

Table 2. Performance of selected indigenous rice varieties for cold tolerance at LRARC, Nepal, 1990.

Genotype	Altitude ^a (m)	Plant height (cm)	Cold tolerance (1-9) ^b		Spikelet sterility (1-9) ^b	Crop duration (d)	Yield (t/ha) at 12% moisture content
			GS2	GS6			
Silange	1900 NE	111	3	1	2	140	5.3
Chhomrong	2000 NE	137	1	3	1	144	4.1
Kalo Patle Tangle	1600 SE	133	1	1	1	144	4.1
Darmali	1700 NE	160	3	3	1	154	4.1
Dangsing Damadi	1620 SW	130	3	5	1	150	4.0
Phalame	1700 NE	137	1	3	1	143	3.9
Bhuin dhan	1600	125	1	1	1	150	3.8
Bhatte	1700 SE	118	1	1	1	154	3.7
Rato Darmali	1600 W	133	1	1	1	153	3.6
Rato Takmare	1800 SE	117	1	5	1	140	3.6
Range	700-2000	90-151	1-5	1-7	1-5	138-170	0.9-5.3
Mean		125±13.7	2±1.2	2.9±1.7	1.6±1.0	152±29.1	3.05±0.61

^a NE = northeast, SE = southeast, SW = southwest, W = west. ^b By the *Standard evaluation system for rice* GS2 = at tillering, GS6 = at anthesis.

1,500-m altitude that show good cold tolerance had dark grains. They will be grouped according to phenology and plant height for further use in cold tolerance breeding.

Thorough collection and evaluation of local rice germplasm would help identify donors of cold tolerance at anthesis, currently lacking in our breeding program. □

Screening for cold tolerance in Nepal

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Rice is grown in all agroecological zones of Nepal, from the foothills to the high mountains. Double cropping is practiced up to about 900 m, and rice reaches its altitudinal limit at 2,000 m.

Chilling injury limits both the rice-producing area and the length of the growing season. Above 1,000-m altitude, cool weather and cold irrigation water cause delayed heading, leaf yellowing, partial panicle exertion, spikelet degeneration, spikelet sterility, and low yields in wetland rice transplanted in July. Poor germination and slow seedling growth are additional symptoms in irrigated short-duration rice seeded in Feb below 900 m.

Of 31 rice varieties recommended so far by the National Rice Research Program, only Khumal 2 and Palung 2

sited below 500 m asl, in the lower hills and the Terai.

Cold stress in rice occurs at specific growth stages in different altitude regime (Fig. 1), and cold tolerance nurseries have been established at off-station research (OSR) sites to include both the diversity and complexity of high-altitude rice production systems.

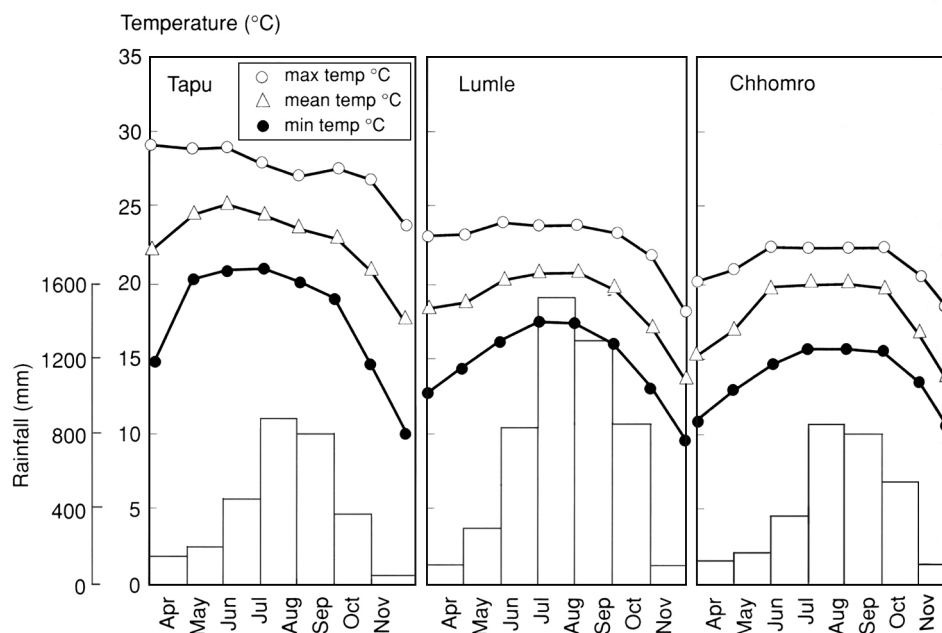
At Tapu (1,000 m), mean air temperature does not fall below 20°C until the crop reaches spikelet filling. At Lumle (1,400 m), mean air temperature does not fall below 20°C until the beginning of the reproductive stage. At Chhomro (2,000 m), mean air temperature is low (15-20°C) throughout the growing season. Water temperatures recorded at Lumle and Chhomro during anthesis are 19.1-21.2 and 15.0-21.2 °C, respectively.

At Tapu, chilling injury in rice is induced by cool air temperatures around ripening time; at Lumle and Chhomro, it is attributed to both cold weather and cold water, and to their durations, at different growth stages.

We evaluated four sets of National Rice Cold Tolerance Nursery, including both indigenous and exotic rice genotypes, at Yampaphant (475 m), Tapu, Lumle, and Chhomro during 1987 and 1988. (Since 1985, 79 local and 528 exotic entries have

have been released for cold tolerance in the midhills. Their performance above 1,400 m asl is poor.

This is not surprising: breeding for low temperature tolerance in Nepal is limited because most research stations are



1. Temperature and rainfall patterns at Lumle (1400 m), Chhomro (2000 m), and Tapu (1000 m) testing sites in Nepal. Data are averages of 10 yr (1980-89), 4 yr (1986-89), and 3 yr (1987-89), respectively. Legend: (○—○) = max temp °C; (△—△) = mean temp °C; (●—●) = min temp °C.

been screened, including internationally known cold-tolerant checks Stejaree 45, Akiyudaka, China 1039, Palung 2, Fuji 102, and Phalame.) Leaf color, panicle exsertion, spikelet sterility, and yield parameters were scored visually at seedling, booting, anthesis, and maturity stages.

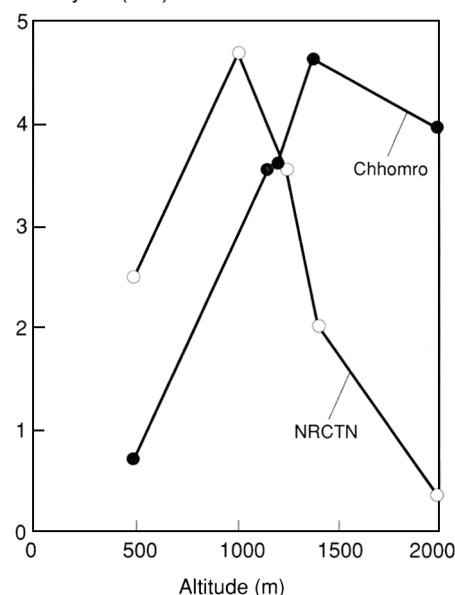
Above 1,400 m, most of the exotic varieties either failed to produce panicles or produced degenerated spikelets with a high degree of sterility. Yield performance of indigenous cultivars was reliable above 1,300 m (Fig. 2). At 1,500 m altitude, local variety Chhomro outyielded all other varieties; at 2,000 m, its performance was outstanding. This variety demonstrated an ability to tolerate

chilling at different growth stages at all altitudes.

The National Variety Releasing Board has released Chhomro as Chhomrong dhan, the first indigenous variety for areas above 1,400 m asl. It also has been included as a cold-tolerant entry in the International Rice Cold Tolerance Nursery and LRARC's chilling-tolerant rice breeding program. Results on segregating materials resulting from crosses between Chhomrong and exotic cold-tolerant lines are very promising.

Identification in recent years of Chhomrong dhan and several other varieties suitable for the low to high hills of Nepal has confirmed the value of field screening at different altitudes. □

Grain yield (t/ha) at 12% moisture content



2. Yield of Chhomro and mean yields of NRCTN across altitudes, 1987-88.

Stress tolerance—adverse soils

Response of some rice cultivars to lime application on acid sulfate soils

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We studied the effect of lime on rice cultivar yields in acid sulfate soils at Unit Tatas Substation, Central Kalimantan, during the 1989 dry season (Table 1).

In split-plot design with three replications, four lime levels (0, 0.5, 1.0, and 2.0 t/ha) were the main plot treatments and five rice cultivars (BW267-3, CR261-

7039-236, IR6023-10-1-1, Kapuas, and IR26) were subplot treatments. Lime was applied 15 d before transplanting. Three 21-d-old seedlings/hill were transplanted at 20- × 20-cm spacing in 4- × 5-m plots. At transplanting, we fertilized the rice basally with 90 kg N/ha, 26.4 kg P/ha, and 41.5 kg K/ha.

Table 2. Effect of lime on yield of rice cultivars in acid sulfate soils at Unit Tatas Substation, Central Kalimantan, 1989 dry season.

Lime (t/ha)	Grain yield (t/ha)				
	BW267-3	CR261-7039-236	IR6023-10-1-1	Kapuas	IR26
0	1.7	1.4	1.4	1.7	1.3
0.5	2.1	1.5	1.5	2.1	1.4
1.0	2.1	1.9	2.0	2.1	2.0
2.0	2.6	1.7	2.1	2.6	2.2
Mean	2.1	1.6	1.8	2.1	1.7

Table 1. Chemical characteristics of acid sulfate soil at Unit Tatas Substation, Central Kalimantan, Indonesia.

	0-20 cm deep	20-40 cm deep
pH (H ₂ O)	3.95	3.90
Total N (%)	0.41	0.19
Organic C (%)	2.78	1.70
Available P (ppm)	17.63	32.96
Exchangeable K (meq/100g)	0.19	0.13
SO ₄ (%)	0.12	0.05
Al ³⁺ (meq/100g)	14.19	15.70
Na (meq/100 g)	0.12	0.26
Fe ³⁺ (meq/100 g)	6.16	5.59
Particle size (%)		
Sand	0.22	0.21
Silt	33.41	31.14
Clay	66.37	68.65

Integrated germplasm improvement—irrigated

New rice cultivar Marianna obtained through anther culture

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Marianna is a new short-stemmed, lodging-resistant rice cultivar.

Yields in plots with 2.0 t lime/ha were significantly higher than those at other levels (Table 2).

In the cultivar treatments, Kapuas and BW267-3 yielded significantly higher than other varieties. In general, yield increased as lime was added. □

It is a dihaploid line, obtained from a 1983 F₁ hybrid combination Belozem/Plovdiv 22 through anther culture.

We tested Marianna alone and with other cultivars until 1986. From 1986 to 1989, it was tested in some regular trials at State Cultivar Commission stations. It was acknowledged as an original cultivar at the commission's 45th plenary session.

Marianna is related to the japonica rices. Its vegetative phase is 121-125 d,