# Supplementary Material (Appendix): Bio-fertilizers based on digestate and biomass ash as an alternative to commercial fertilizers – the case of tomato

**Katarzyna Przygocka-Cyna[1], Przemysław Barłóg [1], Tomasz Spiżewski * [2], Witold Grzebisz [1]**

Department of Agricultural Chemistry and Environmental Biogeochemistry, Poznań University of Life Sciences, Wojska Polskiego 38/42, 60-625 Poznań, Poland; [2] Department of Vegetables Production, Poznan University of Life Sciences, Wojska Polskiego 71F, 60-625 Poznań, Poland

* Correspondence: e-mail@e-mail.com; tomasz.spizewski@up.poznan.pl

**Table S1**. The results of ANOVA analysis: yield, yield components and quality of tomato fruits (*F* ratios)

| Factors | Degrees of freedom | Parameters | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | TY | CY | TFW | CFW | TFN | CFN | EX | TS | CRD | LCP | DM |
| Year (Y) | 2 | 171.4*** | 162.6*** | 16.2*** | 18.1*** | 216.8*** | 222.7*** | 10.5*** | 0.8 | 1.4 | 0.3 | 0.9 |
| Treatments (K) | 13 | 2.1* | 1.8 | 0.9 | 0.7 | 1.9* | 1.5 | 2.7** | 2.7** | 4.1*** | 3.4*** | 3.2*** |
| Y x T | 26 | 0.4 | 0.5 | 0.9 | 1.0 | 0.4 | 0.5 | 0.5 | 0.4 | 1.0 | 0.4 | 0.3 |
| Error | 84 | | | | | | | | | | | |

***, **, * significant at $p < 0.001$; $p < 0.01$; $p < 0.05$, respectively. Explanation of abbreviations: TY – total yield; CY – commercial yield; TFW - total weight of the fruit; CFW - commercial weight of the fruit; TFN – total number of fruits; CFN –number of commercial; EX – extract; TS - total sugar; CRD – carotenoids; LCP – lycopene; DM – dry matter.

**Table S2**. Effect of the year on tomato yield, yield components and quality of tomato fruits

| Year | Parameters | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | TY | CY | TFW | CFW | TFN | CFN | EX | TS | CRD | LCP | DM |
| | t ha$^{-1}$ | t ha$^{-1}$ | g | g | No. m$^{-2}$ | No. m$^{-2}$ | g kg$^{-1}$ | g kg$^{-1}$ | mg kg$^{-1}$ | mg kg$^{-1}$ | g kg$^{-1}$ |
| 2016 | 95.4 [b] | 74.3 [b] | 157.9 [b] | 172.5 [b] | 61.0 [b] | 43.4 [b] | 45.3 [a] | 34.4 | 346.3 | 246.9 | 61.7 |
| 2017 | 173.7 [a] | 125.4 [a] | 158.8 [b] | 161.0 [c] | 109.4 [a] | 77.9 [a] | 45.4 [a] | 34.0 | 361.4 | 249.1 | 62.3 |
| 2018 | 92.7 [b] | 57.7 [c] | 174.7 [a] | 180.8 [a] | 53.2 [c] | 31.9 [c] | 44.3 [b] | 35.1 | 363.6 | 253.0 | 61.4 |

Means within a column followed by the same letter indicate a lack of significant difference between the treatments. Explanation of abbreviations: TY – total yield; CY – commercial yield; TFW - total weight of one fruit; CFW - commercial weight of one fruit; TFN – total number of fruits; CFN –number of commercial; EX – extract; TS - total sugar; CRD – carotenoids; LCP – lycopene; DM – dry matter.

**Table S3**. Effect of interaction between year and treatments on total yield (TY), commercial yield of tomato (CY) and content of nitrogen and potassium in tomato fruits

| Year | Treatment | TY<br>t ha$^{-1}$ | CY<br>t ha$^{-1}$ | N<br>g kg$^{-1}$ | K<br>g kg$^{-1}$ |
|---|---|---|---|---|---|
| 2016 | Absolute control | 82.5 | 63.3 | 32.9 $^{abcd}$ | 37.5 $^{fgh}$ |
| | Mineral control | 111.0 | 91.6 | 31.1 $^{abcd}$ | 42.0 $^{bcdf}$ |
| | A200 | 90.1 | 68.2 | 27.9 $^{cd}$ | 40.6 $^{f}$ |
| | A400 | 94.2 | 73.8 | 33.1 $^{abcd}$ | 40.6 $^{f}$ |
| | A800 | 95.4 | 69.9 | 31.4 $^{abcd}$ | 40.8 $^{f}$ |
| | A1600 | 98.1 | 77.5 | 32.2 $^{abcd}$ | 41.5 $^{cdf}$ |
| | B200 | 86.1 | 69.3 | 34.0 $^{abcd}$ | 41.4 $^{df}$ |
| | B400 | 88.7 | 65.4 | 30.6 $^{abcd}$ | 41.4 $^{df}$ |
| | B800 | 94.4 | 71.8 | 31.8 $^{abcd}$ | 40.9 $^{f}$ |
| | B1600 | 96.3 | 72.4 | 33.8 $^{abcd}$ | 41.0 $^{f}$ |
| | C200 | 96.9 | 79.3 | 35.1 $^{abcd}$ | 38.5 $^{fg}$ |
| | C400 | 103.8 | 78.7 | 29.0 $^{bcd}$ | 41.6 $^{cdf}$ |
| | C800 | 105.4 | 86.7 | 33.6 $^{abcd}$ | 41.4 $^{df}$ |
| | C1600 | 93.1 | 72.1 | 30.8 $^{abcd}$ | 40.8 $^{f}$ |
| 2017 | Absolute control | 167.1 | 120.5 | 32.3 $^{abcd}$ | 28.2 $^{j}$ |
| | Mineral control | 195.5 | 133.4 | 30.8 $^{abcd}$ | 31.4 $^{ij}$ |
| | A200 | 161.7 | 116.9 | 26.8 $^{d}$ | 33.0 $^{hij}$ |
| | A400 | 199.5 | 146.0 | 33.6 $^{abcd}$ | 28.5 $^{j}$ |
| | A800 | 190.6 | 138.0 | 34.1 $^{abcd}$ | 35.5 $^{ghi}$ |
| | A1600 | 192.0 | 139.9 | 35.5 $^{abc}$ | 35.2 $^{ghi}$ |
| | B200 | 157.3 | 111.5 | 27.6 $^{cd}$ | 28.8 $^{j}$ |
| | B400 | 155.4 | 110.6 | 30.3 $^{bcd}$ | 32.0 $^{ij}$ |
| | B800 | 163.2 | 118.3 | 33.3 $^{abcd}$ | 31.9 $^{ij}$ |
| | B1600 | 172.9 | 125.6 | 34.8 $^{abcd}$ | 32.5 $^{ij}$ |
| | C200 | 183.7 | 135.1 | 35.7 $^{abc}$ | 32.4 $^{ij}$ |
| | C400 | 169.3 | 123.5 | 34.3 $^{abcd}$ | 33.1 $^{hij}$ |
| | C800 | 165.0 | 120.7 | 36.3 $^{ab}$ | 33.1 $^{hij}$ |
| | C1600 | 159.1 | 116.0 | 33.9 $^{abcd}$ | 32.2 $^{ij}$ |
| 2018 | Absolute control | 93.0 | 52.9 | 31.3 $^{abcd}$ | 46.4 $^{abc}$ |
| | Mineral control | 115.7 | 59.0 | 30.2 $^{bcd}$ | 48.7 $^{a}$ |
| | A200 | 86.1 | 53.1 | 28.7 $^{bcd}$ | 46.2 $^{abcd}$ |
| | A400 | 120.8 | 82.5 | 29.0 $^{bcd}$ | 46.5 $^{ab}$ |
| | A800 | 106.5 | 74.9 | 32.1 $^{abcd}$ | 48.0 $^{a}$ |
| | A1600 | 94.6 | 55.0 | 29.3 $^{bcd}$ | 47.8 $^{a}$ |
| | B200 | 63.2 | 41.9 | 32.4 $^{abcd}$ | 48.2 $^{a}$ |
| | B400 | 82.4 | 45.2 | 31.0 $^{abcd}$ | 47.9 $^{a}$ |
| | B800 | 85.9 | 54.4 | 31.7 $^{abcd}$ | 47.9 $^{a}$ |
| | B1600 | 95.2 | 64.5 | 35.2 $^{abc}$ | 49.2 $^{a}$ |
| | C200 | 97.1 | 59.9 | 33.5 $^{abcd}$ | 50.6 $^{a}$ |
| | C400 | 87.3 | 54.0 | 34.5 $^{abcd}$ | 48.4 $^{a}$ |
| | C800 | 84.6 | 53.3 | 38.9 $^{a}$ | 49.5 $^{a}$ |
| | C1600 | 84.9 | 57.4 | 32.8 $^{abcd}$ | 49.3 $^{a}$ |

Means within a column followed by the same letter indicate a lack of significant difference between the treatments.

**Table S4**. The results of ANOVA analysis: content of nutrients, lead and cadmium (*F* ratios)

| Factors | Degrees of freedom | Elements | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | N | P | K | Mg | Ca | Na | Zn | Cu | Mn | Fe | Pb | Cd |
| Year (Y) | 2 | 1.3 | 0.4 | 1248.0*** | 16.8*** | 44.1*** | 937.5*** | 8.4*** | 3.6* | 1.5 | 66.8*** | 18.5*** | 54.8*** |
| Treatments (K) | 13 | 5.9*** | 1.6 | 5.6*** | 1.3 | 0.5 | 0.6 | 1.3 | 1.8 | 1.6 | 1.2 | 0.7 | 1.0 |
| Y x T | 26 | 1.8* | 0.7 | 2.7*** | 0.6 | 1.0 | 0.6 | 1.1 | 1.1 | 0.9 | 1.1 | 0.7 | 0.6 |
| Error | 84 | | | | | | | | | | | | |

***, **, * significant at $p < 0.001$; $p < 0.01$; $p < 0.05$, respectively.

**Table S5**. Effect of the year on nutrients, lead and cadmium content in tomato fruits

| Year | Elements | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | N | P | K | Mg | Ca | Na | Zn | Cu | Mn | Fe | Pb | Cd |
| 2016 | 31.9 | 0.42 | 40.7 $^{b}$ | 2.10 $^{b}$ | 0.53 $^{c}$ | 0.35 $^{b}$ | 1.81 $^{b}$ | 0.79 $^{b}$ | 1.94 | 4.84 $^{b}$ | 0.21 $^{b}$ | 0.024 $^{b}$ |
| 2017 | 32.8 | 0.44 | 32.0 $^{c}$ | 2.20 $^{b}$ | 0.88 $^{a}$ | 0.56 $^{a}$ | 2.00 $^{b}$ | 0.85 $^{a}$ | 1.65 | 7.49 $^{a}$ | 0.79 $^{a}$ | 0.034 $^{a}$ |
| 2018 | 32.2 | 0.42 | 48.2 $^{a}$ | 2.34 $^{a}$ | 0.67 $^{b}$ | 0.35 $^{b}$ | 2.31 $^{a}$ | 0.87 $^{a}$ | 1.81 | 5.10 $^{b}$ | 0.21 $^{b}$ | 0.024 $^{b}$ |

Means within a column followed by the same letter indicate a lack of significant difference between the treatments.

**Table S6**. Matrix of Pearson's correlation coefficients between tomato yield, yield components and quality parameters (n = 11)

| Parameter | TY | CY | TFW | CFW | TFN | CFN | EX | TS | CRD | LCP |
|---|---|---|---|---|---|---|---|---|---|---|
| **CY** | 0.95*** | | | | | | | | | |
| **TFW** | 0.38 | 0.40 | | | | | | | | |
| **CFW** | 0.32 | 0.40 | 0.74** | | | | | | | |
| **TFN** | 0.95*** | 0.90*** | 0.08 | 0.10 | | | | | | |
| **CFN** | 0.94*** | 0.97*** | 0.21 | 0.16 | 0.94*** | | | | | |
| **EX** | -0.47 | -0.38 | -0.01 | 0.08 | -0.48 | -0.39 | | | | |
| **TS** | -0.07 | -0.09 | 0.20 | 0.20 | -0.13 | -0.12 | 0.70** | | | |
| **CRD** | 0.04 | 0.05 | 0.18 | 0.16 | 0.01 | 0.03 | 0.24 | 0.25 | | |
| **LCP** | 0.08 | 0.09 | 0.06 | 0.14 | 0.08 | 0.07 | 0.08 | 0.19 | 0.94*** | |
| **DM** | -0.36 | -0.29 | -0.04 | -0.17 | -0.34 | -0.25 | 0.49 | 0.28 | 0.42 | 0.30 |

***, **, * significant at $p < 0.001$; $p < 0.01$; $p < 0.05$, respectively. Explanation of abbreviations: TY – total yield; CY – commercial yield; TFW - total weight of one fruit; CFW - commercial weight of one fruit; TFN – total number of fruits; CFN –number of commercial; EX – extract; TS - total sugar; CRD – carotenoids; LCP – lycopene; DM – dry matter.

**Table S7**. Matrix of Pearson's correlation coefficients between commercial yield of tomato (CY) and content of elements in fruits (n = 11)

| Element | CY | N | P | K | Mg | Ca | Na | Zn | Cu | Mn | Fe | Pb |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **N** | 0.30 | | | | | | | | | | | |
| **P** | 0.06 | 0.28 | | | | | | | | | | |
| **K** | 0.21 | 0.30 | 0.21 | | | | | | | | | |
| **Mg** | 0.15 | 0.39 | 0.26 | 0.60* | | | | | | | | |
| **Ca** | -0.20 | 0.22 | 0.45 | 0.42 | 0.27 | | | | | | | |
| **Na** | 0.18 | -0.08 | 0.17 | 0.50 | 0.46 | 0.18 | | | | | | |
| **Zn** | 0.02 | 0.39 | 0.07 | 0.29 | 0.37 | -0.02 | 0.63* | | | | | |
| **Cu** | -0.23 | -0.05 | 0.15 | 0.11 | 0.54* | -0.22 | 0.38 | 0.44 | | | | |
| **Mn** | 0.06 | 0.58* | 0.10 | 0.33 | 0.29 | 0.16 | 0.50 | 0.92*** | 0.11 | | | |
| **Fe** | -0.22 | 0.51 | 0.15 | 0.42 | 0.58* | 0.26 | 0.21 | 0.56* | 0.27 | 0.62* | | |
| **Pb** | -0.54* | -0.04 | -0.23 | -0.34 | 0.15 | -0.23 | -0.02 | 0.30 | 0.49 | 0.18 | 0.27 | |
| **Cd** | -0.08 | 0.31 | 0.05 | 0.05 | 0.20 | -0.30 | 0.20 | 0.74** | 0.39 | 0.63* | 0.52 | 0.20 |

***, **, * significant at $p < 0.001$; $p < 0.01$; $p < 0.05$, respectively.