

Influence Of Trichoderma Harzianum Seed Treatment On Drought Tolerance In Corn

Narayan Gaikwad, Shikha Verma

Department of Life Science, Pacific Academy of Higher Education and Research University,
Udaipur, Rajasthan, 313001, India

Corresponding author: Mob. NO. 8790152225, E-mail address: gaikwadnp11@gmail.com

The drought tolerance capabilities of soil microorganisms have been acknowledged for years, yet their potential as crop inoculants in agriculture remains underexplored. This study investigates the effects of *Trichoderma harzianum* on the growth and development of corn (*Zea mays* L.) under drought stress conditions. We recorded biometric data on growth parameters, yield, and yield quality. The present experiment was conducted in pots under greenhouse conditions, incorporating four treatments and four replicates. Drought tolerance was assessed by measuring the maximum duration plants could endure drought after the last irrigation, from 15 days post-sowing until temporary physiological wilting or harvest. Results indicated that seed treatment with *Trichoderma harzianum* significantly enhanced drought tolerance, yielding improved vegetative growth and yield performance under soil moisture deficit stress. The maximum drought tolerance was observed in corn treated with *Trichoderma harzianum*, with an average water stress tolerance of 6.61 days, compared to 5.64 days for untreated seeds. Notable metrics included maximum cumulative mean chlorophyll content (41.88 SPADA units), leaf count (15.75 leaves/plant), leaf area (374 cm²), shoot length (161.5 cm), root length (42 cm), fresh weight (625 g), dry weight (130.18 g), cob length (21.25 cm), grains per cob (946), and yield per plant (166.50 g) under soil moisture deficit stress conditions with *Trichoderma harzianum* treatment. In contrast, the treatment with regular irrigation yielded slightly lower metrics. Overall, the use of *Trichoderma harzianum* as a seed treatment emerges as a simple, cost-effective, and eco-friendly approach for farmers, presenting a viable alternative to chemical pesticides and fertilizers.

Keywords: Seed treatment, *Trichoderma harzianum*, Drought tolerance, growth parameters, Corn.

1 INTRODUCTION:

Climate change is a pressing issue, with global warming and associated catastrophic climatic events becoming increasingly frequent. These changes impact global ecosystems, including agroecosystems, leading to significant hardships (Ebert and Engels, 2020). Consequently, plants face various stresses, both biotic (e.g., insect infestations and diseases) and abiotic (e.g., drought, extreme temperatures, salinity, heavy metals). Such abiotic stresses contribute to substantial reductions in crop yields worldwide (Khan et al., 2021).

Corn (*Zea mays* L.) is the world's third-largest source of plant-based food, following rice and wheat. Archaeological and molecular studies suggest that modern corn was derived from annual teosinte (*Zea mays* ssp. *parviglumis*) in southern Mexico around 9,000 years ago.

Originating in Mexico, corn spread north to the Southwestern United States and south along the coast to Peru. Around 1,000 years ago, Indigenous peoples migrating to the eastern woodlands of what is now North America brought corn with them. The introduction of hybrid corn in the early 1900s set the stage for increasing yields that continue to this day. Also known as maize, corn is a vital crop for a rapidly growing global population, with significant uses including livestock feed, fuel ethanol production, and as an ingredient in various foods and industrial products.

Naturally occurring beneficial soil microorganisms, particularly members of the genus *Trichoderma*, are being explored as accessible and sustainable tools for enhancing plant growth and mitigating both biotic and abiotic stressors in research and commercial production settings (Van Wees et al., 2008; Grover et al., 2011; Kim et al., 2012; Meena et al., 2017; Khadka and Miller, 2021). Certain commercial isolates of *Trichoderma* are extensively utilized as effective biocontrol agents, biofertilizers, and phyto-stimulators (Harman, 2011; Hermosa et al., 2012; Waghunde et al., 2016; Kashyap et al., 2017; Khan et al., 2017). However, evidence of their effectiveness in enhancing abiotic stress resistance in crop species remains limited. Recent studies indicate that inoculating water-stressed plants with *Trichoderma* can improve growth by increasing root biomass, enhancing water-holding capacity, and mobilizing nutrients (Mastouri et al., 2010; Harman, 2011; Bakhshandeh et al., 2020). Additionally, *Trichoderma*-inoculated plants demonstrate delayed wilting, increased leaf chlorophyll content, and higher net photosynthesis levels under water deficit conditions (Bae et al., 2009; Shukla et al., 2012; Alwhibi et al., 2017; Harman et al., 2019).

Trichoderma harzianum has been studied for its potential to enhance resistance to environmental stresses, including water soil moisture deficit stress. This research aims to evaluate the ability of this microbial species to alleviate soil moisture deficit stress for applications in sustainable agriculture. Our study focuses on screening *Trichoderma harzianum* for its effectiveness in mitigating soil moisture deficit stress through seed treatment in corn plants. In addition to assessing water stress tolerance, we will investigate the effects of this isolate on key plant growth parameters, such as shoot length, root length, and yield. These growth-promoting activities are indirectly linked to enhancing drought stress tolerance.

2 MATERIAL AND METHODS

The present experiment was conducted during the 2023-2024 post-rainy season at Umergaon village, District Valsad, Gujarat, India, within a fully automated greenhouse that ensured controlled climatic conditions. Throughout the experiments, uniform weather conditions were maintained inside the greenhouse. During the day, temperatures ranged from 28°C to 31°C, with relative humidity between 55% and 60%. At night, temperatures were kept between 18°C and 21°C, while relative humidity remained consistent within the same range. The plants received 12 hours of sunlight and 12 hours of darkness each day.

2.1 Sources of microbial strain and Seed

The high-yielding variety “P3546” from Pioneer Seeds Private Limited. The *Trichoderma harzianum* (WP)-61, marketed under the trade name “Neemoderma-H” by Shri Ram Solvent

Extract Extractions (P) Ltd., was employed for seed treatment. This formulation contains 1% w/w *Trichoderma harzianum* (with a CFU count of $2 \times 10^6/\text{g}$) along with 1.0% w/w carboxy methyl cellulose and 98.0% w/w talc powder.

2.2 Source of soil

The experimental soil is characterized by its black color and is dominated by montmorillonite clay, which has a high coefficient of swelling and shrinkage, leading to deep cracking during the summer. This soil, derived from basaltic material, is classified as Vertisol, specifically Typic Halplusterts, according to the 7th approximation, and is part of the Umergaon series. Surface soil (0-15 cm) was collected from a nearby farmer’s field in Umergaon, air-dried, and passed through a 2-mm sieve. Well-decomposed farmyard manure (FYM) was mixed with the collected surface soil in a 10:1 ratio. The soil and FYM mixture were then autoclaved at 15 PSI and 121°C for 60 minutes to sterilize it. The sterilized soil was uniformly filled into 12.5-inch plastic pots, with each pot containing 6.3 kg of sterilized soil. The pots were randomly arranged in the greenhouse, ensuring uniform spacing between them.

2.3 Seed treatment with *Trichoderma harzianum*

Corn seeds are surface sterilized with a 1% sodium hypochlorite solution for 3 minutes, then rinsed with sterilized water and dried. The dried seeds are primed by hydrating them with a thin film of water and placed in Petri dishes treated with 1 gram of *Trichoderma harzianum* per 30 seeds. Seeds soaked in distilled water serve as the control. Corn seeds are treated with *Trichoderma harzianum* according to the treatments outlined in Table 1.

Table 1. Treatment details of seed treatment

Treatment Number	Number of Replications	Treatment Details
T1	4	T. harzianum + Irrigated
T2	4	T. harzianum + Water Stress
T3	4	Untreated seed + Irrigated
T4	4	Untreated seed + Water Stress (Control)

2.4 Drought Stress Maintaining in Plants

All plants, including the controls, are regularly watered with 500 ml of water every alternate day from the date of sowing until the corn plants reach fifteen days of maturity without any soil moisture deficit stress. The plant population is maintained at one corn plant per pot. After fifteen days, when all seeds have germinated and the corn plants are well-established, regular watering i.e. one liter water at every fourth day was continued for the regular irrigated treatments. Watering were then stopped for the subsequent days until the plants reach the temporary physiological wilting stage due to drought exposure in soil moisture deficit stress treatment pots. Water is provided to the plants in the soil moisture deficit stress treatments, including the controls only after observing temporary wilting and leaf rolling symptoms, with

one liter of water applied using a measuring cylinder. This watering regimen continues from 15 days after sowing until the end of the experiment. Plants of an untreated seed under soil moisture deficit stress conditions serves as a reference for comparing the effects of *Trichoderma harzianum* on corn plants under soil moisture deficit stress.

2.5 Observations recorded

2.5.1 Chlorophyll content of leaves

Leaf greenness was assessed using a SPAD-502Plus chlorophyll meter (Konica Minolta™). The SPAD-502Plus is a compact, non-destructive device that measures chlorophyll content in nanometric SPAD units, ranging from 0 to 200. This tool offers a quick estimation of chlorophyll levels (Lah et al., 2011). Readings were taken at 10 a.m. to minimize the effects of leaf surface droplets and ensure consistency.

2.5.2 Number of Leaves

The total number of leaves per plant was recorded for each plant in all four replications at harvest

2.5.3 Leaf Area

Three leaves from the top, middle, and lower parts of each individual corn plant were selected for measuring leaf area. Leaf length and width were measured using a scale. The average of these three leaves was used to represent the leaf area of the respective plant. Leaf area was measured at harvest using the methods described below:

$$\text{Leaf area} = L \times W \times F$$

where L = Maximum length (cm); W = Maximum width (cm); F = Factor (0.75)

2.5.4 Shoot and Root Length

Shoot and root length for each plant was measured after harvesting. Plants were carefully pulled from the soil and roots were washed gently with running water to remove soil, then dried with blotting paper to eliminate surface moisture before measuring the shoot and root length.

2.5.5 Plant fresh weight

At harvest time, corn plants from each treatment were gently uprooted from the pots and carefully washed to remove soil from the roots using running water. The plants were then blotted with paper to remove surface moisture. Afterward, the shoots were cut at the soil line and separated from the roots. The fresh weights of the roots and shoots were measured using an electronic balance, accurate to three decimal places.

2.5.6 Plant dry weight

At harvesting stage corn plants from each treatment were carefully uprooted from the pots and washed to remove soil from the roots using running water. They were then blotted with paper to eliminate surface moisture. The plants were placed in brown envelopes and dried in an oven set to a low heat (100°F) overnight. After drying, the plants were allowed to cool in a dry environment. Subsequently, the shoots were cut at the soil line and separated from the roots. The dry weight of the shoots and roots was recorded separately for each plant.

2.5.7 Cob Length

Corn cobs were separated from the plants, and the husk and silk were gently removed. The cleaned cobs were then measured for length using a measuring scale after harvest.

2.3.8 Number of Grains per Cob

After harvesting the mature corn plants from each pot, the individual cobs were de-husked and dried for five days. Each cob was then threshed separately, and the number of grains in each cob was manually counted and recorded.

2.3.9 Yield

Each plant's mature cob was harvested and dried for five days. After drying, the cobs were threshed individually, and the weight of the grain was recorded using an electronic digital balance.

2.3.10 Drought Tolerance Capacity

Drought tolerance capacity was assessed starting 15 days after sowing, when soil moisture deficit stress conditions were initiated for the drought treatment groups. The capacity was evaluated by recording the maximum mean number of days plants could withstand drought conditions, from the last irrigation until the appearance of temporary physiological wilting. This assessment continued from 15 days after sowing until the harvesting stage or the end of the experiment.

2.4 Statistical Analysis:

The data from the pot culture experiment were analyzed using a completely randomized design. Statistical analysis was conducted and interpreted according to the methods outlined in Statistical Methods for Agricultural Workers by Panse and Sukhatme (1985). Standard errors (S.E.) and critical differences (C.D.) at a 5% significance level were calculated as needed and used for data interpretation. The present experiment data analysis was performed using Minitab software.

3 Result and Discussion

3.1 Number of leaves per plant

The data presented in Table 2 clearly indicate that *Trichoderma harzianum* significantly impacts the number of leaves in corn. The treatment T₂, which involved *Trichoderma harzianum*-treated seeds under soil moisture deficit stress conditions, produced the maximum

number of leaves (15.75 leaves/plant), significantly outperforming all other treatments. This was comparable to treatment T₁, which had 15 leaves/plant. In contrast, treatment T₄, consisting of untreated seeds under soil moisture deficit stress conditions, had the lowest count at 13.50 leaves/plant. Our findings align with those of Blaszczyk et al. (2014), who highlighted the essential role of *Trichoderma* species in the environment. These fungi utilize various mechanisms to colonize different ecological niches, positively influencing plant growth while providing protection against fungal and bacterial pathogens. They are employed in biological plant protection as biofungicides and in bioremediation. Similarly, Contreras-Cornejo et al. (2014) reported that *Trichoderma virens* and *Trichoderma atroviride* produce indole acetic acid (IAA) and other auxin-related substances, which are crucial for root development. They observed increased root tip growth in *Arabidopsis* plants inoculated with *Trichoderma* under normal conditions.

3.2 Leaf area

Treatment T₂, involving seed treatment with *Trichoderma harzianum*, recorded the highest leaf area at 374 cm² among all treatments. This was closely followed by treatment T₁, which had a leaf area of 373.50 cm². The minimum leaf area was observed in treatment T₄, with a measurement of 355.25 cm². Our findings are consistent with those of Zhang et al. (2018), who reported increased flower numbers, leaf counts, and leaf area in potato plants treated with *T. harzianum* compared to controls under *Fusarium oxysporum* stress. Similarly, previous research by Ommati and Zaker (2012) indicated that *T. harzianum* enhances nutrient uptake through modifications in host plant roots, resulting in increased leaf area, flower numbers, and ultimately, larger fruit size and higher yield.

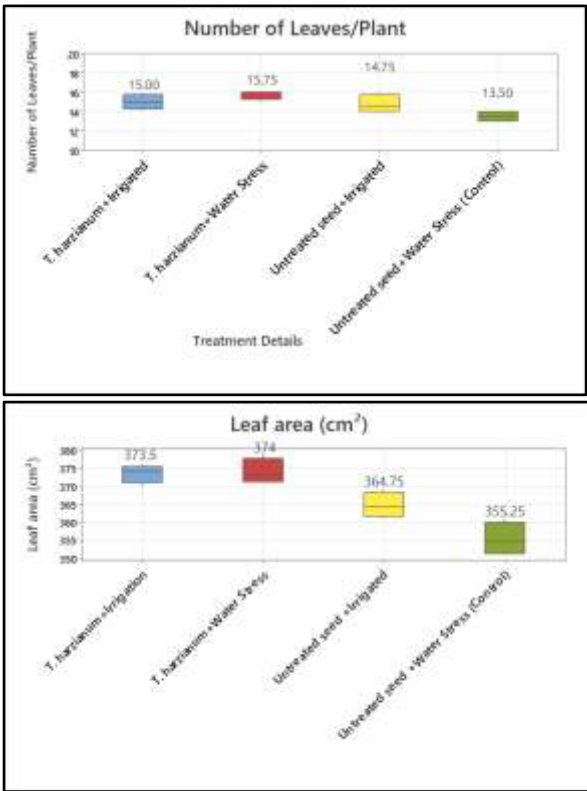


Fig 1. Effect of seed treatment with *Trichoderma harzianum* on number of leaves/plant

Fig 2. Effect of seed treatment with *Trichoderma harzianum* on leaf area

3.3 Shoot and Root length

We observed that treatment T₂, which involved seed treatment with *Trichoderma harzianum* under soil moisture deficit stress conditions, achieved a shoot length of 161 cm, significantly higher than all other treatments. This result was comparable to treatment T₁, which recorded a shoot length of 159.25 cm. In contrast, the least shoot length was noted in treatment T₄, at 131.75 cm. The results of this study align with those of Mukherjee et al. (2013), who reported that *Trichoderma* species provide several benefits to plant development, including increased leaf area, enhanced formation of secondary roots, greater shoot length, higher plant dry weight, and improved crop yield. Similarly, Maisuria and Patel (2009) found that *Trichoderma* seed treatment positively influenced seed germination, root and shoot length, and the vigor index in soybean.

Significantly higher root length was observed in treatment T₂, which involved seed treatment with *Trichoderma harzianum* under soil moisture deficit stress conditions, measuring 42.00 cm. This was followed by treatment T₁ with a root length of 40.25 cm and treatment T₃ at 37.75 cm. In contrast, treatment T₄ exhibited the smallest root length at 30 cm among all

treatments. Harman (2006) noted that while *Trichoderma* species are well-known biological agents for controlling fungal diseases, they also play a significant role in enhancing plant development and crop productivity. Similarly, Contreras-Cornejo et al. (2009) demonstrated that *Trichoderma* species improve drought avoidance mechanisms in plants by promoting root growth and altering root architecture, thereby increasing plant yield under water deficit conditions.

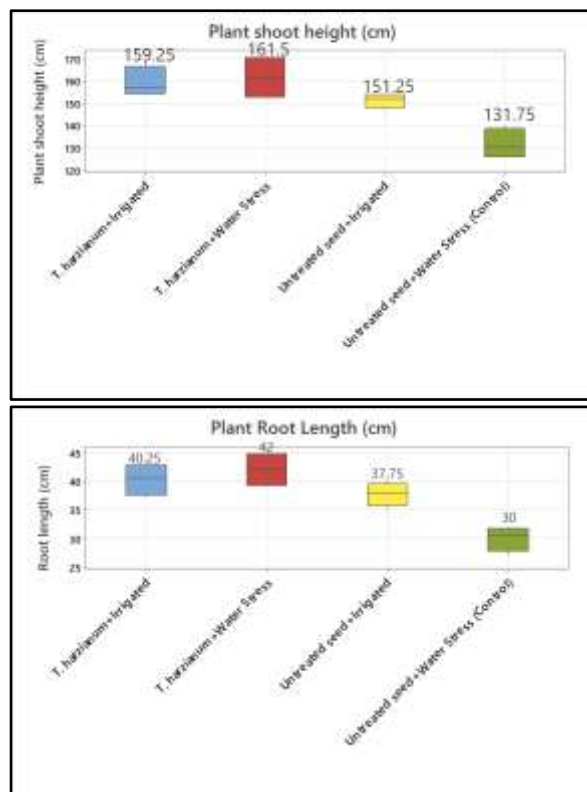


Fig 3. Effect of seed treatment with *Trichoderma harzianum* on plant shoot height

Fig 4. Effect of seed treatment with *Trichoderma harzianum* on Plant root length

3.4 Plant fresh weight

The highest fresh weight was recorded in treatment T₂, which involved seed treatment with *Trichoderma harzianum* under soil moisture deficit stress conditions, measuring 625 g. This treatment significantly outperformed all other treatments and was statistically similar to treatments T₁ and T₃. In contrast, the lowest fresh weight was observed in the uninoculated control group at 578.7 g. Our results align with the findings of Zhao et al. (2021), who reported that *Trichoderma harzianum* ST02 enhances survival rate, plant height, fresh weight, chlorophyll content, and net photosynthetic rate in tomato plants, even under 200 mM NaCl stress. Similarly, Shanmugaiah et al. (2009) observed significant increases in seed

germination, root length, shoot length, fresh weight, dry weight, and vigor index with treatments of *T. viride* and *P. fluorescens*.

3.5 Plant dry weight

At the harvesting stage, treatment T₂, which involved seed treatment with *Trichoderma harzianum* under soil moisture deficit stress conditions, achieved the highest plant dry weight of 130.18 g. This was significantly greater than that of the other treatments and comparable to treatment T₁, which recorded a dry weight of 127.31 g. In contrast, treatment T₄, the control, had the lowest plant dry weight at 114.71 g. Our results are consistent with those of Rabeendran et al. (2000), who evaluated *Trichoderma* isolates in a glasshouse experiment and found that *Trichoderma* treatments significantly increased leaf area (by 58-71%), shoot dry weight (by 91-102%), and root dry weight (by 100-158%) compared to untreated controls. Similarly, Metwally et al. (2020) demonstrated that *Trichoderma aviride* and Arbuscular Mycorrhizal Fungi (AMF) could enhance various morphological characteristics of onions, including leaf area, stem length, root length, pigment content, fresh weight, and dry weight.

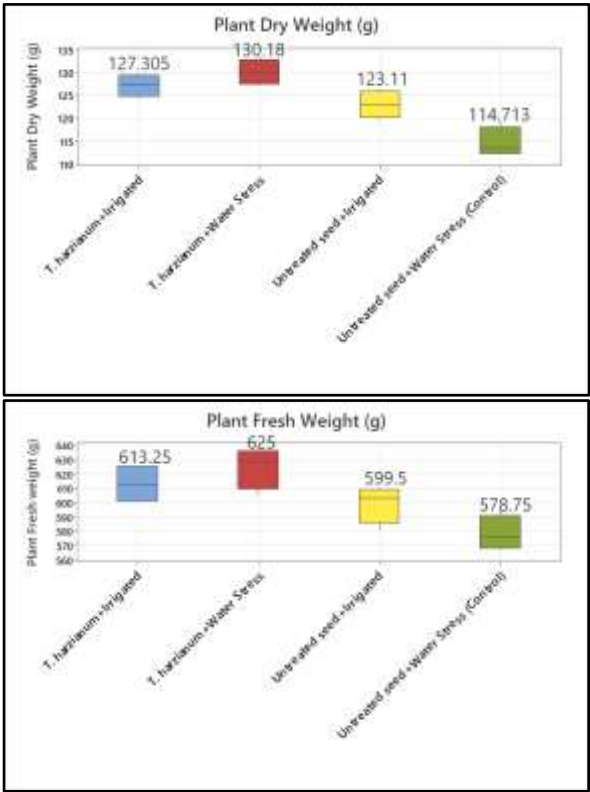


Fig 5. Effect of seed treatment with *Trichoderma harzianum* on plant fresh weight

Fig 6. Effect of seed treatment with *Trichoderma harzianum* on Plant dry weight

3.6 Cob length

The significantly highest cob length was observed in treatment T₂, which involved seed treatment with *Trichoderma harzianum* under soil moisture deficit stress conditions, measuring 21.25 cm. This was followed by treatment T₁, which also included *Trichoderma harzianum* but with regular irrigation, recording a cob length of 19.50 cm. Both treatments were comparable in size. In contrast, treatment T₄, which received untreated seeds under soil moisture deficit stress conditions, had the smallest cob length at 14.25 cm. The experimental data clearly demonstrate that seed treatment with the drought-tolerant microorganism *Trichoderma harzianum* positively impacts cob length in corn. Our findings align with those of Sharma et al. (2017), who reported that *Trichoderma* species enhance plant growth, improve fruit quality, and boost crop yields by producing phytohormones and increasing the availability of phosphates and other essential minerals. Similarly, Buysens et al. (2016) noted that *Trichoderma* species are used as biofertilizers to promote plant growth and increase crop yields, as they enhance plant development in the rhizosphere through the production of auxins and gibberellins.

3.7 Number of grains

Treatment T₂, which involved seed treatment with *Trichoderma harzianum* under soil moisture deficit stress conditions, yielded 946 grains per cob, significantly outperforming all other treatments. The pooled data also indicated that this treatment recorded an average of 931.25 grains per cob. In contrast, the untreated control under soil moisture deficit stress conditions had the lowest number of grains per cob, with counts of 657.50 in the second year and 602.50 in the pooled data. These findings clearly demonstrate the positive impact of *Trichoderma harzianum* seed treatment on corn grain production. Our results align with those of Erazo et al. (2020), who reported that *Trichoderma harzianum* enhances nutrient availability to plants, leading to increased crop yield. Additionally, Chang et al. (1986) observed that *Trichoderma* species are widely utilized in agriculture to improve plant growth through both disease control and yield enhancement.

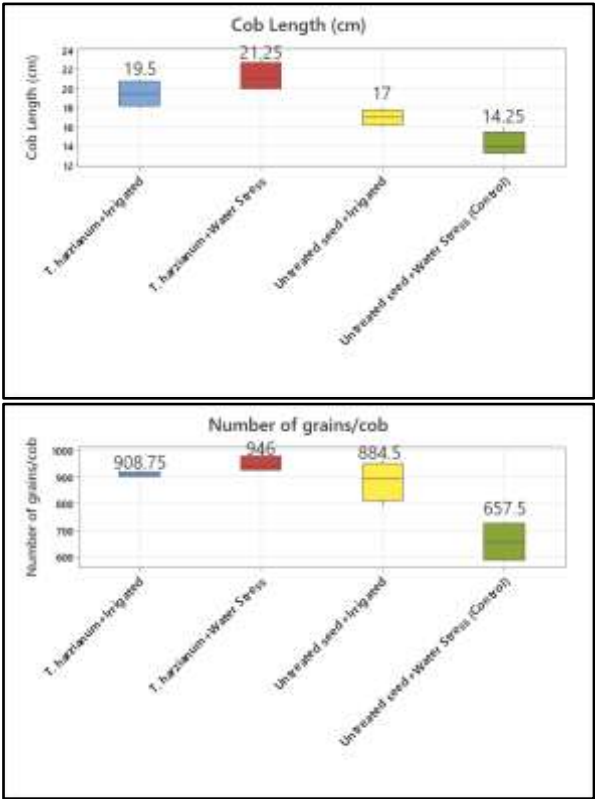


Fig 7. Effect of seed treatment with *Trichoderma harzianum* on cob length grains

Fig 8. Effect of seed treatment with *Trichoderma harzianum* on number of grains

3.8 Yield

Treatment T₂, which involved seed treatment with *Trichoderma harzianum* under soil moisture deficit stress conditions, achieved the highest grain yield of 166.50 g/plant, significantly outperforming all other treatments and demonstrating similar performance to treatment T₁, which had a yield of 163.25 g/plant. Conversely, the control treatment T₄, involving untreated seeds under soil moisture deficit stress conditions, recorded the lowest yield at 129.75 g/plant. These experimental results are consistent with findings by Scudeletti et al. (2021), who conducted field experiments on sugarcane and reported that *Trichoderma* spp. inoculation improved plant morphology and physiological factors under drought stress, leading to increased sugarcane yield. Similarly, Meng et al. (2019) found that *Trichoderma* spp. enhance drought avoidance mechanisms in various plants by promoting root growth and altering root architecture, which ultimately improves yield under water deficit conditions.

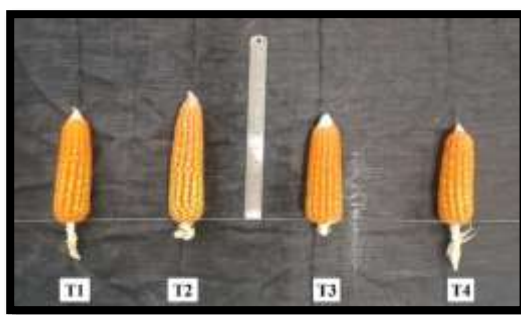


Plate 9: Corn plant root length at harvest

Plate 10: Corn plant cob length at harvest

3.9 Chlorophyll content in leaves

The impact of drought typically reduces chlorophyll content in plant leaves due to soil moisture deficit stress. However, at 60 days after sowing, we observed the maximum chlorophyll content in treatment T₂, which received *Trichoderma harzianum*-treated seeds under soil moisture deficit stress conditions, showing a 53% increase (41.88 SPAD units) compared to the control. Treatment T₁ also demonstrated a significant increase, with a 41% rise (38.54 SPAD units) over the control, which had an untreated seed with soil moisture deficit stress conditions and recorded 27.33 SPAD units of chlorophyll content. Our results align with the findings of Shukla et al. (2012), who noted that plants inoculated with *Trichoderma harzianum* exhibited delayed wilting, increased stomatal conductance, enhanced leaf chlorophyll content, and higher net photosynthesis levels under water deficit conditions. Additionally, Andrzejak and Janowska (2022) demonstrated that *Trichoderma* spp. stimulate shoot elongation and thickening, promote leaf formation, and accelerate flowering. These fungi positively influence chlorophyll and carotenoid content in leaves while enhancing the uptake of micro- and macro-elements.

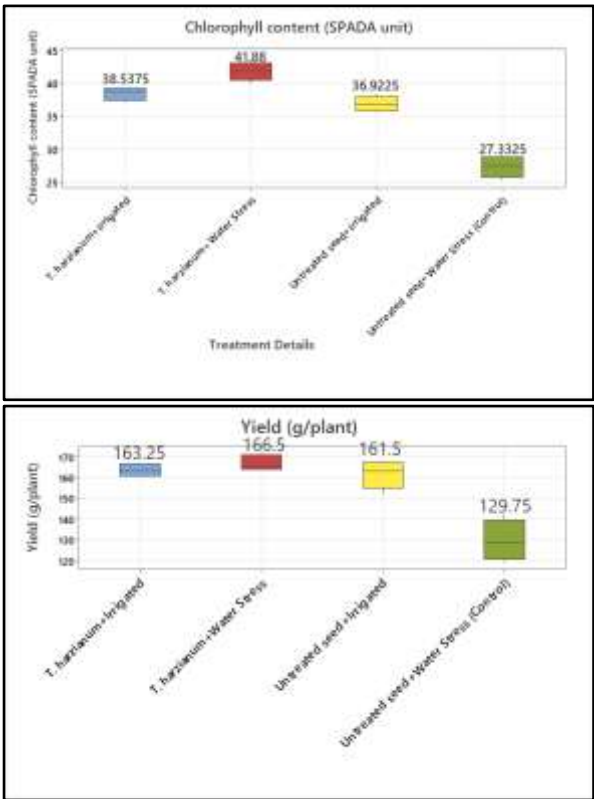


Fig 11. Effect of seed treatment with Trichoderma with harzianum on chlorophyll content yield

Fig 12. Effect of seed treatment Trichoderma harzianum on yield

3.10 Drought tolerance capacity

Treatment T₂, involving Trichoderma harzianum seed treatment under soil moisture deficit stress conditions, demonstrated the highest drought tolerance capacity at 6.61 days, representing a 17.15% increase over the control treatment, which had an untreated seed with a drought tolerance capacity of 5.64 days. In contrast, the regular irrigation treatments, T₁ and T₃, were irrigated at four-day intervals. These results align with the findings of Mayak et al. (2004) and Yildirim et al. (2006), which demonstrated that plant growth-promoting rhizobacteria (PGPR) can help shield plants from adverse environmental stresses, including drought, salinity, and heavy metals. Similarly, Bae et al. (2009) observed that Trichoderma hamatum improved drought tolerance in cocoa plants by enhancing root growth, thereby increasing water availability and delaying the onset of water deficit symptoms.

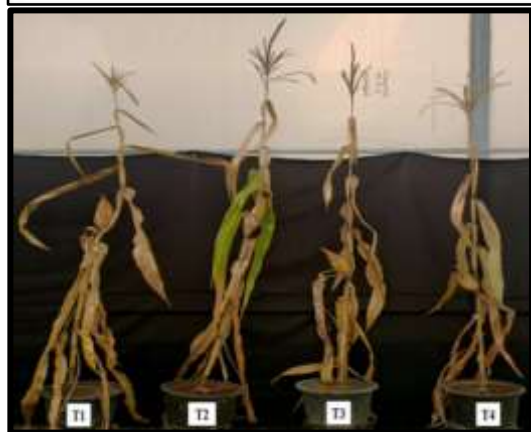
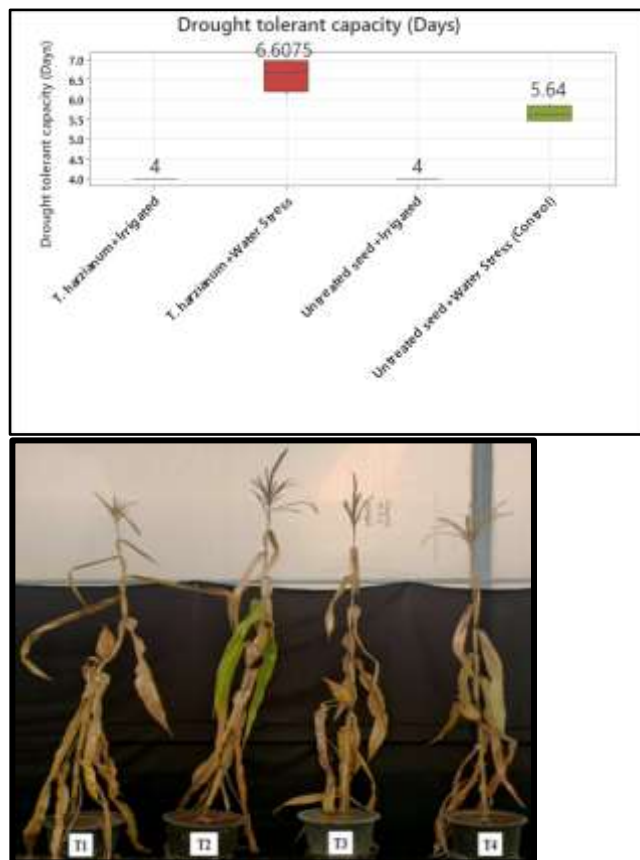


Fig 13. Effect of seed treatment with *Trichoderma*

Plate 14: Corn plant at harvesting stage *harzianum* on drought tolerance capacity

Table 2. Effect of *Trichoderma harzianum* on corn plant vegetative growth, yield and drought tolerance capacity.

T rt #	Treat ment Detail s	Chlor ophyll conten t (SPAD A units)	Nu mbe r of leav es (No.)	Sh oot hei ght (c m)	Ro ot len gth (c m)	Pla nt fres h wei ght (g)	Pla nt dry wei ght (g)	Le af are a (c m ²)	Co b len gth (c m)	Num ber of grain s/cob (Nos.)	Yie ld (g)	Dro ught toler ant capa city (Day s)
T 1	T. harzia	38.54	15.0 0	159 .25	40. 25	613 .25	127 .31	373 .50	19. 50	908.7 5	163 .25	4.00

	num +Irrig ated											
T 2	T. harzia num +Wat er Stress	41.88	15.7 5	161 .50	42. 00	625 .00	130 .18	374 .00	21. 25	946.0 0	166 .50	6.61
T 3	Untre ated seed +Irrig ated	36.92	14.7 5	151 .25	37. 75	599 .50	123 .11	364 .75	17. 00	884.5 0	161 .50	4.00
T 4	Untre ated seed +Wat er Stress (Contr ol)	27.33	13.5 0	132 .00	30. 00	578 .75	114 .71	355 .25	14. 25	657.5 0	129 .75	5.64
	S.Em. ±	0.66	0.39	3.6 9	1.3 2	6.8 7	1.4 5	1.4 7	0.3 9	27.01	3.2 4	0.10
	C.D. at 5 %	2.10	1.25	11. 81	4.2 1	21. 97	4.6 4	4.7 0	1.2 5	86.42	10. 38	0.32
	C.V. %	3.62	5.30	4.8 9	7.0 3	2.2 7	2.3 4	0.8 0	4.3 4	6.36	4.1 8	3.90

4 Conclusion

The performance of the drought-tolerant microbial isolate *Trichoderma harzianum* was evaluated in pot experiments with corn plants. It was concluded that *Trichoderma harzianum* seed treatment was the most effective for enhancing drought tolerance, as it significantly improved growth attributes, yield, and yield quality of corn under soil moisture deficit stress conditions. This was followed by *Trichoderma harzianum* seed treatment under regular irrigation conditions. Furthermore, the longest survival period under soil moisture deficit stress conditions was achieved with seed treatment using the drought-tolerant microbial isolate *Trichoderma harzianum*, compared to untreated seeds in corn plant.

5 Acknowledgement

The author wishes to thank the Department of Life Science, Pacific Academy of Higher Education and Research University, Udaipur, Rajasthan, 313001, India

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