Korean J Crop Sci 50(2) 120~124(2005)

Chemical and Physical Characteristics of Expanded Rice Husk Medium on Growth of Rice Seedling

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ABSTRACT : Expanded rice husk (ERH) is different from commercial rice seedling media in chemical and physical properties such as pH, permeability, and water content. This study was conducted to test a possibility of improving rice seedling growth by improving the texture of ERH as a rice seedling medium. The seedling media used were a commercial seedling medium (CSM), rice husk, and ERH 1, 2, 3, and 4 with different expansion degrees. The pH of the ERHs ranged from 6.3 to 6.8. As the expansion rate increased, ERH particle sizes decreased, and water permeability and absorption rates improved. No significant differences in shoot dry weight and rate of maturity were found among the seedlings cultivated in the different ERH media. However, the mat formation of seedling roots became loose as the expansion rates were decreased. Further studies are necessary to determine the cause of poor root growth in ERH media.

Keywords: Chemical and physical property, expanded rice husk (ERH), rice seedling.

Since 1977 machine transplanting with thirty-day-old seedlings has become common in Korea, resulting in a less labor-intensive technology in rice cultivation (Kim *et al*, 1996). According to Lee *et al* (1977), rice germinates and grows well in seedling media having more than 10 % water content. They also reported that rice seedling growth in a fine soil medium having proper humus and high porosity was better compared with the seedling growth under clay or sandy media.

Rice husk is not permeable to water because the surface of it is formed by neticular tissue with SiO_2, containing 13.7 % lignin (Han *et al*, 1983). When it expands, the physical properties are changed to a more permeable medium (Cha, 1996). There have been some studies with expanded rice husk (ERH) to use it as seedling media for horticultural crops (Han *et al*, 1983; Kim *et al*, 2000; Lee, 1997; Lee, 1999) and for rice (Han *et al*, 1983; Kim *et al*, 2003). Han *et al* (1983) reported that the seedling media including ERH could increase dry mass of seedlings as well as absorption of SiO_2 to plants. According to Kim *et al* (2003), the weight of rice seedling trays could be decreased by using ERH as a seedling medium.

The weight of ERH is less compared with its volume. Because of less effort in handling the seedling trays, labor can be saved by using ERH instead of a commercial medium. Many farmers use the clay soil from mountains for making a rice seedling medium. This, in turn, could result in damage to the environment. One of the solutions would develop the substitute media that can be easily found with a cheap price. ERH has been thought to have a capacity as one of these by some researchers (Han *et al*, 1983; Kim *et al*, 2003). This study was carried out to improve rice seedling growth raised in the ERH media with different expansion degrees. We hope the results of this research could lay a foundation for the use of ERH as a rice seedling medium.

MATERIALS AND METHODS

The seedling media used were a commercial seedling medium (CSM), rice husk, and expanded rice husk (ERH) 1; 2, 3, and 4 with different expansion degrees. An experimental rice husk expander (Fig. 1) was used to produce the ERHs. In this procedure, rice husks are cut into pieces by the cutter at high temperature (°C) and pressure (kPa) when they pass through the gap in the barrel. The ERH degree 1, 2, 3, and 4 represent the gaps between the core and the different O-rings in front of the cutter. As the gap decreases, high temperature and pressure are generated by friction among the rice husks in the gap. As a result, the pieces of ERH become small and polished as shown in Fig. 1B-2.

Particle sizes of the seedling media were classified based

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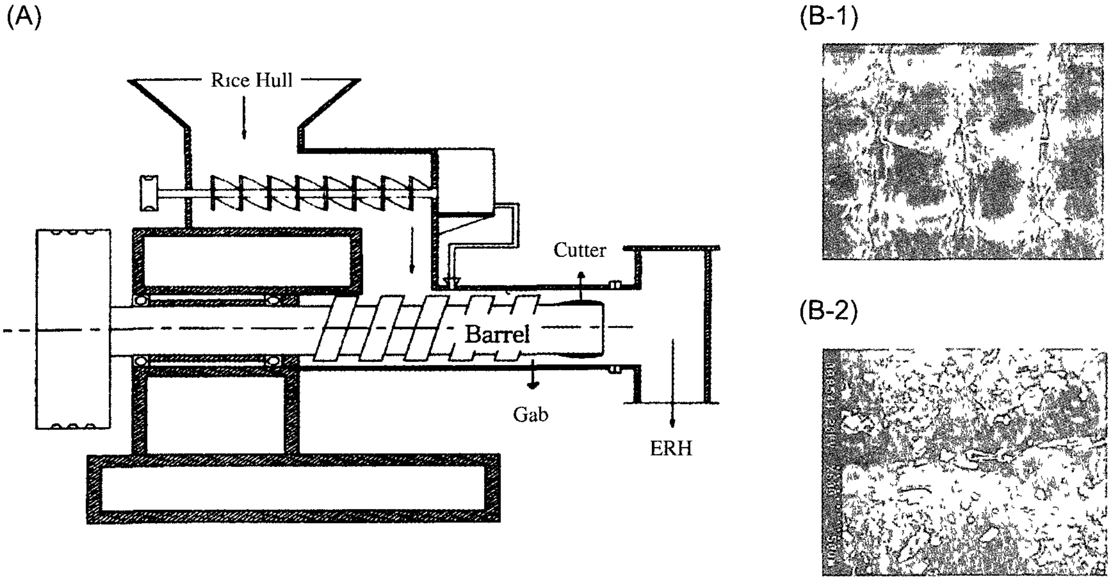

Fig. 1. (A) Cross section view of the experimental rice husk expander (Green Engineering Ltd.), and (B-1) surface appearances of rice husk and (B-2) ERH taken using an electron microscope (600), modified from Kim *et al.* (2000).

on the USDA classification grade, and geometric mean diameters (GMD) were determined according to the method by Mazurak (1950). Water absorption heights of the seedling media were measured after the media were put in transparent acrylic tubes (10 cm in diameter) and then compressed using a sieve shaker (RP-09: CISA) for 60 seconds (Kim *et al.*, 2000).

The experiments were conducted at Chuncheon, Kangwon province, located at 74 m above sea level in the inland region. The rice variety used was Odaebyeo. Uniform seeds were selected. The selected seeds were sterilized in the 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, these were sown in 30 × 60 × 3 cm seedling trays. The seeding quantity was 180 g per tray for young (20-days-old) seedlings. The 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 for 20 days in layered seedling containers in a grass house. Water was applied with a sprinkler system twice a day.

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 (> two true leaves) 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

Table 1. Chemical and physical properties of the media.

Media	pH (1:5)	EC† (dS m^{-1})	T-N‡ (%)	Water potential (-10kPa)
CSM	5.5 c	1,064 b	0.08	131 e
Rice Husk	6.7 a	946 b	0.41	146 d
ERH 1	6.3 ab	1,518 a	0.55	153 a
ERH 2	6.4 ab	1,485 a	0.50	149 bc
ERH 3	6.6 a	1,539 a	0.41	151 b
ERH 4	6.8 a	1,602 a	0.47	148 cd

†EC represents the electrical conductivity.
‡T-N represents the percentage of the total N content.

within the variable averages among treatments or different samples.

RESULTS AND DISCUSSION

Chemical and physical properties were compared between the ERHs and the CSM to see improvement of ERH texture as a seedling medium according to the increased expansion degrees (Table 1). The pH of the ERHs ranged from 6.3 to 6.8, which were higher than the optimum pH range 4.5 to 5.5. The EC increased after the rice husks expanded. There were statistically no differences among the media for the T-N. The water potential increased as the degree of expansion increased from ERH 4 to 1. The particle size distributions of the ERHs were compared with those of the CSM and rice husk (Fig. 2). As the degree of expanding rice husk increases from ERHs 4 to 1, the particle size decreases. However, the particle size distributions of the ERHs showed higher percentages at 2.0 to 1.0 mm and lower percentages at < 1 mm than those of the CBM. When changes of water absorption heights as a function of time were examined (Fig. 3), the water absorption heights increased in general as the degree of expansion increased. The ERH 1 was similar to the CSM for the water absorption curve.

Water absorption characteristics of seedling media are one of the most important factors affecting plant seedling growth. Although the values of water potential could generally represent those for other media, these would not be used for ERH that shows irregular particle shapes. Because of possible measurement errors that might be caused by these (Lee, 1996; Kim *et al*, 2000), the water absorption heights of the media are thought to be more reliable. We believe that the result of these would represent the water absorption characteristics, which would be improved as the degree of expansion increases (Fig. 3).

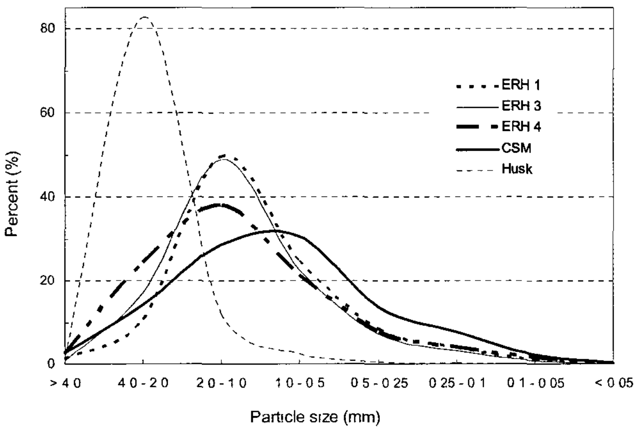

Fig. 2. Distributions of particle sizes for each media

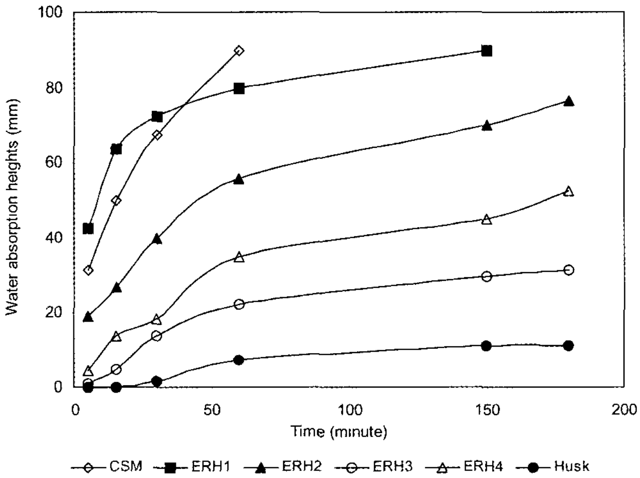

Fig. 3. Changes of water absorption heights according to time change for the different seedling media.

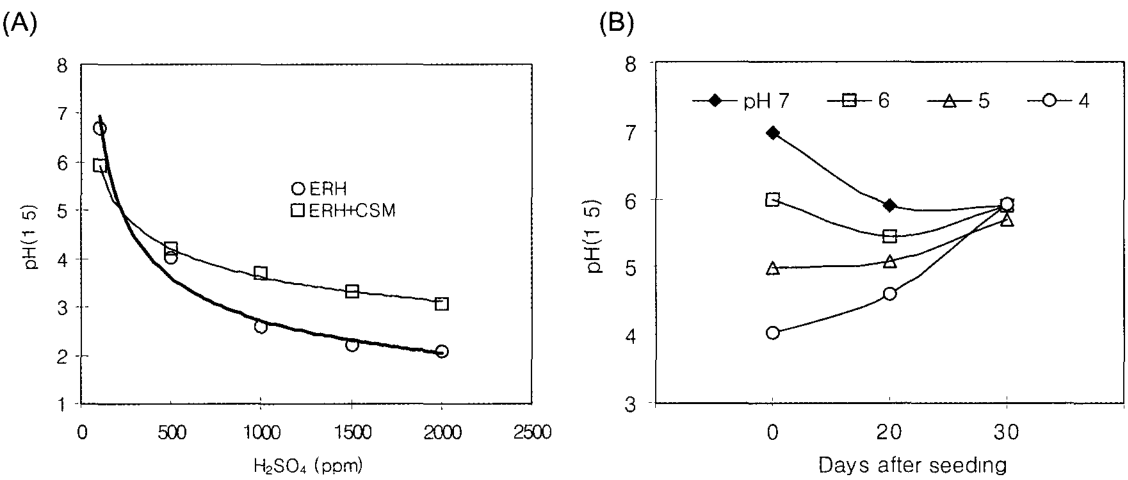

Fig. 4. (A) pH control using H_2SO_4 and (B) pH changes after seeding.

Table 2. Seedling growths at 20 days after seeding.

Media	Plant height (cm)	Leaf number ($plant^{-1}$)	Dry weight (mg $plant^{-1}$)	Maturity† (%)	Mat formation‡
CSM	15 9 a	2.8 a	19.7	96.0	1
Rice Husk	13.1 b	2.3 c	14 4	95.7	5
ERH 1	13.4 b	2.4 bc	15 6	95.0	2
ERH 2	13.3 b	2.6 b	17.1	94.7	2
ERH 3	13 4 b	2.4 c	15.3	96 0	3
ERH 4	14.6 ab	2 7 a	15 2	95.0	4

†Maturity was determined using the percentage of normal seedlings to total seedlings.
‡Degree of mat formation: 1· very good, 2: good, 3: normal, 4· poor, 5. very poor.

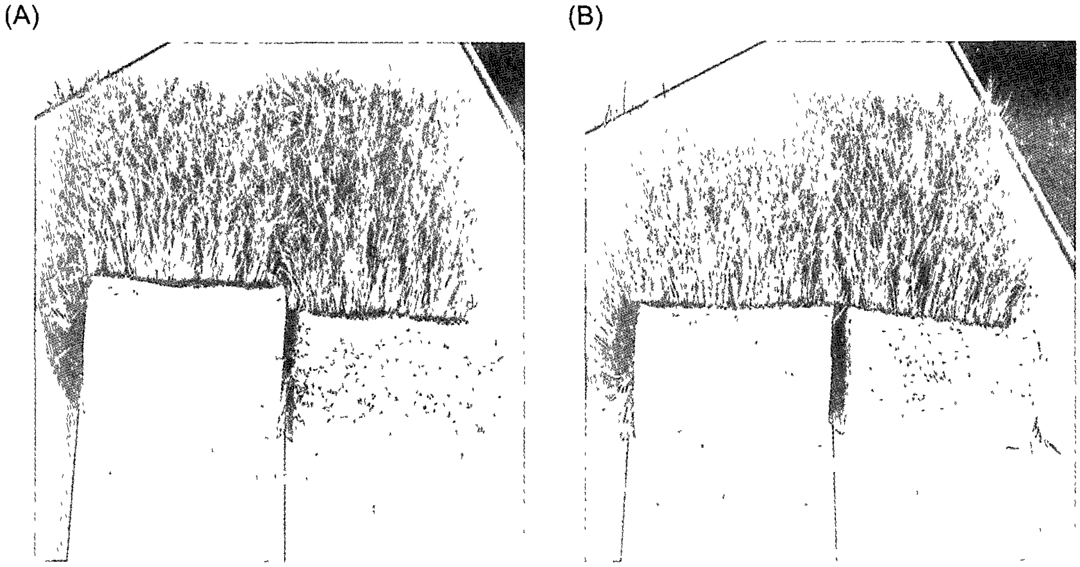

Fig. 5. Mat formation and root distribution (20 days after planting)· (A) CBM (left) and ERH 4 (right), (B) ERH 1 (left) and ERH 2 (right).

Rice seedlings compete among themselves for nutrients since the seedlings are densely planted in the seedling tray. This can cause reduced plant growth when the temperature changes markedly between day and night. In order to reduce the chance of exposure that results in inhibition of plant growth, pH control is required. The pH of the ERH can be reduced from 6-7 to the optimum level by applying 300-400 ppm of H_2SO_4 (Fig. 4 A). When the changes of the pH were monitored over 30 days after planting, the range of the pH values were modified to around 6 (Fig. 4 B).

There were no significant differences among the different ERH-treated plants in their heights, true leaf numbers, seedling dry weights, and percentage of maturity (Table 2). However, root mat formation was poor in the seedling trays with the ERH 3 and 4 media (Fig. 5 A). Poor mat formation causes the rice seedlings to be transplanted with occasional missing hills and floating seedlings in the field. Kim *et al.* (2000) reported that the growth of tomato roots in the ERH media was inferior compared with the Perlite medium. It is suggested that allelochemicals from ERH media influence the poor root growth. According to Ko (1998), rice husk extracts from various rice varieties inhibit germination of other plants but do not have autotoxicity in germinating rice seed itself. However, there have not been studies for autotoxicity to the root growth of rice seedling by rice husk extract. To clarify this, therefore, further studies will be required.

The purpose of this study was to test the possibility of improving rice seedling growth by improving the texture of ERH. As expansion rate of rice husk increases, the texture of ERH could be improved. As the previous studies represented (Kim *et al*, 2003), it is obvious that using ERH as a seedling medium can save farmers labor in the process of seedling cultivation because of the light medium weight. This study shows that rice seedlings grown in the ERH medium and the CSM have no significant difference, indicating the ERH medium may potentially replace the CSM. We hope that the result of this study can provide information for researchers and farmers about the chemical and physical properties of ERH and lay a foundation to develop a rice seedling medium using ERH.

ACKNOWLEDGEMENT

The authors would like to thank research assistants at Kangwon Agricultural Research and Extension Services for their help to collect data and Dr. Maas for his review on this manuscript.

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