PADDY FERTILIZATION AND IRRIGATION

MODULE

Rice Plant Production

I. PADDY FERTIZATION

A. Introduction

In the ICM implementation strategy, technology recommendations are based on the portion of technology's contribution to improvement crop productivity, either separately or integrated. Technology is taught to farmers in step by step. One of the recommendations orders for rice production technology in ICM are using of site-specific balanced fertilizers and organic compost and/or manure as fertilizer as well as soil enhancer.

Synergism between technology components in the application of the ICM model *give* information that we create fertilization method that make fertilizer can sink (deep placement), reducing nutrient loss, weeds become a source of nutrients, increased soil aeration, so, more efficient fertilizer. Providing organic ingredients and an aerobic atmosphere can reduce the accumulation of toxic materials in the soil, and make supply oxygen for better root development. Using organic ingredients can make physical, chemical and biological soils improved, and efficiency of using inorganic fertilizers increases (for about 30%), as well as neutral insects increase as natural enemy prey.

Alternative technology components that can be introduced in the development of the ICM model for soil consist of fertilizing N based on Leaf Color Chart (LCC); fertilizing P and K based on soil nutrient status, of Paddy Soil Test Kit (PSTK), solving problems with soil fertility if they occur and the use of organic matter. Recommendation for organic matter is 5t/ha for hay compost or manure 2 t/ha.

B. Fertilizing N based on Leaf Color Chart (LCC)

To be effective and efficient, the use of fertilizers is adjusted to the needs of plants and the availability of nutrients in the soil. N needs of plants can be known by measuring greenish level of rice leaf color using Leaf Color Chart (LCC). The use of LCC to determine the time of application of N fertilizer can be done in 2 ways. The first method is fixed time, that is, the fertilization time is set beforehand, based on the stage of plant growth, including the phase during active tillers and panicle formation or when primordia. The LCC reading value is used to correct the predetermined dose of N fertilizer so that it becomes more precise according to plant conditions. The second method is the timing of fertilizer application based on the actual LCC reading value (real time), namely the use of LCC starting when the plant is 14 DAP (Day After Planting), then periodically repeated every 7-10 days until the critical value is known when N fertilizer must be applied. For Indonesian conditions, it is recommended to use fixed time.

a. How to Apply fixed time LCC

LCC readings were only carried out before the second fertilization (active tiller stage, 23-28 DAP) and third fertilization (primordial stage, 38-42 DAP), with the aim of smoothing the specified fertilizer dose. If the LCC reading is below the critical value (< 4.0), then the dose of N fertilizer given is increased by about 25% from the predetermined amount. On the other hand, if the LCC reading is above the critical value (> 4.0), the dose of N fertilizer given is reduced by about 25% from the predetermined amount.

b. How to apply real time LCC

1. Before the age of 14 days after transplanting (DAP), rice plants are given basic N fertilizer at a rate of 50-75 kg of urea per hectare. At that time LCC was not needed.
2. Measurement of the greenness of rice leaves with LCC begins when the plants are 25-28 DAP. Measurements were continued every 7-10 days, until the plants were in a pregnant state or in the primordia phase. This method applies to ordinary high yielding varieties. Especially for hybrid rice and new types of rice, measurements of the greenness of plant leaves are carried out until the plants have flowered at 10%.
3. Randomly select 10 clumps of healthy plants on a uniform bed, then select the top leaf that has fully opened in one clump.
4. Place the center of the leaf on top of the LCC, then compare the color of the leaf with the color scale on the LCC. If the leaf color is between the two color scales on the BWD, then use the average value of the two scales, for example 3.5 for the leaf color value that lies between the 3 and 4 LCC scale.
5. When measuring plant leaves with LCC, the officer must not face the sun light, because it can affect the measurement value.
6. Whenever possible, each measurement is made at the same time and by the same person, so that the measurement value is more accurate.
7. If more than 5 of the 10 observed leaves are within the critical limit or with an average value of less than 4.0, the plants need to be given N fertilizer immediately with the following dose:
    - 50-75 kg urea per hectare in low yielding seasons (in certain places such as Subang, West Java, the low yielding season is the dry season).
    - 75-100 kg urea per hectare during high yielding seasons (in certain places such as Kuningan, West Java and Sragen, Central Java, the high yielding season is the dry season).
    - 100 kg of urea per hectare in hybrid rice and new types of rice, both in low and high yielding seasons.

- If the leaf color value of hybrid rice and new rice type when the plant is in panicle out condition and 10% is flowering is on a scale of 4 or less, then the plant needs to be given additional N (bonus) fertilizer at a rate of 50 kg of urea per hectare.

C. Fertilizing P and K based on Soil Nutrient Status, solving problems with soil fertility if they occur and the use of organic matter.

a. Fertilizing based on soil nutrient status

Paddy Soil Test Kit (PSTK)

PSTK is a tool to measure the nutrient status of P, K which can be done directly in the field relatively quickly, easily, and quite accurately. PSTK namely PUTS (Perangkat Uji Tanah Kering/In Bahasa) consists of solvents (reagents) P, K supporting equipment. Rice soil samples that have been extracted with this reagent will give a color change and then the levels are measured qualitatively with the P and K.

The working principle of PUTK is to measure soil P and K nutrients in available form, semi-quantitatively using the colorimetric (staining) method. P state measurement and soil K are grouped into three categories, namely low (L), medium (M), and high (H). From each class of P and K status of paddy soil, a reference for P fertilization (in the form of SP36) and K (in the form of KCl) has been made. Tables 3 and 4 contain general references for P and K fertilization based on soil nutrient status*.

Table 1. General reference for phosphorus fertilization in lowland rice plants

Nutrient status class P ground	HCl extracted nutrient content 25% (mg P_2O_5/100g)	Reference dose of P fertilization (Kg SP-36/ha)
Low	< 20	100
Medium	20 – 40	75
High	> 40	50

** in Indonesia*

Table 2. General reference for potassium fertilization in lowland rice plants with and without rice straw

Status class soil K nutrient	Extracted nutrient content	Reference dose of K. fertilization (kg KCl/ha)	
		+ Rice husk	- Rice husk
Low	< 20	50	100

Medium	10 – 20	0	50
High	> 20	0	50

** in Indonesia*

Guidelines that can be used to determine when to apply P and K fertilizers include:

- Both at low (50 kg SP-36/ha), medium (75 kg SP-36/ha) and high (100 kg SP-36/ha) doses, all P fertilizer was applied as basic fertilizer.
- At low-moderate doses (<50kg KCl/ha), all K can be applied as basic fertilizer.
- At high doses (100 kg KCl/ha), 50% K was applied as basic fertilizer or between 10-14 DAP and the rest at primor

pH Status

PSTK also a tool to measure soil pH in the field relatively quite accurately. PUTS consists of solvents (reagents)for soil pH. Soil samples that have been extracted with this reagent will give a color change and then the levels are measured qualitatively with the pH color charts.

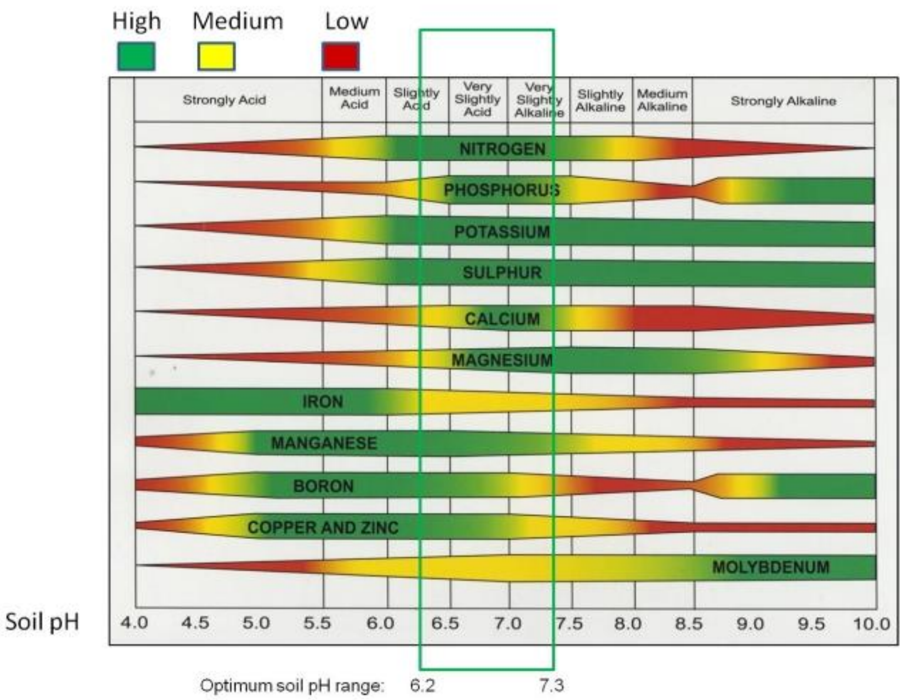

Figure 1. How soil pH affects availability of plant nutrients

We want our soil in neutral condition, soil in ideal condition that all nutrient exist and could absorb by plant roots. pH status can measure buy soil tester or lakmus, then we can have accurate amount of pH.

Figure 2. Soil tester and lakmus

However, we want to estimate our soil pH by simple way or cheaper tools. Instead of that, using natural ingredient is the best way. Turmeric or baking soda can find in the kitchen, easily.

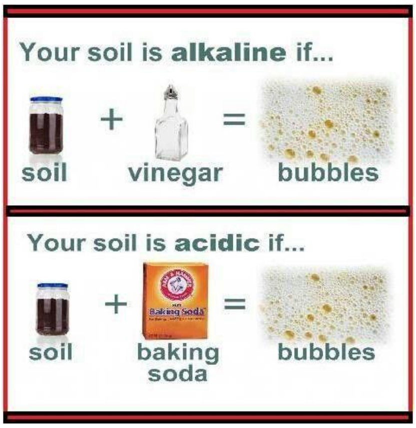

Figure 3. Estimating soil pH

b. Soil fertility problem

Lack of Hara S, Zn and Cu.

The non-optimal yield of rice in some paddy fields in some areas can be caused by a lack of several nutrients such as sulfur (S), zinc (Zn) and copper (Cu). For anticipating these obstacles, it is necessary to measure the level of soil acidity (pH) and soil analysis as an indicator of plant nutrient needs.

Iron (Fe) poisoning.

Iron poisoning in rice plants occurs because of the high concentration of Fe in the soil solution. Young plants that have just been planted in the field are often affected by high concentrations of ferrous ions (Fe^{2+}) after the land is flooded. The black color of Fe-Sulfide in the roots is a sign of a very reductive condition and the plant is Fe poisoned. Drainage can overcome Fe poisoning.

c. Organic Ingredients

Organic fertilizer in composted form plays an important role in the improvement of chemical, physical and biological properties soil and plant nutrients. Organic fertilizer that composted has gone through the decomposition process carried out by several kinds of microbes both under aerobic and anaerobic so it is easily absorbed by plants.

d. How to make compost

Composting can be done both anaerobically and aerobically. The anaerobic method takes 1.5 to 2 months and often produces compost with an unpleasant odor, because the temperature produced is not high enough so that it does not kill nuisance organisms.

Anaerobic way:

1. Put the raw materials in layers starting with plant residues, then manure, husk ash or kitchen ash into the previously prepared hole. The base has been compacted to prevent water seepage. The size of the hole can be adjusted according to the availability of labor and available raw materials, for example, hole size 2 m x 1 m with a depth of 1 m is sufficient to process about 0.5-0.8 tons of compost for about 0.2 to 0.3 ha of land.
2. Cover the top surface with 5-10 cm thick soil and spray 30 liters of water on the surface of the compost every 10 days and mix all the ingredients in the hole after one month of composting
3. Let it last for 1.5-2 months so that the composting process can be perfect. To speed up the composting time, cellulolytic or lignolytic microbes that act as decomposers can be used, including Biodec, Stardec, or EM-4.

Aerobic way:

1. Compost raw materials are arranged in layers and then doused with a microbial solution until it reaches a wetness of 30-40%, or with characteristics when clenched by hand the water does not come out and when the fist is released the raw material will bloom.
2. The raw materials are piled up to a height of 15-20 cm, then covered with burlap or plastic sacks.
3. The temperature of the compost is checked every day, keep the temperature in the range of 40-50^{o}C, if the temperature is higher, the compost is stirred until the temperature drops and closed again,

4. After 3-5 days the raw materials have become compost (bokashi) and are ready to be used.

II. PADDY IRRIGATION

A. Introduction

Irrigation is the process of applying water to the crops artificially to fulfil their water requirement. Crop water requirement is defined as total quantity of water required by a crop in a given period of time for its normal growth and development under field conditions. Paddy is extremely sensitive to water shortages. There are two kind of irrigation system for paddy cultivation, continuous flooding and intermittent irrigation

Water for agriculture is critical for future global food security. Water is essential for rice cultivation and its supply in adequate quantity is one of the most important factors in rice production. In Asia and other parts of the world, rice crop suffers either from too little water (drought) or too much (flooding or submergence). Most studies on constraints to high rice yield shows that water is the main factor for yield gaps and yield variability from experiment stations to farm. Irrigation has helped boost agricultural yields and outputs, stabilize food production and prices.

Irrigated rice was responsible for about 75% of the world's total rice production. A sustainable increase in irrigated rice production however faces a number of critical technical and development factors. Land and water resources for irrigated rice production especially in Asia have been increasingly lost to the expansion of urban and industrial sectors. Ongoing changes in global and local climates will exacerbate many problems and will drive change in irrigation investment patterns in its own right. Changes in temperature, the most predictable of the climatic change impacts, will increase water losses from lakes and reservoirs and raise evapotranspirative demand for water, while increasing atmospheric moisture content.

B. Continuous Flooding Irrigation

Rice is typically grown in bunded fields that are continuously flooded up to 7−10 days before harvest. Continuous flooding helps ensure sufficient water and control weeds. Lowland rice requires a lot of water. Total seasonal water input to rice fields varies from as little as 400 mm in heavy clay soils with shallow groundwater tables to more than 2000 mm in coarse-textured (sandy or loamy) soils with deep groundwater tables. Irrigated rice receives an estimated 34−43% of the total world's irrigation water, or about 24−30% of the entire world's developed fresh water resources. During the crop growth period, the amount of water usually applied to field is often much more than the actual field requirement. This leads to a high amount of surface runoff, seepage and percolation which accounts for about 50-80% of the total water input into the field. Worldwide, water for agriculture is becoming increasingly scarce. Due to its semi-aquatic ancestry, rice is extremely sensitive to water shortages.

C. Intermittent Irrigation

Agriculture activities are very sensitive to climate and weather conditions. Changes in rainfall patterns are expected to exacerbate current rainfall deficits in dry regions and increase rainfall in currently humid regions, leading to severe droughts on the one hand and more intensive flooding on the other. Water-saving rice production systems, such as intermittent irrigation, can drastically cut down the unproductive water outflows and increase Water-Use Efficiency. Intermittent irrigation is a method of alternately irrigating and drying the field for several days.

The use of irrigation water for producing lowland rice on puddled paddy soils can potentially be reduced by lowering the depth of standing water and by allowing the soil surface to dry before the next application of irrigation water. Intermittent irrigation is the regulation of land conditions in dry and flooded conditions alternately. Such conditions are intended to:

- save irrigation water so that the area that can be irrigated becomes wider
- give the plant roots a chance to get air so they can grow deeper.
- prevent iron poisoning
- prevent the accumulation of organic acids and H_2S gases that inhibit root development
- activates beneficial micro-organisms to reduce lying down
- reduce the number of unproductive tillers (do not produce panicles and grain)
- uniform grain ripening and speed up harvest time
- facilitate the immersion of fertilizers into the soil (process layer)
- facilitate the control of gold snail pests, reduce the spread of brown leafhoppers and stem borers, and reduce damage to rice plants due to rats.

How to manage the water

1. Do the irrigation rotation technique in one growing season. Seedlings are planted in saturated soil conditions and the plots of rice fields are irrigated again after 3-4 days. Next water management set as follows:
   a) Perform water rotation at intervals of 3 days. The height of the puddle on the first day was irrigated about 3 cm, and for the next 2 days, there was no addition of water. The rice fields were irrigated again on the 4th day. This method of irrigation continues until the maximum tiller phase.
   b) Starting from the panicle formation phase to seed filling, the paddy fields are continuously flooded.
   c) About 10-15 days before the crops are harvested, the plots of rice fields are dried.

2. Perform irrigation based on the availability of water. Pay attention to the availability of water during the growing season. If the water source is not enough to guarantee for one season, then do rotating irrigation with a longer period up to an interval of 5 days.
3. Perform irrigation by considering the physical properties of the soil. In sandy soils that absorb water quickly, the irrigation cycle time should be shortened.

D. Alternate Wetting and Drying (AWD) Irrigation

International Rice Research Institute (IRRI) generated the technology of Alternate Wetting and Drying (AWD) irrigation system for rice. AWD is intermittent irrigation based on the water level in an installed field tube (perforated PVC tube/bamboo). Even without ponded water, rice roots can access the water in the subsurface soil, which remains saturated. This technology has been field tested and validated by rice farmers in the Philippines, Vietnam and Bangladesh, Myanmar, Indonesia and Lao PDR. AWD is mainstreamed in extension efforts by formal extension institutes and NGOs in a number of countries in Southeast Asia.

How to Implement AWD

- Alternate Wetting and Drying (AWD) can be started a few weeks (1-2) after transplanting, or with a 10 cm tall crop in direct seeding.
- Apply nitrogen fertilizer preferably on the dry soil just before flooding, local fertilizer recommendations for flooded rice can be used.
- When many weeds are present, AWD should be post-poned for 2-3 weeks to assist suppression of weeds by ponded water and to improve the efficacy of herbicide
- Irrigate and then allow the water depth to drop to 15 cm below the surface using a field water tube to monitor the water level depth
- Once the water level has dropped to 15 cm below the surface, re-flood the field to a depth of 5 cm above the surface and repeat
- From one week before to one week after flowering, ponded water should always be kept at 5 cm depth above soil level to avoid water stress which could result to potentially severe yield loss
- After flowering, during grain filling and ripening, the water level can drop to 15 cm below the surface before re-flooding
- In Safe AWD, water savings may be up to 15 to 25 percent with no yield penalty.

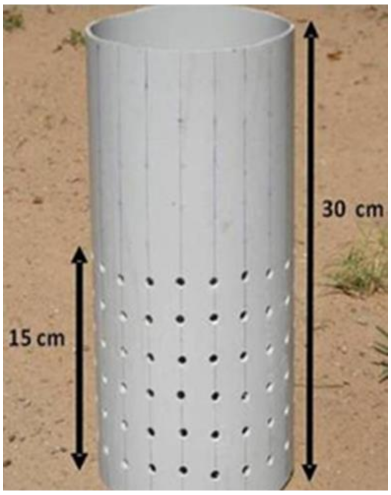

Figure 4. Perforated PVC tube

The field water tube (Perforated PVC tube)

- The field water tube can be made of 30 cm long plastic pipe or bamboo, and should have a diameter of 10−15 cm so that the water table is easily visible
- Perforate the tube with many holes on all sides, these holes should be about 0.5 cm each and 2 cm away from one another, so that water can flow readily in and out of the tube
- Place the tube in a readily accessible part of the field close to a bund (not less than 1 m away), so it is easy to monitor the ponded water depth
- Hammer the tube into the soil so that 15 cm protrudes above the soil surface
- Remove the soil from inside the tube so that the bottom of the tube is visible
- When the field is flooded, check that the water level inside the tube is the same as outside the tube
- If it is not the same after a few hours, the holes a probably blocked with compacted soil and the tube needs to be carefully re-installed
- The location should be representative of the average water depth in the field

Figure 5. Measuring the water level

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