

Agricultural Technology Dissemination Handbook
for the Initial Stages of Rice-Planting:
Rice Seed Treatment, Raising Seedlings in Nursery Trays, and Transplanting

American Friends Service Committee
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For over a decade, the American Friends Service Committee (hereinafter AFSC) has cooperated with four large cooperative farms in developing an agricultural technology dissemination program in North Korea. This program was based on several years of experience gained in farms and farming villages taking into special consideration the local conditions in North Korea. Within this program, “Technology Assistance for Rice Sowing” is an important component that may contribute to increased production of rice, while also providing solutions to the limitations on agricultural investment and labor force.

According to a 2008 study, most of the farms that have adopted the methods proposed under this project have reported increases of 0.5 to 1.0 ton per hectare in their rice harvest. Considering that this project is still in its initial stage of implementation, further increases in rice production can be expected with further improvements that incorporate adaptations to the unique situations of each farm.

Sustainable agricultural development must accommodate the natural, economic and social circumstances of the target region, so the new methods of production and agricultural technology will encourage relevant farmers to be more creative in enhancing their productivity. This *Agricultural Technology Dissemination Handbook for the Initial Stages of Rice Planting* is intended not only to help farms increase their rice production, but also to help them address shortages of labor force and investment during the cultivation season.

I. Rice Seed Treatment

Rice seed, after going through a dormant period at low temperature during the winter, needs to go through a series of treatments in the spring before being planted in order to achieve better germination, more uniformity of seeds, and less susceptibility to disease. Scientific and careful seed treatment is an important aspect of increasing rice productivity. Rice seed treatment before planting includes sun bathing of the seed, sorting, disinfecting, seed dipping, and germination stimulation.

A. Sun Bathing of the Seed

Sun bathing of the seed (exposure of the seed to sunlight) should be done at least one or two days before seed dipping. Seeds should be spread apart and turned over frequently but carefully. Sun bathing has a number of merits:

- First, the germination rate is increased with higher transparency of seed skin from increased oxygen; this turns the grain’s starch into soluble sugar, and promotes enzyme activity from the higher temperature;

- Second, more even distribution of water contained within the seed causes more even germination to occur;
- Third, reduction in anti-germination substances results in better germination rate and speed ;
- Fourth, ultraviolet rays kill germs attached to the skin of seeds; and
- Fifth, sun bathing of the seeds eliminates harmful gases such as CO₂ produced through respiration during the containment period.

As a rule, seed-sunning is recommended for at least one or two days before sowing.

B. Seed Sorting

The size of seed is highly correlated to the growth of young plants. The sprouts and roots of unhealthy seeds do not develop well and die easily, even from minor changes in temperature and conditions. One needs to select large and solid seeds, endowed with sufficient carbohydrates (energy) and nutrients for healthy plants. Eliminate spoiled (deformed, light or small) seeds and select only solid, robust ones. This will make the quality of seeds even and will result in more regular germination and healthier growth of plants. The sorting method recommended is as follows: first, sort the seeds using wind or screen in combination with sunning to eliminate any empty or small grains and foreign substances; and second, after placing the seeds in a bowl with clean water, shake them softly to remove any empty grains or foreign substances.

C. Seed Disinfecting

Diseases like rice blast, *Akmobyong*, *Xanthomonas*, canker, etc., are disseminated through seeds, so seed disinfecting is important. The ways for doing this are various as follow:

- **Seed-dipping in hot water**, which is effective to control canker. First, soak seeds in clean water for 24 hours. Second, maintain the water temperature at 45-47°C for 5 minutes and then at 50-52°C for 10 minutes, which will kill eelworms. Dip the seeds in cold water before the promoting germination. Pathogenic organisms causing rice blast and *Akmobyong* can be killed this way. Then, coat the seeds by application of seed-coating substances such as agrochemicals, fertilizers, hormones, etc. Various kinds of seed coating can prevent damage from diseases like rice blast, *Akmobyong* and canker, as well as from vermin, birds and rats.
- **Seed dipping in limewater**: Dipping seeds in 1% limewater is another method recommended. Don't break the lime film on the water, and let the water be 3 cm above the seeds. This is effective to prevent damages from various kinds of blight.

D. Seed Soaking

Seed soaking enables the seeds to absorb water fully, to become enlarged (swollen) and to generate physiological activity and respiration, which brings seeds to the stage where their solid protoplasm is turned into semi-solid condition. With activated enzymes, the albumen storage component is changed into a soluble component, and at the same time, the concentration of substances inhibiting germination in the seed is

decreased, and soluble components can be brought to the sprout and roots, making them grow. Seeds can germinate when water has been absorbed up to 25% of their weight. However, germination is better if the absorbed water reaches 40% of seed weight. Seeds which did not get enough water absorbed during the seed-disinfecting process should be soaked some more in clean water. Well-soaked seeds are dark and translucent and look inflated; they can easily be damaged with rubbing. Usually, soaking for 20-30 hours is appropriate.

E. Sprouting

Germination requires enough moisture, proper temperature, and oxygen to elicit the start of growth processes. For sprouting, moisture should be fully absorbed into the seeds along with the processes of seed-sorting and seed -disinfecting. Even if there are many ways for inducing sprouting, there is something in common for achieving sprouting quickly, evenly and healthily. To meet these requirements, 3 steps recommended for promoting sprouting -- bursting out at high temperature, sprouting at proper temperature, and then adapting to normal temperature -- must be fulfilled. Note that damage from rice bugs can be prevented and crop productivity may be increased with good seed treatment.

- 1. Bursting out at high temperature:** Seed whitening (exposing the white part) is achieved by a series of physiological changes in accordance with enzyme activity. Enzyme activity is highly correlated with temperature changes. Within a certain range of temperature, the higher temperature brings faster seed whitening by strengthening enzyme activity and dissolution of the nutrient components contained in the albumen quickly. Maintaining proper high temperature is, therefore, important at this initial stage. Usually, a temperature of 35-38°C (no more than 40°C) is adequate. Seed whitening during sprouting is rare only with low caloric value resulting from weak respiration in the early spring with low temperatures. Temperature should in that case be raised artificially. Wash seeds in a bamboo basket in water at 45-50°C for 2-3 minutes (considering weather, maintain seed temperature at no more than 40°C by controlling the water temperature and the washing time for seeds). After taking out the seeds, cover them with disinfected rice straw on vinyl film and put them in a closed room (if there is only a small amount of seeds, it is more convenient to put them in a gunny bag). Bursting starts usually within 12 hours.
- 2. Sprouting at proper temperature:** When the whitening stage reaches 90%, the seeds must be turned over, and temperature should be lowered to 28-32°C. If the temperature is too high, seeds can become scalded, or their nutrients may be exhausted. According to the rule of “dry root, moist sprout,” turn the seeds over every day, and sprinkle water on them 2-3 times a day to lower the temperature. Especially at the late sprouting stage, germination growth becomes faster in high temperature, and corresponding to this, more noxious materials are released. Therefore, special attention is required during shaking and sprinkling to lower the temperature and prevent damage. For even and healthy growth of the young plants, good developmental conditions for sprouts and roots should be guaranteed.

3. Adapting to normal temperature:

When the length of roots becomes 1-2 times the size of the seed, and when the sprouts grow to about half the size of the seed, the temperature of the seed should be lowered by spreading the seeds apart and allowing them to adapt to the normal temperature. During the cold and moist season which is not appropriate for sowing, spread seeds by 3 inches on a bamboo bed in a well-ventilated room, and turn them over frequently, sprinkling water on the seeds to prevent them from drying. Maintaining temperature around 14-16°C can keep the seeds from decaying for several days. When the weather improves, sow at an appropriate time.

II. Raising Seedlings in Nursery Trays

The strategy of growing rice seedlings in indented, soft vinyl sheets was developed from a combination of dry-bed and watered-bed techniques. Growing rice is now conducted by using sowing machines or sowing a mixture of seeds and soil in artificial halls (greenhouses). Not only the rice bed area and the expense for rice growing can be reduced this way, but also there is the advantage of easier management of young rice plants in good condition and with fewer diseases.

Young rice seedlings grown this way can be either planted by hand and by 'throwing' plants, a way of planting rice by tossing young seedlings taken from vinyl sheets into prepared fields. (This is called 'parachute' planting in some places.) Rice seedlings grown in indentations (pockets, wells, holes) in vinyl sheets can easily stand up with the soil stuck around the roots, as is appropriate for the throwing-plant method.

AFSC has adapted the technique of growing young rice plants in vinyl sheets to DPRK. The result is to reduce labor requirements, from using 200-250 *pyoung* of nursery per hectare to 30-50 *pyoung* per hectare, while reducing the labor force needed by 5 or 6 person-days. [One *pyoung* = 3.3 m².] Also, fertilizer consumption is reduced by about 100 kg per hectare. The number of days for growing young seedlings is reduced by 20-25 days, and farmers can cut their use of insecticides and herbicides during this period. Thus there are numerous savings to be achieved.

More importantly, applying this rice seedbed technique is congenial the biological characteristics of rice seedling growth. By using this technique, rice production has been increased by 0.5-1.0 ton per hectare. It enables earlier transplanting of seedlings, at the 3-leaf stage (previously, at least 5-6 leaves were required for rice to be transplanted), and this also gives a positive effect for the future growth of the rice.

A. Preparation before Sowing

1. Prepare seed bed: Vinyl seedling sheets generally have 560 holes each. So considering the rate of transplanting as 80%, 300,000 plants are needed per hectare (the number varies depending on the farm). This means that 600-750 vinyl sheets are required per hectare with hybrid rice. In the case of cultivating regular rice, 450,000 plants are required per hectare, so 825-900 sheets are needed.

2. Seed requirement

In general, for every hectare one needs to prepare 15-18.75 kg for hybrid rice seed and 45-60 kg for regular rice seed. Sun bathing of the seed, soaking in water with chemical protectants, sprouting, and bursting should all be conducted before sowing.

3. Preparation of fertile soil

To prepare a good seed bed, first break up and screen a mixture of kitchen garden soil that has proper cohesion and good fertility, and mix this with fully decomposed acid soil compost. Rice may die with alkaline fertilizer like ammonium carbonate or kitchen soil that has been fertilized with plant ashes, so avoid fertilizing with these materials. Neutralized soil can be made by mixing 50 kg of soft soil with 130 g of chemical admixture and 0.5 kg of compound fertilizer (urea 50 g, potassium chloride 50 g, phosphorus fertilizer 200 g). 35 beds can be filled with this amount. Reservoir lime or ditch lime can be mixed with the proper amount of soft bacillus organic fertilizer, and young rice plant nutrients are also usable.

4. Prepare seedling beds

Farmers can choose either dry seed bed or wet seed bed. In general, using dry seed bed is better. Facing away from the wind and toward the sun will have more fertile and rich soil. Choose neutral or light acid soil. Break soil and mix compost with urea, chloride, and phosphorus fertilizer and enough water to make water paths from a ditch at every 1.5m.

B. Sowing

1. Sowing season

Late sowing usually takes place during 15th to 25th of March, and most typical varieties are sown at the end of March (this will depend on farm location). Beds should be watered enough, and soil should be spread and leveled with a push stick before sowing. Put vinyl sheets on a nursery bed. Two vinyl sheets per bed should be sufficient. Tapping the boards with a stick allows the soil to enter into the indented pocket/well/hole. Cover the corners of the rice bed with soft soil.

2. Sowing method

a. Hand sowing

First, add enough fertile soil to fill 2/3 of each hole on a vinyl sheet and put in seeds, 1-3 seeds for each hole for hybrids and in the case of regular rice, 3-5 seeds for each hole. Next, fill up the hole with soft soil and moisten it, adding young plant neutralizer and filling in enough soil to make it even. Or:

b. Sowing a mixture of seeds and soil

Sow a mixture of seeds and 1-1.5 kg of neutralized soil on the vinyl sheet. Make it even after sowing.

c. Sowing by sowing machine

Put seeds into the sowing machine and press slightly after pouring the rest aimed at the vinyl sheet. Fill with soft soil without young rice plant neutralizer added and even it out. There should not be any soil between holes for the roots to get tangled in.

d. Covering with plastic film

Spray water on the vinyl sheet after sowing. Don't flood with water. Cover the film over the sheets after making bamboo sticks holding it up into a bowed shape. Pull the four corners tightly.

C. Managing the Seedling Bed

1. Humidity

Don't spray water before the seeds sprout. You can spray after the soil turns white. After sprouting, maintain humidity of the bed soil by running water between the ditches of beds. However, water should not be higher than the bed so that roots will not get tangled.

2. Temperature

Maintain temperature not above 35°C after covering the film and maintain 25-30°C after sprouting. Be careful not to damage plants by high temperature on a clear day with no wind.

3. Fertilization

Fertilize at every stage: at 2 leaves, at 3-4 leaves, and 2-3 days before rice planting. After spraying with 1% urea or 1% KH_2PO_4 , wash the tray with clean water.

4. Uncovering plastic film over the nursery

Young rice seedling adaptation starts from the stage of 2 leaves. On the first day, uncover two corners of the plastic film over the vinyl sheets, and after 2-3 days uncover half of it. Cover up the sheets again if there is cold weather, and uncover again after the cold weather has passed.

III. Transplanting and Field Management

The technique of growing rice on soft vinyl sheets allows planting at the stage of 3-4 leaves (5-6 leaves were previously required for planting). Making the planting season earlier brings positive results, including larger ears (panicles) and increased grain density (weight) due to the longer vegetative period and the faster plant differentiation. Also there is a higher rate of grain filling and more disease resistance.

AFSC is planning to embark a wide range of *chohweoseok* grain-growing technique experiments in DPRK to confirm the increased effectiveness of cropping for different transplanting spacing, to ascertain what is optimum distance between plants, both within and between rows. This technique was widely applied at the area

of Heilongjiang province in China and has gotten good results. The basic distances to be evaluated are 33.3×20.0 cm, 36.3×20.0 cm, and (39.6+30.0) × 20.0 cm. Farms are showing high productivity with distance of 40×20.0 cm and 43.3×16.7 cm, with 2-3 plants at each hill. This technique improves airing and light effects on rice fields and individual plants. It can enhance marginal productivity by increasing the rate of grain-setting, grain-filling and ripening. It also strengthens the stems, preventing the plants' susceptibility to diseases, drought, storm damage, etc. and contributes to the goal of increasing rice production.

A. Rice Field Arrangements and Conditions

The aim of plowing is to provide more advantageous soil conditions for root establishment and growth in rice through various plowing field methods. Rice rooting proceeds quickly after plowing and planting, and nutrition components and moisture can be easily absorbed by the rice, which produces positive effects for the growing plant. Stems can also grow more healthily with pruning.

Rice fields should be arranged with enough base manure. Plowing and leveling a rice field in dry condition is better since aerobic conditions improve the physical and chemical nature of the soil and make it easier for nutrients to be taken up.

There are other ways to arrange rice fields without plowing or with less plowing, which decreases the energy consumption and the primary cost while maintaining good physical form of the soil. However, in the long term, it is believed that this method decreases the usage rate of the soil and invites more insects and weeds. Usually, deep plowing is conducted every other year. The cultivated layer should have soft and rich soil and should be even less than 3 cm in depth. Deep plowing under the depth of 20 cm is better.

B. Transplanting at an Appropriate Time

Transplanting at an appropriate time is directly related to the productivity of plants, the sustainability of cropping, and the quality of grains. The condition of young rice plants, stubble, and labor force should be considered for the decision on planting time. Having a single cropping area is advantageous for boosting grain production because if rice planting is conducted quickly at an appropriate time, the field will give more grain production because the field will be preoccupied with rice plants. If you plant before the beginning of summer (with low temperatures at night/high temperatures during the day), the lower parts of stems are stimulated by the low temperature, and pruning time gets delayed, which increases the number of fruits, water accumulation in grain, and the length of the vegetative period.

Bigger size of the rice panicle and increased quantity of grains results not only in a higher fruiting rate and resistance against disease, but also helps to keep the plants from lodging (collapsing). However, for early planting, certain basic conditions must be met, especially the minimum temperature for rice to remain alive is about 12.5°C. The minimum growth temperature for non-glutinous rice plants is 12°C while for jasmine rice it is 14°C. Rice growth is extremely slow below 15°C. Proper planting time should be determined based on minimum temperature for rice survival.

C. Transplanting and Conditions

1. **Hand planting:** From actual experience of planting, it has been proven that hand planting of small young rice plants can delay the pruning time, which can decrease the area of the rice bed with a larger quantity of sowing. This has the following advantages : 1) the size of the rice bed is reduced; 2) plants can more aggressively cope with the change of seasons; 3) this can prune the lower height of a rice paddy; and 4) panicle rate is increased. If you plant rice shallow (1-2 cm), this creates positive conditions for the growth of the plants, making it easier for the nutrients to be fully absorbed, and at a higher temperature; also you can prune from the bottom of the stems.

Hand planting should put the seedlings into the soil at 1.5-2.0 cm depth. The depth can be tested by seeing whether the first leaf can float on the surface of liquid mud. Line spaces should be rather broad to improve the conditions for ventilation, for sunning to increase the amount of light during the ear-ripening period, and to decrease vermin generation. The recommended space for a fertile and productive rice paddy is 28-30 cm×11.5-13 cm (space between rows × space between plants), while for less productive and negative paddy conditions, 23 x 11. 6 cm should be used. In less productive soil, more plants are needed to increase yield; conversely, more productive soil gives higher yield if there are fewer plants. For other paddies, anything between these spacings is recommended. Planting with row spacing less than 20 cm, and plant spacing less than 14 cm, should be phased out gradually.

2. Throwing plants: A way to plant young rice seedlings

This increases elasticity and is advantageous for commercial and specialized production. Dry-grown young rice seedlings raised in vinyl sheets are the best. Before planting, the rice paddy soil must be made thick and muddy by shallow watering and harrowing. It helps roots to set fast in soil, which is important for the survival of young rice.

To guarantee the uniformity of the thrown-plants: 1) The process of raising throwing plants should go through these three steps: 60-70% of young rice is thrown at the first step, 20-30% is thrown at the second step, and 10% is thrown on the corner and side. (2) After throwing the plants, 30 cm wide channels must be made every 2-3 m in the case of dead and damaged rice. Throwing plants at a 2-3 m width is recommended for an average production rice paddy, and 3 m for a larger area paddy.

Because young rice plants thrown this way can be pruned sooner than hand-planted rice and will survive longer than planted rice, the number of young rice seedlings used at the first rice planting is decreased by 20% compared to

those of hand-planting. This helps to form ideal colonies and allows for pruning at the bottom of the stems, which increases the rate of ripening and the amount of cropped grain.

The rule of thumb to confirm the amount of young rice seedlings to use at the first rice planting is “the number of sheets for the needed quantity of young rice and the number of young rice seedlings by the target quantity of production.” For example, if 9 tons per hectare yield is the target quantity, throwing plants might be carried out with 300,000 young rice plants per hectare (assuming that the quality of young rice plants is good), considering that the breed of panicle and grain is important. If the number of young rice plants grown on a sheet is more than 1,000, then 300 sheets per hectare can be expected. Water should be removed at appropriate times in order to prevent the young rice from floating in puddles after rain and wind.

Considerations of water management for rice production, techniques for cropping rice, and test management will be introduced in subsequent manuals.