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SEEDBED & SEEDLING MANAGEMENT IN THE IFUGAO RICE TERRACES

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In DS 2003, 2 studies were conducted in Banaue, Ifugao to compare rice growth and yield responses to different seedbed management approaches and seedling ages. The first study used the split-plot design with 3 replications, with 2 varieties (PSB Rc44 and the traditional variety Palawan) as the main plots and 3 seedbed management methods (SM1, SM2, and SM3) as the subplots. In SM1, which was farmer's practice, the seedbed was maintained submerged. In SM2 and SM3, the raised seedbeds were surrounded with canals (20 x 20 cm) maintained moist but aerated. SM2 was protected by a plastic cover to build and maintain a higher temperature inside, and SM3 was prepared with a mixture of soil, carbonized rice hull (CRH), and compost. Pre-germinated seeds were sown in all the seedbeds at 50 grams/m². Two weeks after seeding, seedling shoot height (SH), shoot dry weight (SDW), root dry weight (RDW) and number of seedlings/m² were determined. For SH, SDW, and RDW, 50 seedlings were sampled and seedlings were counted in 3 sampling areas (0.5 x 0.5 m quadrate) in each seedbed. The second study was identical with the first, with 3 seedling ages (SA1, SA2, and SA3) as subplots. Seeding was staggered to coincide with the transplanting schedule: SA1 with 30-day old, SA2 with 45-day old, and SA3 with 60-day old seedlings. Seedlings were raised in farmers' nurseries at a 100-gram seed rate, and were transplanted in plots (3m x 6m) and in rows (20cm x 20cm) at 3 seedlings per hill. At maturity, rice plants were harvested for grain yield and yield components. Results showed that with plastic cover and compost and CRH used, seedling growth improved and germination percentage increased. In SM2, SH was 20.2 cm; SDW, 107.6 mg/plant; RDW, 25.9 mg/plant; and 756 seedlings/m² survived. In SM3, SH was 11.7 cm, SDW 83.5 mg/plant, RDW 22.5 mg/plant; and 620 seedlings survived. In SM1, SH was 9.2 cm, SDW 64.6, RDW 18.7; and 604 seedlings/m² survived. PSB Rc44 had a more pronounced increase of growth rate and seedling vigor. SA1 seedlings were vulnerable to deeper water and GAS damages, and plots planted to SA1 seedlings were replanted twice. SA2 seedlings of Palawan produced more tillers per hill (14), more filled grains (1,373), and more yield (4,358 kg/ha). PSB Rc44 headed 45 days earlier than Palawan and other neighboring rice varieties, thus was totally damaged by rats and birds. Use of plastic cover accelerated seedling growth. Remarkable differences in growth responses to increased temperature of the 2 rice varieties suggest that PSB Rc44 is less adapted to low temperature than Palawan. Vulnerability of younger seedlings to water depth and GAS damage is a disadvantage. Studies are needed to compare young seedlings with accelerated growth with those raised in traditional nurseries.

carbonized rice hull, compost, low-temperature rice, rice terraces, seedbed management, seedling age, temperature of seedbed

INTRODUCTION

Climate, particularly rainfall patterns and temperature regimes, dictates the suitable crops and production systems within a given area. Culturally and agriculturally important, the Ifugao rice terraces (IRT) are located in an isothermic temperature regime where the mean annual soil temperature is expected to be between 18°C and 22°C, and where the mean soil temperatures between the warm and cool months are not expected to vary by more than 5°C due to high elevation. The region is characterized by 7-9 wet months (with 200 mm or more of rainfall per month) and 2-4 dry months (less than 100 mm rainfall) (IRRI 1989).

In the IRT, land resources are limited, rice yield is low, rice production is costly (CECAP and PhilRice 2000), with a single cropping system in medium to high elevations (600 meters above sea level or more), and the limited land resources remain less productive

(Sigari et al 2003). Low temperature and low solar radiation, erratic rains, cultural practices in which rice growth is prolonged to 7-9 months are factors limiting rice yield and intensified cropping. The temperature regime greatly influences not only the growth duration but also the growth pattern of the rice plants (De Datta 1981). The common symptoms of low temperature stress are poor germination, slow growth and discoloration of seedlings, stunted vegetative growth characterized by reduced height and tillering, delayed heading, incomplete panicle exsertion, prolonged flowering period, degeneration of spikelets, irregular maturity, and increased growth duration (Kaneda & Beachel 1974).

In highland areas, farmers mostly grow traditional varieties with a growth duration of 7-9 months. Rice seedlings are raised in submerged plots and in 60-70 days. Delayed seedling growth and use of old seedlings prolong rice growth duration and may adversely affect yield. Older seedlings usually recover more slowly, and tillering ability of rice increases if younger seedlings are used (CECAP & PhilRice 2000). In temperate regions where summer is short, farmers raise seedlings in a plastic-protected seedbed to increase seedbed temperature. In some cases, seedbeds are heated and kept warm. In this way, the farmer can start rice cultivation in the early spring when air temperatures are still below the critical limit for germination and rooting (Yoshida 1981). On another level, in the tropics upland-grown (aerated) rice seedlings have higher starch and protein contents, thus have higher rooting capacity than lowland-grown seedlings (Yoshida 1981).

Unless improved rice varieties tolerant to cool temperature are adopted and appropriate cultural management approaches for accelerated growth and increased yield are employed, the single rice cropping system in which productivity of both rice and the land is low, would remain the only option in the region.

Overall, the current study was carried out to generate seedbed and seedling management techniques to improve growth performance of rice in the Ifugao rice terraces. Specifically the study aimed to (a) quantify the impact of seedbed management on seedling growth and vigor, (b) examine varietal differences for seedling growth responses to seedbed management, and (c) evaluate rice yield and growth responses to different ages of seedlings at transplanting stage.

MATERIALS & METHODS

In 2003 DS, 2 field trials were conducted in Banaue, Ifugao to compare seedling growth responses of rice varieties to different seedbed management approaches and to evaluate the effects of seedling age on rice growth and yield. The first study used the split-plot design with 3 replications, with 2 rice cultivars (PSB Rc44 and the traditional variety Palawan) as the main plots and 3 seedbed management techniques (SM1, SM2 and SM3) as the subplots. In SM1, the farmer's seedbed management practice was employed where the seedbed was submerged. In SM2 and SM3, the raised seedbeds were surrounded with canals (20 x 20 cm), maintained moist but mostly aerated. SM2 was protected by a plastic cover to build and maintain a higher temperature inside. SM3 used a mixture of compost, carbonized rice hull (CRH), and soil. Seeding rate was 50g/m^2 for all the seedbeds. In SM2 and SM3, after seeding, the seeds were covered with a thin layer of CRH.

Two weeks after seeding, shoot height (SH), shoot dry weight (SDW) and root dry weight (RDW) of 50 randomly selected seedlings per seedbed were measured. For survival percentage, seedlings were also counted in 3 sampling areas per seedbed within a 0.5 x 0.5 meter sampling quadrant.

The second study was identical with the first, with the 3 seedling ages – 30-day old (SA1), 45-day old (SA2), and 60-day old (SA3) as the subplots. Seedlings were raised in traditional seedbeds with staggered seeding (15 days interval). Plot size was 3 x 6 meters with planting distance of 20 cm within and between the rows, at 3 seedlings per hill. For the measurement of yield, 10 m^2 and 4 hills from the 4 corners of each plot were harvested from.

RESULTS & DISCUSSION

In SM1 and SM2, both cultivars showed accelerated growth, improved seedling vigor, and increased number of emerged seedlings. Within 2 weeks, sizeable seedlings were produced in SM2, and SH was 20.2 cm, SDW was 107.6 mg/seeding, RDW was 25.9 mg/seeding, and number of seedlings was 756/.5m^2. In SM3, SH was 11.7 cm, SDW was 83.5 mg/seeding, RDW was 22.5 mg/seeding, and 620 seedlings survived. In SM1, SH was 9.2 cm, SDW was 64.6 mg/seeding, RDW was 18.7 mg/seeding, and 604 seedlings survived (Table 1). The impact of increased temperature appeared more pronounced on SH and SDW than RDW. Warmer temperature favors growth of both shoots and roots, although the adverse effects of low temperature were smaller on roots (Hearath & Ormrod 1965). According to Yoshida (1981), reduction in plant height is a common symptom of cold injury in seedlings and is highly correlated with seedling weight growth.

In the IRT, farmers start seedbed preparation toward the end of October when the main wet season with heavy rains ends. With simultaneous seeding in November, 60-70-day old seedlings are transplanted in January to early February. Available meteorological records of 16 years (1979-1995) (IRRI 1996) show average minimum temperatures of 17.6, 16.9, 15.3 and 15.3°C for October to January (Figure 1). The coolest temperatures are 13.2, 10.8, 8.6 and 8.5°C for the respective months, which are all within critically low temperature limits for germination and seedling emergence, establishment and rooting. De Datta (1981) cited critical low temperatures of 16-19°C for germination, 12-35°C for seedling emergence and establishment, 16°C for rooting, 7-12°C for leaf elongation, 9-16°C for tillering, 15°C for panicle initiation, 15-20°C for panicle differentiation, 22°C for anthesis, and 12-18°C for ripening.

In the study, as a result of increased temperature in the plastic-protected seedbed, PSB Rc44 showed higher growth acceleration, improved seedling vigor, and more seedlings than Palawan. Palawan produced taller and more vigorous seedlings than Rc44 in SM1 with the prevailing lower temperature. Rc44 had a 227% increase in SH, 116% in SDW, 61% in RDW and 36.6 in number of seedlings. Palawan had a 59.8% increase in SH, 27.4% in SDW, 21.8% in RDW, and 15.7% in number of seedlings (Figure 2). Vergara

Table 1. Growth characteristics of two-week-old seedlings of rice cultivars as affected by different seedbed management methods.

Seedbed Management	Seedling height (cm)			Shoot dry weight (mg/seedling)		
	PSB Rc44	Palawan	Average	PSB Rc44	Palawan	Average
SM_1 (Traditional nursery)	6.6(B)(c)	11.7 A)(b)	9.2	56.6(A)(b)	72.6(A)(b)	64.6
SM_2 (Plastic protected nursery)	21.6(A)(a)	18.7(B)(a)	20.2	122.6(A)(a)	92.5(B)(a)	107.6
SM_3 (Compost + CRH are used in seed preparation)	10.7(A)(b)	12.7(A)(b)	11.7	77.8(A)(b)	89.2(A)(ab)	83.5

Seedbed Management	Root dry weight (mg/seedling)			No. of seedlings per m^2		
	PSB Rc44	Palawan	Average	PSB Rc44	Palawan	Average
SM_1 (Traditional nursery)	16.2(A)(b)	21.1(A)(a)	18.7	142(B)(b)	159(A)(b)	151
SM_2 (Plastic protected nursery)	26.1(A)(a)	25.7(A)(a)	25.9	194(A)(a)	184(A)(a)	189
SM_3 (Compost + CRH are used in seed preparation)	19.3(A)(b)	22.7(A)(a)	21	153(A)(b)	155(A)(b)	155

In a column, means with common small letters and common capital letter(s) are not significantly different

(1976) indicated that some rice varieties are more resistant to low temperature. A wide range of varietal differences could occur in cold-air and cold-water temperatures, when shoot length and percentage of survival are taken as measures for cold tolerance (Yoshida 1981).

In the second study, all seedlings were transplanted on 29 January 2003 when SA1 seedlings of both varieties were not yet tall and strong enough to withstand occasional increases of floodwater and damages inflicted by golden apple snails (GAS), a prominent pest in the IRT. As a consequence, the plots planted to SA1 seedlings had to be replanted twice (Table 1).

Plots planted to SA3 were 7-12 days ahead in heading. Palawan yield in SA2 was 4,580 kg/ha, slightly more than in of SA3 (4,455) and SA1 (4,082) (Table 3). PSB Rc44 was 40-45 days earlier in panicle emergence than Palawan and other rice varieties planted in the neighboring rice terraces. Subsequent to unsynchronous heading, birds and rats totally devastated the crop.

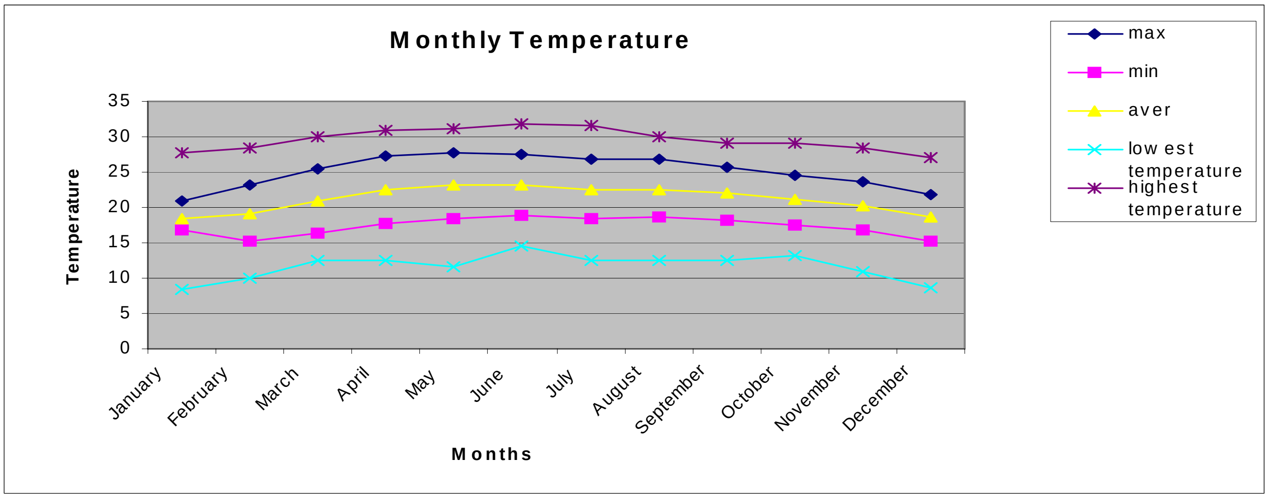

Figure 1. Monthly temperature (1979-1995), Banaue, Ifugao (IRRI, 1996)

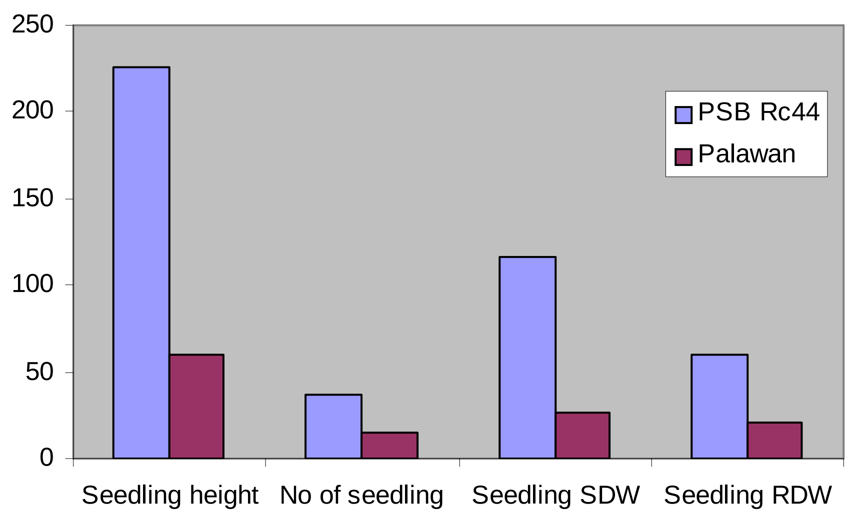

Figure 2. Relative seedling growth of two rice cultivars under plastic-protected nursery (as percent of that in farmers nursery)

Conclusion & Recommendation

Within 2 weeks, more and vigorous seedlings were raised in the plastic-protected seedbed. Use of CRH and compost also improved seedling growth. Genotypic variations were evident in response to increased temperature for seedling growth and vigor, and number of seedlings emerged. Palawan appeared more adapted to lower temperature, while PSB Rc44 had accelerated growth with increased temperature. While use of young seedlings could improve rice yield elsewhere, 30-day old seedlings raised in traditional nursery were not tall and strong enough to withstand deeper floodwater and GAS damage in the IRT. The 45-day old seedlings had relatively better growth and yield performance than the other seedlings, though not significantly different. PSB Rc44, which headed 45 days earlier then the other rices in the area, was totally ravaged by birds and rats.

The results indicate that with a plastic cover for the seedbed, seedling growth duration can be reduced by more than 1 month and more vigorous seedlings can be raised. Palawan, with its relatively taller and more vigorous seedlings in an unprotected nursery, is more tolerant to cool temperature than PSB Rc44, which grew better in a plastic covered seedbed. Use of young seedlings in the area is not recommended due to their vulnerability to deep floodwater and GAS damage.

Studies are needed to compare young seedlings with accelerated growth and improved vigor with seedlings raised in traditional nurseries. The comparison could be made for different varieties under various planting distances and soil fertilities, to examine patterns of growth factors reflecting the actual yield outcomes. Studies are also needed to determine if genotypic variation for seedling cold tolerance can be quantified through growing seedlings in unprotected and protected seedbeds, and to examine the validity of relative growth as the selection index for seedling cold tolerance.

Table 2. Seedling height of 30, 45 and 60-day old seedlings raised in a traditional nursery.

	Seedling height (cm)	
Seedling age	PSB Rc44	Palawan
30-day old	10.6	14.3
45-day old	16.5	19.7
60-day old	19.1	23.6

No significant difference was found among the 3 seedling ages for grain yield.

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Table 3. Plant height, tiller number, number of filled grains, 1000-grain weight. and yield (kg/ha) of traditional variety Palawan, as affected by the age of transplanted seedlings.

Seedling age	Plant height (cm)	Tiller number per hill	Number of filled grains per hill	1000-grain weight (g)	Yield (kg/ha)
30-day old	129.4	11	1172	26.7	4082
45-day old	135.6	13	1374	27.2	4580
60-day old	140.9	13	1326	27.5	4455

No significant difference was found among the 3 seedling ages for grain yield.

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