Rice and nutritional quality: grain quality traits of highland rice genotypes cultivated in Jumla, Nepal

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Background

The cultivation of highland rice relies on cold-tolerant *Oryza sativa* japonica landraces. Depending on the altitude, these genotpyes also have to adapt to very high solar radiation.

Particularly low (night) temperatures delay the phenological development and increase spikelet sterility, resulting in low grain yields. On the other hand, low temperatures combined with high UV radiation at high altitudes may enhance grain quality traits.

Both, morphological traits and nutritional quality may vary between genotypes and along altitudinal gradients.

Thus, we investigated:

i) Differences in rice grain quality traits between genotypes
ii) Effects of altitude on these quality traits

Fig. 1 Rice harvesting and traditional milling in highlands, Jumla, Nepal. Harvested rice in field (A), threshing and grain collection in field (B), traditional manual milling at home (C).

Materials and methods

Grain samples collection and analysis:

Seven genotypes (3 parental lines, local and improved cultivars) were grown at altitudes of 2000 (Tatopani), 2300 (Bijayanagar) and 2900 m (Chhumchaur) in Nepal. Grain morphological traits (grain weight, shape, size) were analysed using scanning electron microscope coupled with energy disperse X-ray (ESEM-EDX). The mineral composition of the grain samples was analysed using Inductively Coupled Plasma –Optical Emission Spectroscopy (ICP-OES).

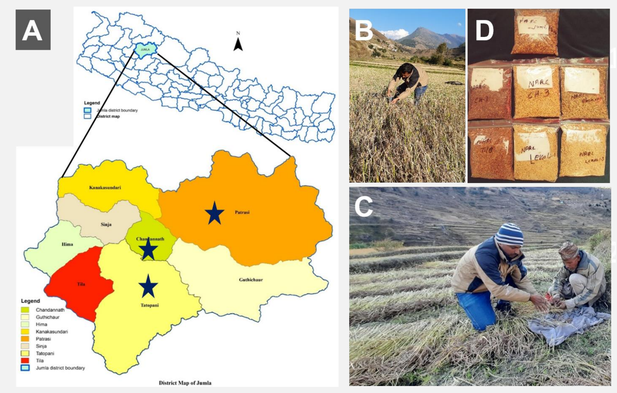
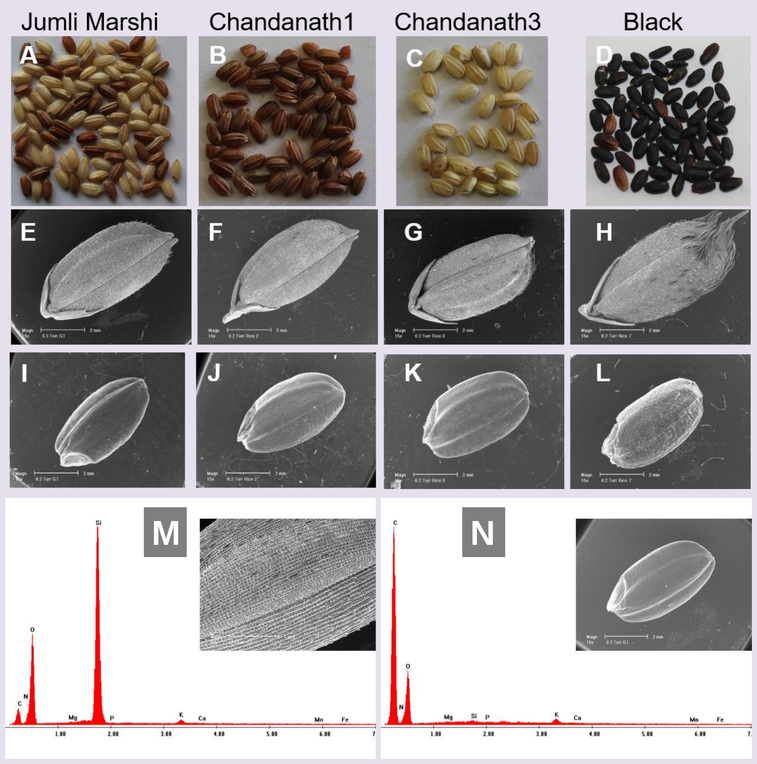


Fig. 2 A: Map of Jumla district and selected study sites (Tatopani-2200 masl, Bijayanagar-2300 masl and Chhumchaur-2900 masl). B-D: Rice grain sampling (harvesting, packaging) at harvest in the farmers field during October, 2021.

Rice grain morpho-chemical traits



Husk color was brown to reddish brown, but grain color differed between cultivars (whitish brown, red, white and black) (A-D). ESEM micrographs show different microstructure of husk and de-husked rice grains (E-L). Relative abundance of mineral elements on the surface of husk (M) and endosperm (N) of cultivar Jumli Marshi.

Conclusions and Outlook

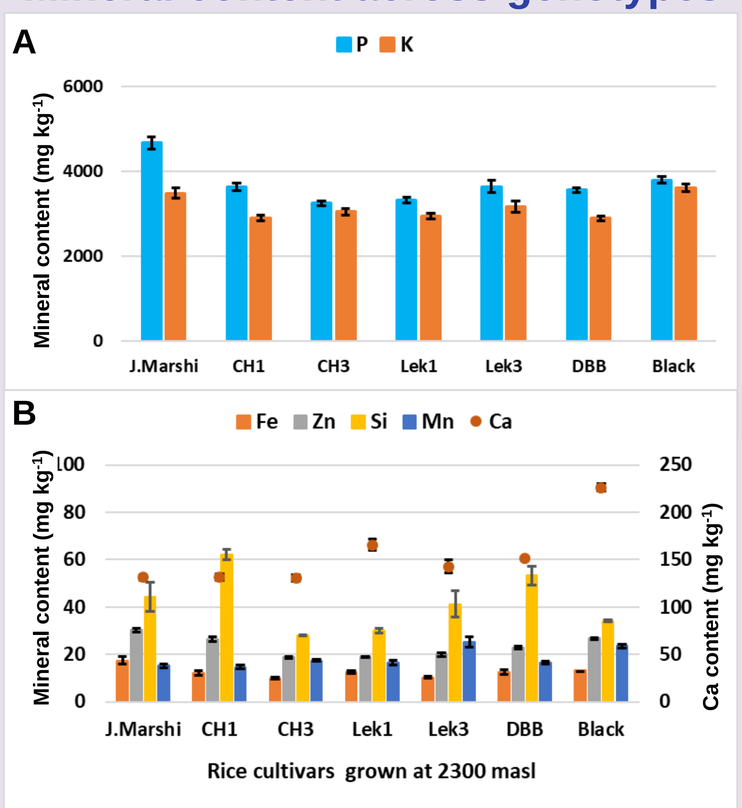
- High-altitude rice shows positive nutritional attribute.
- Grains of genotype “Jumli Marshi” contain highest amounts of Fe and Zn, “Black rice” showed highest Ca content.
- With altitude, most mineral elements (Fe, Zn, Ca, Mn, P, K) increased, while Si content decreased.
- However, mechanical milling removes some of these minerals.
- The study was conducted under farmers´ management and in different soils and ecological conditions along the altitude gradient. Hence, further studies are necessary to quantify altitude effects on grain quality.

1000 grains weight and grain size

Rice cultivar	1000 grain weight at 13% moisture (g)	Average grain length (mm)	Average grain breadth (mm)	
Jumli Marshi	23.3	8.5	3.5	A
Chandanath1	18.0	8.0	3.3	
Chandanath3	24.8	8.0	3.5	
Lekali1	24.1	8.0	3.5	
Lekali3	19.2	7.5	3.3	
D.B.Budha	24.7	7.3	3.5	
Black	17.5	8.0	3.3	
Jumli Marshi	24.0	8.5	3.4	B
Chandanath1	21.3	8.5	4.0	
Chandanath3	20.2	7.5	3.3	
Kali Marshi	18.2	7.6	3.0	C
Chandanath1	18.3	7.5	3.3	
Pakho	21.8	8.5	3.0	

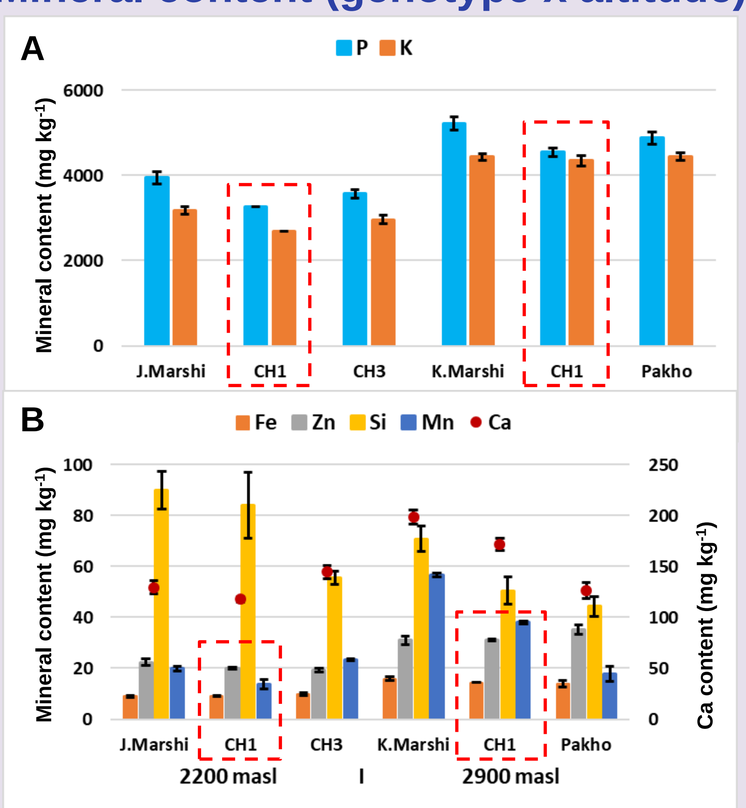
Grain weight (1000 grains at 13% moisture) was higher for cultivars D.B.Budha and Chandanath3 and lowest for Black rice (A). They were cultivated at the same site (2300 masl). While 1000 grains weight was lower and grain size was smaller for Chandanath1 at high (2900 masl, C) than at low (2200 masl, B) altitudes.

Mineral content across genotypes



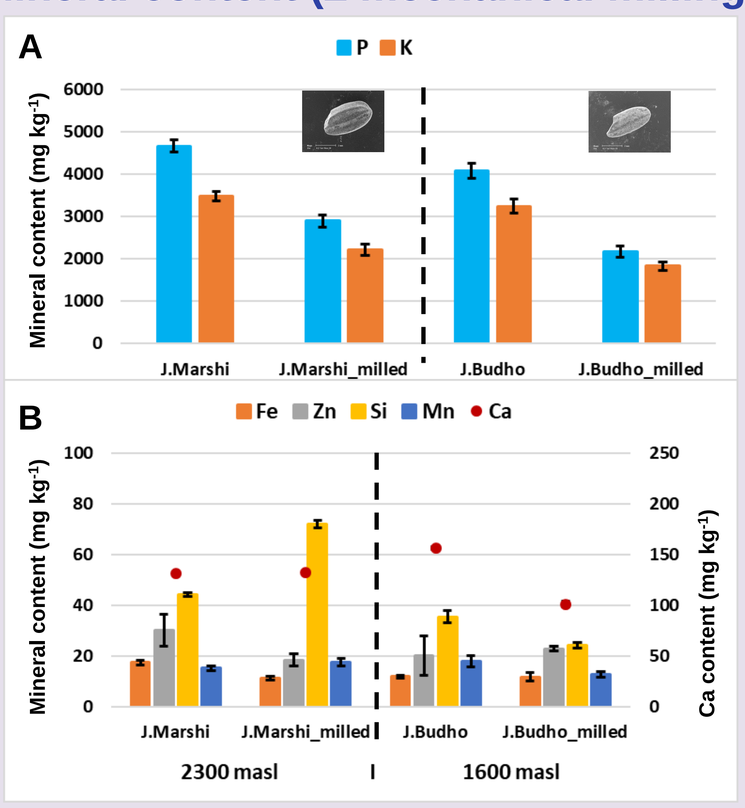
Grains mineral content of 7 cultivars grown at Agriculture Research Station (ARS-Jumla, 2300 masl), Bijayanagar, Jumla, Nepal. The local cultivar Jumli Marshi had higher P, Fe and Zn contents (A, B) than other improved cold tolerant genotypes. Black rice had highest Ca content in the de-husked grain (B). n = 5

Mineral content (genotype x altitude)



Grains mineral content of 3 cultivars grown along 2 altitude gradients (Tatopani, 2200 masl & Chhumchaur, 2900 masl) in Jumla district, Nepal. The cultivar Chandanath1 had higher P, K, Fe, Zn, Mn and Ca contents (A, B, dotted red box) but lower Si content (B) in grains collected from high (2900 masl) than from low (2200 masl) altitudes (A, B). n = 5

Mineral content (± mechanical milling)



Rice grain mineral content of 2 cultivars grown at either in Jumla (2300 masl) or in Kaski districts (1600 masl), Nepal. The mechanical milled (white / polished) Jumli marshi rice had lower P, K, Fe, Zn contents (A, B), but Mn and Ca contents were not affected (B). n = 5

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