dominance effects for Rewa 353-S/IR56 and IR56/Rewa 353. In Rewa 353-4/ IR2811-43-1-1-2, only the additive effects were significant for both Pb and Sb. Among the epistatic effects, additive/ dominance was significant for all crosses. In Rewa 353-5/IR56, dominance/dominance was also significant for Pb and Sb. Duplicate epistasis indicated by the negative value of 'h' and positive value of '1' in Rewa 353-5/IR56 may hinder selection.

Heritability estimates for both Pb and Sb were high in Rewa 353-5/IR56 and Rewa 353-4/IR28211-43-1-1-2 and low in IR56/Rewa 353. Estimates of the number of effective factors were very low for Rewa 353-5/IR56, but two and above for IR56/Rewa 353 and Rewa 353-4/IR28211-43-1-1-2.

With the significant additive effects and high heritability in Rewa 353-5/IR56 and Rewa 353-4/IR28211-43-1-1-2, mass selection in early generations to improve heterogeneous populations by modifying the frequencies of desirable genes, followed by single plant selection, may be advantageous in increasing the number of HD grains. Because of high variation due to dominance and epistatic effects in IR56/Rewa 353, selection in later generations would be better, to diminish dominance effects. ■

Table 2. Estimates of gene effects for number of HD grains in Rewa 353-5/IR56 (1), IR56/Rewa 353 (2), and Rewa 353-4/IR28211-43-1-1-2 (3). IRRI, 1989.

Parameter	Primary branch			Secondary branch		
	1	2	3	1	2	3
Mean	182* π 18.7	248** π 20.4	411** π 73.2	204** π 25.9	359** π 32.0	440** π 75.1
Additive	265** π 20.2	186** π 42.4	- 522** π 103.2	366* π 43.5	- 375** π 61.7	- 346** π 114.6
Dominance	- 298** π 51.3	633** π 122.2	436 π 369.9	- 152 π 98.2	597** π 184.0	113 π 383.4
Additive/additive	- 162 π 85.0	- 8 π 117.8	92 π 358.3	- 44 π 135.4	194 π 177.9	- 208 π 377.7
Additive/dominance	391** π 25.5	- 176** π 43.0	- 379** π 110.6	524** π 48.4	- 324** π 67.2	- 346** π 126.6
Dominance/dominance	780** π 121.3	558** π 119.3	408 π 521.9	916** π 215.8	454 π 293.6	891 π 563.6
Heritability	70.7	15.6	85.2	58.8	14.6	83.5
Effective factors	0.5	5.5	13.6	0.7	1.5	6.1

** = significant at the 1% level.

Genotypic differences in rice yield potential and N, P, and K in leaves

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We studied the yield potential and leaf N, P, and K at peak growth (55 d) in 27 rice genotypes. Soil was alluvial, sandy loam, and alkaline, with pH 7.8, 0.061% N, 0.05% P, 0.45% K, 4.5 ppm available P, and 0.14% total soluble solids. Standard 120 kg N and 60 kg P/ha were broadcast and incorporated before planting. There were 16 hills/m^2. The plots were laid out in a randomized design with four replications. Normal agronomic practices were followed. The first fully emerged leaf from each genotype was collected at 55 d and its N, P, and K content measured.

Leaves were dried and ground in a wiley mill. A 1-g sample was digested using H_2SO_4 and H_2O_2.P was determined colorimetrically by the vanadomolybdo-yellow color method; N, by micro-kjeldahl method; and K, by flame photometer. Straw and grain yields were measured at harvest (115 d).

Yield potential of rice genotypes and N, P, and K content in plant leaf.

Rice genotype	Straw yield (t/ha)	Grain yield (t/ha)	Leaf nutrient content (% dry wt)		
			N	P	K
IR6 (control)	8.1	5.5	1.54	0.31	1.86
Mutant IR6-18	6.6	5.0	1.40	0.33	1.96
Mutant IR6-93	6.7	4.7	1.35	0.29	1.81
Mutant IR6-104	7.2	3.8	0.77	0.28	1.79
Mutant IR6-113	7.0	4.6	0.77	0.30	1.69
IR8 (parent)	8.2	6.1	2.10	0.29	1.75
Mutant IR8-5	6.8	5.2	1.82	0.28	1.80
Bas 370 (parent)	12.0	3.4	1.82	0.30	1.89
Mutant 370-1	6.7	1.9	1.60	0.25	1.63
Mutant 370-5	11.0	2.3	1.49	0.27	1.67
Mutant 370-24	7.1	2.9	1.59	0.28	1.48
Mutant 370-28	6.7	2.8	1.69	0.29	1.53
Jajai 77 (parent)	13.5	3.6	2.03	0.31	1.58
Jajai 77-1	12.8	2.9	1.26	0.24	1.73
Mutant 77-2	6.5	1.7	1.61	0.31	1.33
Mutant LG-1	6.6	1.9	1.73	0.30	1.43
Mutant Jajai 30	8.4	2.1	1.69	0.28	1.53
Sada Gulab (parent)	12.8	2.7	1.82	0.30	1.63
Mutant SG-EF/SD-78	10.7	2.0	1.12	0.27	1.77
Mutant SG-EF/SD-55	9.2	2.1	1.54	0.24	1.61
Sonahri SG (parent)	17.9	5.2	1.68	0.24	1.66
Mutant SS-EF/SD-6	10.6	3.2	1.26	0.28	1.60
Mutant SS-EF/SD-8	10.5	2.6	1.26	0.23	1.53
Pokkali (parent)	7.0	3.8	1.87	0.29	1.63
Mutant pokkali	5.7	3.2	1.75	0.26	1.73
Lateefy (Dokri)	5.5	3.1	1.68	0.27	1.68
DR82 (parent)	6.7	3.7	1.70	0.28	1.69
LSD (0.05)	4.2	2.0	0.40	ns	ns
(0.01)	5.5	2.7	0.50	ns	ns

Rice mutants and their mother cultivars differed in yield potential (see table). IR6, IR8, Bas 370, Jajai 77, Sada Gulab, Sonahri Sugdasi, Pokkali, Lateefy, and DR82 yielded more straw and grain than their mutants. N and P were higher in the parents than in the mutants; K content was variable.

The higher N and P content in parent genotypes contributed to increased yield. ■

Developing a functional model of rice panicle growth

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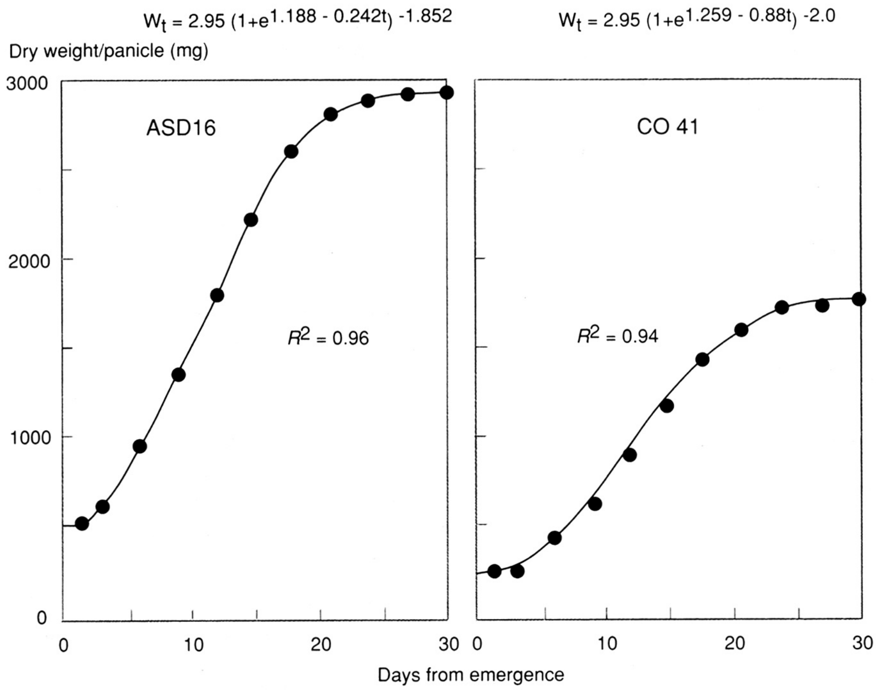
We grew short-duration rice cultivars ASD 16 and CO 41 under field conditions using a randomized complete block design with 12 replications during 1988 wet season. The pattern of panicle growth on 60 panicles/plot that emerged on the same day was studied from emergence to maturity. Five panicles per plot were removed 12 times to 30 d after emergence and dry weight recorded.

Panicle development followed a sigmoidal pattern (see figure). Two distinct lag phases, one at the beginning and one at the end of panicle growth, were evident. These two lag phases were separated by rapid linear growth between 3 and 21 d after emergence. We tried several growth equations: Richard's function, logistic function, nonlinear function, and negative exponential function.



Panicle growth in rice cultivars, Coimbatore, India, 1988 wet season.

Type of function	Functional form	R^2 value	
		ASD16	CO 41
Richard's function	$W_1 = (1+e^{b-kt})^{-1/n}$	0.960	0.945
Logistic function	$W_1 = (1+e^{b-kt})^{-1}$	0.863	0.810
Nonlinear function	$W_1 = (a+bt)^{-1}$	0.780	0.693
Negative exponential function	$W_1 = ae^{-b1}$	0.632	0.542

Richard's function gave the best fit to describe panicle growth in short-duration rice cultivars. The Richard's equations of panicle growth follow:

ASD16 $W_1 = 295(1+e^{1.188-0.242t})^{-1.852}$ (R^2= 0.960)
CO41 $W_1 = 1.79(1+e^{1.259-0.228t})^{-2.0}$ (R^2=0.945)

ASD16 had a mean relative growth rate ($\bar{R}$) of 157 mg/panicle per day, compared with 151 mg in CO 41.

Mean relative growth rate was calculated as

$$\bar{R} = \frac{K}{(n+1)}$$

(Suggested by D R Causton and J C Venus [1981]) The biochemistry of plant growth. Edward Arnold, London. p. 92.) ■

Herbage potential of rice cultivars

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Rice herbage can be an important animal feedstuff: it has high nutritive value, it is readily available in most ruminant production areas, and rice grain yield is not sacrificed by herbage removal. We studied the herbage potential of 20 deepwater and 4 lowland rice cultivars under irrigation at IRRI in the 1989 wet season.

The experimental field was plowed twice. Fertilizer was incorporated basally at 60-40-40 kg NPK/ha 1 d before transplanting. Twenty-day-old seedlings were transplanted at 20- × 20-cm spacing with two seedlings/hill. Herbage was cut at the collar level of the last fully developed leaf 40 d after transplanting (DT) and from different plots at 60 DT. Treatments were repeated three times.

Differences in growth and herbage yield were observed at 40 and 60 DT (Table 1). There was a positive relationship between herbage yield at 40 and 60 DT (R = 0.595**). Deepwater cultivars Khao Mali, Pan Tawng, Khao Lod Chong, and Khao Praguad gave high herbage yields, similar to lowland cultivars; Khao Puang Nak, Pin Gaew 56, Ban Daeng, Plai Ngahm, and Sai Bua gave poor herbage yields.

Herbage yields from one cutting were more than 1 t/ha at 40 DT and about 2 t/ha at 60 DT, suggesting the potential production of rice herbage as animal feed.

Simple linear correlation analysis showed highly significant positive relationships between herbage yield and growth parameters (Table 2). The relationship of herbage yield with sheath and culm weight was high at 40 DT, but