultural measures.** Hand weeding is effective on small farms, therefore hand weeding is common among small-scale cassava farmers. Farmers clear land from a bush fallow of more than 5 years, and weed at 3, 8, and 12 weeks after planting.

**Biological measures.** Use of *in situ* live mulch in the form of a cover crop is an effective method of weed suppression. For example, *Mucuna pruriens* var. *utilis* grown during the season prior to cassava cultivation helps to suppress weeds. Cassava cuttings can be planted directly into the mulch cover with little or no land clearing.

Appropriate intercrops can significantly reduce weeding frequency and intensity. Intercropping with leguminous species has the additional benefit of soil improvement.

**Genetic measures.** Improved cassava cultivars which are vigorous, able to cover the ground rapidly, and are competitive against weeds, effectively suppress weeds during the early and more vulnerable growth stage. Slow-growing and late-branching cultivars are less competitive against weeds.

**Chemical measures.** Several preemergence herbicides have been identified for weed clearing in sole and multiple cropping

- chloramben (1-3 kg/ha)
- diuron (1-3 kg/ha)
- formulated mixtures of fluometuron and metolachlor (2 + 2 kg/ha)
- metobromuron and metolachlor (4 kg/ha)
- fluometuron and pendimethalin (2 + 2 kg/ha)
- primextra (pre-mix of atrazine + metolachlor) (2-3 kg/ha)

Herbicides are most effective if applied before weeds infest a field. When planting or weed control is delayed until weeds become visible, mix preemergence herbicide with a contact herbicide such as glufosinate-ammonium (Basta).

Herbicides are cost-effective when available in appropriate quantities, and when cassava fields are too large to be weeded by hand.

**Integrated control measures.** Integrated control combines the four weed control methods mentioned. Examples of integrated weed control are

- combining one weeding with the use of an improved variety, planted at optimum density;
- combining a preemergence herbicide with late weeding.

## 5 Fertilizer application

Cultivation of cassava is widespread due to its ability to grow in poor soils. Cassava has an extensive root system and uses plant nutrients which are not easily accessible to other crops. In traditional farming, without fertilizers, farmers can obtain yields of 5-6 t/ha on soils that would not support other crops.

However, for good growth and yields, cassava requires friable, light textured and well-drained soils containing sufficient moisture and a balanced amount of plant nutrients. Under such conditions, yields of 40-60 t/ha are possible.

Like all rapidly growing, carbohydrate-producing plants, cassava impoverishes the soil rapidly, unless nutrients are replaced. Depending on the soil fertility, amounts of nutrients removed in a monocrop and an intercrop differ (Table 2).

**Table 2.** Nutrients removed (kg/ha) by cassava and sweet potato after 4 months of monocropping and intercropping in a low-fertility soil (Kapinga et al. 1995).

Cropping system	N	P	K
Monocrop			
cassava	82	6	80
sweet potato	104	6	94
Intercrop (cassava + sweet potato)			
cassava	56	4	45
sweet potato	100	6	60

**Nitrogen.** Nitrogen is readily available to plant roots in the form of nitrate nitrogen. Because nitrogen is easily leached into lower layers of the soil, consider postponing application until plants are well developed. Symptoms of nitrogen deficiency are

- stunted growth
- narrow, pale green leaves, with yellow (chlorotic) discoloration starting at leaf tips and margins
- premature dropping of leaves

Sufficient nitrogen to develop foliage is necessary for the development of tuberous roots. Excessive application of nitrogen without the simultaneous application of potassium and phosphate may promote leaf and stem growth without increasing yield. Yield may even be reduced

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**Phosphorus.** Cassava requires modest amounts of phosphorus for the root system. Response to phosphorus application is low. Symptoms of phosphorus deficiency are stunted growth and violet discoloration of leaves.

**Potassium.** Cassava removes large quantities of potassium. Symptoms of potassium deficiency are

- stunted growth
- dark leaf color, which gradually becomes pale
- dry, brown spots on tips and margins of the leaves
- necrosis on the margins of leaves

Potassium deficiency not only affects yield and content, but also root quality.

## 6 Multiple cropping

The humid tropics are characterized by high rainfall and thick vegetation. Topsoils are protected by canopies of multi-storied or multi-level plant mixtures. Opening up new farmland generally disturbs the topsoil.

However, farmers leave large trees like palms, and burn the rest of the vegetation, leaving ash as mulch on the soil. Fallowing maintains soil fertility. Farmers adapt to changes in soil fertility by first planting crops requiring most nutrients such as maize, yam, and plantain. Root, tuber, and legume crops, which have lower nutrient requirements, are planted later.

Multiple cropping with varying canopies reduces soil erosion and pest and disease incidence. Yields are maintained at a stable but low level.

Under low soil moisture, as in the savanna of West Africa, farmers intercrop cassava with cowpea and maize. Differences in root patterns and growth cycle improve the use of water stored in different layers of the soil. Cassava uses available water at the end of the legume or cereal cycle.

Multiple cropping with cassava is most common in the humid tropics, especially under rainfed conditions. Multiple cropping includes various forms of farming practices where a field produces many crops simultaneously, sole crops in sequence, or a combination of both forms. Multiple cropping can be

- spatial: several crops grow simultaneously on the same field
- sequential or temporal: several crops grow, one after the other, on the same field

Simultaneous cropping is also called intercropping. Intercropping includes ([Figure 4](#))

- strip intercropping: growing two or more crops in strips wide enough to allow independent cultivation and yet narrow enough to induce crop interaction
- row intercropping: growing two or more crops in a well-defined row arrangement
- mixed intercropping: growing two or more crops in an irregular arrangement
- relay intercropping: planting one or more crops within an established crop so that the final stage of the first crop coincides with the initial stage of the next crop

Mixed intercropping is most common in cassava-growing areas of the humid tropics.

Advantages of multiple cropping are

- higher gross returns per unit area of land
- higher yield stability and less risk
- better satisfaction of dietary variability
- better control of pests, diseases, weeds, and erosion
- more efficient use of resources such as labor and land

Disadvantages of multiple cropping are

- reduced possibility for mechanization of planting and harvesting operations
- more difficult fertilizer and pesticide application
- more complicated management of experiments (intercropping is more complex than sole cropping)

Cassava is almost always intercropped, except on a few large-scale mechanized farms. Farmers intercrop cassava usually with vegetables, plantation crops (such as coconut, coffee), yam, sweet potato, melon, maize, rice, groundnut, and other legumes. Intercropping pattern depends on environmental conditions and food preferences of the region.

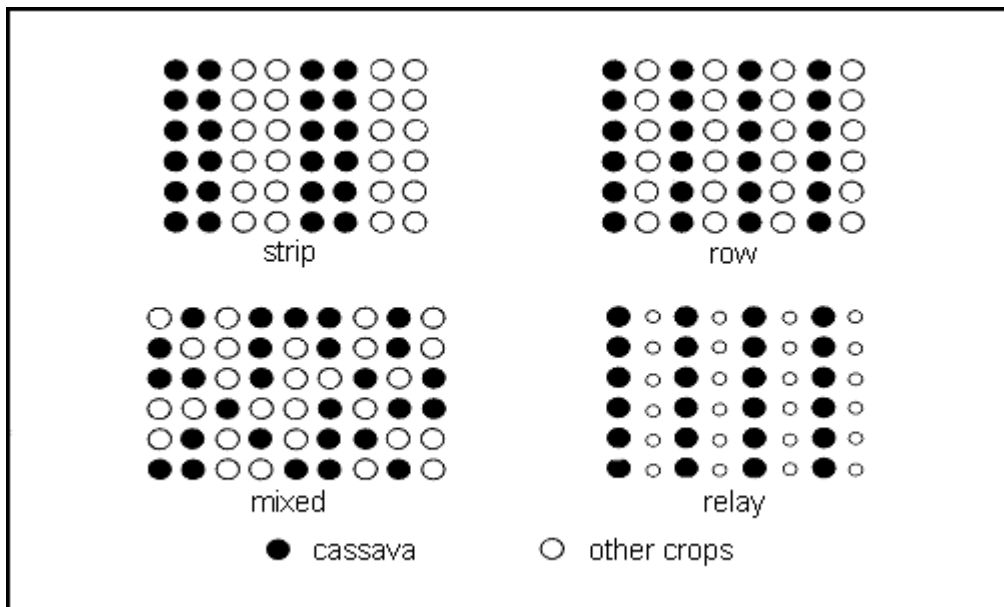
In simple mixtures (consisting of only two crops), farmers select arable crops on the basis of differences in growth habit and time of maturity. For example, cassava (slow initial growth, 9-18 months to maturity) is often intercropped with

- maize (rapid growth, about 100-120 days to maturity)
- cowpea, melon (rapid growth, 70-80 days to maturity)
- groundnut (rapid growth, 120 days to maturity)
- okra (harvested over a period of 50-100 days)

In complex mixtures (consisting of three, four, or more crops), high yields have been obtained with

- maize / cassava / melon
- maize / cassava / okra / melon
- maize / cassava / okra / cowpea
- maize / yam / cowpea

Complex mixtures also suppress weed infestation, reduce soil temperature, retain higher soil moisture in the topsoil up to a depth of 20 cm, and produce more organic matter than sole cropping or simple mixtures. Nutrient loss from erosion in complex mixtures is less than in sole cropping.



**Figure 4.** Examples of intercropping.

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## 7 Harvesting

Harvest cassava as soon as tuberous roots have accumulated sufficient amount of starch, but not too late, when tuberous roots become woody or fibrous. Early-maturing varieties are ready for harvesting at 7 months, while late-maturing varieties are ready 12 months after planting.

Optimum time for harvesting cassava varies according to

- time of planting
- variety
- climatic and soil factors
- market conditions

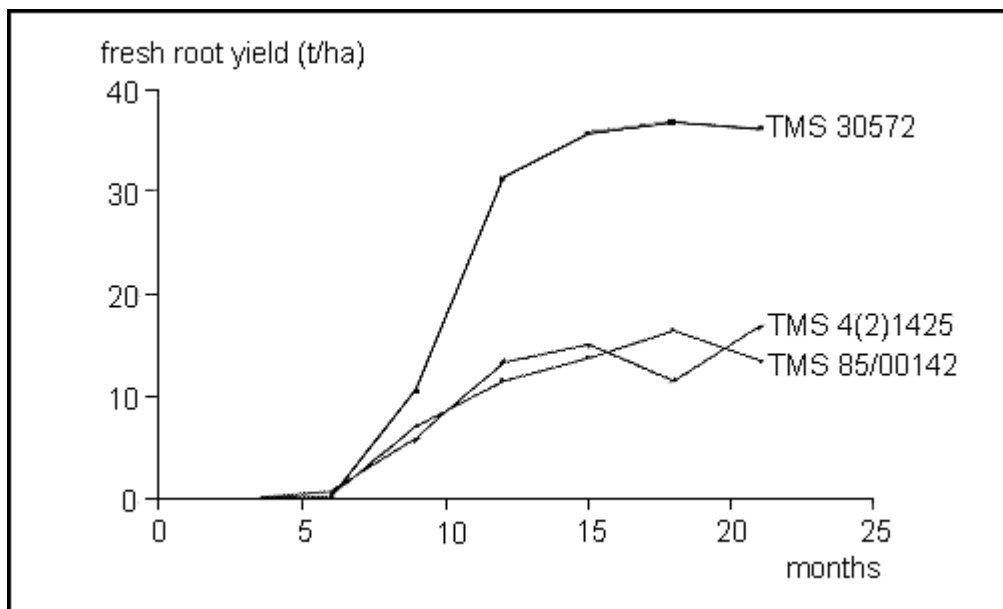
Most cassava varieties attain optimum weight about 18 months after planting when starch accumulation is highest ([Figure 5](#) and [Figure 6](#)).

Farmers do not usually harvest all the plants on a plot at the same time, because cassava remains in good condition for only a few days after harvest. Farmers harvest only the quantity required for immediate use.

In traditional farming, farmers harvest manually. Farmers cut the stems a few centimeters above the ground with a machete, then loosen the soil around the tuberous roots, and pull the stub of the stem to lift out the root.

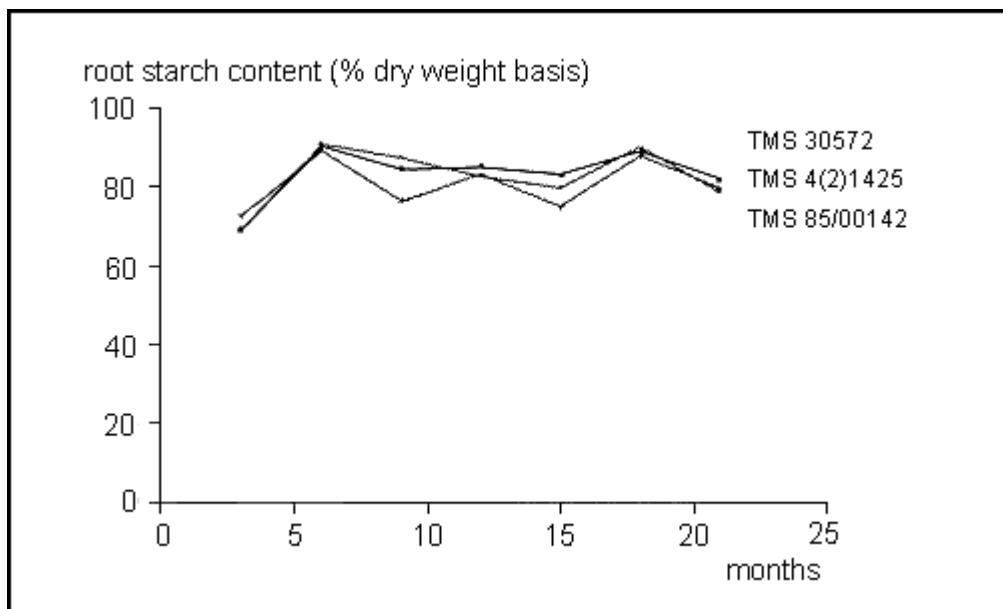
Mechanical harvesters are available to uproot tuberous roots, which are then picked by hand.

Harvesting is easier when the soil is moist. Harvesting is also easier if planting is on ridges or in beds and in loose or sandy soils, rather than on flat ground and in clay or heavy soils.



**Figure 5.** Yield of different cassava cultivars, Ibadan, Nigeria.

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**Figure 6.** Starch content of cassava cultivars, Ibadan, Nigeria.

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