

Effect of Initial Plant Population and Herbage Removal on Herbage and Grain yield of Rice

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Abstract

Rice herbage as an animal feed is significant due to the high nutritional value, and readily available in most animal production areas; the rice grain yield is not sacrificed by herbage removal. In a field experiment at IRRI, high initial plant population significantly increased herbage yield of long duration rice cultivar, IR28333-10-1-1, as a result of more tillers per unit area and partly due to higher biomass tiller. High initial plant population resulted in faster growth rate, higher tiller number area, earlier development of high LAI, and larger tiller size resulting in high biomass and herbage yield at early vegetative. Nitrogen content and crude protein of rice herbage decreased with increasing plant population while total protein yield tended to increase. Rice grain yield, percent fertility, and 1,000-grain weight were not affected by initial plant population and herbage removal. High initial plant population significantly increased panicle number per unit area but decreased spikelet number per panicle. The use of higher plant population to improve herbage yield without decreasing grain yield is economically useful in rainfed areas prone to early submergence or drought.

Keywords : rice herbage, IR 28333 10-1-1, deepwater rice

Rice farmers in developing countries generally practice mixed farming namely rice and animal production. Because of rising demand for meat and milk as a result of increasing human population and of economic growth, the number of ruminants is also rising and has become the basic driving force to produce more good quality forage. Since land is a limiting factor for fodder production in Asian countries and poor farmers generally do not grow forage in place of food crops, the strategy for increasing fodder production should explore the readily available cereal

crops such as rice for forage.

Rice herbage production by leaf cutting at early vegetative stage has been shown to be possible in varieties with growth duration longer than 150 days (Lopez and Vergara, 1988). The resulting herbage has high nutritive value and the grain yields are not affected (Lopez *et al.*, 1987).

Rice herbage yield and quality vary among rice cultivars. It can be modified by agronomic practices and environmental conditions. Herbage yield is related to biomass production. High initial plant population is

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essential to achieve high early biomass yield. In fact, higher initial plant density might be an approach in maximizing production of rice herbage without detrimental effect on grain yield. Farmers in rainfed areas generally use higher seed rate to compensate for possible adverse conditions such as drought or flood during crop establishment.

The experiment was conducted to study the effect of initial plant population and herbage cutting on herbage yield, herbage quality, grain yield, production components and agronomic characteristics of medium growth duration rice varieties.

Materials and Methods

A field experiment was conducted at the International Rice Research Institute farm, Los Banos, Philippines (Maahas clay, Andaqueptic Haplaquoll) from July to December 1989.

The experimental design was a 3×2 factorial in a randomized complete block with four replications. The treatments consisted of three initial plant population in combination with cutting and non-cutting. The experimental field was plowed twice, followed by puddling and leveling. Fertilizer at the rate of 60-40-40 kg N-P₂O₅-K₂O/ha was incorporated one day before

sowing. Pregerminated seeds of IR 28333-10-1-1 (IR 28333), a 130-day deepwater rice promising line, were broadcasted onto the puddled soil at different rates resulting in three initial plant population (100, 200 and 300 seedlings/m²). A second application of 30 N kg/ha was topdressed at 50 days after sowing (DS). General crop protection was done as needed.

Plant sample of 1 m² was taken from each plot at 30, 50, 70, 100, 115 and 130 DS to determine plant height, tiller number, leaf area, and dry matter production. Plant parts were separated into active leaf, dead leaf, sheath and culm, and root. Herbage yield was measured from a 8-m² plot by cutting at the highest collar level of the last fully developed leaf at 50 DS. The samples were dried at 70°C for 72 h. Nitrogen content of the rice herbage was determined (Yoshida *et al.*, 1976). Grain yield and yield components were determined at harvest.

Results and Discussion

Herbage yield.

Herbage yields of IR 28333 cut at 50 DS were 0.72, 0.98 and 1.12 t/ha in plots with 100, 200 and 300 seedlings/m², respectively (Table 1). High initial plant population significantly increased rice herbage yield.

Table 1. Herbage yield, components, and quality from IR28333 at 50 DS as affected by initial plant population. IRRI, 1989 wet season.

Plant density (seedlings/m ²)	Herbage yield (t/ha)	Herbage components		Herbage quality		
		Tiller (no./m ²)	Wt./tiller (g)	N-content (%)	Crude protein (%D.M. basis)	Protein yield (kg/ha)
100	0.72 b	582 b	0.13a	2.89a	20.03a	144 b
200	0.98a	642ab	0.15a	2.69 b	18.70ab	183ab
300	1.12a	746a	0.15a	2.50 b	17.40 b	195a

In the same column, means followed by a common letter are not significantly different at 5% level by DMRT.

Regardless of plant population, rice herbage yield at 50 DS from IR 28333 was comparable to that of cultivar B4259 at 50 DT (Lopez and Vergara, 1988). Average from three plant populations, herbage yield harvested at 50 DS represent about 25% of shoot weight. Iida and Takahashi (1976) recommended high seed rate in growing rice for fodder which corresponds well to the result of this study.

Herbage quality

Rice herbage from IR 28333 was composed mainly of leaf blades; no leaf sheath was included because it was cut at the collar level of the top leaf. The nitrogen content of the rice herbage is comparable to or even better than that of other forage crops (Food and Nutritional Research Institute, 1984). It was comparable to rice herbage form cultivar B 4259 (Lopez *et al.*, 1987;

Jamarun *et al.*, 1987). High initial plant population significantly reduced percent N content of rice herbage indicating high competition for nitrogen among the rice plants in high plant population treatment (Table 1). Percentage of crude protein was likewise lower in high plant density treatment. However, total protein yield was higher in high initial plant population treatment due to higher herbage yield. Low nitrogen content in rice herbage with increased plant population suggests the need for more nitrogen fertilizer in high initial plant population treatment if rice herbage is to be cut.

Grain yield and yield components

Plant density and/or cutting treatment did not significantly affect grain yield (Table 2). Initial plant density of 50-350 plants/m² did not affect grain yield of deepwater rice (Hoque and Nasiruddin, 1988).

Table 2. Grain yield and yield components of IR 28333 as affected by initial plant population and herbage removal. IRRI, 1989 wet season.

Treatments (seedlings/m ²)	Grain yield (t/ha)	Panicle (no./m ²)	Spikelet (no./panicle)	Fertility (%)	1000-grain wt. (g)
100 non cut	3.90	267 c	91ab	82.1	21.56
100 cut	3.69	264 c	93a	83.8	22.13
200 non cut	4.09	289 bc	85abc	84.4	21.96
200 cut	3.93	310abc	82abc	82.2	21.43
300 non cut	3.91	333ab	83abc	85.2	21.85
300 cut	3.90	350a	73 c	84.5	22.23

In the same column, means followed by a common letter are not significantly different at 5% level by DMRT.

Average grain yield of IR 28333 was 3.90 t/ha which was relatively higher than what was reported earlier (IRRI, 1988). Increased herbage yield with no grain yield reduction under high initial plant population shows

the significance of high plant population for rice herbage production, In deepwater rice areas, seeding rate of 40 to 150 kg seeds/ha have little effect on grain yield (Haque, 1974; Toure, 1979). Farmers use higher seed

rate in areas prone to drought or flood. This ensures better crop establishment, i.e. more plants survive after adverse conditions. Using higher seeding rate is more expensive but ensures better crop establishment. If rice herbage is harvested from the crop, the higher plant density would be an advantage.

High initial plant population significantly increased panicle number per unit area but decreased spikelet number per panicle (Table 2). The rice plant appears to be capable of producing at least one panicle per plant even at very high plant density (Yoshida, 1981) but the panicle size may be small. Fertility percentage and 1000-grain weight were not affected by initial plant population nor herbage cutting. Regardless of plant population, herbage removal did not significantly affect grain yield and yield components. Similar results on the effect of herbage removal on grain yield of lowland rice cultivars (Saleh *et al.*, 1974; Iida and Takahashi, 1976; Deshmukh and Upadhyay, 1980; Urkürkar and Chandravanshi, 1984)

and of deepwater rice cultivars (Kupkanchanakul *et al.*, 1988; Kupkanchanakul and Roontun, 1989) were reported.

Biomass production

Biomass production of a rice crop at a given stage is determined by the plant or tiller number per unit area and the weight per plant. A tiller can be separated into active leaf blades, dead leaf blades, leaf sheaths, culm, panicle and root.

Biomass production at harvest (excluding root) of IR 28333 tended to increase with increased plant population although the individual tillers were smaller (Table 3). The size of individual tillers tended to be bigger in the high initial plant population plot at early growth stage due to fewer small newly formed tillers (Table 1). The tiller size is smaller in high plant population treatment at later growth stage because of higher inter-plant competition (Figure 1).

Table 3. Effect of initial plant population and herbage removal on biomass at harvest of IR 28333. IRRI, 1989 wet season.

Treatments (seedlings/m ²)	Dry weight (t/ha)				
	Sheath + culm	Active leaves	Dead leaves	Panicle	Biomass
100 non cut	7.49abc (2.40) [△]	0.34 b (0.11)	2.08ab (0.67)	4.53 (1.45)	14.43abc(4.63)
100 cut	6.00 d(1.93)	0.43ab (0.14)	1.59 c(0.51)	4.28 (1.38)	12.30 c(3.95)
200 non cut	7.83ab (2.32)	0.47ab (0.14)	2.14ab (0.64)	4.73 (1.40)	15.16 ab(4.50)
200 cut	6.13 cd(1.69)	0.36ab (0.10)	1.82 bc(0.50)	4.57 (1.26)	12.88 c(3.56)
300 non cut	8.11a (2.11)	0.55a (0.14)	2.30a (0.60)	4.52 (1.18)	15.24 a (3.97)
300 cut	6.48 bcd(1.60)	0.28 b (0.07)	1.89 bc(0.47)	4.15 (1.11)	13.16 bc(3.40)

In the same column, values followed by a common letter are not significantly different 5% level by DMRT.

[△]In parenthesis is dry weight yield in g/tiller.

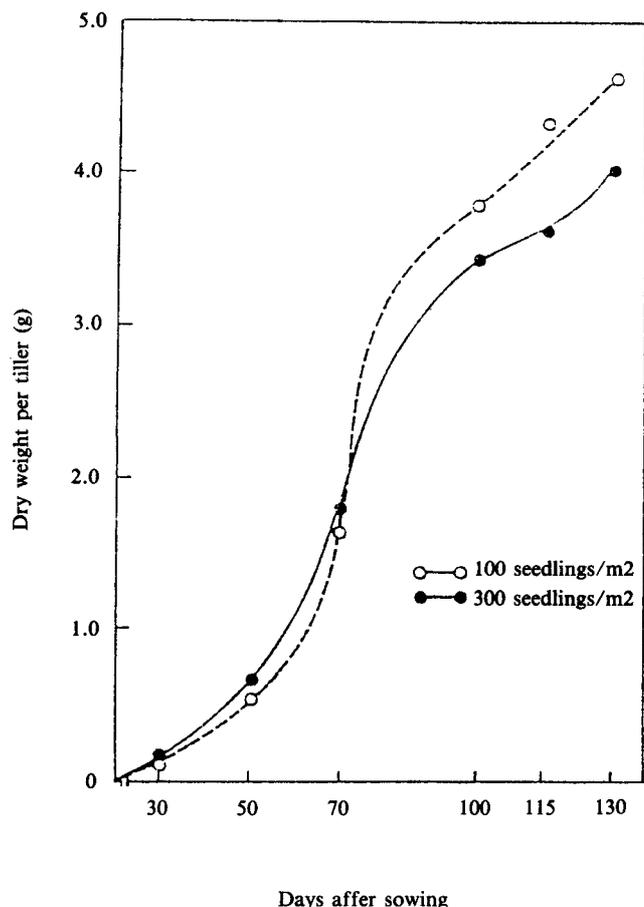


Figure 1. Dry weight per tiller of IR 28333-10-1-1 as affected by plant density. IRRI, 1989 wet season.

Herbage removal generally decreased biomass accumulation at harvest of IR 28333 (Table 3). Similar results were earlier reported (Sato, 1969; Verma, 1969; Tripathi *et al.*, 1973; Lopez *et al.*, 1987; Das and Mukherjee, 1989). Plant parts that were significantly affected by herbage removal were dead leaves, sheath and culm. Decrease in dry weight of dead leaves, sheath and culm by herbage removal might be beneficial to grain production. Active leaves in the cut plot tended to decrease especially at high plant population but tended to increase at low plant population (Table 3) indicating more competition for regrowth at high plant population than at low plant population. Panicle yield was not affected by herbage removal (Table 3).

Plant height, harvest index (HI) and days to maturity

Herbage removal significantly decreased plant height (Table 4). Confirming earlier reports (Mahapatra and Manna, 1962; Eugenio, 1965; Sato, 1969; Iida and Takahashi, 1976; Lopez *et al.*, 1987.) Plant height of IR 28333 abruptly decreased after cutting. The reduced plant height continued until maturity (Figure 2).

Table 4. Final plant height, harvest index, tiller number, percent productive tillers and days to maturity of IR 28333 as affected by initial plant population and herbage removal.

Treatment (seedlings/m ²)	Plant height (cm)	Harvest index	Tiller (no./m ²)	Productive tiller (%)	Maturity (days)
100 non cut	164ab	0.31ab	312 c	85	130
100 cut	158 bc	0.32ab	311 c	85	130
200 non cut	170a	0.29 bc	337 bc	85	130
200 cut	150 cd	0.33a	362abc	85	130
300 non cut	167ab	0.27 c	384ab	87	130
300 cut	148 d	0.31ab	406a	86	130

In the same column, means followed by a common letter are not significantly different at 5% level by DMRT.

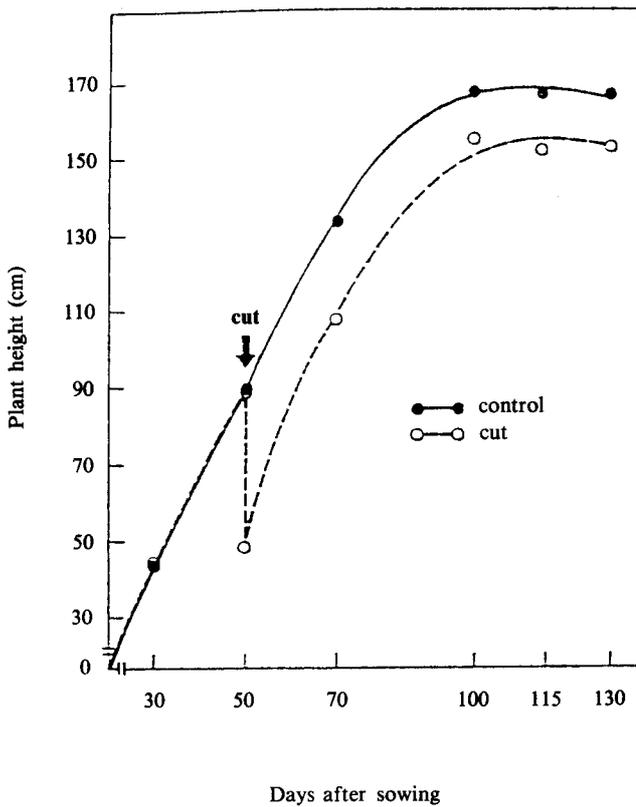


Figure 2. Height of IR 28333-10-1-1 as affected by herbage removal. IRRI, 1989 WS.

Shorter plant height as a result of herbage removal is an advantage since the rice plant becomes less prone to lodging and grain yield can be increased. IR 28333 in the non cut plot tended to bend at 70 DS especially in high plant population treatment while those in the cut plot were erect. However, all plots lodged at flowering stage due to typhoon. Lodging was observed to be more severe in non cut plots than cut plots.

Harvest index increased with herbage removal in plant densities of 200 and 300 seedlings/m² (Table 4). This is partly the result of shorter plant height or less culm weight (Tables 3 and 4). Harvest index of the rice crop is expected to be higher if rice herbage is also considered as economic yield.

Initial plant population and herbage removal did not affect growth duration of direct seeded IR 28333 (Table 4).

Tiller production

High initial plant population developed higher maximum tiller number and reached maximum tillering stage earlier than lower initial plant density (Figure 3).

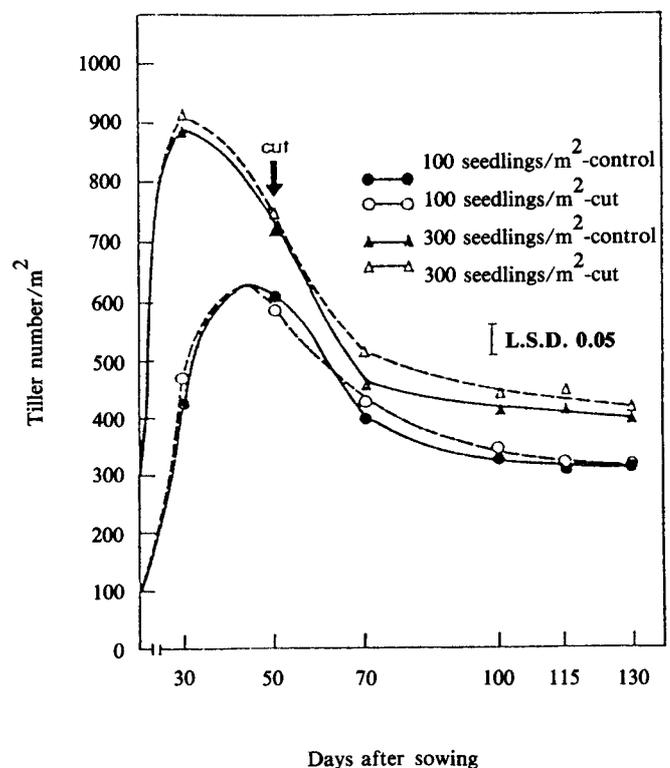


Figure 3. Tiller number of IR 28333-10-1-1 as affected by plant density, and cutting. IRRI, 1989 wet season.

Tiller number per unit area at maturity was significantly higher in high plant density plot than low plant density (Table 4). Herbage removal increased tiller production in high plant density plot but the differences were not statistically significant. Increased tiller number as a result

of herbage removal has been reported in transplanted rice (Tripathi *et al.*, 1973). Percentage of productive tiller was not affected by initial plant population and/or herbage removal (Table 4).

Leaf area index (LAI)

High initial plant population developed earlier high LAI. Maximum LAI values of about 4 and 5 were observed at about 70 DS in low and high initial plant population, respectively (Figure 4). These LAI values were considered as optimum for grain production. Herbage removal abruptly decreased LAI.

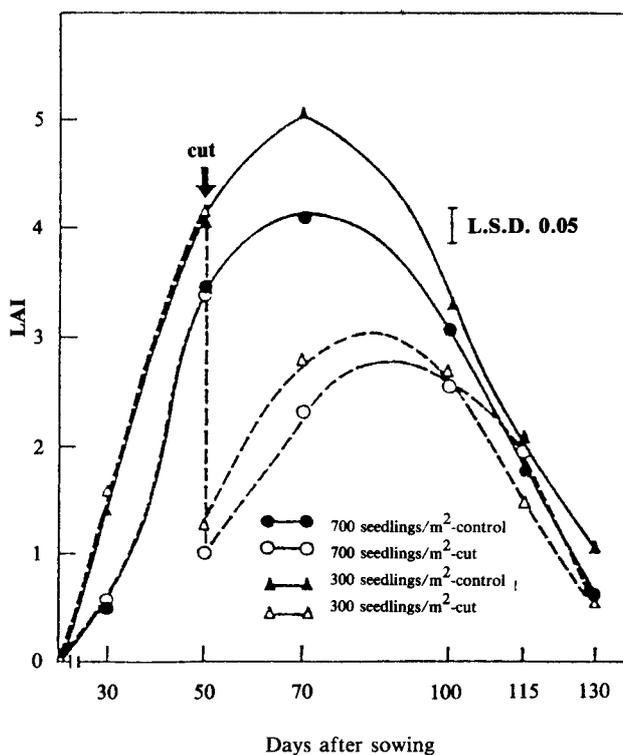


Figure 4. Leaf area index (LAI) of IR 28333-10-1-1 as affected by plant density and cutting. IRRI, 1989 wet season.

Regrowth of the leaves in the cut treatment was very rapid. Leaves were elongating out of the

leaf sheath the following day after cutting. Remaining portion of the leaf blade and reserved carbohydrate in the rice plant play an important role in the formation of new leaf and plant recovery after cutting. Leaves developed after cutting are important in grain production. The new peak of LAI was attained at about 40 days after cutting. The values were lower than those in non-cut plot. However, at flowering the difference in LAI between cut and non cut was small (Figure 4). High plant density tended to develop higher new LAI after cutting but senescence tended to be faster which is probably due to high interplant competition and partition of photosynthate during spikelet formation and grain filling stages.

High herbage yield in high initial plant density treatment was attributed mainly to more tiller number per unit area and partly higher weight per tiller. High initial plant population promoted earlier fast growth rate, higher tiller number per unit area, higher LAI, and heavier weight per tiller at early growth stage which resulted in earlier high biomass production and herbage yield.

Conclusions

Crops differ in their response to increasing plant density. The study using IR 28333, a 130 day promising line, showed that rice herbage yield harvested at 50 DS can be increased significantly by using high plant density. This is attributed mainly to more tiller number per unit area and partly to heavier tiller weight. High initial plant population promoted earlier fast growth rate, higher tiller number and earlier high LAI, resulting in earlier high biomass and herbage yield.

Herbage quality was also affected by plant

density. Increased plant density significantly decreased nitrogen content of rice herbage. Percentage of crude protein was also reduced. However, total protein yield increased with plant density because of higher herbage yield.

Grain yield was not affected by plant density and herbage removal. Increased plant density significantly increased panicle number per unit area but decreased spikelet number per panicle. Percent fertility and 1000-grain weight were not affected by plant density nor herbage removal.

The important role of high plant density on herbage yield improvement without detrimental effect on grain yield is significant in direct seeded rice especially in flood-prone and deepwater rice areas where long growth duration varieties are used. Farmers use high seed density in areas prone to drought or flood to ensure better crop establishment. Higher seeding rate is advantageous for rice herbage production as well. Quality of rice herbage at high plant density can be further improved through N application.

Enormous amount of quality rice herbage available in rainfed areas will stimulate farmers to raise more animal for integrated rice production. Animal feed or fodder is usually a limiting factor especially during the cropping season when there is limited pasture area.

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