# Supplementary material

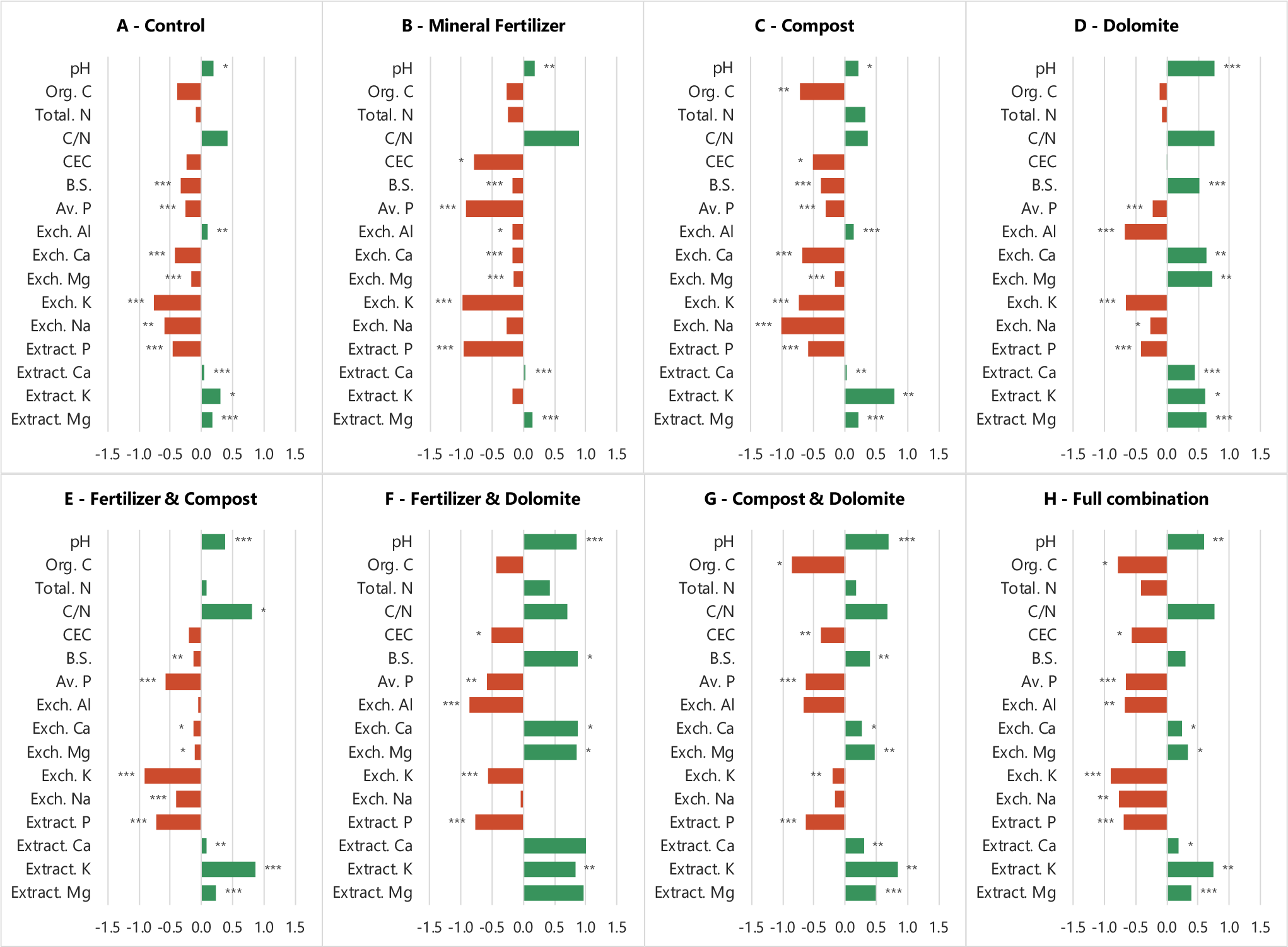
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Figure S1: Summary of the effect of each treatment on soil properties

The length of the horizontal bars refers to the difference between 2014 and 2018. To combine variables with different units, the means for 2014 and *2018* were normalized, to replace them with a number between 0 and 1 (xnormalised = (xi – xmin)/(xmax – xmin). The values reported here correspond to the difference between those normalized values, ranging from -1 to 1. The closer to 1, the stronger the increase of the values between 2014 and 2018 (xmax(2018) – xmin(2014) = 1 – 0 = 1). Conversely, the closer to -1, the larger the decrease (xmin(2018) – xmin(2014) = 0 – 1 = -1). A value of 0 indicates no change because the difference between the two normalized values is null. Stars rating correspond to the following rule, calculated after a Welch one-sample t-test: P ≤ 0.001, \*\*\*; P ≤ 0.01, \*\*; P ≤ 0.05, \*. Bars with no stars indicates no statistical difference between the two years (p=0.05). Please refer to Table S8 in the supplementary material for the exact p-values). For extractable Ca and Mg, F had the largest effect, but the difference is not significant because the variability was very high.

Table S1: Operational timeline of the experiment

|  |  |  |
| --- | --- | --- |
| **Date** | **Operation** | **Details** |
| 2011 | Baseline soil analysis | (exact month not mentioned) |
| Dec-2011 | Cocoa planting | With 100 g NPK (Phonska) + 150 g TSP (36%) per tree |
| May-2012 | First treatment application | And later every year, twice a year |
| Tree height measurement | - |
| Jan-2013 | Tree height measurement | Each month until Jan-2014 |
| Feb-2013 | First leaf analysis | - |
| July-2013 | CPBa and PPRb incidence | Fortnightly between July 2013 and December 2018 |
| Aug-2013 | First harvest | Annual yield, harvest twice a month between 2014 and 2015 |
| June-2014 | Soil and leaf analysis | - |
| Feb-2015 | VSDc incidence | Each month between February 2015 and December 2018 |
| Sep-2015 | CPB and PPR incidence | - |
| Jan-2016 | Replanting | New trees planted to replace the dead ones |
| 2015 to 2018 | Productivity, flowering and pest/disease incidence yearly recordings | |
| Dec-2018 | Soil sampling and tree measurements | This study |

a Cocoa Pod Borer; b Phytophthora Pod Rot; c Vascular-Streak Dieback

Table S2: Description of plot maintenance activities

|  |  |  |
| --- | --- | --- |
| **Operation** | **Description** | **Details** |
| Pests | CPBa treatment | Spraying (knapsack sprayer) / Prevathon (Chlorantraniliprole) @ 1 ml/L |
|  | Helopeltis treatment | Spraying (knapsack sprayer) / Prevathon (Chlorantraniliprole) @ 1 ml/L |
| Diseases | PPRb treatment | Spraying (knapsack sprayer) / Score (Difenoconazole) @ 1.7 ml/L |
|  | VSDc treatment | Spraying (knapsack sprayer) / Score (Difenoconazole) @ 1.7 ml/L |
| Pruning | Shape/production pruning | Manual - Scissors and Long Pruner |
|  | Maintenance pruning | Manual - Scissors and Long Pruner (Water shoot/Chupon) |
| Soil inputs | Compost | Dig 6 holes 10-20 cm deep around the tree / 100 cm from the trunk / 5 kg per tree |
| Sanitation | Infected pod removal | Remove infected pods |
|  | Branch removal | Tidy removal branches in the middle of cocoa trees row |
| Harvesting | Manual harvesting | Harvest ripe pods by plot / Evaluation |
| Weed control | Mechanical weeding | Mechanical - grass cutter machine |

a Cocoa Pod Borer; b Phytophthora Pod Rot; c Vascular-Streak Dieback

Table S3: Calendar of plot maintenance activities

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Operations** | **Description** | **January** | | | | **February** | | | | **March** | | | | **April** | | | | **May** | | | | **June** | | | |
| **1** | **2** | **3** | **4** | **1** | **2** | **3** | **4** | **1** | **2** | **3** | **4** | **1** | **2** | **3** | **4** | **1** | **2** | **3** | **4** | **1** | **2** | **3** | **4** |
| Pests | CPBa treatment |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Helopeltis treatment |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Diseases | PPRb treatment |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| VSDc treatment |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Pruning | Shape/production pruning |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Maintenance pruning (Water Shoot/Chupon) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Soil inputs | Compost, fertilizer, and dolomite application |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Sanitation | Infected pod removal | **Every Harvest & Pruning** | | | | | | | | |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Branch removal | **Every Harvest & Pruning** | | | | | | | | |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Harvesting | Manual |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Weed Control | Mechanical |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **Operations** | **Description** | **July** | | | | **August** | | | | **September** | | | | **October** | | | | **November** | | | | **December** | | | |
| **1** | **2** | **3** | **4** | **1** | **2** | **3** | **4** | **1** | **2** | **3** | **4** | **1** | **2** | **3** | **4** | **1** | **2** | **3** | **4** | **1** | **2** | **3** | **4** |
| Pests | CPBa treatment |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Helopeltis treatment |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Diseases | PPRb treatment |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| VSDc treatment |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Pruning | Shape/Production Pruning |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Maintenance Pruning (Water Shoot/Chupon) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Soil inputs | Compost, fertilizer, and dolomite application |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Sanitation | Infected pod removal | **Every Harvest & Pruning** | | | | | | | | |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Branch removal | **Every Harvest & Pruning** | | | | | | | | |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Harvesting | Manual |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Weed Control | Mechanical |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

a Cocoa Pod Borer; b Phytophthora Pod Rot; c Vascular-Streak Dieback

Table S4: Monthly precipitations (mm)

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Year** | **2014** | **2015** | **2016** | **2017** | **2018** | **Average** |
| January | 198 | 98 | 216 | 96 | 176 | 157 |
| February | 161 | 211 | 348 | 114 | 142 | 195 |
| March | 236 | 261 | 294 | 355 | 261 | 281 |
| April | 316 | 276 | 274 | 128 | 255 | 250 |
| May | 305 | 267 | 383 | 308 | 223 | 297 |
| June | 384 | 381 | 194 | 416 | 424 | 360 |
| July | 489 | 53 | 210 | 167 | 329 | 250 |
| August | 249 | 58 | 182 | 97 | 238 | 165 |
| September | 99 | 72 | 273 | 306 | 228 | 196 |
| October | 177 | 7 | 213 | 331 | 118 | 169 |
| November | 106 | 76 | 191 | 385 | 142 | 180 |
| December | 273 | 218 | 209 | 272 | 149 | 224 |
| **Total** | **2992** | **1977** | **2987** | **2974** | **2684** | **2723** |

This data was obtained from Mars’s Cocoa Development Centre located in Tarengge (South Sulawesi, Indonesia); approximately 20km from the experiment.

Table S5: Basal areas and the formula used to convert trunk circumferences to areas

|  |  |  |
| --- | --- | --- |
| **Treatment** | **Basal area (cm²)** | **Coefficient of variation** |
| **A** | 78.9a (31.7) | 0.4 |
| **B** | 87.6a (25.2) | 0.29 |
| **C** | 124.5ab (31.6) | 0.25 |
| **D** | 111.6ab (38.7) | 0.35 |
| **E** | 122.9ab (39.8) | 0.32 |
| **F** | 114.2ab (33.8) | 0.3 |
| **G** | 149.2b (51.7) | 0.35 |
| **H** | 158.7b (65.4) | 0.41 |

Table S6: Survival rates per individual plot and treatment

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Block** | **Treatment** | **Number of surviving trees** | **Survival rate (over 16 original trees)** | **Average survival rate per treatment** |
| 1 | A | 7 | 44% | 67% |
| B | 12 | 75% | 41% |
| C | 16 | 100% | 94% |
| D | 6 | 38% | 72% |
| E | 15 | 94% | 92% |
| F | 12 | 75% | 88% |
| G | 13 | 81% | 92% |
| H | 13 | 81% | 83% |
| 2 | A | 15 | 94% | - |
| B | 2 | 13% | - |
| C | 16 | 100% | - |
| D | 12 | 75% | - |
| E | 15 | 94% | - |
| F | 13 | 81% | - |
| G | 15 | 94% | - |
| H | 12 | 75% | - |
| 3 | A | 10 | 63% | - |
| B | 7 | 44% | - |
| C | 14 | 88% | - |
| D | 14 | 88% | - |
| E | 14 | 88% | - |
| F | 16 | 100% | - |
| G | 16 | 100% | - |
| H | 13 | 81% | - |
| 4 | A | 11 | 69% | - |
| B | 5 | 31% | - |
| C | 14 | 88% | - |
| D | 14 | 88% | - |
| E | 15 | 94% | - |
| F | 15 | 94% | - |
| G | 15 | 94% | - |
| H | 15 | 94% | - |

Table S7: Pod count, yield per pod, pod indices and proportion of infected pods per treatment and year

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Average pod count per tree (and standard error)** | | | | | | | | |
|  | | **2015** | | **2016** | | **2017** | | **2018** |
| **A** | | 8 (2) | | 5 (0.2) | | 9 (1.1) | | 22 (2.5) |
| **B** | | 10 (2.1) | | 12 (2.3) | | 17 (2.8) | | 44 (3.4) |
| **C** | | 47 (1.4) | | 32 (3.5) | | 27 (3.3) | | 34 (2.5) |
| **D** | | 8 (0.8) | | 11 (1.2) | | 15 (0.9) | | 32 (0.9) |
| **E** | | 27 (0.8) | | 39 (1.4) | | 30 (2.3) | | 33 (1.5) |
| **F** | | 6 (0.7) | | 16 (0.4) | | 21 (1.4) | | 27 (2.6) |
| **G** | | 33 (0.7) | | 42 (1.2) | | 33 (1.2) | | 39 (2.2) |
| **H** | | 29 (1.7) | | 35 (0.8) | | 27 (1.3) | | 35 (3.3) |
| **Mean yield (g) per pod (and standard error)** | | | | | | | | |
|  | | **2015** | | **2016** | | **2017** | | **2018** |
| **A** | | 13.7 (0.8) | | 25.9 (0.9) | | 25.4 (0.7) | | 18.7 (0.9) |
| **B** | | 14.7 (0.8) | | 25 (0.2) | | 30.3 (0.4) | | 23.6 (0.9) |
| **C** | | 12.3 (1.0) | | 23.2 (0.3) | | 28 (0.6) | | 17.9 (1.1) |
| **D** | | 10.8 (0.6) | | 23.7 (0.2) | | 26.9 (0.8) | | 17.3 (0.8) |
| **E** | | 12.3 (0.4) | | 23.5 (0.6) | | 27.3 (0.8) | | 20.5 (1.1) |
| **F** | | 12 (0.9) | | 23.5 (0.8) | | 28.8 (0.6) | | 23.5 (0.8) |
| **G** | | 11.6 (0.2) | | 21.1 (0.4) | | 23.6 (0.3) | | 14.5 (0.4) |
| **H** | | 12 (0.3) | | 20 (0.4) | | 24.1 (0.7) | | 16.9 (0.4) |
| **Mean pod index (and standard error)** | | | | | | | | |
|  | | **2015** | | **2016** | | **2017** | | **2018** |
| **A** | | 77 (5.1) | | 39 (1.5) | | 40 (1) | | 55 (2.8) |
| **B** | | 71 (4.1) | | 40 (0.4) | | 33 (0.5) | | 43 (1.8) |
| **C** | | 88 (6.9) | | 43 (0.6) | | 36 (0.8) | | 59 (3.8) |
| **D** | | 96 (5.2) | | 42 (0.4) | | 38 (1.2) | | 59 (3.1) |
| **E** | | 82 (2.6) | | 43 (1.3) | | 37 (1.0) | | 51 (2.9) |
| **F** | | 90 (6.8) | | 43 (1.4) | | 35 (0.8) | | 43 (1.6) |
| **G** | | 87 (1.8) | | 48 (0.8) | | 42 (0.6) | | 70 (1.9) |
| **H** | | 84 (2.4) | | 50 (1.0) | | 42 (1.2) | | 60 (1.7) |
| **Mean proportion of infected pods (and standard error)** | | | | | | | | |
|  | **2015** | | **2016** | | **2017** | | **2018** | |
| **A** | 0.91 (0.01) | | 0.67 (0.03) | | 0.65 (0.04) | | 0.89 (0.01) | |
| **B** | 0.89 (0.03) | | 0.69 (0.01) | | 0.62 (0.02) | | 0.82 (0.01) | |
| **C** | 0.95 (0.01) | | 0.71 (0.02) | | 0.7 (0.01) | | 0.92 (0.01) | |
| **D** | 0.92 (0.01) | | 0.67 (0.02) | | 0.69 (0.03) | | 0.93 (0.01) | |
| **E** | 0.96 (0) | | 0.78 (0.01) | | 0.78 (0.03) | | 0.92 (0.01) | |
| **F** | 0.94 (0.01) | | 0.78 (0.02) | | 0.77 (0.03) | | 0.91 (0.01) | |
| **G** | 0.97 (0) | | 0.75 (0.01) | | 0.83 (0.02) | | 0.95 (0) | |
| **H** | 0.95 (0.01) | | 0.77 (0.01) | | 0.8 (0.01) | | 0.96 (0.01) | |

Table S8: Evaluation of the statistical significance of the differences between the two years of soil analyses, 2014 and 2018.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Treatment** | **\* pH (water)** | **† C (%)** | **‡ N (%)** | **C/N** | **†† CEC  (cmol.kg-1)** |
| **A** | \* | 0.111 | 0.718 | 0.274 | 0.261 |
| **B** | \*\* | 0.101 | 0.638 | 0.935 | \* |
| **C** | \* | \*\* | 0.423 | 0.050 | \* |
| **D** | \*\*\* | 0.423 | 0.886 | 0.837 | 0.918 |
| **E** | \*\*\* | 0.959 | 0.809 | \* | 0.275 |
| **F** | \*\*\* | 0.301 | 0.342 | 0.227 | \* |
| **G** | \*\*\* | \* | 0.604 | 0.138 | \*\* |
| **H** | \*\* | \* | 0.579 | 0.769 | \* |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Treatment** | **§ Extractable (ppm)** | | | | **‡‡ Exch. Al  (ppm)** |
| **P** | **Ca** | **K** | **Mg** |
| **A** | \*\*\* | \*\*\* | \* | \*\*\* | \*\* |
| **B** | \*\*\* | \*\*\* | 0.098 | \*\*\* | \* |
| **C** | \*\*\* | \*\* | \*\* | \*\*\* | \*\*\* |
| **D** | \*\*\* | \*\*\* | \* | \*\*\* | \*\*\* |
| **E** | \*\*\* | \*\* | \*\*\* | \*\*\* | 0.384 |
| **F** | \*\*\* | 0.201 | \*\* | 0.107 | \*\*\* |
| **G** | \*\*\* | \*\* | \*\* | \*\*\* | 0.089 |
| **H** | \*\*\* | \* | \*\* | \*\*\* | \*\* |

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Treatment** | **¶ Available P (ppm)** | **†† Exch. Bas. Cation (ppm)** | | | | | **B.S. (%)** |
| **Ca** | **Mg** | **K** | **Na** | **Total** |
| **A** | \*\*\* | \*\*\* | \*\*\* | \*\*\* | \*\* | \*\*\* | \*\*\* |
| **B** | \*\*\* | \*\*\* | \*\*\* | \*\*\* | 0.092 | \*\*\* | \*\*\* |
| **C** | \*\* | \*\*\* | \*\*\* | \*\*\* | \*\*\* | \*\*\* | \*\*\* |
| **D** | \*\*\* | \*\* | \*\* | \*\*\* | \* | \*\* | \*\*\* |
| **E** | \*\* | \* | \* | \*\*\* | \*\*\* | \*\* | \*\* |
| **F** | \* | \* | \* | \*\*\* | 0.809 | \* | \* |
| **G** | \*\*\* | \* | \*\* | \*\* | 0.080 | \*\* | \*\* |
| **H** | \*\*\* | \* | \* | \*\*\* | \*\* | 0.082 | 0.062 |

The reported p-values were calculated after a Welch one-sample t-test (p-value = 0.05). Because there was only one measurement in 2014, coming from a composite of four sample, it was used as the ‘true mean’ in the tests, to which 2018 observation were compared to. Star rating correspond to the following rule: P ≤ 0.001, \*\*\*; P ≤ 0.01, \*\*; P ≤ 0.05, \*. The exact value was reported if P > 0.05. “na” stands for not applicable (calculated data). Methods: ♠After Fahmy (1977); ○Core ring method; ∗pH determined by AIAT Soil Laboratories, Maros; †Dry ashing method; ‡Kjeldahl method; §25% HCl extraction; ¶Bray-I method; ††Ammonium acetate (pH 7) extraction; ‡‡KCl (1 N) extraction.

Table S9: Cocoa dry bean yields summary

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Average productivity (kg ha-1)**  for surviving trees only (i.e., excluding mortality rates) | | | |  |  |  |  |  |
| **Treatment** | **2015** | **2016** | **2017** | **2018** | **Mean** | **σ** | **C.V.** | **Cumulated** | **% relative to the control\*** |
| **A** | 112 | 141 | 240 | 432 | 231 | 144 | 0.62 | 925 | 100 % |
| **B** | 154 | 314 | 526 | 1029 | 506 | 381 | 0.75 | 2024 | 219 % |
| **C** | 579 | 737 | 783 | 638 | 684 | 93 | 0.14 | 2737 | 296 % |
| **D** | 87 | 261 | 402 | 558 | 327 | 201 | 0.61 | 1308 | 141 % |
| **E** | 334 | 918 | 813 | 686 | 688 | 254 | 0.37 | 2751 | 297% |
| **F** | 83 | 364 | 622 | 640 | 427 | 262 | 0.61 | 1709 | 185% |
| **G** | 379 | 881 | 780 | 566 | 652 | 224 | 0.34 | 2607 | 282 % |
| **H** | 355 | 701 | 648 | 606 | 577 | 153 | 0.27 | 2310 | 250 % |
| **Mean** | 261 | 540 | 602 | 644 |  |  |  |  |  |
| **σ** | 179 | 303 | 203 | 173 |  |  |  |  |  |
| **C.V.** | 0.69 | 0.56 | 0.34 | 0.27 |  |  |  |  |  |

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Average productivity (kg ha-1)**  for 16 initially planted trees (i.e., including mortality rates) | | | |  |  |  |  |  |
| **Treatment** | **2015** | **2016** | **2017** | **2018** | **Mean** | **σ** | **C.V.** | **Cumulated** | **% relative to the control\*** |
| **A** | 91 | 98 | 165 | 274 | 157 | 85 | 0.54 | 627 | 100 % |
| **B** | 125 | 137 | 228 | 489 | 245 | 169 | 0.69 | 978 | 156 % |
| **C** | 478 | 496 | 490 | 406 | 467 | 42 | 0.09 | 1870 | 298 % |
| **D** | 73 | 194 | 281 | 363 | 228 | 124 | 0.55 | 910 | 145 % |
| **E** | 279 | 628 | 544 | 446 | 474 | 150 | 0.32 | 1897 | 302 % |
| **F** | 69 | 264 | 449 | 464 | 311 | 186 | 0.60 | 1246 | 199 % |
| **G** | 318 | 612 | 556 | 398 | 471 | 136 | 0.29 | 1883 | 300 % |
| **H** | 295 | 499 | 459 | 419 | 418 | 88 | 0.21 | 1672 | 266 % |
| **Mean** | 216 | 366 | 396 | 407 |  |  |  |  |  |
| **σ** | 149 | 216 | 150 | 67 |  |  |  |  |  |
| **C.V.** | 0.69 | 0.59 | 0.38 | 0.16 |  |  |  |  |  |

**σ** stands for standard deviation.

C.V. is the abbreviation for the coefficient of variation.

\* % relative to the control calculated as :

Table S10: Yield index per treatment

|  |  |
| --- | --- |
| **Treatment** | **Yield Index** |
| **A** | 5.58ab (3.47) |
| **B** | 10.29a (0.92) |
| **C** | 4.93b (1.98) |
| **D** | 5.21ab (2.01) |
| **E** | 5.54ab (1.19) |
| **F** | 5.5ab (2.08) |
| **G** | 3.8b (0.73) |
| **H** | 3.9b (2.01) |

The yield index is calculated by dividing the dry bean yield by the basal area.

Table S11: Harvest quality metrics (production sample collected in November 2017)

|  |  |  |
| --- | --- | --- |
| **Treatment** | **Average dry bean weight (g)** | **Waste fraction (%)** |
| **A** | 1.30 | 11% |
| **B** | 1.25 | 12% |
| **C** | 1.44 | 14% |
| **D** | 1.59 | 14% |
| **E** | 1.46 | 18% |
| **F** | 1.39 | 8% |
| **G** | 1.51 | 10% |
| **H** | 1.46 | 10% |

Table S12: Initial and final stocks in soil elements as well as changes between the two soil sampling (sampling depth: 20 cm; bulk density of 1.09g cm-3)

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Initial estimated stocks in kg ha-1 (June 2014)** | | | | | | | | | | | | |
| **Treatment** | **Org. C** | **N** | **Av. P** | **Exch. Al** | **Extractable** | | | | **Exch. Bas. Cation** | | | |
| **P** | **Ca** | **K** | **Mg** | **Ca** | **Mg** | **K** | **Na** |
| **A** | 31 392 | 3 052 | 65 | 1 341 | 495 | 31 | 1 176 | 184 | 1 826 | 360 | 409 | 50 |
| **B** | 28 994 | 2 834 | 198 | 1 953 | 1 027 | 47 | 1 556 | 237 | 856 | 350 | 503 | 40 |
| **C** | 34 008 | 2 834 | 98 | 1 294 | 637 | 109 | 851 | 145 | 2 962 | 397 | 392 | 65 |
| **D** | 30 520 | 3 052 | 52 | 1 347 | 485 | 171 | 977 | 79 | 1 555 | 350 | 358 | 40 |
| **E** | 30 520 | 3 270 | 170 | 1 588 | 856 | 31 | 851 | 184 | 1 022 | 381 | 477 | 45 |
| **F** | 30 084 | 3 052 | 157 | 1 706 | 866 | 47 | 778 | 171 | 647 | 344 | 332 | 35 |
| **G** | 35 970 | 2 834 | 137 | 1 341 | 685 | 93 | 724 | 145 | 1 555 | 472 | 188 | 40 |
| **H** | 33 790 | 3 052 | 146 | 1 582 | 761 | 31 | 887 | 92 | 1 031 | 392 | 469 | 60 |
| **Final estimated stocks in kg ha-1 (December 2018)** | | | | | | | | | | | | |
| **Treatment** | **Org. C** | **N** | **Av. P** | **Exch. Al** | **Extractable** | | | | **Exch. Bas. Cation** | | | |
| **P** | **Ca** | **K** | **Mg** | **Ca** | **Mg** | **K** | **Na** |
| **A** | 27 359 | 2 998 | 8 | 1 537 | 40 | 209 | 1 452 | 728 | 186 | 44 | 85 | 28 |
| **B** | 26 269 | 2 671 | 11 | 1 619 | 74 | 209 | 1 398 | 717 | 177 | 48 | 81 | 30 |
| **C** | 26 487 | 3 052 | 18 | 1 571 | 70 | 256 | 1 559 | 835 | 328 | 87 | 81 | 28 |
| **D** | 29 376 | 2 998 | 4 | 46 | 84 | 2 063 | 1 535 | 2 137 | 4 002 | 1 772 | 75 | 30 |
| **E** | 30 411 | 3 325 | 27 | 1 478 | 149 | 364 | 1 624 | 930 | 540 | 184 | 87 | 30 |
| **F** | 25 561 | 3 325 | 21 | 59 | 105 | 4 386 | 1 523 | 3 357 | 4 063 | 2 031 | 89 | 34 |
| **G** | 27 032 | 2 943 | 9 | 66 | 73 | 1 374 | 1 479 | 1 752 | 2 593 | 1 420 | 98 | 34 |
| **H** | 25 452 | 2 780 | 10 | 307 | 81 | 842 | 1 561 | 1 351 | 1 927 | 1 069 | 85 | 31 |
| **Mean annual rate of change in kg ha-1 yr-1** | | | | | | | | | | | | |
| **Treatment** | **Org. C** | **N** | **Av. P** | **Exch. Al** | **Extractable** | | | | **Exch. Bas. Cation** | | | |
| **P** | **Ca** | **K** | **Mg** | **Ca** | **Mg** | **K** | **Na** |
| **A** | -896 | -12 | -5  \*\*\* | +43  \*\* | -101 \*\*\* | +39 \*\*\* | +61  \* | +121 \*\*\* | -365  \*\*\* | -70  \*\*\* | -72  \*\*\* | -5 |
| **B** | -606 | -36 | -17  \*\*\* | -74  \* | -212 \*\*\* | +36 \*\*\* | -35 | +107 \*\*\* | -151  \*\*\* | -67  \*\*\* | -94  \*\*\* | -2 |
| **C** | -1671  \*\* | +48 | -6  \*\* | +61  \*\*\* | -126 \*\*\* | +33  \*\* | +157 \*\* | +153 \*\*\* | -585  \*\*\* | -69  \*\*\* | -69  \*\*\* | -8 |
| **D** | -254 | -12 | -4  \*\*\* | -289  \*\*\* | -89 \*\*\* | +420 \*\*\* | +124  \* | +457 \*\*\* | +544  \*\* | +316  \*\* | -63  \*\*\* | -2 |
| **E** | -24 | +12 | -10  \*\* | -25 | -157 \*\*\* | +74  \*\* | +172 \*\*\* | +166 \*\*\* | -107  \* | -44  \* | -87  \*\*\* | -3 |
| **F** | -1005 | +61 | -11  \* | -366  \*\*\* | -169 \*\*\* | +964 | +166 \*\* | +708 | +759  \* | +375  \* | -54  \*\*\* | 0 |
| **G** | -1986  \* | +24 | -11  \*\*\* | -283 | -136 \*\*\* | +285 \*\* | +168 \*\* | +357 \*\*\* | +231  \* | +211  \*\* | -20  \*\*\* | -1 |
| **H** | -1853  \* | -61 | -12  \*\*\* | -283  \*\* | -151 \*\*\* | +180  \* | +150 \*\* | +280 \*\*\* | +199  \* | +150  \* | -85  \*\*\* | -6 |

The stock for each element was found by using its content for a given year, assuming a surface bulk density of 1.09 g cm-3 (measured only in 2018), a depth of 20 cm, and a one-hectare area. The mean annual rate of change corresponds to the difference between the two stocks divided by 4.5 years, the time separating the two sampling years. Stars denotes a statistically significant difference over 4.5 years (see Table S8) with: P ≤ 0.001, \*\*\*; P ≤ 0.01, \*\*; P ≤ 0.05, \*. Strong changes that are not statistically significant (e.g., extractable Ca for treatment G) may be so because of the dispersion of the data.