Impact of early transplanting on tillering and grain yield in irrigated rice

Estela Pasuquin[1], Brenda Tubana[1], Jessica Bertheloot[1] and Tanguy Lafarge[1, 2]

[1]IRRI, DAPO Box 7777, Los Ba?os, Laguna, Philippines Email epasuquin@cgiar.org
[2]CIRAD, TA 70/01, avenue Agropolis, 34398 Montpellier, France Email tlafarge@cgiar.org

Abstract

Appropriate crop management in rice is required for newly selected genotypes to match with their growth potential. In irrigated areas, transplanting is the most widely accepted method to obtain high yield. Even though the nursery management, and particularly seedling age at transplanting, is expected to have a great impact on plant growth through potential seedling competition in the nursery, research on its adaptation to the characteristics of promising genotypes has not gained much focus. The impact of early transplanting on rice growth and grain yield of four contrasted genotypes, including hybrid, new plant type and improved inbred line, was compared in the wet and dry growing seasons in IRRI, Philippines. Seedlings were grown in seedling trays and wet-bed nurseries at 3000 seeds m^{-2} and were transplanted 7, 14 and 21 days after sowing at 25 pl m^{-2}. Late transplanting delayed tiller emergence by 15 days for all genotypes in all the studied situations through a delay in main tiller leaf emergence observed before transplanting. Leaf emergence started again as soon as the seedling was transplanted. Early transplanting then induced higher tiller production and higher plant shoot dry matter accumulation at early stage. Compared to later transplanting, early transplanting generated a significant positive effect on grain yield, up to 10% of hybrids and IR72 when seedlings were transplanted at 7 days, and up to 78% of the new plant type when seedlings were transplanted at 14 days. Early transplanting appears to be a relevant practice to improve yield in irrigated rice.

Media summary

Transplanting rice seedlings as early as possible can significantly increase grain yield in irrigated areas.

Key Words

Seedling age at transplanting, grain yield, tillering dynamics, shoot dry matter, rice.

Introduction

Crop management in rice needs to be adapted to newly selected genotypes to express most of their growth potential. In irrigated areas, transplanting is widely practised as a way to improve weed control and to grow a well designed canopy with homogeneous and healthy seedlings. Its grain yield advantage over direct-seeding rice has often been reported. The high-yielding ability of this practice is strongly dependent on transplanting age (Om et al 1989; Hossain et al 2001). Even if transplanting 20 to 40 days old seedlings is recommended, farmers may transplant seedlings as old as 80 days (Khatun et al 2002). Long stay of seedlings in the nursery may, however, affect seedling growth pattern in response to high seedling competition (Mandal et al 1984). The objective of this study was to quantify the impact of transplanting age, as early as 7 days, on plant growth and grain yield.

Materials and methods

Field experiments were conducted in 2003 at the lowland area of the IRRI experimental farm, Los Ba?os, Philippines. IR72 and two hybrids, IR75217H (H1) and IR68284H (H2) in the dry season, IR72, a new plant type IR72967-12-2-3 (N4) and H1 in the wet season, were grown in nurseries at 3000 seeds m^{-2}, either in wet-bed (WB) or seedling trays (ST) and transplanted after 7 (WB07 and ST07), 14 (WB14 and ST14) and 21 days (WB21) at 25 pl m^{-2} in 4 replications. The seeds were sown in the nursery on 26 December 2002 (dry season) and 10 June 2003 (wet season). Water and nutrient management was optimum. Destructive plant measurements were performed weekly from transplanting until maximum tillering, then every second week until flowering and at mid-grain filling (dry season only). Measured plant growth parameters included tiller number, leaf and stem dry weight, yield components, from 2 locations per plot of 0.12 m^2 area, and grain yield from a $5m^2$ harvest area.

Results

Tiller emergence of IR72 was delayed by 15 days with 21-day transplanting in the wet season (Fig. 1a). This reduced the maximum tiller number per plant from 34 to 29 and delayed the time of maturity by almost 10 days by delaying time of panicle initiation (Table 1). The same trend was observed in the dry season for IR72 and H2 (Figs 1b and 2b) and in the wet season for N4 (Fig. 2a). The increase in leaf number of the main tiller for IR72 in WB07 was linear with time until 10-leaf stage, but was delayed from 10 days after nursery sowing (DAS) in WB21 and even stopped between 18 to 21 DAS (Fig. 3a). It then resumed just after transplanting at the same rate as in WB07. This delay in leaf appearance in WB21 probably caused the delay in tiller emergence, as the primary tiller number per plant and the branch tiller number per plant were both related to the leaf number of the main tiller, whatever the transplanting date was (Fig. 3b). This gives little credit to the occurrence of a transplanting shock affecting plant development. From tiller emergence until flowering (80 DAS), these observed differences in tiller emergence with early transplanting induced higher shoot dry matter accumulation by at least 10g for the three genotypes whatever the growing season was (Figs 1c and d, 2c and d). The difference in shoot dry weight from flowering to maturity was still appreciable when comparing 7-days and 14-days transplanting but was, however, non-existent soon after flowering for all varieties when comparing 14-days and 21-days transplanting.

The consequences on plant growth of 7 over 14 days transplanting generated a significant higher grain yield of hybrids by 10% (considering rat damage occurrence in plots where H1 was transplanted after 7 days in the dry season) and of I1 by 7% in the dry season (Table 1). For hybrids, this positive effect was mainly due to the higher shoot dry weight per productive tiller, as the productive tiller number per plant was either not affected, or even lower with early transplanting (in the wet season), and the harvest index was unchanged, as both stem and filled grain dry weight per tiller increased similarly (Table 1). For I1, this positive effect was rather due to the slight increase in productive tiller number per plant, knowing that the small advantage in shoot dry weight per tiller observed in the dry season with early transplanting mainly generated an increase in stem dry weight (Table 1). This early transplanting (7 days) did not affect, however, grain yield of N4, as productive tiller number and shoot dry weight per productive tiller were almost unchanged (Table 1). The consequences on plant growth of 14-days transplanting over 21-days generated a significant higher grain yield for N4 by 78% partly due to a significant higher harvest index (HI). The plant mobilised more assimilate for stem growth thereby reducing grain number per tiller, filled grain fertility and grain size (Table 1). The grain yield of hybrids and their shoot dry weight measured at maturity were similar for plants transplanted at 14 and 21 DAS. The plants transplanted at 21 days seemed to have maintained 1 to 2 productive tillers more, but with lower shoot dry weight per tiller at maturity (Table 1). This trend was similar for I1 in the wet season (Fig. 1c and Table 1). In the dry season, the grain yield of I1 was significantly higher by 5% when transplanted 14 DAS than 21 DAS, even though the productive tiller number per plant was significantly lower by 2 tillers (Table 1).

Conclusion

Early transplanting favoured tiller emergence of three different genotypes grown in two nurseries during the wet and dry season : tiller emergence was affected by long stay of seedlings in the nursery as leaf emergence of the main tiller was delayed (after 14 days) and even stopped (after 21 days) in these nursery conditions. As soon as the seedling was transplanted, leaf emergence resumed, tiller emergence started and occurred according to the dynamics of leaf emergence on the main tiller (Davies and Thomas, 1983). Nursery management, rather than transplanting shock, appears to be the reason for this delay. Early transplanting then increased plant shoot dry matter accumulation and reduced crop duration in all situations studied. It significantly increased grain yield here in three cases: (i) hybrid rice transplanted as early as 7 days, for which shoot dry weight per productive tiller, grain number per tiller increased, even though HI remained unchanged; (ii) IR72 transplanted at 7 days, for which a higher productive tiller number at maturity was observed; (iii) N4 transplanted at 14 days, for which assimilate partitioning to stem was lower than at 21 DAS. As grain yield was either increased or unchanged by early transplanting as also observed by Mandal et al (1984), early transplanting, as early as 7 days, appears to be a promising way to improve grain yield in rice.

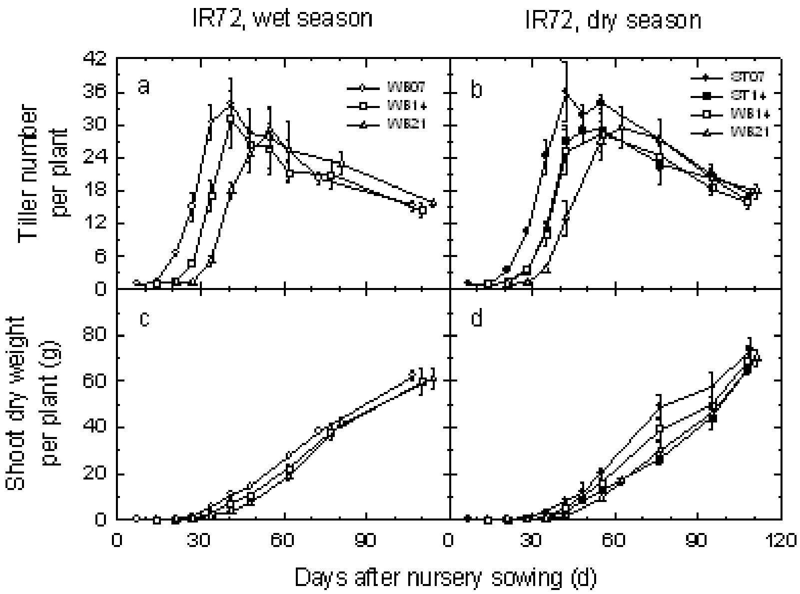

Fig. 1. Change, with days after sowing, in tiller number per plant in the (a) wet and (b) dry seasons, and in shoot dry weight per plant in the (c) wet and (d) dry seasons, of IR72 plants as affected by different nursery management.

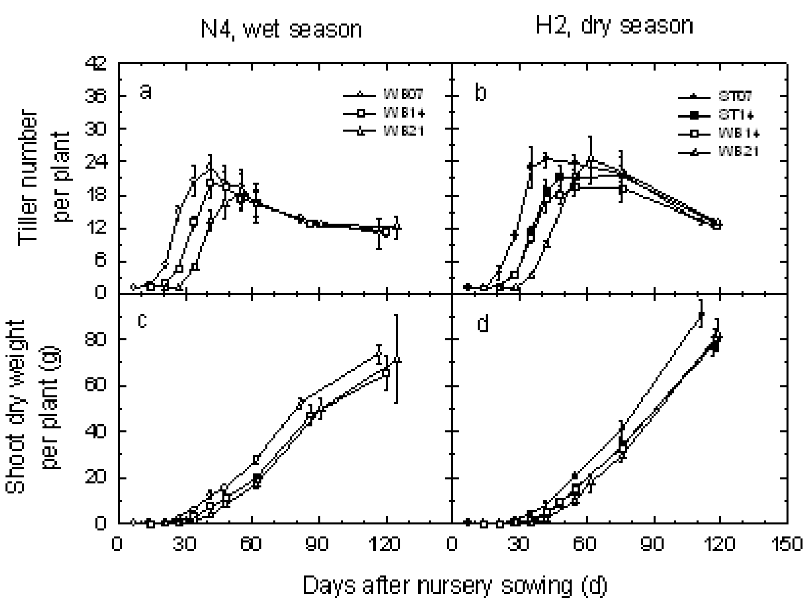

Fig. 2. Change, with days after sowing, in tiller number per plant for (a) N4 in the wet and (b) H2 in the dry seasons, and in shoot dry weight per plant for (c) N4 in the wet and (d) H2 in the dry seasons.

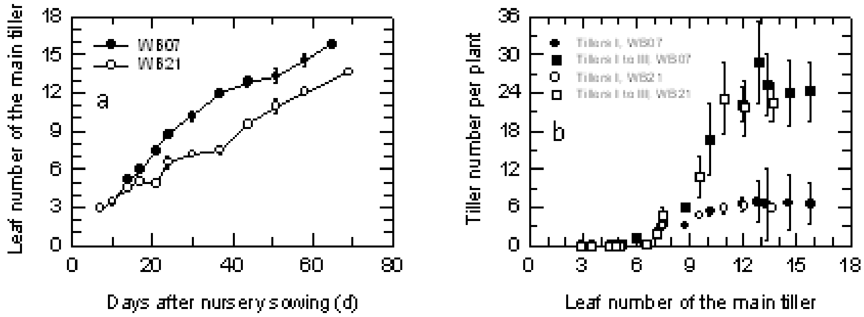

Fig. 3. (a) Increase, with days after sowing, in leaf number of the main tiller, (b) tiller number per plant as a function of leaf number of the main tiller.

Table 1. Variation in crop duration (C dur, days), duration from sowing to panicle initiation (S-PI, days), grain yield (GYield, t ha^{-1}) and main yield components between I1, N4, H1 and H2 for contrasted growing periods and nursery management. PtilNb for productive tiller number per plant, ShDW for shoot dry weight per productive tiller (g), HI for harvest index, StDW for stem dry weight per productive tiller (g), FGrDW for filled grain dry weight per productive tiller (g), FGrNB for filled grain number per productive tiller.

VAR	TRT	Crop dur	S-PI	GYield	PTil	ShDW	HI	StDW	FiGrDW	FiGr
?	?	days	days	(t ha^{-1})	?NB	g	?	g	g	NB
					Wet season 2003					
I1	WB07	108	50	5.32a	15.21a	4.12a	0.35a	1.72a	1.42a	62.76a
I1	WB14	111	53	5.14b	14.42a	4.16a	0.34ab	1.77a	1.40ab	60.22ab
I1	WB21	115	55	5.18b	15.64a	3.93a	0.32b	1.72a	1.24b	55.91b
N4	WB07	118	57	4.56a	12.39a	5.96a	0.28a	2.69a	1.65a	61.71a
N4	WB14	121	60	4.62a	11.31a	5.77a	0.26a	2.63a	1.52a	56.62a
N4	WB21	126	63	2.60b	12.04a	5.90a	0.21b	2.90a	1.12b	46.06a
H1	WB07	104	44	6.62a	11.88a	5.18a	0.42a	1.86a	2.18a	93.42a
H1	WB14	106	47	6.02b	13.06a	4.70ab	0.41a	1.72b	1.92a	76.96ab

H1	WB21	111	50	5.89b	14.36a	4.50b	0.35b	1.88b	1.57b	66.52b
					Dry season 2003					
I1	ST07	108	51	6.99a	17.08ab	4.32ab	0.43ab	1.51a	1.87ab	80.95bc
I1	ST14	109	53	6.55b	16.19b	4.04bc	0.45b	1.39ab	1.83b	78.42a
I1	WB14	108	51	6.34bc	15.77b	4.38a	0.46ab	1.48ab	2.00a	84.61ab
I1	WB21	109	55	6.06c	17.88a	3.94c	0.46ab	1.28b	1.82b	76.91c
H2	ST07	115	55	7.58a	13.06a	6.96a	0.42a	2.50a	2.94a	105.95a
H2	ST14	117	58	6.98b	12.94a	5.98b	0.43a	2.07b	2.58b	95.56ab
H2	WB14	117	56	6.81c	12.36a	6.51ab	0.43a	2.23b	2.81a	104.16a
H2	WB21	118	62	6.99b	12.96a	6.32ab	0.40b	2.24b	2.51b	91.88b
H1	ST07	106	46	7.75a	14.79ab	5.52a	0.53b	1.64a	2.91a	121.11a
H1	ST14	107	48	7.59a	14.81ab	4.72c	0.52b	1.27b	2.47b	103.12b
H1	WB14	107	47	6.98a	14.13b	5.21ab	0.55a	1.42b	2.88a	117.60a
H1	WB21	107	50	6.97a	16.08a	4.81bc	0.51b	1.45ab	2.45b	102.57b

† In a column means followed by a common letter are not significantly different at $P \leq 0.05$ based on LSD.

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