Effect of seeding rate on the growth and quality of rice seedlings in the long-mat seedling culture system

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Abstract

Recently, 'Long-mat Seedling Culture System' (Long-mat System: LS), a new technique for raising rice seedlings hydroponically for modified machine planting was developed aiming at higher efficiency and labor saving in rice production. Because the seedlings raised by LS were partially damaged at the time of machine transplanting, optimal seeding rate for LS was expected to be higher than that by conventional soil-seedbed system (SS). Therefore, the effect of different seeding rate on the growth rate and quality of the seedlings for LS and SS were examined. When LS system at the seeding rate of 200g was compared with the SS system at the conventional seeding rate of 130g, there was no inferiority in the growth and quality of seedlings and also no difference in the growth rate after the transplanting. Therefore adopting higher seedling rate (200g) for LS is recommended.

Media summary

The rice seedlings raised by Long-mat Seedling Culture System, recently developed in Japan, were young and vigorous, resulting in almost same growth with that of conventional seedbed system with soil.

Key Words

Hydroponic LAI Long-mat Rice Seedling

Introduction

The Long-mat seedling culture system (LS) has the advantage that its seedbed weight is much lighter compared with that of conventional seedbed system with soil (SS)(Task et al 1996, 1997). Furthermore, because the seedbed of LS is 10 times longer than that of SS, the former requires only one-tenth seedbed supply to transplanting machine, and therefore, a farmer can accomplish the machine transplanting without any assistants. The LS has now been adopted by the large-scale farmers. However, because the seedbed in the LS raised without soil is softer and more flexible than that of the SS, the seedlings of the former can be injured at the time of machine transplanting, and some seedlings die after the transplanting. Seeding rates of LS should thus be higher (180-200g dry seed weight equivalent to a nursery box of 60x28cm resulting into the planting density of 6-7 seedlings/hill), compared with SS (130-150g dry seed weight equivalent to a nursery box of 60x28cm resulting into the planting density of 3-4 seedlings/hill). However, seeding rate affects the quality of the seedlings and the growth as well. Therefore, we examined the effect of the seeding rate on the growth rate and the quality of the seedlings with an objective of establishing and popularising the LS technology.

Materials and methods

Experiments were conducted by using the hydroponic seedbed device (1.2m) set in the vinyl house at the National Agricultural Research Center (NARC) at Tsukuba in Japan in 2001 and 2002. In 2001, the seeds of rice (*Oryza sativa* L., var. Koshihikari) were sown on May 7, and were hydroponically grown with the continuous-flow solution-culture system with the same principle as Long-mat System. Three seeding rates

(130, 200 and 300g dry seed weight equivalent to a nursery box of 60x28cm) were used. Five days after sowing, commercial fertilizers for hydroponics (Ootsuka No.1 and No. 2, Kentaro (Ootsuka chemical Co.)) were applied. Fertilizers were applied only when the electric conductivity (EC) of the water was higher than +2.5 dS/m, otherwise only the tap water was used. Seedlings were sampled ten days after sowing, followed by sampling at weekly intervals. Plant age in leaf number, shoot length, and shoot dry weight were measured of each sample. Crop growth rate (CGR) at different plant ages was also compared. In 2002, the seeds were sown at the rate of 130g and 200g on May 15, and the measurements were done in the same way as in 2001. However, in 2002, leaf area was also measured for 5 young seedlings and LAI was calculated from that. Seedlings of the SS were analysed in the same way. The seedlings of the LS were repeatedly raised at about two-weeks interval from April until October in 2002 and were planted in the experimental field at NARC, and the dry weight was measured at 3 weeks after each transplanting. Their parameters related to dry matter production in LS were compared with those in SS.

Results

There was no effect of seeding rate on the plant age in leaf number at 10 days after seeding (DAS) in both systems of seedling culture (Table 1). At 16 DAS, however, the plant age in leaf number with the higher seeding rate was lower. For the same seeding rate, the plant age in leaf number with LS was higher than that with SS both at 16 and 24 DAS. It was confirmed, therefore, that the development rate of plant age in leaf number in LS was faster than that in SS. The length of the shoot in LS was smaller than SS at all plant ages in leaf number. In both systems, the higher seeding rate resulted in over-elongated seedlings (>17 cm), especially at 24 DAS (Table 1).

The shoot dry weight in LS was much lighter in comparison with that in SS at 10 DAS. The difference in shoot dry weight between LS and SS became smaller as the plants grew. The seedling age suitable for transplanting in the hydroponics seedling (200g dry seed weight equivalent to a nursery box) was about 16 DAS. The shoot dry weight in LS at this time was about 80% of that in SS (130g dry seed weight equivalent to a nursery box). This result is similar to that observed by Wang et al (1999)(Table 2).

The leaf area in LS was lower in comparison with that in SS (41% and 66% for the 2nd and 3rd leaves, respectively) (Table 3). The LAI increased linearly until 23 DAS, with LAI of some treatments exceeding over 10. After that, the LAI increased slowly for all the treatments. When compared within the same seeding rate, the LAI in LS was lower than that in SS, but LAI in LS at the seeding rate of 200g was the same as that in SS at the seeding rate of 130g (Figure 1). The CGR increased gradually as the plant age in leaf number progressed, reached maximum when the plant age in leaf number reached to 3.0 to 3.5, and then decreased at higher plant age in leaf number for all the treatments (Figure 2). The CGR in LS was lower than that in SS at younger plant age in leaf number, but it reached as high as that in SS at the later stage when the plant age in leaf number was ca. 3.5. The seedling age suitable for transplanting was found to be between 3 and 3.5 plant age in leaf number, at which age the CGR in SS with higher seeding rate (200g) was the same as that in SS at conventional seeding rate (130g).

Finally, the growth of the seedlings raised by the different systems was compared under the field conditions. During the period of 3 weeks after the transplanting, growth rate of the seedlings was well correlated with the average temperature, with no differences between the seedlings raised in LS and SS (Fig. 3). The growth rate after transplanting using LS seedlings was never lower than that using SS, although the shoot dry weight and leaf area of the seedling at the time of transplanting was lower in LS system.

Table 1. Plant age in leaf number and length of shoot of LS and SS in 2001.

Type	Seeding rate	Plant age in leaf number	Length of shoot (cm)

	(g/28cmx58cm)	10 days	16 days	24 days	10 days	16 days	24 days
LS	80g	2.4	3.7	4.2	3.9	8.8	15.7
	130g	2.3	3.5	4.0	4.0	9.2	15.0
	200g	**2.3**	**3.4**	**4.0**	**4.0**	**9.9**	**15.0**
	300g	2.4	3.1	4.0	4.4	9.9	17.5
SS	80g	2.3	3.2	4.0	4.7	11.2	16.4
	130g	**2.4**	**3.1**	**3.9**	**5.0**	**11.4**	**15.6**
	200g	2.4	3.0	3.7	6.3	10.4	17.2
	300g	2.4	3.0	3.4	6.0	10.7	17.3

Table 2. Shoot dry weight and ratio of LS and SS in 2001.

Type	Seeding rate	Shoot dry weight (g/100plant)			Ratio		
	(g/28cmx58cm)	10 days	16 days	24 days	10 days	16 days	24 days
LS	80g	0.27	0.76	1.26	61	82	102
	130g	0.27	0.74	1.04	61	80	85
	200g	**0.26**	**0.72**	**0.97**	**59**	**77**	**79**
	300g	0.28	0.68	0.85	64	73	69
SS	80g	0.43	1.03	1.47	98	111	120
	130g	**0.44**	**0.93**	**1.23**	**100**	**100**	**100**
	200g	0.50	0.83	1.10	114	89	89
	300g	0.42	0.79	0.97	95	85	79

1) Ratio showed the relative value when SS-130g (conventional system) was made 100.

Table 3. The phenotypic characteristics of the seedlings in 2002.

Type	Seeding rate	Plant age in	Length of	Leaf area (mm^2)		
	(g/28x58cm)	leaf number	Shoot (cm)	2nd	3rd	4th
LS	200g	3.2	8.9	24	135	22
SS	130g	3.2ns	12.2**	58**	205**	3
Ratio		100	73	41	66	

1)LB-4 was under growing. 2) The measurements were conducted at 16th day after the sowing. 3) Ratio showed the relative value when SS was made 100.4)**was at 1% significant level.

Fig 1. Comparison of LAI during the seedling growth between LS (solid line and closed mark) and SS (dashed line and open mark) in 2002.

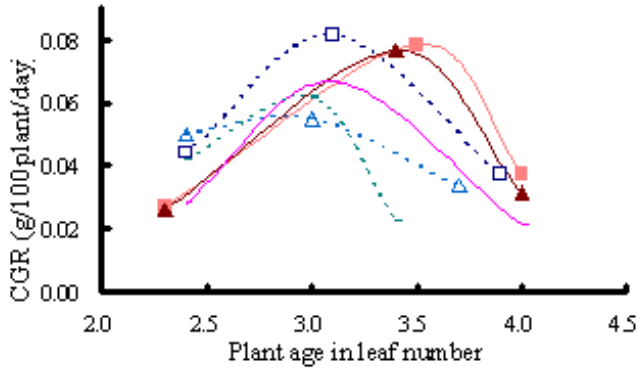

Fig 2. Comparison of CGR during the raising of seedlings between LS (solid line and closed mark) and SS (dashed line and open mark) in 2001. Seeding rate; square: 130g, triangle: 200g, bar: 300g.

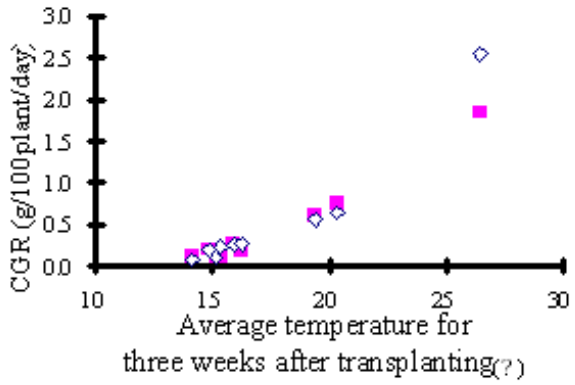

Fig 3. Comparison of CGR under the field conditions during the three weeks after transplanting between LS (closed mark) and SS (open mark) in 2002.

Conclusion

It was concluded that when LS system at the seeding rate of 200g was compared with the SS system at the conventional seeding rate of 130g, there was no inferiority in the growth and quality of seedlings. Also, there was no difference in the growth rate after the transplanting between LS and SS systems of seedling cultures.

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