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Cassava Information Center
Centro Internacional de Agricultura Tropical
CIAT

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CONTENTS

PRODUCTION OF CASSAVA PLANTING MATERIAL

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ABSTRACT

Quality cassava "seed"** production depends on several factors, including the type of material used, sanitary conditions and storage. The quality of the seed per se is determined by the age of the stem used, the number of nodes per cutting, the thickness of the cutting, varietal differences in germination, and the extent of mechanical damage that the cutting may suffer when it is being prepared, transported and planted.

Seed quality can be reduced by the presence of systemic, localized or soil-borne pathogens, as well as by the attack of mites and insects that may be found on the surface of the stem cutting, within the stem, and/or in the soil.

Storage generally reduces germination of cuttings as a result of dehydration or attack by pathogens and other pests during the storage period.

To avoid problems involved with cassava planting material, cuttings should be selected carefully from good-quality stems; they should be disease and pest free and treated with eradicant as well as protectant fungicides, insecticides and/or acaricides. This treatment makes it possible to store cuttings for periods of more than 30 days.

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** Throughout the text the term "seed" is used to refer to the vegetative form of propagation.

Cassava (*Manihot esculenta* Crantz) is a perennial shrub that is best propagated vegetatively. The swollen roots accumulate carbohydrates (25). Since the plant does not mature physiologically, the roots are harvested from 7 to 24 months of age, depending on the ecological conditions, on the demand for the product, and on the variety used. It should thus be considered as a crop with a long growing cycle.

In any vegetatively propagated crop, good cuttings are necessary for high yields; in cassava, losses in germination may reduce yields drastically. Unfortunately, this aspect is underestimated by the majority of farmers. In most cassava plantations, the plant stand is lower than the number of cuttings planted originally; there is little uniformity in plant vigor from one plant to another; production per plant varies considerably; and root rots are generally found at harvesting. Although edaphic and climatic factors may account for some losses, the use of high-quality, clean cuttings will generally reduce the relative frequency and intensity of losses.

In addition, systemic pathogens (viruses or viruslike organisms, mycoplasmas, bacteria and fungi), as well as mites and insects that attack the cassava stem, are disseminated through the use of infected propagating material (1, 14, 15, 19, 20), and are thus frequently introduced into plantations, regions, countries or continents where they did not previously exist.

For these reasons it is of utmost importance that cassava growers always use good-quality seed in order to obtain uniformity in their establishment, as well as good production, to reduce root rots, and to prevent the introduction of pests not found in the area. Good cassava seed is produced from clean, quality stems; proper storage is also important.

QUALITY OF THE CASSAVA SEED

The quality of cassava seed depends on stem age, thickness, number of nodes per cutting, and size. Although there have been no conclusive findings in this respect, repeated observations indicate that control of these factors is essential for the germination of vigorous plants capable of producing a good number of commercial roots.

Age of the stem

The most suitable age of a stem cutting has not been determined. Nevertheless, it is well known that although cuttings from green stems (slightly lignified) will germinate, they are extremely susceptible to attack by soil-borne pathogens as well as by sucking insects. Besides, immature herbaceous (green) stem cuttings cannot be stored for a long period of time since they have a high water content and tend to dehydrate rapidly. Also, since they are succulent, many microorganisms (bacteria and fungi) attack them, causing severe rot a short time after planting (11, 27).

When cuttings are taken from plants more than 18 months old, the stem is highly lignified, containing only a small amount of food reserves for the shoots that germinate from the buds. For this reason, germinating buds have reduced viability, present delayed germination, and/or produce shoots of little vigor. These older stems may also have suffered a greater number of lesions caused by localized pathogens or insects. It is also more difficult to prepare the cuttings from older, woody stems.

It is recommended that planting material be taken from plants ranging from 8 to 18 months of age. The younger the plant, the more lignified should be the part of the stem selected for the cutting. One practical way of knowing whether a stem is sufficiently mature is to determine the relationship between the diameter of the pith and the stem cutting in a transversal cut. If the diameter of the pith is equal to or less than 50 percent of the diameter of the stem, it is sufficiently mature to be used for planting (27).

Number of nodes per cutting

Each stem node has an axilliary bud; theoretically, one plant can be obtained from each node. Nevertheless, it has been found that cuttings with one to three nodes have low percentages of germination under field conditions (27) since they are very short and therefore more susceptible to rapid dehydration. Also, pathogens can invade the whole cutting in a relatively short time. Finally, cuttings with few buds have a greater probability of losing the viability of all their buds during their preparation, transportation and planting. Long cuttings with more than ten nodes theoretically have a better chance of conserving their viability because of the greater number of buds. Nevertheless, when long cuttings are used, much more propagating material per unit of surface area is required, and there is also greater possibility that this material will be affected by localized pathogens and insects.

Based on these data, the stem cuttings used should have from 5 to 7 nodes and a minimum length of 20 cm.

Thickness of cuttings

Although any part of the cassava stem can be used for propagating material in a commercial operation, thin stems, which have fewer nutrient reserves, should not be used since shoots are weak and only a few small swollen roots are produced (9, 27). As a general rule, it is recommended that the thickness of the stems used for cuttings should not be less than one half the diameter of the thickest part of the stem of the particular variety being used.

Variety

Great varietal differences exist as regards the germinating capacity of cuttings. These differences are accentuated when the cuttings are stored: the longer the period of storage, the greater the differences (Sanay and Lozano, personal information). Therefore, varieties with a higher germinating capacity should be used. The germinating capacity of any given variety can be determined easily by evaluating the percentage of germination among cuttings from different varieties after a short storage period; i.e., 15 days.

Mechanical damage

The epidermis and buds of cuttings can be bruised or damaged by friction and machete wounds during their preparation, transportation, storage and planting. Each wound is a new site of entry for microorganisms that cause rot during storage or after planting. It is very important that all precautions be taken to avoid rough handling when cutting and transporting the stems or branches that have been selected for propagating material. The cut should be made with a well-sharpened machete or circular saw, in which case the stem should be held with both hands while it is being cut. When the cut is made at a right angle, perimetral and uniform rooting is obtained (9, 27).

SANITARY CONDITION OF THE SEED

The stem of the cassava plant is attacked by various pathogens that induce internal or external rot and/or cortical or epidermal cankers. Other pathogens invade the woody stem tissue systemically without leaving any visible symptoms (viruses, mycoplasmas, cassava bacterial blight). The cassava stem is also attacked by insects and mites that are localized on the epidermis or within the stem.

Pathogenic aspects related to cassava seed

Based on their localization and presence on the stem, the pathogens attacking cassava can be grouped as follows:

1. **Systemic pathogens** are vascular [viruses and mycoplasmas (10,14); *Xanthomonas manihotis* (19)] and cortical or epidermal [*Sphaceloma manihoticola* (5, 13)] causal agents that invade the host systemically without leaving any visible signs in the mature portion of the stem. For this reason a high percentage of the plants coming from diseased cuttings are diseased; these plants may constitute the source of primary inoculum in the new plantation. It is by this means that systemic pathogens are disseminated from different regions, countries and/or continents (20).

   To prevent the presence of these pathogens, it is essential to use healthy seed. For example, African mosaic, which appears to be caused by a polyhedral virus (2, 24), is not found in the Americas or Asia (except for India); however, its vector (the whitefly *Bemisia* spp.) has been reported in Latin America (1). For this reason it is vital to prevent the introduction of propagating material from Africa and India. In places where the disease is found, its incidence has been lowered through the selection of apparently healthy plants from diseased fields

(2). Resistant varieties exist (22), but their seed may bear the causal agent, thus constituting the source of inoculum for plantations where susceptible varieties are used.

It was recently shown that apparently healthy plants can be produced by culturing plant meristem taken from plants infected with African mosaic (12). Nevertheless, since there is still no method that detects the presence of the causal agent in the host, the system does not provide a margin of absolute safety.

The American viruses (common mosaic and leaf vein mosaic) and mycoplasmas (witches'-broom) appear to be transmitted in cassava only by mechanical means and in relatively low percentages (10, 14). Therefore, the percentage of infection from these diseases is limited (10). Since disease-free plants are always available for selecting seed for planting, disease can be eradicated with a high degree of efficiency by roguing plants with disease symptoms. If this does not completly eradicate the disease, it will at least reduce the percentage of potential inoculum to a great extent (10, 14).

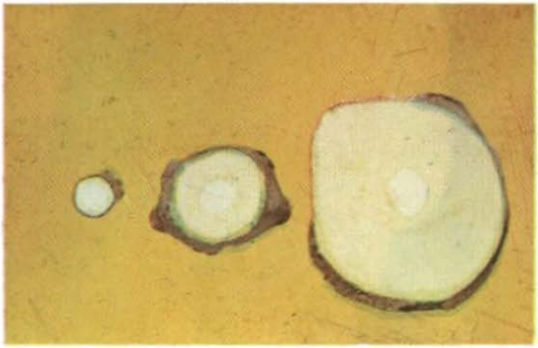
It has been shown that healthy plants can be obtained from plants affected with cassava bacterial blight by taking shoots (5 to 10 cm) from cuttings from diseased plants (17, 18), using the method of rooting in sterilized water (26). The plants obtained by this method constitute the foundation for producing certified disease-free seed (18). The foundation stock can be multiplied by traditional methods or by using the rapid propagation method developed by Cock et al. (8). The disease-free material can then be used to plant lots where cassava has not been planted before or where the pathogen has been eradicated by a six-month rotation with other crops or crop fallowing (16, 17). This seed can be distributed without risk to other regions where the disease does not exist.

The causal agent of superelongation *(S. manihoticola)* can also be introduced by using cuttings taken from infected plantations (4, 5, 6, 13). For this reason, only cuttings from healthy, disease-free plantations should be used. It has been found that treating cuttings with fungicides such as Difolatan and Orthocide (4000 ppm ai.), the pathogen can be eliminated from the cuttings (7). One of these fungicides should

(a)

(c)

(b)



(d)

he quality of cassava stem cuttings depends on:

em age

(a) Left, immature, herbaceous; center, appropriate maturity; right, too woody.

(b) Transversal cut of stems shows the relationship between pith and stem diameter.

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tting

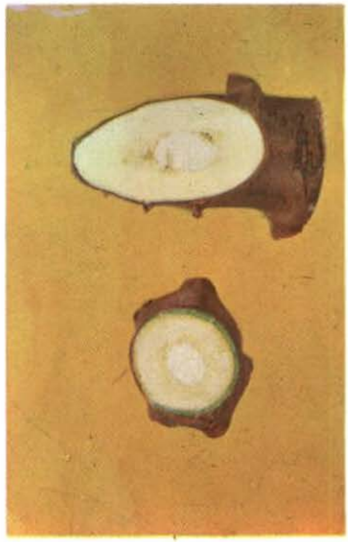
(c) Left, cutting with too few nodes; right, adequate no. of nodes.

(d) Cutting of correct size (20 cm) and sufficient no. of nodes.

(a)

(b)

(d)



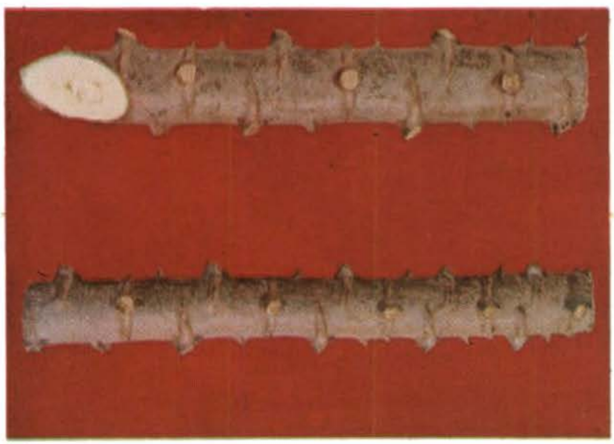
Other factors contributing to cutting quality are:

Thickness (a) Left, thin herbaceous stem; right, suitable diameter.
(b) Transversal cut compares thicknesses. Approx. 50% of the stem at the left is pith.

Cutting angle (c) Above, cutting at an angle is not recommended; below, transversal cut gives better root distribution.
(d) Close-up of the two methods.

Mechanical damage (e) Left, intact cutting; right, damaged cutting should be rejected.

(e)



(c)

(a) Cassava bacterial blight

(b) Stem gall

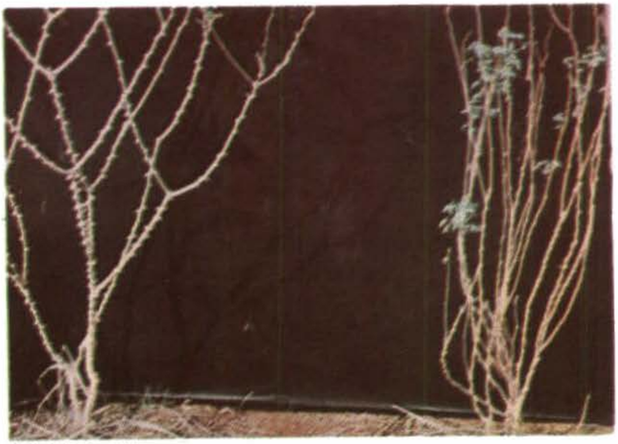
Diseases can be introduced by using cuttings taken from infected plantations.

These are some bacterial and fungal diseases that can be introduced by this means.

(c) Superelongation

(a) African mosaic

(b) Leaf vein mosaic



(c) Witches'-broom

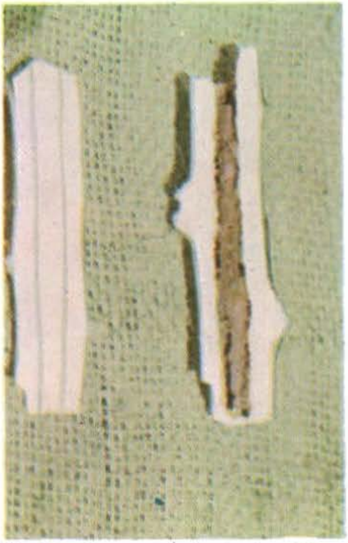
Among other diseases that can be introduced by infected planting material are those caused by viruses and mycoplasma.

(a) Anthracnose

(b) Basidiomycetous stem rot

Localized pathogens can attack the main stem of cassava plants, inducing cankers and rotting which can reduce the germinating capacity of cuttings or the vigor of the resulting shoots.

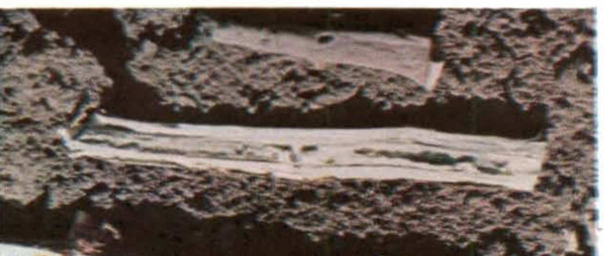
(c) Bacterial stem rot



(a) Stemborer galleries in the pith

Among the most important insect pests of cassava planting material are the stemborers and scales.

(b) Heavy stemborer damage



(c) Damage induced by termites

(d) Heavy infestation of scales

(a)

In selecting the part of the plant to be used for cuttings, the more lignified section should be used as indicated in photo (a) (between the worker's hands). The pieces should be cut carefully to avoid injury to the stem (b). Careful treatment of the stem sections is vital; only small groups should be handled at one time (c).

(b)

(c)

(a)

(b)

(c)

(d)

Untreated cuttings can be infected by pathogens or insects soon after planting. By using pesticides, this damage can be avoided (a). In photo (b), cuttings at the extreme left were untreated; the others were treated with different fungicides at different rates. Certain fungicides not only induce protection but germination of cuttings is also faster. In photo (c), cuttings at the left were unprotected; the others were treated. Fungicides also increase the time that cuttings can be stored. The field in photo (d) shows cuttings stored 1 mo. Those treated with fungicide have germinated well. There are heavily reduced stands in the lower left-hand corner where untreated cuttings were planted.

therefore be used to treat the cuttings that are taken from areas where the disease is endemic.

2. **Localized pathogens** are nonsystemic pathogens (causal agents of bacterial stem rot, anthracnose, concentric-ring leaf spot, some basidiomycetes, etc.), that invade only a part of the stem. These pathogens generally leave cankers of light brown to black necrotic areas on the epidermis of the stem. Other pathogens such as the causal agent of bacterial stem rot also invade the pith region, which turns reddish yellow to dark brown in color.

   This group of pathogens enters the stem through wounds produced mechanically or by insects, or by invading the leaf petioles, penetrating them directly or through the stomata. Others enter directly into the stem, rapidly invading the green portion. The degree of invasion decreases as the stem becomes lignified (15).

   Any part of the stem that is healthy and that does not show any signs of attack from localized pathogens can be used for planting material. When selecting seed, all parts that are affected by these pathogens—i.e., cankers, blackish epidermal areas or reddish pith areas—should be destroyed. It is also advisable to disinfest machetes or saws that are used to cut stems, cleaning them with commercial preparations of formaldehyde at 5 percent to prevent mechanical transmission of the disase through infested tools.

3. **Soil-borne pathogens** that commonly attack some other hosts such as forest trees *(Fomes lignosus, Rosellinia necatrix, Armillariella mellea)*, perennial crops such as coffee, bananas and plantains (*Fusarium* spp., *Rosellinia* spp., etc.), and herbaceous crops with short growing cycles such as cotton and beans [*Rhizoctonia* spp., *Sclerotium rolfsii, Whetzelinia (Sclerotinia) sclerotiorum, Phytophthora* spp., *Pythium* spp.] often attack cassava as well. Attack by these pathogens occurs once the cuttings have been planted, beginning at the ends of the cutting, entering through the epidermal wounds or at the base of the shoots and/or in the rootlets.

   The best way to prevent cuttings and seedlings from attack by these pathogens is to diminish soil infestation by rotating cassava with nonsusceptible crops such as Gramineae and by using certain cultural practices such as good drainage and planting on ridges (3, 23, 27). In addition, it has been shown that treating the cuttings with disinfestants, disinfectants and seed protectants is highly advantageous. Treating cuttings with certain fungicides or mixtures of these has the following advantages: (1) a disinfestant effect, (2) protectant action, (3) longer storage time, and (4) accelerated germination, rooting and growth. Among the fungicides and mixtures that can be recommended are Orthocide + Bavistin, Daconil + Manzate, Dithane M-45 + Manzate, Demosan 65, Brassicol 75, Vitrigran and Agallol (2000 ppm a.i. in mixtures; 4000 ppm a.i. when used alone). Mixtures usually provide a broader protective spectrum.

The cost of the treatment is relatively low (see Table) since only one preparation is required for treating a large number of cuttings. Therefore, it is recommended that this treatment be done as a matter of routine immediately after the propagating material has been prepared. Results suggest that once cuttings have been treated, yields will increase more than 25 percent and the material can be stored for one month without losing its germinating capacity (Sanay and Lozano, personal information). If superelongation is found in the region, Difolatan or Orthocide should be used. In addition, as discussed below, an insecticide such as malathion, Tamaron or Basudin should be used to control insects found on the surface of the cutting.

Entomological aspects of the cassava seed

There are mites and insects that attack the cassava stem, reducing the production and the quality of the propagating material that comes from affected plants.

There are also soil-borne insects that attack cuttings after they are planted, causing wounds or boring holes through which soil-borne pathogens can enter. They may also destroy the epidermis and/or buds of the cuttings completely. Other insects cut the roots and/or shoots shortly after their emergence. Mites and insects attacking cassava can be classified as follows:

1. **Mites and insects on the stem surface.** Mites generally attack leaves and green parts of the plant. When they migrate, they are found on the stem surface of the infested plants, where they attack the germinating buds. Through infested material, they can be carried to other geographical

areas and continents. For example, *Mononychellus tanajoa* was introduced to Africa on infested cuttings (1, 20). The scale insects (*Aonidomytilus albus, Saissetia miranda,* etc.) and the mealybug *(Phenacoccus gossypii)* are also disseminated in this manner. These insects can reduce the germination of infested cuttings up to 70 percent, depending upon the degree of infestation. The eggs and larvae of other insects such as thrips *(Frankliniella williamsi, Corynothrips stenopterus, Caliothrips masculinus),* mealybugs *(P. gossypii),* lace bugs (*Vatiga* spp.) and others can also adhere to the surface of stems and are spread when the infested cuttings are transported from one place to another.

In order to prevent mite and insect infestations on cuttings, acaricides and insecticides such as malathion E.C. (100-300 ppm), Tamaron (200 ppm) or Basudin (200 ppm) should be used. These products can be applied by dipping the cuttings in the solution for 5 minutes; they can also be mixed with the fungicides that are recommended as protectants, disinfestants and/or disinfectants (see table).

2. **Insects found within the stem.** The insects that are found in the cassava stem are generally stemborers (various species of Coleoptera, Lepidoptera and Hymenoptera). Larvae of these and other insects such as the fruit fly (*Anastrepha* spp.) and the surface or subterranean cutworms that feed on the stem *(Agrotis ipsilon, Prodenia eridania)* (2, 21) are often carried inadvertently from one place to another. The tunnels and galleries they make in the stem are another means of access for microorganisms that cause stem rot.

   To avoid using cuttings that have wounds or that are infested with insects, a careful selection should be made of the stems beforehand. Any part of the stem that has external or internal lesions caused by insects should be discarded and burned. Internal damage can often be noted by discoloration of the pith.

3. **Soil-borne insects.** Some insects that attack cassava cuttings after planting are found in the soil. They usually destroy the cortex of the cutting and make tunnels, which favor microbial rots. Losses in germination and/or sudden death of the seedlings result. The most common soil insects are white grubs (Coleoptera belonging to the families Scarabaeidae or Cerambycidae), termites (*Coptotermes* spp.) and cutworms (*Agrotis* spp.). To prevent the attack of these insects, aldrin should be incorporated in the

COSTS OF TREATING CASSAVA CUTTINGS WITH CERTAIN PESTICIDES AND ZINC SULFATE

Product	Price/kg* (Col. pesos)	g/ha	Cost/ha* (Col. pesos)	Aggregate cost/ha (Col. pesos)	Aggregate cost (US $)
Dithane M-45	48.50	333.0	16.00	16.00	0.43
Manzate 80	45.00	187.5	8.00	24.00	0.65
Vitigran	61.00	300.0	18.00	42.00	1.15
Malathion E.C.	86.00	750.0	65.00	107.00	2.93
Zinc sulfate**	20.00	6,000.0	120.00	222.00	6.21

* Including 0.5 man-days
** Use only when there is a deficiency of zinc.

soil (1.5 kg a.i./ha) or carbofuran (0.9 g a.i./plant) should be placed immediately under the cutting. In the case of termites, a residual insecticide such as aldrin, dieldrin or chlordane should be used. Toxic baits (i.e., 10 kg sawdust, 8 to 10 liters water, 500 g sugar or molasses, and 100 g trichlorphon for 1/2 to 1 ha) also give excellent results (1, 21).

STORAGE OF CUTTINGS

Farmers usually store cuttings while they prepare the land for planting or until the rainy season begins. While the cuttings are being stored—whether already cut or in long pieces of stem—buds usually germinate, pathogens and insects contaminate the material, and the material dehydrates. Longer storage periods generally lead to more severe damage. The material may dry out, with signs of visible rotting and cankers on the cortex; or immediately after the cuttings are made, they may lose their germinating capacity. The final result of storage is a reduction in plant population per unit of surface area, which becomes more severe as the period of storage increases.

It has been found that more than 90 percent germination can be obtained after one month of storage when 20- or 50-cm cuttings or stem pieces are treated before storage with the protectant fungicides recommended previously (see section on soil pathogens).

An additional treatment before planting (with the same fungicides) favors germination even more. These treatments can be made when applying the insecticide for controlling the insects found on the cuttings. To prevent dehydration of the cuttings during storage, long pieces of stem, preferabley 50 to 80 cm, should be used. When preparing the cuttings, the 10 cm at each end of the stored stem should be discarded.

The storage area should be well shaded and offer high, but not excessive relative humidity (about 80%) and moderate temperatures (20-23°C). Planting should be done when there is adequate soil moisture since high soil temperatures inhibit germination and the thermal inactivation point of cuttings is low (4).

Although it is not known whether there is varietal resistance to the factors that damage cuttings during storage (dehydration, attack by pests, and rapid germination of the buds), highly significant varietal differences have been found (Sanay and Lozano, personal information). Consequently, varieties that have a high germinating capacity should be used.

CONCLUSIONS

It is necessary to plant good cassava seed in order to obtain high yields. In order to obtain good seed, the following points should be considered:

1. Good-quality seed comes from a variety with good germinating capacity. The part of the stem selected for the cutting should be of sufficient maturity (between 6 and 18 months old), have 5 to 7 nodes, measure at least 20 cm in length, and have a diameter of more than one half the maximum thickness of the stem of the variety planted.

2. Care should be taken to prevent mechanical damage to the cuttings during their preparation, transportation and planting. The cuts should be even and transverse.

3. Propagating material should not be introduced from Africa mosaic-infected regions to clean areas.

4. Propagating material should not be introduced from regions where there is cassava bacterial blight or superelongation. When these diseases are present in a region, sources of planting material should be taken only from those plantations that remain disease free during the rainy season. If there is no such material available, material free of bacterial blight should be produced (18) and the cuttings treated with fungicides that will eradicate the causal agent of superelongation (Difolatan and Orthocide).

5. Cuttings should not be taken from plants that present symptoms of virosis or mycoplasmosis. All such plants should be rogued and burned.

6. All cuttings should be checked carefully a..d any piece of stem that shows signs of localized pathogens (localized epidermal cankers or pith rotting) and insect damage (galleries or tunnels, epidermal wounds) should be destroyed.

7. Cuttings should be treated with fungicides and insecticides as soon as they are cut from the plant and before storage. Storage should be reduced to a minimum, preferably no longer than 30 days.

8. Cuttings should not be planted in soil infested with insects (white grubs, termites, cutworms) without applying insecticides around the cuttings or in the soil.

9. Planting should be done when the soil has a good moisture level and not during the dry season. Good agricultural practices should be used, preparing the soil well before planting.

10. If upon harvesting, there is a lack of uniformity in production and more than 5 percent root rot, cassava should be rotated with Gramineae for a period of no less than six months.

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