RICE CROPPING GUIDE

4R NUTRIENT MANAGEMENT AND BEST AGRONOMIC PRACTICES

NORTHERN GHANA

AFRICAN PLANT NUTRITION INSTITUTE

COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH · GHANA ·

RICE CROPPING GUIDE

4R NUTRIENT MANAGEMENT AND BEST AGRONOMIC PRACTICES

NORTHERN GHANA

Authors

Samuel Njoroge[1], Abdulai Haruna[2], A.L.A Aziz[2], Esther Mugi-Ngenga[1], Krofa Eleazar Ofosu[2]

Affiliations

[1]African Plant Nutrition Institute

[2]CSIR-Savanna Agricultural Research Institute

APNI Website: www.apni.net

E-mail: info@apni.net

SARI Website: www.sari.csir.org.gh

Supported by the 4R Solution Project Implementing Partners:

In partnership with Canada

Co-operative Development Foundation of Canada SINCE 1947

FERTILIZER CANADA
FERTILISANTS CANADA

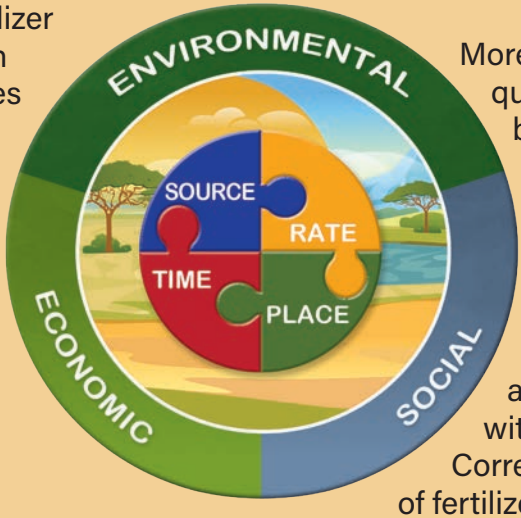
apni AFRICAN PLANT NUTRITION INSTITUTE

Plant Nutrition Canada

nutrient stewardship

THE 4R NUTRIENT STEWARDSHIP CONCEPT

4R NUTRIENT STEWARDSHIP is a framework developed to communicate the **Right way** to ensure sustainable and efficient fertilizer use based on four principles namely: applying the **Right Source** of fertilizers, at the **Right Rate**, at the **Right Time**, and in the **Right Place**.



Effective fertilizer use, as guided by 4R Nutrient Stewardship, is important for developing sustainable smallholder cropping systems that support improved food production, increased income for farmers, and enhancement and maintenance of soil fertility.

More and better-quality rice can be produced with fertilizers. The fertility of soils, which has been largely over exploited can also be restored with fertilizers. Correct management of fertilizers based on the 4Rs can therefore result in better **Social, Economic,** and **Environmental** outcomes for farms, villages, communities, and Africa as a whole.

RIGHT SOURCE:

refers to applying the correct fertilizer that provides crops with the nutrients required for good growth and high yields.

Different fertilizers provide nutrients in different proportions. Matching a crop's nutrient uptake requirements with the fertilizer that supplies the right mix and proportions of required nutrients ensures that the right source is achieved.

RIGHT RATE:

refers to supplying growing plants with the right amount of nutrients for healthy growth and development.

Different crops require different quantities of nutrients for healthy growth and development. The quantity of nutrients required also depends on soil fertility status and the crop yield target. Nutrient requirements will increase as soil fertility decrease. Similarly, as crop yield targets increase, the quantity of nutrients required to achieve those targets also increases.

RIGHT TIME:

refers to matching nutrient application with the timing of plant nutrient uptake.

Most crops take up nutrients slowly during the early stages of growth, but the rate of nutrient uptake increases as crops develop. Fertilizer applications timed to match periods of high plant nutrient uptake ensure efficient uptake of applied nutrients.

RIGHT PLACE:

refers to adding nutrients to the soil at a place where plants can easily access them.

Placement influences the ability of plants to efficiently access and take up applied nutrients. The right placement of fertilizer for a particular crop should be selected to match its growth characteristics. The right placement method will ensure reduced nutrient losses.

RICE CULTIVATION IN GHANA

- Rice grows in almost all agro-ecological zones of Ghana, under either lowland flooded conditions or upland conditions.
- A small percentage of rice is also produced under irrigation.
- Suitable fields for growing rice should be fairly flat to allow for easier water retention.
- The most suitable soils for growing rice are clay or loam soils because they retain water well and have high soil organic matter (indicated by dark colour).
- Ideal fields for rice cultivation should not be susceptible to high weed infestation (particularly to the invasive false rice weed).
- In the Northern Savannah and Transition Zones, rice is produced on imperfectly to poorly drained soils under upland conditions. These soils, which are sandy to silty loam, occur over flat to gently sloping topography and become waterlogged at the peak of the rains.
- In the Forest Zones, rice is grown under flooded conditions in the valley bottoms where drainage is also poor.

LAND PREPARATION

- Land preparation is best conducted by use of tractors for ploughing and harrowing.
- In addition to mechanized ploughing, animal-drawn ploughing or manual ploughing can also be done, depending on common land preparation practices in the area.

Examples of mechanical and manual land preparation for rice planting.

- Care should be taken to ensure that tractors are equipped with the right ploughing and harrowing equipment.
- Avoid ploughing too deep. A ploughing depth of 15 - 20 cm is adequate for rice plants, as deeper ploughing risks moving the most fertile topsoil too deep for the rice crop to access.
- In areas with a lot of perennial weeds, disc plough the field to expose the roots of the weeds to the sun. This helps to reduce weed infestation.
- After ploughing and harrowing, level the field for a uniform seedbed and to help in spreading water throughout the field.
- For lowland rice, as the crop is grown under flooded conditions, it is best grown on land that is nearly level.
- Where the land has a steep slope or has an uneven surface, the field should be levelled to a slope of less than 1% to enable flooding to an even depth.
- The timing of the ploughing exercise depends on the local cropping cycle.
- Early land preparation is recommended and should be based on the expected standards based on site-specific soil and field conditions.
- After ploughing and harrowing, construct bunds around the field for water retention, and suppress weeds using animal traction, hand hoes, etc.
- Flood the field for about 2 weeks to kill weeds.
- Repair all leakages in the bunds.
- Remove water after 2 weeks and mark out the field into basins of required dimensions (e.g., 5m x 5m, 10m x 5m or 10m x 5m) with hand hoes.
- Irrigate or allow water into the basins and level properly (hand puddling or with animal traction).

SEED SELECTION AND SEED RATE

Examples of poor (left) and good quality (right) seed.

- Use good quality seeds with no insect damage and no contaminants (weed seeds, stones, other seed types) with high percentage of viability (>80%).
- Good quality seed grows faster, has higher disease resistance, and produces good yields.
- Using certified seed can increase yields by 15 - 20%. With certified seeds, germination rates are better, so more seedlings will emerge in the field. This results in less re-planting, strong root establishment and a uniform plot growth.
- For uniform growth and good yields, it is recommended to plant the same variety of rice in an entire field.
- 20 kg of rice seeds per acre of seedbed are required when dibbling, 25 kg when drilling, and 40 kg when broadcasting (approximately 50, 65, and 100 kg/ha, respectively).

- If farmers are not sure of the quality of rice seed being used, a germination test can be done, following the procedure below:
  - Pick a handful of seeds, and soak in water for 24 - 36 hrs.
  - Drain the water and place the seeds on a clean surface in a shaded area.
  - Incubate the seeds by covering with polythene bags or raffia palms for another 48 - 72 hrs to stimulate sprouting of the seeds.
  - Determine germination percentage (e.g., 8 out of 10 indicates 80% germination).
  - If germination is ≥ 80%, then the seed lot is good for planting.

Table 1: Rice varieties recommended for northern Ghana.

Variety	Maturity days	Land required	Attainable yield	
			t/ha	Bags/ ha
FARO 15	145	Deep Lowland	5	50
GR 18	132	Lowland and irrigated	6.5	65
GR 19	125	Lowland	5.5	55
GR 21	125	Lowland	4.5	45
Digang	115	Hydromorphic and Lowland	4.8	48
Gbewaa Rice	120-125	Lowland and irrigated	5 -6	50-60
Nabogo Rice	120-130	Lowland and irrigated	6	60
Katanga Rice	130-140	Deep Lowland	6	60
Sikamu	120-125	Lowland and irrigated	6	60

Continued

Table 1: ***Continued***

Variety	Maturity days	Land required	Attainable yield	
			t/ha	Bags/ ha
Amankwatia	120 -125	Lowland and irrigated	6	60
CSIR-Savannah	120-125	Lowland	6	60
CSIR-Malimali	120-125	Lowland	6	60
Legon rice	120-125	Lowland and irrigated	5	50
CIR-Dartey	120 - 125	Lowland	9	90
CIR- Kantinka	120 - 125	Lowland	8.5	85
CRI-Obuafo	130 -135	Lowland	8.5	85
CRI-Emopa	125 -130	Lowland	8	80
CRI-Enapa	125 -130	Lowland	9.5	95
CRI-AgraRice	125 -130	Lowland	8	80
Emo teaa	110 -115	Upland	5	50
Oto moo	115 -120	Upland	6	60
Banse	80-85	Upland	3	30

PLANTING

Planting of rice fields can be conducted either through direct seeding or transplanting of seedlings previously grown in nurseries.

Direct seeding

- Direct seeding can be done in wet areas of the topography.
- When practicing direct seeding, it is recommended to divide the field into smaller plots of about of 50 or 100 m^2 and construct bunds that aid in water retention, as described in the previous section on land preparation.
- Prior to sowing seeds, apply recommended herbicides to control weeds as they can be a problem.
- Sow seeds at a spacing of 20 cm between rows and 20 cm within rows (between hills) by dibbling.

Direct seeding by hand (left) vs. direct seeding using a tractor and drill (right).

- After sowing, monitor the field for germination, which is expected at about 3 - 5 days after sowing.
- The number of emerged seedlings at 5 days after sowing determines the vigor rate (percentage of normal seedlings), while the number of emerged seedlings at 8 days after sowing determines the germination rate.
- Gapping and replacement planting should be conducted at about 10 days after planting.
- Gapping/thinning is conducted by removing extra rice seedlings on each planting hill to retain only two seedlings per hill.
- On planting hills where no plants have emerged/established, some of the gapped seedlings or leftover seedlings from the nursery should be replanted to ensure all planting hills have two plants.

Pros and cons of direct seeding

Pros	Cons
Faster and easier crop establishment and reduced costs	The seeds are exposed to birds, rats, and snails, thus likely to be destroyed.
Less labour needed (1 - 2 man-days vs. 25 - 30 man-days for transplanting method).	There is greater crop-weed competition because rice plants and weeds are of similar age.
Earlier crop maturity by 7 - 10 days than for transplanted rice.	Plants tend to lodge more because there is less root anchorage.
More efficient water use, and higher tolerance to water stress.	More seeds are required; 80 - 100 kg/ha compared to 35 - 65 kg/ha for transplanting.

Establishing rice fields through transplanting

Nursery establishment, transplanting and spacing

- Transplanted seedlings are first established in a nursery bed, which can be either **wet** or **dry**.
- To establish a rice nursery, choose a site with well-drained fertile soil exposed to full sunlight. Ideally, the site should be conveniently located near the main field to facilitate efficient watering and easier transplanting.
- A nursery bed should be prepared after ploughing, puddling (breaking of soil aggregates under water-saturated conditions into finer particles) and levelling the desired area.
- The nursery should be 1 m wide and a convenient length. For example, for 1 acre, 5 plots of 1 m × 15 m should be used, and the soil should be raised 5 - 10 cm above the ground.
- After preparing the nursery, apply the equivalent of 50 kg/ha of NPK 15-15-15 fertilizer or apply 5 t/ha of rice husk + bran as mulch/manure (see **Table 2** for example quantities). A combination of the two, where available, will give better seedlings.
- Soak the seeds in water for 24 hrs at room temperature (25°C).
- Drain the water and place the seeds on a clean surface in a shaded area.
- Incubate the seeds by covering with polythene bags or raffia palms for another 48 hours to stimulate sprouting of the seeds.
- After sprouting, carefully spread the sprouted seeds uniformly on a puddled nursery bed (for wet nursery bed) or on a levelled surface (for dry nursery bed).
- Use a seeding rate of 100 - 200 g/m^2 (about 10 - 15 kg/acre), depending on percentage seed viability and grain filling percentage.

- At about 5 days after sowing seeds, the nursery beds should be flooded to a depth of 2 - 3 cm. This depth of water should gradually be increased to about 5 cm to prevent weeds and ensure easy pulling of seedlings.
- Prevent bird damage during germination by scaring the birds through locally applicable methods.
- Drain excess water from the nursery bed at about a week before transplanting (if using a wet nursery bed).

Removing seedling from wet nursery bed (left) and transplanting in field (right).

- Transplanting of seedlings from a nursery bed should be done between 14 and 21 days after sowing.
- Transplant at a rate of 1 - 2 seedlings per hill, to a depth of 3 - 4 cm, and at a spacing of 20 cm × 25 cm (best for late-maturing cultivars), or 20 cm x 20 cm when soil is fertile or sufficient fertilizer is available.

Table 2: Recommended application quantities of NPK fertilizer and manure during establishment of rice nurseries.

Field size for planting rice	Recommended nursery size	Recommended quantity of NPK	Recommended quantity of manure
1 acre	5 sections of 1 m x 15 m = 75 m^2	400 grams	40 kg
2 acres	10 sections of 1 m x 15 m = 150 m^2	800 grams	80 kg
5 acres	25 sections of 1 m x 15 m = 375 m^2	2 kg	200 kg

Pros and cons of the transplanting method of rice field establishment

Pros	Cons
Transplanting requires less seeds.	Much more labour is required to establish, from nursery stage to the actual transplanting.
It ensures a uniform plant stand and the rice crop is better able to compete against weeds.	Risky in rainfed areas in case of rainfall delays, as seedlings may grow too long before the onset of the rains.
Results in higher rice yields.	

NB: Optimum plant density is a function of many factors including planting season, soil type, rice variety, among others.

FERTILIZER APPLICATION

- For good rice yields, fertilizer application should be based on the 4Rs of fertilizer management to ensure that the rice crop is supplied with the **Right Source** of fertilizer, applied at the **Right Rate**, at the **Right Time** in the growing season, and at the **Right Place** where growing plants can easily access nutrients supplied.
- To understand the best 4R fertilizer management practices for good rice yields, it is important to understand the key nutrients required by the rice crop in large quantities, their role for good growth and yields, and when they should be supplied.
- There are three essential nutrients that are required by the rice crop in large quantities: nitrogen (N), phosphorus (P) and potassium (K). Other nutrients such as zinc (Zn) and sulphur (S) may also be required particularly with increased intensification of rice cropping, but in much lower quantities.

Nitrogen (N) promotes rapid plant growth, enables rice plants to produce many tillers, ensures tillers contain multiple grains, and improves grain quality. Nitrogen is required both during early crop growth and at mid-crop growth when rice plants are preparing to develop grains. Nitrogen should therefore be supplied a few weeks after germination/transplanting, and during mid-crop growth as top dressing. Supplying all fertilizer nitrogen requirements at once should however be avoided as nitrogen is easily lost from the soil. High nitrogen applications can also result in lodging of rice plants.

Phosphorus (P) supports good crop establishment by enabling rice plants to develop healthy roots. Phosphorus also promotes tillering, early flowering and ripening of the rice crop. This ensures uniform and rapid growth and development of rice plants. Phosphorus is mostly required during early crop

growth stages and should be supplied soon after germination or transplanting to support good root growth. Good root growth is crucial for rice plants to take up nutrients and water.

Potassium (K) ensures healthy rice plants with strong stems, reduces lodging of plants, supports plants to withstand drought periods, and helps plants resist pests and diseases. When using compound fertilizers, entire potassium requirement can be supplied soon after germination or transplanting. However, rice absorbs most of its potassium during the vegetative and early reproductive growth stages and a major portion of the potassium absorbed before vegetative stage remains in the stems and leaves.

4R TIPS

To determine the number and quantity of nutrients supplied by a particular fertilizer, check the nutrient content as labelled on the fertilizer bag.

The nutrient content of fertilizers is usually indicated on the bag's label as a series of numbers. The first three numbers always refer to the primary nutrients N, P and K. If any other nutrients are present, additional numbers are given followed by their chemical symbols. For example, a fertilizer bag labelled 15-20-20-5S-0.5B contains 15% Nitrogen, 20% Phosphorus as P_2O_5, 20% Potassium as K_2O, 5% Sulphur, and 0.5% Boron.

Right Source

For basal applications

Soon after germination or transplanting, the right source of fertilizer for basal application in rice is a compound fertilizer that supplies all the nutrients required in large quantities, namely nitrogen (N), phosphorus (P) and potassium (K). Examples include NPK fertilizers such as NPK 15:15:15, NPK 23:10:15.

Multi-nutrient fertilizers that supply secondary macronutrients such as sulphur (S), calcium (Ca) and magnesium (Mg), and micronutrients such as zinc (Zn) and boron (B), in addition to NPK are also a good choice for basal application. An example is NPK 23-10-5+2MgO+3S+0.3Zn (Yara Actyva™).

At top dressing

During topdressing, rice plants require to take up nitrogen in large quantities for good growth and grain development. The right source of fertilizers for top dressing are therefore straight fertilizers that are rich in nitrogen, such as urea or sulphate of ammonia (SA). In addition to urea and SA, different fertilizer companies have developed special multi-nutrient fertilizers for rice top dressing that are rich in nitrogen. Consult your local extension officer or fertilizer company agronomist for advice on other multi-nutrient fertilizers available in your local market for top dressing.

Right Rate

In northern Ghana, the recommended rate of nitrogen is 60 - 90 kg/ha, while the recommended rate for both phosphorus (P_2O_5) and potassium (K_2O) ranges from 30 - 60 kg/ha. These recommendations provide the range of nutrient application that should be applied depending on characteristics of the specific field where rice is to be grown and on the farmer's target yield.

- Fields that have been cultivated for a long time with minimal application of fertilizer are often less fertile and require more quantities of fertilizers.
- Fields that have only recently been converted to farmlands or that usually have large quantities of fertilizers or manure applied are often more fertile and require lower quantities of fertilizers.
- Recommended fertilizer applications can also be adjusted based on the expected or target rice yield.
- Higher target rice yields require more nutrients to be supplied hence higher fertilizer application rates. **Table 3** presents estimated N, P and K and fertilizer product application rates required to achieve various target rice yields.

Table 3: Estimated N, P, K, and fertilizer product application rates required to achieve various target rice yields.

Target yield (t/ha)	Nutrient rates (kg/ha)			Basal Fertilizer	Top dressing
	N	P_2O_5	K_2O	NPK bags per hectare	Urea/SA or Sulphan bags per hectare
2	30	15	15	2 bags	1/1.5
3	60	30	30	4 bags	2/3
4	90	60	60	8 bags	4/6
5	120	60	60	12 bags	6/9

NOTES: In this table, attainable yield without fertilizer application is assumed to be 1 t/ha. These estimates are based on rice sown at the right planting density with good crop management. The recommended fertilizer application for an acre of rice crop can be calculated by dividing the values presented in the Table by 2.47. It is advisable to consult the local area extension advisor to determine the right rate for your rice field based on the NPK content of available fertilizer, current soil fertility, field size, and target yields.

Right Time

- The first fertilizer application (basal application) should be applied shortly after germination or transplanting.
- If the rice crop was established through direct seeding, basal application should be conducted within 2 - 3 weeks after planting.
- If the rice crop was established through transplanting of seedlings, basal application should be conducted within 3 - 7 days after transplanting.
- Basal application provides the rice plant with the amount of phosphorus and potassium required for good growth and development, and part of the nitrogen required in the early crop stages.
- The remainder of the nitrogen required by the rice crop should be supplied through topdressing.
- If the rice crop was established through direct seeding, top dressing should be conducted within 6 - 7 weeks after planting.
- If the rice crop was established through transplanting of seedlings, top dressing should be conducted at 3 - 4 weeks after transplanting.

4R TIPS

Avoid large basal N fertilizer applications (i.e., >50 kg N/ha) in transplanted rice where growth is slow during the first 3 weeks after transplanting.

Divide recommended N fertilizer rates into 2 - 3 split applications. Use more splits especially with long duration varieties and when crop yield potential is greater. N rate is a balance of developing sink and source.

Top dressing at the recommended time coincides with the flowering and panicle initiation stages and helps the rice plant to establish enough grain sites for filling during maturity, and enhances grain filling resulting in high rice yields.

Before topdressing, ensure that the rice field is well-weeded.

After both basal and topdressing fertilizer applications avoid water runoff (movement of water from the field) to ensure that applied fertilizer is not lost.

Right Place

- For both basal and top dress applications, broadcast fertilizer uniformly across the entire rice field and mix into the moist soil.

Broadcasting of urea fertilizer at topdressing.

RICE CROP MANAGEMENT

Management of Weeds

Weed infestation impairs crop growth and productivity, as weeds compete with crops for light, nutrients, and water. In rice, weeds should be controlled before they begin to severely compete with crops, by ensuring they are removed or killed before they set seed. The three classes of weeds found in rice fields include broadleaved weeds, sedges, and grasses. To control weeds in rice, various methods can be used at different periods during the growing season. These include manual, chemical, cultural, and integrated weed management.

Manual weeding

- For perennial weeds, hand weeding can be helpful to remove their roots.
- To perform manual weeding by hands, drain water from the field, and hand weed 14 - 20 days after transplanting, and repeat at around 30 - 40 days after transplanting.
- Manual weeding can be used along with cultural (see next section) and chemical control.

Hand weeding rice crops.

Cultural weed management

- This entails use of agronomic practices to reduce weeds. Examples include:
  - Cleaning equipment used in rice fields such as tractors, reapers, or combine harvesters before working in different fields to ensure weed seeds are not transferred from one field to another.
  - Mulching to suppress weeds.
  - Using certified seeds free of weed seeds.
  - Using competitive crop cultivars (early-duration cultivars with vigorous seed growth and early canopy closure, or long-duration cultivars with high tillering ability and wide, long leaves).
  - Sowing rice in rows to make manual and mechanical weeding easier.
  - Sowing rice on time and using the correct seed rate.
  - Early flooding of rice at the right time to help reduce weed pressure.

Integrated weed management

- This entails the use of different forms of weed control.
- The method is important because different weed species require different kinds of weed management to be effective.
- Integrated weed management improves the management of weeds while reducing development of herbicide resistance.

Chemical weed management

- This involves the application of recommended herbicides to control weeds.
- For chemical weeding, knowing which class the weeds belong to is important for selecting the right herbicide, as different herbicides have been designed for the control of different weeds.
- Chemical control should always be practiced in an integrated weed management program, as weeds develop resistance to

herbicides over time when the same herbicide is applied to the same weed species season after season.

- There are three types of herbicides, which can be in liquid or granular form. These are:
  - **Pre-plant herbicides** applied before sowing to kill all weed types.
  - **Pre-emergent herbicides** applied after seeding but before weeds emerge, usually 1 - 3 days after sowing or transplanting.
  - **Post-emergent herbicides** applied after the weeds have emerged and developed 3 - 4 leaves.
- Before applying any herbicide, carefully read and follow instructions provided by the manufacturer or consult the local agricultural extension advisor.

4R TIPS FOR HERBICIDES USE

Use only herbicides that are recommended for rice at the various growth stages. For example, pre-emergence herbicides should not be applied after the rice crop has germinated.

Herbicides should always be applied using the appropriate equipment.

The person applying the herbicide should wear the appropriate protective clothing.

Herbicides are poisonous and should not be consumed or stored together with grains.

Empty herbicide containers should be carefully disposed of by burying or burning after the herbicides have been applied.

Management of Pests

- Insect pests can cause considerable damage to rice when infestations are high. Therefore, regular monitoring of rice fields should be conducted to monitor the presence of insect pests.
- The most common pests in rice fields include insects such as the African rice gall midge, stem borers, termites, rice weevil, rice grasshopper, rice stink bugs, and birds.

Table 4: Major rice pests, impact on the rice crop, and recommended control methods.

Insect pest	Signs /Mode of damage	Management
African rice gall midge	• Cylindrical swellings known as galls, about 3 mm in diameter, can be short or up to 1 - 1.5 m long, caused by maggots which hatch from eggs laid by female midges. • Often silvery white and are generally known as 'silver shoots' or 'onion leaf galls'.	• Early and synchronised planting. • Uprooting of volunteer plants between cropping seasons. • Ploughing in of straw to reduce carry over insect populations.
Stem borers	• Larvae enter the stem and eat it from within. • Growing parts of young shoots may die (dead hearts). • Flowering affected (dead heads, white panicles). • Plants may fall over.	• Flooding and harrowing or ploughing in of straw to reduce carrying over of insects from one crop to the next. • Uprooting of volunteer plants between cropping seasons. Planting early maturing varieties.

Table 4: *Continued*

Insect pest	Signs /Mode of damage	Management
Termites	• Attack both young and old plants. • Damage roots and fill the inside of the stem with soil.	• Use of recommended pesticides. • Flooding of termite holes. • Digging up termite mounds and destroying the nest and queen.
Rice weevil and larger grain borer (storage pests)	• Attack paddy and grain after milling. • The larvae eat the inside of the grain, emerging as adults through holes.	• Remove infested residues from last season. • Treat grain before storing with recommended pesticide. • Store grain in airtight containers.
Rice grasshopper	• The nymphs and adults eat leaves.	• Cultivate parts of the field that are not cultivated as this will reduce area for adults to lay eggs.
Rice stink bug	• Attacks stems, leaves, and filling grain.	• Remove alternate hosts such as grasses on bunds. • For rainfed rice, plant early at the beginning of the rains.
Birds	• Eat seeds at planting and damage panicles during grain filling.	• Chase birds away by making noise or scaring them off. • Placing scarecrows in a field, hanging tins, cassette tape reels or reflective ribbons in a rice field. • Removing trees or hedges where birds may nest near rice fields.

Management of Diseases

- Rice diseases can be seed, soil or wind-borne, and can affect rice crops throughout the life cycle.
- The most common diseases in rice fields are rice blast, rice yellow mottle virus (RYMV), false smut, brown leaf spot, narrow brown leaf spot, etc.

Table 5: Major rice disease, infestation signs, and recommended control methods.

Disease	Signs	Management
Rice blast	• Diamond-shaped spots with white centres and dark borders occur on the leaves and rots develop on stems and flower heads.	• Using tolerant or resistant varieties. • Dividing nitrogen fertilizer into several splits. • Avoiding water-stressed plants. • Eliminating crop residues. Application of seed treatments if fungicides are affordable and available.
Rice yellow mottle disease	• Leaves turn yellow or orange with green streaks. • Stunted plants. • Reduced tiller numbers. • Panicles with unfilled or sterile grains.	• Use of tolerant varieties. • Use of cultural techniques, e.g., removal of grasses and sedges that are alternative hosts of both virus and insects before planting. • Destruction of crop residues after harvest.
False smut	• Symptoms observed on grains after flowering: small green balls up to 1 cm in diameter appear on grain, the balls burst, become orange, then green.	• Use tolerant or resistant varieties. • Avoid excessive N fertilizer applications.

Table 5: *Continued*

Disease	Signs	Management
Brown leaf spot	• Evenly distributed oval-shaped lesions, up to 1 cm in length. The spots are brown, with greyish centres when fully developed. • Young lesions appear as small, dark-brown spots. • Lesions on the panicles may lead to black spots on grain.	• Use resistant varieties or disease-free seeds. • Apply good balance of inputs (e.g., supply micronutrients if deficient), and combining organic and inorganic fertilizers.
Narrow brown leaf spot	• Narrow brown elongated spots, 2 - 12 mm long and 1- 2 mm wide appear on the leaves, leaf sheaths and panicle.	• Planting early maturing varieties. • Early planting.

4R TIPS FOR EFFECTIVE MANAGEMENT OF PESTS AND DISEASES IN RICE

Use varieties that are resistant to commonly occurring pests and diseases.

Avoid excessive N fertilizer use to prevent the development of a lush green foliage that is conducive for pests and diseases.

Before applying N fertilizer, assess the general crop stand, leaf colour (using a leaf colour chart), and pest and disease incidence.

Ensure sufficient application of K fertilizer in K deficient soils. Insect damage is greater in rice crops affected by K deficiency.

Practice integrated pest management (IPM) in cooperation with neighbouring farmers.

Water Management

- Good water management is important for ensuring good rice growth and high yields.
- Proper water management also helps to control weeds.
- Maintain the water level in the field up to 5 cm from 1 week after transplanting until physiological maturity, targeting the following water levels (cm) for different growth stages of the rice crop.
  - Vegetative stage
    - ✓ Tillering: 2 to 5 cm
    - ✓ Stem elongation: 5 cm
  - Reproductive stage
    - ✓ Panicle initiation to boot: 5 cm
    - ✓ Heading: 5 cm
    - ✓ Flowering: 5 cm
  - Ripening stage
    - ✓ Milk stage: 2 to 3 cm
    - ✓ Dough stage: 1 to 2 cm
- At physiological maturity stage, drain the water.
- Fields should be drained about 7 - 10 days before physiological maturity (i.e., when 90 - 95% of grains have lost their green colour).

Rice crops at different growth stages and water levels.

A rice crop at the physiological maturity stage.

Water + Nitrogen management points to note:

- Lower or remove the floodwater before applying top-dressed N, and then re-irrigate to enhance movement of N into the soil.
- To reduce volatilization (loss of applied N), do not apply urea onto standing water under windy conditions before canopy closure, and at midday when the water temperature is highest.

HARVESTING AND MILLING

1. Harvesting should be done approximately 30 days after full flowering, or when 80 - 85% of the grains are ripened (when most of the panicles turn brown).

A mature rice crop ready for harvesting.

2. Cut all panicles (e.g., using a sickle) either at panicle height or above the ground, and place them in sacks.

Harvested rice panicles.

3. Transport harvested panicles to a place where they can be properly processed, dried, and stored.
4. Thresh panicles manually or mechanically on a clean dry surface within 4 days of harvest to separate the grain, and winnow to remove chaff and unfilled grains.
5. If grain moisture content is more than 14%, dry under the sun to avoid moulding and insect attack.

Threshed rice spread out to dry.

6. With good management, 5 - 6 t per hectare of rice paddy is achievable.
7. The dried paddy is then milled to remove husk from the grain, and the bran from the kernel.
8. Greater efficiency in the milling process results in whole grains with minimal broken grains.
9. Different varieties should be milled separately.

COMMON SYMPTOMS OF NUTRIENT DEFICIENCY

NITROGEN (N)

The soil N supply is commonly not sufficient to support higher rice yields of certified varieties, so that N deficiency is common in all major rice-growing areas.

Causes of N deficiency

- Low soil N-supplying power.
- Insufficient application of mineral N fertilizer.
- Low N fertilizer-use efficiency (losses from volatilization, denitrification, incorrect timing, and placement, leaching, or runoff).

Symptoms of N deficiency

- Short plants with few tillers
- Small and yellowish leaves
- Older lower leaves turn brown at the tip.
- Entire field appears yellow.
- Reduced number of panicles and grains.

Examples of N deficiency

Nitrogen deficient plants have pale young green leaves and yellow to brown lower leaves. Plants are shorter and produce fewer tillers.

Nitrogen deficient rice fields will show a pale-green appearance (bottom) compared to the healthy green crop (top).

Nitrogen deficient leaves begin to turn yellow at the tips. The yellow-brown colouring progresses down towards the base of the leaf.

PHOSPHORUS (P)

Phosphorus (P) requires a long-term management strategy. P fertilizer application provides a residual effect that can persist for several years. Management must emphasize the build-up and maintenance of adequate available soil P levels to ensure that P supply does not limit rice crop growth, grain yield, and N-use efficiency.

Causes of P deficiency

- Low indigenous soil P supplying power.
- Insufficient application of mineral P fertilizer.
- Low efficiency of applied P fertilizer because of high P fixation capacity.
- Excessive use of N fertilizer with insufficient P application.
- Cultivar differences in susceptibility to P deficiency and response to P fertilizer.
- Crop establishment method (P deficiency is more likely in direct-seeded rice, where plant density is high and root systems are shallow).

Symptoms of P deficiency

- Small, dark green plants.
- Erect thin leaves.
- Spindly stems.
- Fewer number of tillers.
- Lower number of panicles and grains per panicle.
- Older leaf tips initially show a purple colour, which progresses throughout each leaf.

N.B: Flooding of dry soil causes an increase in the availability of P in the soil.

Examples of P deficiency

Phosphorus deficient rice plants with thin and spindly growth.

Phosphorus deficient rice plants (left) are stunted and have fewer tillers compared to healthy plants (right).

Older leaf tips initially show a purple colour, which progresses throughout each leaf.

POTASSIUM (K)

Potassium (K) has essential functions in plant cells and is required for transport of the products of photosynthesis. K provides strength to the plant cell walls and contributes to greater canopy photosynthesis and crop growth. Unlike N and P, K does not have a pronounced effect on tillering. K increases the number of spikelets per panicle, percentage of filled grains, and 1,000-grain weight.

Symptoms of K deficiency

- Small, dark green plants with yellowish-brown leaf margins.
- Edges of older leaves turn yellowish-brown.
- Rusty brown spots on tips of older leaves.
- Brown spots visible on panicles.
- Rice field appears reddish in colour.

Examples of K deficiency

Potassium deficient plants have pale young green leaves and yellow to brown lower leaves. Plants are shorter and produce fewer tillers.

***BOTTOM LEFT:** K deficient rice field often has a rusty, reddish colour due to its impact on the plant's leaves and panicles.*

***BOTTOM RIGHT:** Yellowish-brown to yellowish-orange discolouration of edges of leaves due to K deficiency.*

SULPHUR (S)

Sulphur (S) is required in the plant for the formation of amino acids and proteins and is essential to photosynthesis. Sulfur is supplied from organic matter and minerals, but it is often present in insufficient quantities and is available at inopportune times for the needs of high-yielding crops. Sulfur deficiency is often related to sandy soil texture, low organic matter, high rainfall, or irrigation. Some regions have low indigenous S supply due to organic matter losses resulting from rapid mineralization and soil erosion.

Symptoms of S deficiency

- Spindly and stunted with poor growth, small heads, and delayed maturity.
- General yellowing appears on the whole plant and symptoms are generally confused with N deficiency.
- Uniform yellowing on the affected leaf, covering both veins and interveinal tissues alike.
- Symptoms appear first, and become more severe, on younger leaves. The young leaves become dull or bright yellow, while older leaves usually remain green.

Examples of S deficiency

Sulphur deficient rice crop showing pale-green young leaves, and dark-green older leaves.

Uniformly pale-yellow deficient leaf (bottom) compared with healthy dark-green leaf (top).

IRON (FE)

Iron (Fe) is essential for protein synthesis, plant respiratory enzyme systems, and energy transfer. Iron deficiencies are not uncommon in many areas' soils due to conditions high pH, low organic matter, cold-wet conditions, over-liming, and high P fertilization that can decrease its plant availability and induce a deficiency.

Symptoms of Fe deficiency

- Iron deficiency is mainly a problem with rice grown on upland soils. Iron availability increases after flooding.
- Since Fe is not transferred from older to younger leaves, its deficiency symptoms appear first, and most severe, on younger leaves.
- Deficiency symptoms appear as interveinal chlorosis of emerging leaves. Whole emerging leaves become chlorotic in severe conditions of Fe deficiency.

Examples of Fe deficiency

Advanced sulphur deficiency in rice.

New emerging white leaf completely devoid of chlorophyll.

ZINC (ZN)

Zinc (Zn) plays a key role in many enzyme systems in plants. It controls the production of important growth regulators that influence new growth and development, thus one of the first indications of Zn deficiency is the presence of stunted plants resulting from a shortage of growth regulators.

Symptoms of Zn deficiency

- Zinc deficiency causes stunted plant growth, reduced tillering, restricted root growth, and sterility of spikelets.
- Zinc deficiency symptoms in rice commonly occur between 2 - 4 weeks after transplanting.
- Many dusty brown or bronze spots appear on the leaf surface.
- When deficiency persists, spots form larger patches and ultimately cover the entire leaf. In later stages, the entire leaf turns bronze and dies.

Examples of Zn deficiency

Advanced zinc deficiency in rice.

Characteristic brown blotches appearing on rice leaves.

Notes

Notes

Notes

ABOUT **The 4R Solutions Project**

www.4RSolution.org

The 4R Solutions Project is funded by Global Affairs Canada to improve the livelihoods of 80,000 smallholder farmers in Ethiopia, Ghana and Senegal by improving agricultural productivity and farm income through incorporation of 4R Nutrient Stewardship into local farming practices. 4R Nutrient Stewardship supports best management of plant nutrients based on four key practices: Right Source, Right Rate, Right Time, and Right Place.

IMPLEMENTING PARTNERS

In partnership with Canada

Co-operative Development Foundation of Canada SINCE 1947

Fertilizer Canada / Fertilisants Canada

African Plant Nutrition Institute

Plant Nutrition Canada

LOCAL IMPLEMENTING PARTNERS

Savanna Agricultural Research Institute

African Plant Nutrition Institute
www.apni.net

APNI Offices:

Headquarters - Benguérir, Morocco
North Africa - Settat, Morocco
West Africa - Yamoussoukro, Côte d'Ivoire
East & Southern Africa - Nairobi, Kenya