Rice Cultivation by Using Big Powered Machine

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Development of an agricultural method with high labor productivity is urgently needed in the face of the rapid progress made in the industry recently and the increasing exodus of the working population from agricultural districts.

Rice in Japan has been mainly cultivated by the transplanting method which requires a great deal of labor in transplanting, weeding and harvesting.

As a measure to mechanize the transplanting method, small powered rice transplanters, binders and head-feed combines have been developed to the stage of practical application and weeding labor has been greatly saved by using weeding disinfectants. But there is a limitation of lessening labor by the transplanting method.

Consequently in order to promote a further increase of the labor productivity, it is necessary to introduce a direct sowing method by using big powered machines.

Since 1963 a large scale rice field of 25 ha was developed and cropping mechanization by the direct sowing method in submerged conditions was studied at the Tohoku Agricultural Experiment Station considering rice cultivation by using big powered machines—a mixed management with dairy farming. The field developed on a trial basis is located in a cold northern district with an annual average temperature of 10.1°C.

Development of paddy field

Paddy field developed consisted of loamy volcanic soil and pasture land with a slope of about 1/100 on the south side. The block of paddy field has taken a long trapezoid-shape almost along with the contour line (Fig. 1),

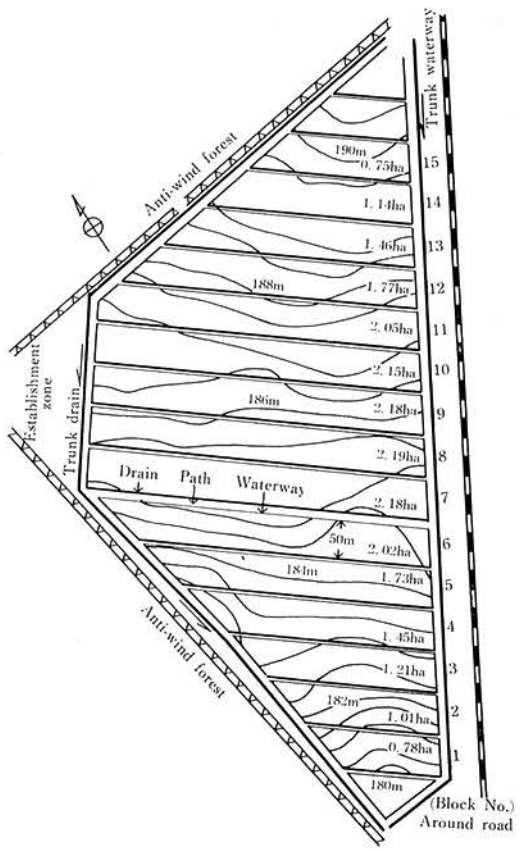

Fig. 1. Sketch of developed paddy field (Curved lines indicate similar sea level)

where the width is 50 m and the length is the maximum value which could be taken on the acreage As a result, the maximum block is 2.2 ha. Small waterway, drain and path have been laid out along the length, and trunk

waterway, drain and road were laid out around the fields.

Special reclamation was applied to the development method to control excessive percolation. Consequently, as the percolation on the field became so small (10 mm/day) that it interfered with the field operation, the construction of underdrain was carried out. The levelling accuracy of field was within ±5 cm, but it was necessary to re-level it, since stagnant water in depressions interfered with the work and checked the rice standing.

Fig. 2. Puddling with cage wheels and cage rotor

Land preparation and sowing

For land preparation and sowing, a 35-ps wheel tractor and equipment were used.

Many equipment such as a 3-12″ reversible bottom plow and a 1.7-m rotary tiller with curved blades were tested for plowing.

It was proved that homemade rotary tiller is the most favorable equipment for 1st land preparation, because its operating efficiency on soft ground is good, its furrow slice is small and there is little movement of soil which facilitates puddling. But, satisfactory accuracy could not have been obtained by general imported tractors, whose minimum speed is high and thickness of cut is large, and it was substantiated that they are unsuitable to plow hard paddy soil due to the bad blade shape of the rotary tiller.

Using plow on paddy field involved many problems. Its burying ability of crop residue is good, but its operating efficiency on soft ground is low attributed to the dependence on the traction power of tractor; its working depth is too deep for rice cultivation; harrowing becomes difficult because of large furrow slice; and it requires much labor for levelling the moving soil. In order to solve these problems, the 3-12″ reversible bottom plow equipped with wheel girdle was employed, but the operating efficiency is inferior to that of a rotary tiller.

It was ascertained that plowing in autumn, which is favorable to promote corrosion of crop residue and to distribute the operation in spring, is not an effective operating method, since the autumn temperature is so low and the ground condition is so bad that the field efficiency and the accuracy of operation become low, and rough top soil absorbs much water of melted snow, which defers operating time in spring and thus requires replowing.

The harrowing by disc harrow before submerging could not be stable in a short operating period in spring, for the field must be sufficiently dried for the operation.

Fertilization was achieved by broadcaster using small granular fertilizer.

Fertilizing with high accuracy could have been performed when one trip width is 5 m, though its application width is about 10 m. When the ground is soft, the wheel girdle is equipped with the tractor for fluctuation is caused by slippage. After plowing, constant running could not have been obtained.

The highest field efficiency and operating accuracy is required for puddling. A tractor equipped with wheel girdle or cage wheel, tractional tooth type paddy harrow and wheel-type paddy harrow, PTO-driven rotary tiller with curved blades and those with cage rotary, etc. were used for puddling.

Tooth-type paddy harrow has a good levelling effect but has a tendency to rake out crop residue, while the wheel-type has a good burying effect of residue but bad levelling. Pulverizing effect was not satisfactory in

both cases. PTO driven-type puddling equipment has good pulverizing effect and curved blades-type rotary tiller is effective when furrow slice of plowing was large and the cage rotor type is suitable to surface pulverizing when furrow slice was small. It has been ascertained to be desirable that all three equipment are equipped with planker to burying of residue since they are apt to rake out residue. Puddling could be entirely finished only in one time work by cage rotor type, after tilling with a curved blades-type rotary tiller.

Sowing has been accomplished by using the same broad caster with that of fertilizing by attaching the girdle to the rubber tire of tractor or changing the tire into steel wheel in narrow width.

In the operation with girdle, standing rice is bad, since the width of wheel is broad and seed rice in the part of wheel is buried even if the field is under drained condition. As there is little stirring of mud caused by running of steel wheel in narrow width, there is little burying of seed rice even if sowing is achieved under submerged condition. But the effort to run the tractor straight accompanies mental strain for the ripple of submergence dazzles the operator.

Fig. 3. Broadcasting of seed with narrow steel wheels

The total operating time from plowing to sowing is about 7 hours per ha. As the available term in operating period in spring on the field developed on a trial basis has been 20.6 days, the area possible of the operation in the period was about 28 ha, and the operation was undertaken by four persons.

Operation for controlling diseases, insects and weeds

Major damage on the field tested were seed and seedling rot, barnyard grass, smaller rice leaf miner and wild ducks.

Seed and seedling rot often breaks out because of low temperature during the sowing period, for which quantity of sowing was increased and coating of Captan wettable powder was applied, since there is no perfect protecting method.

Spraying of DCPA emulsion was effected in drained condition to control barnyard grass, but still there were many problems: it is ineffective on rainy day, and the growth of rice is retarded by draining. Then it was replaced by spreading of Molinate granular and Benthiocarb•Symetryne granular in submerged condition, but the control effect has not been completed and weed damage cannot be ignored.

Smaller rice leaf miner occurs in the deep part of the depth submergence for which control by EPN dust has been accomplished. The damage was greatly decreased with an increase in levelling accuracy on the field and there was no need of control.

Damage by wild ducks, threatened by hunters, occurs after sowing and in maturing time of rice, and also the threat by light and sound is being examined.

Perennial weeds which are difficult to control by weeding disinfectants often enter in the field—carried by water for irrigation, settle at the inlet, and spread and reproduce in the field by plowing and puddling operations. Consequently it is necessary to control them by scrutinizing waterway and inlet of the field.

Pesticide for control is sprayed from path or terrace ridge using a tractor-tracted sprayer or duster with high efficiency. As operating accuracy of these equipment are greatly in-

fluenced by wind, it is important to spray pesticides on windless days or from the windward side to increase the accuracy and protect the body of operator.

Harvesting

Harvesting of rice was effected by four persons (two for harvesting, one for transportation and one for drying) using a three-meter rice type combine.

Head feed combine, developed in this country, shows an excellent performance with the good composition of unhulled rice grains and small loss of grains in the harvesting of Japanese rice which is difficult for threshing. But it is not suitable for the performance in the experimental fields, because its ability is too low in scale and not suitable for broadcasting and lodging plant.

Fig. 4. Storage bin type drying shed in Tohoku National Agricultural Experiment Station

Field efficiency of harvesting by combine has been 8 to 14 a. an hour per meter of cutting width, and the grain loss 4 to 9 per cent. In order to harvest by combine with high efficiency, it is necessary that rice does not lodge and mellows fully enough to possess low moisture content of rough rice.

But as the rice on the field tested is sowed directly in submerged condition, its stubble is not buried in the soil and its culm is slender, so it is apt to be lodging. Moreover, the combine can hardly work at its full ability for lack of simultaneity of heading and ripening owing to the irregular stand of rice plants. And uneven moisture contents of rice grains suffered from cold damage is also one of the causes which decrease the working efficiency of the combine. Sometimes the harvesting of lodged rice has been impossible because of bad ground of the field.

Storage bin type drying shed has been built to dry rough rice in order to dispose of without hindrance the rough rice of bad composition, and a pneumatic conveyor is used to convey it.

The pneumatic conveyor requires greater driving force compared with other conveyors, but it could convey rough rice with high moisture contents without cleaning rough admixtures such as straw, and it has been proved that it is effective especially when rough rice is discharged from storage bin.

Major grain dryer used in this country is the heated air dryer, but in the case of rough rice harvested by combine, some one is always required to operate it, since some troubles of the conveyor, etc. occur often even if it is passed through a paddy cleaner. An observer is not always required in the case of the storage bin-type dryer, which dries by means of unheated air as a rule, and rough rice does not move, though drying speed is low.

Moreover, it has many labor-saving merits such as rice could be stored as it is after drying, and rice will be hulled at the end of harvesting time. There is high possibility of change in quality of rice in the case of this type of drying equipment for it requires considerable time for drying of the rice harvested combine. Consequently care must be taken of temperature, moisture and quantity of forced air. But as temperature in harvesting time at this experimental district is below 15°C, it could have been dried without any trouble by layer drying with forced air of 0.015 m^3/sec•100 kg. The temperatures raised about 5°C by sub-burner only on rainy days in order to attain low humidity.