10.1071/CP21458

Crop & Pasture Science

Supplementary Material

Yield, zinc efficiencies and biofortification of wheat with zinc sulfate application in soil and foliar nanozinc fertilisation

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Suppl. Table S1. Zinc (Zn) concentration in shoot and grain, and Zn accumulation in shoot and grains of wheat as influenced by soil and foliar zinc rates. Selvíria - MS, Brazil, 2019 and 2020

Treatments	Shoot Zn concentration		Grain Zn concentration		Shoot Zn accumulation		Grain Zn accumulation	
	---------- mg/kg ----------				---------- g/ha ----------			
	2019	2020	2019	2020	2019	2020	2019	2020
Soil Zinc application (kg/ha)								
0	30 b	34 b	42	47	146 b	170	143	163
8	35 a	40 a	46	54	175 a	206	173	206
Foliar Zn rates (kg/ha)								
0	28	32	37	42	132	152	119	136
0.75	32	37	44	50	160	189	162	187
1.5	35	41	50	57	183	218	193	227
3	34	40	48	54	177	204	174	201
6	31	36	41	48	151	177	142	172
F values								
Soil Zn (SZn)	27 **	67 **	50 **	102 **	41 **	98 **	121 **	131 **
Foliar Zn (FZn)	9 *	22 **	38 **	72 **	17 **	38 **	90 **	63 **
SZn x FZn	0.8 ns	2.4 ns	5 *	13 **	1.6 ns	5 *	17 **	17 **
CV (%)	8.4	5.8	4.7	3.9	8.7	6.1	5.4	6.5

Means in the column followed by different letters are significantly different (p-value ≤ 0.05);

** and * Significant at $p < 0.01$ and $p < 0.05$, respectively; and ns, non-significant by F-test

Suppl. Table S2. Plant height, dry matter, grain yield, Zn partitioning index (ZPI), Zn intake in Brazil as influenced by soil and foliar zinc rates. Selvíria - MS, Brazil, 2019 and 2020

Treatments	Plant height		Dry matter	Grain yield		ZPI		Zn intake	
	----- cm -----		---------- kg/ha ----------			----- % -----		g/person/ day	
	2019	2020	2019	2020	2019	2020	2020	2019	2020
Soil Zn application (kg/ha)									
0	74 b	76	4851 b	4938	3363	3441	70 b	72	6.6	7.3
8	77 a	79	5045 a	5138	3693	3820	75 a	75	7.2	8.3
Foliar Zn rates (kg/ha)									
0	71	74	4643	4780	3176	3269	69	70	5.8	6.5
0.75	75	77	4974	5074	3637	3702	71	73	6.9	7.9
1.5	79	81	5152	5286	3799	3908	75	77	7.8	8.9
3	78	79	5099	5129	3605	3717	75	76	7.5	8.4
6	73	76	4873	4922	3423	3558	72	72	6.4	7.5

F values										
Soil Zn (SZn)	20 **	20 **	34 **	30 **	55 **	51**	20 **	18 **	38 **	102 **
Foliar Zn (FZn)	21 **	13 **	29 **	23 **	23 **	16 **	5 *	11 **	49 **	72 **
SZn x FZn	2.4 ns	5 *	2.2 ns	4 *	6.5 *	4 *	2.5 ns	3.6 *	5.2 *	13 **
CV (%)	2.5	2.9	2.1	2.3	3.9	4.6	4.8	3.3	4.7	3.9

Means in the column followed by different letters are significantly different (p-value ≤ 0.05); ** and * Significant at $p < 0.01$ and $p < 0.05$, respectively; and ns, non-significant by F-test.

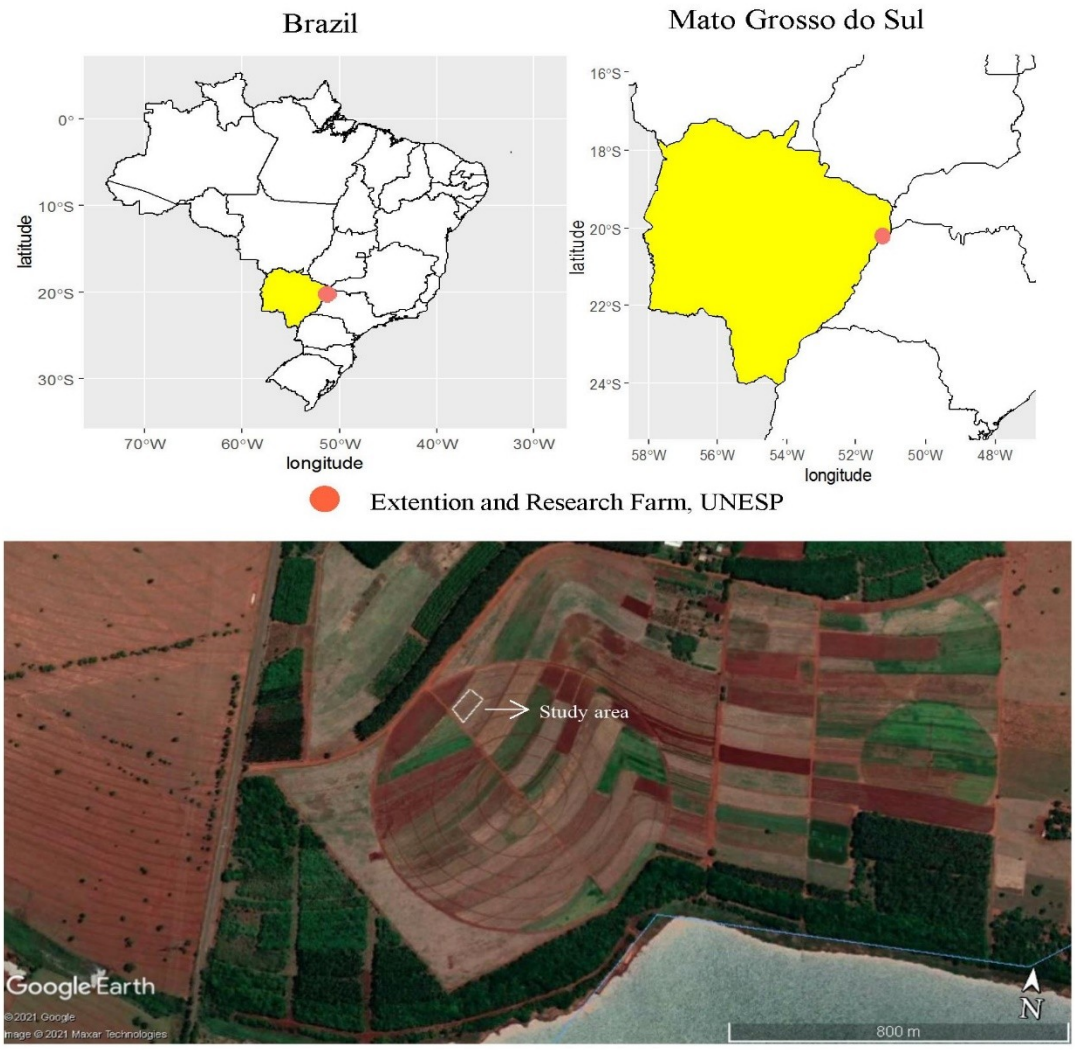
Suppl. Table S3. Zinc efficiencies of wheat as influenced foliar zinc rates associated to soil Zn application. Selvíria - MS, Brazil, 2019 and 2020

Treatments	ZnUE		APE		UE		AZnR	
	---------- kg kg^{-1} ----------						------- % -------	
	2019	2020	2019	2020	2019	2020	2019	2020
Foliar Zn rates (kg/ha)								
0	22	41	0.40	4.9	16	8	7	8
0.75	94	100	0.70	5.3	55	43	16	19
1.5	108	127	0.49	4.4	80	73	23	29
3	48	66	0.32	4.3	53	27	13	11
6	34	42	0.35	4.7	29	6	7	8
F-values								
Zn-foliar	26.8**	38 **	4.8 *	0.41 ns	23	16 **	52 **	31 **
CV (%)	23.8	16	30	27.6	22	44	14	22.4

ZnUE = Zinc use efficiency, APE = Agro-physiological efficiency, UE = Utilization efficiency, and AZnR = Applied zinc recovery.

Means in the column followed by different letters are significantly different (p-value ≤ 0.05);

** and *Significant at $p < 0.01$ and $p < 0.05$, respectively and ns- nonsignificant by F-test respectively.



Sup. Fig. S1. Location of the experimental area at the Research and Extension Farm, UNESP – Ilha Solteira Campus, at Selvíria - Mato Grosso do Sul state, Brazil (20°22′S, 51°22′W, altitude of 335 m) in 2019 and 2020 crop seasons. The map was created using pacot, geobr and ggplot with R software (R software (R Development Core Team, 2015). Projection System WGS 84/UTM 200DC [EPSG: 4326]. This image was taken from Google Earth program, Google Company (2021). Map data: Google, Maxar Technologies.

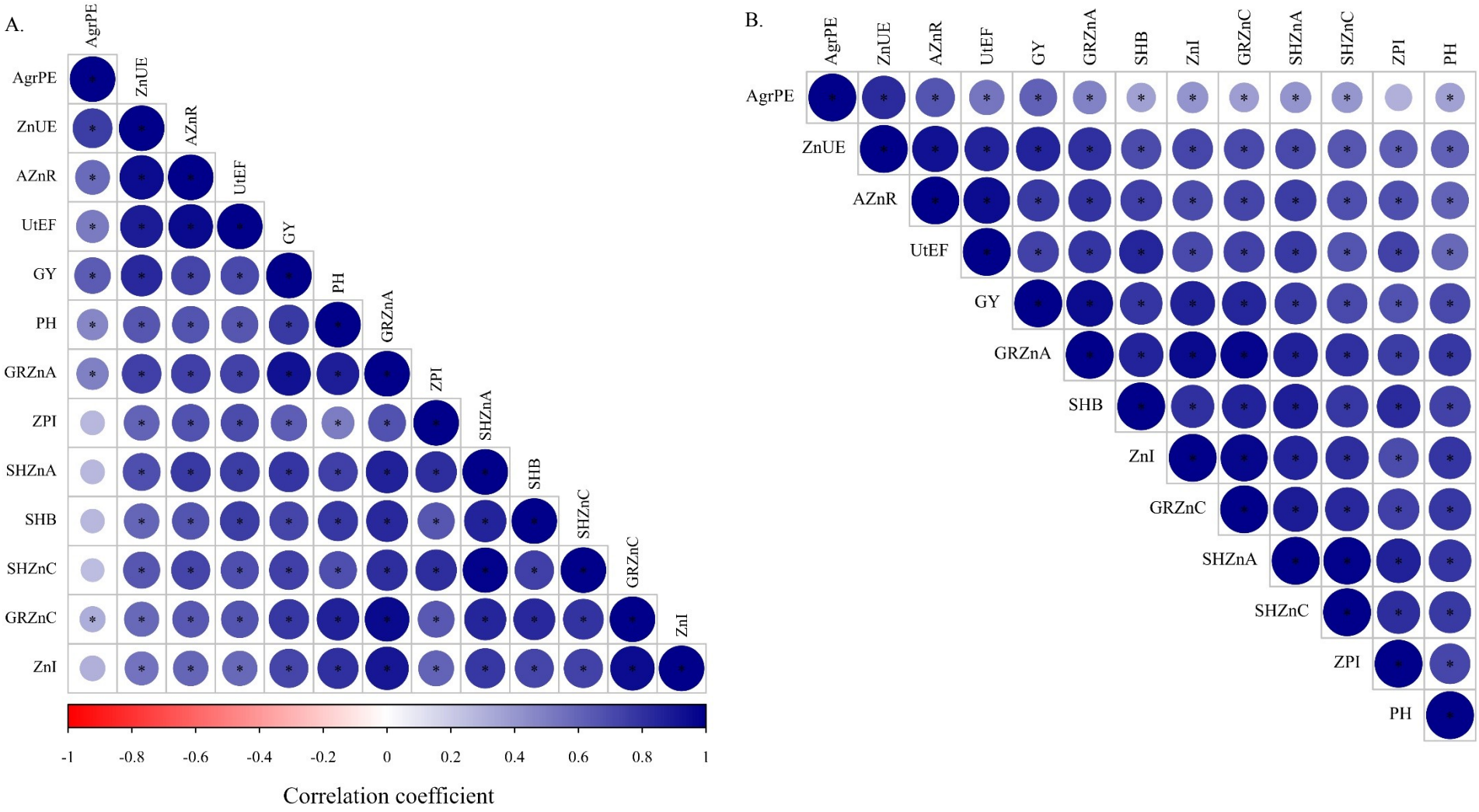

A.
AgrPE
ZnUE
AZnR
UtEF
GY
PH
GRZnA
ZPI
SHZnA
SHB
SHZnC
GRZnC
ZnI
-1
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
0.8
1
Correlation coefficient
B.
AgrPE
ZnUE
AZnR
UtEF
GY
GRZnA
SHB
ZnI
GRZnC
SHZnA
SHZnC
ZPI
PH

Fig. S2. Heatmap indicating correlation among the nutritional, dry matter, productivity and Zn use efficiencies in wheat for soil and foliar Zn rates in 2019 (A) and 2020 (B). * Indicates a significant relationship ($p \leq 0.05$).

Abbreviations: SHZnC = Shoot Zn concentration, SHZnA = Shoot Zn accumulation, GRZnC = Grain Zn concentration, GRZnA = Zn accumulated in grain, SHB = shoot dry matter, GY = grain yield, PH = plant height, ZPI = Zn portioning index, ZnI = Zn intake, ZnUE = Zn use efficiency, AgrPE = Agro-physiological efficiency, AZnR = Applied Zn recovery, and UtEF = Utilization efficiency.