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Germination and Seedling Growth Affected by Seed Specific Gravity

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ABSTRACT The amount of salt to make seed sorting solution of the specific gravity of 1.13 was reconsidered and determined as 3.8 kg salt in 18 L water, which is lower amount than currently used. Five rice cultivars were examined. Percent germination and seedling emergence were not similar. Seedling emergence rate of Japonica varieties, Nampyungbyeo and Daerypbyeo-1 were 87% and 95% under specific gravity of 1.13, respectively. Seedling emergence rate of Tongil type variety, Dasanbyeo was as high as 67% in specific gravity of 1.06. Seedling emergence rate of waxy rice, Hwasunchalbyeo and Aranghangchalbyeo were examined. Seedling emergence rate was 94% in both cultivars in specific gravity of 1.04. Seedling emergence rate was same in specific gravity of 1.08 which is generally used for selecting seed currently. Early growth (plant height, leaf number, and dry weight) were not significantly different by specific gravity within species. In all cultivars except waxy rice, highest seedling emergence rate was observed in specific gravity of 1.13 which is currently used for selection and decreased as specific gravity is lowed. However, considering total amount of seeds in each group of specific gravity, amount of seed in lower specific gravity group is relatively small and total seedling emergence rate within variety dose not show big difference. However, if seeds with low speicific gravity are produced due to the bad grain filling condition and consequently total seed content of low specific gravity increases, results will be differnt. Reduction in total growth and yield could occur. It will be important to comply with the seed sorting criterion of 1.13 for Japonica, 1.06 for Tongil, and 1.04 for waxy rice variety to ensure the maximum rice growth and yield.

Keywords : rice seedling, seedling emergence rate, rice, sorting by specfic gravity

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Seed germination and seedling emergence are essential plant developmental process (Willenborg *et al*., 2005). Rice cultivars with strong seedling vigor are desirable for crop establishment. Germination, seedling emergence and early growth of seedlings are major parameters for seedling vigor (Cui *et al*., 2002). The positive influence of early seedling vigor on yield potential has been reported (Richards, 1987). Effect of seed size on germination and subsequent seedling emergence has been studied and documented in various crop and weed species (Johnson and Leudders, 1974; Gan and Stobbe, 1996; Smart and Moser, 1999; Willenborg *et al*., 2005). Seed size seems to strongly affect to germination, seedling emergence, development, and seedling biomass (Lafond and Baker, 1986; Mian and Nafziger, 1994; Aparicio *et al*., 2002). However, results from those studies are not consistent, varying among species. (Kawade *et al*., 1987; Aparicio *et al*., 2002; Larsen, S. U. and C. Andreasen, 2004). Increased germination percentage and emergence with increasing seed mass has been reported in pearl millet (*Pennisetum glaucum* L.), perenial rye grass (*Lolium perenne* L.), and Kentucky bluegrass (*Poa pratensis* L.) (Kawade *et al*., 1987; Larsen and Andreasen, 2004). The contrasting results have been also document in wheat and rice. It was concluded small seed germinated eariler and more rapidly in wheat and rice (Roy *et al*., 1996; Lafond and Baker, 1986). While Lafond and Baker(1986) did not found a seed size effect on final percent germination, Roy *et al*.(1996) reported that large rice seed had higer final germination percentage, although large seed seemed slower to initiate germination. Parameters determining seed size were used inconsistently among those studies. Little is known about the effect of seed size on the germination of various rice cultivars. Both rapid and complete germination are critical for the establishement of crop yield. Seed size was referred as weight, length, volume, or diameter, but weight and length are most common determinant of seed size. Sorting of rice seeds has routinely been conducted according to seed specific gravity by soaking seeds in salt-containing solution, and seeds with specific gravity higher than 1.13 are selected for sowing. It is well known and educated to dissolve 4.5 kg of salt in 18 L of water to produce seed sorting solution which makes specific gravity be 1.13. However, studies concerning the seed specific gravity effect on germination and seedling emergence and development, and hence early seedling vigor have not established.

The objective of this study was to investigate the seed specific gravity related to the early seedling vigor. Glasshouse and growth chamber experiments were conducted on five different cultivars, which were chosen to cover a wide range of variability.

MATERIALS AND METHOD

Plant Materials

Five rice (*Oryza sativa* L.) varieties were used for germination and early growth experiment: two japonica varieties (Nampyungbyeo and Daerypbyeo-1Ho), one Tongil type (derived from japonica) variety (Dasanbyeo), and two waxy rice varieties (Hwasunchalbyeo and Aranhangchalbyeo). All seeds used in this report were obtained from plants harvested in previous year.

Seed specific gravity

All seeds were sorted with water then wind dried prior to experimental use, so that all seeds were above specific gravity of 1.00. Five each variety, seeds were classified into three groups according to specific gravity. The grading size (i.e. the specific gravity of the seed) of three groups of seeds were 1.00~1.06 for SG1, 1.06~1.13 for SG2, 1.13~ for SG3 for varieties of both Japonica and Tongil type and 1.00~1.04 for SG1, 1.04~1.08 for SG2, 1.08~ for SG3 for varieties of waxy rice. Salt solutions used for seed sorting contained 68, 96, 137, and 212 g NaCl per 1 L water to make their specific gravity of 1.04, 1.06, 1.08, 1.13, respectively (Table 1). One hundred seeds per each specific gravity per each variety with four replicates were used for each experiment.

Seed germination

For quick sterilizing seeds were soaked in ethanol for two minute, then in 5% sodium hypoclorite 30 minute and rinsed with running tap water for one hour. After sterilization, seeds were placed in 9 cm petri dishes with one Whatman No.1 filter paper saturated with distilled water. All petri dishes were covered and placed in an incubator at 30℃. One hundred seeds per dish were used for each specific gravity group. Seeds were considered to have germinated when their axes had broken through the hull. Seed germination rate 5days after soaking was calculated as the percentage of seed that were germinated.

Seedling emergence and early growth

Seeds were soaked in 0.05% proraz solution for 24 hours and in fresh tap water for two days for germination, and seeds were sown on seedling trays. Seedling trays were placed in a growth chamber at 30℃ for two days and under the shadow for two days for greening. Seedling trays were then moved to a glasshouse at 24℃ for growing. In fifteen days seedling emergence rate was calculated and plant height, number of leaflet, and individual plant dry weight were measured. Experimental design was a randomized complete block with four replicates.

RESULTS AND DISCUSSION

Seed sorting with salt water has been currently conducted by soaking seeds in solution of specific gravity 1.13. To make this solution in general, 4.5 kg of salt are dissolved in 18 L of water. However, this experiment confirmed only 3.8 kg of salt are needed to make solution of specific gravity 1.13. Therefore, it is considered that salt solution currently used for seed sorting is above specific gravity 1.13. With

Table 1. The amount of salt dissolved in each solution with different specific gravity (g/1 L H_2O).

Specific gravity	1.04	1.06	1.08	1.13
Amount of Salt (g)	68	96	137	212

this result, salt could be saved and more seeds will be used for seeding and good enough to develop healthy seedlings.

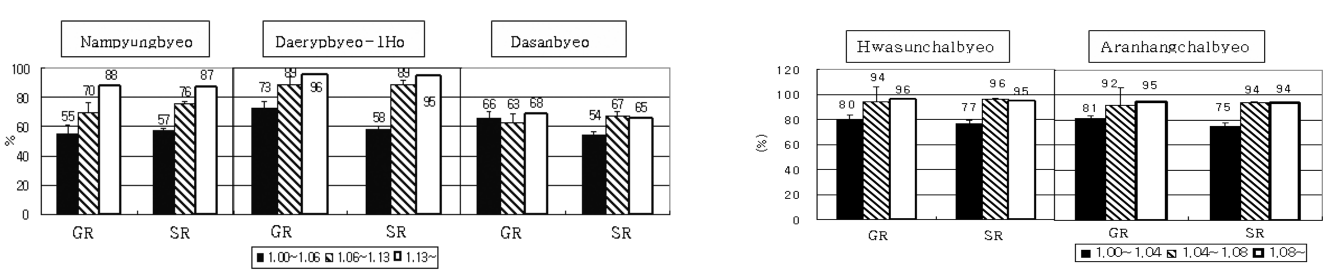
Table 2 shows the percentage proportion of seed amount contained in each specific gravity group. The amount of seeds in specific gravity of 1.00~1.06 is 6% of total seeds which used for salt selection in Nampyungbyeo. Thirty eight percent of total seeds are belonged to specific gravity of 1.06~1.13 and 56% of total seeds are above specific gravity of 1.13 whish is current selection criterion for seeding. In Daerypbyeo-1, 5% and 17% of total seeds are belonged to specific gravity of 1.00~1.06 and 1.06~1.13 respectively. Seventy six percent of total seeds are above specific gravity of 1.13, which is larger amount of seeds are using for seeding than Nampyungbyeo. Tongil variety, Dasanbyeo, currently is seeding with seeds above specific gravity of 1.06. Seeds amount less than specific gravity of 1.06 is 15% of total seeds that are used for selection. Eighty five percent of total seeds are over specific gravity of 1.06. Specific gravity of 1.08 is currently used for waxy rice varieties seeding selection. In Hwasunchalbyeo, 20% of total seeds are in specific gravity 1.00~1.04, 77% are in 1.04~1.08, and only 3 % of total seeds are above 1.08 of sorting criterion. In Aranhangchalbyeo, 8% and 62% of total seeds are belonged to specific gravity of 1.00~1.04 and 1.04~1.08 respectively. In Aranhangchalbyeo, only 30% of total seeds are above specific gravity of 1.08 which is current sorting criterion.

Germination rate, seedling rate, and early seedling growth were investigated as dependent on specific gravity in each variety (Figure 1A and 1B). No difference has been observed between germination rate and seedling rate by seed specific gravity, which means that once seeds germinated, they all developed to adult seedlings. In all varieties, it has been observed that seeds with higher specific gravity have higher germination rate and seedling rate and highest germination and seedling rate occurred in the specific gravity of current selection criterion. In waxy rice varieties, Hwasunchalbyeo and Aranhangchalbyeo, it is apparent that germination rate and seedling rate of specific gravity 1.00~1.04 are lower than others. However, there was no difference in germination rate and seedling rate between specific gravity 1.04~1.08 and

Table 2. Percentage of seed amount in different specific gravity groups

Variety		Percentage of seed amount (%)		
		1.00~1.06	1.06~1.13	1.13~
Japonica	Nampyungbyeo	5.6	38.3	56.1
	Daerypbyeo-1Ho	4.6	16.8	78.6
Tongil	Dasanbyeo	14.5	53.9	31.6

Variety		Percentage of seed amount (%)		
		1.00~1.04	1.04~1.08	1.08~
Waxy rice	Hwasunchalbyeo	20.5	76.6	2.9
	Aranhangchalbyeo	8.4	62.2	29.4



(A) (B)

Fig. 1. Germination rate (GR) and seedling rate (SR) dependent on specific gravity (A) in Japonica type and Indica type of rice varieties and (B) in Waxy rice varieties

above 1.08 which is a current sorting criterion. No significant difference has been observed in plant hight, number of leaf, and individual dry weight according to specific gravity (Table 3).

Total seedling rate of each variety has been estimated and compared with seedling rate of each specific gravity (Table 4). Seedling rate of specific gravity of over 1.13 was highest as 87% and estimated total seedling rate of specific gravity over 1.00 (with pure water selection) was 81% in Nampyungbyeo. In Daerypbyeo-1, seedling rate of specific gravity over 1.13 was also highest as 95% and estimated total seedling rate of specific gravity over 1.00 was also high as 92%. Tongil variety, Dasanbyeo shows the highest seedling rate in specific gravity over 1.06 as 67%. Estimated total seedling rate of specific rate over 1.00 was 65%, which was similar level as highest group. In waxy rice varieties, Hwasunchalbyeo shows similar seedling rate in specific gravity of 1.04~1.08 and in specific gravity over 1.08 as 96% and 95% respectively. Estimated total seedling rate of specific gravity over 1.00 was 92%. In Aranhangchalbyeo, seedling rates in specific gravity of 1.04~1.08 and in specific gravity over 1.08 were the same as 94%. Estimated total seedling rate of specific gravity over 1.00 was 92%. It could be considered that sorting and seeding only specific gravity over 1.00 with water sorting without salt do not affect much on seedling rate and early seedling growth in this experimental condition. However, if seeds with low speicific gravity are produced due to the bad grain filling condition and consequently total seed content of low specific gravity increases, results will be differnt. Reduction in total growth and yield could occur. It will be important to comply with the seed sorting criterion of 1.13 for Japonica, 1.06 for Tongil, and 1.04 for waxy rice variety to ensure the maximum rice growth and yield.

CONCLUSIONS

The amount of salt needed in 18 L water to make seed sorting solution of specific gravity over 1.13, the current sorting criterion for Japonica type rice seeding was confirmed as 3.8 kg which is less than currently recommended

Table 3. Early seedling growth, plant height (cm), number of leaf, and individual dry weight per one seedling (mg) dependent on specific gravity in Japonica type, indica type, and waxy rice varieties

Variety		Growth Index	Specific Gravity		
			1.00~1.06	1.06~1.13	1.13~
Japonica	Nampyungbyeo	Plant Height (cm)	25.0	26.4	26.1
		Number of leaf	4.1	4.1	4.1
		Plant dry weight (mg/plant)	28	28	31
	Daerypbyeo-1	Plant Height (cm)	26.0	30.7	32.0
		Number of leaf	3.9	4.1	4.1
		Plant dry weight (mg/plant)	29	37	43
Tongil	Dasanbyeo	Plant Height (cm)	22.5	23.8	23.5
		Number of leaf	3.9	3.9	3.9
		Plant dry weight (mg/plant)	33	33	36

Variety		Growth Index	Specific Gravity		
			1.00~1.04	1.04~1.08	1.08~
Waxy rice	Hwasunchalbyeo	Plant Height (cm)	21.7	26.6	26.6
		Number of leaf	4.3	4.5	4.4
		Plant dry weight (mg/plant)	29	32	32
	Aranhangchalbyeo	Plant Height (cm)	25.3	28.1	24.7
		Number of leaf	4.1	4.2	4.1
		Plant dry weight (mg/plant)	29	31	28

Table 4. Total seedling rate of each variety estimated as sum of seedling rate of each specific gravity in variety

Variety		[1]SG	[2]ETNG	[3]SR	[4]ETNS	[5]TNS/TNG (%)
Japonica	Nampyungbyeo	1.00~1.06	2,762	0.57	1,574	3.16
		1.06~1.13	19,115	0.76	14,527	29.14
		1.13~	27,980	0.87	24,343	48.83
		Total	49,857		40,444	81.12
	Daerypbyeo-1	1.00~1.06	1,701	0.58	987	2.68
		1.06~1.13	6,165	0.89	5,487	14.92
		1.13~	28,907	0.95	27,462	74.68
		Total	36,773		33,936	92.29
Tongil	Dasanbyeo	1.00~1.06	7,871	0.54	4,250	7.85
		1.06~1.13	29,181	0.67	19,551	36.10
		1.13~	17,108	0.65	11,210	20.70
		Total	54,160		35,011	64.64
Waxy rice	Hwasunchalbyeo	1.00~1.04	10,756	0.77	8,282	15.76
		1.04~1.08	40,245	0.96	38,635	73.51
		1.08~	1,553	0.95	1,475	2.81
		Total	52,554		48,392	92.08
	Aranhangchalbyeo	1.00~1.04	8,210	0.75	6,158	6.27
		1.04~1.08	61,037	0.94	57,375	58.44
		1.08~	28,930	0.94	27,194	27.70
		Total	98,177		90,727	92.41

[1]SG; Specific Gravity, [2]ETNG; Estimated Total Number of Grains, [3]SR; Seedling rate,
[4]ETNS; Estimated Total Number of Seedlings,
[5]ETNS/ETNG (%): Percent Seedling developed

salt amount of 4.5 kg. For Tongil type rice seed, it is currently used solution with specific gravity of 1.06, in turn to make this sorting solution, 1.7 kg of salt are needed in 18 L of water. Current sorting criterion for seeding of waxy rice is specific gravity above 1.08 and the amount of salt needed to make seed sorting solution is calculated as 2.5 kg in 18 L of water. Japonica type and Indica type of rice showed the highest seedling rate in current selection criteria, which is specific gravity above 1.13 and 1.06 respectively. However, the reduced sorting specific gravity above 1.08 to 1.04 did not make any changes in seedling rate. It will be more economic to use new selection criterion for seeding in waxy rice varieties as 1.04.

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