

This supplementary file contains Figure S1 and Tables S1–S3.

## 1. Supplementary Figure

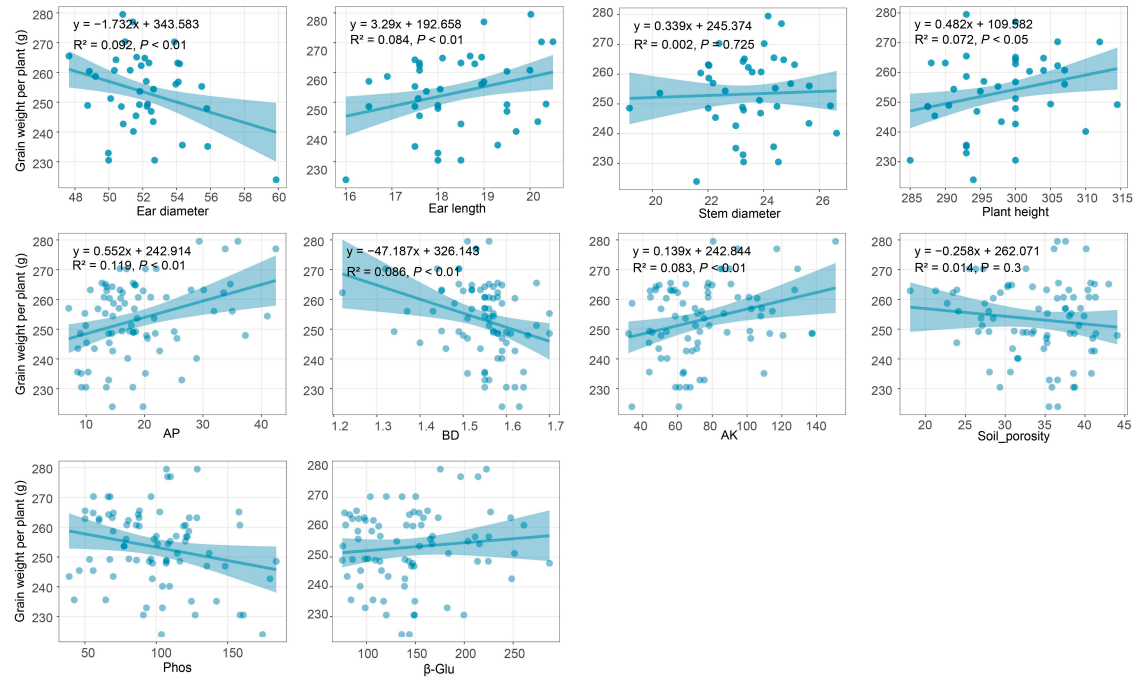


Figure S1. Additional univariate linear relationships of grain weight per plant with ear diameter, ear length, stem diameter, plant height, available phosphorus (AP), soil bulk density (BD), available potassium (AK), soil porosity, phosphatase activity (Phos), and  $\beta$ -glucosidase activity (BG). Points represent individual observations, solid lines represent fitted linear regressions, and shaded bands indicate 95% confidence intervals. Regression equations, coefficients of determination ( $R^2$ ), and  $P$  values are shown in each plot.

## 2. Supplementary Tables

**Table S1 Effects of microbial inoculant treatment and soil depth on soil physicochemical properties in 2024**

| Treatment         | Depth (cm) | BD (g cm <sup>-3</sup> ) | SWC (%)        | Soil porosity (%) | pH            | SOC (g kg <sup>-1</sup> ) | AK (mg kg <sup>-1</sup> ) | AP (mg kg <sup>-1</sup> ) | TN(g kg <sup>-1</sup> ) |
|-------------------|------------|--------------------------|----------------|-------------------|---------------|---------------------------|---------------------------|---------------------------|-------------------------|
| M44               | 10         | 1.533 ± 0.015 a          | 13.77 ± 0.57 a | 39.93 ± 1.18 a    | 7.95 ± 0.05 a | 10.20 ± 0.16 a            | 95.22 ± 8.09 ab           | 29.66 ± 5.53 a            | 0.992 ± 0.029 ab        |
|                   | 20         | 1.580 ± 0.031 a          | 13.89 ± 0.59 a | 35.75 ± 3.06 a    | 8.07 ± 0.06 a | 9.91 ± 0.44 a             | 76.81 ± 6.47 ab           | 19.00 ± 5.28 ab           | 0.933 ± 0.038 ab        |
| CF                | 10         | 1.530 ± 0.009 a          | 14.28 ± 0.43 a | 38.38 ± 0.68 a    | 7.98 ± 0.06 a | 10.37 ± 0.29 a            | 122.20 ± 10.99 a          | 30.81 ± 4.97 a            | 1.018 ± 0.049 a         |
|                   | 20         | 1.553 ± 0.011 a          | 13.02 ± 0.53 a | 37.15 ± 1.20 a    | 8.06 ± 0.06 a | 9.39 ± 0.35 a             | 61.96 ± 6.46 b            | 16.68 ± 4.30 ab           | 0.895 ± 0.026 ab        |
| SF                | 10         | 1.552 ± 0.029 a          | 14.37 ± 0.61 a | 41.09 ± 1.21 a    | 7.97 ± 0.07 a | 10.11 ± 0.12 a            | 106.31 ± 15.51 ab         | 26.81 ± 3.57 ab           | 1.007 ± 0.025 a         |
|                   | 20         | 1.633 ± 0.027 a          | 12.95 ± 0.57 a | 36.15 ± 1.62 a    | 8.04 ± 0.04 a | 9.56 ± 0.18 a             | 80.63 ± 19.42 ab          | 16.11 ± 2.74 ab           | 0.917 ± 0.025 ab        |
| YM                | 10         | 1.583 ± 0.014 a          | 15.11 ± 0.18 a | 38.31 ± 0.27 a    | 7.99 ± 0.05 a | 9.45 ± 0.27 a             | 93.29 ± 11.09 ab          | 14.19 ± 0.54 ab           | 0.932 ± 0.018 ab        |
|                   | 20         | 1.617 ± 0.033 a          | 13.99 ± 0.43 a | 37.99 ± 1.45 a    | 8.02 ± 0.02 a | 9.20 ± 0.25 a             | 58.03 ± 9.19 b            | 9.97 ± 1.43 b             | 0.915 ± 0.014 ab        |
| CK                | 10         | 1.553 ± 0.017 a          | 14.95 ± 0.27 a | 37.56 ± 0.57 a    | 8.04 ± 0.01 a | 9.46 ± 0.11 a             | 77.71 ± 10.97 ab          | 21.07 ± 1.83 ab           | 0.960 ± 0.027 ab        |
|                   | 20         | 1.587 ± 0.022 a          | 14.28 ± 0.30 a | 35.29 ± 2.35 a    | 8.07 ± 0.04 a | 9.15 ± 0.19 a             | 58.35 ± 8.80 b            | 11.88 ± 1.35 b            | 0.863 ± 0.011 b         |
| Treatment         |            | 0.07                     | 0.104          | 0.708             | 0.771         | 0.016                     | 0.145                     | 0.008                     | 0.245                   |
| Depth             |            | 0.004                    | 0.006          | 0.014             | 0.049         | 0.006                     | < 0.001                   | < 0.001                   | <0.001                  |
| Treatment × Depth |            | 0.746                    | 0.499          | 0.557             | 0.866         | 0.596                     | 0.351                     | 0.735                     | 0.418                   |

Values are presented as means ± standard errors (n = 4). Different lowercase letters within the same column indicate significant differences among the 10 Treatment × Depth combinations according to Tukey's multiple-comparison test ( $P < 0.05$ ). P values for the main effects of Treatment and Depth and their interaction were obtained using two-way analysis of variance. Significant P values ( $P < 0.05$ ) are shown in bold. BD, bulk density; SWC, soil water content; SOC, soil organic carbon; AK, available potassium; AP, available phosphorus; TN, total nitrogen.

**Table S2 Effects of microbial inoculant treatment and soil depth on soil physicochemical properties in 2025**

| Treatment         | Depth (cm) | BD (g cm <sup>-3</sup> ) | SWC (%)         | Soil porosity (%) | pH            | SOC (g kg <sup>-1</sup> ) | AK (mg kg <sup>-1</sup> ) | AP (mg kg <sup>-1</sup> ) | TN (g kg <sup>-1</sup> ) |
|-------------------|------------|--------------------------|-----------------|-------------------|---------------|---------------------------|---------------------------|---------------------------|--------------------------|
| M44               | 10         | 1.445 ± 0.067 a          | 13.28 ± 0.58 ab | 31.71 ± 3.36 a    | 8.31 ± 0.10 a | 10.28 ± 0.57 ab           | 90.25 ± 16.18 a           | 18.20 ± 2.76 ab           | 1.120 ± 0.045 ab         |
|                   | 20         | 1.528 ± 0.023 a          | 12.54 ± 0.22 b  | 31.69 ± 3.27 a    | 8.28 ± 0.05 a | 8.37 ± 0.85 abc           | 62.65 ± 10.01 ab          | 17.51 ± 1.58 ab           | 0.995 ± 0.047 ab         |
| CF                | 10         | 1.523 ± 0.055 a          | 13.18 ± 0.60 ab | 33.88 ± 2.91 a    | 8.12 ± 0.06 a | 10.94 ± 0.57 a            | 94.53 ± 9.24 a            | 21.82 ± 4.43 ab           | 1.143 ± 0.042 a          |
|                   | 20         | 1.565 ± 0.050 a          | 11.67 ± 0.33 b  | 30.02 ± 2.62 a    | 8.16 ± 0.08 a | 8.67 ± 0.43 abc           | 58.24 ± 5.39 ab           | 19.27 ± 4.38 ab           | 1.022 ± 0.032 ab         |
| SF                | 10         | 1.525 ± 0.016 a          | 13.22 ± 0.59 ab | 28.48 ± 3.73 a    | 8.06 ± 0.11 a | 9.70 ± 0.56 abc           | 66.94 ± 9.23 ab           | 20.84 ± 3.51 ab           | 1.115 ± 0.058 ab         |
|                   | 20         | 1.515 ± 0.038 a          | 12.00 ± 0.44 b  | 26.21 ± 2.45 a    | 8.22 ± 0.09 a | 7.84 ± 0.23 bc            | 52.52 ± 4.79 ab           | 18.10 ± 0.84 ab           | 0.980 ± 0.041 ab         |
| YM                | 10         | 1.472 ± 0.087 a          | 12.99 ± 0.38 ab | 27.59 ± 2.62 a    | 8.18 ± 0.07 a | 9.82 ± 0.97 abc           | 63.83 ± 12.46 ab          | 25.27 ± 3.73 a            | 1.110 ± 0.076 ab         |
|                   | 20         | 1.520 ± 0.036 a          | 11.74 ± 0.31 b  | 28.45 ± 1.30 a    | 8.29 ± 0.08 a | 8.40 ± 0.69 abc           | 64.56 ± 7.20 ab           | 15.96 ± 0.51 ab           | 0.960 ± 0.060 ab         |
| CK                | 10         | 1.587 ± 0.021 a          | 14.76 ± 0.39 a  | 32.31 ± 1.70 a    | 8.06 ± 0.09 a | 8.64 ± 0.55 abc           | 76.98 ± 8.42 ab           | 12.98 ± 1.30 ab           | 1.065 ± 0.009 ab         |
|                   | 20         | 1.465 ± 0.031 a          | 12.74 ± 0.24 ab | 29.76 ± 2.06 a    | 8.27 ± 0.08 a | 7.34 ± 0.23 c             | 45.12 ± 1.36 b            | 11.15 ± 2.11 b            | 0.913 ± 0.020 b          |
| Treatment         |            | 0.751                    | 0.018           | 0.298             | 0.299         | 0.065                     | 0.207                     | 0.031                     | 0.380                    |
| Depth             |            | 0.792                    | <0.001          | 0.366             | 0.071         | <0.001                    | <0.001                    | 0.069                     | <0.001                   |
| Treatment × Depth |            | 0.250                    | 0.669           | 0.903             | 0.605         | 0.930                     | 0.288                     | 0.601                     | 0.995                    |

Values are presented as means ± standard errors (n = 4). Different lowercase letters within the same column indicate significant differences among the 10 Treatment × Depth combinations according to Tukey's multiple-comparison test ( $P < 0.05$ ). P values for the main effects of Treatment and Depth and their interaction were obtained using two-way analysis of variance. Significant P values ( $P < 0.05$ ) are shown in bold. BD, bulk density; SWC, soil water content; SOC, soil organic carbon; AK, available potassium; AP, available phosphorus; TN, total nitrogen.

**Table S3 Effects of microbial inoculant treatment and soil depth on soil extracellular enzyme activities**

| Treatment                | depth<br>(cm) | $\beta$ -glucosidase ( $\mu\text{g}\cdot\text{g}^{-1}\text{ h}^{-1}$ ) |                     | Cellobiohydrolase ( $\mu\text{g}\cdot\text{g}^{-1}\text{ h}^{-1}$ ) |                   | Phosphatase ( $\mu\text{g}\cdot\text{g}^{-1}\text{ h}^{-1}$ ) |                    |
|--------------------------|---------------|------------------------------------------------------------------------|---------------------|---------------------------------------------------------------------|-------------------|---------------------------------------------------------------|--------------------|
|                          |               | 2024                                                                   | 2025                | 2024                                                                | 2025              | 2024                                                          | 2025               |
| M44                      | 0-10          | 238.37 $\pm$ 10.8a                                                     | 143.93 $\pm$ 4.32ab | 84.51 $\pm$ 7.03a                                                   | 62.61 $\pm$ 4.81a | 140.32 $\pm$ 11.92a                                           | 77.09 $\pm$ 5.51a  |
| M44                      | 10-20         | 167.38 $\pm$ 13.45ab                                                   | 87.83 $\pm$ 5.56a   | 63.13 $\pm$ 4.83a                                                   | 52.25 $\pm$ 5.45a | 111.89 $\pm$ 3.79a                                            | 66.33 $\pm$ 5.33a  |
| CF                       | 0-10          | 227.75 $\pm$ 6.91a                                                     | 157.34 $\pm$ 4.08a  | 69.79 $\pm$ 8.95ab                                                  | 59.81 $\pm$ 3.32a | 120.44 $\pm$ 4.33a                                            | 93.92 $\pm$ 10.25a |
| CF                       | 10-20         | 178.05 $\pm$ 11.6a                                                     | 92.9 $\pm$ 7.25a    | 65.7 $\pm$ 7.61a                                                    | 59.92 $\pm$ 3.4a  | 114.36 $\pm$ 6.29a                                            | 68.21 $\pm$ 9.08a  |
| SF                       | 0-10          | 227.29 $\pm$ 29.16a                                                    | 132.19 $\pm$ 19ab   | 71.94 $\pm$ 2.66ab                                                  | 56.07 $\pm$ 0.6a  | 137.83 $\pm$ 16.51a                                           | 83.11 $\pm$ 9.87a  |
| SF                       | 10-20         | 143.98 $\pm$ 1.74abc                                                   | 83.7 $\pm$ 5.27a    | 45.27 $\pm$ 5.13a                                                   | 52.28 $\pm$ 3.84a | 109.27 $\pm$ 9.01a                                            | 70.71 $\pm$ 7.7a   |
| YM                       | 0-10          | 196.14 $\pm$ 9.95ab                                                    | 125.5 $\pm$ 11.34ab | 58.58 $\pm$ 2.12b                                                   | 58.28 $\pm$ 4.33a | 138.13 $\pm$ 19.97a                                           | 87.71 $\pm$ 7.78a  |
| YM                       | 10-20         | 126.89 $\pm$ 8.27bc                                                    | 101.03 $\pm$ 6.64a  | 45.22 $\pm$ 1.29a                                                   | 58.28 $\pm$ 6.57a | 114.14 $\pm$ 6.9a                                             | 86.96 $\pm$ 17a    |
| CK                       | 0-10          | 156.3 $\pm$ 8.86b                                                      | 111.5 $\pm$ 4.55b   | 52.57 $\pm$ 1.35b                                                   | 52.64 $\pm$ 0.77a | 145.48 $\pm$ 15.24a                                           | 71.63 $\pm$ 8.73a  |
| CK                       | 10-20         | 118.17 $\pm$ 7.66c                                                     | 89.3 $\pm$ 4.23a    | 53.4 $\pm$ 1.91a                                                    | 53.81 $\pm$ 1.08a | 103.08 $\pm$ 7.68a                                            | 52.07 $\pm$ 9.68a  |
| Treatment                |               | ***                                                                    | ns                  | ***                                                                 | ns                | ns                                                            | ns                 |
| depth                    |               | ***                                                                    | ***                 | ***                                                                 | ns                | **                                                            | *                  |
| Treatment $\times$ depth |               | ns                                                                     | ns                  | ns                                                                  | ns                | ns                                                            | ns                 |

Values are means  $\pm$  SE (n = 4). Lowercase letters within a year and enzyme column indicate differences among the ten treatment  $\times$  depth combinations (Tukey HSD,  $P < 0.05$ ). ANOVA significance: ns,  $P \geq 0.05$ ; \* $P < 0.05$ ; \*\* $P < 0.01$ ; \*\*\* $P < 0.001$ .