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Effect of Rotational Speed and Length of the Fluted-Roll Seed Metering Device on the Performance of Pre-germinated Paddy Seeder Unit

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Abstract

Metering device is the most important component of a seed planter which effectively influences on crop yield and yield components. Therefore it is necessary to determine important parameters that affected on the performance of metering device. In this study a fluted-roller seed metering device with upside feed mechanism was used and effects of such important parameters as variety (Hashemi, Binam, Hasani), length (3,4,5,6 and 7 cm) and rotational speed (5,10,15,20 and 25 rpm) of metering unit was investigated on the seed flow rate, variations of seed flow rate and percent of damaged seed. Results of this study indicated that the seed flow rate of pre-germinated paddy significantly ($P<0.01$) affected by variety, rotational speed, length of the fluted-roller metering unit and their interactions. For each type of paddy variety, the seed flow rate increased with increasing in length and rotational speed of metering device from 3 to 7 cm and 5 to 25 rpm, respectively. The average seed flow rate of Hashemi (2.91 g/s) was higher than Binam (2.66 g/s) and Hasani (2.44 g/s). The lower variations of seed flow rate were achieved as the rotational speed and length of the metering unit increased. There was a significant effect of rotational speed ($P<0.01$) and variety ($P<0.05$) on the damaged pre-germinated seeds. The percent of damaged was varied from 6.56 to 10.69 %, 5.98 to 13.25 % and 5.91 to 12.73% for Hashemi, Binam and Hasani, respectively as the rotational speed of metering unit increased from 5 to 25 rpm.

Keywords: Metering device, Fluted-roller, Pre-germinated paddy, Seed flow rate, Seed planter.

INTRODUCTION

Rice (*Oriza Sativa* L.) is one of the leading food crops of the world and is second only to wheat in terms of annual production for food use. The common method of planting rice is transplanting which is not only more laborious and time consuming but also expensive and inconvenient [3,5]. The aging of farmers and falling rice price have created serious problems for rice farmers. Therefore, in order to save labor and promote conservation agriculture, it is essential to replace transplanting with direct seeding which could reduce labor needs by more than 20 % in terms of working hours [9,12].

Rice is direct seeded by essentially two methods (dry and wet seeding) based on the physical condition of the seedbed and seed (pre-germinated or dry). Dry seeding of rice can be done by drilling the seed into a fine seedbed at a depth of 2-3 cm. Wet seeding required leveled field to be harrowed and then flooded (puddling). The field is left for 12-24 hours after puddling, and then pre-germinated seeds are sown. Shekar and Singh (1991) reported that the direct seeding of pre-germinated seed in puddled soil had significant effect on the grain yield and number of effective tillers [10]. Cabangon et al. (2002) studied increasing water productivity in rice cultivation by comparison between transplanting with wet and dry seeding of rice. They reported that land preparation duration was significantly reduced in wet and dry seeding of rice compared with transplanting. This led to a significant reduction in irrigation and total water input during the land preparation period [2].

Proper seed drilling is one of the important factors to improve crop yield and yield components. Many factors including crop and machine parameters influence the performance of a seed metering device; however such variables as rotational speed and length of the metering device, as well as the type of variety have a major impact on the machine performance [1].

Many researches have been conducted to study the performance of metering unit. Guler (2005) studied the effects of speed, flute diameter and length of metering unit on the flow rate and flow evenness of sesame seed and reported that in order to get uniform flow of sesame seeds, the flute diameter, length and rotational speed of metering unit should be in range of 6 to 8 mm, 15-25 mm and 20-40 rpm, respectively [4]. Maleki et al. (2006) used multi-flight auger as a metering device for sowing of wheat grains in a laboratory condition and studied different auger configuration. They reported that the coefficient of uniformity was significantly higher than those for the fluted roller meter at lower speeds. However, there was not any significant difference at higher speeds between feed units test [7].

Lacayanga et al. (2009) improved efficiency, capacity, seeding rate, missed and drudgery of pulling seeder with change in cell metering size, kind of material to be used for the metering disc and seeder frame for rice hill seeder that used in wetland paddy [6]. Raheman and Singh (2004) developed a manual drawn multi-crop drum seeder for dry land with considering the effects of hole size, hole space and forward speed on the value of seed rate, uniformity of metering, band width and missing seed dropped for wheat and mustard seeds [8]. Sivakumar et al. (2005) studied some parameters affecting performance of the drum seeder to determine the appropriate shape of the drum [11]. The study of drum seeders, the commonly used device for direct seeding of pre-germinated paddy seed, showed that the uniformity of seed distribution in this type of seeder not only depends on the amount of seed in drum space but also depends to paddy variety, so that there are many difficult to operate the seeder for paddy with awns. Hence, a fluted roller seed metering device with upside feed mechanism was used for this study. However, there is a little information about the performance of the fluted seed metering device for pre-germinated paddy seeds. Therefore, the objective of this research was to investigate the effects of such important parameters as rotational speed and length of the fluted-roller seed metering device on the seed flow rate, variations of seed flow rate and percent of damaged grain for three paddy varieties.

MATERIAL AND METHODS

This study was carried out at the Department of Agricultural Engineering, Rice Research Institute of Iran (RRII), Rasht, Iran. Schematic representation of the seeder unit used in the experiment is shown in Fig 1.

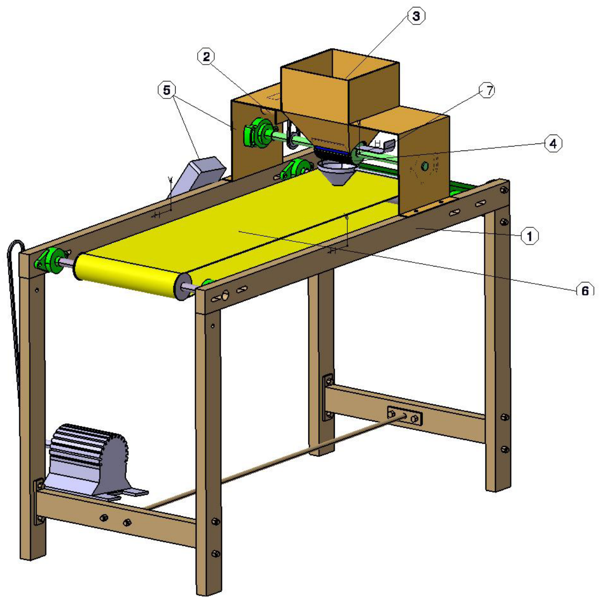

Figure 1. Schematic representation of the seeder unit

1) Chassis, 2) Electric motor, 3) Seed hoper, 4) Fluted-roll seed meter, 5) Rotational speed controller, 6) Conveying belt, 7) Discharge gate

The test apparatus comprised of (1) chassis, (2) electric motor, (3) seed hopper, (4) fluted-roll seed metering device, (5) rotational speed controller, (6) conveying belt, (7) discharge gate. Three local paddy varieties, namely Hashemi (long-grain), Binam (medium-grain) and Hasani (short-grain) were used in this experiment.

The paddy seeds were cleaned to remove all foreign matters and broken seeds. To prepare the pre-germinated paddy seeds, the unfilled grains were separated by using solution of water and salt. The filled paddy seeds soaked into fresh water for 48 hours, and then the samples were poured into separate polyethylene bags and were kept in temperature of 27-30°C for starting the germination process. After the germination completed, the samples kept in the refrigerator. Before starting a test, the required quantity of pre-germinated seeds was taken out of the refrigerator and allowed to warm up to room temperature.

In each test run, the hopper of the seeder unit was filled with the pre-germinated paddy seeds. The rotational speed of the metering device was controlled by using a motor DC 24V-1.5A, (Bodine, W.E2032R-ZR2, IRAN). DC motor can rotate in the different speeds through rotational speed control that works with PWM. A counter sensor was installed on the distributor's axis. This sensor was composed of two infrared transmitter and receiver diodes and circle grooved sheet between these two diodes. With rotation of distributor's axis, information produced from rotation of axis was given to rotational speed control device and finally actions of comparison and control of distributor's rotational speed with received rotational speed by user was down inside of rotational speed control circuit.

In evaluation of device's performance, the effects of variety of paddy in three level (Hashemi, Binam, Hasani) and length of distributor in five level (3,4,5,6,7 cm) and rotational speed of distributor in five level (5, 10, 15, 20, 25 rpm) were investigated on the seed flow rate and variation of seed flow rate. Also the effects of variety of paddy in three levels and rotational speed in five levels at length of 4 cm on the percent of damaged seed were investigated. Select of rotational speed range and suitable length of distributor were down on the basis of elementary experimental experiment. In every experiment, 2/3 of the hoper was filled with pre-germinated paddy seeds and in order to prevent of growth of sprouts after testing, germinated paddies were kept in the refrigerator.

RESULTS AND DISCUSSION

Seed flow rate

The analysis of variance showed that the effects of variety, length, rotational speed and their interactions on the value of seed flow rate were significant at 1 % of probability level (Table 1). Also the effect of rotational speed and length of metering device on the value of seed flow rate of the three paddy varieties used in the experiments are illustrated in Fig. 2a, 2b and 2c. It can be seen that at each level of length, the seed flow rate increased as the rotational speed increased from 5 to 25 rpm. The average seed flow rate increased from 1.21 to 4.63 g/s, 1.12 to 4.28 g/s and 0.91 to 4.00 g/s as the rotational speed of metering device increased from 5 to 25 rpm for Hashemi, Binam and Hasani varieties, respectively. This may be due to that at higher fluted- roll speed, the number of seeds filled into the grooves of the metering device in unit time increased, resulting to more seed flow rate. The similar trend has been reported by Sivakumar et al. (2005) during evaluating a manually drawn rice seeder for direct sowing [11].

The results indicated that at each level of rotational speed, the seed flow rate increased with increasing fluted-roll length. The highest seed flow rate of 4.44, 4.01 and 3.66 g/s was recorded at fluted-roll length of 7 cm and the lowest values of 1.62, 1.53 and 1.39 g/s was obtained at length of 3 cm for Hashemi, Binam and Hasani varieties, respectively (Fig 2a, 2b and 2c). This could be attributed to that at higher length; more seeds are delivered by the fluted roll, leading to more seed flow rate at each revolution of the roll. The results also showed that at each level of fluted-roll rotational speed and length, the highest value of seed flow rate was obtained for Hashemi variety and the lowest value was recorded for Hasani. This could be related to the varietal differences in physical properties affecting flow characteristics of the grains through seed metering device discharged from the hopper.

Variations of seed flow rate

Effect of rotational speed and fluted-roll length on the variations of seed flow rate for the three tested varieties is presented in Fig. 3a, 3b and 3c. It can be seen that at each level of fluted-roll length, the variations of seeding rate decreased with increasing the fluted-roll rotational speed of the seeder machine. It was varied from 10.12 to 5.22 %, 10.14 to 3.96 % and 12.46 to 5.80 % with increasing the rotational speed form 5 to 25 rpm for the paddy varieties of Hashemi, Binam and Hasani, respectively. Therefore higher uniformity in flowing seed could be achieved at higher fluted-roll rotational speed. It was observed that there was an increasing trend in the variations of seed flow rate with decreasing fluted-roll length (Fig. 3a, 3b and 3c). Seed flow rate variations were ranged between 4-12.21 %, 2.72- 11.5 % and 4.3- 14.07 % for Hashemi, Binam and Hasani varieties, respectively.

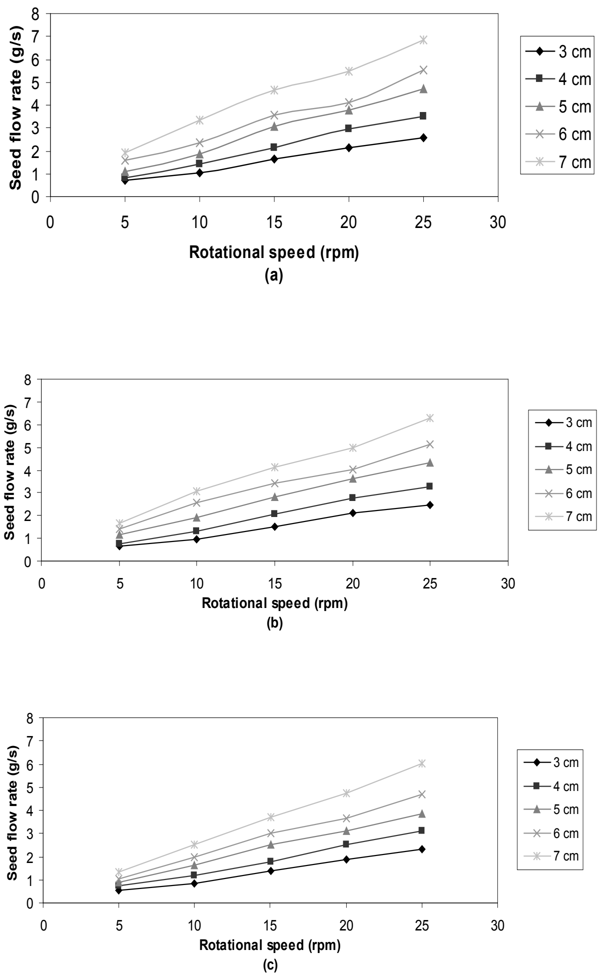

Figure 2. Effect of rotational speed and length of metering device on the seed flow rate of the tested varieties (a) Hashemi (b) Binam (c) Hasani.

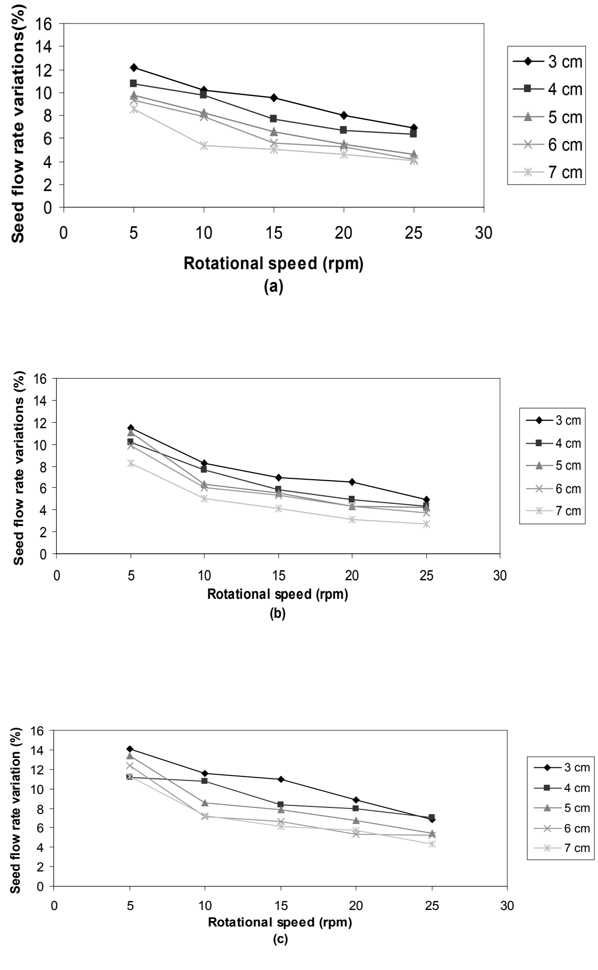

Figure 3. Effect of rotational speed and length of metering device on the seed flow rate variations of (a) Hashemi (b) Binam (c) Hasani varieties.

Table 1. Analysis of variances of the effect of variety, length and rotational speed on the value of seed flow rate

Source of variation	df	Mean squares	F
Variety	2	29.54	1028.27**
Length (cm)	4	329.84	11480.6**
Rotational speed	4	501.22	17446**
Variety × Length	8	2.45	85.39**
Variety × Rotational speed	8	0.98	34.27**
Length × Rotational speed	16	12.36	430.38**
Variety × Length × Rotational speed	32	0.48	15.57**
Error	1500	0.03	

**Significant at 1 % of probability

Damaged paddy seeds

Results of analysis variance show that the effects of variety and rotational speed of seed meter on the percent of damage seed were significant at 5 and 1 % of probability, respectively. Effect of rotational speed of fluted-roll on the damage of pre-germinated paddy seeds for the three varieties is shown in Fig. 4. The damaged pre-germinated seeds increased with increasing metering device rotational speed. It was varied from 6.56 to 10.69 %, 5.98 to 13.25 % and 5.91 to 12.73 %, as the rotational speed of the fluted-roll increased from 5 to 25 rpm for Hashemi, Binam and Hasani varieties, respectively.

CONCLUSIONS

This study intended to evaluation a flute-roller unit with upside feed mechanism as a metering device for direct seeding of pre-germinated paddy seed. The following conclusions were drawn from the results of this study:

1. The seed flow rate of pre-germinated paddy significantly affected by variety, rotational speed and length of the metering unit. For each type of variety, higher seed flow rate was obtained at higher rotational speed and length of the metering unit.
2. There was a decreasing trend in variations of seed flow rate with increasing the length and rotational speed of the metering device from 3 to 7 cm and 5 to 25 rpm, respectively.
3. The percent of damaged pre-germinated paddy seed significantly influenced by rotational speed and type of variety, however the rotational speed had more predominant effect on the damaged seeds compared to the type of variety.

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Table 2. Analysis of variance of the effect of variety and rotational speed on the percent of damaged seed

Source of variation	df	Mean squares	F
Variety	2	10.22	4.21*
Rotational speed	4	100.01	41.18**
Variety × Rotational speed	8	3.95	0.14ns
Error	60	2.43	

**Significant at 1 % of probability * Significant at 5% of probability ns Not significant

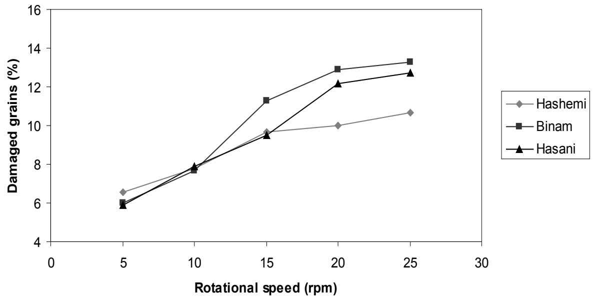

Figure 4. Effect of rotational speed on percent of damaged grain of Hashemi, Binam and Hasani varieties

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