

Table S1. Chemical and physical soil attributes assessed in two environments, Lavras (E1) and Lambari (E2).

Soil attributes (0–20 cm)	E1	E2
pH	4.90	4.70
K _{exchangeable} (mg dm ⁻³)	86.85	62.07
P _{exchangeable} (mg dm ⁻³)	20.64	12.49
Ca _{exchangeable} (cmol dm ⁻³)	2.26	1.55
Mg _{exchangeable} (cmol dm ⁻³)	0.59	0.21
Al _{exchangeable} (cmol dm ⁻³)	0.30	1.10
H+Al (cmol dm ⁻³)	7.50	8.00
SB (cmol _c dm ⁻³)	3.07	1.92
t (cmol _c dm ⁻³)	3.37	3.02
T (cmol _c dm ⁻³)	10.57	9.92
V (%)	29.07	19.35
m (%)	8.90	36.42
OM (dag kg ⁻¹)	2.64	2.63
P-Rem (mg L ⁻¹)	19.50	12.00
Zn _{exchangeable} (mg dm ⁻³)	2.70	1.20
Fe _{exchangeable} (mg dm ⁻³)	30.60	66.90
Mn _{exchangeable} (mg dm ⁻³)	12.00	17.10
Cu _{exchangeable} (mg dm ⁻³)	0.40	69.50
B _{exchangeable} (mg dm ⁻³)	0.08	0.01
S _{exchangeable} (mg dm ⁻³)	5.30	4.80
Clay (dag kg ⁻¹)	46	36
Silt (dag kg ⁻¹)	13	32
Sand (dag kg ⁻¹)	41	32

pH: hydrogen potential; K: potassium; P: phosphorus; Ca: calcium; Mg: magnesium; Al: aluminum or exchangeable acidity; H+Al: total acidity; SB: sum of exchangeable bases; t: effective cation exchange capacity; T: total cation exchange capacity; V: base saturation; m: aluminum saturation; OM: organic matter; P-Rem: remaining phosphorus; Zn: zinc; Fe: iron; Mn: manganese; Cu: copper; B: boron; exchangeable sulfur.

Table S2. Fertilization applied in the experimental areas in two environments (E1 and E2).

Soil fertilization 60 days before sowing			
Nutrients	E1	E2	Source
Ca e Mg	V%=50	V%=50	CaCO ₃ /MgCO ₃
Pre-plant fertilization			
Nitrogen (N)	20 kg ha ⁻¹	20 kg ha ⁻¹	8-28-16
Phosphorus (P)	35 kg ha ⁻¹	70 kg ha ⁻¹	8-28-16
Potassium (K)	20 kg ha ⁻¹	40 kg ha ⁻¹	8-28-16
Fertilizers in top dressing (40 days after sowing)			
N	50 kg ha ⁻¹	50 kg ha ⁻¹	AS
K	20 kg ha ⁻¹	20 kg ha ⁻¹	KCl

V%: base saturation, 8-28-16: percentages of nitrogen (N), phosphorus (P), and potassium (K) present in the fertilizer, respectively; CaCO₃/MgCO₃= dolomitic limestone; NA = not applicable; KCl= potassium chloride; U= urea; AS= ammonium sulfate.

Table S3. Summary of the analysis of variance for agronomic traits, plant height (PH, cm), thousand grain weight (TGW, g), and grain yield (GY, kg ha⁻¹) evaluated in five upland rice lines across two environments.

Sources of Variance	DF	Mean Square		
		PH	TGW	GY
Environment (E)	1	0.384	1.726	590953.300**
Zn (Zn)	1	0.043	1.034	131873.300
Genotype (G)	4	238.528**	164.571**	367215.700**
G x E	4	11.536	1.897	415979.200**
G x Zn	4	6.138	0.801	64833.060
E x Zn	1	0.600	0.3565	44639.190
E x Zn x G	4	2.768	1.510	300896.200**
Block/E	4	137.347**	1.457	163471.200**
Error	36	23.587	0.801	55011.8
Overall Mean		85.93	26.49	1201.55
CV (%)		5.65	3.38	19.52
r _{gg}		0.94	0.99	0.92

** : Significant by F-test at 1%.

Table S4. Summary of the analysis of variance for Zn content (mg kg^{-1}) in grains of upland rice lines, derived from different rice processing methods, in two environments.

Sources of Variance	DF	Mean square
		Zn content
Environment (E)	1	3308.193**
Zn (Zn)	1	6444.516**
Genotype (G)	4	263.387**
Rice Processing (RP)	2	2083.752**
E x Zn	1	95.716**
E x G	4	139.662**
E x RP	2	256.721**
G X Zn	4	63.867**
Zn x RP	2	1237.916**
G x RP	8	19.851
E x Zn x G	4	63.017**
E x Zn x RP	2	121.407**
E x RP x G	8	5.196
RP x G x Zn	8	2.737
E x Zn x G x RP	8	4.115
Block/E	4	141.88**
Error	36	10.658
Overall Mean		35.57
CV (%)		9.18
$r_{\hat{g}g}$		0.98

** : Significant by F-test at 1%.

Table S5. Summary of the analysis of variance for germination percentage (%) and Zn content (mg kg^{-1}) in 10-day-old seedlings from biofortified upland rice lines.

Source of variation	DF	Mean Square	
		Germination	Zn content
Block	2	10.23	115.97
Genotype (G)	4	193.22**	1618.94**
Zn (Zn)	1	790.53**	5546.78**
G x Zn	4	154.32**	320.63*
Error	18	25.19	106.72
Overall Mean		61.93	134.62
CV (%)		8.10	7.67
$r_{\hat{g}g}$		93.25	96.64

** : Significant by F-test at 1%.