



*Supplement of*

## **Organic wastes from bioenergy and ecological sanitation as soil fertility improver: a field experiment in a tropical Andosol**

**A. Krause et al.**

*Correspondence to:* A. Krause ([krause@ztg.tu-berlin.de](mailto:krause@ztg.tu-berlin.de))

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## Supplement

Table S1. Plot data I for Fig. 2: untreated Andosol and soil treated with, urine, biogas slurry, compost, and CaSa-compost; measured using ceramic pressure plates.

|                              | pF  | $\theta$ | Error ( $\theta$ ) |
|------------------------------|-----|----------|--------------------|
| <b>Andosol ceramic plate</b> | 0   | 0,593    | 0,013              |
|                              | 1,8 | 0,357    | 0,014              |
|                              | 2,5 | 0,292    | 0,014              |
|                              | 3   | 0,262    | 0,007              |
|                              | 4,2 | 0,228    | 0,022              |
| <b>Urine</b>                 | 0   | 0,612    | 0,036              |
|                              | 1,8 | 0,342    | 0,040              |
|                              | 2,5 | 0,274    | 0,036              |
|                              | 3   | 0,254    | 0,032              |
|                              | 4,2 | 0,225    | 0,027              |
| <b>Biogas slurry</b>         | 0   | 0,621    | 0,022              |
|                              | 1,8 | 0,355    | 0,028              |
|                              | 2,5 | 0,294    | 0,028              |
|                              | 3   | 0,268    | 0,025              |
|                              | 4,2 | 0,221    | 0,021              |
| <b>Compost</b>               | 0   | 0,634    | 0,045              |
|                              | 1,8 | 0,344    | 0,028              |
|                              | 2,5 | 0,286    | 0,025              |
|                              | 3   | 0,250    | 0,041              |
|                              | 4,2 | 0,227    | 0,022              |
| <b>CaSa-compost</b>          | 0   | 0,594    | 0,029              |
|                              | 1,8 | 0,353    | 0,021              |
|                              | 2,5 | 0,290    | 0,015              |
|                              | 3   | 0,265    | 0,015              |
|                              | 4,2 | 0,223    | 0,020              |

Table S2. Plot data II for Fig. 2.: untreated Andosol measured using the simplified evaporation method (Hyprop, UMS, Munich, Germany) with the Peters–Durner–Iden (PDI) model.

|                  | pF    | $\theta$ | pF    | $\theta$ | pF    | $\theta$ | pF    | $\theta$ |       |       |
|------------------|-------|----------|-------|----------|-------|----------|-------|----------|-------|-------|
| <b>PDI model</b> | 0,166 | 0,556    | 0,808 | 0,554    | 1,449 | 0,459    | 2,090 | 0,319    | 2,731 | 0,268 |
|                  | 0,186 | 0,556    | 0,828 | 0,554    | 1,469 | 0,452    | 2,110 | 0,317    | 2,752 | 0,267 |
|                  | 0,206 | 0,556    | 0,848 | 0,554    | 1,489 | 0,445    | 2,130 | 0,315    | 2,772 | 0,266 |
|                  | 0,226 | 0,556    | 0,868 | 0,554    | 1,509 | 0,438    | 2,150 | 0,313    | 2,792 | 0,264 |
|                  | 0,246 | 0,556    | 0,888 | 0,553    | 1,529 | 0,431    | 2,170 | 0,311    | 2,812 | 0,263 |
|                  | 0,267 | 0,556    | 0,908 | 0,553    | 1,549 | 0,424    | 2,190 | 0,310    | 2,832 | 0,261 |
|                  | 0,287 | 0,556    | 0,928 | 0,552    | 1,569 | 0,418    | 2,210 | 0,308    | 2,852 | 0,260 |
|                  | 0,307 | 0,556    | 0,948 | 0,552    | 1,589 | 0,412    | 2,230 | 0,306    | 2,872 | 0,259 |
|                  | 0,327 | 0,556    | 0,968 | 0,551    | 1,609 | 0,406    | 2,251 | 0,304    | 2,892 | 0,257 |
|                  | 0,347 | 0,556    | 0,988 | 0,550    | 1,629 | 0,400    | 2,271 | 0,302    |       |       |
|                  | 0,367 | 0,556    | 1,008 | 0,549    | 1,649 | 0,394    | 2,291 | 0,301    |       |       |
|                  | 0,387 | 0,556    | 1,028 | 0,548    | 1,669 | 0,389    | 2,311 | 0,299    |       |       |
|                  | 0,407 | 0,556    | 1,048 | 0,547    | 1,689 | 0,384    | 2,331 | 0,298    |       |       |
|                  | 0,427 | 0,556    | 1,068 | 0,545    | 1,709 | 0,379    | 2,351 | 0,296    |       |       |
|                  | 0,447 | 0,556    | 1,088 | 0,544    | 1,729 | 0,374    | 2,371 | 0,294    |       |       |
|                  | 0,467 | 0,556    | 1,108 | 0,542    | 1,749 | 0,370    | 2,391 | 0,293    |       |       |
|                  | 0,487 | 0,556    | 1,128 | 0,540    | 1,770 | 0,366    | 2,411 | 0,291    |       |       |
|                  | 0,507 | 0,556    | 1,148 | 0,537    | 1,790 | 0,362    | 2,431 | 0,290    |       |       |
|                  | 0,527 | 0,556    | 1,168 | 0,534    | 1,810 | 0,358    | 2,451 | 0,288    |       |       |
|                  | 0,547 | 0,556    | 1,188 | 0,531    | 1,830 | 0,354    | 2,471 | 0,287    |       |       |
|                  | 0,567 | 0,556    | 1,208 | 0,528    | 1,850 | 0,351    | 2,491 | 0,285    |       |       |
|                  | 0,587 | 0,556    | 1,228 | 0,524    | 1,870 | 0,348    | 2,511 | 0,284    |       |       |
|                  | 0,607 | 0,556    | 1,248 | 0,520    | 1,890 | 0,345    | 2,531 | 0,282    |       |       |
|                  | 0,627 | 0,556    | 1,269 | 0,515    | 1,910 | 0,342    | 2,551 | 0,281    |       |       |
|                  | 0,647 | 0,556    | 1,289 | 0,510    | 1,930 | 0,339    | 2,571 | 0,279    |       |       |
|                  | 0,667 | 0,556    | 1,309 | 0,505    | 1,950 | 0,336    | 2,591 | 0,278    |       |       |
|                  | 0,687 | 0,556    | 1,329 | 0,499    | 1,970 | 0,333    | 2,611 | 0,277    |       |       |
|                  | 0,707 | 0,556    | 1,349 | 0,493    | 1,990 | 0,331    | 2,631 | 0,275    |       |       |
|                  | 0,727 | 0,556    | 1,369 | 0,486    | 2,010 | 0,328    | 2,651 | 0,274    |       |       |
|                  | 0,747 | 0,556    | 1,389 | 0,480    | 2,030 | 0,326    | 2,671 | 0,272    |       |       |
|                  | 0,768 | 0,556    | 1,409 | 0,473    | 2,050 | 0,324    | 2,691 | 0,271    |       |       |
|                  | 0,788 | 0,556    | 1,429 | 0,466    | 2,070 | 0,321    | 2,711 | 0,270    |       |       |

Table S3. Plot data for Fig. 2: Total above-ground biomass production (“harvest product”) and marketable crop yields (“market product”) given as g per plot. Different letters reflect means differing significantly from one another (HSD, Tukey test,  $\alpha=0.05$ ; n=4 for the untreated control plots and n=5 for the amended plots).

| Harvest products: total above-ground biomass production [g plot <sup>-1</sup> ] |       |    |        |   |         |   |       |    |       |    |
|---------------------------------------------------------------------------------|-------|----|--------|---|---------|---|-------|----|-------|----|
|                                                                                 | Onion |    | Carrot |   | Cabbage |   | Beans |    | Maize |    |
| Control without                                                                 | 880   | a  | 1312   | a | no      |   | 192   | a  | 7177  | a  |
| Urine                                                                           | 834   | a  | 2246   | a | 1788    | a | 270   | a  | 9086  | a  |
| Biogas slurry                                                                   | 1211  | ab | 2439   | a | 7417    | b | 360   | ab | 10028 | a  |
| Compost                                                                         | 1679  | b  | 2991   | a | 8571    | b | 518   | b  | 11086 | ab |
| CaSa-Compost                                                                    | 1516  | ab | 2169   | a | 9390    | b | 1244  | c  | 15173 | b  |

| Market Products: marketable crop yields [g plot <sup>-1</sup> ] |                           |    |                   |   |                            |   |                             |    |  |
|-----------------------------------------------------------------|---------------------------|----|-------------------|---|----------------------------|---|-----------------------------|----|--|
|                                                                 | Onion bulb<br>(air-dried) |    | Carrot<br>(fresh) |   | Head of Cabbage<br>(fresh) |   | Maize grains<br>(air-dried) |    |  |
| Control without                                                 | 444                       | a  | 918               | a |                            |   | 497                         | a  |  |
| Urine                                                           | 393                       | a  | 1572              | a | 636                        | a | 774                         | ab |  |
| Biogas slurry                                                   | 691                       | ab | 1707              | a | 4320                       | b | 1181                        | ab |  |
| Compost                                                         | 1056                      | b  | 2093              | a | 4950                       | b | 1431                        | bc |  |
| CaSa-Compost                                                    | 1088                      | b  | 1518              | a | 6101                       | b | 1973                        | c  |  |



Table S4. Plot data for Fig. 4: Total nutrient concentration in DM [ $\text{g kg}^{-1}$ ], total nutrient uptake [ $\text{g plant}^{-1}$ ], and air-dry grain yield ( $\text{g plant}^{-1}$ ). The response levels (relative nutrient concentration, relative nutrient uptake, and relative biomass) are given relative to the control treatment's performance. Different letters reflect means differing significantly from one another (HSD, Tukey test,  $\alpha=0.05$ ;  $n=3$ ).

|                 | Total nutrient concentration in dry maize grains |                         |                         |                          |                          |                           | Relative nutrient concentration in dry maize grains |       |       |       |       |       |
|-----------------|--------------------------------------------------|-------------------------|-------------------------|--------------------------|--------------------------|---------------------------|-----------------------------------------------------|-------|-------|-------|-------|-------|
|                 | N<br>$\text{g kg}^{-1}$                          | P<br>$\text{g kg}^{-1}$ | K<br>$\text{g kg}^{-1}$ | Ca<br>$\text{g kg}^{-1}$ | Mg<br>$\text{g kg}^{-1}$ | Zn<br>$\text{mg kg}^{-1}$ | N                                                   | P     | K     | Ca    | Mg    | Zn    |
| Control without | 15,9                                             | 2,3                     | 4,4                     | 0,1                      | 1,0                      | 22,1                      | 100,0                                               | 100,0 | 100,0 | 100,0 | 100,0 | 100,0 |
| Urine           | 16,4                                             | 2,4                     | 4,5                     | 0,1                      | 1,0                      | 19,2                      | 103,5                                               | 102,8 | 101,7 | 71,1  | 98,1  | 87,1  |
| Biogas slurry   | 16,5                                             | 2,6                     | 4,0                     | 0,1                      | 1,0                      | 18,0                      | 103,6                                               | 113,5 | 91,5  | 74,8  | 97,9  | 81,4  |
| Compost         | 15,6                                             | 2,5                     | 3,6                     | 0,1                      | 1,0                      | 19,0                      | 98,2                                                | 108,4 | 82,9  | 82,3  | 99,2  | 86,1  |
| CaSa-Compost    | 16,8                                             | 3,0                     | 3,9                     | 0,1                      | 1,1                      | 18,2                      | 105,8                                               | 128,8 | 88,2  | 75,8  | 109,4 | 82,3  |

|                 | Total nutrient uptake in dry maize grains |                            |                            |                             |                             |                              | Relative nutrient uptake in dry maize grains |       |       |       |       |       |
|-----------------|-------------------------------------------|----------------------------|----------------------------|-----------------------------|-----------------------------|------------------------------|----------------------------------------------|-------|-------|-------|-------|-------|
|                 | N<br>$\text{g plant}^{-1}$                | P<br>$\text{g plant}^{-1}$ | K<br>$\text{g plant}^{-1}$ | Ca<br>$\text{g plant}^{-1}$ | Mg<br>$\text{g plant}^{-1}$ | Zn<br>$\text{mg plant}^{-1}$ | N                                            | P     | K     | Ca    | Mg    | Zn    |
| Control without | 0,33                                      | 0,05                       | 0,09                       | 0,00                        | 0,02                        | 0,46                         | 100,0                                        | 100,0 | 100,0 | 100,0 | 100,0 | 100,0 |
| Urine           | 0,67                                      | 0,10                       | 0,18                       | 0,00                        | 0,04                        | 0,78                         | 202,9                                        | 201,5 | 199,3 | 139,4 | 192,3 | 170,7 |
| Biogas slurry   | 0,79                                      | 0,13                       | 0,19                       | 0,00                        | 0,05                        | 0,87                         | 240,8                                        | 263,6 | 212,6 | 173,9 | 227,5 | 189,1 |
| Compost         | 1,13                                      | 0,18                       | 0,27                       | 0,01                        | 0,07                        | 1,38                         | 343,8                                        | 379,4 | 290,3 | 288,0 | 347,2 | 301,5 |
| CaSa-Compost    | 1,51                                      | 0,27                       | 0,35                       | 0,01                        | 0,10                        | 1,63                         | 456,1                                        | 555,2 | 380,2 | 326,5 | 471,4 | 354,7 |

|                 | Total biomass                                | Relative biomass    |
|-----------------|----------------------------------------------|---------------------|
|                 | air-dry grain yield<br>$\text{g plant}^{-1}$ | air-dry grain yield |
| Control without | 33,0                                         | 100                 |
| Urine           | 54,5                                         | 165                 |
| Biogas slurry   | 68,0                                         | 206                 |
| Compost         | 89,6                                         | 271                 |
| CaSa-Compost    | 119,1                                        | 361                 |



Fig. S1. The soil profile. The photograph was taken on February 2nd, 2014.



Fig. S2. The experimental site. The photograph was taken on March 14th, 2014.





Fig. S3. The experimental site. The photograph was taken on March 26th, 2014.



Fig. S4. The experimental site. The photograph was taken on May 2nd, 2014.



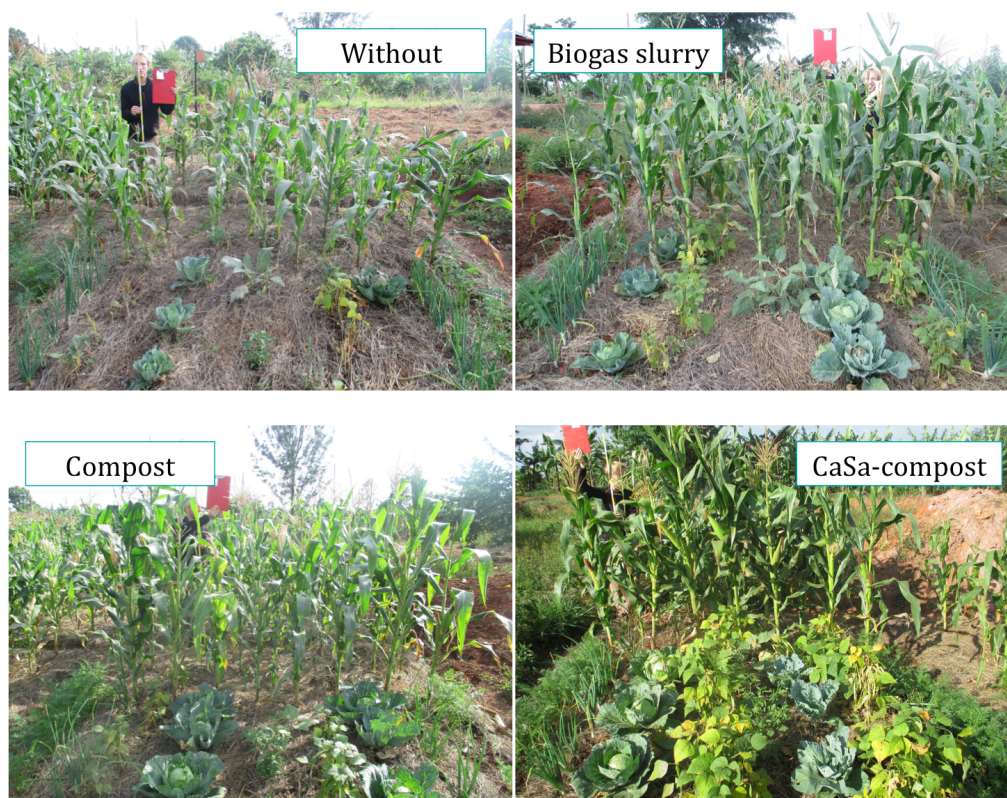


Fig. S5. Progress on an untreated plot (without) and a plot amended with biogas slurry, compost and CaSa-compost respectively. These photographs were taken on June 2nd, 2014.