NATIONAL
AGRICULTURAL
RESEARCH
ORGANISATION

RICE CULTIVATION HANDBOOK




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RICE

Rice in the world

The rice planted area in the world is 157,000,000 ha
Its production in the world is about 650,000,000 tonnes.

Half the world population eats it as staple food.

Rice varieties in the world.

There are 76,000 rice varieties in the International Rice Germplasm Center at International Rice Research Institute（IRRI）.

Rice cultivation in Uganda （2008 estimated）

Rice cultivation area: 110,000 ha
- Rainfed lowland : 65,000 ha
- Irrigated lowland : 5,000 ha
- Upland : 40,000 ha

Production（Paddy） : 170,000 t
（Milled rice） : 102,000 t
Rice importation : 60,000 t
Rice consumption : 162,000 t
Par capita consumption（kg / year）: 7.75 kg
Rice price :2,000 Ush / kg = $ 1.1

Botanical name of rice

Oryza sativa L.（Asia rice）,
Oryza glaberrima Steud.（Africa rice）

- *Oryza sativa* L.
  - Indica → K-85, Supa, IR-64, etc
  - Japonica → Koshihikari, Nihonbare, etc
  - Javanica → NARIC-2,Moroberekan, etc.
    （= tropical japonica）
- *Oryza glaberrima* Steud.
- *Oryza rufipogon* Griff.
- *Oryza nivara* Sharma et Shastry
- *Oryza longistaminata* A. Chev et Roehr.
- about 20 wild rice in the world.

(*Oryza rufipogon*, *Oryza nivara*, *Oryza longistaminata*, about 20 wild rice in the world: Wild rice)

Oryza sativa L. has 3 types namely indica, japonica and tropical japonica.

Classification of Seed

Breeder seed: Kept by breeder or breeding institute.
Foundation seed: Multiplied from breeder seeds at research station etc.
Registered seed: Seed produced by a seed center / company.
Certified seed: Seed growen in seed grower's field.

Seed Dormancy

Dormancy can prevent germination of grains on the panicle when panicles are submerged.
Dormancy period: 0 〜 8 weeks
Breaking dormancy: heat 50 ℃ for 4-5 days.
（Do not close up the container of seeds）
Practical method: dry on the concrete floor for 2-3 days

Germination

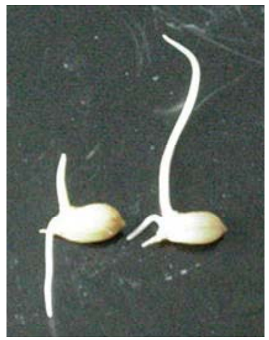
When the tip of coleoptile emerges from seed.
Imbibition stage → Activation stage → Post germination growth stage
0 － 18 hours　18 － 72 hours　72 hours →（at 20 ℃）
When moisture content of seed is 30-40 % germination commences.
Lower than 8 ℃ and more than 45 ℃ no germination

Seedling Emergence

Tip of the seedling emerges from the soil.

Temperature
- Optimum temperature for seedling emergence is 25 - 30 ℃.
- Higher than 40 ℃ seedlings die.
- Lower than 10 ℃ seedlings can not grow.

Oxygen
Growth of seedlings need 5-6 ppm oxygen.
Lack of oxygen: Root growth is poor and coleoptile shows abnormal elongation.



left: under enough O2
right: under lack of O2

Rice Growth Stage

Vegetative growth: Germination → Panicle initiation 60 days
Reproductive growth: Panicle initiation → Heading 30 days
Heading → Maturity 30 days
(milky → dough → yellow ripe → maturity)

Germination Test

Before sowing, a germination test should be done to ensure 80% germination. The following procedure should be used;
If the germination percentage is lower than 80%, then use a higher seed rate.

①

Count 100 seeds

②

Soak seeds for 24 hours

③

Wrap in wet paper

④

Incubate for 2 days

⑤

2 days after incubation

⑥

Count the number of seeds

Seed Selection at Planting

It is difficult to determine seed viability with the naked eye. It is advisable to carry out seed selection using the floatation method. Separate sunken seeds (filled grain) with high potential to germinate from those that float (empty grain) that are unable to germinate.

Seed Production

Since rice is self-pollinated plant, rice seed can be produced by yourself.

Rice seed can be produced by the farmers
1 kg of seed → plant 200 ㎡
50 kg of seed can be harvested

Genetic purity of rice varieties can be maintained by removing the off-types detected in the field
Some characteristics for identifying off-types

Stem Colour

Time to maturity

Apiculus Colour

without awn

with awn

Purification through removal of off-types ensures uniformity in growth and stability of yields of rice.

UPLAND RICE CULTIVATION

Upland Rice Varieties

NARO/NaCRRI has released 5 Upland Rice Varieties being grown by farmers. They are more superior to the previous variety **Abilony** (IRAT 112).

NARIC 1 (ITA 257): Maturity 115 - 120 days   Yield 3.5- 4 t / ha

NARIC 2 (ITA 325): Maturity 115 - 120 days   Yield 3 - 3.5 t / ha

NERICA 4 (NARIC 3): Maturity 110 - 120 days   Yield 4 - 5 t / ha
This variety is also known as SUPARICA 2

NERICA 1: Maturity 105- 115 days.   Yield 3−4 t / ha with aroma.

NERICA 10: Maturity 100 - 105 days Yield 3−4 t / ha Grain with long awn

NERICA 1

NERICA 4

NERICA 10

Note: However, yields of upland rice depend largely on the rainfall pattern and good agronomic practices like weeding and fertilization.

What is NERICA   NERICA = NEw RICe for Africa

NERICA is the product of interspecific hybridization between the cultivated rice species of Africa and Asia.
It was developed by scientists from WARDA (Dr. Monty Jones) in the early 1990s.

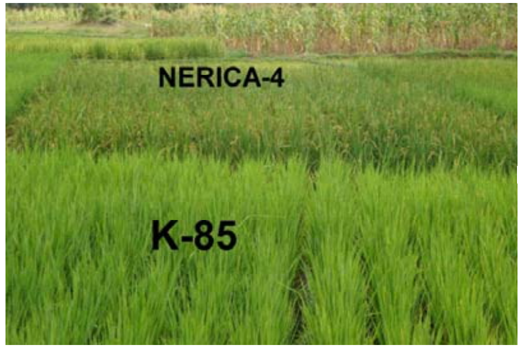
Asian Rice (WAB-56-104)♀ X African Rice (CG-14) ♂

Characteristic of NERICA:

・Early maturity: 90-100 days

・Drought tolerance

・Resistance to rice blast disease



NERICA-4 has panicles, K-85 not yet heading

・Secondary branches on panicles
→ many grains (300 grains / panicle)

Big panicles

NERICA-4 317 grains

・Resistance to Rice Yellow Mottle Virus

With RYMV symptom

No RYMV symptom

18 days after inoculation

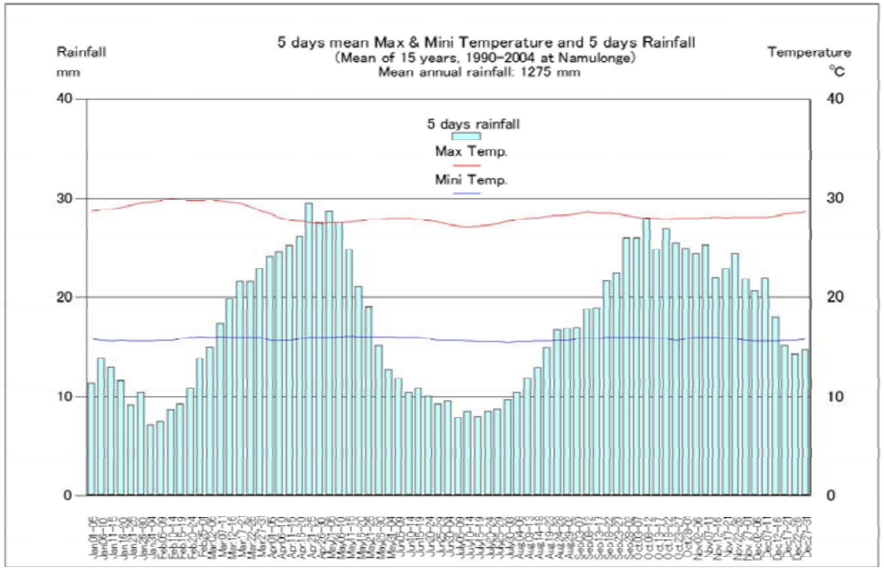
Rainfall and Fields

You have to check rainfall pattern in your area. (Please see appendix)

Upland rice grow well where 5 days total rainfall is more than 20 mm from sowing to 15 days before harvesting (about 90 days).

Field location should preferably be in the low lying areas since these areas have more water available to sustain rice to maturity.

It is advisable to make bands around the field to avoid rain water from running off.



Rainfall at NaCRRI, Namulonge

(See Appendix 4 for other areas)

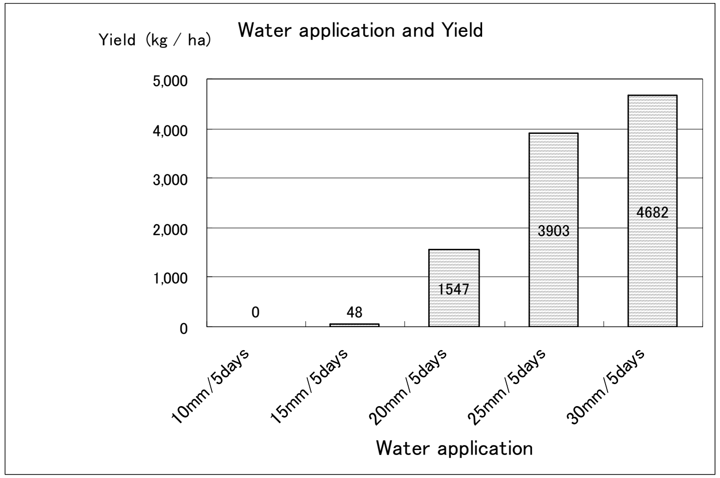
Water Application Trial at NaCRRI

107 Days after sowing

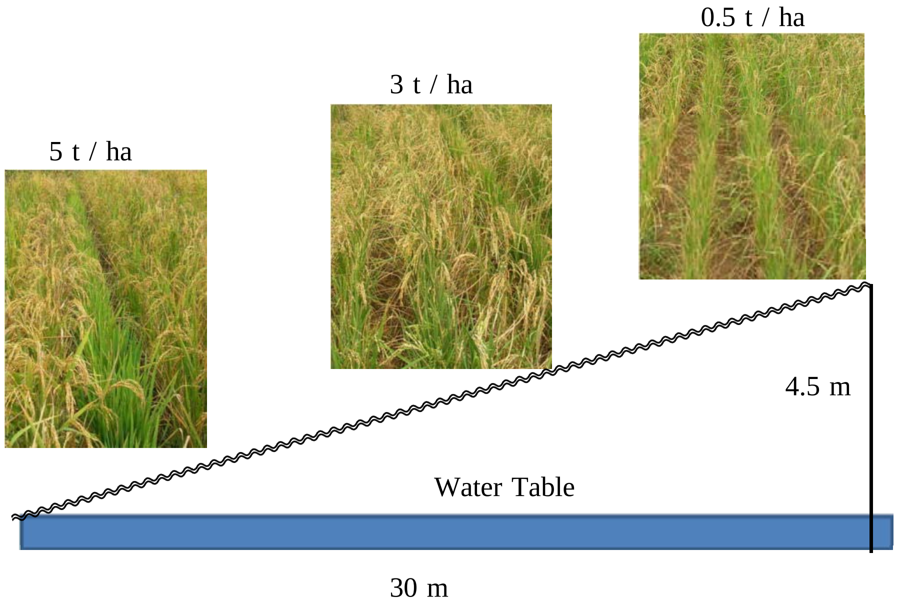
15 mm / 5 days
No panicle

25 mm / 5 days
With many panicles

Effect of Water Application on Yield of NERICA-4



Upland NERICA at a slope (at harvest)



Rice planted where water table is less than 70 cm shows good performance and higher yield.

Water table is easily known where you dig the hole.

Water Harvest Technology

Terracing in slope

At terrace: no missing hill
At no terrace: many missing hills
These missing hills are due to seeds were washed away by heavy rain.

Upland Rice Planting in the Paddy Fields.

Upland NERICA perform well under paddy condition (with standing water).

Soil pH for Rice

Rice does not perform well with soil which has pH 7.5 or above.

Most of soil in Uganda has no problem except few area.

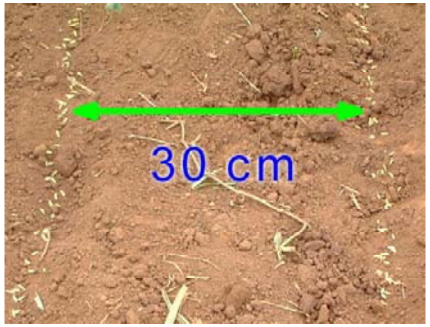
Planting Methods

There are 3 methods of planting upland rice namely; Drill, Dibble, Broadcast. Drilling and Dibbling allow straight row planting that ensures optimum plant population and use of a hoe for weeding. Straight row planting can be achieved by using a planting rope or using line markers.

Drill

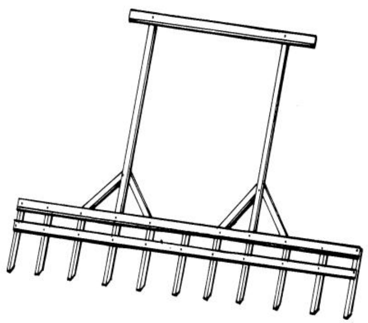
Dibble

Framer's practice（drill）



Sow 50−60 seeds for 1m

A forked-rake for rice drill-planting



A wooden rake for drill planting

Plant Spacing and Seeding Rate

Method	Plant spacing	hills /m^2	seed / hill	Seeding rate / ha	Seeding rate /acre
Drill	30 cm x 1.8 cm	185	1 seed / hill	50 kg	20 kg
Dibble	30 cm x 12.5 cm	26.7	7 seeds / hill	50 kg	20 kg

Germination and Emergence of Upland Rice

3 days after sowing
Germinated

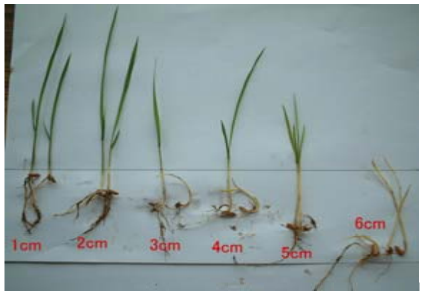
4 days after sowing

It takes 5 days to emerge from the soil surface.

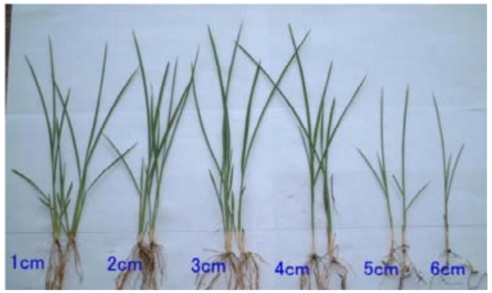
5 days after sowing
Emerged!

Sowing Depth

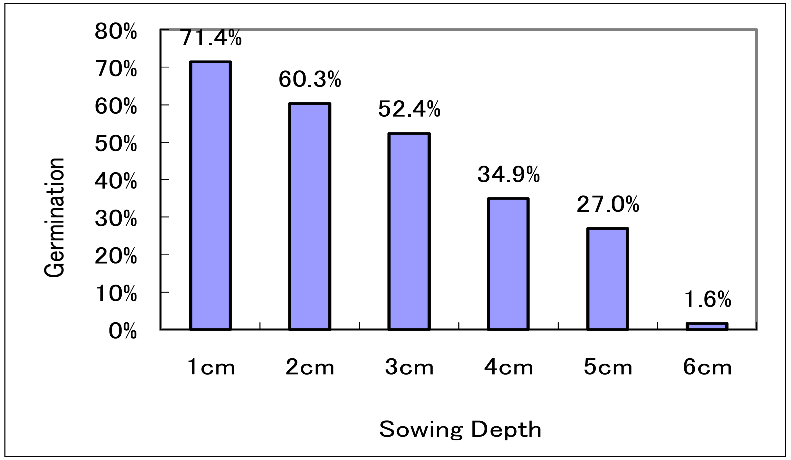
It is recommended that upland rice be planted at a depth of between 3 - 4 cm. Planting at a depth of more than 5 cm has been observed to result in low germination, delayed emergence, delayed maturity and thus low yields.



2 weeks after sowing



4 weeks after sowing



Emergence % at different sowing depth

Maturity is delayed where sowed deeper.

Rice develop secondary roots due to lack of oxygen, therefore growth is delayed.

Intercropping with Other Crops

Upland rice can be intercropped with maize, soybeans, banana and coffee.

with maize

with soybean

with coffee

with banana

Refilling of Missing Hills

Missing hills lead to low yield. It is therefore advisable that you set a small nursery bed beside the mother garden to raise seedlings for purposes of refilling gaps. Gap filling should be done 15-20 days after sowing and it's important to water the seedlings after transplanting.

Fertilization

Rice should not be continuously grown on the same fields, it should be rotated with other crops to conserve soil fertility.
Composted organic material such as rice straw and animal manure can be added to the soil to supplement soil fertility.

Fertilizer rates and regimes

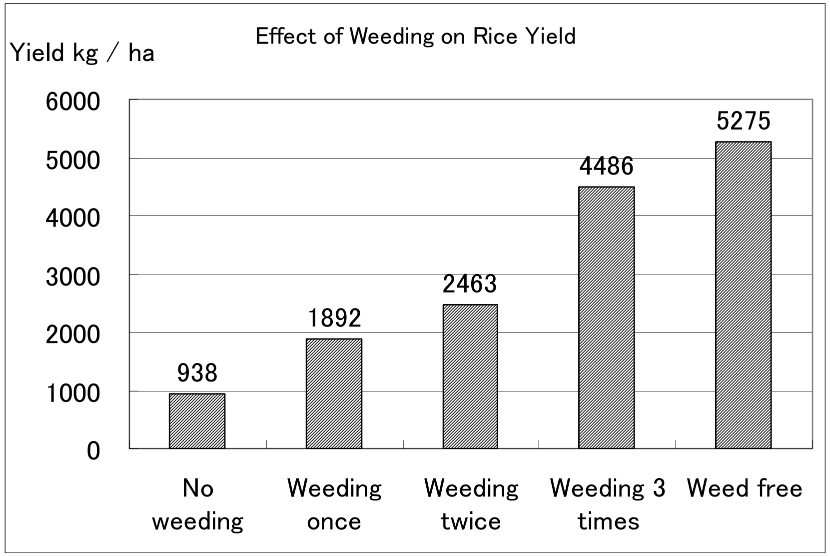
55-23-0 NPK kg / ha *DAG (Days After Germination)

Fertilizer	15-20 DAG	55-65 DAG
DAP(18-46-0)	50 kg / ha (20 kg / acre)	0
Urea(46-0-0)	50 kg / ha (20 kg / acre)	50 kg / ha (20 kg / acre)

Weed Control in Upland Rice Fields

Weeding must be done at least twice (2 times) at 3 and 6 weeks after germination either by hand or hoe.

Weeds should be removed before they produce seeds.



Effect of Weeding Frequency on Yield of NERICA-4

No weeding

2 times weeding

Weed free

Farmers weeding practice

Striga (paracitic weed)

Ratoon Crop

After harvest, rice plant produce new shoot and panicle.
About 1 - 2 t / ha can be harvested within 60 days after harvest.
Height of harvested rice plant (stubble) should be 15–25 cm.

First Crop (120 days)

Ratoon crop (50-60 days)

LOWLAND RICE CULTIVATION

Transplanting of Rice

Advantage of transplanting method:

- Reduce weed problems.
- Planted seedlings are about 3 weeks old by the time weed seeds germinate.
- Rotary weeder can be used if transplanted in straight rows.
- Reduce lodging problem

Disadvantage of transplanting method:

- Seedbed preparation and transplanting cost/labour are needed.

Land preparation

A well-prepared field has the following advantages:

- Controls weeds and recycles nutrients through the decomposition of rice stubble and weeds which are incorporated into the soil.
- Provide a soft soil mass for transplanting.
- Makes a hard soil layer which reduces the percolation of water, so, minimizing the loss of fertilizer through leaching.

For good land preparation, follow these steps:

- First, repair bund to impound water in the fields.
- After repairing the bund, irrigate the fields 3 - 5 days before tilling.
- Irrigate the field and cut the bund to increase planting area.
- Bund should be narrow and small to avoid making nest of rats.
- Irrigate the field again after tilling. This hasten the decomposition of organic materials that were incorporated with soil.
- Keep the field flooded to minimize the loss of nitrogen.
- One week after 1st tilling, puddle the fields. Puddling minimizes the loss of water and increases nutrient retention and availability.
- Drain standing water in the field, apply basal fertilizer before final tilling to incorporate it with the soil. This minimizes the loss of nitrogen into the air.
- Basal fertilizer application: DAP 25 kg / acre + Urea 25 kg / acre
- Level the field.

Seed Preparation

① Floating empty grains

It is difficult to determine seed viability with the naked eye. It is advisable to carry out seed selection using the floatation method.

Separate sunken seeds (filled grain) with high potential to germinate from those that float (empty grain) that are unable to germinate.

② Soak seeds for 24 hours in clean water.

③ Incubate the seeds for 30-36 hours by placing in a sack filled to half its capacity.

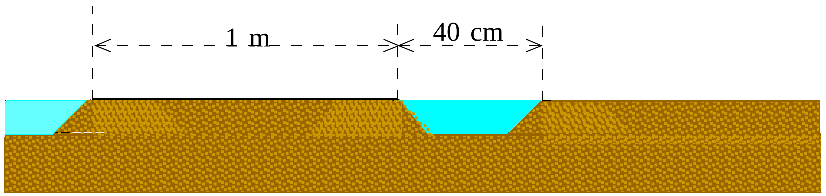
Warm temperature is needed to increase the enzymatic activities inside the seed.
Incubation keeps the seeds warm, increases growth of the embryo, and results in uniform germination.
But where temperature is too high, germination rate decreases and the embryo may be killed.

Seedbed Preparation and Seedling Management (Wet Seedbed)

① Prepare seedbed plots of 1 m wide and any convenient length 1 day before sowing.

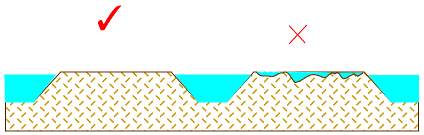
A plot area of about 100−150 ㎡ is needed to sow 15 kg of seeds for one acre.

② Collect mud around the seedbed area and raise it to about 5 cm above original field level. Provide a 40 ～ 50 cm space between beds.



③ Level and smooth the seedbed surface.

④ Sow evenly about 100 g of seeds / ㎡.
Do not cover the soil after sowing.



⑤ Once seeds have sprouted, about 3-4 cm high, irrigate and keep shallow water level.

⑥ Increase water depth gradually as seedlings grow taller.
(Do not allow seedbed surface to dry)

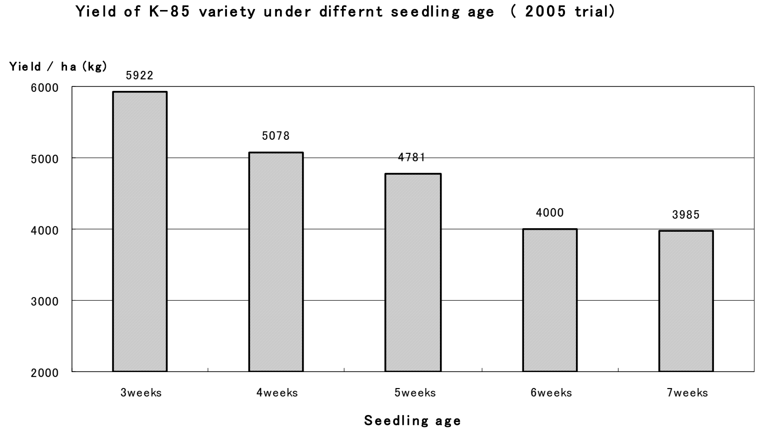

⑦ When more than half of the leaves are damaged, apply insecticide.



Damage of Leaf miner (Apply Furadan 5G: 2 g / ㎡)

⑧ 16 days after sowing, seedlings are ready to transplant.
When we uproot seedlings, keeping deep water in the seedbed makes it easier to remove the mud from the seedling root.

⑨ Seedlings should be transplanted before 25 days after sowing.
Transplanting of old seedlings cause low yield.



Yield are decreased by 28 kg / acre if transplanting is delayed by one day.

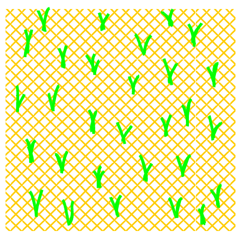
How to transplant

If seedlings are tall, you may cut tip of the seedlings.
This makes handling and transplanting easier.

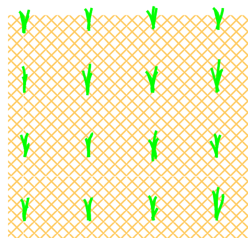



Transplanting method

Random transplanting

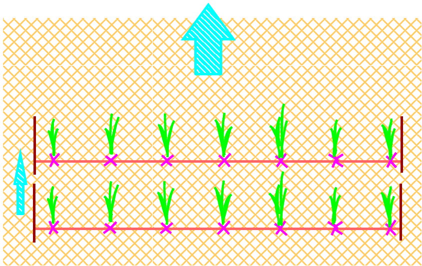


Straight row transplanting



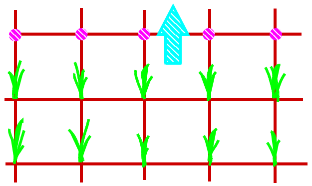
Straight row transplanting has an optimum plant population and facilitates the application of fertilizer, agricultural chemicals, and use of rotary weeder for weeding.

Straight row planting
Using guide rope.



Transplanting can be done with standing water in the field.
It takes more time, many persons are needed for efficient transplanting.

Using line marker



Drain the field one day before using line marker.
If soil is too soft, line marker can not make good straight lines
Generally take less time compere to using guide rope.

Plant Spacing

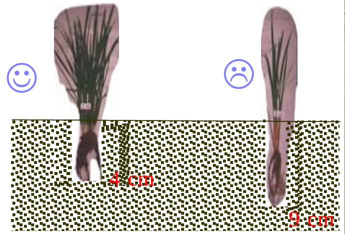
25 cm x 25 cm（16 hills / ㎡）, 25 cm x 20 cm（20 hills / ㎡） and 30 cm x 15 cm（22.2 hills / ㎡） can be recommended.

Number of Seedling / Hill

Plant 3 - 4 seedling / hill

Planting Depth

Planting depth: 3 - 4 cm



Deep transplanting: rooting delay, less tillering, less panicle, less yield

Do not transplant deep!

Refilling of Missing Hills

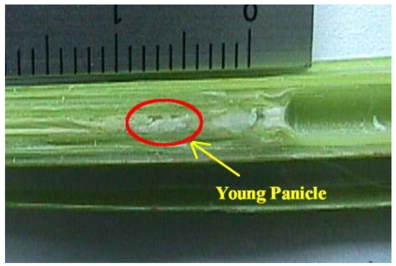
Missing hills lead to low yield. It is therefore advisable that you place extra seedling at the corner of the field to be used for replanting.
Replant missing hills 10 days after transplanting.

Fertilization（amount and timing）

Basal: Apply 25 kg of DAP（18-46-0） and 25 kg of Urea（46-0-0） before final harrowing.

Top dressing: Apply 25 kg of urea at panicle initiation stage（65-70 days after sowing）.

When you apply top dressing, irrigate the field and keep 2 - 3 cm standing water.
If there is no water in the field, fertilizer application become useless.
After fertilizer application, keep water in the field for one week to avoid fertilizer runoff.



Panicle initiation stage

HARVESTING AND POST HARVEST

Harvesting

The stem of the rice is cut close to the ground by serrated sickles. This method of harvesting is much faster than harvesting by panicle using a knife. Harvesting should be done when 80-85% of the grains are straw coloured and the grains in the lower part of the panicle are in the hard dough stage.

Harvesting by sickles

Harvesting panicles by knife

Threshing

Threshing can be done by beating with sticks against a log or using thresher. However, threshing by beating increases the chances of broken grains at milling.

Beating with sticks

After beating, many paddy are remained

Two types of thresher are are available in Kampala.

Manual thresher

Engine driven thresher

Winnowing and Drying

Before drying, winnow empty grains and straw away.

Open air drying under the hot sun heat is widely practiced in the tropics.

Preferably drying should be done on a tarpaulin or a clean drying floor free of stones.

The rice should be 4 - 5 cm thick and needs to be turned over 30-60 minutes to allow equal exposure to the sun heat. Its important to monitor moisture reductions, less than 3% reductions are recommended per day.
Rapid drying lead to broken rice when milling. **DRY SLOWLY!**

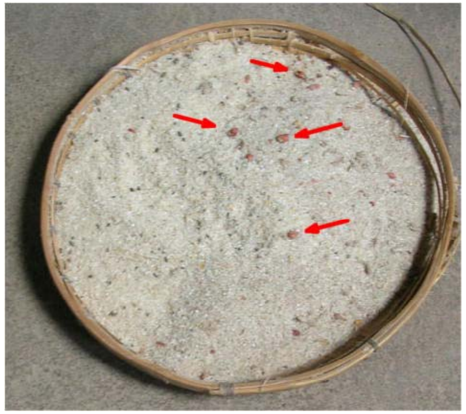
Keep 4-5 cm thickness for sun dry

Rapid drying cause broken rice

Rice Milling

New Type

Old Type



Big stones should be removed before milling

Destoner

SOIL MANAGEMENT

Fertilizer

Fertilizers（inorganic or organic） contain nutrients needed by the rice plant. The soil sometimes does not provide sufficient nutrients needed by the rice plant, hence, the need to apply fertilizer.
There are several nutrients needed by the rice plant but nitrogen（N）, phosphorus（P）, and potassium（K）are needed in large amounts.
These nutrients must therefore be constantly replenished to sustain the growth of rice plant.

Symptoms due to deficiency of elements in the soil

N:
Early growth retarded.
Tillering reduced.
Leaf color: yellow-green from lower to upper leaves.
Flowering and ripening accelerated.

P:
Early growth retarded.
Tillering reduced.
Leaf color: dark green, mixed with red, purple.

K:
Early growth retarded.
Leaf color: yellowing interveinal zone from top to lower.
Leaf color: dark green.
Brown spots（helminthosporium）.

Symptoms due to excess of elements in soil

Fe:
Leaf color: purple-brown discoloration.
Small brown spots from tip to basal part of lower leaves

Al:
Roots do not elongate.
Leaf color: interveinal zone becomes orange, white, necrosis.

Salts:
Early growth retarded.
Poor tillering.
Leaf color: white of leaf tip and other parts.

Iron toxicity（NERICA-1）

Kind of fertilizer

Nitrogen（N）: Urea 46-0-0, Ammonium sulphate 21-0-0

Phosphorus（P）: Superphosphate 0-18-0, Triple superphosphate 0-46-0

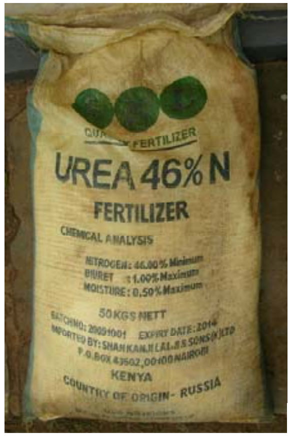
Potassium（K）: Potassium chloride（muriate of potash）0-0-60

Potassium sulphate 0-0-53

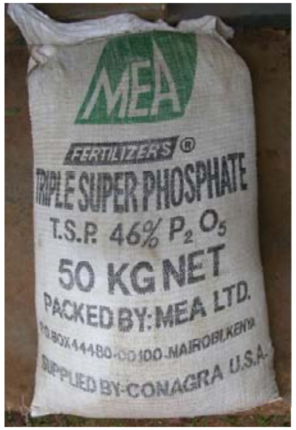
N,P fertilizer : 16-20-0（AP）, 18-46-0（DAP）

N,K fertilizer : 13-0-46（Potassium nitrate）

N,P,K fertilizer : 17-17-17



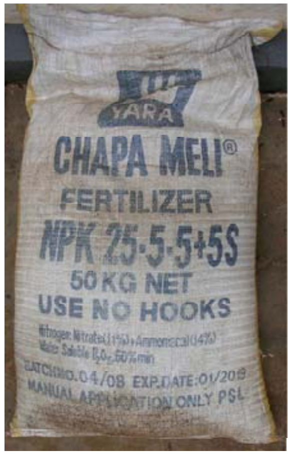
Urea（46-0-0）



TSP（0-46-0）

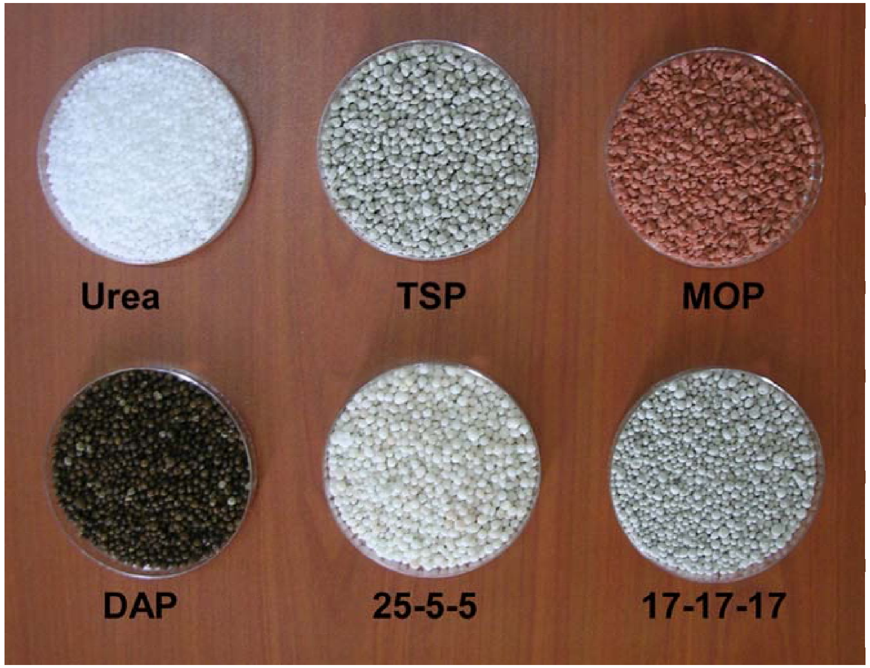
MOP（0-0-60）

DAP（18-46-0）



NPK（25-5-5）

NPK（17-17-17）



Use of Organic Material / Manure

Availability
Slow release of nutrients（poor ratio）
Too bulky to handle
Expensive, if purchased（transportation）

Chemical Composition of Animal Manure

Type of animal	C/N Ration	Nitrogen (N)	Phosphorus (P)	Potassium (K)
Cattle	19	1.50	1.00	0.94
Sheep	29	2.02	1.75	1.94
Horse	24	1.59	1.65	0.65
Pig	13	2.81	1.61	1.52
Chicken	-	4.00	1.98	2.32
Duck	-	2.15	1.13	1.15
Human※	8	7.24	1.72	2.41

Source: Gachene, Charles K.K. and Gathiru Kimaru, 1999.

Note:

※Though human manure is treated and used in some Asian countries, it is not recommended for use in Africa because of the inadequacy of safe handling and therefore the obvious danger of spreading human disease.

PLANT PROTECTION

Weed Management

Weeds reduce rice yields by competing with the rice plants for soil nutrients, moisture, and sunlight.

Fertilizer application may not increase yield in weedy fields because weeds absorb nutrients more effectively than the rice plants.

Weeds are also harmful because they may be alternate hosts for insects and diseases of rice, and provide shelter for rats.

Weed control measure that you can use are the preventive, mechanical, cultural, and chemical method.

- The preventive method includes use of good seeds (without weed seeds), control of weeds before flowering and keep bund and canals free of weeds.

- The mechanical method involves hand weeding and use of rotary weeder.

Using hoe

Rotary weeder

- The cultural method involves good land preparation, closer crop spacing, flooding. Most weed seeds or rhizome can not germinate or grow without air under the surface of puddled soil.

- Chemical control involves the use of appropriate herbicides.
  A herbicide is a chemical used to kill or prevent the growth of weeds.

Kind of herbicide

Contact herbicides: kill only the parts that are sprayed.
Normally applied to leaves and stems.
Propanil (selective), Paraquat (non selective)

Systemic herbicides: herbicide move within the plant to kill portions that were not sprayed.
Applied to leaves and stems or to the soil.
Butachlor and 2,4-D (selective), Glyphosate (non selective)

Herbicide injury (Phytotoxicity)
Improper herbicide use.
Applying too much herbicide or high rate.
Applying herbicide at the wrong time.

Upland rice

Lowland Rice

herbicide injury

Herbicide label information should be followed at all time to prevent damage to the rice.

Insect Pests of Rice

Stalked-eyed flies ***(Diopsis thoracica)***

The larvae bore and feed on plant tissue inside the rice stem causing dead heart.

Larva

Damage

Adult

African Rice Gall Midge (*Oreolia oryzivora*)

The African rice gall midge is a insect pest of lowland rice.

The larvae attack the growing point of the apical bud at a node and cause the leaf sheath tissues to form a tube-like structure called a 'silver shoot gall' or 'onion shoot'.

Rice fields planted early are less damaged than those planted late.

There are some resistant varieties.

(WARDA)

Caseworm (*Paraponynx stagnalis Zelle*)

The larva may eat the leaf tissue. The insect attacks from seedling to tillering stage.

Larvae make their cases from leaf.

The damage is not uniform because the larvae floating in their cases are carried to one side of the field by wind or water currents.

Draining the field for 4-6 days kill larvae.

Stem borers (*Pyralidae*)

The larvae bore through the stem and eat up the plant tissue resulting in a condition called dead heart and / or white head.

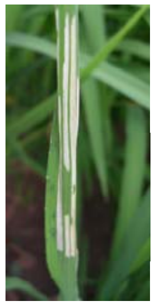
Larva

Adult

Damage (white head)

Rice leaffolder (Lepidoptera, Pyralidae)

The larvae scrape the leaves and folds the leaf together and scrapes inside.



Damage

Larva

Stink bug and Rice bug

The bugs stay on the panicle and suck the milky juice in young panicles causing staining of the grains hence lowering grain quality.

Stink bug

Rice bug

← Damaged rice

Other Insect Pest

Rice mealybug

Rice Weevil
(storage insect)

Termite

Note: Usually insect damage does not necessitate chemical control since it does not reduce yields significantly.

Diseases of Rice

Rice Yellow Mottle Virus（RYMV）

RYMV is known only in Africa and one of the most damaging diseases of rice in Africa. RYMV is now a severe problem in eastern and northern Uganda.

Symptoms:

・Stunting of rice plants if infected at early stage.
・Reduce tiller number.
・Yellowing and mottling of leaves.
・Infected plants are easily attacked by other diseases (such as brown spot).

Transmission of RYMV

RYMV is transmitted by a vector and also mechanically.

Control of RYMV

There are no practical ways (no chemicals) of curing a plant after it becomes infected.

Planting resistant varieties is the cheapest and most effective way of controlling RYMV. Tolerant varieties: NERICA 4, 6, NARIC 1, 2

Eliminating sources of virus:

Rogue（remove） infected rice plants from the rice field. Roguing is successful when only a low percentage of plants are infected.

Prevent ratoon growth, which is a main source of RYMV.

Direct seeding (Not transplanting) can reduce the occurrence of RYMV.

Rice Blast（*Magnaporthe grisea*）（*Pyricularia oryzae*）
It is one of the most destructive diseases of rice.
Symptoms:
The fungus produces spots or lesions on leaves, nodes, and panicles and grains. The spots are elongated and pointed at each end.
Damage of blast:
In severe infections, yields may be reduced by 50 %.
Upland rice is more severely damaged than lowland rice.
Control:
Planting resistant varieties is the most economical way of controlling this disease.
Avoid excess nitrogen fertilizer.
There are several fungicides that effectively control blast but for economic reason, these are not used in the tropics.

leaf blast

neck blast

Sheath Blight（*Thanatephorus cucumeris*）
Sheath blight causes spots on the leaf sheath. High temperature and humidity increase the severity.
Disease cycle:
Sclerotia develop on lesions and drop to the soil → The fungus survives in sclerotia in the soil → The sclerotia float on the water surface during land preparation → The sclerotia germinate and fungus penetrates the plant → The fungus grows on the plant.

Damage of sheath blight:
Many of the leaves are killed during severe infections and yields may be reduced by 20-25 %.
Control:
No variety has a high level of resistance to the disease. Do not apply too much nitrogen.

There are effective fungicides controlling the disease, but are economically not recommendable.

Brown spot（*Cochliobolus miyabeanus*）
The disease is common in soils that are poorly drained or deficient in nutrients.
Symptoms:
The symptoms are brown spots on the leaf and grain.

Disease cycle:
The disease is transmitted by the infected seeds.
Damage of brown spot:
It lower grain quality and weight.

Control:
The most effective way of controlling brown spot is to grow plants in good soil and provide adequate fertilizer.
Planting a resistant variety is the most practical way of controlling.
Treating the seeds with fungicide or hot water help control the disease.

Seedling stage

Leaf scald（*Metasphaeria albescens*）

Symptoms:

The symptoms are lesions starting from leaf tip.

Disease cycle:

The fungus survive on the rice straw.

The fungus penetrate lower leaves.

Flooding of rice induce sever occurrence of this disease.

Damage of leaf scald:

It lower the filled grain ratio and grain quality.

Control:

Avoid excess nitrogen fertilizer.

Sheath rot（*Acrocylindrium Oryzae*）

Symptoms:

Spots develop on the uppermost leaf sheaths enclosing panicles.

The young panicles remain in the leaf sheath or emerge partially.

Grains remain unfilled or are discoloured.

Disease cycle:

The disease is usually found in plants injured by insect or diseases, particularly stem borer and virus（RYMV）.

Hot humid weather favors sheath rot development.

Damage of sheath rot:

Little is known about crop losses caused by sheath rot.

Control:

Little is known about control of this disease.

Grain rot（*Burkholderia glumae*）

Symptoms:

Usually, after heading, spikelets loose green colour and become whitish then finally turn to brown.

Disease cycle:

Seed transmitted disease.

Hot humid weather favours grain rot development.

This disease is also transmitted by wind and rain from infected panicles to near by panicles.

Damage of grain rot:

It lower grain quality and weight.

Control:

There is no resistant variety for this disease.

There are several fungicides which effectively control grain rot but for economic reason, these are not used in the tropics.

False smut（*Claviceps virens*）

The occurrence of the disease is believed to indicate a good yield because weather favourable to the development of false smut also favours good crop production.

Symptoms:

The fungus changes single grain of the panicle into velvety balls, which may grow to a diameter of 1 cm.

Usually, only a few grains on the panicle are infected and the rest remain normal.

Damage of false smut:

Usually, damage of this disease is minimal.

Control:

Usually, no control measures are necessary.

Appendix 1

Cost Benefit Analysis for One Acre of Upland Rice Cultivation

(Assuming the yield is 1,500kg / acre)

Expenditure		Ush
Seeds	20 kg x 1500	30,000
Fertilizer DAP(18-46-0)	25 kg x 2,000	50,000
Urea(46-0-0)	50 kg x 2,000	100,000
Sacks	15 bags x 1,000	15,000
Slashing		60,000
Digging		80,000
2nd digging		80,000
Planting		30,000
Hand weeding	50,000 x 2	100,000
Bird scaring	2,000 x 30 days	60,000
Harvesting and threshing		40,000
Transport		30,000
Milling cost (if one gains 67% of milled rice out of paddy)	1,000 x 100	100,000
	Total	775,000
Income		Ush
15 bags x 100 kg	1,500 kg x 67%	
Milled rice 1,000 kg	1,800 x 1,005 kg	1,809,000
Income − Expenditure	1,809,000 − 775,000	**1,034,000**

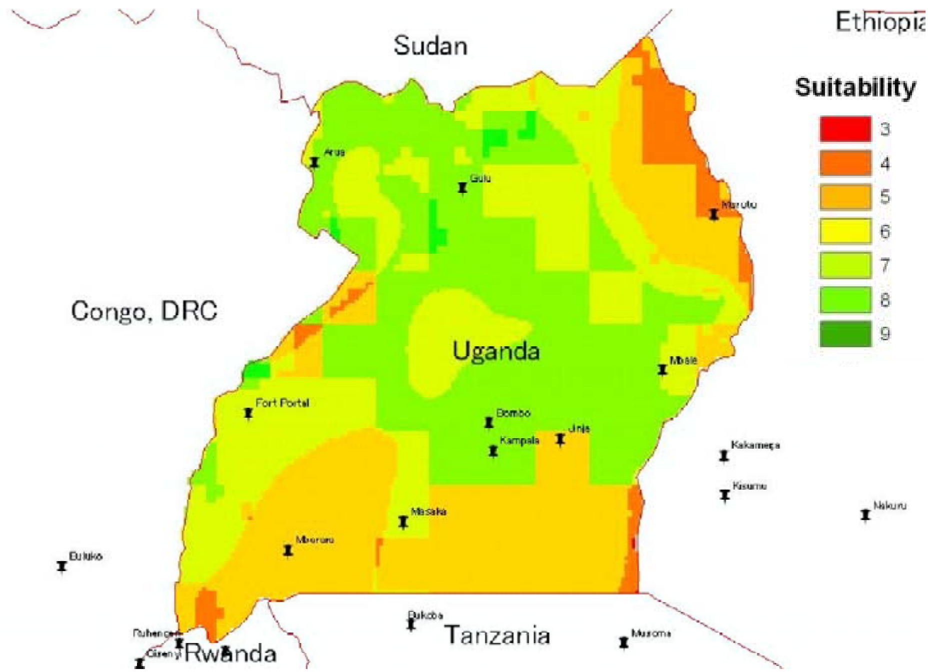
Appendix 2

Cost Benefit Analysis for One Acre of Lowland Rice Cultivation

(Assuming the yield is 2,000kg / acre)

Expenditure		Ush
Seeds	15 kg x 1,500	22,500
Fertilizer DAP(18-46-0)	25 kg x 2,000	50,000
Urea(46-0-0)	50 kg x 2,000	100,000
Sacks	20 bags x 1,000	20,000
Slashing		60,000
Digging		80,000
Paddling and levelling		80,000
Transplanting		60,000
Hand weeding	50,000 x 2 times	100,000
Bird scaring	2,000 x 30 days	60,000
Harvesting and threshing		60,000
Transport		40,000
Milling cost (if one gains 67% of milled rice out of paddy)	1,300 x 100	130,000
	Total	862.500
Income		Ush
20 bags x 100 kg	2,000 kg x 67%	
Milled rice 1,300 kg	1,300 kgx 1,800	2,340,000
Income − Expenditure	2,340,000 − 862,500	**1,477,500**

Appendix 3
Uganda Suitability Map for NERICA Cultivation



This suitability map for growing rice is created based on the following three factors; Annual rainfall / Elevation / Soil pH. Using the following datasets, original datasets are classified into three categories（not suitable / suitable / very suitable） and summed up to produce the above suitability map.

The original data is downloaded free from the following institutions' websites.
Annual rainfall : Africa Climate from FAO/Agrhymet

Elevation : National Geophysical Data Center /NOAA

Soil pH : International Soil Reference and Information Center（ISRIC）

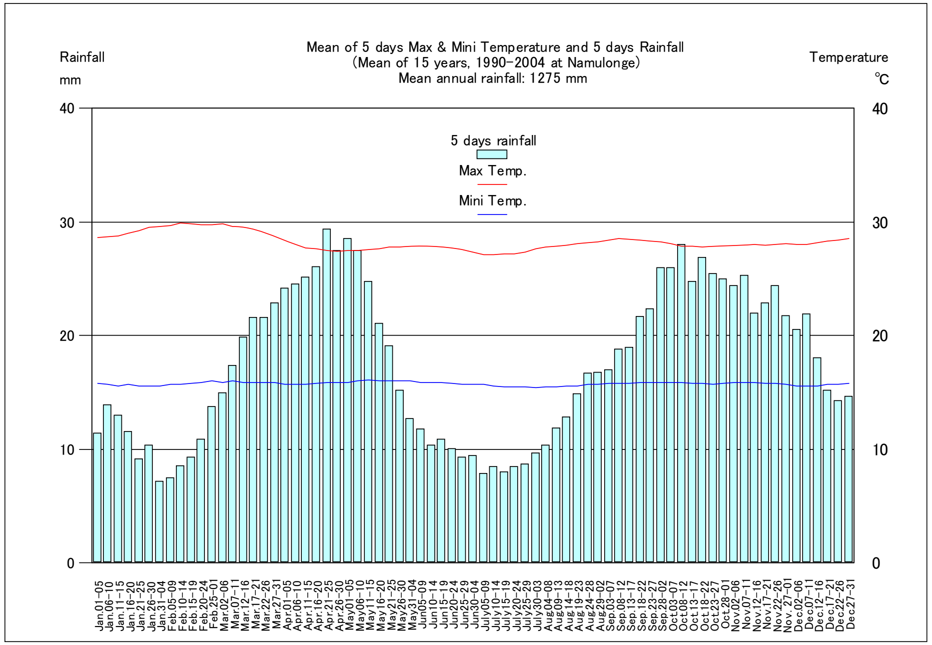
The suitability condition for each factor is as follows.

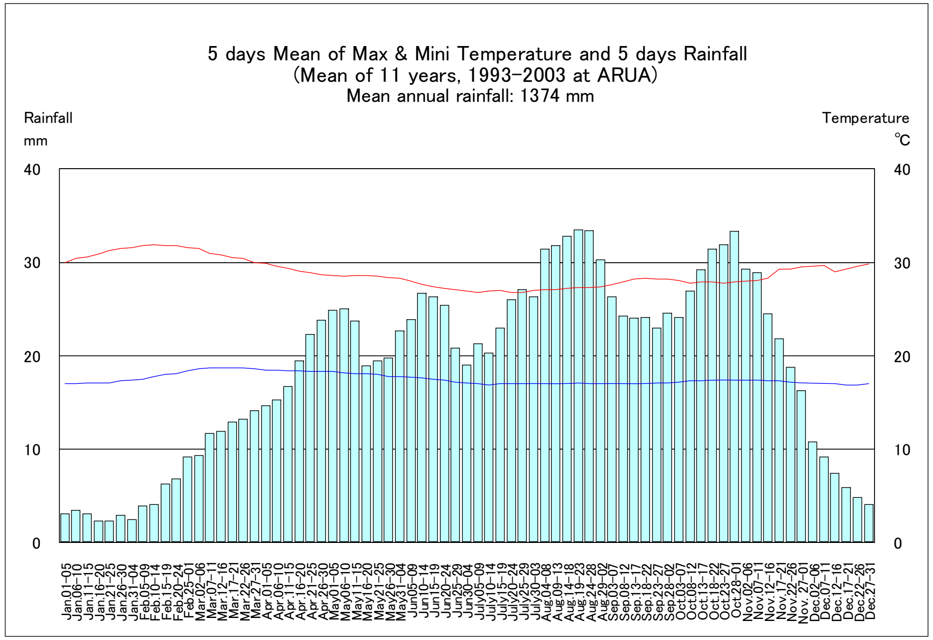
Annual rainfall : Not suitable＜ 800, Suitable 800-1200, Very Suitable ＞1200

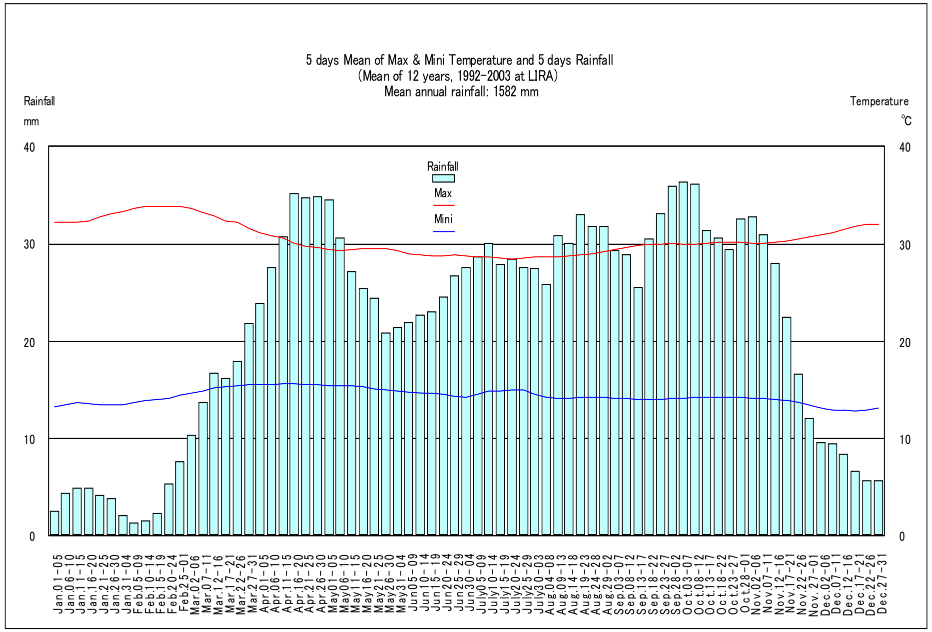
Elevation : Not suitable＞ 1700, Suitable 1000-1700, Very Suitable＜ 1000

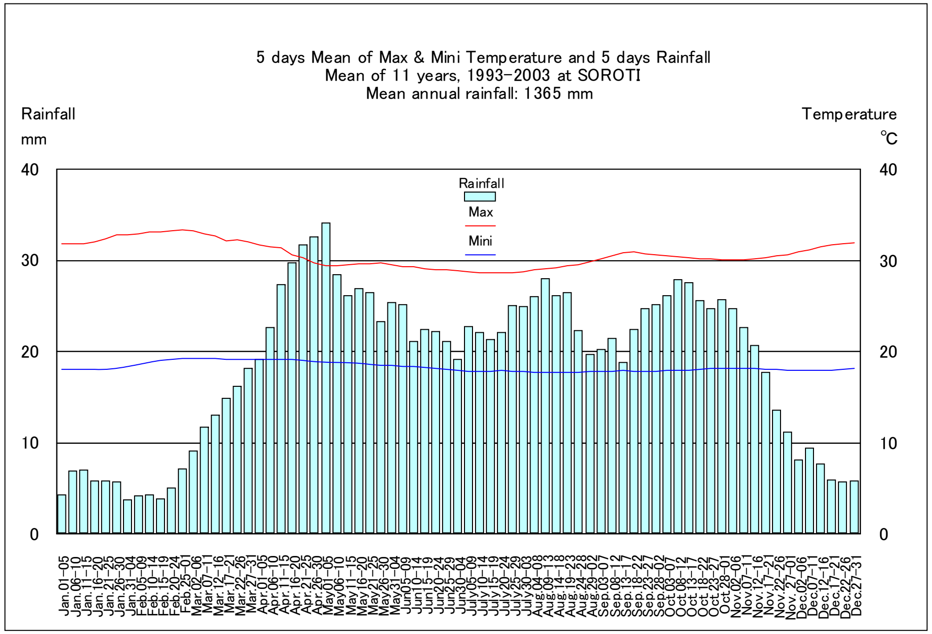
Soil pH : Not suitable＜ 4.5 or＞ 7.0, Suitable 4.5 - 5.5, Very Suitable 5.5 -7.0

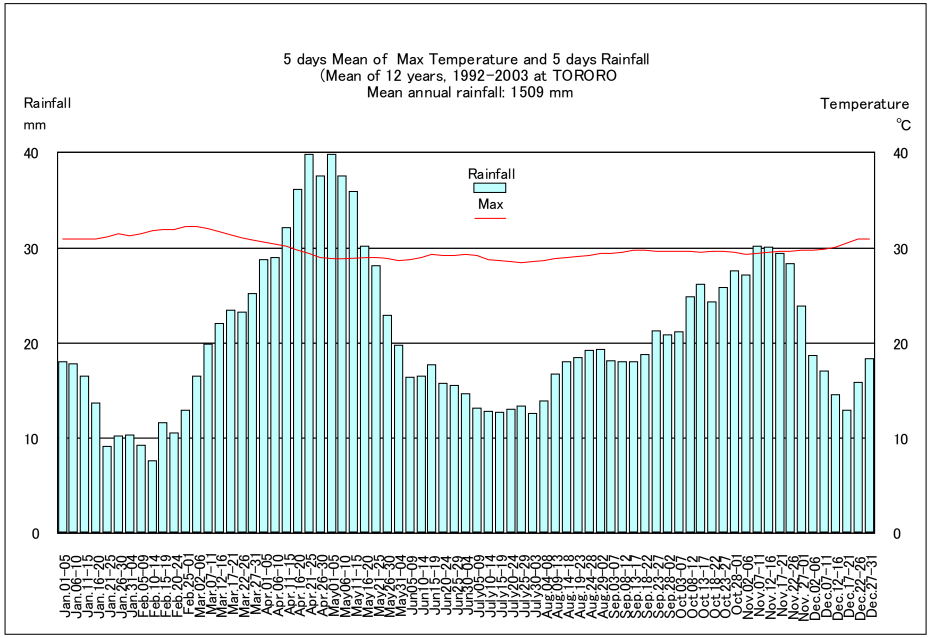
Appendix 4 Rainfall Patterns in Uganda

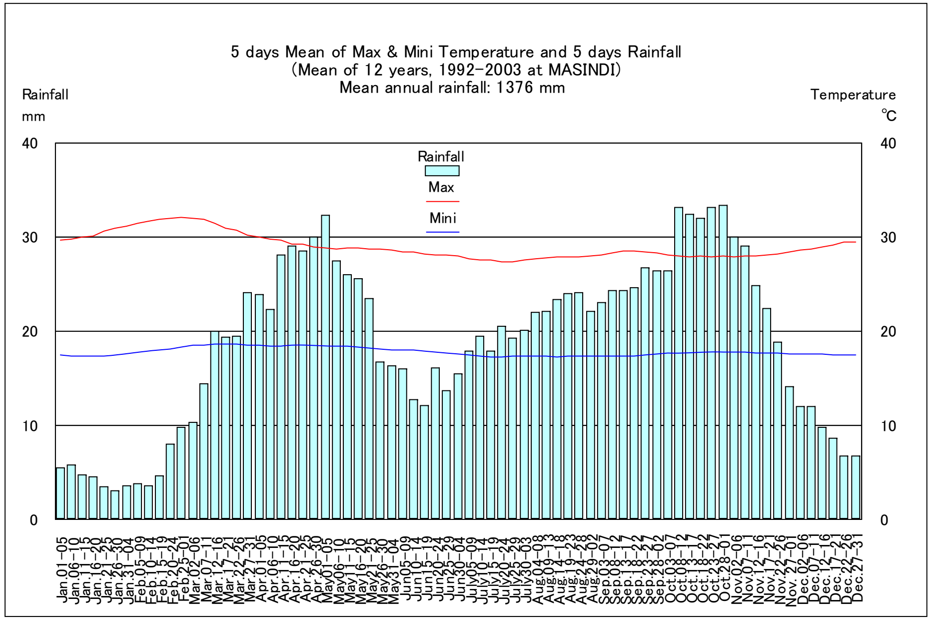


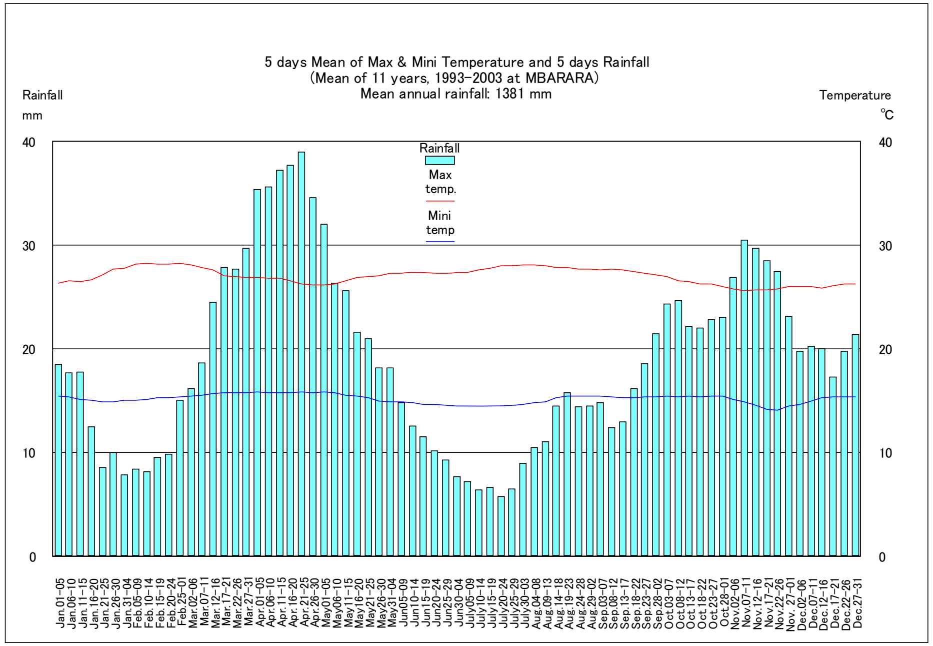


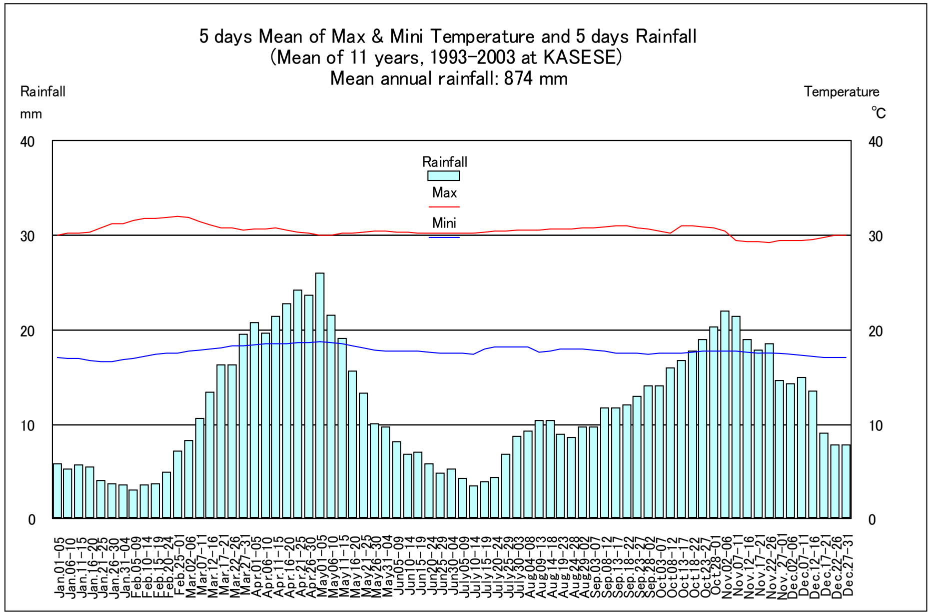

5 days Mean of Max & Mini Temperature and 5 days Rainfall
(Mean of 12 years, 1992-2003 at LIRA)
Mean annual rainfall: 1582 mm
Rainfall
mm
Temperature
℃
Rainfall
Max
Mini


5 days Mean of Max & Mini Temperature and 5 days Rainfall
Mean of 11 years, 1993-2003 at SOROTI
Mean annual rainfall: 1365 mm
Rainfall
mm
Temperature
℃
Rainfall
Max
Mini


5 days Mean of Max Temperature and 5 days Rainfall
(Mean of 12 years, 1992-2003 at TORORO
Mean annual rainfall: 1509 mm
Rainfall
mm
Temperature
℃
Rainfall
Max


5 days Mean of Max & Mini Temperature and 5 days Rainfall
(Mean of 12 years, 1992-2003 at MASINDI)
Mean annual rainfall: 1376 mm
Rainfall
mm
Temperature
℃
Rainfall
Max
Mini


5 days Mean of Max & Mini Temperature and 5 days Rainfall
(Mean of 11 years, 1993-2003 at MBARARA)
Mean annual rainfall: 1381 mm
Rainfall
mm
Temperature
℃
Rainfall
Max temp.
Mini temp
40
30
20
10
0


5 days Mean of Max & Mini Temperature and 5 days Rainfall
(Mean of 11 years, 1993-2003 at KASESE)
Mean annual rainfall: 874 mm
Rainfall
mm
Temperature
℃
Rainfall
Max
Mini
40
30
20
10
0

March　2010