Africe Rice Center (WARDA)

Growing lowland rice: a production handbook

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About Africa Rice Center (WARDA)

Africa Rice Center (WARDA) is an autonomous intergovernmental research association of African member states and also one of the 15 international agricultural research Centers supported by the Consultative Group on International Agricultural Research (CGIAR).

WARDA's mission is to contribute to poverty alleviation and food security in sub-Saharan Africa (SSA) through research, development and partnership activities aimed at increasing the productivity and profitability of the rice sector in ways that ensure the sustainability of the farming environment.

WARDA hosts the African Rice Initiative (ARI), the Rice Research and Development Network for West and Central Africa (ROCARIZ), the International Network for Genetic Evaluation of Rice in Africa (INGER-Africa) and the Inland Valley Consortium (IVC). It also supports the Coordination Unit of the Eastern and Central African Rice Research Network (ECARRN), based in Tanzania.

WARDA has its headquarters in Cotonou, Benin and regional research stations near Saint-Louis, Senegal and at the International Institute for Tropical Agriculture (IITA) in Ibadan, Nigeria. WARDA's main research center is in Côte d'Ivoire but most scientists and researchers are temporarily located in Cotonou.

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Preface

Lowland rice accounts for 50% of the total rice produced in Nigeria. In recent years, WARDA has introduced several rice varieties, together with efficient natural resource/crop management and pest and disease management technologies to rice farmers in Nigeria and other West and Central African countries. Typical examples are the high yielding rice varieties: FARO 44 (SIPI), FARO 51 (CISADANE), FARO 52 (WITA 4), FARO 57 (TOX 40043-1-2-1), and the lowland varieties of the New Rice for Africa (NERICA) that are currently being evaluated in several parts of Nigeria prior to full release. The majority of these introduced technologies have been accepted and become widespread in some states of Nigeria. However, these technologies came to the farmers without an accompanying handbook on how to plant/grow the varieties, quantity of seed to plant per hectare, how to apply fertilizers and herbicides, etc.

WARDA believes a combination of factors including a simple manual is required to teach farmers how to increase their yields at the farm level. This handbook is intended for agricultural researchers, technicians, trainers, extension specialists, non-governmental organizations and farmers involved in growing lowland rice. It is also intended to provide a reference source for research and training of MSc and PhD students. It will also be a valuable document for undergraduate agricultural students in colleges of agriculture and universities seeking practical information on lowland rice production. The intention is to make existing information more easily accessible and to present it in a simple and understandable way. Thus, technical terms have been kept to a minimum, and those used are explained.

The references provided at the end of the book are not intended to be exhaustive, but rather represent suggested reading for more technical detailed information on the subject. Agronomic information for the new lowland NERICA will be available shortly.

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Introduction

Rice has become an important strategic and daily staple food crop in Nigeria. The potential land area for rice production in Nigeria is between 4.6 million and 4.9 million ha. Out of this, only about 1.7 million ha—or 35 percent of the available land area—is presently cropped to rice.

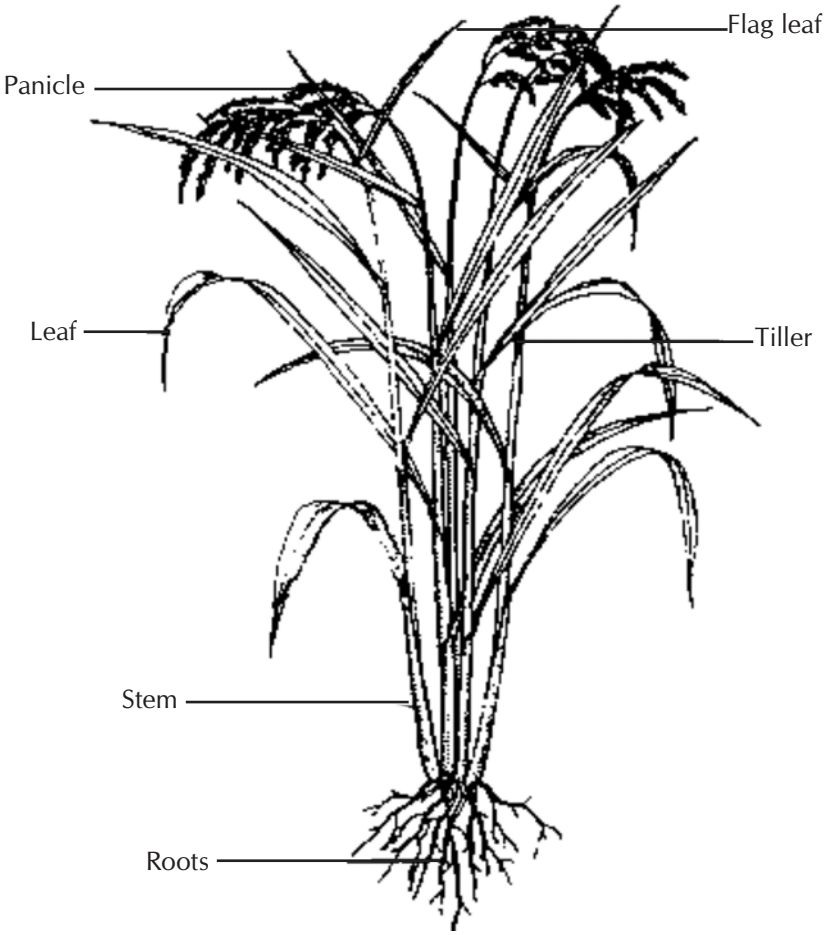
The main production ecologies for rice in Nigeria are rainfed lowland, rainfed upland, irrigated lowland, deep water/floating and mangrove swamp. Of these, rainfed lowland rice has the largest share of the rice area (50%) and rice production. New high-yielding lowland varieties of the NERICA are undergoing agronomic evaluation in Nigeria and several other countries.

Small-scale farmers with farm holdings of less than 1 ha cultivate most of the rice produced in Nigeria. However, rice productivity and production at the farm level are constrained by several factors. These constraints include insufficient appropriate technologies, biotic factors, poor supply of inputs, ineffective farmer organizations and groups, low yield and poor milling quality of local rice varieties, poor marketing arrangements, inconsistent agricultural input and rice trade policies, poor extension systems and environmental constraints. These environmental constraints include poor drainage and iron toxicity in undeveloped lowland swamps, poor maintenance of developed lowland swamps, drought, deficiencies of N and P, insufficient rain for rainfed lowland rice production, and poor soil management practices.

The unavailability of lowland rice production manuals has also been identified as a major factor limiting production of lowland rice in Nigeria. Farmers need to be taught how to prepare land and nursery beds, quantity of seed to plant per hectare, when to transplant their rice, how to apply inputs such as chemical fertilizers and herbicides, the weeding regimes and disease control methods, among others. This handbook is designed to address the above issues and assist lowland rice farmers to obtain higher returns on their investment in rice production.

The rice plant

A rice plant with four tillers



A tiller is a shoot different from the main stem and has roots and leaves. It may or may not have a panicle.

Tabel 1. Share of rainfed/irrigated lowland rice areas in Nigeria

Production system	Major states covered	Estimated share of national rice area (%)	Average yield (tonne/ha)	Share of rice production (%)
Rainfed lowland	Akwa Ibom, Bayelsa, Benue, Cross River, Edo, Ebonyi, Ekiti, Delta, Ogun, Ondo, Kaduna, Lagos Niger and Rivers states.	50	2.2	53
Irrigated	Anambra, Benue, Borno, Cross River, Ebonyi, Enugu, Kano, Kebbi, Kogi, Niger and Sokoto states.	16	3.5	27

Major lowland production constraints

Biotic

- Weeds
- Insects:
  - African rice gall midge (AfRGM)
  - Stem borers
- Diseases
  - Rice yellow mottle virus (RYMV)
  - Blast
  - Sheath rot
  - Smut

Abiotic

- Drought/flooding.
- Low soil fertility (P and N deficiencies).
- Iron toxicity.
- Salinity/alkalinity problems in the irrigated lowland production system.

Choice of land

- Choose fertile land with good water retention capacity (contain some clay and/or organic matter, i.e. loamy soil); clayed soils are most desirable.
- Heavy soils of valleys and *fadamas* are preferred.
- Consult Soil Survey and Testing Service of the Institute of Agricultural Research and Training (IAR&T), Ibadan or any other reputable soil-testing unit if growing rice for one or more consecutive years on the same piece of land.

Recommended lowland varieties

- Early maturing (<90–100 days): FARO 44 (SIPI) and 'etumbe' (local).
- Medium maturing (100–120 days): FARO 21, 26, 29, 52 (WITA 4), 57 TOX 4004-43-1-2-1, and others.
- SUAKOKO 8 and FARO 15: Suitable for iron toxic areas.
- Late maturing (>120 days): FARO 10, 12, 13, 16, 17, 19, 24, 28, and others.
- Gall midge-affected areas: Cisadane (FARO 51).

Choice of seed

- Use good quality seeds with no insect damage and no contaminants (weed seeds, stones, other seed types) with high percentage of viability (> 80%).

Sources to contact for good quality seed

- State Agricultural Development Project (ADP) that includes rice in its production programs.
- River Basin Development Authority.
- Branch office of the National Agricultural Seed Council.
- Seed company.
- Other rice farmers.
- WARDA–Nigeria.

Avoid seeds of mixed varieties

Seed dormancy

- Dormancy is the failure of good quality mature seeds to germinate under favorable conditions. Dormancy of freshly harvested seed should be broken by using heat treatment at 50°C in an oven if available or by placing the seeds on a plastic sheet and covering with itself or another under direct sunlight for 1 or 2 days. Acid treatment may also be used.
- Acid treatment: soak seeds for 16 to 24 hours in 6 ml of concentrated nitric acid (69% HNO_3) per liter of water for every 1 kg of newly-harvested seeds. After soaking, drain acid solution off and sun-dry the seeds for 3 to 5 days to a moisture content of 14%. Store in dry conditions for sowing.
- Conduct germination test on seeds to establish rates to use based on seed viability.

Seed viability testing and seed requirement

- Use only filled grains of good quality for sowing: add water to seeds and discard all empty grains that float in water.
- When the seed viability is not known, carry out a simple seed viability test to guide the actual seeds required for sowing.
- Place moistened tissue paper (preferably filter paper, if available) in a dish with lid (use Petri-dish if available) and put in 100 randomly selected filled seeds. Cover and keep the dish at room temperature for 4–5 days to allow germination.
- Then count the number of sprouting seeds (only those with shoots >1 cm). If 75 germinating seeds are counted, it means the viability rate is 75% (% germination).
- If the seed rate is 80 kg/ha, the actual quantity of seeds to be used for sowing is calculated thus:

$$\text{Seed required (kg/ha)} = \frac{\text{Seed rate (kg/ha)} \times \text{Area to be planted}}{\text{\% germination}} \times \text{\% filled grain}$$

$$= \frac{80 \text{ kg/ha} \times 1 \text{ ha}}{0.75} \times 1 \text{ (assuming 100\% filled grains)}$$

$$= 107 \text{ kg/ha}$$

- To estimate percentage filled grains, select at random 100 seeds from the seed lots to be sown and count the number of filled grains. If 100, it means 100% filled grains.

Seed treatment

- First, treat selected seeds with a mixture of insecticide and fungicide. For example, Apron Star™ 42 WS (thiamethoxam 20 g/l + difenoconazole 2 g/l + metalaxyl-m 20 g/l) at the rate of one sachet per 4 kg seeds or any available seed dressing chemical before sowing.
- Other products can be used:
  - PROCOT 40 WS (carbosulfan + carbendazim + metalaxyl-m.
  - CALTHIO C 50 WS (thiram + chlorpyriphos-ethyl).

- In areas with termite and nematode problems, incorporate carbofuran (Furadan™) at the rate of 2.5 kg a.i. per hectare into planting row. To ensure uniform application, mix Furadan with sand at a ratio of 1 : 4.
- Soak seeds in water for 24 hours and incubate for 48 hours before sowing to ensure uniform seedling emergence and good establishment.

Establishment of nursery

Dry bed nursery

- The nursery bed should be watered regularly to keep the soil moist but not puddled. Good drainage should be provided to ensure that the nursery is never flooded.

Wet bed nursery

- Select a good site with well-drained fertile soil exposed to full sunlight, and conveniently located in an area close to the main field and to facilities for efficient watering when needed.
- Prepare seed bed at least 7 days but preferably 14 days before the seeds are sown.
- Seed bed should be 1 to 1.5 m wide, 10 m long, 4 to 6 cm above the ground surface and well leveled.
- Soak the seeds in water for 24 hours. Spread seeds on the floor. Incubate seeds by covering with polyethylene bags or raffia palms for another 48 hours for seeds to sprout.
- Spread the sprouted seeds uniformly on a puddled nursery bed (wet bed nursery) or on a leveled surface for dry bed nursery. Use seed rate of 80–100 kg/ha depending on percentage seed viability and grain filling percentage for the actual requirement.
- Drain the excess water from the nursery bed for about a week. Then flood to 2–3 cm depth if using wet bed nursery.

- Apply 50 g/m^2 of NPK 15-15-15 fertilizer or apply 5 t/ha of rice husk + bran as mulch/manure. A combination of the two, where available, will give better seedlings.
- About 5 days after sowing seeds, the nursery beds should be kept flooded to a depth of 2–3 cm. To prevent weeds and also ensure easy pulling of seedlings, water depth should gradually be increased to a depth of about 5 cm.
- Avoid bird damage during germination by scaring the birds.
- In areas prone to gall midge, apply carbofuran at 1 kg a.i./ha in the nursery beds a week before uprooting.

Note: In general, about 1000 m^2 seedbed nursery is required to transplant a 1 hectare field, i.e. a ratio of 1:10.

Land preparation

- In areas with lots of perennial weeds, disc plow the field immediately after harvest in November/December to expose the rhizomes (roots) to the sun.
- Plow and harrow field.
- Flood the field for about 2 weeks to kill weeds.
- Remove water after 2 weeks and mark out field into basins (e.g. 5 m × 5 m or 10 m × 5 m) with hand hoes.

Preparing the field for rice

- Construct bunds around the field to retain water and suppress weeds using animal traction, hand hoe, etc.
- Irrigate or allow rain into the basins and level properly (hand puddling or with animal traction).

Puddling with hydrotiller

Time of sowing

- Forest zone – March to April.
- Derived savannah – May to June.
- Guinea savannah – June to July.
- Sahel savannah – seed at any time of the year depending on water availability.
- In all cases, seeding should be done when rains are well established.

Transplanting and spacing

- Transplant seedlings to the well-puddled and leveled main field between 14 and 21 days after sowing.
- Transplant at a rate of 2–3 seedlings per hill, to a depth of 3–4 cm, and at a spacing of 30 cm × 30 cm (best for late-maturing cultivars), or 20 × 20 cm when soil is fertile or sufficient fertilizer is available.

Note: Optimum plant density is a function of many factors including planting season, soil type, rice variety, among others. Therefore, the above density should serve only as a guide

Direct seeding

- Direct seeding can be done in hydromorphic areas of the toposequence.
- Divide the field into plots of 50 or 100 m^2 and construct bunds.

- Apply herbicides to control weeds as they can be a problem.
- Sow seeds at a spacing of 20 cm between rows and 15–20 cm within rows (between hills) by dibbling.
- Direct seeding can be done using pregerminated seeds on wet soils.

Gap filling

- Gap fill the empty spaces with seedlings within 7–10 days after transplanting using leftover seedlings from the nursery.

Fertilizers

- Fertilizers supply nutrients essential for growth, nutrition and health of the rice plant.
- Fertilizers can be applied in the form of organic or inorganic (mineral) or both.
- Organic fertilizer can be in the form of manure, compost or crop residues.
- Mineral fertilizers are manufactured. It is important to apply the right quantity and at the right time to obtain optimum yields and for environmental protection.

Types of fertilizers

- Straight (single) fertilizers: These supply only one primary nutrient (e.g. N, P or K) to the crop.
- Some examples:
  - Nitrogen: urea, ammonium sulphate, ammonium nitrate, calcium ammonium nitrate (CAN), and others.
  - Phosphorus: single super-phosphate (SSP), triple super-phosphate (TSP), and others.
  - Potassium: muriate of potash (MOP; KCl)

- Compound fertilizers: these supply more than one nutrient (e.g. N, P and K) to the crop.
- Some examples:
  - NPK 15-15-15 (15% N; 15% P_2O_5; 15% K_2O);
  - NPK 20-10-10 (20% N; 10% P_2O_5; 10% K_2O);
  - NPK 30-10-0 (30% N; 10% P_2O_5; 0% K_2O);
  - Ammonium phosphate nitrate (APN).

Note: There is no specific compound fertilizer formulated for rice. In this handbook, the preparation of formulations from straight fertilizers for a specific recommendation for immediate application for rice production has been demonstrated..

Fertilizer application

- Fertilizer should be applied based on the residual nutrients found after soil testing, the expected yield and the type of fertilizer materials available.
- The farmer should strive to obtain fertilizer recommendations based on the analyses of soil samples. Table 2 can serve as a guide.
- In situations where it is not possible to conduct a soil test due to high cost and unavailability of analytical services, or when the farmer is running out of time because the crop is subnormal in growth, the general recommendations in this handbook should serve as a guide.

General fertilizer recommendation based on agroecology

- Humid forest:
  Apply 60 kg N, 30–60 kg P_2O_5 and 30 kg of K_2O per hectare
- Savannah:
  Apply 60–80 kg N, 30–60 kg P_2O_5 and 30 kg K_2O per hectare
- Sudan/Sahel (under irrigation):
  Apply 100–120 kg N, 60 kg P_2O_5 and 60 kg K_2O per hectare

Table 2. Nitrogen, phosphorus and potassium fertilizer recommendations based on soil testing[1]

Nutrient	Soil fertility class	Recommended rate (kg/ha)	Fertilizer source and rate (kg/ha)
Nitrogen[2]	Low (<1.0 g total-N/kg) Medium (1.0–2.0 g total-N/kg) High (> 2.0 g total-N/kg)	100–120 60–80 ≤40	120 kg N≡ Urea (260 kg or 5 bags) 80 kg N≡ Urea (174 kg or 3½ bags) 60 kg N≡ Urea (130 kg or 2½ bags) 40 kg N≡ Urea (87 kg or 1¾ bags)
Phosphorus	Low (< 8 mg/kg [Bray-1]) (< 15 mg/kg [Bray-2]) (< 7 mg/kg [Mehlich III]) Medium (8–20 mg/kg [Bray-1]) (15–25 mg/kg [Bray-2]) (7–15 mg/kg [Mehlich III]) High (>20 mg/kg [Bray-1]) (>25 mg/kg [Bray-2]) (>15 mg/kg [Mehlich III])	30 – 60 P_2O_5 15 – 30 P_2O_5 0 – 15 P_2O_5	60 kg P_2O_5≡ (333 kg or 6⅔ bags SSP) or 60 kg P_2O_5≡ (132 kg or 2⅔ bags TSP) 30 kg P_2O_5≡ (167 kg or 2⅓ bags SSP) or (66kg or 1⅓ bags TSP) 15 kg P_2O_5≡ (83 kg or 1⅔ bags SSP) or 15 kg P_2O_5≡ (33 kg or ⅔ bags TSP)
Potassium	Low (<0.2 Cmolc/kg) Medium (0.2–0.4 Cmolc/kg) High (> 0.4 Cmolc/kg)	30 – 60 K_2O 15 – 30 K_2O 0 –15 K_2O	60 kg K_2O ≡(100 kg or 2 bags MOP 30 kg K_2O≡ (50 kg or 1 bag MOP) 15 kg K_2O≡ (25 kg or ½ bag MOP)

[1]Modified from Fertilizer Use and Management Practices for Crops in Nigeria.
[2]Not commonly used to guide N needs of soils. Leaf Color Chart (LCC) serves as a better guide.

Time of application

Basal Application of Phosphorus and Potassium

- Apply P and K within one week before transplanting and work the fertilizer well into the soil.

Topdressing of N fertilizer (e.g. urea)

- Apply in three equal doses:
  - Deep placement (2–3 cm) at transplanting.
  - Broadcast at about mid-tillering (3–5 weeks after transplanting [WAT]).

– Panicle initiation (i.e. when the plants are about 'pregnant'; 8 WAT for late maturing cultivars ≥ 150-days or earlier, [6 WAT] for medium maturing cultivars).

- Maintain water level on the field to 3–5 cm at the time of fertilizer application to ensure efficient use of the applied fertilizer.

Methods of fertilizer application

The fertilizer can be applied in two ways:

- For small areas: in irrigated system, close the irrigation inlet and drainage outlet. Then apply the fertilizer between rows. Irrigate and close the canals for about 10 days to facilitate nutrient absorption.
- Drain the field and apply the fertilizer by broadcasting. The fertilizer should be flooded immediately to prevent denitrification .

Topdressing N from straight fertilizers (e.g. urea)

General recommendations:

- Use 15 to 20 kg N for every tonne of target (expected) yield.
- Apply in 2-3 splits for ≥ 60 kg N/ha (≥ 2½ bags urea); use more splits for late-maturing cultivars (> 120 DAS).
- Do not apply more than 35 kg N/ha (1½ bags urea) in a single dose (split) to minimize losses.
- Use IRRI Leaf Color Chart (LCC) when available, to guide in topdressing.

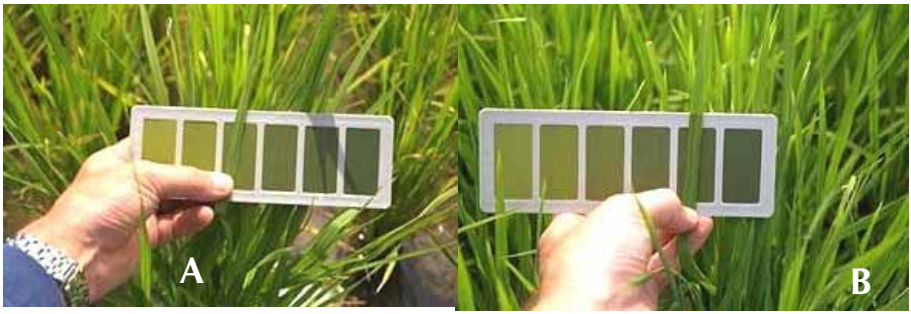
Use of color chart to guide topdressing N

- When a Leaf Color Chart (LCC) is available, it could be used to guide in topdressing with urea when N deficiency (–N Fertilizer below) is observed in the field.

N deficiency (–N fertilizer) and N sufficiency (+N fertilizer)

- Use LCC starting from the beginning of tillering (~2 weeks after transplanting) and take readings once every 7–10 days.
- Use the uppermost fully expanded leaf which best reflects the N status of rice. Compare the color of the middle portion of the leaf with the LCC. Take the readings of 10 leaves from randomly selected hills in the field. If the color is $\geq$ 3, then topdressing is needed.

Caution: Because leaf color is affected by the sun, always shade the leaf being measured with your body. The same person should take the readings and at the same time of the day.



Use of LCC for N topdressing: (A) Topdressing is needed beacause leaves have pale color; (B) No topdressing needed because leaves have dark color

Mixing fertilizers

- When it is required to apply two or more elements and the desired compound fertilizer is not available but the straight fertilizers are available (Annex 1), you may weigh and mix the fertilizers before application. This is particularly important for large mechanized rice farms.
- However, note that not all fertilizers are compatible when mixed. For example, if basal N is necessary and you need to apply N and P as basal, do not mix ammonium sulphate with rock phosphate, or urea with super-phosphate. The elements will react with one another and become less effective. The chart in Annex 2 can serve as a guide for mixing fertilizers for application to various crops, not only rice.

Fertilizer calculations

Example:
Recommended rate : 100 kg N – 60 kg $P_2 0_5$ – 60 kg $K_2 0$ per hectare (irrigated system).

Compound fertilizer available : NPK 15–15–15

Objective : To calculate the amount of NPK 15–15–15 + urea to get the recommended rate.

- In the recommended rate, there is less P and K than N. Therefore, we have to first start the calculation with P and K.

- Formula : Quantity required $(Q) = \frac{R}{C} \times 100$

  R = Recommended rate; i.e. 60 kg $P_2 0_5$/ha
  C = Fertilizer grade; i.e. 15 for $P_2 0_5$
- Amount of fertilizer = Q = 60/15 kg × 100 = 400 kg
- Since for $K_2 0$, also R = 60 kg $K_2 0$; C = 15, it means that the amount of fertilizer = 400 kg
- Therefore, if you take 400 kg of 15–15–15, you will get 60 kg $P_2 0_5$ and 60 kg $K_2 0$. But how much N will you get?
- The amount of N in 400 kg (= Rate) of 15–15–15 NPK is: $R = (Q \times C)/100$

$$R = \frac{400 \text{ kg} \times 15}{100} = 60 \text{ kg N}$$

- If 100 kg N is required and NPK supplies 60 kg N, the balance of 40 kg N will be supplied from urea.
  Amount of urea:
  46 kg N ≡ 100 kg urea (46 kg N is contained in 100 kg urea)

Therefore, 40 kg N $= \frac{40}{46} \times 100 = 87$ kg. Amount of urea is 87 kg / ha

Summary: Apply 400 kg NPK 15–15–15 as basal before transplanting and 87 kg (1¾ bags) urea as topdressing in 2 equal splits (mid-tillering and at about panicle initiation).

Table 3. To convert recommended rate from R kg/ha of nutrient element to Bags of Fertilizer/ha

Straight/compound fertilizer	Factor to multiply by R kg/ha (bags)
Nitrogen (N)	
• Urea	0.043 (e.g. 60 kg N/ha ≡ 0.043 × 60 = 2.6 bags/ha urea)
• Calcium Ammonium Nitrate (CAN)	0.077 (e.g. 60 kg N/ha ≡ 0.077 × 60 = 4.6 bags/ha CAN)
• Ammonium sulphate (AS)	0.1 (e.g. 60 kg N/ha ≡ 0.1 × 60 = 6 bags/ha AN)
• 20:10:10 (N:P:K)	0.1 (e.g. 60 kg N/ha ≡ 0.1 60 = 6 bags/ha 20-10-10)
• 15:15:15 (N:P:K)	0.133 (e.g. 60 kg N/ha ≡ 0.133 × 60 = 8 bags/ha 15-15-15)
Phosphorus (P_2O_5)	
• Single super-phosphate (SSP)	0.111 (e.g. 60 kg P_2O_5/ha ≡ 0.111×60 = 6.7 bags/ha (SSP)
• Triple super phosphate (TSP)	0.044 (e.g. 60 kg P_2O_5/ha ≡ 0.044×60 = 2.6 bags/ha (TSP)
• Diammonium phosphate (DAP)	0.038 (e.g. 60 kg P_2O_5/ha ≡ 0.038×60 = 2.3 bag/ha (DAP)
• 20:10:10 (N:P:K)	0.2 (e.g. 60 kg P_2O_5/ha ≡ 0.2×60 = 12 bags/ha (20:10:10)
• 15:15:15 (N:P:K)	0.133 (e.g. 60 kg P_2O_5/ha ≡ 0.133×60 = 8 bags/ha (15:15:15)
Potassium (K_2O)	
• Muriate of potash (MOP)	0.033 (e.g. 60 kg K_2O/ha ≡ 0.033×60 = 2 bag/ha (MOP)
• Sulphate of potash (SOP)	0.04 (e.g. 60 kg K_2O/ha ≡ 0.04×60 = 2.4 bags/ha (SOP)
• 20:10:10 (N:P:K)	0.2 (e.g. 60 kg K_2O/ha ≡ 0.2×60 = 12 bags/ha (20:10:10)
• 15:15:15 (N:P:K)	0.133 (e.g. 60 kg K_2O/ha ≡ 0.133×60 = 8 bags/ha (15:15:15:)

Iron toxicity

- Plant tolerant varieties such as Suakoko 8, FARO 15, ITA 247, ITA 249.
- Eliminate excess iron through good water management by draining the field..
- Use balanced nutrients such as N, P, K, and Zn.
- Cultural practices such as ridging, organic manure application, among others.

Iron toxicity symptoms

Water management

- Maintain the water level in the field up to 5 cm from one week after transplanting until grain matures
- Drain the water a week before harvesting
- Cracks should not be seen on the field.

Weed control

Hand weeding

- Drain water from the field
- Hand weed 14–20 days after transplanting
- Hand weed again around 30–40 days after transplanting

Hand weeding

Chemical weed control

For Pre-emergence in direct-seeded fields

- Rice Force and Gramoxone (paraquat) at 150 ml each in 20 liters of water per hectare sprayed not later than 24 hours after seeding.

Chemical weed control

Post-emergence application in both transplanted and direct-seeded fields

- Delmin Forte (2,4-D amine salt) or Amine Force (2,4-D amine) plus Propan 360 (propanil) at 200–250 ml (depending on seedling age) or propanil mixed with 50 ml of the 2,4-D in 20 liters of water per hectare.

- Alternatively, apply Tamarice™, Basagran™ PL, Ronstar™ PL, Risane™ or Orizoplus™ at 3 kg a.i. per hectare, 2–3 weeks after transplanting or 25days after seeding for direct seeded rice on a clear sunny day.

Volume of water to mix herbicide

- Volume of water to spray per hectare (WHA) depends on the output of the spray nozzle, the walking speed of the person spraying, and the width of the area to be sprayed.
- For a knapsack sprayer with low to very low pressure nozzles, in general, WHA ranges between 400 and 500 liters per hectare.
- If the recommended herbicide rate is 4 liters ha^{-1} and a low to very low pressure knapsack sprayer with WHA of 400 liters per hectare is to be used for spraying the concentration of the herbicide can be calculated thus:

  Concentration (C) = 4 × 1000 cm^3/400 liters
  = 10 cm^3/liter
- If the size of the knapsack sprayer is 15 liters, then the quantity of herbicide is 10 cm^3/liter × 15 liters = 150 cm^3.
- Therefore, take a graduated bottle or a cylinder marked at 150 cm^3. Pour in 150 cm^3 of the herbicide, and transfer into the sprayer, and fill the sprayer with water to the 15-liter mark, while stirring with a rod.

Table 4: Names and rates for herbicides used in controlling weeds in rice

SOME COMMON HERBICIDES USED IN RICE	GROWTH STAGE OF RICE	GROWTH STAGE OF WEEDS	RATES		WEEDS CONTROLLED	SOME RESISTANT WEEDS
			Active ingredient (a.i.) kg/ha	Commercial product (liter/ha)		
PARAQUAT	After land preparation and just before rice seeding	Seedling stage to full development	0.6	3	Most broadleaves	Imperata, Cynodon dactylon, Cyperus
GLYPHOSATE	After land preparation and 2–3 weeks before rice seeding	Seedling stage to full development	2	6	Most weeds comprising sedges and grasses with rhizomes	None
OXADIAZON	Post rice seeding and pré-emergence (0–2 days) after seeding	Pre-emergence	1	4	Grasses, sedges, broadleaves	Composea, commelinacea, papilionacea and grasses with rhizomes
OXADIAZON	Post rice seeding (3 weeks after seeding)	3 to 4 leaves	0.5	2	Grasses, sedges, broadleaves	Composea, commelinacea, papilionacea and grasses with rhizomes
OXADIAZON+PROPANIL	10–15 days after rice seeding (plantlets emergence)	3 to 4 leaves	0.5+1.5	5	Grasses, sedges, broadleaves	Most weeds if 3–4 leaves stage is over
BENTAZON+PROPANIL	10–15 days after rice seeding (plantlets emergence)	3 to 4 leaves	0.9+1.5	6	Grasses, sedges, broadleaves	Most weeds if 3–4 leaves stage is over
FLUORFEN+PROPANIL	10–15 days after rice seeding (seedling emergence)	3 to 4 leaves	1.2+1.8	10	Grasses, sedges, broadleaves	Most weeds if 3–4 leaves stage is over
BENTHIOCARB+PROPANIL	10–15 days after rice seeding (seedling emergence)	3 to 4 leaves	0.9+1.7	8	Grasses, sedges, broadleaves	Most weeds if 3–4 leaves stage is over

Disease control (RYMV, blast, brown spot, grain discoloration)

- Use disease resistant/tolerant varieties to RYMV and Blast.
- Use good cultural practices to limit infection of blast and RYMV.
  - High nitrogen associated with low potassium can increase blast damage.
  - Split application of nitrogen is better than one application to reduce blast damage.
  - Removing surrounding weeds to destroy the alternate host of RYMV can reduce the virus infection.
- Use clean healthy seeds.
- Treat the seeds 1–2 days before sowing to control seed-borne pathogens

- In case (and only in case) of being in an area conducive to fungal diseases, spray Dithane™ M-45 (80% of mancozeb) at 1.0 kg or Benlate™ (50% of benomyl) at 1.5 kg a.i/ha, in 500 liters of water to control rice blast, brown spot and grain discoloration. If the damage is severe, spray again after 15 days.

Insect control

Diopsis species

Diopsis species

- Cultural practices such as early sowing, narrow spacing of plants and maintaining weed-free fields should be observed to minimize Diopsis infestation.
- Synchronize planting over a large area to allow the most susceptible stage of rice to escape from Diopsis damage.
- Use of variety such as WAB 1159-2-12-11-6-9-1-2 with highly hairy leaves can trap *Diopsis thoracica* larvae.

African rice gall midge control

African Rice Gall Midge

Control

- Early and synchronized planting of rice fields can minimize damage than late planting.
- Destroy alternative host plants such as rice ratoons, volunteers and *Oryza longistaminata*.
- Use of fertilizers: moderate levels of fertilizer (e.g. 60 kg/ha) should be used and applied in split doses.
- Movement of seedlings should be discouraged because such seedlings can be infested by AfRGM in the nursery.

- Plant spacing: narrow spacing such as drilling should be discouraged because it provides a suitable micro-environment for the survival of the exposed life stages of AfRGM.
- The gregarious endoparasitoid (*Platygaster diplosisae*) and the solitary ectoparasitoid (*Aprostocetus procerae*) are the most important wasps (natural enemies) attacking AfRGM and should be protected on the field.
- Habitat manipulation by planting paspalum grass (*Paspalum scrobiculatum*) at the edge of the rice fields can increase the carry-over of parasitoids from *Paspalum* gall midge (*Orseolia bonzii*) to AfRGM. Such cultivation can be done in the dry-season to encourage *Paspalum scrobiculatum* abundance early in the wet season.
- Use of traditional *Oryza sativa* variety such as TOS 14519.
- Use of tolerant rice varieties such as Cisadane , BW 348-1, Leizhung, and others.
- Use of tolerant lowland NERICA varieties such as NERICA L-25, NERICA L-19, NERICA L-29, NERICA L-49.
- Use of traditional *Oryza glaberrima* varieties such as TOG 7106, 7206, 7442, 6346, 5681, and others.

Insect Vectors of Rice Yellow Mottle Virus (RYMV)

Short-horned grasshoppers - Oxya sp.

Chrysomelid flea beetle – Chaetocnema pulla

Control

- Use biopesticides to control insect vectors.
- Transplant seedlings early with reduced plant spacing before the outbreak of *Trichispa sericea*.
- Destroy rice residues after harvest and the ratoons that harbor the virus and insect vectors.
- Practice synchronous planting.
- Diversify varieties on a single plot.
- Change nursery sites.
- Rouging of infected plants and immediate replanting.
- Reduction of fertilizer application (e.g. urea) on attacked plots.
- Early and double weeding to reduce the weed reservoir of the virus and insect vectors.
- Withhold irrigation water between plantings to provide a rice-free period and so restrict the build-up of the virus infection and insect population.

- Use resistant/tolerant rice varieties such as LAC 23, Moroberekan, IR 47686-1-1 for direct seeded rainfed lowlands; and WITA 9, WITA 11 and Gigante (tete) for irrigated lowlands.
- Use Traditional *Oryza glaberrima* varieties such as TOG 5674, 5675, 5681, 7235, 7291, and others.

Grain sucking insect pests *(e.g. Stink bug - Aspavia armigera and Green stink bug - Nezara viridula)*

Nezara viridula

Aspavia armigera

Control

- Apply Decis™ at 1 liter/ha in 500 liters of water to control rice bugs which suck the sap after flowering.
- Adjust planting date to allow for manipulation of *N. viridula* numbers.
- Destruction of weed hosts around rice fields.
- The green-manuring crop, *Sesbania rostrata*, can be used as a trap crop to protect rice against *N. viridula*.

Bird control

- Erect scarecrows randomly in the field.
- Scare the bird manually.
- Tie old VHS tapes diagonally across and around the field.
- Install bird nets if available.
- Use catapults.

Scarecrow

Rodent control

- Leave an uncropped margin of 1-2 meters around the field.
- Distribute poison (bait) mixed with maize, sorghum, millet or rice in bamboo boxes or containers in the uncropped margins and alleys.

Rice rat

- Fencing with bamboo or chicken wire mesh or polythene sheet round the field may deter rats and grass-cutters.
- Use of local metal traps.

Rogueing

From heading until harvest, inspect field, remove and destroy off-type plants and weeds. The off-types can be identified through differences in:

Removing off-type plants

- height
- growth cycle
- grain color
- grain shape
- panicle shape
- leaf shape
- leaf base colour
- awnness

Harvesting

- The crop is ready for harvest when the grains are hard and are turning yellow/brown. That is about 30–45 days after flowering or a month after 50% flowering.
- Cut the stems with a sickle about 10–15 cm above the ground.
- Lay harvested rice crop in upright position for drying before threshing.

Harvesting matured rice

Expected yield

- With good management and use of improved high yielding variety, 5 to 6 t/ha paddy is expected.

Threshing

- Thresh immediately after harvesting and drying to avoid losses.
- Use whacking frames or mechanical devices, but avoid threshing on bare floor to prevent the introduction of sand, pebbles and other foreign matter.
- Thresh on a mat or tarpaulin over concrete floor by flailing (i.e. beating rice against the floor or against a stick or drum).
- Thresh carefully and avoid dehusking the grains.

Mechanical threshing of rice

Winnowing

- Winnow to separate the chaff and empty grains from the well-filled matured grains.
- Remove foreign matter in the paddy to avoid localized heating spots during parboiling.

Mechanical winnowing of paddy rice

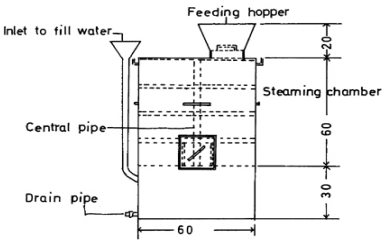
Drying

- Dry paddy properly to a safe moisture content of 13–14% by spreading in a thin layer (2–3 cm thick) on clean concrete floors, mats or tarpaulins and turning over periodically.
- Sun-dry slowly for 2–3 days to reduce breakage during milling.
- On a clear bright day, sun-dry for one day (about 9–10 hrs) only by spreading paddy thinly on clean concrete floors, mats or tarpaulin.
- Use a mechanical drier if available.
- Caution: avoid drying on bare floors or roadside, the main source of contamination with sand pebbles, stones and other foreign matter that can reduce the quality of rice.

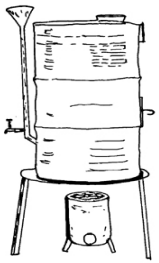
Sun-drying paddy on concrete floor

Parboiling

- Parboiled rice has the advantages of better storage, cooking quality, being richer in food value, devoid of unpleasant odor and breaking less during milling.
- Soak paddy in hot water at 70°C (hot enough for your fingers to withstand the heat for about two seconds) for 5 to 6 hours.
- Discard all floating empty grains.
- Parboil rice by steaming soaked paddy in a jute bag for 10 to 16 minutes.



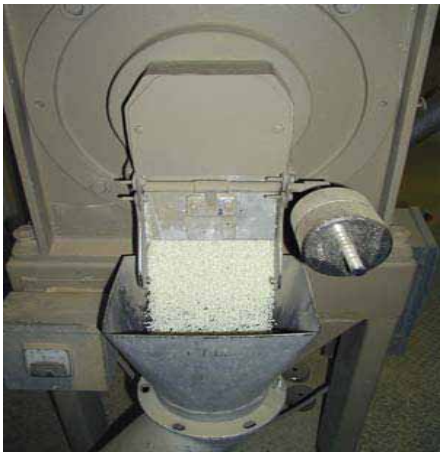
All dimensions in mm



Parboiling unit

- Suspend the bag over steaming water in a drum.
- Stop parboiling when rice husks start to split open
- Chalky grains or white centers indicate incomplete parboiling, which may cause breakage of grains during milling.
- Parboiling can be done in earthen pots or empty petrol drums depending on the quantity of rice.
- *Note:* steaming dexterises the kernels and drives the vitamin thiamine and other water-soluble nutrients from the testa or seed coat into the starchy core.

Milling



Rice milling machine

- Milling is the process of removing the husk or hull from the grain and the bran (pericarp, testa and aleurone layer) from the kernel (brown rice).
- Greater efficiency in the milling process results in whole grains with minimal broken grains to attract premium prices.
- Mill rice in a two-stage milling machine.
- Always mill one pure variety at a time.

Storage conditions

Milled rice stored in sacks

Good storage practices include:

- Store at 65% relative humidity.
- Store rice at a temperature within 10°F (5.5°C) of the average monthly air temperature and below 60°F (15.6°C) as long as possible during the year.
- Design and operate aeration system to maintain uniform. rice moisture and temperature.
- Store only well cleaned rice.
- Inspect rice regularly (weekly) during storage.

Storage insect pests of rice

Rice weevil – Sitophilus oryzae

Lesser grain borer – Rhizopertha dominica

Control of storage pests

- Use dried chilli pepper to keep pests away.
- Apply 2 tablets of Phostoxin® a.i. aluminium phosphide in an unsealed envelope per 50 kg bag of rice grains.
- Caution: Phosphine gas is highly toxic and should not come in direct contact with the rice grains. Wear protective gloves and nose masks when handling.
- Treat seeds/grains with activated silica gel powder to dehydrate possible insects in the bulk.
- Store grains at extremely low temperatures (-15 to -20°C) for minimum of 12 hours or high temperatures (above 55°C) for minimum of 3–4 hours.
- Use of airtight containers for grain storage

Further reading

Dobermann, A. and T. Fairhurst. 2000. Rice: nutrient disorders and nutrient management. IRRI, Los Baños, (The Philippines).

Aduayi, E. A., V. O. Chude, B. A. Adebusuyi and S. O. Olayiwola. 2002. Fertilizer use and management practices for crops in Nigeria, 3rd ed. Federal Ministry of Agriculture and Rural Development, Abuja, Nigeria.

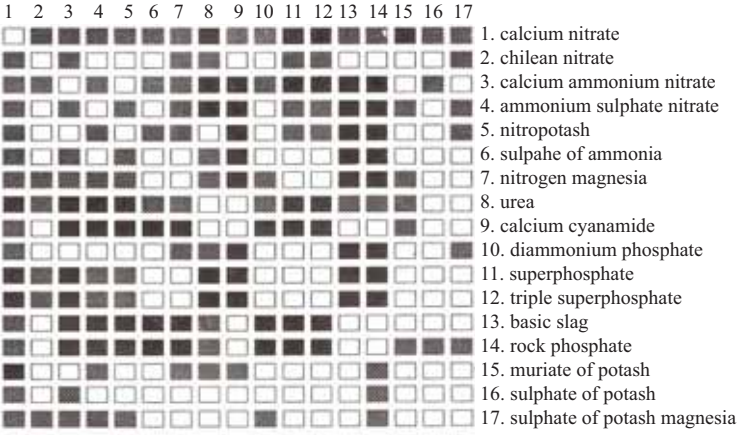
NSPFS. 2002. Fertilizers and their use: A pocket guide for extension officers. National Special Program on Food Security, Abuja, Nigeria.

NSPFS. 2004. Handbook on soil test-based fertilizer recommendations for extension workers. Federal Department of Agricultural Land Resources and National Special Program on Food Security, Abuja, Nigeria.

Annex 1
Common fertilizers

Fertilizer		Nutrient
AN	Ammonium nitrate	33–34% N
ANL	Ammonium nitrate-limestone mixture (see CAN)	
AS	Ammonium sulfate	21% N
ASN	Ammonium sulfate nitrate	26% N
CN	Calcium nitrate	15% N
CAN	Ammonium nitrate/calcium carbonate mixture (may contain chalk, marl, dolomite, limestone, or chemically precipitated calcium carbonate. Also called calcium ammonium nitrate and ammonium nitrate limestone (ANL)	20–28% N
UAN	Urea ammonium nitrate (solution)	28–32% N
APN	Ammonium phosphate nitrate	30-0-0 to 18-36-0
APS	Ammonium phosphate sulfate	16-20-0
DAP	Diammonium phosphate	18-46-0
MAP	Monoammonium phosphate	11-55-0
APP	Ammonium polyphosphate (solution)	10-34-0
NK	Nitrate of potash (potassium nitrate)	13-0-44
MOP	Muriate of potash (fertilizer-grade) potassium chloride	60–62% K_2O
SOP	Sulfate of potash (fertilizer-grade) potassium sulfate	50% K_2O
SSP	Single superphosphate	16–22% P_2O_5
TSP	Triple superphosphate	44–48% P_2O_5
KMP	Potassium metaphosphate	0-55-37
MKP	Monopotassium phosphate	0-47-31

Annex 2
Guide for mixing straight fertilizers



Pesticide safety

Pesticides can be highly poisonous and it is therefore important to take adequate safety precautions when transporting, storing or handling agricultural and other pesticides. Misuse of pesticides and other chemicals used in agriculture is responsible for many serious injuries and deaths in rural areas each year.

Always read and follow thoroughly the instructions printed on the pesticide label. Do not remove the label from the containers or boxes. Make sure that the chemical you want to use is still permitted for use in your country. Do not mix agrochemicals unless you have clear label guidance that the chemicals are compatible.

Always wear suitable protective clothing. Rubber gloves, overalls, a face mask and respirator are recommended when mixing pesticides. Gloves, long trousers and a long-sleeved shirt should be worn when applying less hazardous pesticides. This clothing can be uncomfortable to wear in humid climates but it is important that pesticides are not allowed to enter the body through the skin, mouth or lungs. Keep and wash this clothing separately from other garments.

Handle pesticides with care. Inspect pesticide containers for leaks before handling them. Avoid splashing or spilling liquids and causing powders to puff up or be spilled. Avoid inhaling dusts or vapors. Never work alone when handling the more toxic pesticides. Do not re-enter the treated area until the spray is dry or the specified re-entry time on the label has elapsed. In case of injury or accidental swallowing etc., go immediately to the nearest health center or infirmary with the box or container for the chemical.

Antidote: Make sure you know the antidote of the chemical you are using so that it can be used in case of accidental intoxication.

Never eat, smoke or drink when handling pesticides. Always wash thoroughly with soap and water after handling agrochemicals. If possible, have a container of water readily to hand for emergency wash use.

Only use pesticides when the weather is still and dry. Read the label for appropriate instructions. Do not use agrochemicals designed for a particular crop, e.g. cotton, on another unrelated crop such as cabbage or onion. Nor should crop pesticides be used to treat animals.

Keep an accurate record of pesticide usage, including quantity used, rate and date of application.

Storage: Store pesticides in a building or storage area reserved solely for this purpose and which can be securely locked. Keep pesticides in a store which is not likely to flood and is well away from food, feed and water supplies. Prevent unauthorized people, especially children, from having access to or contact with pesticides. Store pesticides in the original labeled container and protect the labels in storage so that they remain readable. Store large quantities of herbicides in a separate building or area from other pesticides.

Management of leftover agrochemicals: Always try to prepare only the quantity that is needed for the area to be treated so as to avoid having small quantities left over. These are difficult to keep or dispose of safely. The remaining chemicals, no matter how much or how little they are, should never be thrown away behind the store or in a nearby stream or bush. They should not be transferred to improper containers such as an empty food, feed, medicine or beverage container nor misplaced, but must be securely kept in the store in the original container or box until they can be used or disposed of safely. Small quantities of chemicals can be added to your next spray tank in the correct quantities. Washings from used chemical containers can also be added to the spray tank.

Transportation: Transport pesticides in an upright position in the open box of a truck, securing all containers. Do not transport pesticides in the passenger area of any vehicle. Do not allow anyone to ride in the back with the pesticides.

Disposal of pesticide containers: Rinse all pesticide containers three times prior to disposal to reduce environmental contamination. Puncture or break the used containers before taking them to a designated pesticide containers disposal site. Do not throw empty pesticide containers carelessly about the farm or into rivers. Where there is no designated pesticide containers disposal site, such containers should be buried deeply in a properly labeled area that is far from water sources.

Notes

About the Consultative Group on International Agricultural Research (CGIAR)

The Consultative Group on International Agricultural Research (CGIAR), established in 1971, is a strategic partnership of countries, international and regional organizations and private foundations supporting the work of 15 international Centers. In collaboration with national agricultural research systems, civil society and the private sector, the CGIAR fosters sustainable agricultural growth through high-quality science aimed at benefiting the poor through stronger food security, better human nutrition and health, higher incomes and improved management of natural resources.

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IRRI	International Rice Research Institute (Los Baños, Philippines)
IWMI	International Water Management Institute (Colombo, Sri Lanka)
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