Table S1. Assessment measures according to the grouping method used to generate application zones.

Harvest year	Indices [1]	Fanny	C-means	K-means	Mcquitty	Ward
2013-2014	D	0.0013	0.0049	**0.0053**	0.0038	0.0040
	DB	1.0136	1.0007	**1.0004**	1.1620	1.1519
	C	0.1264	0.1230	**0.1228**	0.2051	0.1834
	SD	34.3238	33.9659	**33.9549**	38.2531	37.0772
	VR	46.1936	46.2690	**46.2692**	39.4736	38.3279
2014-2015	D	0.0031	0.0044	0.0034	0.0047	**0.0083**
	DB	1.1280	1.1115	**1.1081**	1.4141	1.1822
	C	0.1391	0.1368	**0.1367**	0.2464	0.1759
	SD	79.1748	77.4998	**76.5687**	99.0186	82.8300
	VR	52.3989	**52.5292**	51.1738	38.8561	46.4901
2015-2016	D	0.0096	0.0076	**0.0106**	0.0099	0.0095
	DB	0.9552	0.9471	**0.9467**	0.9787	0.9564
	C	0.1032	0.1016	**0.1015**	0.1457	0.1159
	SD	57.0478	56.6668	56.6466	57.1677	**56.6015**
	VR	50.4092	50.4698	**50.4701**	44.7660	48.6003

[1] D: Dunn index; DB: Davies Bouldin index; C: C index; SD: SD index; VR: Variance reduction index. In bold, the best results of the indexes are highlighted.

Table S2. Estimated values of the parameters of the geostatistical model adjusted for the soil chemical attributes, considering the random (R), proportional random (PR), systematic (S) and proportional systematic (PS) sample configurations reduced by 50% and 25%, for the 2013-2014 harvest year.

Method	Attributes	Model [1]	$\hat{\mu}$	$\hat{\varphi}_1$	$\hat{\varphi}_2$	$\hat{a}$	$\widehat{NSR}$
R50	Ca	M. κ=2.5	6.34	0.43	1.81	224.51	19.30
	Cu	M. κ=2.5	3436.90; -0.0005	0.00	0.43	325.30	0.00
	Fe	Gaus.	36.25	62.90	31.96	702.30	66.31
	H+al3	Gaus.	8.55	1.68	4.03	203.18	29.43
	Mn	Gaus.	61.76	257.31	106.10	361.81	70.80
R25	Ca	Gaus.	6.05	0.85	1.15	182.47	42.54
	Cu	Gaus.	1.27	0.28	0.29	572.89	49.16
	Fe	Gaus.	37.55	4.06	71.78	147.21	5.36
	H+al3	Exp.	8.75	2.06	3.09	137.98	39.95
	Mn	Exp.	59.81	209.12	188.12	370.99	52.64
PR50	Ca	Exp.	6.14	0.84	0.88	287.61	49.89
	Cu	M. κ=2.5	3381.10; -0.0005	0.08	0.49	378.60	14.16
	Fe	M. κ=2.5	37.83	28.92	48.04	223.62	37.58
	H+al3	Gaus.	8.79	4.40	0.13	23.74	97.11
	Mn	Gaus.	-1.33×10^5; 0.018	390.90	46.20	563.43	89.42
PR25	Ca	Exp.	6.23	1.39	0.49	483.99	74.34
	Cu	M. κ=2.5	1.30	0.19	0.34	723.80	35.59
	Fe	Gaus.	36.91	57.90	25.40	746.06	69.51
	H+al3	Gaus.	-415.51; 0.002	3.45	0.66	629.70	83.94
	Mn	Exp.	61.68	160.81	254.51	355.38	38.71
S50	Ca	Gaus.	6.34	0.85	1.07	166.52	44.21
	Cu	Exp.	1904.91; -0.0003	0.00	0.39	377.74	0.00
	Fe	Gaus.	34.75	41.95	20.26	792.17	67.44
	H+al3	Gaus.	8.48	2.48	2.09	148.28	50.28
	Mn	Gaus.	60.58	146.50	202.19	161.44	42.01
S25	Ca	Gaus.	6.13	0.00	1.76	75.90	0.00
	Cu	Gaus.	-1174.44; 0.0002	0.30	0.35	961.42	46.06
	Fe	Gaus.	37.99	3308	40.67	183.20	44.85
	H+al3	Gaus.	8.70	4.67	0.12	24.45	97.41
	Mn	Gaus.	60.29	223.65	257.75	197.91	46.46
PS50	Ca	Gaus.	6.16	0.00	1.91	106.42	0.00
	Cu	Gaus.	1.24	0.26	0.26	838.71	49.79
	Fe	Gaus.	37.77	0.00	83.20	62.40	0.00
	H+al3	Gaus.	-426.62; 0.002	4.74	0.24	23.87	95.25
	Mn	Gaus.	59.19	381.09	29.09	674.35	92.91
PS25	Ca	Exp.	6.27	0.00	1.75	138.35	0.00
	Cu	Gaus.	1.22	0.28	0.26	828.18	52.12
	Fe	Gaus.	35.53	43.42	14.60	754.81	74.84
	H+al3	Gaus.	8.55	4.64	0.06	200.84	98.75
	Mn	Gaus.	59.30	170.70	234.20	183.54	42.16

[1] M. κ=2.5: Matérn with κ=2.5; Gaus.: Gaussian; Exp.: Exponential. $\hat{\mu} = \beta_0$, $\hat{\varphi}_1$, $\hat{\varphi}_2$, $\hat{a}$: estimated values of the mean, nugget effect, partial sill, and practical range (meters) parameters, respectively; $\widehat{NSR} = \hat{\varphi}_1/(\hat{\varphi}_1 + \hat{\varphi}_2)$: nugget-to-sill ratio (%); for attributes that showed a directional trend $\hat{\mu} = \beta_0 + \beta_1 Y_1$, where $\hat{\beta}_0$ (first value of the mean column), $\hat{\beta}_1$(second value of the mean column): estimated values of the parameters of the regression model and Y_1 represents the directional trend identified.

Table S3. Estimated values of the parameters of the geostatistical model adjusted for the soil chemical attributes, considering the random (R), proportional random (PR), systematic (S) and proportional systematic (PS) sample configurations reduced by 50% and 25%, for the 2014-2015 harvest year.

Method	Attributes	Model [1]	$\hat{\mu}$	$\hat{\varphi}_1$	$\hat{\varphi}_2$	$\hat{a}$	$\widehat{NSR}$
R50	Al	Exp.	0.32	0.00	0.16	64.74	0.00
	Ca	Gaus.	5.17	1.50	0.13	251.15	92.02
	Mn	M. κ=2.5	75.96	147.29	337.57	517.27	30.38
	Zn	Gaus.	2.71	1.25	1.73	319.62	41.92
R25	Al	Gaus.	0.27	0.02	0.11	146.85	16.14
	Ca	Gaus.	5.48	0.95	0.81	187.80	53.85
	Mn	Gaus.	77.58	227.18	252.35	609.35	47.38
	Zn	Gaus.	2.89	1.72	1.06	375.91	61.93
PR50	Al	Gaus.	0.27	0.00	0.11	167.69	0.00
	Ca	Gaus.	5.38	0.51	1.12	207.75	31.25
	Mn	Exp.	74.73	0.00	430.55	410.26	0.00
	Zn	Exp.	2.86	0.00	3.45	268.52	0.00
PR25	Al	Gaus.	0.29	0.02	0.12	133.29	13.39
	Ca	Exp.	5.42	0.95	0.95	215.92	50.04
	Mn	Gaus.	77.24	209.96	229.34	409.35	47.79
	Zn	Gaus.	-331.61;0.0014	0.00	2.54	186.27	0.00
S50	Al	Gaus.	0.30	0.11	0.06	21.82	64.59
	Ca	Gaus.	5.40	1.17	0.57	22.15	67.45
	Mn	M. κ=2.5	76.03	82.96	422.67	164.25	16.41
	Zn	Gaus.	-288.75;0.0012	0.50	1.19	185.35	29.53
S25	Al	M. κ=2.5	0.24	0.09	0.01	14.40	92.77
	Ca	Gaus.	5.64	1.73	0.13	703.06	92.83
	Mn	Gaus.	78.99	271.55	214.55	561.24	55.86
	Zn	Gaus.	2.98	1.52	1.60	296.54	48.77
PS50	Al	M. κ=2.5	0.30	0.03	0.07	186.37	31.03
	Ca	Gaus.	5.32	0.47	1.27	178.41	26.81
	Mn	M. κ=2.5	72.49	80.24	243.16	203.30	24.81
	Zn	Gaus.	-278.20;0.0012	0.00	2.94	201.68	0.00
PS25	Al	M. κ=2.5	0.30	0.00	0.15	163.63	2.25
	Ca	Exp.	5.41	0.96	1.02	215.41	48.49
	Mn	Gaus.	77.06	129.19	342.52	212.70	27.39
	Zn	Gaus.	-292.44;0.0012	0.06	1.57	169.33	3.44

[1] Exp.: Exponential; Gaus.: Gaussian; M. κ=2.5: Matérn with κ=2.5. $\hat{\mu} = \beta_0$, $\hat{\varphi}_1$, $\hat{\varphi}_2$, $\hat{a}$: estimated values of the mean, nugget effect, partial sill, and practical range (meters) parameters, respectively; $\widehat{NSR} = \hat{\varphi}_1/(\widehat{\varphi_1} + \hat{\varphi}_2)$: nugget-to-sill ratio (%); for attributes that showed a directional trend $\hat{\mu} = \beta_0 + \beta_1 Y_1$, where $\hat{\beta}_0$ (first value of the mean column), $\hat{\beta}_1$(second value of the mean column): estimated values of the parameters of the regression model and Y_1 represents the directional trend identified.

Table S4. Estimated values of the parameters of the geostatistical model adjusted for the soil chemical attributes, considering the random (R), proportional random (PR), systematic (S) and proportional systematic (PS) sample configurations reduced by 50% and 25%, for the 2015-2016 harvest year.

Method	Attributes	Model [1]	$\hat{\mu}$	$\hat{\varphi}_1$	$\hat{\varphi}_2$	$\hat{a}$	$\widehat{NSR}$
R50	C	Exp.	32.00	5.00	5.56	667.47	47.31
	Ca	Gaus.	5.47	1.62	0.03	28.07	97.97
	Cu	Exp.	4.03	0.36	0.45	621.03	44.03
	Mn	Gaus.	87.18	414.95	204.33	311.75	67.01
	SB	Gaus.	7.90	4.25	0.07	28.45	98.33
	Zn	Gaus.	-7959.24; 0.0011	1.82	2.82	503.47	39.31
R25	C	M. κ=2.5	32.24	2.03	8.51	194.92	19.23
	Ca	Exp.	5.57	0.65	1.14	309.92	36.33
	Cu	Exp.	3.88	0.42	0.41	881.74	50.50
	Mn	Gaus.	88.18	277.36	233.12	396.91	54.33
	SB	Gaus.	8.01	3.36	0.21	290.90	94.06
	Zn	Gaus.	5.09	0.69	2.84	266.86	19.57
PR50	C	Gaus.	32.14	4.41	5.03	260.07	46.72
	Ca	Gaus.	5.48	1.31	0.97	220.71	57.33
	Cu	Gaus.	3.87	0.41	0.28	454.90	59.86
	Mn	Gaus.	86.53	174.69	287.74	292.73	37.77
	SB	M. κ=2.5	7.94	3.22	1.42	219.14	69.49
	Zn	Gaus.	-9941.32; 0.002; 0.0013	0.27	2.51	296.40	9.84
PR25	C	Gaus.	31.77	6.42	4.23	519.47	60.28
	Ca	M. κ=2.5	5.55	0.92	1.11	357.98	45.28
	Cu	Exp.	-5623.04; 0.0008	0.34	0.36	824.88	48.33
	Mn	M. κ=2.5	86.19	214.60	358.78	594.86	37.43
	SB	Gaus.	7.97	2.49	1.89	318.34	56.77
	Zn	Gaus.	5.05	1.53	3.43	374.04	30.82
S50	C	Exp.	32.38	7.22	2.42	384.32	74.92
	Ca	M. κ=2.5	5.61	0.43	1.96	245.37	17.96
	Cu	Gaus.	139.32; -0.0006	0.51	0.08	655.94	86.30
	Mn	Gaus.	89.61	354.15	172.38	488.14	67.26
	SB	Gaus.	8.03	3.31	1.48	214.87	69.04
	Zn	Gaus.	-1.15×10^{-4}; 1.80×10^{-3};1.50×10^{-3}	0.73	2.41	202.61	23.22
S25	C	M. κ=2.5	31.86	6.71	2.90	724.60	69.80
	Ca	Gaus.	5.42	1.77	0.12	250.39	93.77
	Cu	M. κ=2.5	3.88	0.45	0.29	674.78	60.64
	Mn	Exp.	87.09	211.84	303.69	355.57	41.25
	SB	Gaus.	7.82	4.36	0.08	23.32	98.24
	Zn	Gaus.	-8136.22; 0.0011	0.91	3.76	284.26	19.42
PS50	C	Gaus.	32.34	7.73	1.62	540.98	82.66
	Ca	M. κ=2.5	5.56	0.49	1.75	201.95	21.71
	Cu	M. κ=2.5	3.89	0.56	0.12	808.21	82.51
	Mn	Exp.	89.06	282.24	258.80	580.85	52.17
	SB	Exp.	7.90	4.49	0.14	12.45	96.96
	Zn	Gaus.	-1.16×10^{4}; 1.6×10^{-3}	1.59	1.93	261.55	45.12
PS25	C	M. κ=2.5	31.86	6.42	4.09	668.41	61.08
	Ca	Exp.	5.40	1.06	0.91	199.81	53.86
	Cu	Gaus.	4.04	0.52	0.26	951.95	66.63
	Mn	M. κ=2.5	86.23	286.88	214.75	415.08	57.19
	SB	Gaus.	7.78	4.14	0.34	25.26	92.45
	Zn	Gaus.	-1.03×10^{4}; 1.40×10^{-3}	1.75	2.68	292.23	39.53

[1] Exp.: Exponential; Gaus.: Gaussian; M. κ=2.5: Matérn with κ=2.5. $\hat{\mu} = \beta_0$, $\hat{\varphi}_1$, $\hat{\varphi}_2$, $\hat{a}$: the estimated values of the mean, nugget effect, partial sill, and practical range (meters) parameters, respectively; $\widehat{NSR} = \hat{\varphi}_1/(\widehat{\varphi_1} + \hat{\varphi}_{2)}$: nugget-to-sill ratio (%); for attributes that showed a directional trend $\hat{\mu} = \beta_0 + \beta_1 Y_1$, where $\hat{\beta}_0$ (first value of the mean column), $\hat{\beta}_1$(second value of the mean column): estimated values of the parameters of the regression model and Y_1 represents the directional trend identified.

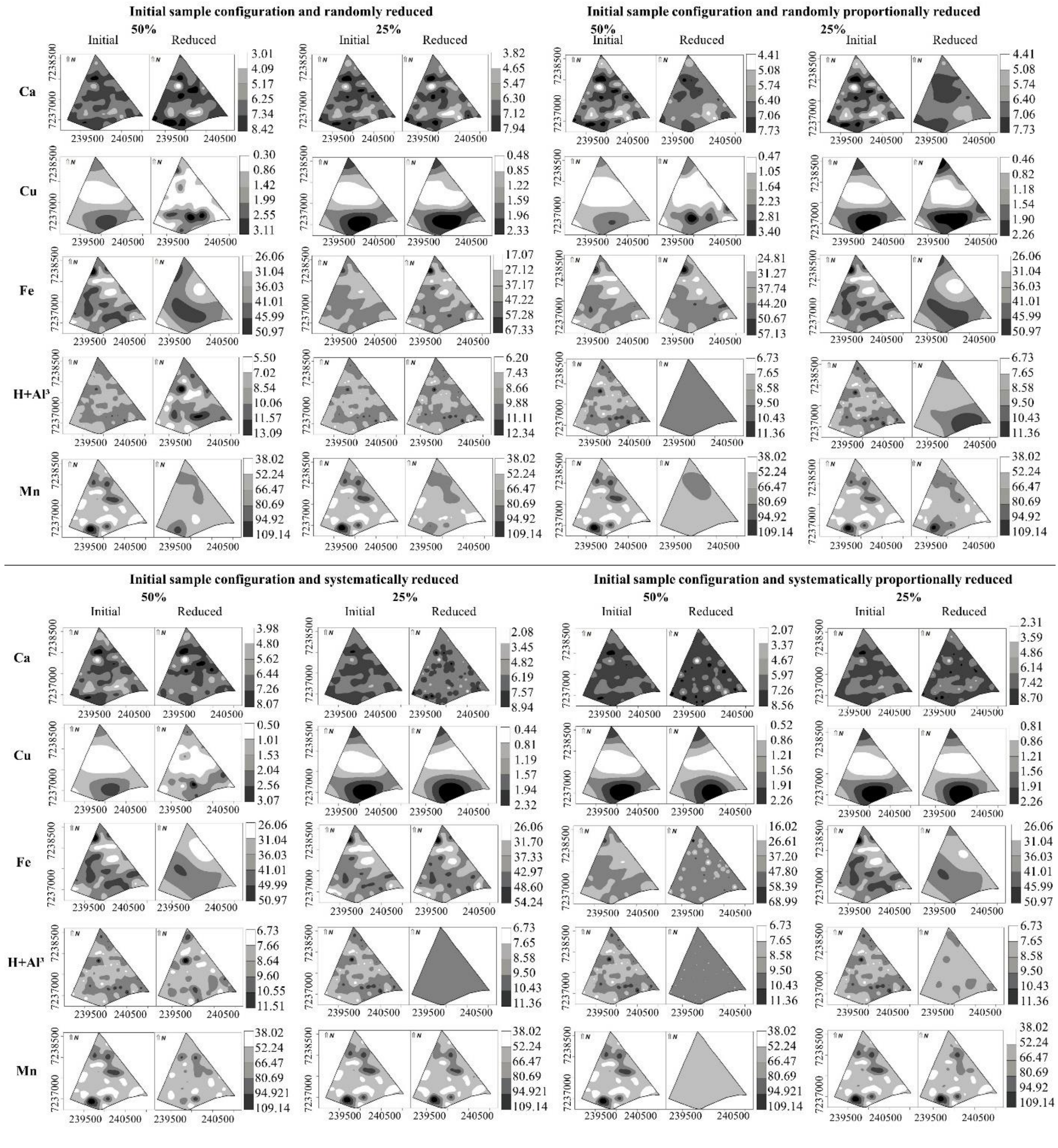

Figure S1. Thematic maps of the soil chemical attributes prepared considering the initial sample configuration and those randomly; randomly proportionally; systematically; and systematically proportionally reduced by 50% and 25% for the 2013-2014 harvest year (X axis: East-West and Y axis: North-South).

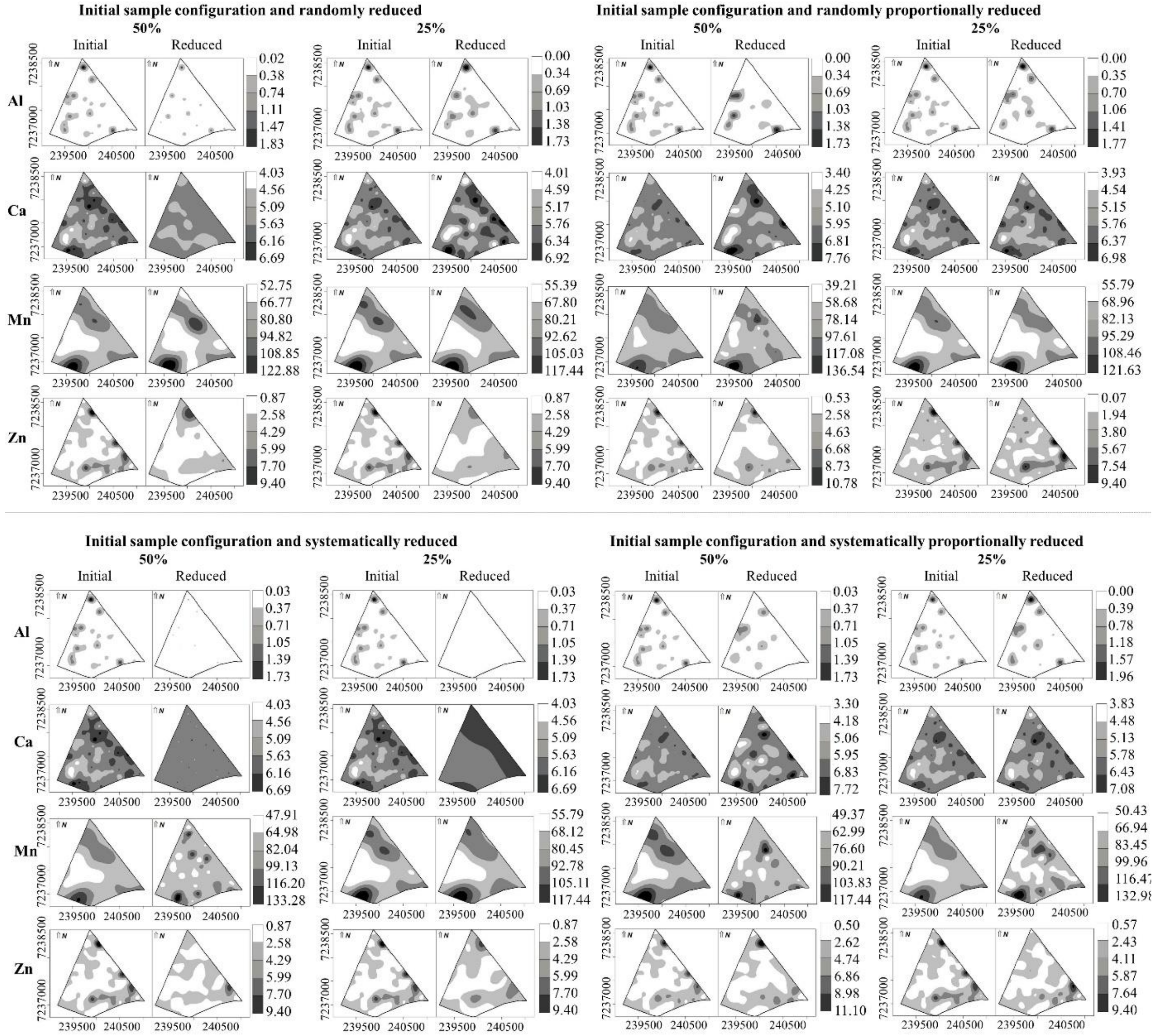

Figure S2. Thematic maps of the soil chemical attributes prepared considering the initial sample configuration and those randomly; randomly proportionally; systematically; and systematically proportionally reduced by 50% and 25% for the 2014-2015 harvest year (X axis: East-West and Y axis: North-South).

Supplementary tables and figures to the article "Multivariate spatial sample reduction of soil chemical attributes by means of application zones", by Tamara C. Maltauro, Luciana P. C. Guedes, Miguel A. Uribe-Opazo, and Letícia E. D. Canton. Spanish Journal of Agricultural Research, Vol. 21, No. 2, 2023 (https://doi.org/10.5424/sjar/2023212-19521)

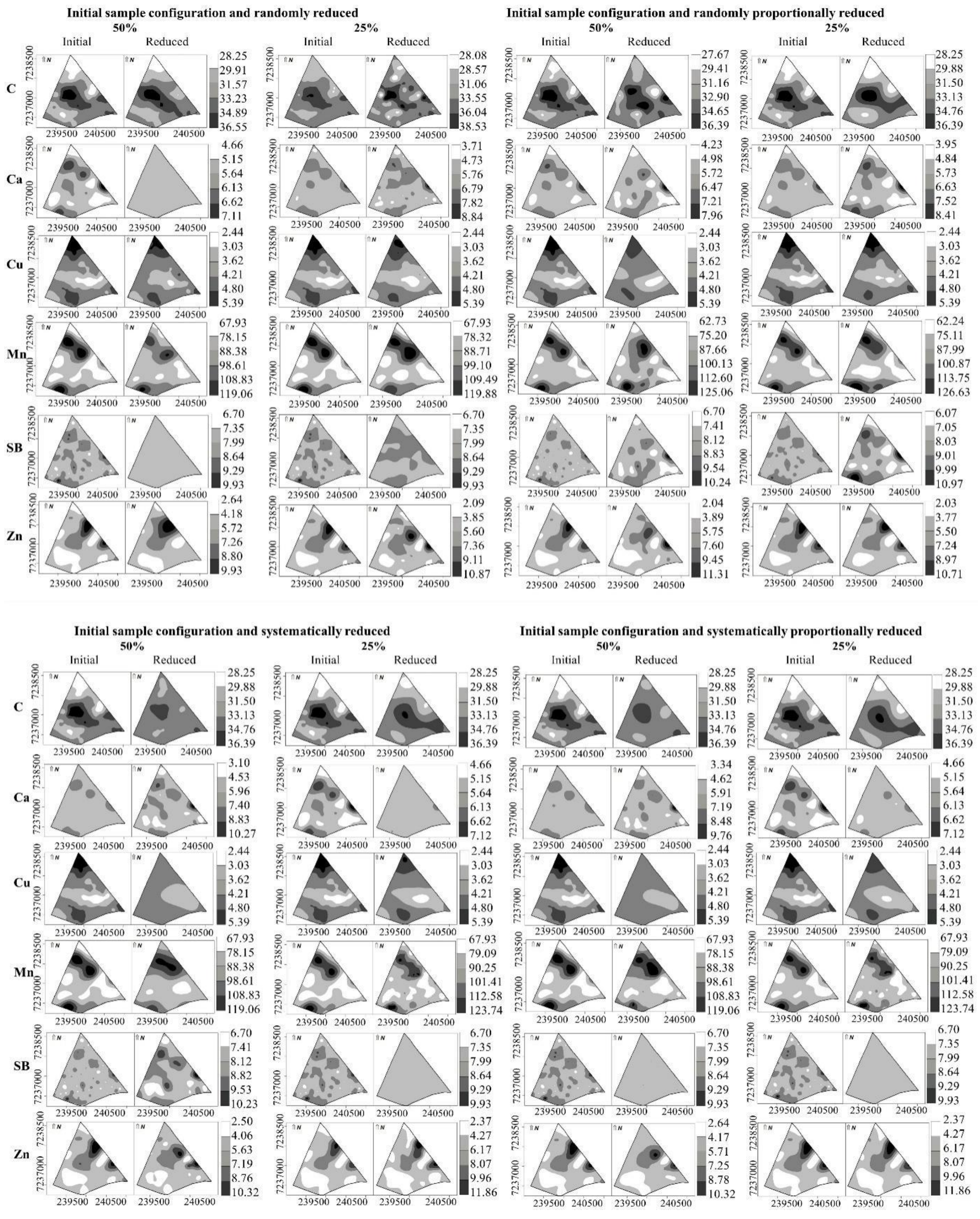

Figure S3. Thematic maps of the soil chemical attributes prepared considering the initial sample configuration and those randomly; randomly proportionally; systematically; and systematically proportionally reduced by 50% and 25% for the 2015-2016 harvest year (X axis: East-West and Y axis: North-South).