

Supplementary material

S.1. Detection and quantification limits (LOD and LOQ) of ICP-OES

Detection and quantification limits (LOD (LOQ), ppb) for Thermo Scientific™ iCAP™ 7400 ICP-OES are following 6.01 (20.0) for P, 4.05 (13.5) for Cr, 2.09 (6.96) for Mn, 4.25 (14.2) for Zn, 105 (350) for S, 11.3 (37.7) for Pb, 1.87 (6.22) for Ni, 3.31 (11.1) for Mg, 2.00 (6.65) for Cu, 63.1 (210) for Al, 183 (608) for Na, 70.3 (234) for K, 9.84 (32.8) for Fe, 1.87 (6.24) for Cd and 82.5 (275) for Ca.

Table S1. Nutrient solutions for each treatment used in the pot experiment.

Solution (mg pot⁻¹)	Zero P	TSP	P salt CL	MA	CCM	SSA PI
KNO ₃	304	303	302	279	300	299
CaNO ₃ ·4H ₂ O	2296	2216	2147	2132	0	2201
NH ₄ NO ₃	0	0	0	0	936	0
Mg(SO ₄)·7H ₂ O	219	216	205	0	74	157
MnCl ₂ ·4H ₂ O	25	25	22	24	25	24
ZnSO ₄ ·7H ₂ O	16	16	16	15	16	13
CuSO ₄ ·5H ₂ O	5	4	4	0	4	4

Zero P - no P fertilizing product addition, TSP - triple superphosphate, P salt CL - chemically leached phosphorus salt, MA - microalgae, CCM - crab carapace material, SSA PI - sewage sludge ash obtained by pyrolysis incineration.

S.2. Plant digestion using closed MW AR

The procedure consists of weighing 0.050 g plant shoot DM yield into a glass tube with the addition of 4 mL HCl and 1 mL HNO₃. The solution was left to react for 30 min before placement in the microwave digester (ultraWAVE, Milestone Srl, Italy), upon it was subjected to a microwave at a pressure of 110 bar, power of 1500 W, and a hold temperature of 240 °C which was achieved after a ramp time of 20 min, and held for 10 min, upon which cooling need additional 20 min. The solutions were filtered using a 10 mL syringe and a 0.45 µm membrane filter, transferred to a 50 mL centrifuge tube, and filled up with MiliQ water till its mark.

S.3. Reference material MNF

The standard reference material used for quality control of elements after *aqua regia* extraction and ICP-OES determination method was multi-nutrient fertilizing product (MNF) from NIST (NIST[®]SRM[®]695). Measured (certified) concentrations for NIST[®]SRM[®]695 were 6.8 ± 0.3 (7.2 ± 0.1)% for P, 11.17 ± 0.37 (11.65 ± 0.13)% for K, 1.93 ± 0.07 (1.79 ± 0.05)% for Mg, 2.30 ± 0.08 (2.26 ± 0.04)% for Ca, 0.43 ± 0.02 (0.405 ± 0.007)% for Na, 0.324 ± 0.008 (0.325 ± 0.005)% for Zn, 1252 ± 8 (1225 ± 9) mg kg⁻¹ for Cu, 242 ± 4 (244 ± 6) mg kg⁻¹ for Cr, 208 ± 4 (200 ± 5 mg kg⁻¹) mg kg⁻¹ for As, 20.4 ± 0.4 (16.9 ± 0.2) mg kg⁻¹ for Cd, 66.0 ± 1.5 (65.3 ± 2.4) mg kg⁻¹ for Co, 133 ± 1 (135 ± 2) mg kg⁻¹ for Ni, 4.58 ± 0.33 (3.99 ± 0.08)% for Fe, 0.55 ± 0.01 (0.61 ± 0.03)% for Al, 282 ± 4 (273 ± 17) mg kg⁻¹ for Pb and 0.320 ± 0.004 (0.305 ± 0.05)% for Mn.

Table S2. Organochlorine (OC) pesticides in the tested fertilizing products.

Substance analysed, mg kg ⁻¹	TSP	P salt CL	CCM	MA	SSA PI
alpha HCH	<0.01 ¹⁾	<0.001	<0.001	<0.01 ¹⁾	<0.01 ¹⁾
beta HCH	<0.01 ¹⁾	<0.001	<0.001	<0.01 ¹⁾	<0.01 ¹⁾
gamma HCH	<0.01 ¹⁾	<0.001	<0.001	<0.01 ¹⁾	<0.01 ¹⁾
delta HCH	<0.01 ¹⁾	<0.001	<0.001	<0.01 ¹⁾	<0.01 ¹⁾
Hexachlorobenzene	<0.01 ¹⁾	<0.001	<0.001	<0.01 ¹⁾	<0.01 ¹⁾
Heptachlor	<0.01 ¹⁾	<0.001	<0.001	<0.01 ¹⁾	<0.01 ¹⁾
Heptachlor epoxide (cis or A)	<0.01 ¹⁾	<0.001	<0.001	<0.01 ¹⁾	<0.01 ¹⁾
Heptachlor epoxide (trans or B)	<0.01 ¹⁾	<0.001	<0.001	<0.01 ¹⁾	<0.01 ¹⁾
Hexachlorobutadiene	<0.01 ¹⁾	<0.001	<0.001	<0.01 ¹⁾	<0.01 ¹⁾
Aldrin	<0.01 ¹⁾	<0.001	<0.001	<0.01 ¹⁾	<0.01 ¹⁾
Dieldrin	<0.01 ¹⁾	<0.001	<0.001	<0.01 ¹⁾	<0.01 ¹⁾
Endrin	<0.01 ¹⁾	<0.001	<0.001	<0.01 ¹⁾	<0.01 ¹⁾
Isodrin	<0.01 ¹⁾	<0.001	<0.001	<0.01 ¹⁾	<0.01 ¹⁾
Telodrin	<0.01 ¹⁾	<0.001	<0.001	<0.01 ¹⁾	<0.01 ¹⁾
alpha-Endosulfan	<0.01 ¹⁾	<0.001	<0.001	0.16	<0.01 ¹⁾
beta-Endosulfan	<0.01 ¹⁾	<0.001	<0.001	<0.01 ¹⁾	<0.01 ¹⁾
Endosulfan sulfate	<0.02 ¹⁾	<0.002	<0.002	<0.02 ¹⁾	<0.02 ¹⁾
alpha-Chlordane	<0.01 ¹⁾	<0.001	<0.001	<0.01 ¹⁾	<0.01 ¹⁾
gamma chlorine	<0.01 ¹⁾	<0.001	<0.001	<0.01 ¹⁾	<0.01 ¹⁾
o, p'-DDT	<0.01 ¹⁾	<0.001	<0.001	<0.01 ¹⁾	<0.01 ¹⁾
p, p'-DDT	<0.01 ¹⁾	<0.001	<0.001	<0.01 ¹⁾	<0.01 ¹⁾
o, p'-DDE	<0.01 ¹⁾	<0.001	0.0018	<0.01 ¹⁾	<0.01 ¹⁾
p, p'-DDE	<0.01 ¹⁾	<0.001	0.0019	<0.01 ¹⁾	<0.01 ¹⁾
o, p'-DDD	<0.01 ¹⁾	<0.001	<0.001	<0.01 ¹⁾	<0.01 ¹⁾
p, p'-DDD	<0.01 ¹⁾	<0.001	<0.001	<0.01 ¹⁾	<0.01 ¹⁾
HCH LB (sum)	<0.03	<0.003	<0.003	<0.03	<0.03
Drins (sum)	<0.03	<0.003	<0.003	<0.03	<0.03
DDX (sum)	<0.06	<0.006	0.020	<0.06	<0.06
Heptachlor epoxide (sum)	<0.02	<0.002	<0.002	<0.02	<0.02
Chlordane (sum)	<0.02	<0.002	<0.002	<0.02	<0.02
OCB LB (sum)	<0.021	<0.021	<0.021	<0.021	<0.021
OCB WB (sum)	<0.024	<0.024	<0.024	<0.024	<0.024

1) Reporting limit increased due to sample dilution.

Table S3. Polychlorinated biphenyls, PCB and Polycyclic Aromatic Hydrocarbons, PAH in the tested fertilizing products.

Substance analysed, mg kg ⁻¹	TSP	P salt CL	CCM	MA	SSA PI
<i>Polychlorinated biphenyls, PCB</i>					
PCB 28	<0.001	<0.001	0.0038¹⁾	<0.001	<0.001
PCB 52	<0.001	0.0035	0.0032	<0.001	<0.001
PCB 101	<0.001	<0.001	0.0023	<0.001	<0.001
PCB 118	<0.001	<0.001	0.0011	<0.001	<0.001
PCB 138	<0.001	<0.001	<0.001	<0.001	<0.001
PCB 153	<0.001	<0.001	<0.001	<0.001	<0.001
PCB 180	<0.001	<0.001	<0.001	<0.001	<0.001
PCB (sum 7)	<0.007	<0.007	0.010	<0.007	<0.007
<i>Polycyclic Aromatic Hydrocarbons, PAH</i>					
Naphthalene	<0.050	<0.050	<0.050	0.058	<0.050
Phenanthrene	<0.050	<0.050	<0.050	0.095	<0.050
Anthracene	<0.050	<0.050	<0.050	<0.050	<0.050
Fluoranthene	<0.050	<0.050	<0.050	0.057	<0.050
Benzo (a) anthracene	<0.050	<0.050	<0.050	<0.050	<0.050
Chrysene	<0.050	<0.050	<0.050	<0.050	<0.050
Benzo (k) fluoranthene	<0.050	<0.050	<0.050	<0.050	<0.050
Benzo (a) pyrene	<0.050	<0.050	<0.050	<0.050	<0.050
Benzo (ghi) perylene	<0.050	<0.050	<0.050	<0.050	<0.050
Indeno (123-cd) pyrene	<0.050	<0.050	<0.050	0.064	<0.050
PAH Total (10)	<0.50	<0.50	<0.50 ¹⁾	<0.50 ²⁾	<0.50 ³⁾

1) PCB 28 can be positively influenced by PCB 31.

2) Indicative value(s) due to matrix failure.

3) Indicative value(s) related to adsorption of the internal standard.

Table S4. Obtained and certified concentrations of (internal laboratory) reference soil material A and B. Mean \pm SD (n = 4).

Element, mg kg ⁻¹	Soil A			<i>Soil A (certified)</i>			Soil B			<i>Soil B (certified)</i>		
P	972	\pm	1	962	\pm	55	940	\pm	20	937	\pm	63
Ca	28456	\pm	375	27330	\pm	1288	27447	\pm	212	26090	\pm	1153
Mg	6074	\pm	711	6124	\pm	414	5882	\pm	626	6160	\pm	1067
K	3770	\pm	608	3418	\pm	412	3589	\pm	555	3147	\pm	345
Na	168	\pm	17	172	\pm	36	227	\pm	9	225	\pm	39
S	n.a			n.a			3540	\pm	130	3.4	\pm	0.2
Al	12289	\pm	431	1268	\pm	162	12647	\pm	776	13420	\pm	1350
Fe	19601	\pm	268	n.a			19696	\pm	280	18740	\pm	849
Cd	n.a			n.a			n.a			44.18	\pm	7.84
Co	6.0	\pm	0.0	6.4	\pm	0.2	80.1	\pm	1.6	74.9	\pm	1.9
Cr	33.6	\pm	0.5	30.6	\pm	0.7	32.2	\pm	2.0	29.1	\pm	3.1
Cu	n.a			n.a			253	\pm	8	242	\pm	17
Ni	17.6	\pm	0.0	17.6	\pm	2.8	243	\pm	5	227	\pm	4
Pb	16.3	\pm	0.5	17.4	\pm	0.6	251.5	\pm	5	244	\pm	16
Zn	50.9	\pm	0.1	46.0	\pm	2.6	954	\pm	21	942	\pm	25
Mn	330	\pm	9	297	\pm	24	778	\pm	22	759	\pm	24

n.a. – not applicable.

Shoot P concentration in
treatments with Zero P
(mg P g⁻¹)

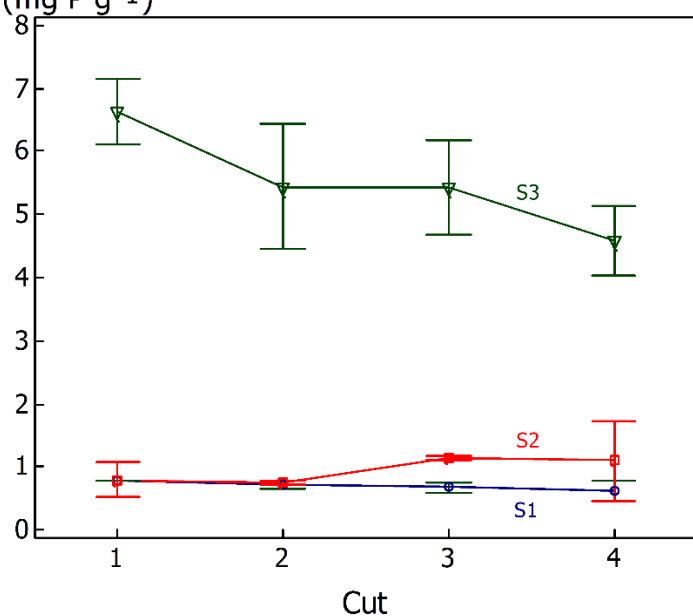


Figure S1. Shoot P concentration (mg P g⁻¹) in Zero P (no fertilizing product) on three different substrates (S1 – river sand, S2 – artificial mineral substrate, S3 – organic horticultural substrate) over four months. Shapes present mean values (n = 4) and error bars indicate two standard errors.

Shoot P concentration on S3 (mg P g⁻¹)

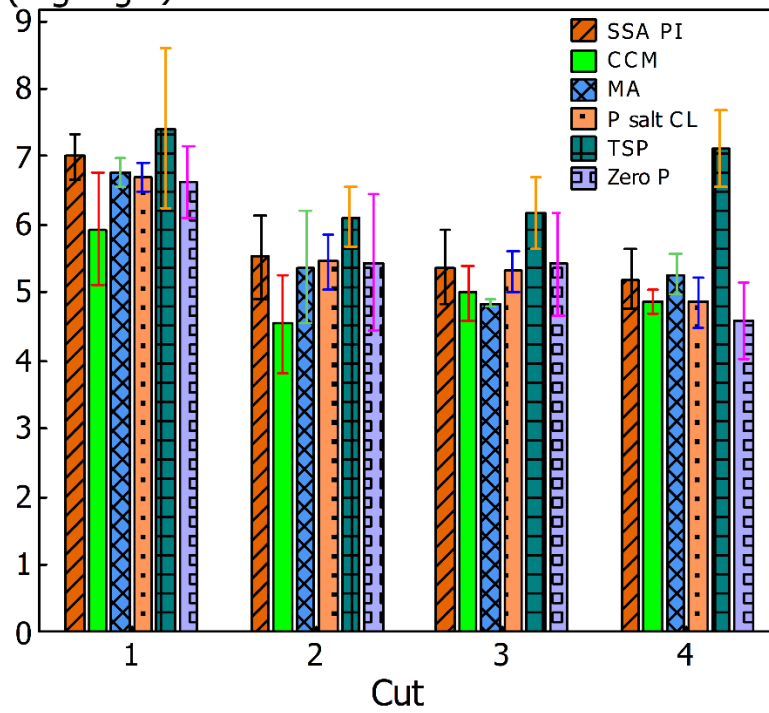


Figure S2. Shoot P concentration (mg P g⁻¹) in treatments with examined fertilizing products (TSP - triple superphosphate; P salt CL - chemically leached P salt; MA - microalgae; CCM - crab carapace material; SSA PI - sewage sludge ash obtained by pyrolysis and incineration; Zero P - no fertilizing product) on S3 (organic horticultural substrate) over four months. Shapes present mean values and error bars indicate two standard errors.

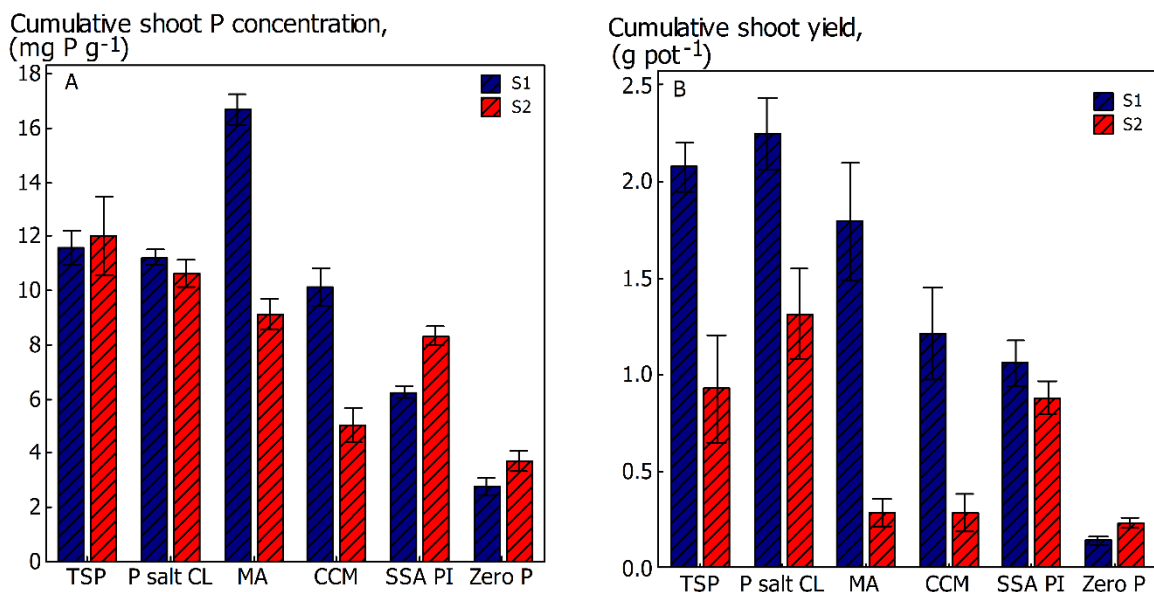


Figure S3. Cumulative shoot A) P concentration (mg P g⁻¹) and B) yield (g pot⁻¹) as affected by tested fertilizing products (CCM - crab carapace material; MA - microalgae; P salt CL - chemically leached P salt; SSA PI - sewage sludge ash obtained by pyrolysis and incineration; TSP - triple superphosphate; Zero P - no fertilizing product) on two different substrates (S1 - river sand, and S2 - artificial mineral substrate) after four months. Shapes present mean values and error bars indicate two standard errors.

Table S5. Concentrations (mg kg⁻¹) of trace elements in plant shoots on S1 during four months (mean ± standard deviation). Note: Cr was under detection (< 0.14 mg kg⁻¹) for all the samples.

Fertilizer	Cut	Co, mg kg ⁻¹	Ni, mg kg ⁻¹	Cu, mg kg ⁻¹	Zn, mg kg ⁻¹	As, mg kg ⁻¹	Cd, mg kg ⁻¹	Pb, mg kg ⁻¹
SSA PI	1	4.7 ± 0.8	8.3 ± 1.6	14 ± 2	98 ± 18	0.49 ± 0.25	0.043 ± 0.013	0.52 ± 0.23
	2	7.6 ± 1.8	9.5 ± 2.1	14 ± 1	146 ± 35	0.45 ± 0.18	0.13 ± 0.04	0.28 ± 0.09
	3	10 ± 2	17 ± 2	17 ± 2	239 ± 25	0.45 ± 0.09	0.31 ± 0.01	0.77 ± 0.28
	4	9.7 ± 1.0	15 ± 1	17 ± 2	241 ± 40	0.56 ± 0.08	0.43 ± 0.13	1.0 ± 0.4
CCM	1	1.4 ± 0.4	5.4 ± 0.5	15 ± 2	144 ± 32	0.33 ± 0.03	0.05 ± 0.03	0.49 ± 0.21
	2	2.0 ± 0.5	8.3 ± 1.8	17 ± 1	208 ± 39	0.31 ± 0.03	0.12 ± 0.04	0.51 ± 0.49
	3	4.4 ± 0.8	15 ± 4	17 ± 1	218 ± 31	0.62 ± 0.13	0.17 ± 0.03	1.0 ± 0.2
	4	4.8 ± 0.9	15 ± 3	16 ± 2	229 ± 55	0.64 ± 0.10	0.25 ± 0.04	0.91 ± 0.19
MA	1	0.28 ± 0.12	7.8 ± 3.4	11 ± 2	97 ± 33	0.84 ± 0.10	<0.009 ± <0.009	0.52 ± 0.10
	2	0.39 ± 0.08	4.9 ± 0.8	13 ± 1	76 ± 5	0.68 ± 0.05	0.018 ± 0.005	0.67 ± 0.21
	3	0.75 ± 0.15	6.7 ± 0.2	13 ± 0	81 ± 4	0.81 ± 0.06	0.028 ± 0.011	0.94 ± 0.62
	4	1.1 ± 0.2	7.8 ± 2.1	13 ± 2	94 ± 12	0.90 ± 0.13	0.064 ± 0.020	0.62 ± 0.17
P salt CL	1	3.7 ± 0.3	9.3 ± 1.5	15 ± 1	89 ± 6	0.51 ± 0.02	0.039 ± 0.009	0.63 ± 0.31
	2	5.8 ± 0.3	9.0 ± 0.3	16 ± 0	119 ± 13	0.60 ± 0.11	0.087 ± 0.009	0.43 ± 0.06
	3	5.8 ± 0.6	9.7 ± 0.6	18 ± 2	141 ± 7	0.59 ± 0.11	0.17 ± 0.02	0.57 ± 0.15
	4	6.3 ± 1.1	9.7 ± 0.9	20 ± 1	170 ± 15	0.77 ± 0.11	0.33 ± 0.08	0.84 ± 0.50
TSP	1	6.3 ± 1.6	11 ± 2	13 ± 0	81 ± 9	0.66 ± 0.20	0.076 ± 0.019	0.43 ± 0.07
	2	5.4 ± 0.1	9.9 ± 1.7	14 ± 1	86 ± 7	0.62 ± 0.09	0.13 ± 0.03	0.23 ± 0.03
	3	4.8 ± 0.5	9.1 ± 0.2	16 ± 1	96 ± 7	0.66 ± 0.07	0.21 ± 0.05	0.67 ± 0.06
	4	5.5 ± 0.4	10 ± 0	19 ± 1	123 ± 10	0.90 ± 0.15	0.34 ± 0.06	0.53 ± 0.07
Zero P	1	6.7 ± 0.3	15 ± 0	14 ± 3	126 ± 1	0.31 ± 0.05	0.069 ± 0.013	0.53 ± 0.17
	2	12 ± 1	22 ± 2	12 ± 3	245 ± 25	0.19 ± 0.04	0.22 ± 0.01	0.31 ± 0.01
	3	22 ± 4	34 ± 0	14 ± 2	372 ± 98	0.29 ± 0.02	0.55 ± 0.03	0.67 ± 0.15
	4	26 ± 9	44 ± 7	14 ± 4	480 ± 202	0.35 ± 0.04	0.95 ± 0.42	1.5 ± 0.2
SRM 1750a (Measured)	1	0.28 ± 0.02	0.82 ± 0.27	9.6 ± 0.3	75 ± 2	0.06 ± 0.01	2.6 ± 0.0	0.24 ± 0.02
	2	0.30 ± 0.01	1.2 ± 0.0	9.7 ± 0.2	72 ± 2	0.05 ± 0.01	2.5 ± 0.1	0.26 ± 0.02
	3	0.31 ± 0.01	1.0 ± 0.0	9.9 ± 0.2	75 ± 2	0.08 ± 0.01	2.5 ± 0.1	0.25 ± 0.02
	4	0.31 ± 0.01	1.1 ± 0.0	10 ± 0	79 ± 2	0.09 ± 0.00	2.5 ± 0.1	0.34 ± 0.02
(Certified)		0.0393 ± 0.030	2.142 ± 0.058	12.22 ± 0.86	82.3 ± 3.9	0.068 ± 0.012	2.876 ± 0.058	0.2

TSP - triple superphosphate; P salt CL - chemically leached P salt; MA - microalgae; CCM - crab carapace material; SSA PI - sewage sludge ash obtained by pyrolysis and incineration; Zero P - no fertilizing product; SRM 1750a – Standard reference material, Trace elements in Spinach leaves, from NIST.

Shoot P uptake
(mg P pot⁻¹)

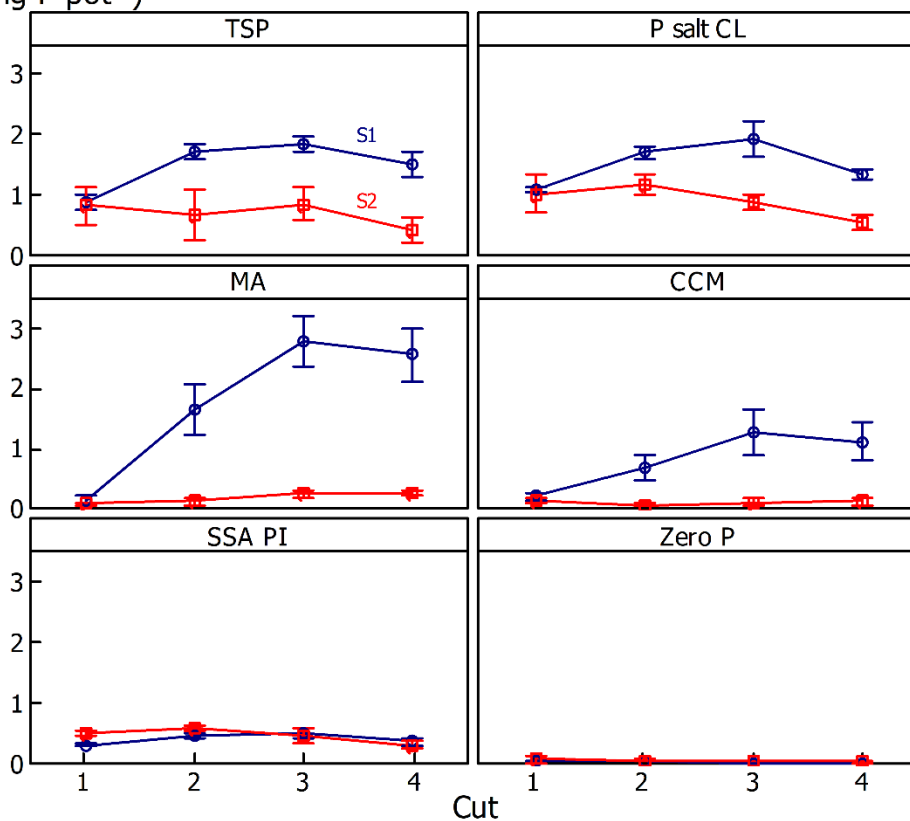


Figure S4. Shoot P uptake (mg pot⁻¹) as affected by tested fertilizing products (TSP-triple superphosphate; P salt CL- chemically leached P salt; MA-microalgae; CCM-crab carapace material; SSA PI-sewage sludge ash obtained by pyrolysis and incineration; Zero P-no fertilizing product) on two different substrates (S1-river sand, and S2-artificial mineral substrate) over four months. Shapes present mean values and error bars indicate two standard errors.