DEVELOPMENT OF A GRANULAR HERBICIDE APPLICATOR ATTACHED TO RICE TRANSPLANTER

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ABSTRACT

A granular herbicide applicator attached to conventional ride-on rice transplanter with 6 rows was developed in order to carry out both transplanting and herbicide application at once. It resulted in labor saving by 98%. The prototype is composed of a metering device and a spinning disc spreader. The application rate per 10a can be varied from 1 to 3 kg and the application swath is 1.8 m, which is the planting width of the ride-on rice transplanter with 6 rows. The angular speed of spinning disc and the application height were used as design factors to obtain the uniform distribution of herbicide granules. As the result of experiment, the distribution uniformity showed a tendency to be proportional to the increases of both spinner angular speed and application height. The prototype with angular speed of spinning disc of 7359 rpm and the application height of 20 cm was made and its distribution uniformity was relatively uniform with the CV(coefficient of variation) of 21.7%. In field test, when the tested herbicides such as AC140+Stomp and Londax+YRC were applied, the weed control has continued for 65 days since transplanting was done.

Key words: Rice transplanter, Granular applicator, Spinning disc, CV, Weed control

INTRODUCTION

Owing to a growing concern for the environment and a demand for greater efficiency in application of agricultural chemicals on the field, the uniform application of agricultural chemicals is now a major topic in agricultural research. In Korea, most of the herbicide in paddy field is used in granular type and it is applied by hand as well as a duster. However, the methods have difficulty in applying herbicide uniformly and finding out applied region because the spraying heights of the duster and hand are higher than them of the transplanter attachments. They thus are liable to cause overlaps in applying.

Erbach et al.(1976) studied the effect of weed control with respect to the application uniformity. They reported that the amount of application has to increase 2~4 times as large as that of recommended application in case of agricultural chemical not being applied uniformly. Jung et al.(1995) carried out the experimental study to find out the design factors of spraying device of boom sprayer for low volume application. They selected proper nozzles and determined effective swath, spraying height and nozzle spacing for row crop spraying and broadcast spraying. Azimi(1985) studied the feasibility of CV to evaluate spraying uniformity. They noted that the distribution pattern was very uniform in case of CV being lower than 10% whereas it was relatively uniform in case of CV being 15~25%.

Several researchers investigated the particle flow of spinning disc spreaders. Patterson and Reece(1962) described the motion of a particle on the disc of the spreader, considering a near-center feed. In their analysis, bouncing of the particle against the vanes was neglected because of the near center feed. A distinction was made between rolling and sliding of the particles.

The goal of this study is to develop a granular herbicide applicator that can spread the particles of herbicide uniformly, which is attached to the planting device of rice transplanter. And the specific objectives are:

1. to build a granular herbicide application system which includes both adjustable granules metering device and spinning disc spreader.
2. to verify the effect of weed control using prototype in field, varying both herbicides and treatment timings.

MATERIALS AND METHODS

Prototype

As shown in Fig. 1, a prototype which consists of hopper, metering device, spinning disc and drive wheel was fixed to the frame of planting unit of rice transplanter in order to attach and remove it easily.

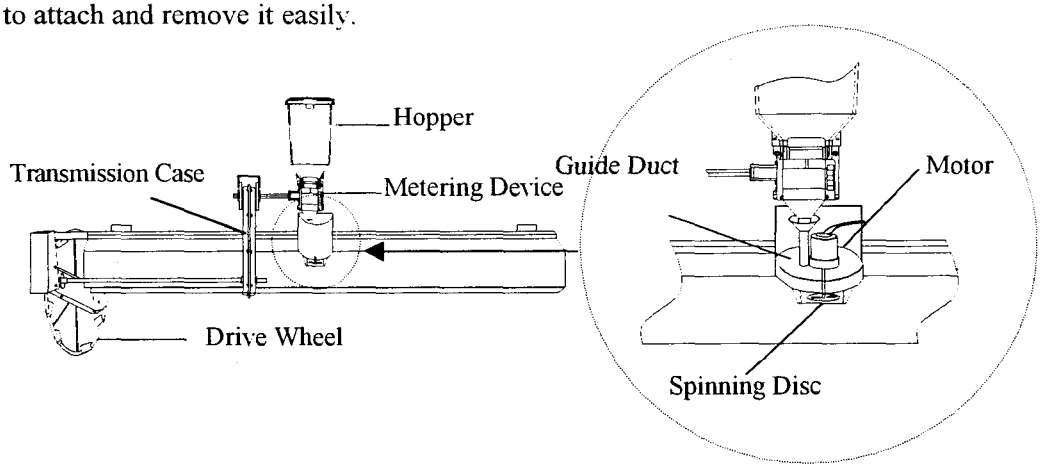


Fig. 1 The schematic diagram of a prototype

The specifications of prototype are listed in Table 1.

Table 1. The main specifications of the prototype

The granules passing through metering roller driven by the drive wheel drop onto the rotating spinning disc driven by motor, and then they are made scatter by centrifugal force of the spinning disc and impact force of vanes. Discharge rate of the granules can be adjusted from 1 to 3 kg/10a by changing the opening length of metering roller grooves. The application width is designed to be 180cm, considering the planting width of the ride-on rice transplanter with 6 rows.

The power transmission is divided into two sections; discharging section and spreading section, respectively. The discharging section which makes the granules from hopper drop is driven by the drive wheel rotating on soil surface and spreading part which makes them scatter to the soil surface is driven by motor connected to a battery of rice transplanter. This is designed to apply herbicide only if the rice transplanter travels.

Physical properties of granular herbicides

As shown in Table 2, the various granules such as 4 types(A, B, C, D) were tested to investigate the size distributions of granular herbicide. For A type, the size distribution rate of granules (< 3 mm in diameter) was 92%, for B type, it(< 5 mm) was 97% and for C type, it (1 ~ 3 mm) was 82%, whereas all the granules of D type were lower than 3mm.

Table 2. The physical properties of tested granules

Type	Size distribution of granules(%)				Particle size(mm)		Bulk density (g/ℓ)
	< 1mm	1 ~ 3	3 ~ 5	> 5mm	Max.	Min.	
A	9.0	83.0	4.0	4.0	6.2	0.7	904.0
B	1.0	37.0	59.0	3.0	7.2	0.8	789.3
C	7.0	82.0	10.0	1.0	6.1	0.6	909.3
D	27.0	73.0	-	-	1.9	0.7	1,010.2

Experiment of application pattern

In order to determine the values of optimal design parameters such as application height and angular speed of the spinning disc for uniform application, the experiment was carried out varying both the application height , from 10 to 30 cm at intervals of 5 cm, and the angular speed of spinning disc, 5000, 6000, 7350 and 9140 rpm, respectively.

The application height was controlled by the lever of adjusting planting depth. The angular speed of spinning disc was measured by Tachometer and the application rate was calculated by weighing the granules collected in the rectangular steel box of 30× 20× 10 cm in the scales.

Field test for verifying the effect of weed control

Size (mm)	Weight (kg)	Hopper (ℓ)	Spinner (ø,mm)	Motor (DC,V)	Wheel (ø,mm)	Metering roller (ømm;No. of grooves)
1,590× 630× 820	23.5	5	80	12	400	62, 8

The prototype designed based on the experiment of application pattern was tested in field in order to verify the effect of weed control. The used herbicides are classified into two types; the commercial herbicides such as Nonanmae, Amhangeosa, Keunsori, and Nondamae, and the tested herbicides such as Londax+YRC and AC140+Stomp. They were applied at the same time when transplanting was done and on the 10th day after transplanting, respectively. The investigation of chemical injury on rice plants was conducted on the 10th and 20th day after transplanting, respectively. That of weed control was also conducted on the 45th and 65th day after transplanting, respectively.

RESULTS AND DISCUSSION

Application rate

When the opening length of metering roller grooves increased from 0 to 8 mm at 2 mm intervals, the application rates of tested granules in 4(A, B, C, D) types, as shown in Fig. 2, were measured to be 1.1~3.7, 0.9~3.2, 0.7~3.2, 1.5~3.9 kg/10a, respectively.

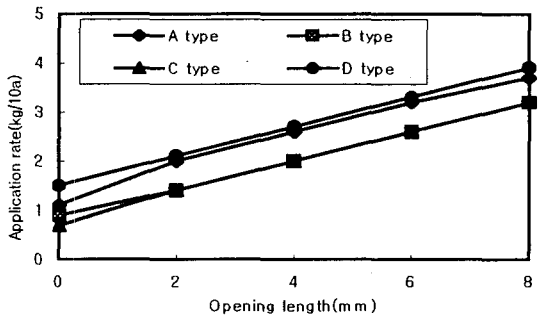


Fig. 2 Effect of the opening length of metering roller grooves on the application rate

Application Uniformity

As shown in Fig. 3, the application uniformity was proportional to the increases of both the spinner angular speed and the application rate showed a tendency to be a peak near at the center of spinner and come to become low as the distance from spinner center increases.

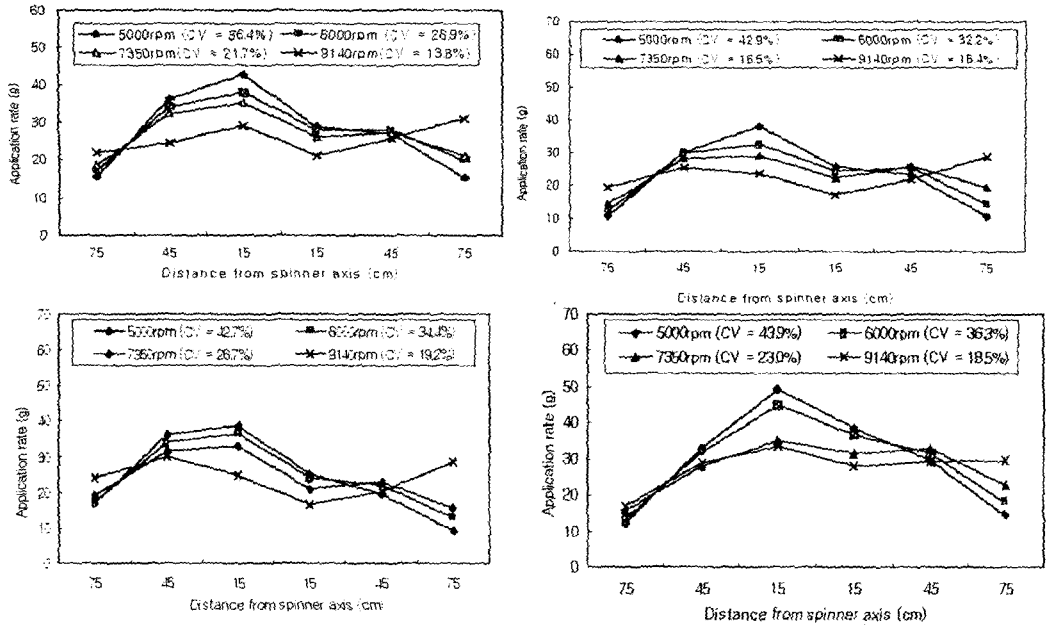
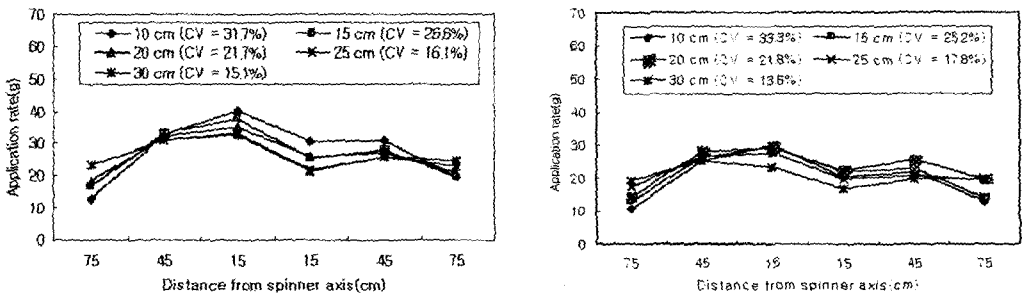


Fig. 3 Effects of spinner angular speed on CV (A, B, C, D type)

For granules of A type, when the angular speed of spinning disc increased from 5000 to 9140 rpm, the value of CV decreased from 36.4 to 13.8 %. Also other granules such as B, C, D type showed the characteristics similar to A type granules. However, at the rate of 9140 rpm, the granules showed a tendency to drift beyond target region and result in overlapping in them. They were also damaged by heavy collision of granules with the vane of spinning disc. Based on the experiment for the effect of spinner angular speed on CV, the optimal spinner angular speed of 7350 rpm was chosen as a motor speed of the prototype. And its CV was 21.7%.

Fig. 4 shows the relation between application rate and CV with change of application height. For granules of A type, when the application height increased from 10 to 30 cm, the value of CV decreased from 31.7 to 15.1 %. However, at the rates of both 25 and 30cm, the granules had a possibility to be liable to drift beyond target region by wind. Therefore, the application height of 20cm was chosen as a spinner ground height of the prototype.



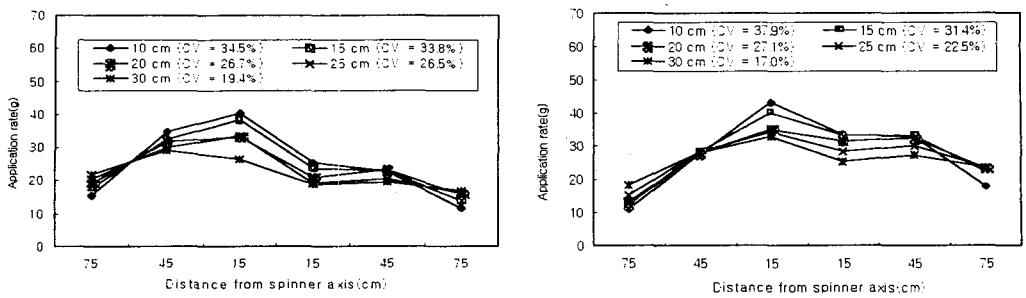


Fig. 4 Effects of application height on CV (A, B, C, D type)

The field capacity of prototype

Both transplanting and herbicide application were accomplished by rice transplanter with the prototype. As shown in the Table 3, the total time taken to complete by prototype was 4.7 hours per 10a. When the herbicide application was only accomplished by manual operation such as hand-scattering, the elapsed time was 6.0 hours per 10a. The work using the prototype can also make labor input decrease by 98% because it can remove labor of herbicide application totally except that of herbicide supply.

Table 3. Performance Comparison of the prototype with manual operation

Types	Travelling speed (m/sec)	Turning time(sec/time)	Transplanting time (min/10a)	Supplying time of herbicide (min/10a)	Total elapsed Work time (hr/10a)
Prototype	0.52	22	276	0.6	4.7
Manual	-	-	-	-	6.0

Field test for verifying the effect of weed control

As shown in Table 4, the weed control by the tested herbicides such as AC140+Stomp and Londax+YRC has continued for 65 days since transplanting was done, which was similar to the result of the conventional method that the commercial herbicides were applied on the 10th day after transplanting. However, when the commercial herbicides such as Nonanmae, Amhangeosa, Keunsori and Nondamae were applied at the time when transplanting was done, they were not able to control the weeds effectively.

Table 4. Chemical injury and weed control index of rice plants

Variety	Herbicide	Application rate (kg/10a)	Treatment Timing	Chemical injury index		Weed Control index		Rice yield (kg/10a)
				10 DAT	20 DAT	45 DAT	65 DAT	
Ilpum byeo	Pyraezosulfuron-ethyl+Molivate (Nonanmae)	3	0 DAT	0	0	90	67	455
	Cyhalofop-butyl+Molivate+ Azimsulfuron(Amhangeosa)	3	0 DAT	1	0	74	47	336
	Cyhalofop-butyl+Pretilachlor+ Pyrazosulfuron-ethyl(Keunsori)	1	0 DAT	2	0	58	45	267
	Molivate+Imazosulfuron (Nondamae)	1	0 DAT	1	0	69	52	352
	Cyclosulfamuron+Pendimethalin (AC140 + Stomp)	3	0 DAT	1	0	97	96	528
	Londax + YRC	1	0 DAT	2	0	95	96	515
	None treatment	-	-	0	0	0	0	216
	Pyraezosulfuron-ethyl+Molivate (Nonanmae)	3	10 DAT	0	0	94	92	501

* DAT : Day after transplanting
** Chemical injury index: 0 ~ 10, 10 is 100% damaged rice
*** Weed control index : 0 ~ 100, 100 is no weed at all in the field

In case of a chemical injury, some of rice plants showed a tendency to have the chemical injury problems in early stage, however, after 10 days passed, they almost recovered from the chemical injury. Therefore, if the tested herbicides such as AC140+Stomp and Londax+YRC are used, then such a new cultivation technology that herbicide is applied at the time when transplanting is done is effective.

CONCLUSIONS

This study is conducted to develop the granular herbicide applicator attached to Korean rice-on transplanter with 6 rows, which can apply uniformly at the same time when transplanting is done. The prototype is composed of hopper, metering device, spinning disc and drive wheel. The application rate per ha can be adjusted from 10 to 30 kg and the application swath is 1.8 m.

The main results can be summarized as follows.

1. When the opening length of metering roller grooves was increased from 0 to 8 mm at 2 mm intervals, the application rates of tested granules in 4(A, B, C, D) types were measured to be 1.1 ~ 3.7, 0.9 ~ 3.2, 0.7 ~ 3.2, 1.5 ~ 3.9 kg/10a, respectively.
2. The spinner angular speed of 7350 rpm and the application height of 20 cm were chosen as the motor speed and spinner ground height for prototype, respectively. The distribution uniformity of the prototype was relatively uniform with the CV of 21.7%.

3. The work using prototype could also make labor input decrease by 98% because it could remove labor of herbicide application totally except that of herbicide supply.
4. The weed control by the tested herbicides such as AC140+Stomp and Londax+YRC using prototype has continued 65 days since transplanting was done, similar to the result from conventional method that the treatment with commercial herbicide like Nonanmae was done on the 10th day after transplanting. However, when the commercial herbicides such as Nonanmae, Amhangeosa, Keunsori and Nondamae were applied at the same time when transplanting was done, they were not able to control the weeds effectively.
5. In case of a chemical injury, some of rice plants showed a tendency to have the chemical injury problems in early stage, however, after 10 days passed, they almost recovered of the chemical injury. Therefore, if that the tested herbicides such as AC140+Stomp and Londax+YRC are used, then such a cultivation technology, that herbicide is applied at the same time when transplanting is done, is effective.

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