ISSN 2304-2427

Good agricultural practices for irrigated and rainfed lowland rice in East Africa

IRRI
INTERNATIONAL RICE RESEARCH INSTITUTE
East and Southern Africa
Mikocheni, Dar es Salaam, Tanzania

Good agricultural practices for irrigated and rainfed lowland rice in East Africa

2012

IRRI

International Rice Research Institute

The International Rice Research (IRRI) was established in 1960 by the Ford and Rockefeller Foundations with the help and approval of the Government of the Philippines. Today, IRRI is one of the 15 nonprofit international research centers that are members of the CGIAR Consortium (www.cgiar.org). It is supported in part by government funding agencies, foundations, the private sector, and nongovernment organizations.

The responsibility for this publication rests with the International Rice Research Institute.

This bulletin builds on rice research and development experience of staff at the International Rice Research Institute working in Africa and Asia. It is designed to meet the needs of development workers, extension personnel, and rice farmers in East and Southern Africa and particularly in Tanzania.

Suggested citation: International Rice Research Institute (IRRI). 2012. Good agricultural practices for Irrigated and rainfed lowland rice in East Africa. Bulletin No. 1, IRRI-Tanzania, Dar es Salaam. 36 p.

Contributors: Yash Pal Singh, Stephan Haefele, Nhamo Nhamo, Rosemary Mutegi-Murori, Mohammed Mkuya, Raheli Elibariki, Zakaria L. Kanyeka, and R.K. Singh.

ISSN 2304-2427

Contents

STEP 1 Choose the most suitable variety for each field

Why use suitable varieties?

Because fields differ in their soil quality, risk of flooding, and diseases, a suitable variety must be selected for each field. Using suitable varieties minimizes the risk of crop loss or failure and ensures good yields.

What are suitable varieties?

Suitable varieties give good yields, have good taste, have a high market price, and much more. Important criteria follow:

- Plant height: In most fields, farmers prefer varieties of medium height (1–1.2 m). Tall varieties (about 1.4 m) give low yields and are prone to lodging. Very short varieties (less than 1 m in height) should be used only in favorable fields with low drought or flooding risk.
- Duration: Long-duration varieties (more than 150 days) are preferable in flood-prone fields; early varieties (less than 120 days) are better suited to upper, drought-prone fields.
- Water requirement: Generally, varieties requiring a low amount of water are preferable because of uncertainty/nonuniform distribution of rainfall.
- Low fertilizer requirement: Resource-constrained farmers in rainfed lowlands prefer a variety that requires low inputs, including water.

Variety types, their characteristics, and best uses

Traditional varieties/landraces: usually tall, have few tillers, bold/ undesirable grains, photoperiod sensitive, lodge easily, and are low yielding (for example, SUPA). But, they can be a better choice on very poor soils or in flood-prone fields.

Improved varieties: usually of medium height, have many tillers, slender grains, respond to inorganic fertilizer, and can give high yields. They are preferable in most fields.

Example of suitable varieties

Choose a variety according to your experience, local recommendations, and the field situation. Examples of some commonly grown varieties follow:

Duration	Varieties	
	Traditional	Improved
Short	Wahi wahi, Dunduliyamlimani, Kulanabwana, Shingoyamwali	IR8, IR64, Mwangaza, Kalalu
Medium	SUPA, Kasegese, Supa India, Tule Na Bwana, Super mbeya, Kialakonda, Muungaja, Sido	SUPA BC, TXD 86, TXD 88, TXD 85, SARO 5
Long	Ringa, Kilombero, Zambia, Rangimbili, Mwangulu, Domolafisi, Fayatereza, Moshiwatta, Mbawambili, Machale, SUPA, Kigunia, Kilogo, Mosiwataa, Borakupataa, Muunguja	PINLOT 10, Kihogo Red

STEP 2

Use pure, clean, and healthy seed

Why use good seed?

Good seed reduces the seed rate, provides good germination and healthy and strong seedlings, gives a uniform crop stand in the field, and results in higher yields.

What is good seed?

Good seed is

- clean (contains no stones, soil particles, weed seed),
- pure (contains only grains from one variety), and
- healthy (full big grains, same color, no cracks).

Dirty seed Impure seed Clean, pure, and healthy seed

How do you obtain good seed?

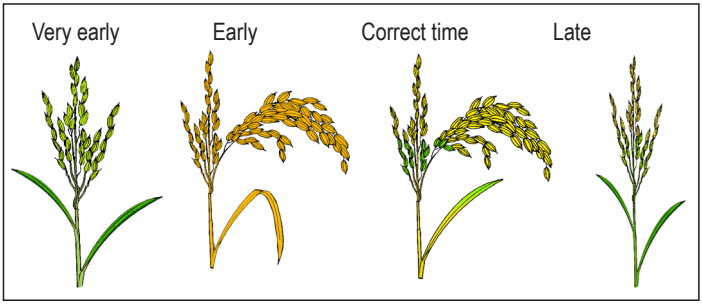
Buy certified seed that is pure and labeled or produce your own good seed:

1. Choose a good field: fertile soil with low flooding or drought risk.
2. If available, use clean, pure, and healthy seed to start with.
3. Use good management practices (Steps 3, 4, 5, and 6) and put extra effort into weeding.
4. Around flowering, remove all rice and other off-plants that clearly look different (different height, plant color, flowering time, panicle type, grain shape and color). Also remove sick and insect-damaged plants/panicles.
5. Harvest at full maturity (80–85% of the grains are straw-colored).
6. Thresh and dry within 2 days after harvest. Clean thoroughly by winnowing. If a thresher is used, clean it before use to avoid mixture of any other seed.
7. Use a separate container for the seed, label it with the name of the variety, and store the seed in a cool, dry, and clean area.

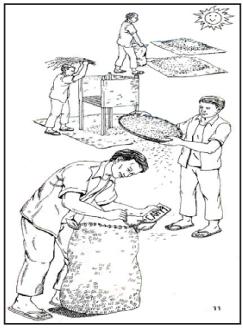
How to produce your own good seed:

1. Choose a good field: fertile soil with low flooding or drought risk.
2. Select healthy panicles of the same variety to get healthy seed.
3. Sow the seeds in a raised bed separately.
4. Use good management practices.
5. Transplant the nursery in a well-prepared field.
6. Manage the crop well (see Steps 3, 4, 5, and 6).
7. Remove all plants that differ in height, plant color, flowering time, panicle type, or grain shape. Also remove sick plants and insect-damaged panicles.

8. Harvest at maturity when 80–85% of the grains are straw colored (see Step 7).



9. Thresh and dry immediately after harvest. If a machine is used, clean the thresher before use. Clean the seed thoroughly by winnowing. Label the seed and store it in a cool, dry, and clean area.



STEP 3 Prepare and manage the seedbed well (transplanted rice)

Why is seedbed management important?

Good seed together with a well-prepared and managed seedbed give the crop a better start.

After transplanting, the seedlings will grow faster and cope better with poor soils, weeds, insects, and diseases.

What is good seedbed management?

1. Choose a spot with good soil, water availability, and protected from farm animals.
2. Prepare the seedbed well and keep it weed free.
3. Use good seed (see Step 2).
4. Apply recommended dose of fertilizer to get healthy seedlings.
5. Use the right amount of seed (seeding density).
6. Transplant seedlings at the right time.

How do you manage the seedbed well?

Seedbed preparation:

Dry seedbed: Make a raised bed of 1.5-m width with length at your convenience. An access path of 25 cm has to be allowed between adjacent beds. Nursery beds are raised 4–5 cm above the ground level. Generally, 1/10 of the area is required for raising seedlings to transplant on 1 hectare.

Wet seedbed: Puddle the field and level it. Divide the field into 1 × 10-m subplots by making a drain on four sides and level it. One hundred beds are required for planting on 1 hectare. Open the furrow in each subplot and sow the seeds in a line. Cover with fine soil. Apply recommended dose of fertilizer at the time of final field preparation.

Seed rate: For transplanting: 40 kg/ha (4 kg/100 m^2 nursery). Some 40 g of presoaked seed is recommended for broadcasting evenly per 1 m^2.

For direct seeding: 80–100 kg/ha

Seedbed nutrient management: Apply 1 kg N (2.25 kg urea) and 1 kg P (6.25 kg single superphosphate) and 0.5 kg K (1.0 kg muriate of potash) as basal and 0.5–1.0 kg N (1.25–2.25 kg urea) 10–15 days after emergence on 100 m^2 (1 m × 100 m) as topdressing.

Transplanting age: Use only 18–30-day-old seedlings for transplanting. Two to three seedlings should be planted per hill. A spacing of 20 cm between rows and 20 cm between plants within a row should be maintained. In a random planting, care should be taken in maintaining 30–35 hills/m^2. Transplanting old seedlings gives low yields because they are less healthy and do not produce many tillers. Closer transplanting (more seedlings per area) can partly compensate for this. Avoid transplanting seedlings older than 40 days.

Nursery water management: For the first week, keep the nursery bed moist but do not submerge it. From the second to fourth week, raise and maintain the water level at 1–5 cm depending on seedling height.

Well-managed seedbed

STEP 4 Prepare the field with care—level the field, repair bunds, and apply organic fertilizer

Why is field preparation important?

A well-prepared field provides the rice crop with good conditions for growth.

Careful field preparation helps to make the best use of available water and nutrients (and organic matter), maintain soil quality, and reduce weeds.

What is good field preparation?

1. To conserve the moisture *in situ* and impound the water, make bunds and divide the field into small plots. Size of the main bunds can range from 30 to 50 cm in height and from 60 to 100 cm in width. The constructed bunds need regular repairing and maintenance.

2. Plow twice and harrow once to incorporate crop residues and weeds, and to make a fine seedbed.

3. In heavy clay soils (vertisols), one can use a rotavator (if available) with a 4 × 4 tractor or a lightweight hydrotiller.

4. Level the field well to ensure even crop growth, and to maintain a uniform water depth.

5. Apply organic/mineral fertilizer to provide plant nutrients and keep the soil healthy.

6. Repair old bunds to reduce water losses and destroy rat burrows.

How do you prepare the field well?

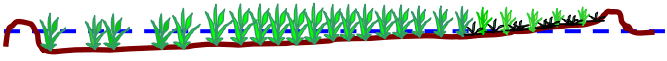
Organic fertilizer (manure, compost, rice husk, straw, tree leaves): Make application uniform across the field, before land preparation. Apply about 2 t/ha (about 20 cart loads) of organic matter if available. But, it is usually not profitable to buy organic fertilizer.

Plowing: Plow under weeds, stubble, and organic fertilizer at the beginning of the cropping season (best at 3–4 weeks before transplanting).

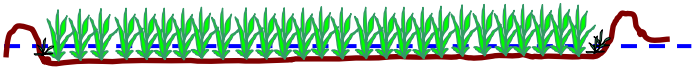
Harrowing: Harrow the field at least once. Harrowing breaks the clods, incorporates organic residues, and kills weeds that have germinated after plowing.

Puddling: To create ideal conditions for paddy seedlings, puddling should be done before planting the seedlings. It provides good soil conditions for better crop establishment, improves nutrient and water uptake by the plant, enhances water conservation, improves even distribution of nutrients, incorporates organic materials and amendments, contributes to leveling of the plot, and reduces weed intensity. At puddling, water depth should be 10–15 cm. For heavy clay soils (vertisols), use a rotavator or lightweight hydrotiller.

Leveling: Leveling can be done with a shallow water layer in the field. After leveling, the water level should be equally deep in the whole field and no mounds of soil should be visible above a shallow water layer.



Unleveled field: Rice growth is bad in the deep and high parts of the field; many weeds grow in the high part. The crop does not ripen at the same time.



Well-leveled field: Rice grows well and evenly in the whole field, and weed problems are minimal. The crop will ripen at the same time in the whole field and **yield will be high.**

Bund repair: Compact the bunds, repair gaps, and destroy rat burrows.

STEP 5

Keep your field weed free

Why is weeding important?

Weeds take away space, light, nutrients, and water from the rice plants, resulting in a lower rice yield.

Weeds do most damage early—during the first 30–40 days after transplanting. But, later control is also important to prevent seed setting of weeds.

What is effective weed management?

Effective weed management is achieved by doing the following:

1. All crop management favoring strong crop growth, including choice of a suitable variety, clean seed, and healthy seedlings (Steps 1–3).
2. Land preparation reducing weed infestation and favoring crop growth (Step 4).
3. Weed control measures through hand weeding and/or appropriate use of herbicides (chemicals that kill weeds).

How do you minimize weed infestation?

- Prefer varieties of medium height and that grow fast.
- Use clean rice seed, free of weed seeds.
- Plowing and harrowing should be timed (10–20 days between plow passes) so that weeds germinate in between operations and are thus killed by the following operation.
- Good land leveling significantly reduces weed growth because most weeds cannot germinate under water.
- Time of weeding is very important. In an irrigated system, weed twice at 2 weeks after transplanting and then at 3 weeks after the first weeding (before panicle initiation). In a rainfed direct-seeded system, weeding should be done 2 weeks after germination and the second weeding is done 3 weeks after the first weeding.

- Chemical weeding with herbicides. Both pre- and postemergence herbicides can be applied to control weeds. Preemergence herbicides are applied before both weeds and rice germinate, usually in direct dry-seeded rice. Apply postemergence herbicides when the weeds are at the 2–3 leaf stage. Always read and follow the instructions on the product label. Use herbicides at the recommended rate, and use the right herbicide for your weed problem (see Annex 1 for further advice).

- Spray butachlor (1.5 kg a.i./ha) at 3 liters/ha 5 days after transplanting. Assure that water is there in the field for the next 24 hours after spraying.

  NOTE: Herbicides are poisonous; if they are not used properly, they can cause health and environmental problems. Label them clearly and keep them out of children's reach.

STEP 6 Fertilizer is essential to achieve high yields and keep the soil healthy

Why is fertilizer important?

Plants need nutrients to grow. Most soils provide only small amounts of nutrients, causing limited crop growth and low yields.

Fertilizers supply additional nutrients to the crop and improve crop growth and yield. Fertilizers can also improve soil health.

What is fertilizer?

1. Organic fertilizer: materials such as manure, compost, rice husk, straw, and tree leaves. They are cheap and improve soil health, but they need much labor and their nutrient content is low.
2. Inorganic fertilizer: has high nutrient content and improves plant growth fast, but is expensive.
3. The most important nutrients are nitrogen (N, makes the plant big and green), phosphorus (P, increases number of tillers), and potassium (K, makes the plant healthy and strong).

How do you manage fertilizer properly?

- Use organic fertilizer (manure, compost, straw, husk, tree leaves) whenever possible (see Step 4), preferably on upper, sandy soils.
- The recommended dose of fertilizer (in kg) for 1 ha of rainfed lowland rice is 80:40:40 (N:P:K). Only a half dose of the N and a full dose of P and K should be applied as basal and the remaining half dose of N should be applied in two equal splits at tillering and panicle initiation (PI) stages.
- Topdressing should be applied when rice leaves are not wet.
- Base the amount on season, fertility, variety, and time and method of application.

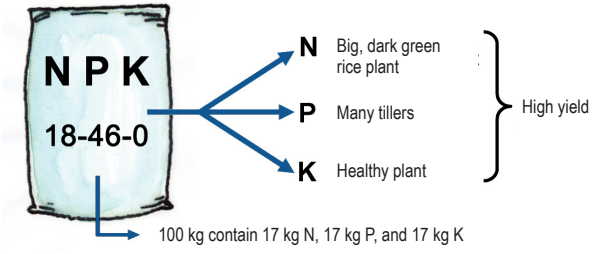
  Note: Inorganic fertilizers must be stored in a dry and cool place. They are not poisonous but keep them out of children's reach.

How to use organic and inorganic fertilizers

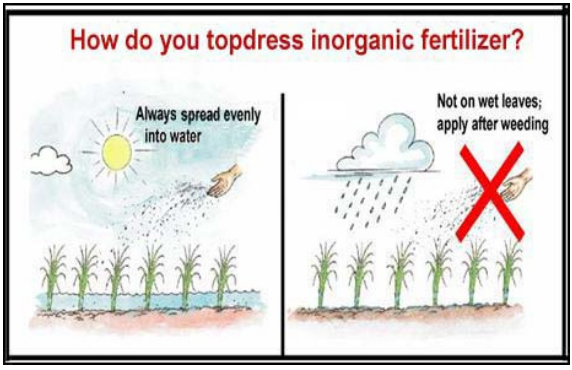
- Use organic fertilizer (manure, compost, straw, husk, tree leaves) whenever possible (see Step 4), but preferably on upper fields and on very sandy soils.
- Use inorganic fertilizer to increase rice yields (rates below are for a 1-hectare field).
- To apply 80:40:40 (N:P:K), use 235 kg NPK (17:17:17) fertilizer for basal application and 90 kg urea/ha for topdressing in two splits at tillering and PI stages.
- The inorganic fertilizer rate above is a good recommendation for good fields with a low drought or flooding risk.
- In many fields having no deficiency of K, the use of N and P fertilizer through DAP (N 18, P 46) is sufficient. Use 17:17:17 NPK fertilizer preferably on very sandy soils or when K deficiency occurs (see Annex 4).
- At the time of topdressing with urea, sufficient moisture should be in the field to increase fertilizer-use efficiency. If the urea is not applied at the recommended time (because of low moisture content in the field or continuous rain), you can apply it 7 days before or after the recommended optimal time.
- Do not apply urea at or after booting. If it is too late, it will not increase yield.

General knowledge on inorganic fertilizer

1. The most important nutrients for rice are nitrogen (N), phosphorus (P), and potassium (K).

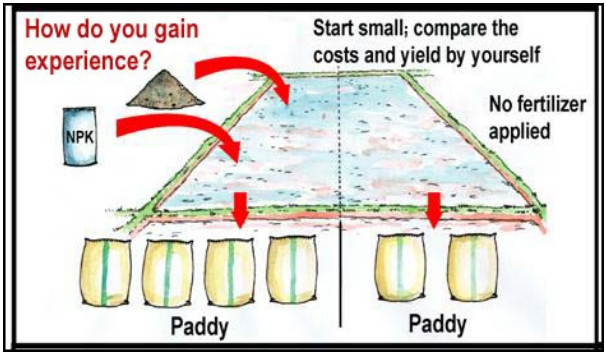


2. The NPK content of inorganic fertilizer is written on the bag, for example, "NPK 17:17:17" means that 100 kg contain 17 kg N, 17 kg P, and 17 kg K.



3. Top-dress inorganic fertilizer only into shallow water and when rice leaves are dry.

4. If you do not have not enough fertilizer for all your fields, apply it to good fields (low risk) and improved varieties first.



5. To gain experience, use inorganic fertilizer on half of your field. Compare the yield with the other half where no inorganic fertilizer was used.

Note: NPK rates are actually given in N-P_2O_5-K_2O but, for simplicity, we used N, P, and K in the text above.

Calculating fertilizer rates for a field of a specific size

Example: Your field is half a hectare (0.5 ha), the available fertilizer is urea (46% N) and mixed fertilizer (17:17:17 NPK), and the recommended fertilizer rate is 80:40:40 kg NPK/ha.

1. First, calculate the quantity of mixed fertilizer that you need:
   Recommended rate (40 kg P/ha) multiplied by the area (0.5 ha) divided by the P in the mixed fertilizer (17) multiplied by 100 = 117.65 kg mixed fertilizer:

   $$\text{Formula} = \frac{\text{Recommended dose of P (40 kg/ha)}}{\text{17 (P \% in NPK fertilizer)}} \times 100$$

2. Now, calculate the quantity of K available with 117.65 kg mixed fertilizer.

   Recommended rate (40 kg K/ha) multiplied by the area (0.5 ha) divided by the K in the mixed fertilizer (17) multiplied by 100 = 117.65 kg mixed fertilizer. This means the calculated quantity of mixed fertilizer is sufficient to fulfill the requirement of K. There is no need to add any additional potassic fertilizer.

3. Then, calculate the quantity of urea that you need:
   The mixed fertilizer already contains some N: 117.65 kg mixed fertilizer multiplied by the N in the mixed fertilizer (17) divided by 100 = 20 kg N.

   The remaining N rate is the recommended rate (80) multiplied by the area (0.5 ha), minus the N in the mixed fertilizer (20) divided by the N in urea (46) multiplied by 100 = 43 kg urea.

   So, for 0.5 ha, you need 117.65 kg of 17:17:17 mixed fertilizer (NPK) and 43 kg urea to apply the recommended rate of 80:40:40 kg NPK/ha.

   Note: NPK rates are actually given in N-P_2O_5-K_2O but, for simplicity, we used N, P, and K in the text above;

Quantity of fertilizer to be applied in case you have NPK (17:17:17), DAP, urea, and muriate of potash (MOP) to fulfill the recommended dose of fertilizers in irrigated and rainfed conditions.

Time of application	Irrigated (120N:60P:40K)		Rainfed (80N:40P:40K)	
	If you have DAP, urea, and MOP	If you have N:P:K (17:17:17)	If you have DAP, urea, and MOP	If you have N:P:K (17:17:17)
Basal (at the time of sowing/ transplanting)	DAP—130 kg Urea—80 kg MOP—66 kg	N:P:K—235 kg Triple superphosphate—44 kg Urea—44 kg	DAP—87 kg Urea—53 kg MOP—66 kg	N:P:K—235 kg
First topdressing at tillering (20–25 days after sowing/ transplanting	Urea—65 kg	Urea—65 kg	Urea—43 kg	Urea—43 kg
Second topdressing at panicle initiation stage (60–65 days after sowing/ transplanting)	Urea—65 kg	Urea—65 kg	Urea—43 kg (subject to availability of sufficient moisture in field)	Urea—43 kg (subject to availability of sufficient moisture in field)

STEP 7 Timely harvest to avoid grain losses, maximize milling recovery, and ensure high grain quality

Why is timely harvest important?

Harvest too early: many grains will be immature, slender, and chalky; this causes large amounts of bran and broken grains during milling.

Harvest too late: many grains will be lost because of shattering and the grains become too dry; this causes cracking during threshing and cracked grains will break during milling.

What is timely harvest?

- Usually 25–30 days after flowering.
- When 80–85% of the grains are straw colored.
- Grains in the lower part of the panicle are hard, not soft.
- When the grains are firm but not easily broken when squeezed between the teeth.

How can you ensure high grain quality?

1. Use pure seed; it contains only one variety as explained in Step 2.
2. Prepare your field well so that the crop matures uniformly. Good field leveling is essential for homogeneous crop ripening (Step 4).
3. Harvest when 80–85% of the grains are straw colored.

Too early | Early | Correct time | Too late

4. Minimize the time that cut panicles remain lying in the field; field drying causes low grain quality. Make sure that the panicles stay dry and do not touch the ground.

5. Threshing should be done as soon as possible after cutting, on a clean surface.

6. Dry the grains as quickly as possible after threshing. If sun drying is used, (a) turn or stir the grains at least once every hour to achieve uniform drying, (b) keep the thickness of the grain layer at 3–5 cm, (c) on hot days cover the grain during mid-day to prevent overheating, and (d) cover the grain immediately if it starts raining. Drying is best on a mat or plastic sheet.

7. Clean thoroughly by winnowing. Store the rice in a cool, dry, and clean area, preferably in a sealed container.

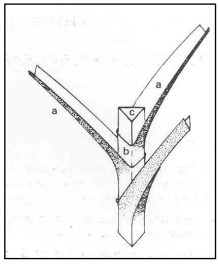
8. If a sealed container or airtight plastic bag is used for storage, make sure the paddy is dried well; otherwise, it might spoil.

Annex 1

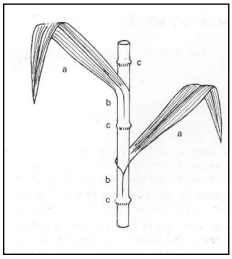
Characteristics of weed types for optional herbicide use

Dominant weed types have to be identified to select the correct herbicide for weed control.

Sedges: narrow leaves and triangular stems.



Grasses: narrow leaves and round stems.



Broadleaves

Selected herbicides for transplanted rice and their use

Follow Steps 1 to 5 to minimize weed infestation. If you want to control weeds with herbicides, use them at the recommended time, at the recommended rate, and use the correct herbicide for the dominant weeds in your field (see picture above). Always read and follow the instructions on the product label.

Chemical name	Weed type	Amount (g a.i./ha)*	Time of application	Remarks/spray volume (amount of water to be mixed with the chemical)
Pretilachlor (30)	Sedges, grasses, broad-leaves	300	0–3 days after transplanting	Apply to shallow water layer and retain water for 2–3 days. Spray volume is 150–200 liters per hectare.
Butachlor (80)	Sedges, grasses, broad-leaves	750	2–5 days after transplanting	Apply on saturated soil. Spray volume is 150–200 liters per hectare.
Butachlor + propanil (35)	Sedges, grasses, broad-leaves	600	6–10 days after transplanting	Apply on saturated soil. Spray volume is 150–200 liters per hectare.
2,4-D (40)	Sedges, broad-leaves	320	15–21 days after transplanting	Weeds need to be above the water. Re-flood within 2–3 days after application.
Metsulfuron methyl (20)	Sedges, broad-leaves	4	20–25 days after transplanting	Apply on saturated soil. Spray volume is 150–200 liters per hectare

* The active ingredient (a.i.) is the chemical killing the weeds and the name is written on the label of the container; the product may have a different name. The list above is not complete but covers some common herbicides useful in transplanted rice.

Further instructions:

Spray herbicides when there is little wind movement; avoid spraying in strong winds. Spray products from a height of about 50 cm above the soil or plants.

Spray while facing the wind direction so that the herbicide is not blown in your face.

Herbicides are poisonous: if they are not used properly, they can damage your health, the crop, and the environment. Label them clearly and keep them out of children's reach.

Annex 2

Calculations to compare prices of fertilizer

For rice, two types of fertilizer are usually used: urea, which contains only N, and mixed fertilizers containing N, P, and sometimes K. Different mixed fertilizers are available and you may need to calculate which one is the cheapest (this is an example; real prices might be different):

Fertilizer 1

Price/sack Weight Fertilizer type	50,000 Tsh 50 kg DAP 18-46-0	How much P is in this sack of fertilizer? 50 kg multiplied by 46P divided by 100 = 23 kg P
		How much does 1 kg of this P fertilizer cost? 50,000 Tsh divided by 23 kg P = 2,173 Tsh for 1 kg P
		How much N is in this sack of fertilizer? 50 kg multiplied by 18N divided by 100 = 9 kg N
		How much does 1 kg of this N fertilizer cost? 50,000 Tsh divided by 9 kg N = 5,556 Tsh for 1 kg N

Fertilizer 2

Price/sack Weight Fertilizer type	60,000 Tsh 50 kg NPK (17:17:17)	How much P is in this sack of fertilizer? 50 kg multiplied by 17P divided by 100 = 8.5 kg P
		How much does 1 kg of this P fertilizer cost? 60,000 Tsh divided by 8.5 kg P = 7,058 Tsh for 1 kg P
		How much N is in this sack of fertilizer? 50 kg multiplied by 17N divided by 100 = 8.5 kg N
		How much does 1 kg of this N fertilizer cost? 60,000 Tsh divided by 8.5 kg N = 7,058 Tsh for 1 kg N

The cost per kg of P in fertilizer 2 (NPK) is three times higher than the cost of P in fertilizer 1 but fertilizer 2 has 8.5 kg K also. Similarly, the cost of N in fertilizer 2 is also higher than in fertilizer 1.

You can use these calculations for any two fertilizers you want to compare.

The general rule is that, the lower the nutrient content of a fertilizer, the more fertilizer you have to apply for the same nutrient amount. Therefore, compare fertilizer prices based on their nutrient concentration.

Common inorganic fertilizers and their composition

100 kg urea (46-0-0) contain 46 kg N.

100 kg DAP (18-46-0) contain 18 kg N and 46 kg P.

100 kg MOP (0-0-60) contain 60 kg K.

100 kg mixed fertilizer 1 (15-15-15) contain 15 kg N, 15 kg P, and 15 kg K.

100 kg mixed fertilizer 2 (16-20-0) contain 16 kg N and 20 kg P.

100 kg mixed fertilizer 3 (16-8-8) contain 16 kg N, 8 kg P, and 8 kg K.

100 kg mixed fertilizer 4 (17:17:17) contain 17 kg N, 17 kg P, and 17 kg K.

Note: All NPK rates are actually given in N-P_2O_5-K_2O but, for simplicity, we used N, P, and K in the text.

Annex 3

Common nutrient problems in lowlands and their symptoms in the rice crop

1. Nitrogen (N) deficiency: widespread; most rice soils have limited amounts of N.

Plant symptoms: stunted, yellowish plants, especially older leaves, or the whole plant is yellowish. To test whether N deficiency is the cause of poor crop growth, apply urea to a small part of the field.

No N applied | With N applied | Without N

2. Phosphorus (P) deficiency: The second most common deficiency after N, most rice soils contain limited amounts of P. Extreme P deficiency occurs in some of the areas.

Plant symptoms: stunted, dark green plants with erect leaves and few tillers, and delayed plant growth.

With P applied No P applied

No P With P

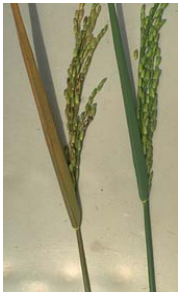
3. Potassium (K) deficiency: K deficiency is not common but occurs on some very sandy soils. K deficiency is favored by constant removal of rice straw without a return of organic fertilizers. Also, constant use of N and P fertilizer only can cause K deficiency.

Plant symptoms: dirty dark green plants with yellowish brown leaf tips. Upper leaves are often short and droopy.

Yellowish brown/orange leaf tips and droopy leaves.

4. Iron toxicity: not common, occurs on lower fields with long flooding periods and on mid-terraces where iron-rich groundwater surfaces. Can be stronger if large amounts of organic materials are applied.

Plant symptoms: small brown spots on lower leaves starting from the tip, or whole leaves colored orange-yellow to brown. Frequently, black coating on root surfaces present.



Annex 4

Nutrient removal at harvest and nutrient content of organic fertilizer

Organic and inorganic fertilizers are used to increase yields. But they are also needed to return nutrients removed with grain and straw, and thereby they maintain soil fertility.

Average amount of nutrients (N, P, K) removed from a rice field for each ton of rice paddy harvested (kg removed per hectare):

	N	P	K
Only the rice grains are removed	10.5	4.6	3.0
Rice grains and straw are removed	17.5	6.9	20.5

Average amount of nutrients (N, P, K) added for each ton of organic fertilizer applied per hectare (kg added per hectare):

	N	P	K
Fresh cattle manure (60% water)	5.0	3.4	6.0
Pig manure (80% water)	8.5	5.7	7.2
Poultry manure (55% water)	15.0	14.9	9.0
Rice straw	7.0	2.3	17.5

Note: NPK rates are actually given in N-P_2O_5-K_2O on this page but, for simplicity, we used N, P, and K in the text.

Annex 5

Direct seeding: an alternative to transplanted rice

What is direct seeding? In direct seeding (DS), rice seeds are sown directly in the soil, either as dry grains (dry DS) or pregerminated grains (wet DS). The seed can be broadcast or drilled in lines.

Advantages of direct seeding: For DS, no nursery seedbed is needed and DS requires much less labor for crop establishment than transplanting.

Disadvantages of direct seeding: More seed is needed for DS than for transplanting; animals, drought, or waterlogging can reduce seed germination; weeds can be a serious problem.

Dry direct seeding: In rainfed systems, dry seed can be manually broadcast onto the soil surface and then incorporated by shallow plowing or by harrowing while the soil is still dry. Care must be taken not to incorporate the seed too deep (only 1–3 cm deep), especially on clay soils or where surface "sealing" is a problem. Alternatively, dry seed can be sown in a row with a seed drill. Seeding rates vary between 80 and 200 kg per ha. Some gap filling (transplanting) is normally undertaken within the field after establishment.

Wet direct seeding: In irrigated areas, pregerminated seed is broadcast or sown in lines with a drum seeder. Seeding rates are 60–120 kg per hectare. Pregerminate the seed by soaking in water for 24 hours and incubating for another 24 hours (the little roots should not be too long because they break easily). Seedlings should be broadcast on recently drained, puddled, and leveled fields. If the field is too wet, allow it to dry for 12 to 24 hours before seeding. Avoid flooding the emerging seedlings and keep the field drained for the first few days. If possible, a shallow water layer is re-introduced 7 to 10 days after seeding.

Important accompanying management issues

The 7 Steps of good crop management are equally important in direct-seeded rice (except Step 3 in seedbed management).

Good soil preparation and leveling (Step 4) are essential for direct seeding; otherwise, establishment will be irregular and weeds will cause large yield losses.

Weed management (Step 5): Extra care in weed management is needed for direct seeding. Do not use direct seeding in fields with severe weed problems in the previous season. Otherwise, herbicides may be necessary to reduce weeds. In rainfed rice, farmers often prefer postemergence herbicides. With good soil preparation and leveling, one herbicide application and one manual weeding during the season should be sufficient.

Fertilizer application (Step 6): Basal fertilizer application is usually avoided in direct seeding. The mixed NPK fertilizer can be topdressed at 10–20 days after seeding and after weeding. Only in the case of dry direct seeding is basal fertilizer application with a seed drill a good option.

In rainfed lowlands: Avoid direct seeding in very wet/lower fields where the danger of seeds being washed away or submergence after heavy rainfall is high. Avoid direct seeding on very dry/upper fields where lots of weeds grow.

Selected herbicides for wet-seeded DS rice and their use

Active ingredient (in %)*	Weed type	Amount(g a.i./ha)	Time of applica-tion	Remarks and spray volume (amount of water to be mixed with the chemical)
Pretila-chlor (with safener for DS) (30)	Sedges, grasses, broad-leaves	300	0–3 days after seeding	Drain and apply to saturated soil. Spray volume is 150–200 liters per hectare.
Butachlor (80)	Sedges, grasses, broad-leaves	750	6–8 days after seeding	Apply on saturated soil. Spray volume is 150–200 liters per hectare.
2,4-D (40)	Sedges, broad-leaves	320	15–21 days after seeding	Weeds need to be above water. Re-flood within 2–3 days after applica-tion.
Metsulfuron methyl (20)	Sedges, broad-leaves	4	20–25 days after seeding	Apply on saturated soil. Spray volume is 150–200 liters per hectare.

* The active ingredient (a.i.) is the chemical killing the weeds and the name is written on the label of the container; the product may have a different name. The list above is not complete but covers some common herbicides useful in transplanted rice.

Annex 6

Alternate wetting and drying

Why do you use alternate wetting and drying (AWD)?

AWD is a water-saving technology for irrigated environments that can be used to reduce the water needs for rice cultivation. Thus, it can help to reduce pumping costs or to increase cropping area with the same amount of water.

What is safe AWD?

In AWD, flooded field conditions alternate with nonflooded field conditions. Safe AWD is a technique to save water and have the same yield as with full irrigation.

Three rules for safe AWD:

1. For 10 days after transplanting (or 20 days after direct seeding), the field should be flooded to ensure good crop establishment and to suppress weeds.
2. Keep the field flooded from 1 week before to 1 week after flowering to avoid any damage to the rice flowers.
3. For the rest of the season and until 2 weeks before harvest, the water level should never be below 15 cm from the soil surface.

   In these periods, the field is flooded with a water layer of 5-cm depth during irrigation. The next irrigation is done only when the groundwater level in the field falls below 15 cm from the soil surface.

To see how deep the water level is below the soil surface, you need to install a pipe in the soil (15 cm deep), which allows you to see the water underground. If you cannot see the water any more in the pipe, it is time for the next irrigation.

Annex 7

General recommendations on insecticide use

- Insecticides are poisonous for humans and the environment. Therefore, they should be used as little as possible.
- Insecticides should not be used within the first 4 weeks after transplanting or direct seeding. They also should not be used just before harvest.
- Insecticides can help to control insects that reduce rice yields. But insecticides also kill helpful insects and spiders, which might cause even bigger insect problems later in the season.
- If insecticides are used, they must be used according to the instructions on the label. Otherwise, they might not have any effect.
- If you cannot read the label (foreign language), do not use the product.
- Insecticides should be kept out of the reach of children, the living room, the kitchen, and eating places. They must be kept in a container with a large warning picture signifying “Poisonous” on the outside.