Surface Irrigation Increases Paddy Field Rice Yield in Clayey Soil

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In a clayey paddy field soil it is very difficult to increase rice production because soil is not suitable for rice plants under flooding condition. The author has been engaged in this subject since 1963 and solved this problem by experimenting with the surface irrigation system in a paddy field with his associates, including Y. Hashimoto. (1968).

This method is described here from agronomical and soil scientific viewpoints. For this purpose, priority should be given to improving the soil condition rather than adopting higher yielding varieties. Also it is important to improve cultivation methods.

Soil improvement not only insures a higher yield but also facilitates introduction of farm machinery. Moreover productivity can be increased by using paddy and upland fields in rotation.

Land improvement work such as underdrainage is often carried out to drain the paddy field and to improve the soil but drainage is not so effective in clayey paddy field soil because generally permeability of such soil is very poor.

Surface irrigation method in paddy field

The surface irrigation method in a paddy field is different from that employed in upland field. Excessive amount of irrigation water will aggravate the soil condition especially soil trafficability, but shortage of water will stunt the growth of rice plants. Therefore supply of moderate quantity of irrigation water periodically is very important in clayey paddy field. This method can increase the yield and does not affect the quantity of produced grains, uniformity of grains, volume weight and quality compared with rice grown in ordinary flooding fields.

The following experiments in surface irrigation were carried out on clayey paddy field in Kameda, Niigata Prefecture.

Condition of paddy field

This method is suitable for a well drained paddy field with underdrainage in general. If the field is flooded for a long time, especially during the later half of the growth period, the decomposition of organic matters in well oxidized soil will accelerate so rapidly that the roots of rice plants will decay.

Variety

Medium to heavy panicles-type varieties seemed to be suitable for this method. The condition at the beginning is the same as the non-flooding direct sowing system so common varieties suitable for such method are recommendable. But close attention should be focused to the heading date of varieties because it comes later than in ordinary cultivation. Generally, a superior variety resistant to disease and lodging is preferable.

Land preparation and seeding

Precautionary steps are essential in using a harrow for direct sowing in a well drained paddy field and the surface soil blocks should be very fine. If the land surface is coarse, it is expedient to increase the quantity of seeds for seeding than in the case of fine surface. The quantity of seeds for seeding is about 0.4 to 0.45 kg per are as the standard on fine surface. The seeds are drilled about 3 cm in depth, covered with soil and then pressed by a roller and others.

Spacing

The number of plants per square meter should be 100 to 120 by drill and the distance between rows, 30 to 35 cm. When there are not enough plants, dosage of fertilizer application, especially for nitrogen, should be increased together with the quantity of irrigated water.

Fertilizer application

Nitrogen gives the strongest influence to the growth and yield of rice plants. Due to the oxidized conditions of soil and intermittent irrigation, leaching of nitrogen can be expected anytime so the application of nitrogen should be made in installments. Application of phosphoric acid is more effective compared with the flooding irrigation method. These facts are observed by the author in the Kameda district, but these may vary according to location and soil. Consumption of organic materials in the soil becomes very rapid.

Irrigation

The irrigation method is the main point of this experiment, and it influences the growth of rice plants and soil conditions. For soil improvement it is wise to save as much irrigation water as possible, but in order to ensure a practical higher yield of rice, irrigation water is necessary to a certain extent. For the time being, the index during the irrigation period is set to cover the surfaces with shallow irrigation water whenever the ground-water table is lowered to 30 to 50 cm. Thus irrigation water is unnecessary during a rainy season. When plant growth is vigorous under a high temperature with a great deal of sunshine, the paddy field is completely irrigated. At a farm in which no puddling is carried out and managed in upland condition, it takes a long time to irrigate a whole plot of only 20 acres. In such a case it is advantageous to construct weirs at several places in the ditch drain and raise the ground-water table of the field as well as the surrounding areas by adjusting the water level of the ditch drain.

Weeding

DCPA (3, 4-dichloro-propionanillide)-CH CH emulsion is used in weeding. Immediately after sowing, NIP (2, 4-dichloro-phenyl-4-nitrophenyl-ethyl) emulsion is sprayed by 25 gr component per are. Then at each of the four leaves and seven leaves periods DCPA is sprayed by 30 gr component per are. Paddy field weeds, particularly barnyard grass, can be eradicated.

Insect and disease control

To control sparrow and mole cricket damages, seeds for sowing are mixed with EPN (o-ethyl-o-(p-nitrophenyl) phenylphonothioate) powder and red material such as minium. For the control of rice stem borer and blast, the methods are the same as in normal cultivation.

Some of the changes in soil under the surface irrigation method are hereinunder outlined.

Various changes in ground water table soil by the surface irrigation system in a paddy field are described item by item as follows:

1) Ground water table

A feature of this method is that it has lower ground water table than that of the ordinary flooding method. After rainfall or irrigation, even the ground water table reaches to the surface and it rapidly goes down to 30 to 50 cm from the surface then becomes lower slowly. For improvement of the soil, drainage of ground water is very important and for this purpose ditch drain and underdrain are effective. And adoption of the surface irrigation system can accelerate the effect.

2) Moisture content of soil

With the surface irrigation method, large pore spaces increase indicating an increase of the differences between the maximum water holding and field capacities. In Kameda, the difference between the maximum water holding capacity to field capacity is about 30 per cent in the first year. After adoption of the surface irrigation system, decrease of moisture content of soil can be observed.

3) Oxidation-reduction potential of soil

The oxidation-reduction potential of soil is constantly higher in comparison with the flooding irrigation system.

4) Structure of soil profile

A paddy field which had been planted with rice for a long duration under flooding condition was examined under the surface irrigation method. The soil profile prior to the planting showed a typical reduction condition. Iron concretions can be found only in the upper two soil layers but α, α' dipyridyl color reaction is extremely strong at the lower part of the two layers and the reaction can be vividly observed even at the upper part.

But after the harvesting period under the surface irrigation system, iron concretions are found even in the lower layer in comparison prior to the planting. As the years pass by, some times iron concretions cannot be recognized in the first layer and this is attributed to the approach of the first layer toward upland conditions. As for the change in soil structure, cracks develop in the lower layer with the development of aggregated structure in the cultivating soil layer.

5) Three phases of soil

The changes in the three phases capacity ratio observed during planting period are mainly the changes in ratio between the liquid and vapor phases. The investigation of soil after harvest by soil depth reveals a distinct difference existing between this cultivation and the flooding cultivation methods, and in the surface irrigation system the water-holding capacity of surface soil declines and the air-holding capacity increases throughout the whole layers.

6) Physico-chemical changes in soil

Physico-chemical changes in soil are examined before and after the adoption of the surface irrigation method in Kameda. These are as follows:

(1) Maximum water-holding capacity: After the second year it begins to decrease in both the first and second layers but it is not clear in the first year.

(2) Sedimentation volume: In general, the sedimentation volume of wet soil is larger than those of dry soil and those volume changes indicate hysteresis of soil drying. According to the relative ratio between A/F (dry soil/wet soil), an increasing trend is observed in both the first and second layers during before and after planting by the surface irrigation method in a paddy field. The above fact shows the reformation in a well-drained paddy field.

(3) Total carbon (TC) and total nitrogen (TN): No remarkable change was observed in the TC and TN.

(4) Substitutional salts: In the first year during the seeding to harvesting period, increase of alkali saturation is observed by the augmentation of substitutional salts such as MgO, CaO, etc.

(5) Ammonium formation: At 30°C it is increased in wet soil but it is decreased in an air dried soil in the first layer. Tendencies in the second layer are almost the same and the

temperature-rising effect, drying effect, and decompositional organic materials are decreased. Physicochemical changes in the soil before and after planting are similiar to those in the first or second years in a rotated upland field from paddy field.

Soil hardness

At the time of ploughing in spring, increase of soil hardness of the soil by the surface irrigation method could be observed. This tendency continued during adoption of the surface irrigation method. Influences of the quantity of irrigation water could be observed only in the surface down to 15 cm in depth.

Conclusion

As stated already, surface irrigation improves vastly the soil conditions and can possibly give better yield compared with the flooding irrigation method in a clayey paddy field. A rotation between the flooding irrigation and surface irrigation methods is recommended because this rotation is beneficial for the maintenance of soil fertility and control of weed, pests and diseases in the fields.

Moreover, the surface irrigation method on clayey soil can introduce large machinery in a paddy field. These operations will deepen the depth of the soil layer useful for rice plant, thus, increasing the productivity of the land.

Reference

1) Hashimoto, Y. et al.: Studies on the cultivating method of rice plant by surface irrigation. I. Changes in underground water level and soil caused from the cultivation by surface irrigation. *J. Niigata Agr. Exp. Sta.*, **18**, 49–60 (1968). [In Japanese with English summary.]