Rice Production, Processing, Utilization and Marketing in Nigeria

Extension Bulletin No: 230

Acknowledgments

This bulletin replaces the National Agricultural Extension and Research Liaison Services (NAERLS) Extension Bulletin on Rice production practices in Nigeria. It has been revised to align with value chain approach of the Agricultural Transformation Agenda (ATA) of the Federal Ministry of Agriculture and Rural Development (FMARD). The information contained is a synthesis of information from across various local and international scientists and organizations. These include National Cereals Research Institute (NCRI), Badeggi; Federal Fertilizer Department (FFD), Abuja and the Africa Rice Centre.

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1.0 Introduction

Rice has become a food security crop as well a cash crop in Nigeria, employing over 15 million people in its value chain. The rice grain consists of 75-80 % starch, 12 % water and only 7 % protein with a full complement of amino acids. Its protein is highly digestible with excellent biological value and protein efficiency ratio owing to the presence of higher concentration (about 4 %) of lysine. Minerals like calcium, magnesium and phosphorus are present along with some traces of iron, copper, zinc and manganese. The bran oil is used for cooking, soap making, carrier for insecticides and anti-corrosive and rust resistant oils. Rice is also used in the brewing industries. Rice straw is used as a source of fuel, the manufacture of straw board, for thatching and for making hats and mats. Rice is usually cooked by boiling in water or steaming and eaten with soup. It is also frequently made into balls or *'tuwo'* and consumed with soup.

The demand for rice in Nigeria has soared over the years. It is consumed across all income groups and consumption is reported to have increased at 5% per year between 1961 and 2006. Production has however not kept pace with consumption. Nigeria consumes more rice than it produces leading to significant imports over the years. Nigeria's rice consumption is expected to jump to 35 million metric tons by 2050. The widening domestic rice deficit is being met by importation. Nigeria is both the largest producer and consumer of rice in the West African sub-region. Nigeria is currently one of the world's top ranking importers of rice.

Rice is cultivated in virtually all Nigeria's agro-ecological zones, from the mangrove and swampy ecologies of Niger delta in the coastal areas to the dry zones of the Sahel in the north.

The crop is predominantly produced by small-holders. The area put under its cultivation production in 2010 was estimated at 2,012,740 ha which increased to 3,095,900ha in 2014. Similarly, the estimated output of rice increased from 4,080,940 MT in 2010 to 6,734,100 MT in 2014 (NAERLS, 2014).

Rain fed lowland rice is the most predominant rice production system, accounting for nearly 50% of the total rice-growing area in Nigeria; while rain fed upland rice, irrigated systems, deep water rice and mangrove swamp rice make up the remaining 50%. Most farmers still rely on traditional production systems which are of low productivity.

Various research recommendations for improving rice production from universities and research institutes especially the National Cereal Research Institute (NCRI) and the Africa Rice Centre are yet to be communicated to potential users. The aim of this bulletin is to empower farmers, extension agents and other actors in the rice value chain with required technical knowledge to increase production efficiency and quality management along the chain.

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2.0 Choice of land

Rice can be grown practically on all types of soil, sandy loams to heavy clays. However, heavy soils characteristics of river valleys and basins of fadamas which have higher water holding capacities are better suited to rice growing than lighter soils. A heavy soil, slightly acidic to neutral (PH 5.5 to 7.0) is suitable for rice growing. High yields are usually associated with soils that have a high clay content of 40 to 60%. The soil should contain a moderate amount of organic matter with high degree of humification and good but not excessive drainage to minimize water loss. Farmers should therefore select sites where rice is grown traditionally with level fields (flat land). Where slope is significant, soil and water conservation measures such as

planting across slope should be conducted with the advice of Extension Agents. The following tips should be considered for rice production:

- Use soils that are suitable for rice production i.e. fertile land with good drainage and water retention capacity (contains some clay and/or organic matter i.e. loamy soil) and are slightly acidic to near neutral. Heavy soils are considered most desirable.
- Where continuous cropping is practiced i.e. planting rice for more than two years on the same piece of land, soil fertility conservation/improvement measures (such as growing legumes after rice, and ploughing rice residues into the soil as organic matter) should be adopted

2.1 Land preparation

Proper land preparation is necessary in rice production to minimize competition with weeds, enhances adequate mixture of stubbles and fertilizer as well as ensures uniform water distribution. Harrow the land twice to provide sufficient tilth for rice growth. Ridging is not necessary (unless the slope of the land is considerable) and often leads to low population and yields. Upland rice is better planted on flat land.

Paddy fields can be prepared under either dry or wetland conditions; the choice depends on time of operation, soil properties and implements to be used. In either case, the field should be disc ploughed immediately after harvest to expose the rhizomes of perennial weeds to scorching action of the sun.

For direct seeded rice, the field should be ploughed and harrowed just before the first rain. For wet or transplanted rice, the field should be flooded with the first rains and then roto-vated using power tillers. Construct bunds depending upon the slope, to accumulate rain water. Level the land to reduce erosion. Divide the field into plots of 50-100m^2 for better water management. Cover the paddy field with water to prevent the loss of nitrogen through de-nitrification.

(i) Mechanization: For newly cleared areas, cut big trees before the rains preferably from November to February and remove all stumps, roots and trees before ploughing. Plough once and disc harrow twice with the first rains from late February to early March to make good tilt if land is flat. Plough twice and disc harrow once if land is sloppy.

(ii) Manual Cultivation: Clear bush and pack thrashes between November and February, and use hoe to remove stumps and weeds. In the Savannah, land preparation may start in February, depending on the onset of the rains.

Fig. 1: Land prepartion using tractor

Fig. 2: Land prepartion using ox drawn

2.2 Variety selection and management

Select the variety that matches your production environment and market demand.

If in doubt, please consult the nearest Agricultural Officer or extension worker or the nearest office of State Agricultural Development Project/ River Basin Development Authority/ National Agricultural Seed Council/ Seed companies to obtain information on most suitable variety as well as supply of good quality rice seeds.

Recommended varieties

Early maturing

FARO 38 (IRAT 133), FARO 39 (IRAT 144), FARO 45 (ITA 257), FARO 44 (Sipi 6920233) FARO 46 (ITA 150)

Medium maturing- Non-Iron Toxic and Flood-Free Areas

ITA 222, ITA 306, ITA 212, FARO 29.

Medium maturing-Iron Toxic and Flood-Prone Areas

FARO 15, ITA 247, ITA 249, Suakoko 8, FARO 11(OS 6), FARO 43 (ITA 128), FARO 47 (ITA 117), FARO 48 (ITA 301), FARO 49 (ITA 315), ITA 321, ITA 331, IDSAID, WAB 35-2-FX, TDX 1012-12-28

Late maturing

FARO 15 (water-logged areas)

Gall Midge-Affected Areas:

Cisadane (FARO 51)

Upland ecology

FARO 43 (ITA 128); FARO 46 (ITA 150); FARO 48 (ITA 301); FARO 55 (NERICA 1); FARO 56 (NERICA 2); FARO 58 (NERICA 7); FARO 59(NERICA 8); OFADA 1 and OFADA 2, ITA 368, Tox 400 4-43-1-2-1, WITA 4 (Tox 3100-44-1-2-3-3)

Irrigated lowland and Iron toxic areas:

WITA 1(Tox 3118-6-E2-3)

Lowland ecology

FARO 44 (SIPI); FARO 51 (Cisadane); FARO 52 (WITA 4); FARO 60 (NERICA L19) and FARO 61 (NERICA L34)

Mangrove ecology/ deep floating environment

ROK 5, IR 54, WAR 77-3-2-2; BKN 6986-17;

Table 1: Agronomic characteristics of some recommended rice varieties;

New name	Cultivar name	Ecology	Days to maturity	Plant height *(cm)*	Yield range *(tonnes/ha)*	Grain shape	Amylose content	Reaction to blast	Year of release
FARO 44	SIP1692033	Shallow swamp	115	95	4.0-6.0	Long	26.0	Resistant	1992
FAR0 45	ITA 257	Upland	100	100	2.0-3.0	Medium	17.4	Resistant	1992
FARO 46	ITA 150	Upland	105	110	2.0-3.5	Medium	22. 5	Resistant	1992
FARO 47	ITA 117	Upland	115	105	2.0-4.0	Long	10.5	Resistant	1992
FARO 48	ITA 301	Upland	128	100	2.5-4.0	Medium	16.4	Resistant	1992
FARO 49	ITA 315	Upland	120	100	2.0-4.5	Medium	16.2	Resistant	1992
FARO 50	ITA 230	Shallow swamp	125	100	4.0-6.5	Medium	28.0	Resistant	1992
FARO 51	Cisadane	Shallow swamp	130	100	4.0-6.0	Long	-	Resistant	1997
Faro 56	Nerica 2	Upland	120	100	**4.0-6.0**	Long	16.2	Resistant	2004
Faro 58	Nerica 7	Upland	110	95	4.0-6.0	Long	15.5	Resistant	2006
FARO 60	L19	Low land	125	100	4.0-6.0	Long	Long	Resistant	2012
FARO 61	L34	Low land	125	105	4.0-6.0	Long	Long	Resistant	2012

2.3 Seed management and priming

Seed treatment protects the crop from seed borne diseases and insects as well as gives better germination. Chemical treatment should be undertaken with a mixture of insecticide and fungicide. Use one 10g sachet of Apron Star50 DS to dress/4kg seed or 10g of Seed-plus of Dressforce to dress 2kg of seeds.

Seed priming is conducted in order to hasten germination and crop emergence. Priming is achieved by soaking the seeds in cold water for 12 hours or overnight and then drained. For direct seeding, seeds are air-dried for about two hours and then sown.

Advantages include higher percentage of viable seeds, vigorously established plants that can withstand stress and higher yields. It also gives higher level of germination, reduces the need to replant or fill the gaps, and leads to more uniform plant stands. It also leads to high crop vigor at early growth stages which enables the rice to compete better with weeds, increases resistance to insect pests and diseases and high paddy yield.

Fig. 3: Soaking seeds in salt water

Fig. 4: seed dressing with chemicals

2.4 Planting

Direct seeding

When the seeds are viable (germination rate of more than 80%), seeding rate of 50–60 kg/ha is recommended for dibble sowing, 80 kg/ha for sowing by drilling and 80–100 kg/ha by broadcasting. If germination percentage is less than 80%, the seed rates should be increased accordingly. Plant the rice seed at a depth of 2 to 4cm. Do not plant rice deeper than 5 cm in order to avoid delayed seedling emergence. For ease planting, divide the field into plots of 50 m^2 or 100 m^2, and construct small bunds. Direct seeding can be done with pre-germinated seeds in wet soils. Dibble 5–6 seeds at a spacing of 25 cm between rows and 20 cm intra row and later thin to 3 to 4 seedlings per stand at 2 to 3 weeks after sowing. In drilling method, drill rows should be 15–20 cm apart.

Fig. 5: Dibbling method of planting rice

Fig. 6: Drill method of planting rice

Nursery bed practices

Select nursery beds near cultivation areas to ease management. Soak the seeds in water for 24 hours. Spread them on the floor and incubate them by covering them with polyethylene bags for 48 hours for the seeds to sprout. To provide seedlings for 1 ha of land, raise the nursery in 500m^2. Plough the land to a very fine

structure and construct raised beds of about 1.2m wide. A mixture of 60g Urea and 42.6g SSP/m^2 should be worked thoroughly into the soil before sowing seeds. Drain excess water from the field for a week. Ensure that seed beds are raised in high rainfall areas. Avoid bird damage during germination by scaring birds. In gall midge affected areas, apply Furadan TM (Carbofuran) at 1 kg/ha in nursery beds a week before uprooting.

Fig. 7: Rice in field nursery

Fig. 8: Rice in container nursery

Sowing date

The actual timing of sowing should be guided by the time of establishment of the rains, sowing rice in rows makes manual weeding easier.

(i) In the forest area, plant in mid-March to mid-April, after 2 to 3 good rains.

(ii) In the savannah, plant rice in mid-May to Mid-June, depending on the rain establishment.

Transplanting

Transplant seedlings from nursery after 21 days or at 2–6 leaf stage. This is done by carefully uprooting the seedlings. Transplant 2–3 seedlings per hill. Spacing should be 20 cm between rows and 15–20cm between plants.

Transplant early maturing varieties 15 cm apart and transplant medium and late maturing varieties 20 cm apart. At 7-10 weeks after sowing, use remaining seedlings to fill gaps where seeds have not germinated 7–10 days after transplanting.

Plant population

In dibbling or direct seeding, sow seeds 25 x 25 cm to give 160,000 stands/ha. Use a "pinch" or 4 to 5 seeds paddy per hole. Plant about 3-5cm deep, cover lightly and press. In drilling method, drill in rows 15–20 cm apart

2.5 Nutrient management and fertilizer application

Integrated nutrient management is the management of both organic and inorganic plant nutrients for optimal rice production while conserving the natural resource base essential for long-term sustainability. It consists of:

- Application of plant nutrient on the basis of soil test recommendation.

- Use of organic manures, crop residues, green manures, bio-fertilizers and soil amendments.
- Proper time and method of nutrient application.
- Proper management of water

The amount of fertilizer to apply depends on the quantities and level of residual nutrients in the soil and the type of fertilizer materials available. It is advisable to apply fertilizer based on soil test results and expected yield. Rice responds well to nitrogen fertilization. The recommended doses of major plant nutrients to rice are 70-50-40, 60–30–30 and 80-30-30 N, P and K/ha respectively under upland (Sahel and Northern Guinea Savanna upland), (Southern Guinea Savanna) and Forest and shallow swamp rice ecosystems. For efficient management of chemical fertilizers the following are to be taken into consideration.

- Nitrogenous fertilizers are to be applied in more number of splits. The lighter the soil, the more will be the number of splits. It is usually applied in three splits – 40% N at the time of planting, top dressed with 30% N at 4 weeks after planting or at the time of tillering and the other 30% N at 7 weeks after the planting or when the crop start to flower (panicle initiation stage).
- Full amount of phosphate and potassium fertilizers are to be applied during land preparation.
- In virgin soils and land that has been under 1 to 2 years fallow cropped with rice, apply a moderate rate of N (60 kg/ha) and on that has been more frequently used, apply 80 kg/ha. When Top dressing with N fertilizer, applied between the rows and buried. When P and K are applied separately, it is proper to broadcast them before sowing. However application times may vary due to weather constraints and individual farmers.

For upland rice, apply all N, P and K at 2-3 weeks after planting during first weeding. This could also be spilt applied at sowing or one week after germination. Incorporate (bury) the fertilizer in the soil properly to avoid losses. The second dose of nitrogen may be given in the form of urea fertilizer applied at 6-7 weeks after sowing.

For upland rice Southern Guinea and Forest zones, apply all N, P and K 2-3 weeks after planting and first weeding. This could also be spilt applied at sowing or one week after germination. Incorporate (bury) the fertilizer in the soil properly to avoid losses. The second dose of urea fertilizer should be applied at 6-7 weeks after sowing.

For upland rice in Sahel, Sudan and Northern Guinea, apply half N and all P and K in furrows between rows at 2- 3 weeks after planting. Broadcast the remaining N at 6 weeks after planting.

For lowland rice (shallow swamp, irrigated, hydromophic and inland valley swamp) apply half the N and all P and K at planting and the remainder broadcast at 6 - 10 weeks after planting or at panicle initiation stage.

Method of fertilizer application

By drilling or broadcasting, ensure incorporation into the soil. Apply fertilizer after a sufficient rain at 10cm from base of plant (hill application).

2.6 Water management

Water is the most limiting factor in rice production. With adequate water supply, rice can be grown in most parts of the country. Water has a dual function of meeting physiological demands of the rice crop as well as controlling weeds. Rice requires an annual rainfall of 1200-1600mm that is evenly distributed during the growing season. Water management is

directed at maximizing the efficiency of fertilizers and herbicides. Apply herbicides in completely drained fields. When fertilizers are to be applied, reduce water levels in the field to 3 cm for about 4-5 days before application. The crop is most sensitive to water stress during the reproductive stage. Wherever water is available, irrigate the crop at tillering, panicle initiation (PI), flowering, milking and dough stage. Collect maximum rain water by strengthening field bunds. Maintain saturation to 3 cm standing water till 25-30 days after transplanting and low depth of 3-5 cm of water till 15 days after flowering. The rice field is completely drained 10-15 days before harvesting to promote uniform ripening of the grains, but primarily to allow for a timely harvest. Dikes should be built across flood plains to control seasonal flooding during the months of July and August. Bunds should also be constructed around fields to conserve water and check erosion

2.7 Weed control

Hand weeding

Rice fields should be weeded regularly, especially during the early stages of growth. First weeding should be thorough and should be done within 2 to 3 weeks after emergence, using hoes. (The earlier the first weeding is done the better).

Second weeding should be done 5 to 6 weeks after emergence. Weed a third time, if necessary.

Use of herbicides

(i) **Pre-emergence**

- Oxidiazon at 3.0kg a.i. ha^{-1} (4-5 liters Ronstar 25 EC/ha)

(ii) Roundup (3 litres ha) applied pre- land preparation, Or spray 3litres of Gramoxone applied pre-emergence (1-3

days after planting) along with 4-5 litres of Oxidiaxone or 5-6 litres Butachlor 50 or 60EC as tank mixture.

(iii) **Post-emergence**

- Propanil + bentazon at 3.0kg a.i. ha^{-1} (5 litres Basagram 500PLha^{-1})
- Propanil + Fluorodifen at 3.0kg a.i. ha^{-1} (5 litres Risane 3000ECha^{-1})
- Propanil + thiobencarb at 3.0kg a.i. ha^{-1} (5 litres Tamarice 336ECha^{-1}) 2 - 3 weeks after planting
- Propanil + 2.4D Amine at 3.0kg ai ha^{-1}

Any resistant weed species or newly germinating weeds like corn grass should be removed and destroyed. A weed-free seed-bed at planting also contributes to the effectiveness of the herbicides. Caution must always be exercised in selecting and handling all herbicides. Consult the extension agent nearest to you for guidance.

***Striga* attack on rice**

Striga is increasingly becoming a serious problem in rice production. This weed is a parasite which germinates only when the rice plants (hosts) which it attacks are present. *Striga* is common in soils that have been used continuously and are poor in nutrients. The symptoms of *Striga* damage on the host crop can be seen before the parasite emerges from the soil. Usually, the symptoms are similar to those on drought affected crops which include stunted growth, wilting, yellowing and scorching of leaves, lower yield and plant death in severe attacks. *Striga* produces numerous tiny seeds which make it easy for the parasite to spread from place to place. The seeds can contaminate the crop during harvest, (paddy/straw) which may be carried from one farm to another or by animals when they

feed on the straw or may attach to their feet as the animals pass by *Striga*-infested areas or by machine tools during land preparation. *Striga* seeds are also easily dispersed by wind and water.

Control:

Some of the measures recommended for the control of *Striga* in rice include the use of *Striga*-free seeds, proper cleaning of farm tools especially after working on infested fields, proper fertilization (use of organic manure and inorganic fertilizer), crop rotation especially with soybean and groundnut, and intercropping as well as timely weeding. Rice farms should be weeded before *Striga* produces seeds to reduce the *Striga* seeds in the soil. A combination of the control measures often referred to as the integrated *Striga* control approach is recommended and is more effective than the individual control measures.

2.8 Pests and diseases control

Pest management

Integrated Pest Management (IPM) is the integration of available pest control tactics to keep pests below economic threshold levels with an aim of least or no hazards to the environment. It includes options aimed at eliminating pests by use of chemical (synthetic) pesticides along with biological and cultural options.

Cultural and mechanical methods

Crop residue management; Use of healthy seeds; Use of resistant/tolerant varieties; Adjustment of sowing date; Crop rotation; Intercropping, trap cropping; border cropping; Crop sanitation; Efficient fertilizer management; Efficient water management; Removal of affected plant parts; Use of traps/poison bait.

Termites

Preventive: Destroy all dead woods and plant residues by burning. Locate termite mounds in surrounding bush and destroy. Apply chloropyriphos (2litres ha^{-1}) or Carbofuran 3G (10-15kg ha^{-1}) treatment to control termite.

Army worm and stem borer

Watch the rice crop closely for dead hearts during early vegetative growth. Apply 1lter per hectare or cypermethrin 10 EC or Lamdacyhalothrin 2.5E for control of stem borer and army worms.

Apply Deltamethrin EC at 1 litre a.i/ha in 500 litres of water to control rice bugs which suck the sap after flowering.

Apply FuradanTM (Carbofuran) at 1 kg/ha to control African rice gall midge 20–30 days after transplanting as symptoms are seen on the field.

Some common pests of rice (*pictures*)

Fig. 9: Rice army worm life cycle

Fig. 10: Rice stem borer larvae and adult

Fig. 11: Rice bugs

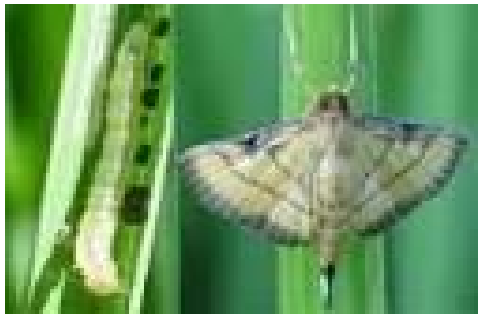


Fig. 12: Rice gall midge

Rodents:

Keep 2 to 3 metres border round the field free from grass, weed and burn thrash to control rodents. Build bamboo or palm frond fence (if possible), around the field immediately after planting. Create openings at short intervals and place traps in the openings. If rats and grass cutters become troublesome, catch them with traps.

Birds:
Use scaring devices to control birds. Employ people to drive birds away from farms between 6.00am to 7.00pm for the first two weeks after planting and from heading to harvesting.

Disease management
Integrated Disease Management (IDM) may be defined as managing plant disease severity below the economic threshold level following cost-effective, viable and easy operational procedures. The various methods used for IDM in rice include; Use of resistant/tolerant varieties; Use clean and healthy seeds; Destruction of alternative host plants; Selection of suitable land; Seed/seedling treatment; Proper land preparation; timely planting; Appropriate plant population; Crop rotation with non host crops; Burning of stubbles; Judicious fertilizer application. Proper weeding, regular inspection of the crop for disease incidence and removing and destruction of diseased plants

Bacterial leaf blight
Causal organism: *Xanthomonas campestris pv. oryzae,*
Symptoms of bacterial leaf blight

i. Bacterial leaf blight is a typical vascular disease and has three distinct phases of symptoms. viz., leaf blight phase, kresek phase and pale yellow leaf phase.
ii. Symptoms of the disease appear from the tip or edges of leaves as yellow, water soaked, undulate lesions, parallel to' the veins, later turning to straw yellow.
iii. Often amber coloured bead-like bacterial exudates are present on lesions. In systemic infection, the seedlings wilt and die.
iv. Grains get partially filled or become chaffy. Rain splashes and wind aid in dissemination of the bacterium. Field to field irrigation also aids in the spread of the pathogen.

Control of Bacterial Leaf Blight:
The control measures for bacterial leaf blight are:
1. Growing resistant varieties
2. Split application of nitrogen fertilizer

Bacterial leaf streak
Causal organism: *Xanthomonas oryzae* pv. oryzicola

Symptoms of bacterial leaf streak
This is a bacterial foliar disease caused by *Xanthomonas campestris* pv. Oryzicola, the disease first starts on the leaves as small water-soaked to translucent interveinal streaks of 1-10 cm long. They elongate parallel to the veins and turn yellowish brown, which often coalesce to form large blotchy lesions covering the entire leaf Surface. Minute, yellowish orange beads of bacterial exudates appearing all along the lesions is a characteristic feature of this disease.

Control of bacterial leaf streak: To eradicate the disease, following steps should be taken:
1. Procure seeds from authentic source to minimize the seed borne inoculums.
2. Soaking of the seeds in 0.025% Streptomycine and hot water treatment at 52°c for 30 minutes.
3. Use of resistant varieties.

Rice blast
Causal organism: *Pyricularia grisea, Magnaporthe grisea* (Fungus)

Symptoms of rice blast
Rice blast affects all above ground parts of rice plant at all growth stages but the severe damage occurs during the seedling stage. An infected leaf has diamond-shaped or elliptical or

spindle-shaped spots with gray or white centers and brown margins. The spots may merge leading to a complete drying of the infected leaf. The infected panicle turns white, causing panicle blast, and dies before being filled with grain. The infected node rots causing all above parts to die.

Conditions that favor development

1. Infested or diseased seeds
2. Excessive use of nitrogen
3. Poor air flow and poor sunlight penetration
4. Rainy days with high humidity

Prevention and control

1. Use diseased-free seeds
2. Use resistant cultivars
3. Proper plant spacing, transplanting is advisable rather than broadcasting
4. Split applications of nitrogenous fertilizer
5. Apply compost
6. Avoid farm activities when plants are wet
7. Burn diseased-straw and stubble
8. Spraying the nursery with 5gm of Mancozeb 80% wet table powder
9. Benlate (Benomy 50%) mixed in 3.8 litres of water plus 5ml of Tenac as sticker where available sprayed at 10 days interval after seeding
10. Diethane at the rate of 1.5 – 2kg per hectare

Brown leaf spot: *Helminthosporium oryzae*

Brown leaf spot is a fungal disease that can infect both seedlings and mature plants. This disease is more severe in areas of poor management. It is the major cause of 'Bengal Famine' in 1942, due to yield loss of 50-90%, resulting in death of about 2 million people. Occurs mostly in deficient & poor soils, the disease is

easily transmitted by wind. Inoculum sources of the disease include; seed, collateral hosts, rice straw or stubble.

Favorable conditions for the pathogen

- Temperature of 25-30°C
- Relative humidity (>90%)
- Cloudy days
- High doses of Nitrogen fertilizer

Damage symptoms

- The symptoms of the disease appear on the coleoptile, the leaves, leaf sheath and also the glumes.
- On the leaves the spots vary in size (1cm) and shape from minute dots to circular, eye shaped or oval spots is seen in the central portion.
- The seeds are sometimes shriveled and discolored.

Management of brown leaf spot

Preventive measures:

- Use of resistant varieties
- Proper crop nutrition
- Avoid water stress
- Clean cultivation

Cultural practices:

- Use disease free seeds for sowing
- Do not use high nitrogenous fertilizer
- Burn all crop residues and alternative hosts

Chemical control:

If the disease is observed in the field then spray 1g or 2g mancozeb or 2.25g Zineb in 1liter of water.

Harvesting

Rice is ready for harvesting when the grains are hard and are turning yellow/brown (about 30–45 days after flowering). Harvest when 80–85% of the grains have turned straw colour to avoid shattering, this is usually about 4-5 weeks after at least 50% flowering. Cut the rice stems with a sickle at about 15-20cm above the ground to permit hand threshing. Tie the panicles in bundles. Then place the tied-up bundles of harvested rice crop in heaps for drying before threshing 80 percent of the paddy.

Fig. 13: Matured rice field ready for harvest

Storage

Rice paddy intended for storage should be properly dried. Rice paddy should be stored in a cool, dry and rodent proof condition. Clean the store (*rumbu)* before putting in your paddy. To protect the paddy against insect pests, use 1½ match boxes full of Actellic 2.5 dust to about 25 kg of paddy. Infested paddy should be fumigated with phostoxin in air-tight containers at the rate of one tablet per jute bag (100 kg paddy) or 10-15 tablets per ton of paddy.

Yield

Farmers' yields range between 1,200 and 3,000kg ha^{-1} (16-40 bags) for swamp rice and 1,000 - 1,500kg ha^{-1} (13-20 bags) for upland rice. With improved practices yields of up to 5,000 - 6,000 (about 73 bags) and 2,500- 3,000kg ha^{-1} (about 37 bags) of paddy are possible for swamp/lowland and upland rice, respectively.

Rice processing

Rice processing is the combination of several operations to convert paddy rice into well milled silky-white rice, which has superior cooking quality attributes. The majority of household prefer well milled rice (WMR) with little or no bran remaining on the endosperm.

Objectives of rice processing are as follows:

- ✓ To produce a maximum number of unbroken grains that have had their bran layers uniformly removed, resulting in an appearance that is of a desired color and luster.
- ✓ Maximize practical through put capacity.
- ✓ Minimize consumption of power.
- ✓ Minimize consumption of consumable parts.
- ✓ Maximize productivity of human resource.

Most of Nigerian rice is produced by small-scale cottage processing industries and is consumed locally.

Steps in cottage processing:

Threshing:

Threshing separates the paddy from the straw. Thresh immediately after harvest to avoid losses. Use whacking frames or mechanical devices, but avoid threshing on bare ground. Traditionally threshing can be done by trampling with feet or using a work bulls to trample on the rice. The second one is by

pounding gently on the rice ears pin in the mortar with pestle. Threshing can also be done by spreading tarpaulin or mat on the ground and the bundle of rice ears threshed on the frame while the mat or tarpaulin collects the paddy. Thresh carefully to avoid de-husking the paddy. Damaged paddy become stained and coloured after parboiling and milling. Threshing disadvantages include;

- ✓ Grain breakage.
- ✓ Rice paddy mixed with sand and stones.
- ✓ The process is energy draining because it is labour intensive.
- ✓ Low capacity of threshing.

Fig. 14: Traditional rice threashing on the field using metal drum

Winnowing:

Winnowing comes after threshing; it is done to separate the chaff and other contaminants from the rice paddy. It is done traditionally by putting the paddy and the chaff in a flat tray and shaken seriously in a circular motion and the contents tossed up in the air, the air blows the chaff away and materials like stones

are removed or picked with hands. Another method involves using either basket, calabashes or head pan, the paddy and the chaff are put in one container and carried up in the air while the second one is placed on the ground and the paddy fall from the first container to the one placed on the ground while the wind blows the chaff away. The winnowing disadvantage includes;

- ✓ Ineffective separation when there is no wind.
- ✓ Paddy loss or waste if the wind is too strong.

Fig. 15: Rice winnowing

Drying

Dry the paddy to a safe moisture level of between 12 and 14 % before storing. Freshly harvested paddy does not store well under high temperatures. Remove foreign matter in the paddy to avoid localized heating spots, sun-dry slowly for 2–3 days on mats spread on concrete floors and should be done slowly for the first few days so as to reduce breakage during milling. Avoid drying on bare floors to reduce contamination with sand, pebbles and other foreign matter as they reduce the quality of the rice.

Parboiling:

Parboiling is an ancient method of rice processing, widely used in the developing countries like Nigeria, and in some rice exporting countries. Parboiled rice (PBR) is produced by both traditional and modern methods. The parboiling treatment gelatinizes the rice starch, improves the hardness of the rice upon drying, minimizes the breakage losses and thus increases the milling yield. Parboiling treatment also induces various physicochemical changes in paddy rice which play an important role in the subsequent storage, milling, cooking and eating qualities. The local parboiling devices range from pottery to boiler, use direct or indirect heating and single or double steaming, which consume all different amounts of energy. Agricultural residues are the main sources of energy for local parboiling, especially the residues of rice processing industries. However, sun drying is a common practice in local parboiling processes. A nearby pond, river, lake or tube-well is the source of the water for parboiling. In Nigeria, over 90% of rice produce are parboiled.

Fig. 16: Rice parboiling using metal drums

Fig. 17: rice after parboiled

Benefits of parboiled rice

Eating parboiled rice is healthy and nutritionally beneficial. It is easily digestible compared to the brown rice. Parboiled rice is not very different from brown rice, when it comes to nutritional content, it tastes far better and takes less time to cook. This alone should be reason enough to use parboiled rice compared to other rice varieties.

Advantages of parboiled rice include;

- ✓ Parboiled rice has Low Glycemic Index: GI index is the scale which measures how quickly the body turns a food into sugar. A high GI index means that the food gets converted to sugar very quickly, and thus can lead to a spike in your sugar levels (and hence unhealthy for people with sugar problems or diabetes). It's found that parboiled rice has a much lower GI index compared to untreated white rice, and hence it's a great option for diabetic people.

- ✓ Rich source of B vitamins: Compared to the untreated rice, the parboiled rice contains a high percentage of B vitamins, thiamine and niacin, which help digest the sugars and converts carbohydrate into energy. The vitamin content in parboiled rice is similar to that present in brown rice.

Disadvantages include;

- ✓ It requires more energy, water and time for processing and cooking than untreated rice.
- ✓ Over-parboiling results in over-opening of the husk components followed by bulging out of the endosperm which initiates surface scouring during milling and the resultant ground particles being lost into the husk and bran.
- ✓ Incomplete or non-uniform parboiling produces white-bellied rice, which breaks easily during milling, and reduces the head rice yield.

Local parboiling processes include:

- ✓ Soaking: it involves soaking of rice paddy in water for some time in order for the rice grain to attain high and uniform moisture content. Locally soaking is done by submerging the rice grain in cool water for three to four days by the time in which fermentation must have taken place thereby giving the rice grain an odour.
- ✓ Steaming: this process involves heat – treating the rice grains. While heating the rice, the macro nutrients in the aleurone layer of the grain are transferred into the endosperm and all enzymes and microbial activies are destroyed thereby increasing storability and the nutritional content of the grain. Locally, the rice is soaked after the water have reach boiling point, it is left in the water with heat continuously until the husks crack. After which the heat will be put off and the rice removed from the water.

Disadvantages include:

- ✓ Prone to injuries or burn due to unloading of rice grain from the hot water.
- ✓ Incorrect timing and uncontrolled temperature.

Some rice parboiling hardware's are;

(a) Improved Traditional Firewood Rice Parboiled: This is made up of a hydro gravimetric tank filled with 12% brine solution to facilitate the removal of sand pebbles, straw defective and empty grains or any foreign material in the grain.

(b) Improved Steam firewood Rice parboiled: This system has double tanks. One as a boiler and the second as a soaking and steamer tank. The boiler is placed on a furnace fired by wood and with pipe networks and control valves for control of hot water and steam into the steamer. Hot water is allowed to flow into the steamer for soaking. It is drained after soaking and steam is then allowed to flow in for the steaming operation.

Drying after parboiling:

This is done to bring the parboiled rice to low moisture content (13 – 14% w.b). This moisture is quite safe for milling and storage if the usage is not immediately. The rice paddy is spread on the concrete, tarpaulin or mats and not to be exposed directly to the sun. Parboiled rice should be dried as much as possible under a shade. Drying should be done properly to avoid the growth of mould on the paddy.

Disadvantages of traditional or local dry include:

a. Contaminations by sand and stones.
b. Pest, rodents, birds and lizards attack.
c. Space requirement and time control.

Milling:

Milling in rice processing refers to the combined process of cleaning, husking, polishing and grading of rice grains or grain size reduction process, for example to flours.

Cleaning:

Dried parboiled rice coming to the mill is first cleaned before the entire milling process. Contaminants or foreign particles are separated from the grain by winnowing. In a large scale processing, heavier ones are separated by a machine called de-stoner. Traditionally, stones, sands and other foreign particles are removed by hand picking.

Disadvantage Includes:

- ✓ Time consuming
- ✓ Ineffective in picking the stones and other materials.

De-husking:

This is the process of removing the husk from the paddy. Locally, de-husking is done by using a pestle to pound the paddy gently in the mortar. After pounding, the grain is winnowed and poured in the mortar for another pounding, this continued till a fine product is achieved.

Disadvantages include:

(a) Excessive grain breakage
(b) Energy tasking
(c) Time consuming

Removal of bran and polishing:

The traditional methods includes use of a pestle to pound a mixture of rice grains and straws of dewatered sugar cane or guinea corn husks placed in a mortar. The sugar cane chaff and guinea corn husks functions as abrasive during the pounding and help in the polishing of the rice grains.

Large scale processing:

Most large scale processing involves the use of modern technology equipment. Modern methods are energy and capital intensive, and are not suitable for small-scale operation at the village level. Large scale processing consists of the following rice processing operations:

Electric rice parboiler

This system is made up of two metal boxes, one placed within the other and the environment well insulated for heat conservation. It comes with a heat bottom where bags of rice grain are placed and other electrical heating elements which supply the heat.

Rice analyzer

Identify good, immature, dead, damaged, cracked, and discolored grains. However, an automatic, easy-to-use system has been developed to inspect a 1000-grain sample of brown or milled rice with high accuracy and repeatability.

Broken rice analyzer

The broken rice analyzer examines a 25- to 50-g sample of milled rice and determines its broken percentages based on weight. Principle of broken rice analyzer: rice is transferred to an analysis tray for scanning; a broken rice analyzer is equipped

with artificial intelligence and advanced image-processing capabilities.

Separation of broken grains from whole grains:
Broken grains are removed from whole grains through a process called length-grading actions. Later these broken grains can either be marketed separately or blended with whole grains to produce specific products.

Sifters
This involves the separation of milled rice into whole and broken grains. It is done typically with a high- capacity, moderately efficient length grader.

Color sorting
The objectives of the color sorting are to improve the quality of rice and the yield. The advantage of color sorting includes the following:

- ✓ Removal of unwanted paddy and other foreign materials
- ✓ Removal of inorganic materials including clear and white impurities such as glass fragments, plastics, and stones
- ✓ Removal of stained rice
- ✓ Removal of ‘‘peck’’ (dark spot) damage

Paddy cleaner:
The paddy cleaner consists of screening and aspiration sections. An oscillating movement applied to the sloping screen by vibratory motors causes paddy to move downward across the screen surface. Paddy cleaners provide screening and aspiration operations in perforated screen (upper screen) removes objects that are appreciably wider than rice (i.e., seed in pods, corn, beans, or other), whereas a round perforated screen (lower screen) removes objects that are significantly shorter than rice.

The aspiration section separates light materials from the paddy, allowing the cleaned paddy to drop through to a bottom outlet. The aspiration section removes objects that are significantly lighter than rice (i.e., dust, husks, and such). Keys to the performance of paddy cleaners are (a) uniformity of feed, (b) perforation size and shape, and (c) air velocity. These determine the effectiveness of screening and aspiration and affect through out capacity of the machine.

De-stoner
Depending on the rice’s variety and harvesting techniques, foreign objects may be present in paddy. A simple gravity separator, called a de-stoner, fluidizes a bed of paddy and then conveys the heavier stones to the high side of a sloping screen. The lighter paddy is not in contact with the conveying surface and thus moves downward under the force of gravity. In this way stones are removed from the paddy stream. After paddy cleaners remove foreign materials and seeds that are (a) wider than rice, (b) shorter than rice, and (c) less dense than rice, a process is required to remove objects, such as stones, mud, and even dense glass, which are denser than rice.

De-husking
This process removes the outer part of paddy rice (husk and bran) to make it edible. There are three main types of husking machine, including stone de-hullers, rubber rolls and impeller type huskers. Stone de-hullers are still common in tropical Asia, where BR is immediately milled with either an abrasive or a friction mill. It has been reported that different types of liner significantly affect the husking performance. It has also been reported that the Engelberg-type or steel hullers are no longer acceptable in the commercial rice milling sector, as they lead to low milling recovery and high grain breakage. Abrasive or

friction type milling machines are used to remove the bran. It has been reported that the abrasive mill can over-mill readily. In the Engelberg or huller type mill, de-husking and milling are performed in one step with greater grain breakage. Using a de-husker before milling improves both the milling and head rice yields. During parboiling treatment the husk splits and loosen, which makes de-husking easier.

Water mist polishing

One of the goals in rice processing is enhancing the quality of the finished rice. The ‘‘water mist’’ polishing machine was developed as a processing step to improve the finish or appearance of milled rice. As the name suggests, this machine uses a fine mist or spray of water to remove traces of dust, bran, and rice polish from the surfaces of milled rice grains. Moreover, bran and polish hidden deep inside the grooves of rice grains can be stripped away. The water mist and the subsequent rubbing action of the machine impart a high polish or luster to the milled rice, which substantially elevates its appearance. From a dull appearance, the rice grains are transformed into shiny, almost translucent kernels, which have good visual appeal and shiny appearance.

Labeling of rice and rice products

i. Packaging – poor and unattractive packaging
ii. Purpose of Food /Rice Labeling

The food label is one of the most important and direct means of communicating product information between buyers and sellers. It is one of the primary means by which consumers differentiate between individual foods and brands to make informed purchasing choices.

A label serves three primary functions:

- ✓ It provides basic product information (including common name, list of ingredients, net quantity, durable life date, grade/quality, country of origin and name and address of manufacturer, dealer or importer);
- ✓ It provides health, safety, and nutrition information. This includes instructions for safe storage and handling, nutrition information such as the quantity of fats, proteins, carbohydrates, vitamins and minerals present per serving of stated size of the food (in the Nutrition Facts table), and specific information on products for special dietary use;
- ✓ It acts as a vehicle for food marketing, promotion and advertising (via label vignettes, promotional information and label claims such as low fat, cholesterol-free, high source of fibre, product of Nigeria, natural, organic, no preservatives added, and so on).

All statements designed to promote the consumption or sale of rice are considered to be advertising and therefore are subject to a variety of legislation from the Standards Organization of Nigeria (SON) and National Agency for Food and Drug Administration and Control (NAFDAC).

Beneficial use of rice and rice products / over other crops

Table 2: Rice contains the following Nutrients based on 100g of every variety and using ½ cup each

	BROWN		REGULAR WHITE (enriched)		PARBOILED WHITE (enriched)		PRECOOKED WHITE (enriched)	
Nutrients of Rice	**Uncooked 100g**	**Cooked 1/2 cup = 98g**	**Uncooked 100g**	**Cooked 1/2 cup = 79g**	**Uncooked 100g**	**Cooked 1/2 cup = 79g**	**Dry Form 100 g**	**Ready to Serve 1/2 cup = 83g**
Water (%)	10.4	71.3	11.6	54.1	9.7	55.6	8.4	59.4
Food Energy (Kcal)	370	108	365	103	374	97	380	97
Protein (gms)	7.9	2.5	7.1	2.1	8.1	2.3	7.8	1.8
Fat (gms)	2.9	0.9	0.7	0.2	1.04	0.3	0.9	0.4
Carbohydrate: Total (gms)	77.2	22.4	80	22.3	80.4	20.6	82.3	20.7
Dietary Fiber (gms)	3.5	1.8	1.3	0.3	2.2	0.7	1.9	0.5

	BROWN		REGULAR WHITE (enriched)		PARBOILED WHITE (enriched)		PRECOOKED WHITE (enriched)	
Nutrients of Rice	**Uncooked 100g**	**Cooked 1/2 cup = 98g**	**Uncooked 100g**	**Cooked 1/2 cup = 79g**	**Uncooked 100g**	**Cooked 1/2 cup = 79g**	**Dry Form 100 g**	**Ready to Serve 1/2 cup = 83g**
Ash (gms)	1.5	0.5	0.6	0.3	0.7	0.2	0.5	0.2
Calcium (mgs)	23	10	28	8	55	15	22	7
Iron (mgs)	1.5	0.4	**4.3	**1.0	**5.3	**1.4	**6.3	**1.5
Phosphorous (mgs)	333	81	115	34	156	43.5	118	31
Sodium (mgs)	7	***	5	***	3	***	10	***
Potassium (mgs)	223	42	115	28	187	44	27	7.5
Thiamin (mgs)	0.4	0.09	**0.58	**0.13	**0.7	**0.17	**0.93	**0.06
Riboflavin (mgs)	0.09	0.02	0.05	0.01	0.05	0.02	0.03	0.01
Niacin	5.1	1.5	**4.2	**1.1	**5.1	**1.8	**7	**1.4

	BROWN		REGULAR WHITE (enriched)		PARBOILED WHITE (enriched)		PRECOOKED WHITE (enriched)	
Nutrients of Rice	**Uncooked 100g**	**Cooked 1/2 cup = 98g**	**Uncooked 100g**	**Cooked 1/2 cup = 79g**	**Uncooked 100g**	**Cooked 1/2 cup = 79g**	**Dry Form 100 g**	**Ready to Serve 1/2 cup = 83g**
(mgs)				7				
Folate (mgs)	20	4	**231	***46	**257	**64	**275	**58
Vitamin E (mgs)	1.2	0.03	0.11	0.03	0.03	0.01	0.04	0.01

Source: USDA National Nutrient Database

Benefit of rice/ superiority to others:
Rice is an excellent food to help keep the body healthy. Rice has the following nutritional benefits:

- ✓ Excellent source of carbohydrates
- ✓ Good energy source
- ✓ Low fat
- ✓ Low salt
- ✓ No cholesterol
- ✓ Low sugar
- ✓ No gluten
- ✓ No additives
- ✓ No additives

Rice is low in fat, salt and has no cholesterol:
Being low in fat, rice is suitable to include in a diet for those watching their weight. Rice is also cholesterol free, therefore being an excellent food to include in a cholesterol lowering diet. Brown rice contains a small amount of rice bran oil.

Rice is gluten free:
Some people are unable to tolerate the proteins found in wheat, barley, rye, and oats. These people choose foods that are gluten free. All rice is gluten free, making rice the essential choice for people with gluten free dietary requirements.

Rice contains no additives or preservatives:
Rice contains no additives or preservatives, making it an excellent inclusion in a healthy and balanced diet. Rice also contains resistant starch, which is the starch that reaches the bowel undigested. This encourages the growth of beneficial bacteria, keeping the bowel healthy.

Rice marketing
Rice production and consumption in Nigeria presently is beyond the traditional levels as a result of introduction of several improved cultivars, improved production practices as well as improved processing, marketing and utilization techniques and equipment. The price of rice as any other crop is cheapest at the time of harvest and increases during the periods of scarcity. Farmers are advised not to sell their harvest immediately after harvest, but to provide good storage to derive more profits by selling when demand is highest. There are many sources through which farmer can sale his paddy/grain and should take the advantage of the opportunity to sell to the highest bidder this is usually between March to July every year.

Survey by NAERLS show that the price of a bag of milled rice in the north steadily increased from ₦11, 000.00 in 2009 to ₦14, 000:00 in the first quarter of 2013. The report also indicated a steady increase in the price of milled rice in the southern part of the country from ₦10, 700:00 in 2009 to ₦14, 100:00 in the first quarter of 2013. Although, there is no record of paddy prices in the southern part of Nigeria, however, the price of paddy rice has also increased in the north from ₦4, 420:00 in 2009 to ₦5, 060:00 in the first quarter of 2013.

Survey of farmer's production record indicated that total production cost of rice under recommended practices is ₦81, 600:00 per hectare see table 3.

Table 3: Average production cost of cultivating 1 ha of rice

s/no	Activity/item	Cost(₦)
1	Land preparation	7, 000:00
2	Planting	3, 000:00
3	Seed	16, 000:00
4	Fertilizer	34, 400:00
5	Weeding	8, 000:00
6	Harvesting	13, 200:00
Total		**81, 600:00**

Considering the yield of rice of up to 5,000 - 6,000kg ha^{-1} (about 73 bags) for swamp and 2,500- 3,000kg ha^{-1} (about 37 bags) for upland rice depicts that the profitability of swamp/lowland rice production is higher than that of upland rice production see table 4. The analysis shows that for each naira spent on lowland rice a profit of three naira twenty four kobo is gained, while on upland production on each naira spent a profit of one naira fifteen kobo is gained.

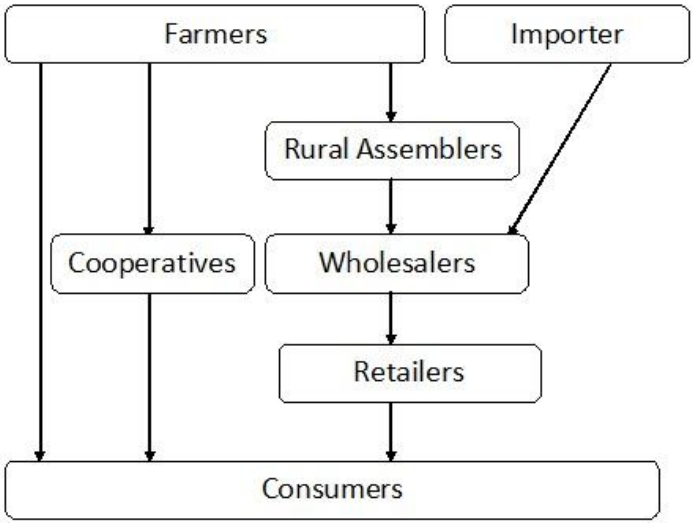
Table 4: Estimated gross and net income for swamp and upland rice production

s/no	Item	Swamp/lowland	upland
1	Grain yield (bags)	73	37
2	Gross income in (₦/ha)	346, 020:00	175, 380:00
3	Production cost (₦/ha)	81, 600	81, 600:00
4	Net income (₦/ha)	264, 420:00	93, 780:00
5	profitability	*3.24	*1.15

Rice marketing channel

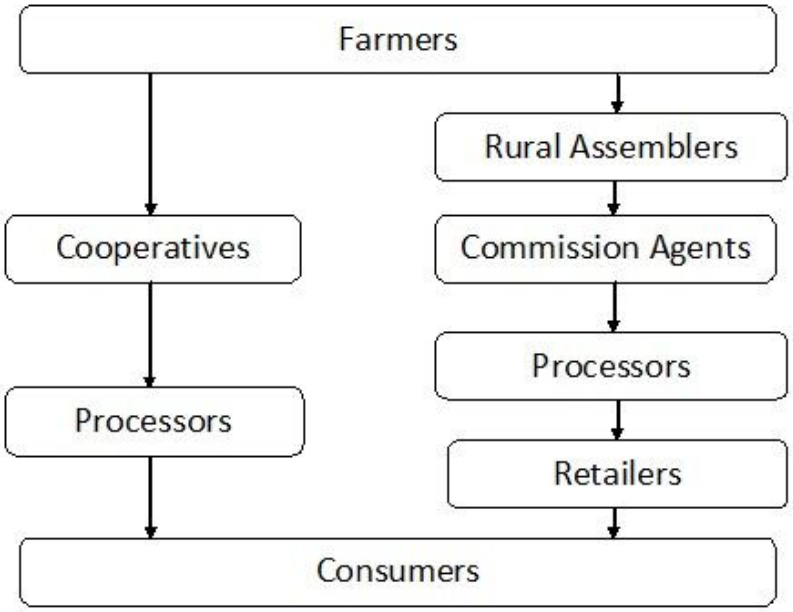
The rice marketing channel is simply the path through which rice moves from the producer to the final consumers. Rice marketing channels indicate how the various market participants are organized to accomplish the movement of a rice product from the producer to the final consumer.

The market for rice in Nigeria is not specialized and the rice value chain is under-developed. Almost all of the paddy rice produced is marketed and utilized for local consumption. Paddy rice, local parboiled rice or imported rice is usually sold in the local markets. The following major marketing routes can be identified for rice marketing in Nigeria.



Source: Adapted with modification from Olukosi, Isifor and Ode (2005)

Rice market in Nigeria has a lot of potentials for expansion through the value addition. Modern processing equipments and de-stoning machine for example, is one way of developing a viable market for local rice as it will benefit small to medium scale entrepreneurs. If this is done, the following marketing routes can be exploited for rice marketing in Nigeria.



Source: Adapted with modification from Olukosi, Isifor and Ode (2005)

Marketing agencies and their functions in rice marketing

Marketing agencies or intermediaries carry out marketing functions or offer marketing services. In order to understand the part they play in rice marketing, it is important to distinguish each by the functions and services they undertake rather than by the ownership of the produce they handle:

(a) **Rural buyers;** this group of middlemen undertakes the initial task of assembling rice from farms or local rural markets. They may be farmers who collect the produce of other cultivators. The rural buyer may either act on commission or purchase on his own account.

(b) **Wholesalers;** the wholesaler has a central role to play in rice marketing system. He takes the product from farms or rural buyers and sells to retailers, to other wholesalers in the domestic market and to processors.

(c) **Retailers;** the main function of the retailers in rice marketing is to obtain supplies and display them for sale in forms and at times and places convenient for the consumers. Usually the retailer buys from one or more wholesalers, sometimes on credit and serves consumers who buy smaller quantities on daily basis.

(d) **Commission agent;** These specialized in buying and selling rice on behalf of producers and wholesalers who cannot conveniently attend the markets in person. They run no risk, but must do at least as well for their client as the clients could do themselves, if they are to attract business.

(e) **Brokers;** this group of middlemen specialize in bringing buyers and sellers together. Brokers do not take title to or physically handle goods, but specialized in providing an intimate knowledge of supplies, requirements and prices in various markets.

(f) **Speculative middlemen;** this group of middlemen buy rice with the aim of selling them at a time when prices rise. They often attempt to earn their profit from short-run fluctuations in prices.

Rice consumption: preferences and consumer awareness issues

Rice is utilized mostly at the household level, where it is consumed as boiled or fried with stew in Nigeria. The major factors that significantly influence household preferences for either a combination of local and imported rice or the imported rice only to the local rice have been reported to be the income of

the head of household, household size and the educational status of the heads of household. The poor quality of the local rice is a major problem to its consumption by households. Consumers in Nigeria appear to display a distinct preference for imported rice over domestic rice, which has led to a market price premium for imported rice. Rice demand in Nigeria is affected by the total expenditure of household and quality. Quality is important in the demand for rice, even in the rural areas. Rural households also value quality and respond more than urban households for every 1% increase in their income.

Habit persistence and perceived quality differences both play an important role in explaining consumer preference for imported rice in Nigeria. Research on imported rice consumer's preferences suggest that imported rice cleanliness is the main feature explaining the expansion of imported rice consumption in Nigeria at the cost of local rice market development. Next to cleanliness are swelling capacity (mostly preferred by restaurants and fast food joints), taste, availability and grain shape.

The second explanation is that the long history of consuming imported rice in Nigeria has led to habit persistence, which makes it more difficult for locally produced rice to compete with the imported rice. It has also been shown that, as the income and the educational status of the household appreciates; households tend to prefer the imported rice to the local rice.

An important implication is that policies designed to encourage production of relatively high quality local rice, thereby replacing imported rice in consumption baskets, will face considerable inertia due to the persistence of consumer habits and mindset regarding purchase and consumption of imported rice, even if the locally produced rice is of comparable quality. Companion policies designed to shift consumer-buying habits and alter already established cultural mindset via extension (as well as

advertising) and promotion programs will be required to overcome this consumption inertia.

The public and private sector need to be strengthened towards the utilization of modern equipment for the local rice industry. Such efforts are expected to improve the Nigerian local rice grade, thereby enhancing its competitiveness amongst the rice varieties consumed by Nigerian households. Extension activities will be undertaken to raise the awareness of the middle class and the general populace on the adverse consequences of importing large tonnages of rice into Nigeria, at the expense of the nation's domestic rice market. Government and extension agents can play pivotal roles in such campaigns.

Rice nutrition and benefits

Rice is a predominant staple food in Nigeria, providing significant proportions of dietary energy supply, dietary protein and dietary fat. Rice can contribute nutritionally significant amounts of thiamine, riboflavin, niacin and zinc to the diet, but smaller amounts of other micronutrients. Rice has a healthful image and research has demonstrated that particular components of rice can help reduce risk factors associated with heart disease and colon cancer. Even though rice is an industrialized seed-based food, the difference between its glycemic load and those of most industrialized carbohydrate-rich foods is large. The amount of carbohydrate per gram in white rice is about half that of white bread. One of the reasons is that the water content in rice, as usually consumed, is comparable to that in fruits. Rice's glycemic load is 15 (medium), which is half the glycemic load of 30 (high) of white bread. White rice combines this utilitarian purpose with a very low anti-nutrient content. It is often said that white rice's nutrient content is very low, but this problem can be easily overcome

The rice grain is reported to consist of 75-80 % starch, 12 % water and only 7 % protein with a full complement of amino acids. Its protein is highly digestible with excellent biological value and protein efficiency ratio owing to the presence of higher concentration (about 4 %) of lysine. Minerals like calcium, magnesium and phosphorus are present along with some traces of iron, copper, zinc and manganese.

The different layers of rice seed (outer hull, caryopsis, aleurone, subaleurone and endosperm) and the embryo contain differing amounts of nutrients. Dietary fibre, minerals and B vitamins are highest in the bran and lowest in the aleurone layers; the rice endosperm is rich in carbohydrate and contains a fair amount of digestible protein, with an amino acid profile which compares favourably to other grains. Rice is a good source of B vitamins, thiamine, riboflavin and niacin, but contains little to no vitamin C, D or beta carotene, the precursor of vitamin A. The amino acid profile of rice is high in glutamic and aspartic acids, but low in lysine. The main anti-nutritional factors, most of which are concentrated in the bran, are phytate, trypsin inhibitor, oryzacystatin and haemagglutinin-lectin.

Based on an average consumption of 300g of rice for an adult male and 250g of rice for an adult female in Asian countries, a male aged between 19 and 50 years, consuming the cooked equivalent of 300g of raw rice per day, white rice supplies: 2-5% of the Recommended Nutrient Intake (RNI) of calcium, folate and iron; 9-17% of the RNI of riboflavin, thiamine and niacin; and 21% of the RNI of zinc. Rice provides no vitamin C or A. With brown rice the RNI is increased for all nutrients except riboflavin: the RNI of iron, thiamine and niacin is increased by more than 10 percent. Due to the greater quantity of phytate in brown rice, the bio-availability of many nutrients decreases, particularly iron, zinc and calcium (to which it chemically bonds). Further analysis is required in order to gain a full

understanding of the difference between brown and white rice in terms of the bio-availability of nutrients. Rice supplies a smaller proportion of the RNI of all nutrients for women, due to the smaller portion consumed and the greater requirements for certain nutrients, particularly iron.

Research on the cholesterol-lowering properties of rice bran has produced mixed results. Some studies indicate that rice bran and/or rice bran oil reduce plasma cholesterol in test animals while others have shown no effect. Studies also indicates that under the proper conditions, the oryzanol found in rice may be as good or better than other, similar plant compounds currently used in margarines to reduce cholesterol

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