Ministry of Agriculture

SMALLHOLDER AGRICULTURAL PRODUCTIVITY ENHANCEMENT AND COMMERCIALIZATION (SAPEC) PROJECT

RICE PRODUCTION TRAINING MANUAL

Dr. Inoussa Akintayo (AfricaRice)

Dr. Sizi Z. (Greenstar Inc.)

RICE PRODUCTION TRAINING MANUAL

(OUTLINE)

INTRODUCTION

IMPORTANCE OF RICE IN LIBERIA

- **Rice is Liberia's No. 1 staple food and historically acclaimed political crop – the cause of the 1979 rice riot.**
- **Consumption wise, Liberians are ranked among the top 15 rice eating nations of the world.**
- **In Liberia, most citizens have not eaten unless they eat rice.**
- However, for Liberians, rice is more than just a political and staple commodity.
- Rice represents the principle crop upon which the rural farming calendar evolves.
- It is the progenitor of the traditional social and seasonal calendars.
- Holidays and festivities are traditionally scheduled so that they do not interfere with peak rice cultivation activities.
- Holiday festivities are always schedule for periods of rice harvest, when there is assured abundance of food.
- Alternative crop production activities i.e. cassava, plantain, banana, eddoes, potatoes, pineapples or forest garden production activities are performed when non-conflicting with the main upland rice production activities.

PURPOSE OF THIS MANUAL

To provide rice technicians with the knowledge and skills they need to be effective agents of change in rice development and the agriculture sector. Basically this manual should be a tool to assist technicians in carrying out the below tasks:

1. WHEN TO INTRODUCE INTERVENTION PROGRAMS THAT POSITIVELY IMPACT PRODUCTIVITY.
2. HOW TO INTRODUCE INTERVENTION PROGRAMS THAT POSITIVELY IMPACT PRODUCTIVITY.
3. HOW AND WHEN TO INFLUENCE FARMERS CROP PRODUCTION HABITS.

RICE GROWING ECOLOGIES IN LIBERIA

Worldwide, rice is grown on two separate ecologies; upland and lowland ecologies. Liberia has plenty of both ecologies. Liberia's toposequence is that of undulating, gentle rolling hills to steep intersurfaces interspersed with valley bottoms (lowlands).

THE LIBERIAN FARMING SYSTEM

From time immemorial, the predominant farming system practiced in Liberia is done on uplands where forest is brushed, felled, burnt, cleared and the rice broadcast and scratched or dibbled. This process is repeated every year, moving to a new fertile spot and leaving the old to fallow (5-7 years), hence the name **"slash and burn shifting cultivation".**

Liberian farmers generally farm across both ecologies in a fashion known as "continuum farming", that has many ills and shortcomings. Recognizably, despite the ills and shortcomings this traditional farming system, it is the way of life of the rural farmers; their mores, norms and social and cropping calendars are based on this system.

As one embarks on a mission to intervene in farmers' production habits and impact productivity, it is important that we know the differences in terms of soil, water and growth regimes and requirements between the two ecologies and more over understand their production requirements as we strive to develop more sustainable production systems.

UPLAND ECOLOGY

The rice must grow under a freely drain soil condition – not water logged. The rice grows under an obligate aerobic environment.

The crop naturally possesses some tolerance to extreme soil conditions but not for long. It can withstand and recover from short periods of drought and/or flooding but not for long spells. Wherever water stands in the field for a prolonged period, the crop dies out.

The rice crop is totally rain fed, i.e. dependent on the seasonal rainfall to support crop growth to maturity. Naturally the production season coincides with the main rainy season. Varieties here are usually medium to long duration to fit into the traditional system of harvesting some early varieties to upkeep the farmer during the hunger spells and letting the main crop mature with the end of the rainy season.

Most traditional post-harvest measures are dependent on the weather – harvesting, stacking, drying, threshing, etc. depend on the dry season.

ADVANTAGES OF UPLAND ECOLOGY

- possibility of multi cropping/ planting several crops at the same time e.g. Rice, cassava, plantain, corn, okra, beans, etc.
- Some second crops get ready first, giving farmers food before the main rice crop is ready or during off season
- **DISADVANTAGES OF UPLAND ECOLOGY**
- Yield per acre is low (ranging from 0.5t/ha to 0.8-1.3t/ha)
- Environmental impact greater (destroys forest through the annual slash and burn shifting cultivation)
- Nutrient loss is high – Nutrient is depleted quickly during run-off/ erosion
- Crop growth is mainly dependent on nature (soil fertility status, rainfall and sunshine)
- Weed and insect incidences very high during the second year
    - ***Upland rice varieties***: rice varieties which require obligate upland environment (freely drain soils) for optimum growth and productivity. **Examples** – Lac 23, WAB series and most of our traditional rainfed upland varieties.
    - These varieties depend on the rainy season for all the water they need to grow and produce.

- They can normally withstand slight variations in moisture regimes but not excessive stress conditions (prolong drought or water saturation).

LOWLAND ECOLOGY

Research over the years has shown and proven that lowland rice farming is more profitable in terms of yield per acre. Lowlands' biggest advantage over upland is their fertility and their ability to hold / store water which makes them more suitable for cultivation.

Lowlands also have the capacity to support two or more cycles of rice crops in one year; or to support other crops through a complete production cycle after a rice crop.

Advantages of Lowland Ecology

- Suitable for continuous farming
- High nutrient availability and efficiency
- Constant water supply
- High yielding production

Disadvantages of Lowland Ecology

- High labor and initially cost intensive
- High disease incidence

MORPHOLOGY OF THE RICE PLANT

- The rice plant is a round and hallow annual grass with vegetative parts consisting of roots, culms, stems (nodes and internodes), leaves and the panicles (reproductive organs).
- The different stages of the rice plant growth and morphology.
    - **Roots**: anchor the rice plant in the soil and absorb water and nutrients.
    - **Culm**: The jointed stem of the rice plant.
    - **Stem**: made up of a series of nodes and internodes.
    - **Node** – is the solid portion of the culm. The nodal region bears a leaf and a bud.
    - The **bud** appears on the upper portion of the node and is enclosed by the leaf sheath.
        - The bud gives rise to a leaf or a tiller.
        - Young internodes – are smooth and solid
        - Mature internodes – are hallow and finely grooved with a smooth outer surface
    - **Primary tillers**
        - Arise from the main culm in an alternate pattern from the lowermost nodes.
        - Give rise to secondary tillers.
        - **Secondary tillers** produce **tertiary** tillers
    - **Leaf** -Borne at the nodal region of a culm, alternately and in opposite directions. One leaf at each node
        - **Flag leaf** – the topmost leaf below the panicle
        - Leaf blade and leaf sheath are continuous
        - Collar – circular structure that joins the leaf blade and the leaf sheath
    - **Leaf sheath** wraps around the culm above the node
    - **Sheath pulvinus** – swelling at the base of the leaf sheath, just above the node
    - **Leaf blade** –generally flat, but differ by varieties in blade length, width, thickness, area, shape, color, angle and pubescence.
    - **Panicle** – inflorescence at the terminal portion of the rice tiller. The panicle bears spikelets

- **Neck** – panicle base
- **Panicle axis** – continuous and hallow except at the nodes where branches are borne
- **Panicle pulvinus** – swellings at the panicle axis where branches are born
- **Primary branch** – arranged singly or in pairs. Give rise to secondary branches
- **Secondary branch** – give rise to spikelets

- **Spikelets** – develop into grains.
  - The basic unit of the inflorescence and panicle.
  - Consists of the pedicel and the floret.
  - Pedicel – is the support of the floret.
- **Floret** - supported by the rachilla, sterile lemmas and the rudimentary glumes covering the flower.
- **Lemma** – larger protective glume covering the floret
- **Palea** – smaller protective glume covering the floret
- **Nerves** – ridges on the lemma(5) and palea (3)
- **Keel** – constricted structure at the end of the lemma
- **Awn** – an elongated thin extension of the keel

RICE GROWTH PHASES

Rice growth is generally categorized into 3 phases:

Vegetative phase (Germination to panicle initiation)

- Germination – emergence – seedling – tillering – stem elongation to panicle initiation
- The relative length of this stage determines whether the variety is short, medium or long growing cycle.
- This is the period of most crop management operations – weeding, fertilizer application, insect and disease control

Reproductive Phase (Panicle initiation to flowering)

- Panicle initiation – booting – heading/ flowering
- Is characterized by the emergence of the panicle, the development of the spikelets and the reproductive organs.
- Phase duration is relatively fixed at 30-35days irrespective of variety or season.

Maturity/ Ripening phase (flowering to grain filling on to complete maturity)

- Milky and dough stages and maturity.
- Phase duration also relatively fixed at about 30 days,
- Susceptible to climatic hazards (high temperatures, violent winds and drought) first 15 days after flowering

Components of rice plant

Grains

Florets

Spikelets /Branches

Panicles

Flag leaves

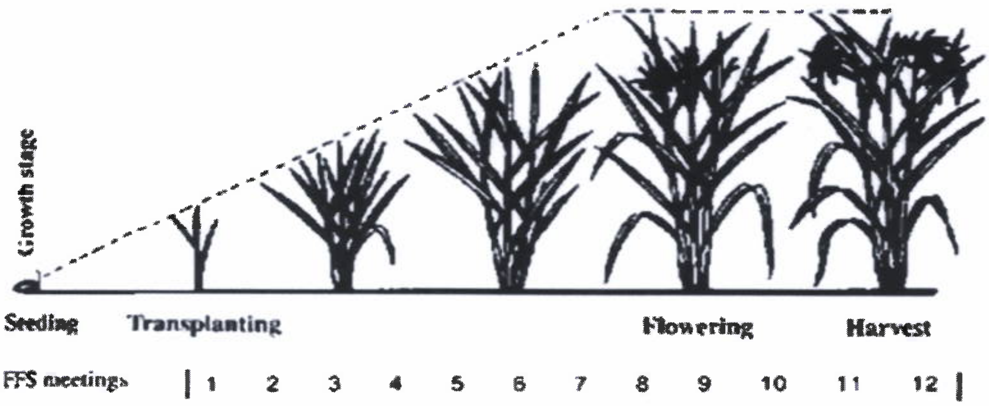
Leaves

Stem

Tillers

Roots

Growth stages of the rice plant



Important Growth Stages of Rice Plant

SEED GERMINATION	Variable	PANICAL INITIATION	25 (+/-) 10 Days	FLOWERING	25 -30 (+/-) 10 Days	HARVESTING
	Long duration variety means its vegetative growth stage is longer; Medium duration variety means its vegetative growth stage is medium Short duration variety means its vegetative growth stage is short That means period for tiller formation is variable for short, medium and long duration varieties. There are two types of rice (a) Panicle number type and (b) Panicle weight type					

Crop management for higher yield

SEED GERMINATION	How to produce maximum number of tillers early ????? -Use vigorous seeds -Early transplant -Adequate and balanced fertilizer -Weed control -Water management -Disease and pest management -Discourage non-productive tillers	PANICAL INITIATION	25 (+/-) 10 Days	FLOWERING	25-30 (+/-) 10 Days	HARVESTING

SEED

The reproductive unit of a plant produced for the purpose of replanting. Good quality seeds are those which are varietally pure, have at least 80% germination and are free from weed seeds and other physical impurities. Benefits of good quality seeds are:

- In high yielding varieties, seed is the most important input in the agricultural enterprise.
- It is the only practical means of transmitting to succeeding generations the genetic improvements incorporated into small populations of improved varieties by breeders
- Farmers can maintain productivity at maximum levels only if they have good quality seeds available to them.

SEED MULTIPLICATION

Seed multiplication is a complex process which requires a good organization and management capability. Seed multiplication starts with the breeder seed to foundation seed and subsequently to registered and certified seeds.

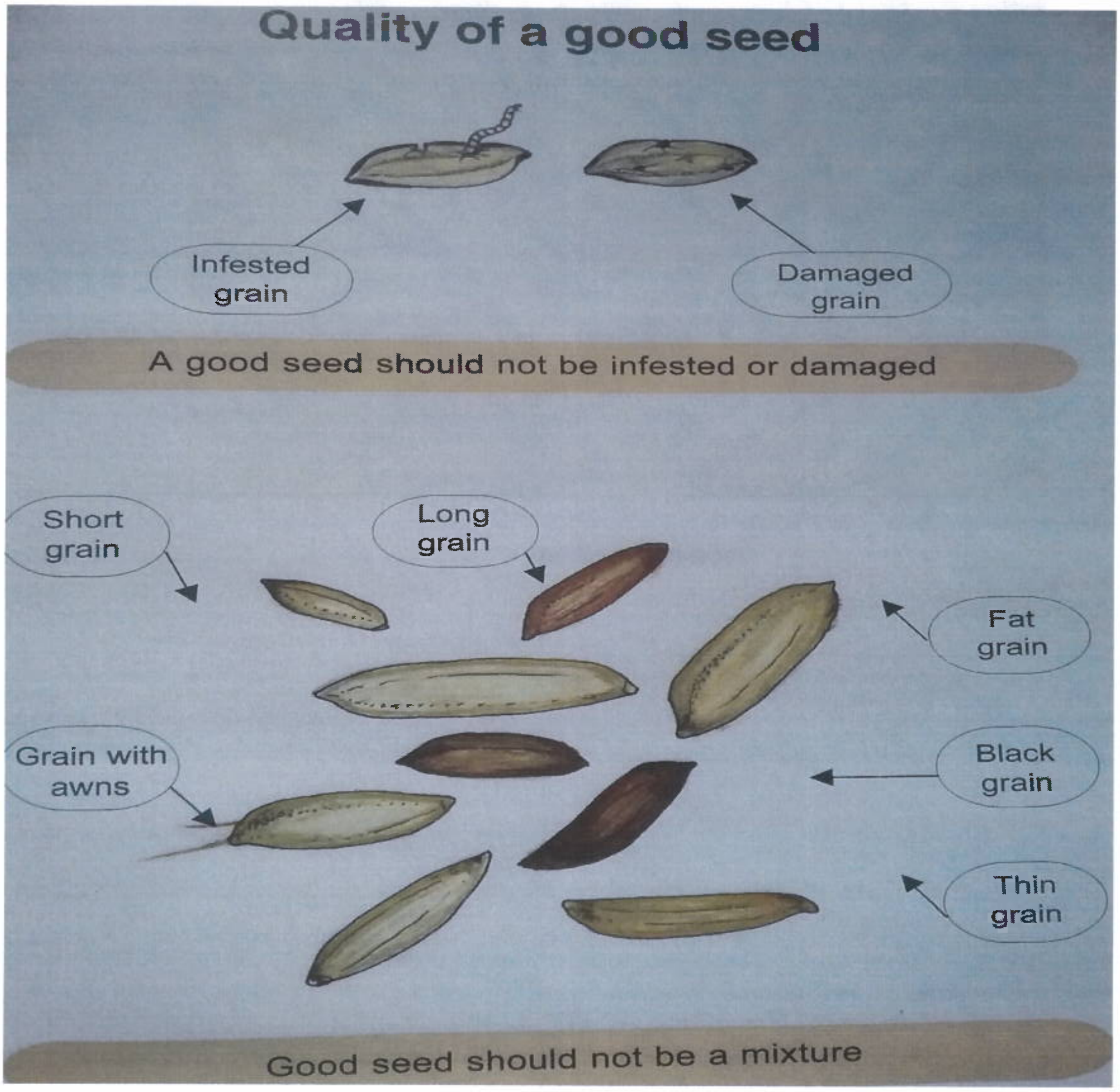
- Production of breeder and foundation seeds should be closely supervised by a research institute.
- Registered and certified seeds can be done at the Outgrowers and private enterprise levels. Some Private enterprises with the requisite expertise (breeders) can also be involved in breeder and foundation seed development.

Seed multiplication requires technical expertise, a clean environment with good soil fertility, a dependable water supply (rain or irrigation), low insect pest and disease incidence, absence of noxious weeds and good infrastructure, including production, harvesting and processing facilities, storage, road, transport and communication.

Seed Multiplication/ Production Programs – can be public (government-owned or official), semi-official or private.

- In public or official seed production programs, all operations, from planting to production, distribution and marketing, are under strict government control and supervision. Outgrowers can be used to produce registered and certified seeds but they must be under the control of government officials. Experience has shown this not to be very efficient but the need of the public sector program to initiate seed multiplication must be recognized.
- In semi-official seed production programs, the government agencies involved award contracts to selected, qualified farmers, private firms for the production of certified, registered and sometimes foundation seeds. The government institutions handle only the production of the breeder and foundation seed.
- In private seed production management, all activities from planning to production, distribution and marketing, are handled strictly as a private enterprise. It is a profit-oriented operation that exists to compete.

Good quality seeds



MAIN DIFFERENCES BETWEEN SEED AND GRAIN

	SEED	GRAIN
1	It is living, i.e. it is viable	It may or may not be living. It should not, however, have deteriorated.
2	Seeds in a seedlot must possess uniform physical and genetic characteristics.	May or may not be uniform. Uniform grain, however, is more appealing and is of higher quality.
3	Its sole purpose is for planting.	It is mainly for consumption. Some farmer plant grain not consumed.

Nursery Bed Preparation

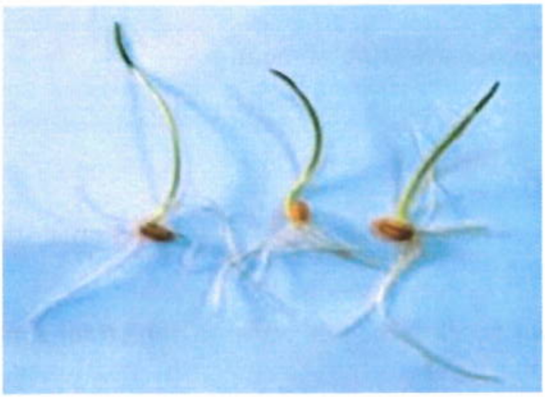
Site selection

Install nursery site in an accessible and sunny place (not be under shade trees), close to the rice fields and near water source, or even in a section of the field since seedlings need to be transplanted within 15 – 30 minutes after uprooting from the nursery. This is to reduce the transplanting shock normally experienced by the seedlings when uprooted from the nursery and transplanted to the field. The nursery soil should not be too sandy but rather clayey loam to be able to retain moisture and facilitate easy removal of seedlings for transplanting. Consider rich soil with organic manure or applied mineral fertilizer. Nursery should be kept from predators (rats, birds, ants).

Ensuring Viability of Seeds/ Germination Test

Before sowing seeds it is essential to check the viability of a given stock of the seeds by a germination test. Sowing of filled grains of good quality seeds is recommended. To obtain pure and quality seeds with high germination percentage, one of the below simple seed viability tests should be carried out to determine the actual quantity of seeds required for sowing.

A. **Petri dish test**:
   - Add water to seeds in the bucket and discard the empty grains that float in the water.
   - Place a moistened tissue paper in a dish with lid and put in 100 randomly selected filled seeds.
   - The dish should be covered and kept for 4 – 5 days at room temperature to germinate.
   - Count the number of sprouting seeds. Consider those with shoots greater than 1cm. Number of germinating seeds counted indicates the viability rate percentage (i.e. 75 germinating seeds = 75% germination).



   - If the recommended seed rate is 80kg/ha, the actual quantity of seeds to be sown is calculated thus:

$$\text{Actual seed required} = \frac{Seed\ rate(kg/ha)x\ Area\ to\ be\ planted\ x\ \%\ filled\ grains}{\%germination}$$

$$= 80kg/ha)x\ 1\ ha\ x\ \ 1\ (assuming\ 100\%\ filled\ grains)/\ 0.75$$

= 107kg/ha

B. **Salt Solution Test:** Another method of seed viability test is by using a salt solution prepared by adding table salt to the water in a bucket.

- Add a fresh chicken egg to the solution and check whether it floats. If not, the egg should be removed and more salt added to the solution until the egg floats.
- Remove the egg and put the rice seeds into the solution, stir vigorously and allow it to settle.
- Good seeds will settle at the bottom while the bad seeds will float.
- Discard the floating seeds, rinse the good seeds thoroughly with fresh water 3–5 times to clean off the salt.

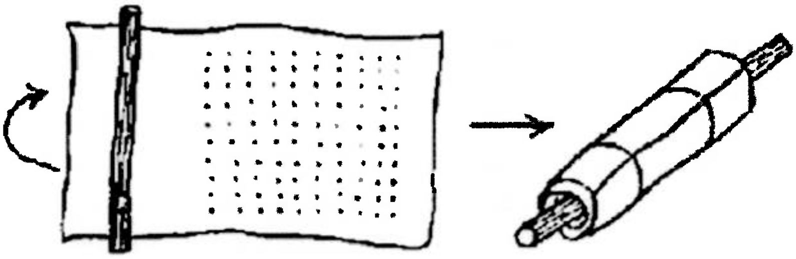
- Proceed to soak the seeds for nursery establishment.

C. Ragdoll test for seed germination

Materials: rice seeds, 3 – 5 handkerchief – sized rags, 3 – 5 small sticks and several short lengths of thread or twine.

- Soak the rags in clean water, allow the free water to drip off for a minute and spread the rag on a flat surface.
- Count out 100 seeds and place them evenly within the cloth. (e.g. 10 rows of 10 grains to facilitate the counting).
- Roll the rag carefully around a stick, leaving the seeds undisturbed.
- Fasten the rag to the stick and store the finished doll in a warm place.
- Keep the rag moistened every day.
- Unroll the rag after 5 days and count the number of seeds that germinate (i.e. seeds with roots).

- The number of sprouted seeds represent the germination rate of the seed sample e.g. (80 seeds out of 100 seeds = 80%).



Nursery Systems

The type of nursery system to use depends on water availability, labour and available agricultural Implements. There are 4 types of nursery systems for rice seedling production: i) Wet bed nursery, ii) Dry bed nursery, iii) Dapog or mat nursery, and iv) Seedling boxes for mechanical transplanting.

Soaking or Pre-germination of the seeds before sowing into Nursery

Irrespective of the type of nursery system to be used, it is recommended to soak and pre-germinate selected good quality seeds following the viability test and before putting seeds on nursery. Pre-germination enhances rapid growth and reduces the risk of seeds being washed away since emerging radicles quickly burrow into the soil after planting.

- Pour the seeds into a bucket containing clean water and discard all the floating seeds.
- Soak the rice seeds in water for 12-24 hours
- Transfer the soaked seeds into gunny/jute bag or in a basket lined with leaves.
- Ensure that the sack or basket is loosely filled to give room for seeds expansion during incubation.
- Leave it for 24-48 hours: the seeds should germinate during this period.
- Pre-germination takes place when white root or radicle emerges from the seed.

Wet-bed nursery

This nursery system is practiced in areas with enough water and pre-germinated seeds are broadcast on a well thoroughly puddled and levelled soil. Beds are prepared 1m wide by convenient length. The bed is raised 5–10cm height. It involves construction of drainage lines or canals across the field for proper removal of water when it is not needed. Decomposed organic manure and small amount of inorganic fertilizer should be added as basal dressing to promote seedling growth and vigor and increase the ease of seedlings uprooting. The total seed bed area is about 10% of the area to be planted with a seed rate of 25 kg per hectare. Seedlings can be transplanted within the ages of 15 – 21 days. The nurseries should be weed free and pest and disease incident should be prevented.

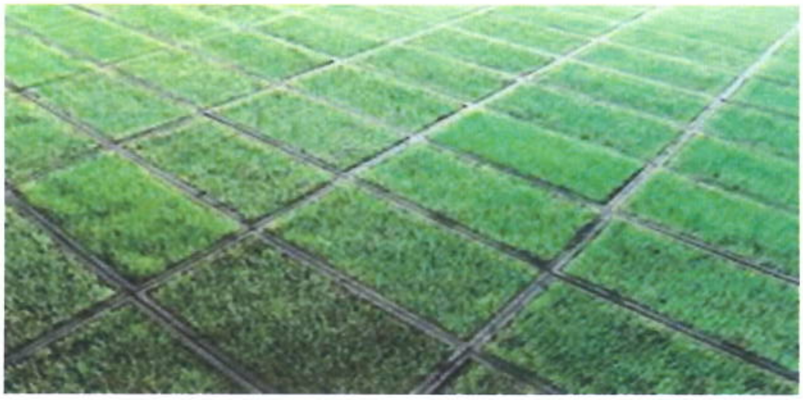
Dry-bed nursery

The nursery is prepared in dry soil conditions by constructing seed beds of convenient dimensions (usually 1m X 10m is recommended) for easy management. A maximum of 2kgs of seeds should be planted on a nursery bed of 10 m^2. Uprooting of seedlings for transplanting should be carried out between 15 – 21 days after germination. Heavy seedlings should be avoided as this produces weak seedlings that break easily during transplanting. A basal application of fertilizer mixture is required if the soil nutrient is low. The advantage of this system is that it produces short and strong seedlings with a longer root system compared with wet-bed nursery system. However the disadvantage is that roots may get damaged during pulling for transplanting and upland nurseries are more prone to pests and diseases.

Dapog or Mat Nursery System

Dapog nurseries can be established anywhere on a flat firm surface with reliable water supply and control. Irrigation is obligatory to prevent moisture stress. It requires less land and fewer inputs, mainly seeds, fertilizers and water. Area needed is about $100m^2$/ha or 1% of the transplantable area with a seed rate of 12 – 25kg/ha. Mark out 1m wide by 10m – 20m long plots. The seedbed is covered with burned paddy husk or compost of about 1 cm while the entire bed surface can be covered with layers of banana leaves or plastic sheets. Sow pre-germinated seeds on the seedbed, sprinkle water unto the seeds after sowing and then press down by hand or with a wooden flat board.

Young seedlings from dapog nurseries suffer less transplanting shock compared with other nurseries, thus the seedlings are more suitable for short duration varieties. Seedlings can be transplanted after 12 – 15 days when it reaches 4-leaf stage that favours quick establishment.



Seedling boxes for mechanical transplanting

This system requires the use of seedling boxes that are adapted to mechanical transplanter. Seedlings are grown on a thin layer of soil packed in trays of 30cm x 60cm dimensions. In some cases, seedlings can be grown on larger areas and then cut into rectangular strips (mats of seedlings) that fit well into the planting trays of the transplanter.

Seedling box nursery

Mechanical Transplanter in action

NURSERY WATER MANAGEMENT

It is essential that the nursery should never dry out. Avoid excess water as it leads to weak and elongated/ tall seedlings. Drain the nursery to sow and then keep the nursery moist for 3-4 days until emergence. Thereafter progressively increase watering/ water level until seedlings are pulled for transplanting.

NURSERY FERTILIZATION

If nursery soil fertility is poor or seedling growth slow, it is necessary to apply nitrogen fertilizer to promote vigorous seedlings. Apply urea at 10g/m2 = equivalent to 100gms per 1m x 10m nursery bed.

PREPARING THE FIELD FOR PLANTING THE CROP

Land preparation include several operations, some optional depending on the state of the land (developed or undeveloped). The below operations are for developed lowlands.

- Clearing and weeding the field: involves cutting the weeds and stacking them on the bunds, or spreading them over the field.
- Pre-irrigation: involves flooding the field for 2-3 days before the first plowing to moisten the soil and facilitate plowing.
- Plowing: involves incorporating weed and crops residue into the soil to decompose. It should be about 10-15cm, not too shallow because it will not favor plant development and not too deep to bury nutrients beyond the reach of rice roots.
- Flooding: After plowing, field is flooded for 2-3 weeks to kill insects and weeds.
- Second plowing and levelling 2-3 days before transplanting to break up soil lumps and spread soil from higher areas to flooded portions for better water dispersion and management.

PULLING SEEDLINGS

For wet bed nursery, seedlings are ready for transplanting when they are 14-21 days old.

Pulling rice seedlings is a delicate operation that should be done with care to avoid root damage and the need to re-transplant missing hills. Recommended techniques are:

- Keep nursery bed moist or wet
- Hold 2-3 seedlings between thumb and index finger, positioning the index finger also perpendicular to, and the thumb parallel to the seedlings.
- Exert a little pressure downwards before slowly pulling the seedlings towards you. Hold the seedlings close to the root.

TRANSPLANTING

Seedlings can be transplanted either in random or straight-row methods. Straight-row method involve the use of planting guide made of rope, twine or wood to have uniform spacing. Planting in straight rows make it easier to weed or apply fertilizers, herbicides, or insecticides. It should be noted that the optimum plant density is a function of many factors such as planting season, soil type, and rice variety among others. Therefore, there is no hard and fast rules with respect to plant density. However, we recommend the following spacing: 20x20 cm/30x30 cm

Empty spaces can be gap-filled with leftover seedlings from the nursery within 7 – 10 days after transplanting.

PLANT NUTRIENTS

For normal growth and full development, plants need solar radiation (light) water and nutrients. The rice plant requires 18-19 different nutrients subdivided into major/macro-nutrients – carbon, hydrogen, oxygen, nitrogen, phosphorus, potassium, calcium, magnesium and sulfur; and micro-nutrients – iron, manganese, copper, zinc, molybdenum, boron, chlorine, silicon and nickel. Nutrients are present in the air, soil or water (soil solution).

Carbon (C) comes from the air, oxygen (O) comes from water and air and hydrogen (H) comes from water. C, H and O are transformed by photosynthesis into carbohydrates for the plant.

The remaining major and minor nutrients come from the soil. However they are not always readily available and in an accessible form for immediate plant uptake. This discussion shall focus on the three major nutrients – nitrogen, phosphorus and potassium for rice growth.

MACRONUTRIENTS	Available from air and water
	Carbon
	Hydrogen
	Oxygen
	Primary nutrients (available in soil/solution)
	Nitrogen
	Phosphorus
	Potassium
	Secondary nutrients (available in soil/solution)
	Calcium
	Magnesium
	Sulfur

MICRONUTRIENTS	Boron
	Chlorine
	Copper
	Iron
	Manganese
	Molybdenum
	Zinc
	Silicon
	Nickel

NITROGEN

Nitrogen is considered the most vital nutrient for rice growth. Nitrogen is needed for the normal development of the plant (photosynthesis), especially throughout the vegetative cycle, but more particularly at tillering and panicle–initiation stages. It is accumulated in the leaves and then migrates to the panicles and the grains at maturity.

Nitrogen is present in the soil but often in insufficient quantities. It is highly mobile and is easily transported deeper into the soil, beyond the roots. Its deficiency induces stunting and uniform yellowing of plants.

Two types of nitrogen fertilizers are commonly used in West Africa: Urea (46%N) and ammonium sulfate (20-21%N). Urea is the best type of fertilizer to use because nitrate (NO_3) is easily leached to the bottom of the profile, out of the reach of the rice roots. The best times for N application in rice is at tillering, panicle initiation and at heading

PHOSPHORUS

Phosphorus plays a significant role in the physiological development of the plant. It stimulates root development, encourages active tillering and pollination, promotes good grain development, reduces the period to maturity and stimulates recovery after stress. Phosphorus is not mobile like nitrogen and will not be easily lost over years in the soil.

Commonly available phosphorus sources are rock phosphate and mineral fertilizers single super phosphate (18% P_2O_5), triple superphosphate (TSP 46% P_2O_5). Phosphorus is preferably applied basally and very early to stimulate tillering.

POTASSIUM

Potassium coordinates the biochemical activity of nitrogen and phosphorus, plays an important role in the transformation and transport of carbohydrates to the grains and also plays important role in the tolerance to unfavorable climatic conditions (stresses) and resistance to some insect damages and diseases. Potassium is a mobile element in the soil.

Potassium fertilizers commonly used in West Africa are potassium sulfate and potassium chloride but are found mainly as compound fertilizers. Potassium can be applied as basal (50%) at transplanting and as top dressing (50%) at panicle initiation.

NUTRIENT DIFFICIENCY AND TOXICITY SYMPTONS IN THE FIELD

Reference 14

Plant nutrients

Photo 14.1. Symptoms of nitrogen deficiency

Photo 14.2. Symptoms of phosphorus deficiency

hoto 14.3. Symptoms of potassium deficiency

Photo 14.4. Symptoms of zinc deficiency

Iron Toxicity

Iron toxicity is a serious constraint to rice production in inland valley lowlands in Liberia. It is observed as a red oxidized scum (looks like oil spills and reddish stains) in lowlands and stagnant waters all over Liberia. Iron toxicity is associated with high iron concentrations in the soil itself and the soil water solution that come from surface erosion and sub-surface flow. Visible red oxidized iron in inland-valley bottoms is transformed into reduced iron, which is toxic to rice.

Photo 4.1. Symptoms of iron toxicity

Photo 4.2. Symptoms of iron tox in the field

Screening for Iron Toxicity

Among the several iron-toxicity control options, e.g. blocking or interrupting the sub-surface flows, or water management to evacuate excess iron in the irrigation water, the best control at the field/ plot level is to use tolerant rice varieties. Introduction of any new variety requires a screening process.

CARI station in Suakoko offers one of the best site for screening in Africa. Suakoko 8, selected in the mid-70s is known internationally to be resistant to iron toxicity and is used as a test material.

FERTILIZER APPLICATION METHODS

Methods of fertilizer application in common use:

Broadcasting

Uniform distribution over the whole area, often followed by plowing or harrowing in of the fertilizer.

Band placement

Method by which the fertilizer is applied in bands a little below and a few inches to one side or both sides of the seed or plant.

Top dressing or side dressing

Additional fertilizer application to the crop at certain stages of growth. This usually follows a single application at sowing or planting.

Foliar application

Fertilizer application in solution to the foliage usually for the application of nitrogen or minor elements needed in small quantities.

WEEDS

A weed is any unwanted plant growing with a crop in the field. It reduces crop yield by interfering with the normal growth of the crop.

Weeds constitute one of the most important constraints to rice production because they compete with the rice for soil nutrients, water and light. Weeds reduce yield and quality and act as alternate host for insect pests. Weeds can be annuals or perennials but are generally categorized into three (3) groups: grasses, sedges and broad leaves.

GRASSES

Grasses (Gramineae) have long thin leaves, usually with parallel veins and round and hallow stems composed of segments separated with nodes. Grasses look like rice when they are young but their roots are fibrous without a principal root. Common annual weeds are *Echinochloa crus-pavonis*, *Echinochloa colona* and *Ischaemum rugosum*

SEDGES

Sedges look like grasses and have long, thin leaves, smooth solid stems that are triangular, polygonal or rarely round but in general do not have nodes. Most frequent sedges in rice are *Cyperus difformis, Cyperus iria and Kyllinga pumila.*

BROAD-LEAVES

Broad leaves are weeds with wider leaves than grasses or sedges, and have branched veins and one principal root that develops into a tap root. Common broad-leaved weeds frequenting inland valleys are: *Ludwigia abyssinica, Sphenoclea zeylanica, Ipomea aquatic and Heteranthera callifolia.*

WEED CONTROL METHODS

Strategies for weed control includes hand-weeding, mechanical control and chemical control;

Curative control methods

Hand- or Hoe-weeding (including rouging)

Hand weeding is popular because of its simplicity and effectiveness, though it is back-breaking, labor intensive, time consuming and but nevertheless is the control method used mostly in direct sowing/broadcast and smallholder farmer conditions. As the name applies, the main operation is by hand pulling, but sometimes other traditional tools like scratching hoes, cutlasses or knives are used. Hand weeding is very effective when the rice is transplanted or sown in rows. Hand-weeding after direct broadcast may damage the crop as workers walk through the field. Rouging can be done by removing any plant—including weeds, rice off-types and wild rice—other than the rice varieties been cultivated. Hand weeding should be carried out 14 – 20 days after transplanting and the water should be drained from the field before the exercise. A second hand weeding could also be carried out 30 – 40 days after transplanting in lowland rice production.

Mechanical weeding: involves the use of animal-drawn or engine powered weeders, suitable for medium – large scale farming and requires that rice is planted on lines. There are now many types of weeders available for especially lowland conditions.

Mechanical control

Mechanical weed control as a preventive measure of weed control can be distinguished into two forms: (i) Pre-season land preparation (ii) Off-season dry soil tillage type

Pre-season land preparation activities usually take place prior to crop establishment and it include tillage, levelling and puddling that promotes vigorous rice growth and enhances crop competitiveness with weeds.

Off-season dry soil tillage type carried out at sufficient depth may help breaking and drying subsoil rhizomes of perennial weeds. Power tillers or tractors can also be used for mechanical weeding if available.

Chemical weeding: relies on the use of chemicals (herbicides) to kill weeds in order to protect a crop against competition from unwanted plants. A herbicide can be either contact or systemic (translocated) herbicide depending on the mode of action:

- **Contact herbicide:** kills weeds by destroying the green plant parts it comes in contact with. It is applied by spraying on leaves and stems. Roots are not directly affected. Not suitable for perennial weeds. Examples; Paraquat (Gramoxone) and Propanil (Stem F-34).
- **Systemic herbicide:** kills by travelling inside the treated plants and destroying their plant tissue either at the point of contact or away from it. Suitable for controlling perennial weeds and weeds with rhizomes. Examples: Fluorodifen (Preforan), Glyphosate (Roundup), 2-4 D (Weedone) and Picloram (Tordon).

Herbicides can also be selective or non-selective:

Selective herbicide: kills the weeds without damaging the crop for which they are recommended and when used at the recommended rate. They are usually specific to certain types of weeds (products against grasses, sedges or broad leaves). Some herbicides are selective for more than one crop.

Non-selective: destroys both the young weeds and the young crop when applied at the recommended rate. It kills a large range of plant species and must therefore be applied under certain conditions to avoid damaging the crop.

Table 20.1. Herbicides used for weed control in inland-valley rice and guidelines for application

Names	Active ingredients (g/L)	Target weeds	Stages	Dosage (L/ha)	When to apply	Obser-vations
Propanil Stam F 34 Surcopur	Propanil: 360	Grasses and some broadleaved weeds	2–3 leaf stage of weeds	5 to 8	After drainage	Contact herbicide
Weedone TP	2,4-D: 480	Broad leaves and sedges	2–3 leaf stage of weeds	1 to 1.5	After drainage	Contact herbicide
Basagran PL2	Bentazon: 140 Propanil: 360	Broad leaves and sedges	2–3 leaf stage of weeds	6 to 8	After drainage	Contact herbicide
Garil	Triclopyr: 72 Propanil: 60	Grasses, sedges and some broad-leaved weeds	2–3 leaf stage of weeds	5	After drainage	Contact herbicide
Ronstar 12 L	Oxadiazon: 120	Grasses, sedges and broad-leaved weeds	Before emergence of rice and weeds	6	Apply on water layer, three days after sowing or transplanting	Contact herbicide
Ronstar PL	Oxadiazon: 120 Propanil: 360	Grasses, sedges and broad-leaved weeds	After emergence of rice and weeds	5	After drainage	Contact herbicide
Ronstar 25 EC	Oxadiazon: 120	Grasses, sedges and some broad-leaved weeds	Before emergence of rice and weeds	4	Apply on moist soil	Pre-emer-gence herbicide
Londax	Bensulphu-ronmethyl	Sedges and broad-leaved weeds	2–5 leaf stage of weeds	80 g/ha	Applied to the floodwater	Apply using a bottle

Depending on time of application, herbicide can be a pre-plant, pre-emergence or post-emergence herbicide.

- Pre-plant herbicide is applied to kill weeds before the crop is planted, especially in non-tillage cropping systems.
- Pre-emergence herbicide is applied to the soil shortly after seeding with rice in order to kill and germinating weeds whilst not killing the germinating rice.
- Post-emergence herbicide is applied after the rice and weed have germinated and are at the 2-3 leaf stages.

Weeds cause more damage within the first six weeks after sowing or transplanting. Contact herbicides are more effective and efficient when weeds are very young (2-3 leaves), especially for grasses and sedges. Herbicide is usually less efficient with delayed or late application and causes more damage to the rice crop. Below, see roster of some herbicides used for weed control in rice and guidelines for application.

PESTS

An organism that is injurious or constitutes a nuisance to man either directly or indirectly through their feeding and damaging attacks on livestock and crops. Such pests include insects, weeds, birds, rodents, . bacteria and fungi.

INSECT PESTS OF RICE

Insect pests that cause damage or injury to the rice plant by chewing or piercing and sucking and consequently cause plant death or yield reduction are broadly classified according to the type of damage they cause as below. The development cycle of most insects follow four stages: adult, eggs, larvae and cocoon, with the larvae stage the most destructive stage to the rice crop.

- Stem borers
- Defoliators
- Piercing – sucking
- Root cutters
- Storage pest

Table 21.1. Insects in rice cropping

Name of damage	Order/ Family/ Species	Type of damage	Symptom description	Stage of insect causing damage	Susceptible plant stage	Impact on yield
Rice Yellow Mottle Virus (RYMV)	Coleoptera Locusts Leafhoppers	Leaf destruction Cut leaves Perforated spots with minute strips	Early yellowing Stunting	Adult	Vegetative stage, even when transplanted	Sometimes no yield at all
Onion tube	Fly (African Rice Gall Midge)	No leaf destruction	Some leaves change into yellowy-white tubes, looking like onion leaves	Larva (small yellow worm)	Vegetative stage	Sometimes no yield at all
Dead heart	Red flies with black antennae: *Diopsis* and butterflies: *Chilo, Sesamia, Scirpophaga*	No leaf destruction	Some leaves change into yellowy-brown tubes called dead heart Plants can be pulled up easily	Larva (small yellow worm)	Early vegetative stage	High yield despite attack
Defoliation	Small white butterflies *Nymphula*	Many leaf fragments floating on water: they are the sheaths/ covers that protect the larvae	Tips of rice leaves are cut Field whitening	Larva	Early tillering	Rice fields usually recover without losses
Destruction of roots	Termites *Microtermes Macrotermes*	No tube formed No leaf destruction	Early yellowing and drying of leaves	Adult termite "workers"	Any time in cycle whenever water is lacking	Losses may be high
Grain blackening	Stinking bugs *Aspavia leptocorysa*	Small black or brown spots on grains	Bad grain quality (color, fragrance, flavor)	Adult	Reproductive stage and maturity	Small-scale indirect losses

Stem borers

Major stem borer pest in West Africa belong to two families: Lepidoptera - *Maliarpha separatella, Chilo zacconius, Sesamia calamistis, Nymphula depunctalis, Eldana saccharina* and *Scirpophaga spp. and Diptera – Diopsis spp. and Orseolla oryzivora ("the African rice gall midge").*

All stem borer damages are similar: the adult deposits eggs on the rice plant and the emerging larvae gain entry into the stem and begin feeding on the soft internal tissues, disrupting the flow of nutrients to the upper growing parts of the plant, sometimes completely severing the stem. Stem borer damages to the stem causes "dead heart" while damages to the panicles causes "white heads".

Reference 23

Rice stem borers

Photo 23.1. Symptom of stem borer: dead heart

Photo 23.2. Symptom of stem borer: white head

Photo 23.3. Lepidopteran stem borer *Chilo zacconius*

Photo 23.4. Dipteran stem borer *Diopsis thoracica*

Defoliators

Defoliator damage leaf fragments or tips and sometimes cut off entire leaf. Infestations in early plant development up until mid-tillering may harm a greater part of the plant and lead to irretrievable losses. Most common defoliators are *Nymphula depunctalis*, *Cnapalocrosis medinalis*, *Marasima trapezalis*, *Diacrisia scortilla*, *Parnara* spp., *Hispides* spp., the armyworm (Spodoptera exempha), the leaf minor *(Hydrellia posternalis*), and grasshoppers and locusts.

Photo 22.1. African rice gall midge; adult

Photo 22.2. African rice gall midge; eggs

Photo 22.3. African rice gall midge; larva

Photo 22.4. African rice gall midge; cocoon

Photo 22.5. Symptoms of the African rice gall midge in the field

Photo 22.6. Symptom of the African rice gall midge on the plant (onion leaf)

Piercing – sucking insects

These insects attack the leaves, stems and grains, causing damage during maturation, at the milky and dough grain-filling stages and include bugs, whiteflies and acarids – the rice bugs.

Root cutters

Major Root cutting pests of rice are the *termites*, which feed on the roots and underground elements of the plant, and the *crickets,* which dig shallow tunnels in the ground and feed on the roots.

Storage pests

Storage insect pest attack both in the field and in storage but very often begin their infestation in the field. Most important storage insect pest are: the rice weevils (*Sitophilas oryzae*, and *S. zeamais*), and the lesser grain borer (Sitotroga cereallela). There are other storage insect pests that attack only stored grains and can come from either inside outside the store.

Insect Pest Control

Recognized methods of control for insect pests on rice include: cultural/crop management practices, varietal resistance, biological control, chemical control and integrated pest management. Methods are briefly describe below.

Cultural/crop management practices: Hinders harmful insects multiplication and favor rice growth by efficient cultural practices such as destruction of stubbles and residues where larvae and nymphs can survive, use of good quality or treated seeds, identification and destruction of insects host weeds, and use of crop rotation and intercropping cultures to disrupt insect cycles and prevent proliferation.

Varietal resistance: crop varieties which attract fewer insect pest species and suffer less damage when attacked, i.e. they survive heavy infestations without a significant loss in yield.

Biological control: Aims at limiting the density of insect pests by using natural enemies as predators, parasites or pathogens.

Chemical control: very affective as it kills insects in a short time, but nevertheless kills both harmful and beneficial insects, is expensive and frequent use leads to insects resistance.

Integrated pest management: combines the judicious use of different control techniques to keep the insect population as low as possible so that the ecosystem stability is not disturbed and rice cropping is economically efficient.

MAJOR DISEASES OF RICE

Diseases are major constraints in rice production caused by fungi, bacteria or viruses that result in stunting, color changes, wilting or abnormal development of certain organs. Most common and severe diseases in rice are blast, rice yellow mottle virus (RYMV) and bacterial leaf blight. Other minor diseases and pathogens are presented in the table below.

Table 24.1. Classification of rice diseases in western Africa

Category	Disease name	Pathogen Scientific name	Nature
Major pathogens	Blast	*Magnaporthe grisea*	Fungus
		Pyricularia oryzae	Fungus
	Rice yellow mottle virus	RYMV	Virus
	Bacterial blight	*Xanthomonas oryzae orysae*	Bacterium
Secondary pathogens	Brown spots	*Drechsiera oryzae*	Fungus
		Bipolaris oryzae	Fungus
		Gerlachia oryzae	Fungus
	Leaf blast	*Monographella albescens*	Fungus
		Rhizoctonia solani	Sterile fungus
	Sheath blight	*Thanatephorus cucumeris*	Fungus
Minor pathogens	False smut	*Ustilaginoidea virens*	Fungus
		c. oryza sativa	Fungus
	Bakanae disease	*Fusarium moniliforme*	Fungus
		Gibberella fujikuroi	Fungus
	Cercosporiosis	*Cercospora oryzae*	Fungus
	Sheath rot	*Acrocylindrium oryzae*	Fungus
	White gall	*Corallocytostroma oryzae*	Fungus
	Fading color of sheaths	Fungi complex	Fungus
	Culm disease	Fungi complex	Fungus
	Bacterial stripes	*Xanthomonas oryzae*	Bacterium

Blast

Blast is a fungus disease caused by *Pyricularia oryzae Cav.* and variable races that affect many organs of the plant: leaf (leaf blast), neck (neck blast), stem node (node blast), panicle rachis, grain, etc. Chlorophyll disappears in the attacked parts and resultantly, photosynthesis and yield are reduced. Blast is favored by high dose of nitrogen and high humidity. The disease is usually controlled by the use of resistant varieties.

Rice Yellow Mottle Virus

This virus on plant leaves turns leaves yellow, with alternate yellow and green stripes and causes stunting, reduced tillering, leaf mottle with yellow stripes, incomplete panicle exsertion and panicle sometimes badly formed, and spikelet sterility. The virus is transmitted from infested plants to healthy plants by insect vector or mechanically through tillage practices (transplanting, weeding, etc.)

Bacterial Leaf Blight

The third main rice disease is bacteria blight caused by the bacterium ***Xanthomonas oryzae orysae***, mechanism being transparent stripes on leaves that dry and become brown and opaque. When severe, the entire field seems to have been brunt. The spread is favored by wind, storm and ill balanced mineral nutrients in the soil.

Reference 24

Major diseases in rice

Photo 24.5. Bacterial leaf **blight**

Photo 24.6. **Bacterial leaf** blight

Photo 24.1. Pyriculariosis: symptom on leaf

Photo 24.2. Pyriculariosis: symptom on the node

Photo 24.3. Rice Yellow Mosaic Virus (RYMV): symptoms of leaves

Photo 24.4. RYMV: symptoms in the field

14.0 LOWLAND SELECTION PROCEDURES/ POINTERS

Nowadays, it is both a national and an environmental necessity to mitigate against the massive deforestation by developing and bringing under cultivation more lowlands. Liberia has numerous ideal lowlands (swamps) and many farmers already carry on traditional lowland rice production under the continuum farming system. Besides being initially labor and cost intensive to develop, not all lowlands are ideal for development. Technicians and farmers need to know a few details about the lowland before investment of labor and time can be initiated.

One needs to first know the history of the lowland. Details on the lowland will guide you during the development process. Primary questions of interest are:

- Does the lowland have a good and constant water supply?
- Does the lowland get over flooded?
- Is the lowland a seasonal lowland? Water-fed lowland?
- What type of soil is in the lowland?
- What type of vegetation is in the lowland?

WATER SUPPLY

The production cycle of the lowland depends on the constant supply of water. The history of the lowland provides the requisite knowledge for lowland development.

SOILS

The type of soil is very important. Is it loamy, sandy, clayey, clay loam, sandy clay, or sandy clay loam?

The soil must have good water holding/ storing capacity. Sandy soils will lose water and therefore make development work useless.

VEGETATION

Look around the lowland. What is the most common vegetation, whether trees, shrubs, grass, legumes or non-legumes? The presence of a lot of piassava (small or large) shows some indication of a poor quality soil. Leguminous plants (cover crops) and Mitragyna (Christmas bush) indicate good soil fertility.

ABSENCE OF LARGE TREES

Too many large trees make development work more laborious, costly and difficult. Were possible, try to avoid too many large trees.

TOPOGRAPHY

Is the lowland level? Fairly level? Are there some elevations that have to be leveled? Can nutrients be easily distributed throughout the developed area? Can all plots get equal amounts of water and therefore plant nutrients?

When fields are leveled, water distribution is easy and all areas of a plot will receive equal nutrients.

LABOR

When making selection, it is also very important to be aware of the presence of a good source of labor force. Development works is usually faster where you have many farmers/ workers.

14.1 LOWLAND DEVELOPMENT PROCEDURES/ PROCESSES

When the lowland has been identified for development or rehabilitation, then the works start. The initial jobs to do are:

- Brushing/ slashing the undergrowth
- Tree felling and overlapping of branches
- Burning and clearing / cleaning
- Destumping and removal of debris
- Pegging and laying out. Then follows the actual development work.

Brushing in used lowland

Brushing/ slashing in used lowland for rehabilitation

Felling and overlapping in new lowland for drying, burning and development

New underbrushed lowland to be burn and developed

New lowland brushed, felled, lapped and dried, waiting for burning and development

Burning in rehabilitated lowland

Burning of new lowland

Land clearing and debris removal after burning

Destumping of Abura tree in traditional lowland

Using 'Come-A-Long' for destumping

Debris removal

Debris removal

Main Drainage

Constructed initially. This carries the excess water out of the lowland. This commences from the bottom and not from the top to prevent water hindering development work. Water will normally flow downhill. Leveling of canals should begin at the lower end to ensure water run-off and permit a conducive working canal (free of water). A one-percent (1%) slope within the canals from bottom to top is recommended.

The general width of each drainage canal is as designated in the drawings and laid out in the field. Differences will be noticed from community to community depending on soil type and water regime. The drainage canal must be able to carry the expected volume of flood water.

- General depth of main/ drainage canal is 50cm
- All drainage canals are advised to go 30-50meters beyond the end of the plot to enable proper draining and avoid back flooding.

Pegging, layout, canal and bund construction

Peripheral Canals

These are the side waterways which are used to feed the plots/ fields. With wide lowlands, there will be multiples of these.

- General width of peripheral canal is 50cm
- General depth of peripheral canal is 30cm unless otherwise designated.

Head Dyke

This is the head water catchment area. It diverts or facilitates the distribution of water into the individual paddies/ fields via the peripherals.

Head dyke under construction

Constructed head dyke

Tail Dyke

This receives the excess water from the field for disposal. It is constructed at the end/ tail end of the field.

Inlets: These are openings in the plot bunds constructed of pipes, reeds, through which water is let into the different fields.

Outlets: These openings in the bunds let used water out of the plots/ fields into the drainage canal.

BUNDS (CANAL & PADDY BUNDS)

The **main canal bund** controls the overflow of excess water.

General width of main canal bund is 75cm to 100cm

Pegging, Bund and canal construction

The **peripherals** permit water into the plots.

General width of peripheral bund is 50cm

The paddy/ plot bunds separate the different plots for water control in each field.

- Commence plot bund construction after construction of main and peripheral canals and bunds are complete. Plot bunds will form a link from the main bund to the peripheral bund.
- Plot bund width is 50cm and 50cm high.
- Individual plots are measure and pegged at 10m intervals along the drainage canal, beginning 1-2m below the head settling pond.
- Plot bunds run left and right from the 10m pegs to the peripheral canal or irrigation canals.
- General plot dimensions are 10 meters wide by the length of the span between the drainage and peripheral canals or irrigation canal to irrigation canal.

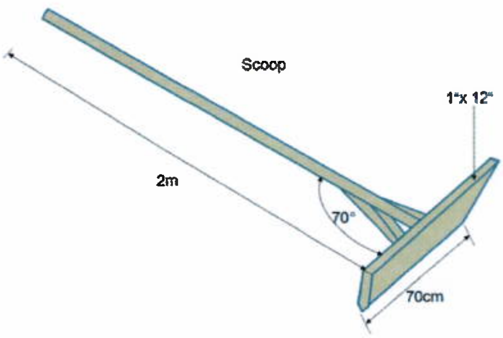
Plot Preparation for Planting

Puddling; The process of tilling/turning and softening the soil mostly with the aid of country hoe and the feet.
Leveling; this is the process of earth movement within a plot to ensure that the plot gets level to promote effective water distribution. The scoop could be used, headpans can also be used.

Digging and leveling of individual plots should commence only after the entire canal network and plot bunds are in place.

Ploughing/ digging of plots

Puddling and Leveling



Leveling with the Scoop

Plot levelling with scoop.

15.0 PRACTICALS AND SKILLS DEVEOPMENT SESSION

A good field technician or farmer should measure everything he/she does using the simplest tool. For example, a measuring tape can help measure the area of land or a scale can help to weigh produce. Some important benefits of measurement are:

- Measurement helps technicians and farmers to know the weight of seeds, chemicals, volume of water, yield, and even plan for labor and mandays, or calculate the quantity and costs of production items.

- Measurement will help the farmers to determine profit and loss; and help to know the profit margin

- Measurement will help the farmers to change production strategy so that farmers can have a comparative advantage in production.

15.1 FERTILIZER CALCULATIONS

Good technicians must be able to calculate the amount of fertilizer to apply to a given area at a recommended rate. See procedures outlined below.

Decide what fertilizer material to use

Is it available locally?
Is it the least expensive fertilizer available?
Is it suitable for the target soil conditions?

A.1 CALCULATING FOR SINGLE ELEMENT FERTILIZERS

List the necessary data

R = recommended rate of fertilizer application
C = concentration (%)
A = area to be fertilized (m^2)

Calculate the amount of fertilizer (Q = kg/ha) required per hectare (A)

$$Q = \frac{R \times 100}{C}$$

Calculate the amount of fertilizer (Q1) required per square meter

$$Q\,1 = \frac{R \times 100}{10{,}000C} = \frac{R}{100\,C}$$

Calculate the amount of fertilizer required for the given area (A)

$$Q\,2 = \frac{R}{100\,C} \times \text{Area } (m^2)\text{, or}$$

$$Q2 = \frac{R(kg/ha) \times Area\ (m^2)}{100 \times C}$$

A.2 CALCULATING FOR COMPOUND FERTILIZERS

Required data

- Recommended rate of fertilizer application
- Area to be fertilized
- Recommended proportions of nutrient elements (e.g. NPK 14-14-14 plus urea to satisfy the recommendation of 80-30-30).

Step 1: Calculate the amount of fertilizer that satisfies the element required in the smallest quantity.

In the example above where the recommendation is 80-30-30, phosphorus (P) and potassium (K) are the least required. Calculate the amounts of these element first.

30kg of P and 30 kg of K are supplied by the compound 14-14-14

$$Q = \frac{R \times 100}{C} = \frac{30 \times 100}{14} = 214.3 \text{ kg of 14-14-14}$$

Step 2: Calculate the remaining amount of the element required

In our example 214.3 kg of NPK 14-14-14 gives 30-30-30. Subtract this from 80-30-30.

80-30-30
30-30-30
50-00-00

50 kg of N is yet to be supplied. Available fertilizer is urea. The amount of urea is calculated thus:

$$Q = \frac{R \times 100}{C} = \frac{50 \times 100}{45} = 111.1 \text{ kg of urea}$$

15.2 FIELD MEASUREMENT

Why field measurements. Most often people want to know

- How wide is the farm, creek, swamp, river, (width)?
- How far is the farm? The village? The Market place? The clinic? (distance/time),
- How large is the farm (area)?
- How much rice, pepper, bitter balls, etc. did you harvest/ sell/ buy/or see (quantity)?
- How heavy was the bag of produce (weight)? Etc.

We most often don't know and will either feel embarrass to say we don't know or want to bluff our way out by giving some guesstimates. As field personnel, it is necessary that we have a good working knowledge of some of these measurements for our own everyday activity instead of waiting until we are asked. This session should help us be more prepared.

Standard measurements: Use of precise, calibrated instruments (tape line, time, scale, etc.) to take data or information that will help calculate distance, area, volume and weight.

Field estimation: We will use some knowledge known to the technician or farmer to help him estimate the distance, width, area, volume, time or weight.

- Let participants determine their individual paces and use that to estimate distances.
- Compare paces with timing to develop an appreciation for telling distances in terms of time also.
    - Distance exercises
    - Area calculation exercises for blocks; odd shapes; farm sizes

15.3 CALCULATING PACE AND PACE FACTOR

1. Mark off 10m distance on the ground. Make distinct lines at both ends.
2. Each participant walks this distance (M) to and fro until the number of paces it takes to cover the 10m distance becomes constant.
3. Calculate average pace (Ᵽ) it takes participants to cover the 10m

   (Ᵽ) = (# of paces at attempt 1) + (# of paces at attempt 2) + (# of paces at attempt 'n')
   (# of times participant covered 10m before pace became constant = 'n')

4. Calculate pace factor for each participant

   PF = (Ᵽ)/10m =0.______M

   This PF is always less than 1.0
   This PF is constant for each individual throughout his/her life.

Using the pace factor in field estimation (distance measurements and area calculations).

- The group designates an area to be measured
- Participants walk the length of this area and note # of paces for length = (~~PL~~)
- Participants walk the breadth of this area and note # of paces for width = (~~PW~~)
- Estimated length and width of area is calculated as below:
  - o Est. Length = (~~PL~~) x PF =E(~~PL~~)
  - o Est. Width = (~~PW~~) x PF = E(~~PW~~)

- Using the formula for area calculation as A = L x W, calculate A = E(~~PL~~) x E(~~PW~~)

Verification

- Take a standard tape line and measure the actual length and width of the designated area
- Using the formula for area calculation as A = L x W
- Compare the 2 area calculations and note the difference.

Participants are encouraged to continue using field estimation to gain their confidence and develop their skills at distance measurements and area calculations.

15.4 SURVEY AND AREA CALCULATIONS

After site selection, the farmer can decide either to survey before land clearing or survey and layout. It is better to do total land clearing before survey and layout.

15.4.1 SURVEY

a. First cut a **transverse** - a wide path to follow in reaching the width or length of the field.

b. Next establish the **main station**. This is the point from which all measurements, including the baseline will start from. The main station can be established on the side of the land or in the middle.

c. Determine the direction of the baseline.

d. Establish from the main station the **baseline** - a straight line (180°) in the desired direction.

e. Along the baseline, using the 3, 4, 5 method establish the base and height of a right triangle. The height is along the baseline, in the direction of the length (long side) and the base is in the direction of the width (short side) of the field/farmland.

f. Cut transverse to accommodate the baseline to the end of the field.

g. Along the baseline, mark **waypoints** (agreed intervals) at 5, 10, 20, 30 ... or 50m intervals. Ensure the distances between waypoints are uniform.

MAKING OFFSETS (90° line running off the baseline from the **waypoint**)

For our practical, we will assume that the baseline is established in the center of the field. The total length of the baseline gives us the total length of the field. The waypoints along the baseline (intervals where pegs have been placed equal-distance along the baseline) will provide us the reference point to find the distances from the baseline to either end of the land.

The waypoints are designated A, B, C, etc.

The 90° line running off the baseline from the waypoint to the end of the land is known as an **offset**.

Offsets are used to find the distances on both sides of the baseline from each waypoint to the end of the swamp. At each offset, designate each straight line to the end of the field as segment A & B; segment C & D; etc.

For easy reference, mark the segments going to either side of the offset as side A, side B, etc. At the end of the field, put pegs indicating the correct measurement from the offset.

E.g. From offset A to Side A = 50m
From offset A to Side B = 50m
From offset B to Side C = 40m
From offset B to Side D =28m
From offset C to Side E = 35m
From offset C to Side F = 55m

The total width of the two segments running from any offset to the swamp margin gives us the width of the land at that waypoint.

The distances measure to the swamp margins/ fringes from each offset defines the shape of the land and will be helpful in making a sketch of the lowland.

15.4.2 How to Find an Area

After surveying, use the data collected in the field measurements to find the area of the field.

- Use the distance from one waypoint to another as the height of the segment
- The length of the segment is calculated as the sum of the two (2) sides divided by 2
- Use the formula for a rhombus or trapezoid - Area = (A + B)/2 x H
- Take every segment in the diagram and find the area separately.
  Seg A = (A + B)/2 x H =
  Seg B = (A + B)/2 x H =
  Seg C = (A + B)/2 x H =
  Seg D = (A + B)/2 x H =
  .
  .
  Seg G = (A + B)/2 x H =

- Add the areas of all the segments to get the total swamp area.
  Total farm area = Seg A + Seg B + . . . Seg G m^2

15.5 ESTIMATING WEIGHT MEASUREMENT

Field technicians must make it their prerogative to find out materials and skills used by the community members for measuring weight or quantity, i.e. cups, era paint bucket /cans, rice bundle (handful of rice panicles tied).

Compare each material used one after the other and verify the claimed amount (volume or weight) along a standard measurement scale. Some leading directives:

- How many cups will make a paint bucket?
- How many cups or paint buckets will make a tin?
- How many cups, bucket or tins will make a bag?
- How many cups or bucket do you get out of a bundle of rice when threshed?
- How many bundles will make one tin?

15.6 SEED RATE CALCULATION

To avoid seed wastage, it is always good to calculate the amount of seed needed to be sown or transplanted in a given area. To do this you need the following information:

1. Measurement of the area you want to plant (area = A)
2. Recommended Seed Rate (RSR) of the country or a given location. Let's use 20kg/ha for lowland transplanting.
3. The germination percentage of the seed stock (% G). This should be known, otherwise ask for it or run a germination test.
4. The amount of seed needed is always calculated over one hectare area (1ha = 10,000m^2).

With all the above information, we can now apply the formula.

Amount of Seed = RR/% G x A/10,000 x 100/1

Sample Problems

1. The area of the land to transplant is **500m2**. The seed stock has the **germination of 80%** and the recommended seed rate of **20kg/ha**. How much seed do you need to plant this area?

SOLUTION

A = 500m2
RR = 20kg/ha
%G = 80

Amount of seed = RR/%G x A/10,000 x 100/1
= 20/80 x 500/10,000 x 100/1
= 1.25kg

2. In case the **germination % is 90**, what will the amount of seed be?

SOLUTION

A = 500m2

RR = 20kg/ha

%G = 90

Amount of seed = RR/G x A/10,000 x 100/1

= 20/90 x 500/10,000 x 100/1

= 1.20kg

3. In case the **germination % is 100**, what will the amount of seed be?

SOLUTION

A = 500m2

RR = 20kg/ha

%G = 100

Amount of seed = RR/G x A/10,000 x 100/1

= 20/100 x 500/10,000 x 100/1 = 1.00kg

POST HARVEST

This chapter is discussed in a separate document. It is currently available at SAPEC Coordination Unit.