Row-and Dot-Application Equipment for Granular Materials Mounted on Rice Transplanter

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Although the application of insecticides and fertilizers immediately after rice transplanting in paddy fields exerts a direct effect on growth and yield of rice, it sometimes requires much farm-labour. The combined machine recently developed in the Institute of Agricultural Machinery[2] is a granule-applying equipment mounted on the rice transplanter. Since two operations, i.e., rice transplanting and granule-application, can be done simply as one work its labour-saving effect is highly evaluated in rice cultivation. The granules loaded on the machine are applied to paddy soil at the vicinity of rice seedlings and at a certain depth from soil surface, either as row- or dot-application. Another advantage of this machine is that it can save the quantity of granules to be used, because less amount is enough for the row- or dot-application than for the over-all application. Granular materials have a tendency that their ingredient acts slowly, so that their effectiveness lasts longer than that of the liquid application. Performance of this combined machine was examined at agricultural experiment stations by using granular materials such as CARTAP, 1.3-bis (carbamylthio)-2-(N,N-dimethylamino) propane hydrochloride, and compound fertilizers (nitrogen + phosphorus + potassium) since 1976.

Construction of the combined machine

The combined machine developed as the No. 1 model consists of a granule-hopper, a regulator, two leading pipes, and two applying shoes as shown in Plate 1, and is used for the row-application along the planted rice. The volume and the setting position of the hopper on the planter are well prepared to keep the stability of the planter when it runs on muddy fields, and replenishment of granules to the hopper is done simultaneously with that of rice seedlings to the planter. The regulator which adjusts the granule discharge is a rotary cylinder with many concaves at its surface, located at the bottom of hopper, and the discharge rate can be adjusted by exchanging the cylinder with concaves. As the rotation of cylinder coincides with the motion of planting nail, the accuracy of application rate is practically sufficient. The granules flow down smoothly to the applying shoes through the leading pipe after passing the regulator. The applying shoe consists of a set of two wings for dividing muddy soil, a steel bar under the shoe, and a cover of leading pipe is illustrated in Fig. 1. In the fields where surface water was drained, the granules are dropped down into furrows made by the wings on the field surface. The steel bar fixed to the top of applying shoes and curved towards the bottom of shoes as shown in Fig. 2 removes the rotted stubbles or straws which sticked to the body of shoes, so that the accuracy of site of application is sufficiently high in paddy fields after puddling. As the cover at the end of leading pipe protects the end of the pipe from splashed muddy water, the end of the pipe is

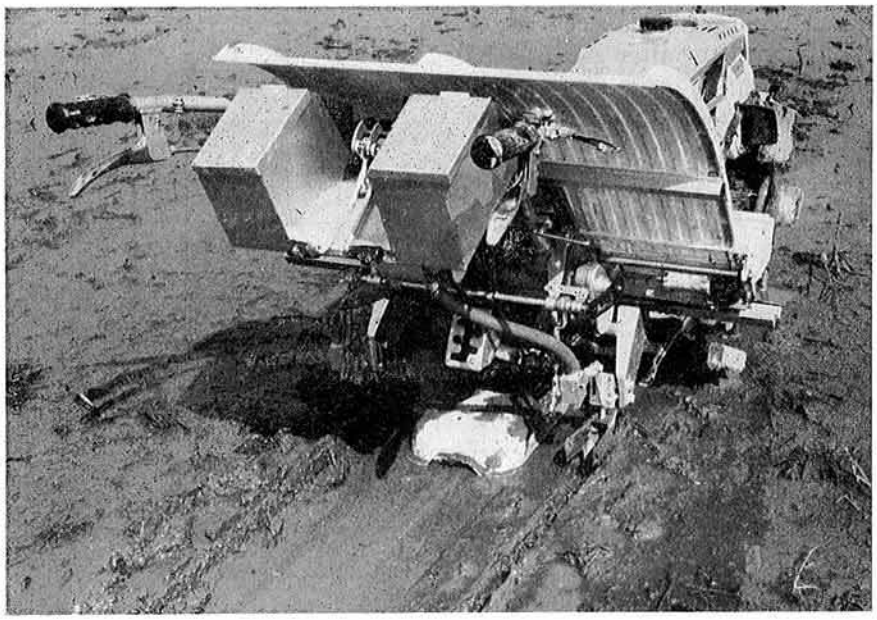

Plate 1. Granule-application equipment mounted on rice transplanter

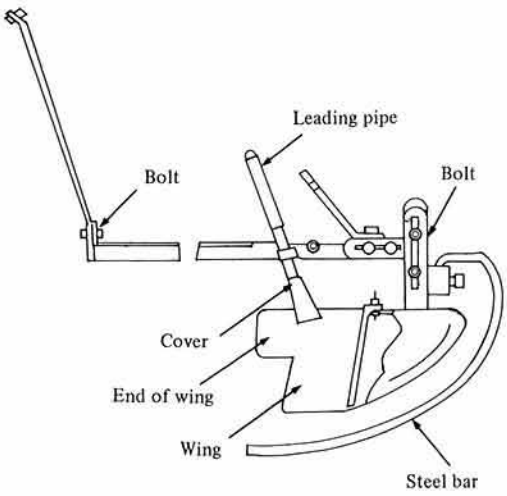

Fig. 1. Construction of applying shoe

always kept clean without any clogging by paddy soil.

The No. 2 model was designed for dot application, applying the granules at the same intervals as planted seedlings. A device newly added is a rotary shutter, set on the end of leading pipe. Fig. 2 shows construction of the assembling. Swing action of the shutter

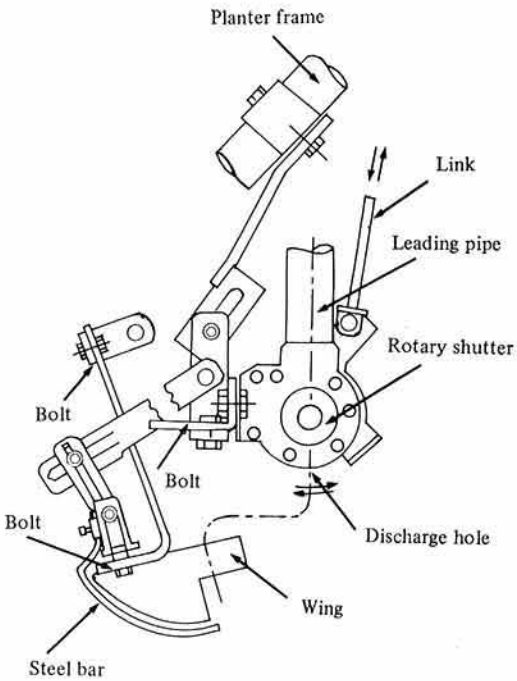

Fig. 2. Construction of rotary shutter

exactly gives an intermittent discharge of granules. Driving of the shutter corresponds to the motion of planting nail, so that the spacing of granule application is nearly the same as the intrarow spacing of planted seedlings. The end of leading pipe is directly connected to the clutch of planter. When the planter turns at the end of paddy field, the clutch is released by hand, and immediately the end of leading pipe lifts up to avoid muddy water-splash.

Results of performance tests

The performances of the combined machines were generally as follows: At the start of the study the following performances were anticipated:

a. Application rates per ha: 30–40 kg for granular insecticides, and 300–400 kg for granular fertilizers.

b. Site of applications: 2–3 cm apart from planted seedlings, and 2–3 cm in depth from the soil surface.

c. Rice planter to be used: 2-row, walking type rice transplanter.

d. Regulation of granule discharge rate: 50–80 g/min for insecticides and 500–800 g/min for fertilizers.

e. Travelling speed of planter: 0.4–0.6 m/s.

f. Time required for application: 8–10 hr/ha by 2-row type planter theoretically.

1) Application of granular insecticides

(1) Discharge rate and application rate

The granules used were rather fine with main range of diameter distribution of 0.8–1.3 mm. Their angle of repose was about 35 degrees, so that their fluidity from the hopper to the end of leading pipe was actually available, and the regular and constant discharge rate was continuously obtained. The discharge rate per planted seedling was 0.10–0.16 g with the dot application machine No. 2. The application rate per 0.1 ha is shown in Fig. 3 which gives the relation between intrarow spacing in cm and discharge rate in g/seedling, at the usual inter-row space of 30 cm.

With the dot-application, the granules have

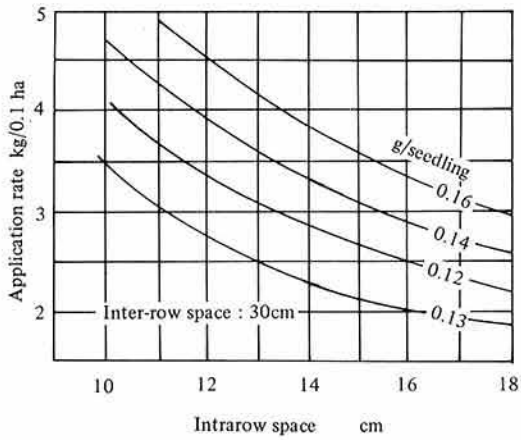

Fig. 3. Relation between intrarow space and application rate at different rates of discharge (g/seedling)

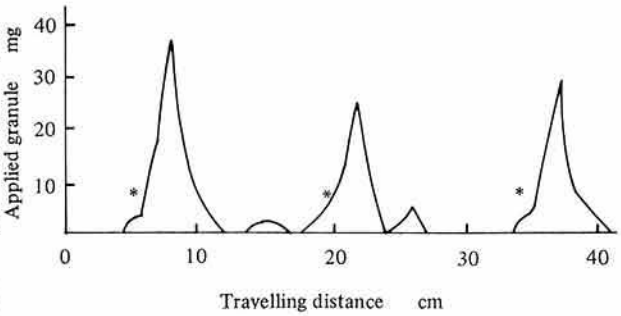

Fig. 4. Pattern of intermittent application of granular insecticide by dot-application machine
* : Site of rice seedlings planted

to be distributed concentratedly to the vicinity of each planted seedling. Fig. 4 shows the pattern of regularly spaced application of insecticide by the dot-application machine. The distribution was found almost satisfactory.

(2) Performance of application and pest control efficacy

A paddy field which was tilled at the depth of 15–20 cm by a rotary in the preceding autumn was harrowed by a rotary harrow in the spring, and well puddled by a rotary cage after irrigation. Then, the surface water was perfectly drained before the testing. When the seedlings used were about 13 cm in length, rate of missing hills was only 7.4% at the travelling speed of 0.6 m/s. Thus, the performance of the planter was clearly successful,

Table 1. Control of rice leaf beetle by dot application of CARTAP

Plot	Plant height (cm)	No. of stems examined	No. of eggs	No. of larvae	No. of pupae	Percent injured stems
Dot-application	36.8	25.1	13.7	13.0	2.0	7
No treatment	38.5	23.5	5.7	83.7	24.0	28

and the working capacity of 1.3 hr/0.1 ha at 14 cm of intrarow spacing was obtained. Although rate of insecticide application was anticipated to be 3 kg/0.1 ha, the actual rate was 2.54 kg/0.1 ha when the application was made at 3.5 cm (2.5–4.5 cm) deep and about 3 cm apart from seedlings. Thus, the application was also regarded to be successful.

CARTAP of granular formulation was used to know its effect on rice leaf beetle (*Oulema oryzae*). Sampling of insect eggs, larvae, and pupae was made at the time 30 days after the application, that is the most injurious time to the rice. The results are given in Table 1, which shows clearly the control effect of the dot-application of granular CARTAP (at 1% level of significance[2]). However, when much water remained on the field surface, less control effect was recognized, because ingredient of the insecticide drifting in the field-water was removed by the water and hence effective transition to the roots was hindered.

2) Application of granular fertilizer

The granular compound fertilizer has 2–4 mm of particle size, larger than insecticidal granules, and its application rate much higher than insecticides. Therefore, size and construction of the regulator, the leading pipe, and others were modified for the use of granular fertilizers.

(1) Discharge rate and application rate

The granular fertilizer showed a desirable fluidity from the bottom of hopper to the end of leading pipe, and hence regular and constant discharge rate because its angle of repose was than 33 degrees. When application rate, travelling speed, and inter-row space were set to 300 kg/ha, 0.5 m/s, and 30 cm respectively as the test condition for the combined machine No. 1, the measured discharge rate of fertilizer in the two-row application was 270 g/min. Fig. 5 shows the relation between the discharge rate in g/seedling and the application rate in kg/0.1 ha at two intrarow spaces. As mentioned above, the size of concaves on the rotating cylinder was previously adjusted to give the necessary discharge rate of the granular fertilizer. Distribution of the fertilizer along the row of seedlings was measured by using fodder seeds which have the property equivalent to granular fertilizer, because the distribution of the fertilizer in the soil can not easily be detected. Fig. 6 shows that the dot-application of fertilizer can be done successfully together with transplanting of seedlings.

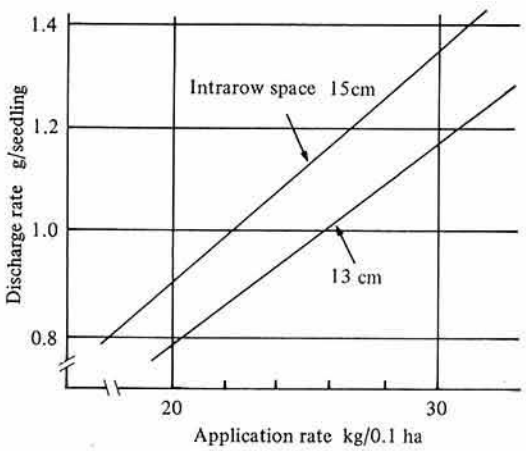

Fig. 5. Relation between discharge rate and application rate at two different intrarow spaces

(2) Results of field experiment

On the basis of the combined machine No. 1, trial-made machines to be used for the row-application of granular fertilizer was published by Yammer Agricultural Machinery Co. Ltd., Mitsubishi Agricultural Machinery Co.

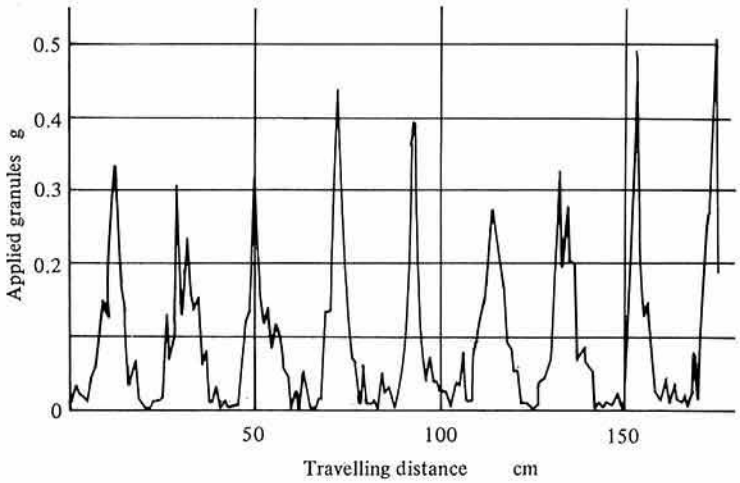

Fig. 6. Pattern of intermittent application of granular fertilizer (simulated by fodder seeds) by dot-application machine

Ltd., and Kubota Iron Works Co. Ltd. in 1979. Field tests were performed at the Saga Prefectural Agricultural Experiment Station and others in collaboration with the National Federation of Agricultural Co-operative Associations.[1] Granular compound fertilizer NPK 464 and others were used. The field was tilled in June of the preceding year and in the spring, and puddled after irrigation. At the time of planting water depth was 2 cm in an average and submerged sinkages of planter-wheel about 8 cm. Application rates of fertilizer granules were 31 kg/0.1 ha with the Yammer's machine and 33.3 kg/0.1 ha with the Mitsubishi's, corresponding to nitrogen of 2.48 and 2.66 kg/0.1 ha respectively. When the travelling speed of these machines was both measured as 0.5 m/s, the working capacity of planting and application was 87 min/0.1 ha with the Yammer's and 69 min/0.1 ha with the Mitsubishi's, and high rate of missing hills was not recognized for both machines.

Table 2 shows growth of seedlings 21 days after planting. The use of the machines gave better growth of seedlings than in a customary field.

The difference between two machines, however, was not significant in this test condition.

Movement of NH_4-N in the paddy soil was measured in a period of 55 days after the application. Fig. 7 shows the NH_4-N contents (mg) in 100 g of dried soils sampled from three different sites, i.e., the site where fertilizer was applied, the site in the middle of inter-row space, and that in the middle of intrarow space. The movement of NH_4-N from the site of application to the plant rows

Table 2. Plant growth as effected by the use of the combined machines

Method of planting	Days after planting	Plant height (cm)	No. of stems (%)
Y	21	33.0	262
	29	40.6	435
	34	51.2	470
M	21	29.7	163
	29	39.7	286
	34	50.2	366
Customary planting	21	29.8	100
	29	34.6	281
	34	44.7	326

Notes: Y: by Yammar's machine
M: by Mitsubishi's machine
No. of stems: shown in percentage by taking that of customary planting plot at 21 days after planting as 100.

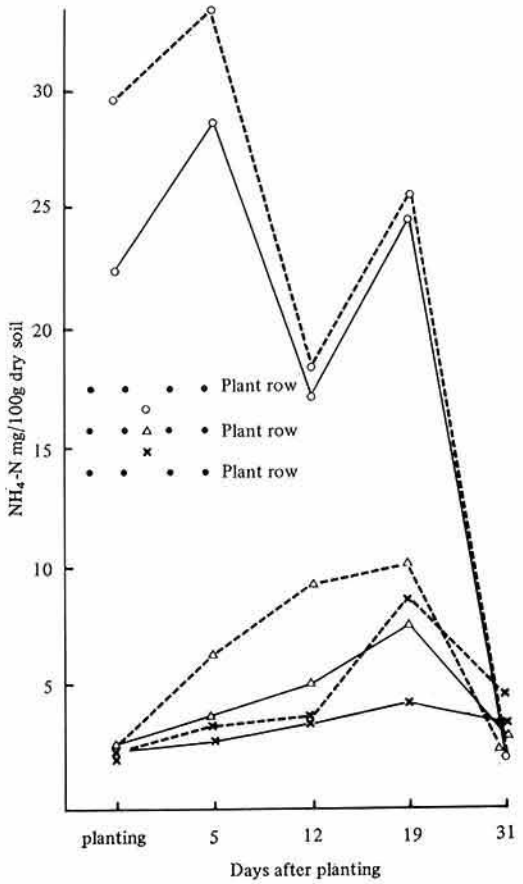

Fig. 7. Movement of NH_4-N applied by dot-application machine in paddy soil
○ : N in soil at the place of application
△ : N in soil at the middle of intrarow space
× : N in soil at the middle of inter-row space
— : Yammar's machine used
··· : Mitsubishi's machine used

was recognized, but it was comparatively less, as shown by a slight increase of nitrogen content at the middle of inter-row space, particularly when the Yammer's machine was used.

Discussion and conclusion

The combined machine consisted of insecticide or fertilizer granules application equipment mounted on the rice transplanter was proved to be good in the field conditions. However, there still remains several problems to be solved. A problem caused by setting the applicator onto the planter is that missing hills occur sometimes, and the steering is not easy for operator, so that a suitable setting position is generally required to be selected according to the construction of planters. As the small capacity of the hopper effects the working capacity of the machine, the replenishment of granules to the hopper should exactly be synchronized with that of seedlings to the planter. When there are many rotted stubbles and straws on the field, the sticking of them to the applying shoes can not be avoided, so that effort has to be made to remove them. Control of weeds and carrying out of straw after harvesting are also necessary in practical works. As shown earlier, the application rate of granular materials (fertilizers or insecticides) can be curtailed by the use of this combined machine, but this advantage can be realized only when they are applied to the place where full absorption of their ingredient by roots is possible.

If the outflow of ingredients from paddy fields may occur, it causes contamination of water in rivers, lakes, and ponds. If this is the case, a protecting device should be provided to the applying part of the machine. The remarkable feature of the combined machine has gradually been recognized in rice cultivation and commercial manufacturing is under way since 1980.

Acknowledgment

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