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Effect of Expanded Rice Husk Medium on Rice Seedling for Machine Transplanting

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ABSTRACT: Rice farmers can save labor and expenses by using expanded rice husk (ERH) as a seedling medium since ERH is lighter and cheaper than other commercial seedling media (CSM). This study was carried out to develop a method for rice seedling cultivation using ERH as a seedling medium. It is suggested that a mixture of 60% of ERH and 40% of a CSM could be used as a seedling medium; the planting densities would be 240 g per tray for infant seedlings and 200 g for young seedlings; and nitrogen (N) would be applied at a rate of 1 g per tray for infant seedlings prior to planting and 2 g per tray for young seedlings with division. Great care should be taken to use $CO(NH_2)_2$ as an N-source fertilizer. These results would lay a foundation for the rice seedling cultivation with ERH as a medium.

Keywords: Expanded rice husk (ERH), nitrogen application, rice, seeding density.

Rice seedlings have been cultivated using seedling trays for machine transplanting since 1977 in Korea (Lee *et al.*, 1977). It is important to grow healthy seedlings so that they can be transplanted successfully and grow rapidly after transplanting. According to Kim *et al.* (1990) and Lee *et al.* (1977), recommended rice seedling media should have more than 10% porosity and high water potential. The media should also be comprised of fine or clay fine soils with high cation exchange capacity (CEC).

94,000 tons of rice seedling media are required in Kangwon Province a year (KARES, 2000a). Since many farmers have used the clay soil from mountains as their rice seedling medium source, a possible damage to the environment has been presented. Therefore, it is necessary to substitute the previous medium. One of the substitute media would be expanded rice husk (ERH). Labor can be saved by using it as a rice seedling medium because of less effort in handling the seedling trays that contain ERH, which is lighter in weight compared with its volume. If ERH is used for rice seedling medium for all rice farms in Kangwon Province, 9,000 tons of ERH will be required a year. Therefore, Kangwon Province can be self-sufficient for ERH if 45,000 tons of ERH could be produced a year (KARES, 2000a).

Rice seedlings have been classified into infant (8 - 10 day old), young (20 day old), and middle-aged (30 - 35 day old) seedlings, according to the seedling growth periods (RDA, 1992; Yang *et al*, 1989). In general, the seeding densities per tray (30 × 60 cm) are recommended 200 g for the infant seedlings, 180 g for the young seedlings, and 130 g for the middle-aged seedlings (KARES, 2000b; Nam *et al.*, 2002; Yang *et al.*, 1989; Yang *et al.*, 1998).

Rice seedlings depend on their nutrients from their endosperms until the third leaf comes out, and grow using the nutrients absorbed from their roots after the fourth leaf comes out (Lee, 1997). Therefore, seedlings can grow using their in-source nutrients of the endosperm until about 20 days after seeding. However, if their growth depends only on their endosperm nutrients, they may be poor in seedling growth compared with the seedlings grown by absorbing the nutrient sources from seedling media (Kim *et al.*, 1996; RDA, 1992). The objectives of this study are to present the cultivation methods such as seedling densities and nitrogen applications in raising seedlings using ERH as a medium.

MATERIALS AND METHODS

The experiment was performed at Chuncheon, a 74 m elevated inland region in Kangwon Province. The rice seedling media used were a commercial seedling medium (CSM), a clay fine soil (CFS), and an expanded rice husk (ERH). The rice variety Odaebyeo was used. Uniform seeds were selected. The selected seeds were sterilized in a mixed solution of a prochloraz (Kyung Nong Co., Ltd, Korea) and a metalaxyl (Sungbo Chemicals Co., Ltd, Korea) for 24 hours. The seeds were then soaked in running water for 48 hours. After sprouting, they were seeded in 30 × 60 × 3 cm seedling trays

Three different rice seedlings (i.e. infant, young, and middle-aged seedlings) were grown. They were grown and transplanted 10 days after seeding for the infant seedlings, 20 days after seeding for the young seedlings, and 30 days

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after seeding for the middle-aged seedlings respectively. The seeding quantities applied as standards were 220 g per tray for the infant seedlings, 180 g per tray for the young seedlings, and 130 g per tray for the middle-aged seedlings. Nitrogen (N) was applied with 1 g per tray for the infant seedlings, and 2 g per tray for the young and the middle-aged seedlings. Seedling trays were put in a seed emerging room (30 °C, 80 - 90% of humidity, and dark condition) until emergence (2 days). Seedlings were grown in upland conditions to make their roots healthy.

The completely randomized design (CRD) was used with five replications. In each plot or seedling tray, twenty representative plants were selected, measured for heights and number of true leaves. Maturity was determined with the percentage of normal seedlings to total seedlings. Root mat formation was determined from 1 to 5 based on degrees of mat formation. Plant shoot samples were dried at 75 °C for 72 hours to obtain dry mass.

The SAS software (SAS version 8.1, SAS Institute Inc. Cary, North Carolina) was used for statistical analysis. The mean separation technique of Duncan's multiple range test (DMRT) was used to determine which averages differed within the variable averages among treatments or different samples.

RESULTS AND DISCUSSION

Table 1 shows a comparison of seedling growths as a function of the different seedling media. The seedling growths in the media of CFS, ERH 6 + CBM 4, and ERH 3 + CFS 7, were similar to those in the CSM medium. However, the seedling growths in the ERH medium were inferior compared with those in the CSM medium. This result suggests that the seedling growths might be affected by the excluded substances from the ERH. Ko (1998) reported that rice husk extracts from various rice varieties could inhibit germination of other plants but did not show autotoxicity in germinating rice seed itself. However, since there have not been studies for autotoxicity to the root growth of rice seedling by rice husk extract, further studies will be required to clarify this.

In Table 2, the tray weights, the labor costs, and the transplanting status were compared as a function of the different seedling media. The ERH medium was not only the lightest

Table 1. Seedling growths as a function of the different media.

Medium†	Emergence (%)	Shoot height (cm)	Leaf number (plant^{-1})	Shoot dry weight (mg plant^{-1})	Maturity‡ (%)
CSM	98 0 a	14 3	4 80	22.4 a	99.3 a
CFS	96.4 a	14 9	4.87	21 1 a	98.0 a
ERH	87.8 bc	13.5	4.87	19.3 b	88 7 b
ERH 6 + CSM 4	97.5 a	13.7	4 60	22.2 a	99 3 a
ERH 3 + CSM 7	93 9 ab	15.0	4.93	21 3 a	98.0 a

Letters following numbers are Duncan's multiple range test (alpha = 0.05)
†CSM represents commercial seedling medium, CFS clay fine soil, and ERH expanded rice husk ERH 6 + CSM 4 the mixed medium with 60% of ERH and 40% of CSM, and ERH 3 + CSM 7 the mixed medium with 30% of ERH and 70% of CSM.
‡Maturity was determined using the percentage of normal seedlings to total seedlings

Table 2. Tray weights, labor costs, and transplanting status as a function of the different media.

Medium†	Tray weight at transplanting (kg tray^{-1})	Labor cost‡ (₩)	Transplanting status			
			Missing hill (%)	Floating seedling (%)	Seedlings (hill^{-1})	Index¶
CSM	5 65 a	16,530	1 4 a	0.0	3.7 a	2
CFS	5.84 a	3,240	1 7 a	0.0	3 6 ab	2
ERH	3.62 d	1,800	3 4 a	1 0	2.6 c	3
ERH 6 + CSM 4	4.49 c	5,978	2.8 a	0.0	3.2 abc	2
ERH 3 + CSM 7	5.05 b	10,612	1 5 a	0 0	3 7 a	2

Letters following numbers are Duncan's multiple range test (alpha = 0.05)
†CSM represents commercial seedling medium, CFS clay fine soil, and ERH expanded rice husk. ERH 6 + CSM 4 the mixed medium with 60% of ERH and 40% of CSM, and ERH 3 + CSM 7 the mixed medium with 30% of ERH and 70% of CSM.
‡Labor cost for seedling cultivation was calculated based on 30 trays, which are tray numbers available to be transplanted using 30 day-old seeding for 10 a.
¶Transplanting status indices: Very good-1, Good-2, Normal-3, Poor-4, Very poor-5

in weight but also the cheapest in labor cost. Given the results in Table 1 and 2, the medium of ERH 6 + CSM 4 was the recommended choice as a seedling medium. Based on this result, the medium of ERH 6 + CSM 4 was used for the seedling cultivation studies about seeding density and nitrogen (N) application in the ERH medium, presented in the following results.

The seedling growths were compared as a function of the different seeding densities for the infant seedlings (Table 3) and for the young seedlings (Table 4). In both Tables, the seedling growths generally did not show significant differences among the three experimental plots However, root

Table 3. Comparison of the seedling growths as a function of the different seedling densities prior to transplanting with the infant seedlings.

Medium†	Seeding density (g tray^{-1})	Shoot height (cm)	Leaf number (plant^{-1})	Shoot dry weight (mg plant^{-1})	Maturity‡ (%)	RMFI¶
CSM	220	12 7a	2 0	7 3	97.3	1
ERH 6 + CSM 4	220	12 2 b	2.0	7 1	91 3	2
ERH 6 + CSM 4	240	13.0 a	2.0	7.5	96.7	1

Letters following numbers are Duncan's multiple range test (alpha = 0.05)
†CSM represents commercial seedling medium, and ERH 6 + CSM 4, the mixed medium with 60% of ERH and 40% of CSM
‡Maturity was determined using the percentage of normal seedlings to total seedlings.
¶Root mat formation indices. Very Good-1, Good-2, Normal-3, Poor-4, Very poor-5.

Table 4. Comparison of the seedling growths as a function of the different seeding densities prior to transplanting with the young seedlings.

Medium†	Seeding density (g tray^{-1})	Shoot height (cm)	Leaf number (plant^{-1})	Shoot dry weight (mg plant^{-1})	Maturity‡ (%)	RMFI¶
CSM	180	15.9	2.2	10.7a	95.3	1
ERH 6 + CSM 4	180	14.3	2.2	10.6a	93.3	2
ERH 6 + CSM 4	200	15.0	2.1	9.7b	93.3	1

Letters following numbers are Duncan's multiple range test (alpha = 0 05).
†CSM represents commercial seedling medium, and ERH 6 + CSM 4, the mixed medium with 60% of ERH and 40% of CSM
‡Maturity was determined using the percentage of normal seedlings to total seedlings.
¶Root mat formation indices Very Good-1, Good-2, Normal-3, Poor-4, Very poor-5

Table 5. Comparison of the seedling growths as a function of the nitrogen (N) applications prior to transplanting with the infant seedlings

N application†	Shoot height (cm)	Leaf number (plant^{-1})	Shoot dry weight (mg plant^{-1})	Maturity‡ (%)	N content¶ (%)
Nil	12 9 b	2.0	7.9 a	95 3	4.63 b
Prior to planting	15.5 a	2 0	8.3 a	95.3	5 77 a
At 1st true leaf	13.1 b	2.0	6.9 b	95.3	5 54 a

Letters following numbers are Duncan's multiple range test (alpha = 0.05).
†N was applied with 1 g per tray.
‡Maturity was determined using the percentage of normal seedlings to total seedlings
¶Percent of N contents in seedlings.

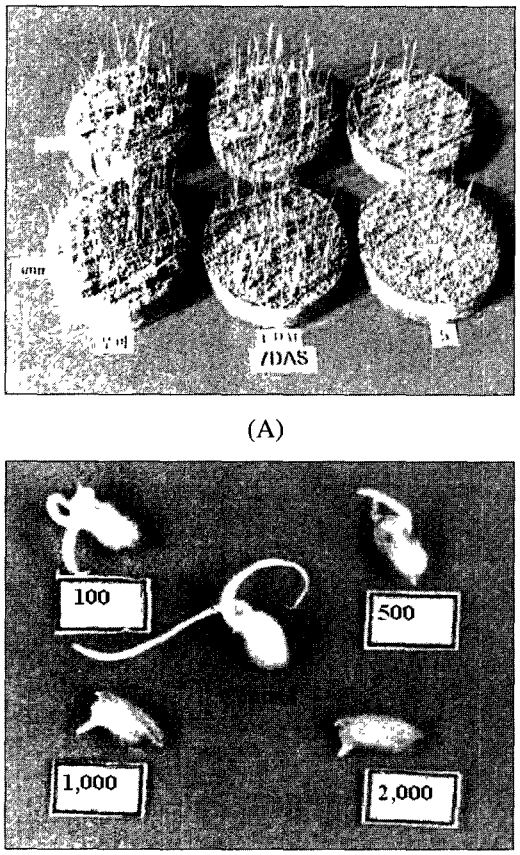
Table 6. Comparison of the seedling growths as a function of the nitrogen (N) applications prior to transplanting with the young seedlings.

N application†	Shoot height (cm)	Leaf number (plant^{-1})	Shoot dry weight (mg plant^{-1})	Maturity‡ (%)	N content¶ (%)
Nil	15 1 b	2.1	9.9 b	96 0	3 92 b
Prior to planting	17 7 a	2 4	11.7 ab	98.0	5.34 a
Division#	18 9 a	2.3	12 5 a	98 7	5.30 a

Letters following numbers are Duncan's multiple range test (alpha = 0.05).
†N was applied with 2 g per tray. For division, N was applied prior to planting with 1g per bed and at 1st leaf with 1g per tray.
‡Maturity was determined using the percentage of normal seedlings to total seedlings.
¶Percent of N contents in seedlings.
#N application of the division was applied with a division of prior-to-planting and at-1st-true-leaf.

Table 7. Rice seedling growth as a function of the $CO(NH_2)_2$ concentrations.

Item	0 ppm	100	500	2,000	4,000
	---------- mm ----------				
Shoot	13 92	13 62	7.99	1 13	1.18
Radicle	12.87	8.47	2.11	0	0



(A)

(B)

Fig. 1. Pictures showing rice seedling growth inhibitions as a function of the different $CO(NH_2)_2$ concentrations. A. The seedling growths at 7 days, seeded in the media without N application (left column), and seeded at 15 days (center) and 5 days (right) after N application B. Individual seeds showing inhibitions by 100 ppm, 500, 1,000, and 2,000 of $CO(NH_2)_2$ at 3 days after seedling in the growth chamber.

mat formations were better in the 240 g-seeded plot than the 220 g-seeded one grown in the medium of ERH 6 + CSM 4 (Table 3), and likewise better in the 200 g-seeded plot than the 180 g-seeded one (Table 4). This result corresponds to Nam *et al.* (2002) in that root mat formations were better in the higher seeded seedlings.

Table 5 shows a comparison of the seedling growths as a function of the different N applications for the infant seedlings. The prior-to-planting plot showed better seedling growths (i.e. plant height and dry weight) than the nil-N plot. In Table 6, the seedling growths were compared as a function of the different N applications for the young seedling. As compared with the nil-N application, the prior-to-planting and the division ones showed better seedling growths.

ERH-based rice seedling media may differ from soil-based media in buffering ability for chemicals in the media. Because of this, great care should be taken when $CO(NH_2)_2$ is used as an N-source fertilizer since it is deoxidized to N_2 in the air, which inhibits shoot and radicle growths. Table 7 shows the rice seedling growth inhibitions as a function of the $CO(NH_2)_2$ concentrations and suggests that the minimum inhibitory concentration (MIC) of rice seedling for urea ($CO(NH_2)_2$) was 500 ppm. As shown in Fig. 1, it is suggested that rice be sown over 2 weeks after $CO(NH_2)_2$ is applied in the ERH contained media.

We believe that labor and expenses can be saved in the process of rice seedling cultivation by using ERH as a seedling medium because of the light weight and cheap price of ERH compared with CSM. Hopefully, the study results would lay a foundation for a seedling cultivation method using the ERH media and provide necessary information to rice farmers and researchers.

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