**Supplementary Table S1: Detailed Methodologies.**

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| --- | --- |
| Methods | Descriptions |
| Isolation of *Trichoderma* spp. | *Trichoderma* spp. were isolated from soil samples obtained from two organic rice fields in West Java, Indonesia: Nusantara Organic SRI Center in Sukabumi and SRI Mukti Sadaya Organic Rice Farm in Tasikmalaya. The isolation process involved a multilevel dilution technique on potato dextrose agar (PDA) medium. For this study, 1 g of soil sample was added to 10 mL of distilled water. The solution was homogenized to make a suspension and labeled as A. Before the sedimentation of the soil, 1 mL of the suspension was extracted using a sterile pipette and put into 9 mL of distilled water. The mixture was homogenated and labeled as B. This dilution step was repeated three times, each time with 1 mL of the previous suspension and 9 mL of distilled water and labeled sequentially as C, D and E. This results in a dilution rate of 10**−1** to 10**−5** g of soil per mL. A total of 100 μL of solution was pipetted out and poured (pour plate) onto the prepared potato dexstrose agar (PDA) medium. The agar was then incubated at 26 °C until fungal colonies formed. Subsequently, the isolates underwent purification and was moved to a petri dish containing fresh PDA medium (Mishra et al. 2019). |
| Morphological characterizations of *Trichoderma* | Morphological characterization was carried out after obtaining pure isolates of *Trichoderma* spp. The macroscopic observations of *Trichoderma* strains were performed using an interactive strains identification key given by Jiang et al. (2016). Isolates were identified by observing concentric rings, conidia and pigmentation, and mycelium texture (Kannangara et al. 2017). The microscopic observation carried out using slide culture method as described by Asis et al. (2021). After three days, the slide culture was observed with 100× and 400× magnifications using a light microscope (Olympus CX-21). |
| Spore suspension of *Trichoderma* | *Trichoderma* spp. were cultivated in PDA and incubated at 26 °C for seven days. *Trichoderma* spores were taken out from the plates after incubation by adding sterile distilled water, and the spores were immediately transferred to an Erlenmeyer flask. Based on the number of spores counted in a hemocytometer, the spore concentration was adjusted to 107 spores/mL (Doni et al. 2017). The following formula is used to count spores (Anhar et al. 2018):  Spore density (spores/mL) = |
| Rice seed inoculation | Prior to experimentation, the rice seeds underwent surface sterilization with 70% ethanol, followed by a thorough rinse with distilled water. Each treatment comprised a set of 100 seeds. *Trichoderma* spore treatment involved immersing 100 seeds in a suspension containing 107 spores/mL for a duration of 24 hours. As a control, an equivalent number of seeds were subjected to a 24-hour soaking in sterile distilled water. The planting medium used is a mixture of andosol soil, compost, and husk charcoal with a ratio of 2:1:1. The plant growth medium used has the following chemical characteristics as pH 7.9; total N 0.3 %; total P 0.39 %; and total K 0.11 %. The soil was sterilized in an autoclave before use. The amount of 1 kg of soil was put into aseedling tray size 54 **×** 28 cm. Subsequently, seeds assigned to each experimental condition—treatment groups (Tasikmalaya: TM and Sukabumi: SB, with *Trichoderma* inoculation) and the control group (C, without inoculation)—were cultivated separately for a period of 14 days under greenhouse conditions (with temperature of 29 °C; light intensity of 296 μmol; 99% humidity; and photoperiod of 12 h 7 m 17 s). Irrigation was performed using a water sprayer to minimize potential trauma to the growing seedlings (Doni et al. 2017). |
| Measurement of seedling growth | Root and shoot length measurements were conducted when the seedlings reached 14 days after planting, involving the random selection of 10 seedlings from each treatment groups. For shoot length (cm), measurements were taken from the base of the primary leaf to the base of the hypocotyl, while for root length (cm), measurements were made from the tip of the primary root to the base of the hypocotyl. The fresh weight and dry weight of the seedlings (g) were determined using a digital scale. Additionally, photographic documentation of the seedlings was captured using a camera (Fujifilm X-A5 with 15–45 mm lens) (Doni et al. 2014). |
| Measurement of seed germination percentage, vigor index, and germination speed | Germination refers to the mean ratio of seeds that undergo the process of sprouting within a specific duration. Germination parameters were assessed on the 14th day after sowing. The formula used to determine the germination percentage of seeds in each seedling tray is as follows (Li et al. 2022):  Germination (%) = × 100  The seed vigor index is calculated using the formula given by Abul-Baki and Anderson (1973), which is as follows:  Vigour index = Germination (%) × seedling length (shoot length + root length) (cm)  Germination speed is used to determine the speed at which seeds germinate. Seed germination speed was measured from the first day to the 14th day following the formula explained in Gupta (1993), which is as follows:  Germination speed = |
| Rice plant preparation and *Trichoderma* inoculation | Before transplanting, 14-day-old seedlings were taken out along with their roots, and the roots were inoculated with *Trichoderma* spp. by soaking it in the spore suspension (density of 107 spores/mL) for a duration of 10 minutes (Khadka and Uphoff, 2019). Control plants did not undergo *Trichoderma* inoculation. After that, the seedlings were cultivated in plastic pots under a controlled greenhouse environment to monitor the growth of the rice plants during the vegetative phase for a period of 60 days.This experiment utilized a completely randomized design with 31 treatments, consisting of 30 different isolates of *Trichoderma* and a control group without *Trichoderma* inoculation. The experiment was conducted with four replications. The planting medium composition was the same as in the previous experiment. The 2 kg of soil was put into a plastic pot with a diameter of 20 cm (Doni et al. 2014). |
| Measurement of rice growth | The growth parameters were measured at 60 days after planting. The measurement of plant height (cm) is taken from the plant's base to the apex of the highest leaf (Awala et al. 2021). The leaf count was immediately assessed for each treatment. In order to determine the fresh weight (g) of the rice plant, it is meticulously detached from the soil and thereafter measured using a digital scale. The dry weight (g) was determined by extracting the whole plant, dividing the roots and branches, enveloping it in paper, and subjecting it to a temperature of 65 °C in an oven for a duration of three days (Mishra et al. 2019). |
| Measurement of chlorophyll content | Chlorophyll content was measured 60 days after planting. Chlorophyll content was determined using a spectrophotometric method. A total of 0.1 g of leaves that had been cut ~2 mm was put into a test tube to which 20 mL of 80% acetone had been added. This mixture was homogenized with a vortex, then incubated for 48 hours in the dark condition. Chlorophyll *a* and chlorophyll *b* concentrations were analyzed using a spectrophotometer at wavelengths λ 663 nm and λ 645 nm. Chlorophyll *a* and *b*, calculated according to the equation below, are expressed as mg/g leaf fresh weight (Shibghatallah et al. 2013).  Cchl−*a* = 12,7 A663−2,69 A645  Cchl−*b*= 22,9 A645−4,68 A663 |
| Measurement of stomatal density | To obtain stomata imprints, a thin layer of transparent nail polish was applied to an area of ~5 cm2 from the adaxial side of the flag leaf and allowed to dry before being peeled off using transparent tape (Kusumi 2013). The stomata were then observed under a microscope with a magnification of 400x. The diameter (2r) of the field of view is measured using a micrometer. The area of the field of view is then calculated based on the formula: A = 3.14 × r2, where A is the area and r is the radius (Doni et al. 2017). Stomata density is calculated based on the following formula (Fanourakis et al. 2019):  Stomatal density (stomata/mm2) = |
| Plant growth promoting traits of *Trichoderma*: phosphatase activity | The activity of the phosphatase enzyme was assessed using the method developed by Tabatabai and Bremner (1969). The mineralization of phosphorus (P) was assessed in 100 mL Erlenmeyer flasks, each containing 40 mL of Czapek's Dox broth for each fungal culture. The flask contents underwent autoclaving, cooling, and subsequent inoculation with 0.1 mL of a spore suspension derived from a 5-day-old broth culture of the appropriate fungal strain, each done separately. Additionally, control samples that were subjected to autoclaving but not infected were added for comparison. The flasks were incubated at a temperature of 30 °C. After seven days of incubation, the contents of the flask were filtered using Whatman No. 42 filter paper. The filtrates were utilized to measure the activity of extracellular acid phosphatase. The quantification of extracellular acid phosphatase in the culture filtrate was performed by utilizing acetate buffer (pH 5.4), substrate, *p*-nitrophenyl phosphate (pNPP), and 0.5 mL of the culture filtrate. The reaction mixture was subjected to incubation at a temperature of 37 °C for a duration of one hour. Subsequently, acid phosphatase activity was measured spectrophotometrically by monitoring the release of para-nitrophenol from pNPP at a wavelength of 400 nm using a UV–vis spectrophotometer. |
| Plant growth promoting traits of *Trichoderma*: IAA production | *Trichoderma* isolates grown in potato dextrose broth (PDB) media with the addition of L-Tryptophan to determine the ability to produce IAA based on the modified method by Mehmood et al. (2018). *Trichoderma* spp. inoculated in 5 mL of PDB which had been added with L-tryptophan with a concentration of 500 µg/mL. *Trichoderma* was then incubated and homogenized with a shaker speed of 120 rpm for seven days in dark conditions at a temperature of 26°C. After seven days, *Trichoderma* centrifuged at 3000 rpm for three minutes. Following that, 1 mL of the resulting supernatant was transferred into a sterile test tube. The supernatant was added with 2 mL of Salkowski's reagent and incubated for 30 minutes in dark conditions. As a control (without *Trichoderma* inoculation), 1 mL of PDB medium was added with Salkowski's reagent. After incubation, positive results were obtained in the form of changes in color from pink to dark red and brownish in the mixture between the supernatant and Salkowski reagent, which indicates the potential for IAA production. Absorbance was measured using a UV-Vis spectrophotometer at a wavelength of 540 nm. The IAA concentration was calculated using the IAA standard curve (concentrations: 10, 25, 50, 100, 150, 200, 250, 300 µg/mL). |
| Plant growth promoting traits of *Trichoderma*: ammonia production | Ammonia production was conducted via the colorimetric method as described by Chen et al. (2022), with some modifications. *Trichoderma* was inoculated into 10 mL of peptone water. After incubation at 26 °C for seven days, the culture was centrifuged at 3500 rpm for 10 minutes. 1 mL of the supernatant was taken and then 1 mL of Nessler's reagent was added to the test tube which had previously been washed with ammonia-free water. The mixture was incubated at room temperature for 10 minutes then diluted with distilled water until the volume reached 10 mL. The color change to yellow indicates a positive result and the absorbance of the solution is measured using a UV-Vis spectrophotometer at a wavelength of 450 nm. The ammonia concentration was calculated using the ammonium sulfate standard curve (concentrations: 10, 15, 20, 25, 30, 35, 40 µg/mL). |
| Plant growth promoting traits of *Trichoderma*: HCN production | *Trichoderma* inoculated on PDB medium supplemented with 4.4 g L-1 glycine in a test tube. White filter paper was cut in strips and soaked in picric acid solution (0.5% picric acid in 2% (w/v) sodium carbonate). A sheet of filter paper is placed on the wall of the test tube. The media surface was sealed with parafilm and incubated for seven days at 26°C. After incubation, HCN production was observed by changing the color of the filter paper from yellow to light brown or reddish brown which indicated HCN production (Meera and Balabaskar 2012). The discolored filter paper was soaked in 10 mL of distilled water for 30 minutes. using a UV-Vis spectrophotometer by measuring absorbance at a wavelength of 510 nm. Quantitative measurement of HCN concentration was carried out by calculating the total cyanogen content using the following formula (Vijayan et al. 2015):  Total cyanide content(ppm) = 396 × absorbance at 510 nm |
| Molecular identification and phylogenetic analysis of the best *Trichoderma* isolates | Two high-performing *Trichoderma* isolates were selected for their significant impact on rice plant germination, growth, and physiological characteristics, underwent molecular identification. The genomic DNA extraction was conducted using the ZymoBIOMICS DNA Kit, followed by amplification of the internal transcribed spacer region (ITS) using universal primers ITS1 (5’-TCCGTAGGTGAACCTGCGG) and ITS4 (5’-TCCTCCGCTTATTGATATGC). Sequencing was performed by Saraswanti Genomics Institute in Bogor, Indonesia, and the nucleotide sequences were analyzed via BLAST on the NCBI site. The TM10 and SB8 isolates' sequences were deposited in the GenBank database, and *Trichoderma* identifications were verified with a minimum 99% sequence identity. Phylogenetic analysis was conducted using MEGA software version 11, aligning DNA sequences with reference *Trichoderma* sequences from GenBank. The neighbor-joining method generated the phylogenetic tree, and its topology was assessed through bootstrap analysis with 1000 replicates. |
| Statistical analysis | All data were analyzed statistically using one-way analysis of variance (ANOVA) methods. Mean separation was carried out for significantly different parameters using the Duncan’s Multiple Range Test (DMRT) at p ≤ 0.05. |

**Supplementary Table S2: Morphological characteristics of indigenous strains of *Trichoderma* isolated from West Java.**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Isolate Codes** | **Macroscopic characteristics** | | | | **Microscopic characteristics** | | | |
| **Colony colors** | **Colony patterns** | **Colony surfaces** | **Yellow pigmentation** | **Phialides** | **Conidial shapes** | **Branched conidiophore** | **Septate hyphae** |
| TM1 | White and dark green | Radiate | Powdery | No | Lageniform | Globose | Yes | Yes |
| TM2 | White and yellowish green | Radiate | Cottony | No | Lageniform | Obovoid | Yes | Yes |
| TM3 | White and dark green | Zonate | Cottony | No | Ampulliform | Globose | Yes | Yes |
| TM4 | Green | Radiate | Powdery | Yes | Ampulliform | Globose | Yes | Yes |
| TM5 | White and yellowish green | Zonate | Cottony | No | Ampulliform | Globose | Yes | Yes |
| TM6 | White and yellowish green | Zonate | Cottony | No | Ampulliform | Globose | Yes | Yes |
| TM7 | White and green | Zonate | Cottony | No | Ampulliform | Globose | Yes | Yes |
| TM8 | White and yellowish green | Zonate | Powdery | No | Ampulliform | Globose | Yes | Yes |
| TM9 | White and green | Zonate | Cottony | No | Ampulliform | Globose | Yes | Yes |
| TM10 | White and yellowish green | Zonate | Cottony | No | Ampulliform | Obovoid | Yes | Yes |
| TM11 | Green | Radiate | Powdery | Yes | Ampulliform | Globose | Yes | Yes |
| TM12 | White and dark green | Radiate | Powdery | No | Ampulliform | Obovoid | Yes | Yes |
| TM13 | White and green | Zonate | Cottony | No | Ampulliform | Globose | Yes | Yes |
| TM14 | White and green | Zonate | Cottony | No | Ampulliform | Globose | Yes | Yes |
| TM15 | White and green | Zonate | Cottony | No | Lageniform | Globose | Yes | Yes |
| SB1 | White and green | Zonate | Cottony | Yes | Ampulliform | Globose | Yes | Yes |
| SB2 | White and yellowish green | Zonate | Powdery | Yes | Ampulliform | Obovoid | Yes | Yes |
| SB3 | White and green | Zonate | Cottony | No | Ampulliform | Globose | Yes | Yes |
| SB4 | White and green | Zonate | Cottony | Yes | Ampulliform | Globose | Yes | Yes |
| SB5 | White and dark green | Radiate | Cottony | No | Lageniform | Globose | Yes | Yes |
| SB6 | White and yellowish green | Zonate | Powdery | Yes | Lageniform | Globose | Yes | Yes |
| SB7 | White and green | Zonate | Cottony | No | Ampulliform | Globose | Yes | Yes |
| SB8 | White and green | Zonate | Cottony | No | Ampulliform | Obovoid | Yes | Yes |
| SB9 | White and yellowish green | Zonate | Powdery | Yes | Ampulliform | Globose | Yes | Yes |
| SB10 | White and dark green | Radiate | Cottony | Yes | Lageniform | Globose | Yes | Yes |
| SB11 | White and yellowish green | Zonate | Powdery | Yes | Lageniform | Obovoid | Yes | Yes |
| SB12 | White and green | Zonate | Cottony | Yes | Ampulliform | Globose | Yes | Yes |
| SB13 | White and green | Zonate | Cottony | Yes | Ampulliform | Globose | Yes | Yes |
| SB14 | White and green | Zonate | Cottony | No | Lageniform | Globose | Yes | Yes |
| SB15 | White and green | Zonate | Cottony | Yes | Lageniform | Globose | Yes | Yes |

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