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RELATION OF SPECIFIC GRAVITY TO VIGOR AND VIABILITY IN RICE SEED[1/]

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Rice is the staple food crop for about half of the world's population. Demands for greater productivity of rice brought about by rising standards of living and ever increasing population pressures in countries of the East where it is the predominant crop, have made it one of the most intensively cultivated crops. Agriculturalists and farmers in these countries have become aware of the importance of using good seed in advancing agricultural production. In some respects, they are even more aware of the importance of good seed than are farmers in the more agriculturally developed countries.

Prior to planting, the farmers in Taiwan, Japan and to some extent in other countries of the East, use a flotation method to separate the light seed from their planting stock. In practice, rice seed are placed in a solution of ammonium sulfate adjusted to 1. 13 specific gravity. Only the seeds which sink in the solution and thus are heavier than 1. 13 in specific gravity are used for planting purposes. The ammonium sulfate solution is then used as a liquid fertilizer for the rice crop. This practice is not something new; it has long been used. The work of Tseng and Lin (11) illustrates the importance of this practice. They reported that in Taiwan an average of about 25 percent of the certified rice seed was lighter than 1. 13 in specific gravity and thus discarded by farmers in the flotation process. Yet, all of the seed were within the definition of "pure seed" as used by seed laboratories in North America and Europe. They found that seed above 1. 13 in specific gravity produced earlier, stronger and more uniform seedlings than did seed 1. 13 or lighter in specific gravity. Seedlings from heavy seed also tillered more rapidly and produced more and larger panicles and more and heavier grain than did seedlings from light seed. In this country, Finfrock (2) has suggested that in addition to germination, rice growers should consider individual seed weight as a criterion of seed quality. Several investigators (4, 5, 7, 8, 9, 10, 12) have found a close relationship between seed weight or specific gravity and seedling vigor in crops other than rice. Others have used flotation methods to separate inert material from seed (3, 8).

The objective of this study was to determine the effect of seed specific gravity on some common indices of rice seed quality.

Materials and Methods

One hundred pounds of seed from each of three rice varieties, Nato, Belle Patna, and Bluebonnet 50, were obtained from the Delta Branch Experiment Station, Stoneville, Mississippi. The seed were taken direct from the combine without further processing or cleaning. They were then stored for several months in a cold room, after which samples were drawn from each lot and a purity analysis made. Seed from the pure seed fraction were then separated into six classes based on specific gravity.

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Specific gravity separations were accomplished by using ammonium sulfate solutions adjusted to the following specific gravities: 1.00 (water); 1.05; 1.10; 1.13; 1.16; and 1.20. One hundred grams of seed were placed in the solution of 1.20 specific gravity (the highest), and those seed which sank were removed, washed and recorded as having a specific gravity greater than 1.20; the seeds which floated were also removed and placed in the solution with the next highest specific gravity (1.16). Again the seeds which sank were removed, washed and recorded as having a specific gravity of 1.16; those which floated were transferred to the solution with the next highest specific gravity (1.13), and so on. After separation and washing, the seed were dried under conditions of low relative humidity (10 to 20 percent) at room temperature.

Four replicates of 50 seed from each specific gravity class were planted on paper towels, the towels were rolled into a cylinder and placed at a 45° inclination in a 30° C. dark germinator. Growth of the radicle and plumule was measured daily for eight days. Germination tests were made according to methods specified in the Rules for Testing Seed (1) except that a germination temperature of 30° C. was used.

In another study, the specific gravity classes were re-combined into three general groups: light (less than 1.10); medium (1.10 to 1.16); and heavy (greater than 1.16). Four replicates of 50 seed each were then planted 1.5 inches deep in a mixture of clay loam, sand, and peat and placed under greenhouse conditions. After 25 days, percentage emergence was determined and then the seedlings were cut at the soil surface for green and dry weight determinations. Dry weights were determined after drying the seedlings at 100° C. for 24 hours.

Results and Discussions

The percentages of combine-run rice seed in various specific gravity classes are shown in Table 1. The seed lots differed considerably with respect to the proportions of seed in each specific gravity class. Only about 4.5 percent of the seed of Belle Patna had a specific gravity of 1.13 or less while almost 17 percent of the seed of the Nato variety were 1.13 or below in specific gravity. In comparison, Tseng and Lin (11) reported that on the average 25 percent of the certified seed rice harvested in Taiwan was below 1.13 in specific gravity. Although the number of samples involved are not sufficient to support broad generalizations, it appears that the combine is relatively efficient in separating light, immature seeds as compared to the hand harvesting and processing methods employed in Taiwan. Undoubtedly, the seeds below 1.13 specific gravity would have been almost entirely eliminated had the seeds been processed with conventional processing equipment.

Germination percentage was closely related to specific gravity of the seed (Table 2). In general, germination percentage increased with increasing specific gravity up to 1.14. Seeds with specific gravity of less than 1.00 had germination percentages ranging from 48 to 67 percent. Length of the radicle and plumule after eight days was even more closely related to specific gravity (Table 3). The greater the specific gravity of the seed the greater the length of the radicle or plumule at the end of the eight day period. Total seedling length of the Belle Patna variety after three, five and seven days is shown in Figure 1. It is evident that the superiority of the heaviest seed was maintained throughout the germination period. It was also observed that seed from the heavier specific gravity classes produced stouter seedlings that were relatively freer of molds than did seed from the lighter specific gravity classes.

When the seeds were planted in soil under greenhouse conditions, the superiority of the heavy seed was even more apparent than in the laboratory (Table 4). An average of only 58 percent of the light seeds (less than 1.10 in specific gravity) emerged as compared to a 76 percent laboratory germination for the same class of seed. Emergence of the other two classes, particularly the medium class, was also less in the greenhouse than in the laboratory.

The total green and dry weight of the seedlings produced by 50 planted seeds also increased as specific gravity increased (Table 5). This, however, was to be expected since emergence percentage also increased with specific gravity of the seed. When the green and dry weights per emerged seedling were calculated, there was a statistically significant difference only in average green weight per seedling among the specific gravity classes. Thus, it appears that main vigor differences among the specific gravity classes were manifested in percentage emergence rather than in growth characteristics of the emerged seedlings. These results can, probably, be attributed to the rather severe conditions of the greenhouse tests. In those countries where light seed in rice are a problem, the transplant method of culture is used. The seeds are pre-soaked for 1 to 3 days and then planted on carefully prepared seed beds. They are then covered lightly with compost. Such conditions tend to favor the emergence and development of light seed of low vigor.

Although there was little difference in green and dry weight of the seedlings that did emerge from the three specific gravity classes, it was noted that the seedlings produced by the light seed were generally yellowish or chlorotic in contrast to the bright green seedlings produced from seed medium to high in specific gravity.

It appears from the results of these limited experiments that seed vigor in rice in terms of rate of emergence and seedling growth under laboratory conditions, and percentage emergence in the greenhouse, is closely related to specific gravity of the seeds. Further, under the highly mechanized system of rice seed harvesting and processing in this country, the "light" seed do not constitute as significant a proportion of the seed as is the case in countries where hand harvesting and processing is practiced.

The classification of light seeds of rice (less than 1. 13 in specific gravity) constitutes a unique problem in seed testing laboratories in those Eastern countries where farmers use the flotation method of separating their planting seed. The current concept of "pure seed" used in the agriculturally developed countries of North America and Europe has relatively little meaning in their situation, for the fact that a particular seed lot has a pure seed percentage of 99. 5 means almost nothing. Since the seeds are hand harvested and almost completely free of weed seed or other crop seed most lots have a pure seed percentage of 99 or better. What is most important is the percentage of seed remaining after the farmer has floated off the seed lighter than 1. 13 in specific gravity. As previously indicated, on the average about 25 percent of the rice seed in Taiwan are lighter than 1. 13 in specific gravity. Individual lots, however, vary considerably; some lots may contain as many as 75 percent light seeds while others contain as few as 5 percent light seed. It would appear that in such countries an additional quality factor of rice seed must be evaluated, viz., the percentage of seeds in the sample that sink in a solution of 1. 13 specific gravity.

Agriculturalists in undeveloped countries are aware of the importance of a sound seed improvement program in advancing agricultural production. They are also rapidly becoming aware of the important position occupied by seed testing in the overall seed improvement program, as evidenced by the considerable number of trainees from undeveloped countries studying seed improvement in this country. It is, therefore, incumbent upon seed technologists who have occasion to serve as instructors in seed training programs to familiarize themselves with the problems of the participants. It must be recognized that our methods and concepts do not always provide solutions to their problems.

Summary

The vigor of rice seed in terms of percentage germination, rate of germination and seedling growth in the laboratory, and percentage emergence from soil under greenhouse conditions was closely related to the specific gravity of the seed. Seeds with a specific gravity higher than 1. 13 were distinctly superior in all characteristics measured to those 1. 13 or less in specific gravity.

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Table 1. Percentages by weight of combine-run rice seed in various specific gravity classes.

	Specific gravity			
Variety	< 1.10	1.11-1.13	1.14-1.16	> 1.16
Belle Patna	4.30	0.13	4.02	91.55
Nato	10.37	6.59	12.88	70.16
Blue Bonnet 50	6.84	4.86	3.96	84.34

Table 2. Germination percentages of rice seed in various specific gravity classes.

	Specific gravity						
Variety	<1.00	1.01 -1.05	1.06 -1.10	1.10 -1.13	1.14 -1.16	1.17 -1.20	> 1.20
Belle Patna	56.8	91.8	91.8	96.8	98.2	96.8	96.8
Nato	48.2	76.8	86.8	78.2	95.0	91.8	95.0
Blue Bonnet 50	66.8	83.2	93.2	96.8	100.0	100.0	100.0

Table 3. Average Length (mm.) of the radicle and plumule of rice seedlings from various specific gravity classes after 8 days at 30° C.

		Specific gravity						
Variety		< 1.00	1.01 -1.05	1.06 -1.10	1.11 -1.13	1.14 -1.16	1.17 -1.20	> 1.20
Belle Patna	P[a]	26.0	34.1	34.9	38.6	39.7	41.7	45.1
	R[b]	68.9	82.8	79.0	93.7	99.9	107.5	111.7
Nato	P	15.7	21.5	23.8	27.0	30.6	31.0	32.1
	R	41.5	49.1	41.0	49.2	56.0	61.9	66.8
Blue Bonnet 50	P	27.0	25.9	33.4	34.5	35.7	40.2	42.5
	R	70.2	73.4	88.6	88.1	93.1	103.4	114.1

[a]Plumule
[b]Radicle

Table 4. Comparative emergence and germination percentages of rice seed in various specific gravity classes in the greenhouse and laboratory.

	Specific gravity					
	Light[a]		Medium[b]		Heavy[c]	
Variety	Soil	Lab.	Soil	Lab.	Soil	Lab.
Belle Patna	60.5	77.8	80.5	95.8	94.0	96.8
Nato	48.0	71.2	75.0	87.5	90.5	92.2
Blue Bonnet 50	66.0	81.2	87.5	98.2	94.5	100.0

[a]Specific gravity less than 1.10
[b]Specific gravity 1.11 to 1.16
[c]Specific gravity greater than 1.16

Table 5. Average green and dry weight produced by 50 rice seed in various specific gravity classes.

		Specific gravity		
Variety	Weight (grams.)	Light[a]	Medium	Heavy
Belle Patna	Green	1.24	1.92	2.44
	Dry	0.31	0.49	0.59
Nato	Green	1.01	1.73	2.42
	Dry	0.24	0.40	0.54
Blue Bonnet 50	Green	1.45	2.25	2.64
	Dry	0.35	0.52	0.62

[a]See footnotes Table 4.

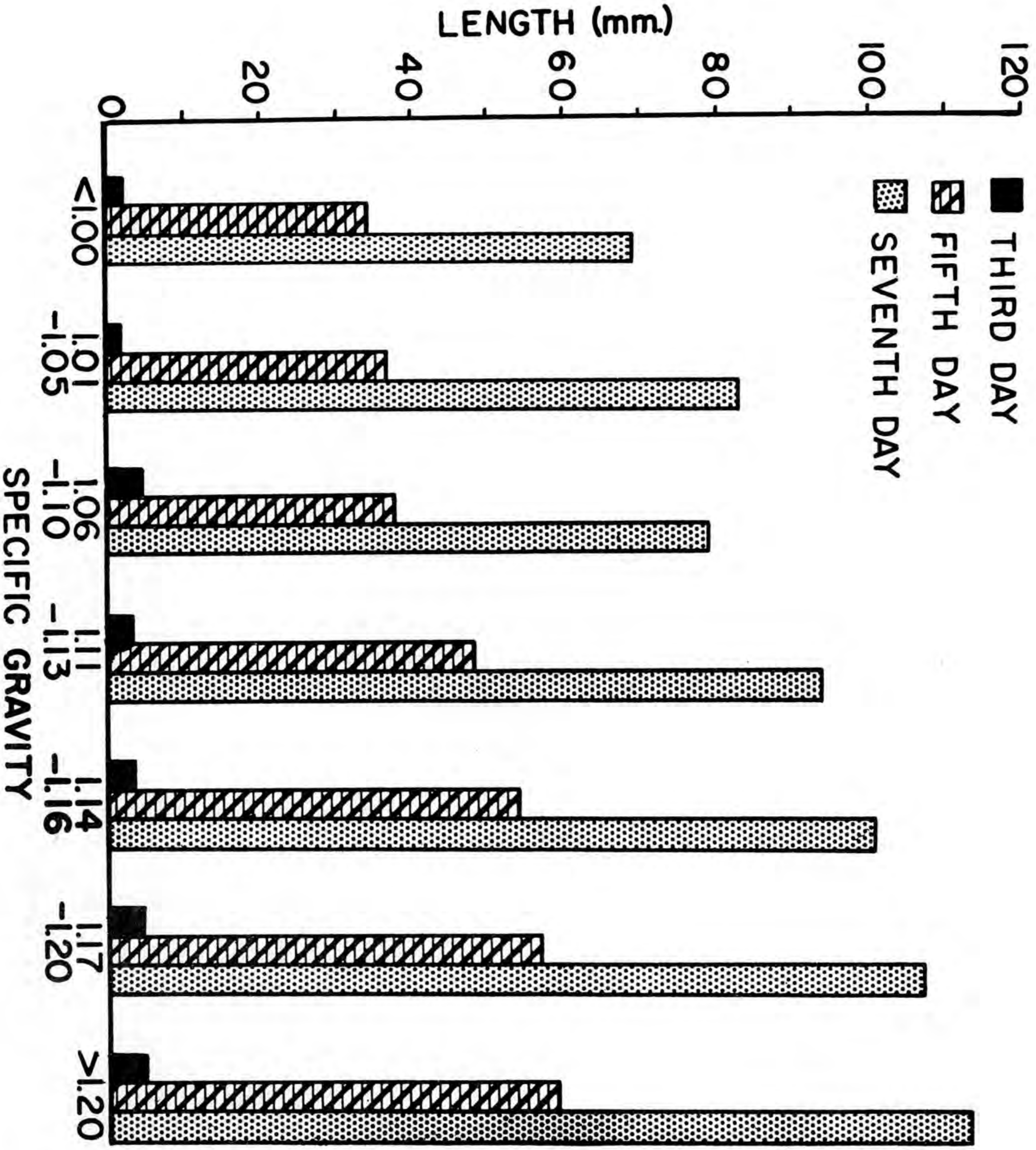

Figure 1. Effect of seed specific gravity on length of Belle Patna rice seedlings after 3, 5 and 7 days at 30^{o} C.