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Uniform Seedling Establishment and Weed Occurrence Inhibition by Seed-Mulching in Wet Seeded Rice

Woon-Ho Yang*†, Jae-Hyun Kim*, Je-Kyu Kim*, Hee-Suk Han*, and Moon-Hee Lee**

National Crop Experiment Station, Suwon 441-100, Korea
*** National Honam Agricultural Experiment Station, Iksan 570-080, Korea*

ABSTRACT : In spite of simple and cheap cultivation method, water broadcast-seeded rice demonstrates uneven and unstable seedling establishment per unit land area and requires more herbicide and labor-input for weed control. Three experiments were conducted in a phytotron at 18°C to evaluate the adaptability of seed-mat mulching cultivation technologies in water seeded rice for the uniform seedling establishment and the inhibition of weed occurrence without herbicide application. Five different kinds of mat with different mesh sizes and fabric properties were tested. The emergence of rice was the highest in Lawn-mat treatment, being comparable with the control, in which seeds were sown without mat. The Lawn-mat also exhibited the lowest mat tension. Mat tension may influence the emergence of rice. And once it was soaked in water, it didn't maintain its original shape any more. The emergence rate of rice was the lowest in Safer-mat treatment. In Lawn-mat treatment, which was the most effective for rice emergence in the first study, the differences of emergence and seedling establishment of rice depending on the seeding position (upper, beneath, and between mats) treatments were negligible, while they were higher in dry seeds than in pre-germinated seeds treatment. The emergence as affected by the kinds of mat also showed the same trend when tested using barnyard grass. Depending on the kinds of mat, the inhibition effect of weeds was the greatest in Safer-mat and the poorest in Lawn-mat. These results strongly suggest the possibility that the uniform seedling establishment and weed management without chemical could be achieved simultaneously by seed-mat mulching through the combination of effective mat for the emergence of rice and another efficient mat for the inhibition of weed occurrence. This possibility was also tested in the field.

Keywords : seed-mat, mulching, seedling establishment, weed, water seeded rice

Direct seeding cultivation technologies of rice were introduced to minimize labor- and cost-input. So far, direct seeded rice culture has been classified into two major categories: dry and water seeding in Korea. Just recently, furrow drill seeding technology was introduced to combine the advantages of wet and dry seeding of rice (Park *et al.*, 1995). Dry seeded rice is subjected to the problems of insufficient panicles per unit land area (Park *et al.*, 1989), difficult weed control (Kim, 1992), and difficult seeding by rainfall in seeding season, which limit the adoption of this technology. Among the direct seeding cultivation technologies, water broadcast-seeded rice provides the simplest seeding method with advantages such as sufficient panicles per unit land area and easier weed control, as compared to dry seeded rice. As reported earlier (Lee *et al.*, 1974), the yield in water seeded rice was comparable to transplanted rice. However, in water seeded rice, the seeding rate and seedling establishment per unit land area are not uniform and the rice seeds are subjected to different environmental conditions resulted from uneven land preparation or water management during the period of seedling establishment. The seeds of rice subjected to anaerobic condition requires more time to emerge and show poorer root elongation than those subjected to aerobic condition. These uneven seeding, improper field management, and environment result in uneven seedling establishment. The growth and environment of rice plants involved in tillering pattern, penetration of solar radiation into the canopy, humidity in the canopy, occurrence of plant lodging, and yield depend on the status of seedling establishment. Kim *et al.*(1987) reported that the varieties with better emergence and seedling establishment at early growth stage produced more spikelets per unit land area in water seeded rice. Moreover, hill-seeded rice was reported to demonstrate higher percentage of productive tiller and more spikelets than row-seeded rice (Won *et al.*, 1996). These reports imply the importance of seedling stand in rice. Therefore, the uniform seedling establishment is one of the most important factors that contribute to the stable cultivation of rice.

Another difficulty in water seeded rice is weed control. Even though weed management in water seeded rice is easier compared to dry seeded rice, the competitive ability of weeds in water seeded rice is greater than the transplanted rice (Guh *et al.*, 1980). Unlike the transplanted rice which begins to grow earlier than weeds, weed germination or

†Corresponding author: (Phone) +82-31-290-6652 (E-mail) whyang@rda.go.kr
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emergence in water seeded rice starts simultaneously with rice germination or emergence. The greater competitive ability of weeds than rice plants brings the difficulty in weed management. In water seeded rice, weeds have been controlled mainly by herbicides, just like in transplanted rice. But water seeded rice requires more herbicides and more labor-input for weed control than transplanted rice does (Kim, 1992; Song *et al.*, 1987). In water seeded rice, herbicides are generally applied at 10 to 15 days after seeding and at intermediate growth stage of rice. However, additional weed elimination by manual labor is required to complete the weed control. Polyethylene mulching system has been applied mainly in upland crops for weed management (Park *et al.*, 1991; Pyon, 1985), increase of water use efficiency (Eom *et al.*, 1990; Lee *et al.*, 1986), higher soil temperature (Kim and Lee, 1985; Lee and Yoon, 1975; Park *et al.*, 1991; Oh *et al.*, 1994), and for minimizing soil erosion (Oh *et al.*, 1992). Also, the plastic film mulching system for transplanted rice was estimated to provide the increase of soil temperature, water and nitrogen use efficiency as well as the effect of weed control and yield increase (Peng *et al.*, 1999). However, the material used in the mulching system was polyethylene which is non-biodegradable. Recently, there have been attempts to control weeds by using recycled paper (Ueno *et al.*, 1999; Lee *et al.*, 1999), which is a biodegradable mulching media. Also there have been attempts to apply the allelopathic effect on the weed control (Kim *et al.*, 1999; Yu and Chung, 1997), but satisfactory result for efficient weed control was not obtained yet in the field condition.

These experiments were conducted to evaluate the adaptability of seed-mat mulching cultivation technology in water seeded rice for uniform seedling stand and inhibition of weed occurrence without herbicides.

MATERIALS AND METHODS

Two studies were conducted to test the possibility of mat mulching system in water seeded rice in 1998 in the temperature-controlled phytotron using Juanbyeo, an adaptable Japonica variety for direct seeding of rice. Another experiment was carried out using barnyard-grass to compare the inhibition of weed occurrence as affected by the kinds of mat. Rice and barnyard-grass plants were subjected to 18°C (day/night 23/13°C), which is the mean air temperature from 10 May to 10 June when the seedling establishment is determined in Korea.

In the first study, five different kinds of mat for mulching were tested to evaluate their effects on emergence and seedling establishment of rice. According to the mesh size and weight of mat, 60 g-8 mesh, 40 g-8 mesh, 30 g-3 mesh, and Safer-Mat (Y&K Co., located at Seoul, Korea) and Lawn-mat (Korean Green Development Co., located at Seoul) were tested. The 60 g, 40 g, and 30 g in the former 3 kinds of mat represent weights (g m^{-2}), and 8mesh and 3mesh stand for the mesh sizes. The Lawn-mat used in this study is developed for the installation of lawn seed. The mats attached with 5 dry rice seeds beneath the mats at 5×5 cm spacing with glue were installed on the soil that had been puddled one day before seeding. Square boxes, with the size of 60×30×15 cm (length×width×height), were used for this test. The emerged rice seedlings were monitored every two days from three days after treatment. The seedling establishment and early growth of rice were determined at 25 days after seeding. Additional treatments, non-mulching seedings with dry seed and pre-germinated seed, were tested as controls to compare the mulching effects on seedling establishment and early growth of water seeded rice.

Among the mats tested in the first study, seedling establishment and early growth of rice as affected by the attached position of rice seeds on mat were examined with dry and pre-germinated rice seeds in the selected Lawn-mat and 30 g-3 mesh, which showed better seedling establishment than the other kinds of mat. Each of the five rice seeds was glued at the upper, between, and beneath the mats with 5×5 cm spacing. Seedling establishment and early growth of rice were determined at 25 days after the installation of mats. Treated temperature and seeding methods were the same as in the first study.

In the third study, weed occurrence and early growth were tested at the same set of mats (except the 30 g-3 mesh) utilized in the first study to compare their effects on the inhibition of weed occurrence. In a similar size of square box used in the first study, 200 barnyard-grass seeds, which were harvested in the previous year, were broadcast-seeded. The four kinds of mat described above were installed on the seeds. Temperature and treatment methods were the same as in the first study.

Mat tension was determined by breaking moment meter. Percent seedling establishment and plant height were measured at 25 days after seeding with selected 15 hills per plot. Thereafter, the seedlings were labelled and oven-dried at 75°C to stable weight to determine the biomass production at early growth stage of rice. In the third study, the seedlings of barnyard-grass inside the box were counted and calculated the percentage of seedling establishment. After labelling, they were oven-dried at 75°C to constant weight to determine the biomass production.

All kinds of mat tested in these studies were biodegradable and spunbonded fabrics, which are biodegradable. The treatments in these studies were subjected to three replications.

RESULTS AND DISCUSSION

The tensions in all kinds of mat tested, except for Lawn-mat, weakened drastically for 10 days after treatment, and the decreasing rates of tension were reduced after that time (Fig. 1). Especially, the tension of Lawn-mat after being treated in water could not be measured because the mat turned like sludge and didn't maintain its shape once put in water.

The emergence with time as affected by the kinds of mat were shown in Fig. 2. Rice emergence was earlier in the pre-germinated seed without mat treatment than any other kinds of mat. From 5 to 10 days after seeding, the emergence of rice increased sharply in all treatment expect for Safer-mat plot, and decreased or did not increase from 10 days after seeding (Fig. 2).

The seedling establishment of rice at 25 days after seeding was observed to be very high in the Lawn-mat and dry seed without mat mulching. This was followed by pre-germinated seed without mat and 30 g-3 mesh plots. In comparing the seedling establishment as affected by the kinds of mat, Safer-mat demonstrated low percentage of seedling stand, shorter plant height, and less biomass production than the other kinds of mat (Table 1). Lawn-mat was the most effective in emergence and seedling establishment of rice, which didn't demonstrate significant difference from the mat non-treated seeding in seedling establishment and early growth of rice. Whereas, Safer-mat was the most effective in inhibiting rice emergence.

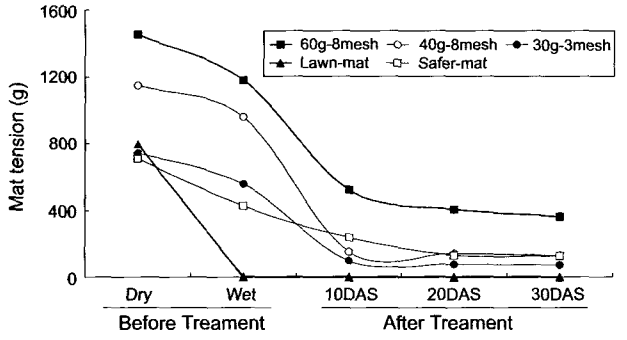

Fig. 1. Changes of mat tension with time. Mat tension was determined by breaking moment meter with 3×7 cm size of mat.

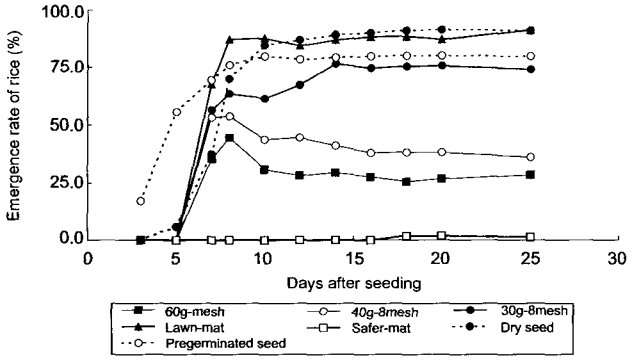

Fig. 2. Temporal changes in emergence of rice as affected by the kinds of mat used for mulching. Dry seeds were glued beneath the mat.

Table 1. Seedling establishment, plant height, and dry weight of rice plants at 25 days after seeding as affected by the kinds of mat.

Mat	Seedling establishment (%)	Plant height (cm)	Dry wt. (g/hill)
60 g-8 mesh	28.4 d†	10.1 b	19.4 b
40 g-8 mesh	36.0 c	11.0 b	30.2 b
30 g-3 mesh	74.2 b	13.7 a	77.9 a
Lawn-mat	90.7 a	13.9 a	84.5 a
Safer-mat	2.0 e	7.5 b	0.8 c
Dry seed†	90.7 a	13.9 a	73.7 a
Pregerm. seed†	79.6 b	15.1 a	78.9 a

†Dry seed and Pregerm. seed : dry seed and pre-germinated seed without mat mulching

‡The same letters in a column are not significantly different by DMRT, $P<0.05$

Figure 3 shows the seedling establishment of rice as affected by the pre-treatment status and attached position of rice seeds in Lawn-mat and 30 g-3 mesh treatments that showed higher emergence and seedling establishment of rice, respectively. Seedling establishment was higher in dry seed plots than in pre-germinated seed plots, which was a different result from the pattern of seedling establishment in water broadcast-seeded rice. In dry seed plots, percentage of seedling establishment was higher in the order of beneath > between > upper position of rice seed attachment in 30 g-3 mesh treatment. This result indicates that water supply to seeds was better in beneath and between attachment plots than in upper attachment plot. However, in the Lawn-mat treatment, there was no significant difference of the percentage in seedling establishment depending on the attached position of rice seeds.

Based on these results, attachment of dry seed on Lawn-

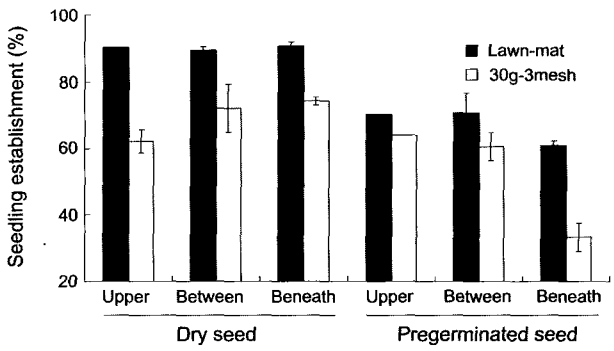

Fig. 3. Seeding establishment of rice as affected by the status and attached position of rice seed in two kinds of mat.

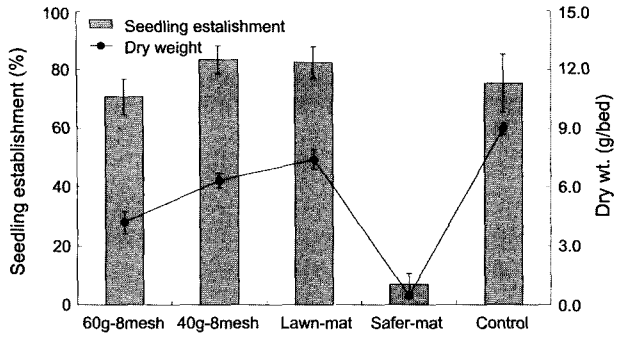

Fig. 4. Seedling establishment and dry weight of barnyard-grass as affected by the kinds of mat. Control : Barnyard-grass seeded without mat mulching.

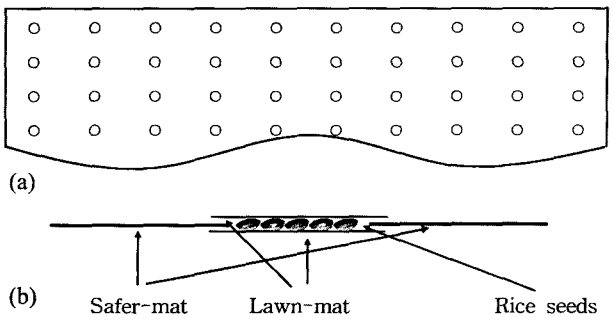

Fig. 5. Diagram of seed-mat mulch, which was made with Safer-mat and Lawn-mat. : Safer-mat with holes at 30×14 cm spacing (a) and attachment of Lawn-mat and rice seeds at the site of hole (b).

mat was appropriate for the seedling establishment and the attachment of rice seeds beneath the mat is expected to be profitable, since it can prevent plant lodging and water shortage.

Figure 4 shows the seedling establishment and dry weight of barnyard grass at 25 days after seeding. The emergence of barnyard grass in Safer-mat treatment was considerably lower than the control, while 60 g-8 mesh, 40 g-8 mesh, and Lawn-mat treatments didn't demonstrate significant differences of seedling establishment from the control. Comparing the pattern of weed occurrence to that of rice seedling establishment, the inhibitory effect of mat mulching on the emergence of rice was greater than that on the weed occurrence (Fig 2. vs. Fig. 4). Mulching with Safer-mat was effective for the inhibition of weeds occurrence.

Figure 5 shows the diagram of seed mat combined by Safer-mat and Lawn-mat with rice seeds. The two kinds of mat were combined not to inhibit rice emergence by Lawn-mat and simultaneously to suppress weed occurrence by Safer-mat. As the first step, the round-shape holes on Safer-mat were punctured by 30×14 cm spacing (Fig. 5a). Then, a small piece of rectangular-shape Lawn-mat was attached on

Fig. 6. Water seeded rice by seed mat (a), seedling establishment of rice in seed mat treatment (b), and that in water broadcast-seeded rice (c).

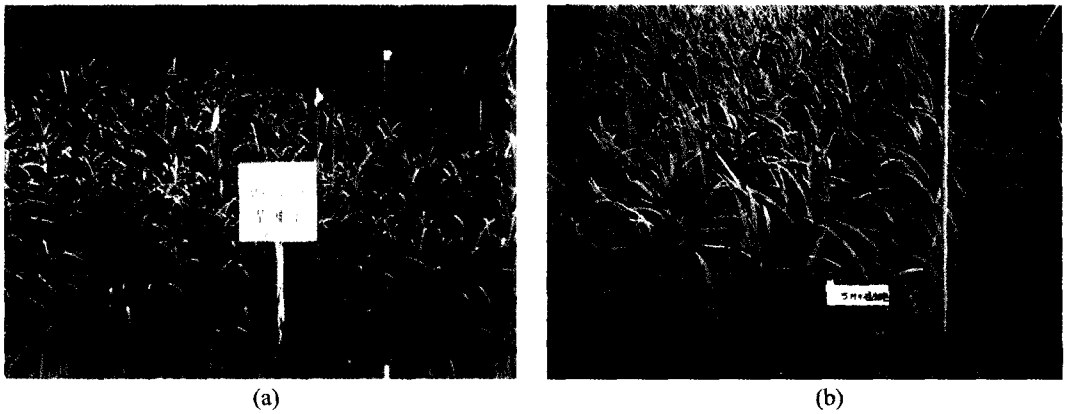

Fig. 7. Paddy field without weed control in water seeded rice by hand broadcasting (a) and by seed mat (b).

Safer-mat at the hole site. As a final step, 5 rice seeds on the Lawn-mat and another small piece of Lawn-mat on the seeds were attached in turn at the site of a hole (Fig. 5b).

When the processed seed-mat was installed on the irrigated paddy field (Fig. 6a), unlike with the uneven seedling stand in water broadcast-seeded rice (Fig. 6c), the seedling establishment (Fig. 6b) of rice at 30 days after seeding was uniform (data not shown) similarly to the transplanted status by machine transplanter.

Figure 7 shows the patterns of weed occurrence in water broadcasting and seed-mat mulching of rice when herbicide was not applied. Weeds occurrence could be effectively inhibited (data not shown) without herbicides by seed-mat mulching cultivation (Fig. 7b), while a lot of weeds occurred in water broadcast-seeded rice (Fig 7a).

CONCLUSION

The uniformity of seedling establishment of rice was improved and weeds occurrence was significantly inhibited by seed-mat mulching, when seed-mat mulch was made with an effective mat to rice emergence and another efficient mat to weed control as in Fig. 5. These results suggest that this cultural practice or modified system could be adopted in rice culture. The problems that should be addressed in seed-mat mulching cultivation system of rice involve selection or development of practical mat that is biodegradable and cheap manufacturing cost. In addition, the mechanical system for attachment of seed on mat and mat installation system should be developed for applying this technology to farmers' cultural practices.

REFERENCES

Chung K. W. 1984. Effects of polyethylene film mulching and planting dates on growth and yield of summer type of soybean (*Glycine max*). *J. Korean Soc. Crop Sci.* 29(1) : 50-54.

Eom K. C., E. R. Son, and K. S. Ryu. 1990. Changes in evapotranspiration and soil water status to vinyl mulching. *J. Korean Soc. Soil Sci.* 23(2) : 100-106.

Guh J. O., S. K. Chung, and B. H. Chung. 1980. Studies on the weed competition. 1. Interpretation of weed competition of paddy rice under various cultural patterns. *J. Korean Soc. Crop Sci.* 25(1) : 77-86.

Kim K. S. and Y. B. Lee. 1985. Study on the physical properties of high density polyethylene film and utilization for nursery materials. *Res. Rept. RDA (P. M&U)* 27(1) : 11-16.

Kim K. U., D. H. Shin, H. Y. Kim, I. J. Lee, and M. Olofsdotter. 1999. Study on rice allelopathy. I. Evaluation of allelopathic potential in rice. *Kor. J. Weed Sci.* 19(2) : 105-113.

Kim K. U., D. H. Shin, I. J. Lee, H. Y. Kim, J. H. Kim, and K. W. Kim. 1999. Study on rice allelopathy. II. Factors affecting allolepathic potential of rice. *Kor. J. Weed Sci.* 19(2) : 114-120.

Kim S. C. 1992. Weed ecology and effective weed control technology in direct-seeded rice. *Kor. J. Weed Sci.* 12(3) : 230-260.

Lee B. Y. and J. Y. Yoon. 1975. Effect of polyethylene film mulching on the soil temperature and the growth and yield of red pepper. *J. Kor. Soc. Hort. Sci.* 16(2) : 185-191.

Lee C. Y., D. H. Kim, Y. H. Han, B. G. Oh, J. E. Choi, J. Y. Won, and H. H. Kim. 1999. Studies on utilization of waste papers for rice cultivation. 1. The effect of weed control. *J. Korean Soc. Crop Sci.* 44(5) : 142-143.

Lee J. C., C. S. Moon, and H. Y. Suh. 1974. Effect of different cultivating methods on the growth and yield in rice. *Res. Rept. RDA* 16(Crops) : 111-115.

Lee J. I., S. T. Lee, and C. W. Kang. 1986. Effects of vinyl mulching culture on soil moisture content and growth of sesame plant. *Res. Rept. RDA(Crop)* 28(1) : 180-184.

Oh S. J., P. K. Jung, and K. T. Um. 1992. Soil erosion control with vinyl mulch on different crops. *Res. Rept. RDA (S&F)* 34(2) : 30-35.

Park K. H., J. T. Kim, M. S. Park, Y. S. Oh, and M. G. Shin. 1991. Effects of black PE film mulching on growth and yield at mono-cropping of sesame in southern area of Korea. *Res. Rept. RDA (U&I)* 33(3) : 42-46.

Park. S. T., A. C. Chang, S. C. Kim, B. H. Jun, S. K. Lee, and Y. J. Oh. 1995. Cultural characteristics in water broadcasting under corrugated furrow soil of rice. RDA *J. Agri. Sci.* 37(1) : 11-19.

Park S. T., S. C. Kim, S. K. Lee, and G. S. Chung. 1989. Rice growth and yield for direct seeding of rice in southern area. *Res. Rept. RDA(Rice)* 31(4) : 36-42.

Peng S., K. Shen, X. Wang, J. Liu, X. Luo, L. Wu. 1999. A new rice cultivation technology : Plastic film mulching. *IRRN* 24.1 : 9-10.

Pyon J. Y. 1985. Effects of colored polyethylene film mulching on germination, emergence, and growth of weeds. *Kor. J. Weed Sci.* 5(1) : 19-23.

Song G. W., Y. J. Choe, J. K. Kim, G. M. Shon, and Y. S. Lee. 1987. Effects of herbicides on direct-sown rice (*Oryza sativa* L.) in paddy condition. *Res. Rept. RDA (Crop)* 29(1) : 119-126.

Ueno H., M. Shimura, and M. Yamauchi. 1999. Rice direct seeding method with recycled-paper mulching. *Plant Prod. Sci.* 2(1) : 53-57.

Won J. G., W. H. Lee, C. D. Choi, C. R. Kim, and B. S. Choi. 1996. Growth characteristics and yield of hill-seeded rice in direct seeding. *RDA J. Agri. Sci.* 38(1) : 49-55.

Yu C. Y. and I. M. Chung. 1997. The evaluation of allelopathic potential barley and sorghum residues on germination and early growth of some weeds. *Korean Journal of Environmental Agriculture.* 16(1) : 67-71.