Sawah Based Rice Production System

Introduction

The term Sawah refers to leveled rice field surrounded by bund with inlet and outlet connecting irrigation and drainage canals. The term originates from Malayo-Indonesian. The English term paddy or paddi also originates from the Malayo – Indonesian term, Padi which means rice plant

The term paddy refers to rice grain with husk in Nigeria and West Africa in general. Most of the paddy fields in the Asian countries correspond to the definitions of the term Sawah. Paddy field is almost equivalent to Sawah for Asian scientist and used only for lowland rice. However, the term paddy fields refer to just rice field and is sometimes confused to include upland rice field in West Africa. Therefore in order to avoid confusion between the terms rice plant, paddy, and the improved man-made rice-growing environment through ecological engineering the term Sawah which means leveled rice-field surrounded by bund has been adopted for use.

There is a long history of rice research and production in Nigerian and ironically Nigerian is still the largest importer of rice in the whole of sub-Saharan Africa. Despite the potential for rice production and possible exportation, the potential has not been transformed into actual production. Principal constraints identified in past studies for low productivity are poor soil fertility, poor water management and the use of in-appropriate rice varieties or low yielding varieties.

With the improved and research break through of International Institute of Tropical Agriculture (IITA) and WARDA - African Rice Center, the constraint of in-appropriate varieties has been eliminated substantially. However, the existing improved varieties need appropriate water management and soil fertility conditions before the expected yield can be realized.

Rainfed Lowland Rice Production

It is the most dominant system of rice production with 47% coverage of the total hectarage and it is followed by upland with 31% but the yield levels of upland rice remains low usually averaging just 1.5ton/ha and cannot be sustained at a high

level of 4 tons or above. This high level of production can only be sustained by lowland rice production.

The irrigated lowland has 16 % coverage. It therefore implies that rice cultivation in lowland is sustainable with higher yield than that of upland because intensive cultivation without fallow can be applied

The agro-ecological conditions of the core region of West Africa are quite similar to those of northeastern Thailand, one of the rice centers in that country, therefore the potential of Sawah based rice farming is enormous in West Africa. Ten to twenty million ha of sawah can produce additional food for more than 300 million people in future.

Irrigation and drainage without farmers' sawah farming technologies has proved inefficient or even damaging because of accelerated erosion and waste of water resources. Thus, the development of irrigation has been slow. In the absence of water control, fertilizers cannot be used efficiently. Consequently, the high yielding varieties perform poorly and soil fertility cannot be sustained.

The sawah based rice farming can overcome such soil fertility problems through the enhancement of the geological fertilization process, conserving water resources, and the high performance multi-functionality of the sawah type wetlands. It will utilize the inland valleys more efficiently, which are reported to be high in fertility and can sustain and enhance the water management for rice production through puddling and the inlet and outlet canals for irrigation and drainage

Despite the predominance of rain-fed agriculture in Nigeria, the Sawah system use in the inland valleys will enhance continuous cropping and better use and distribution of the production activities. Sawah is a multi-functional constructed wetland, which is a prerequisite for realizing the green revolution as well as the restoration of the ecological environment.

The Sawah System Approach

Sawah Stages:

1. Bunding
2. a. Break the mounds/ridges
   b. if grass fallowed, slash or spray herbicides
3. Flooding (10cm water level)
4. Puddling
5. Plot setting for 2 weeks if grass fallow
6. Puddling and leveling
7. Transplanting (on less than 2cm water level)
8. First fertilizer application
9. First weeding herbicide or hoe weeding
10. Second Fertilizer application (Top dressing)
11. Hand weeding if herbicide application
12. Final weeding if manual weeding
13. Final Top dressing of Fertilizer
14. Harvesting

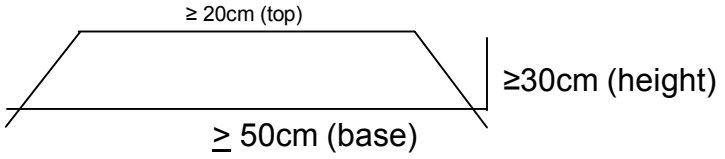
These stages are described in detail in the following sections with illustration.

1. Bunding:

It is advised that the bunding of the field into plot sizes should be done first, even though in some cases breaking of the mounds or ridges could be presided by bunding. But because most farmers would not start the mound breaking until after the soil is saturated or sometimes flooded making of strong and lasting bunds at this period would be difficult. Bunding covers the four sides of the plot. The size of the plot to be bunded is determined by the slope of the land. If the slope is $0.5 \leq 1\%$, the plot size should be between 400-800m^2 while when the slope is $0 \leq 0.5\%$ the plot size can be above 800m^2

The base of the bund should be greater than or equal to 50cm, with a height of at least 30cm and the top should not be less than 20cm. In this way the farmer is able to walk on the bund round the plot without the bund collapsing. For easy access by the Power tiller to individual plots a one meter portion is reduced in height on the bund for passage.

The bund can be represented as illustrated below



2. The next stage in the Sawah system is breaking of mound and or ridges from the existing/previous cultivation activities if the Inland valley has been cultivated before depending on the traditional farming activities of the area where Sawah is to be practiced. On the other hand if the land is grass fallowed there is need for slashing of grass or spraying with herbicide. The options of breaking the existing mounds and or ridges as well as grass slashing may be very appropriate among subsistent and resource poor farmers. It is appropriate that the grasses are not taller than 20cm and if there are twining grasses or grasses with stolon they should be removed from the field, this will improve the efficiency of the power tiller.

3. After bunding and the breaking of the mounds and or ridges, the basin is then flooded, the plot should have a minimum of 10cm and maximum of 15cm water level. This is controlled by the inlet and outlet that are 15cm in height created in the bund. It is important to maintain a water level that allows the whole plot to be flooded.

4. Puddling of the plot within the bund is done with the aid of a Power tiller. Previously, turtle plough had been used and still being used in some parts of Asia but the Power tiller gives a better rate of return. A Power tiller can use 10 liters of gasoline to cover one hectare within 8

hours. The effectiveness and speed of operation is affected by the terrain – lumps of soil, nature of weed left, the soil type, slope of the plot and finally the competency or efficiency of the operator.

5. Next to puddling is plot settling if the plot has originally been grass fallowed for at least 2 weeks, this will allow the proper decaying of grasses and keeping the soil in good conditions for subsequent activities. This also helps to control the weeds by reducing the weed seed bank in the soil.

6. Next to plot settling is the final puddling and leveling. In case of high slope, in areas where the top soil is thin, the leveling is better achieved over years through gradual movement of top soil from higher gradient to lower areas. An immediate leveling through top soil movement during the first year will lead to infertile patches on the plots leading to low yield. With deep top soil immediate leveling can be achieved using an attached plank to the Power tiller. Leveling enhances water management on the plot which is crucial to rice growth. For large scale plots development as seen in Japan or China, tractor mounted tillers are often used, the layout of the bunds are permanently laid and the designing with construction are more technically advanced which gives the entire terrain an aesthetic landscape to last a lifetime. This is also enhanced by the thick top soil of about 1m in these areas, which are sometimes introduced.

7. Transplanting of rice seedling in <2 cm water level on the plot follows the final puddling and leveling which is based on 25 by 25cm intra rows and inter rows. Conventionally knotted / marked rope is laid based on the spacing and rice seedlings are planted on the knotted/marked points on the rope. A 25cm stick is used at the two ends of the line to place the inter row spacing. The use of transplanting is recommended as against direct seeding due to the efficiency and effectiveness as recorded by past studies on transplanting vis-à-vis direct seeding. In many parts of Asia, rice transplanter is often used

which facilitates the transplanting, as this seems to be the most labour demanding stage of the Sawah system. However, the labour requirement is offset by the eventual plant density, which translates to better yield returns. Recommend rice variety for rainfed lowland to achieve optimal yield is WITA 4 (FARO 52) which matures in 120 days for favourable valleys that are not drought prone. SIPI 692033 (FARO 44) is early maturing variety that is recommended for unfavourable valleys that are drought prone.

8. Fertilizer application is better split into 2 or 3 times. The first application just before transplanting or 5-7 days after transplanting. The second application should be carried out 4-6 weeks after transplanting and soon after the first weeding is completed. The third and final application should be done just before flowering. The usual recommended fertilizer rate is 90Kg N/ha, 40kg P_2O_5/ha and 40Kg K_2O/ha. However, due to prevailing conditions in some West Africa states an application rate of 60-80kg N/ha, 30kg P_2O_5/ha and 30kg K_2O/ha should be appropriate with split fertilizer application to attain the recommended rate effect. In practice this is 4 bags of NPK and 2 bags of Urea. However, it has been observed that resource poor farmers often apply fertilizer once. This one time application is often practiced due to fertilizer in-availability, cost and affordability.

Weeding could be manual or with herbicide application. The herbicide application after transplanting could be done from 3-4 weeks after transplanting to take care of pre and post emergence weeds. The second weeding is done before flowering using the hoe or hand pulling depending on the growth of the weeds. The field is minimally maintained after this until harvesting.

It should be noted that water level on Sawah plot throughout the different stages of activities ranges from 0 – 5cm – 10cm – 15cm but not more than 20cm at any point.

9. The harvesting is done as soon as the rice ripens. The plot should have been drained at least two weeks before harvesting. In case of high moisture threshing might be delayed for few days.

10. The Sawah Package being advanced with the farmers consists of the following: bunded plot (at least 400m^2), puddled and leveled, transplanted rice seedling that is less than 30 days old, transplanted in straight rows of 25cm x 25cm, use of improved variety and fertilizer equivalent to 6 bags i.e. 4 bags of NPK and 2 bags of Urea.

CONVENTIONAL METHOD

Land Acquisition, Mapping, Estimation and Development

(a) Land ownership issues involving individuals, community and state. It affects the lengths of time the farmer has to use land for rice production.
(b) Vegetation and soil characteristics of the land (canopy arrangement of trees, shrubs sedges, nutrient status and environmental stress factors)
(c) Water regime and ecology (drainage, flooding, health hazards)
(d) Surveying of land (land area survey, topography survey, soil survey)
(e) Estimation of land:
Estimate land area using pegs to create intervals of 10m, 20m
Walk round the entire land, examine and take note of the terrain
Measure linear distances by pacing, using a cloth tape, or a steel tape stadia method.
Development of the land (clearing, locating water control structures, construct water facilities)

Nursery Raising/Establishment & Management

(a) Prepare land and seed 3-4 weeks before transplanting time
(b) Nursery size – 1/20 (50%) of field to be planted
(c) Till the land to fine tilth and make seed beds of width 1-1.2m and of convenient length.
(d) Use good seeds of recommended varieties e.g FARO 27, FARO 44 (Early duration); FARO 35, FARO 29, FARO 51, FARO 52, (Medium Duration); FARO 8, FARO 12, FARO 15 (Late maturing).
For deep water swamp areas use FARO 7, FARO 14, FARO 15.
(e) Apply little quantity of a mixture of nitrogen and phosphorus fertilizer (50/ha of NPK 15:15:15: can do)
(f) Seed rate is 50kg/ha
(g) Select good healthy, viable seeds of improved varieties by soaking in 12% salt solution for two minutes. Wash and dry seeds that settle at the bottom of the solution. Separate the seeds, wash them with freshwater thoroughly free of salt and dry.
(h) Broadcast seeds in rows 10cm apart (use planting frame if possible
(i) Plant when soil is moist or irrigate.
(j) Mulch with dry grass and keep seedbed moist always.
(k) Weed the nursery at least once.
(l) Inspect growing seedlings regularly for signs of insect/disease infestation and treat.

(m) Scare birds from the nursery for two weeks from time of seeding.

Seedling Preparation/Time of Transplanting

(a) Before transplanting at 3-4 weeks, uproot seedlings from nursery making sure the nursery bed is wet
Transplant seedlings not late than 2 days after uprooting seedlings
Transplant 21-28 day old seedlings
Seed the field with first rain

(b) Wash and trim roots and or tops if necessary
(c) Transplant from July to August / early September
(d) Synchronize planting

Land Preparation/Site selection

(a) Select fertile, heavy clay or poorly drained soil as found in lowland areas i.e. with moderately high water holding capacity. Plough and harrow two weeks later. Good land preparation is the first step in weed control. Harrow the field just before the rains and direct seed. Broadcast and cover the seeds with thin layer of soil during the first rain.

Slash weeds/wild growth and burn the crop residue. Where possible apply herbicide to the weeds a week before ploughing

(b) Where tractor is available, plough before the rains to expose rhizome/roots of perennial weeds for desiccation and puddle with rotavator just before transplanting when soil is already waterlogged
Uniform puddling of the soils leads to moisture and nitrogen retention and therefore increases in yield.

(c) With hoe method, build heaps or mounds before the rains to expose roots of weeds. Puddle when flooding starts (just before transplanting) by breaking and spreading the heaps and mounds
Plant into clean field in which all germinated weeds has been buried during puddling.

(d) Construct bunds around the paddy field and flood the field with water to prevent nitrogen losses through denitrification
Bunds help to accumulate water as well as control the inflow and out-flow of water

Field Planting/Seed Rate

(a) Transplanting 2 to 3 seedlings per stand (use knotted ropes for easy planting operation). Transplant at 20 x 20cm for irrigated ecology and 25 x 25cm for rainfed ecology.
If plants are crowded together, fewer tillers per plant develop because the plant is competing for sunlight, nutrients and moisture.

(b) Where irrigation is possible flood the planted field initially to a depth of 5-8cm and gradually increase depth of flood to 10cm as the plants develop. Divide the field into plots measuring 50 or $100m^2$ and construct small bunds.
Flooding continuously helps to reduce weed growth.

(c) Seed rate: 30-50kg/ha transplanting; 80-100 kg/ha broadcasting, (have 86% germination).
In dibbling, the spacing should be 20-25cm between rows and 15-20cm between plants.

Weeding/Weed Control

(a) Bury all germinated weeds during puddling
(b) Drain water from the field
(c) Hand weed twice at 2 and 6 weeks from transplanting time
(d) Where herbicides are available, drain field at 2-3 weeks from transplanting and `apply recommended herbicides. Leave for three days before re-flooding. Where necessary hand weed again at 4 weeks from herbicide application.
Use herbicides dosages recommended by research organizations e.g Butachlor at 3.5lt/ha, Propanil +2,4 D amine at 4-6lt propanil to 1-2lt 2,4 D /ha. or Orizo plus at 4lt/ha Apply when soil is moist.
(e) R-Box® (Rice Production Technology Package) ensures planting with conservation or minimum tillage of the soil. This reduces drudgery.

Fertilizer Application

(a) General recommendation is 80:30:30kg NPK/ha
Apply more nitrogen to short non-lodging varieties and less to tall lodging varieties.
(b) Give basal application of 30:30:30kg NPK/ha by applying about 200kg (4 bags/ha) of 15:15:15 NPK fertilizer may be used
In direct seeding the fertilizer should be applied after the first weeding

© Apply remaining nitrogen fertilizer in two split applications
(i) 50 kg/ha (1 bag/ha) of Urea may serve
(ii) 50 kg/ha (1 bag/ha) Urea at 4 weeks from the last application.

Gap Filling

Gaps fill the areas where there are empty spaces with remnants of seedlings, 7-10 days after transplanting.
In direct seeded rice, thin and gap fill.

Water Control

(i) Maintain water in the field up to 5cm, one week after transplanting till grain maturity
(ii) Drain water a week before harvesting
Cracks should not be visible in fields.

Pest Control

Stem borers (Larvae or moths)

(i) Burn rice stubble so as to kill hibernating pupae or moths
Close and regular inspection of the field is important for early detection of attack by all kinds of pests
(ii) Apply Furadan (Carbofuran) at 30kg/ha before or at planting time
(iii) Close and regular inspection of the field is important for early detection of attack by all kinds of pests.

Grass Cutter/Rats

(i) Maintain a clean border of about 3m width around the field or
(ii) Fence round the field and set traps at openings in the fence

Sap sucking Bugs, Army Worms, African Rice Gall Midge, Diopis, Beetles, etc.

(i) Apply Delvap (Monocrotophos) and λ-cyalothrin at 1 litre in 150l of water/ha as soon as attack is observed.

Birds control

(i) Scare birds from grain filling stage to maturity
(ii) Bird-scaring should be between 6.00 am to 7.00pm daily

(iii) Use human bird scarers aided by cheap instruments like scarecrow and noise producing objects. Mannequins are also used.
(iv) Use as many as 4 bird-scarers per ha depending on the bird population and intensity of their attack.

Disease Control

Blast/Brown Spot

(i) Use clean seed of recommended varieties
(ii) Treat seed with Fernasan D. or Apron plus before planting
(iii) Spray infested field with Dithane M 45 at kg ai/ha or Benlate at 1.5kg a.i/ha in 500 liters of water to control brown spot, blast and grain discoloration.
(iv) Use clean seeds and inspect field regularly for early detection of disease infestation.

Rice yellow mottle virus **(RYMV)**

(i) Use tolerant varieties
(ii) Rogue, bury or burn previously infected stubble/straws
(iii) Control insect outbreaks such as beetles and grasshoppers with insecticides
(iv) Keep the rice field clean and free of weeds. Clean the bunds and edges of fields

Harvesting/Storage Grain Quality

The crop is ready for harvest when 80% of the grains have turned to straw colour. All materials must be harvested close to ground 10-15cm and with long straw to permit manual threshing. Thresh and winnow. Dry paddy for 3-4 days before storage (Moisture content of 13-14%). Dry paddy should be stored in airtight containers or bags in well ventilate fumigated rooms.

Factors affecting grain quality: inherent physical characteristics, harvest conditions, processing methods, mixtures with foreign particles, storage, consumer preference and miller' preference.