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Mechanisms and Applications of Fungal Plant Growth Promoters for Increased Crop Yields

Shashank Tiwari

Abstract

The soil fungus known as Trichoderma longibrachiatum may be found in almost every warm environment. Wheat growth promotion and induction of plant resistance to parasitic nematodes have both been attributed to the plant-growth boosting fungus Trichoderma longibrachiatum T6, however whether or not T6 may also increase plant tolerance to salt stress is uncertain. Reduced agricultural output is a global concern caused by soil salinity. It is uncertain, however, whether the plant-growth stimulating fungus Trichoderma longibrachiatum T6 (T6) can improve plant tolerance to salt stress, despite evidence that it stimulates wheat growth and induces resistance to parasitic nematodes.Wheat seedlings' physiological, biochemical, and molecular responses to NaCl stress were studied, along with the impact of the plant-growth-promoting fungus T6 on these responses.The nitrogen needs of legumes are mostly satisfied by symbiotic nitrogen fixation, which also has some positive effects on subsequent crops in the system by enriching the soil. The United Nations designated 2016 as the "International Year of pulses" to draw attention to the crop's environmental benefits and boost its production. Extreme yield losses occur regularly in grain legumes due to abiotic and biotic stressors. Despite widespread use of conventional and molecular breeding techniques during the last five decades, global yields of legumes have remained mostly unchanged. Use of biological solutions for crop production and protection is essential due to the rising prices and bad effects of pesticides and fertilizers. One promising approach to creating environmentally friendly, low-cost, and resource-conserving agricultural systems is to employ the plant growth-promoting (PGP) fungus T6 to boost soil and plant health.

Key wordsPlant growth promotion mechanism and use of Trichoderma longibrachiatum T6

Introduction:

Microorganisms have emerged that can serve the same function as fertilizers, or perhaps perform a better job, bringing closer to reality the goal of eliminating the usage of fertilizers, which are often ecologically dangerous. Some of the negative impacts of these chemical fertilizers include the depletion of soil nutrients due to leaking into the rivers and the pollution it causes.in search of acceptable substitutes. This leads us to the concept of creating biological fertilizers (bio fertilizers) from bacteria. Being natural, living entities, they pose no threat to the surrounding ecosystem.They are less costly than chemical fertilizers in underdeveloped nations and boost agricultural productivity and output. Some fungi, in addition to PGPB, have been shown to stimulate growth in plants. Some bio fertilizers not only boost crop production but also protect plants from a wide range of diseases

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Department Biological Science,Kadapa,A.P

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The widespread use of bio fertilizers, as opposed to chemically manufactured fertilizers, is considerably more likely to bring about the desired global sustainable agriculture. To achieve this goal, however, a detailed understanding of the different processes used by PGPF is necessary so that workers may fully harness the potentials of these bacteria. This article reviews where our understanding currently stands with regards to the core processes used by PGPF. As environmental deterioration and human population pressure rise over the globe, it's possible that food production could soon fall short of meeting the needs of everyone who needs it. As a result, boosting agricultural output dramatically during the next several decades is crucial. As a result, the agricultural industry is shifting toward methods that are less taxing on the environment. Both transgenic plants and fungus that stimulates plant growth are becoming commonplace in commercial agriculture. Several of the processes that beneficial fungi use to stimulate plant development are discussed here. It is hoped that the use of pesticides in farming, gardening, forestry, and environmental cleaning would be phased out in favor of plant growth-promoting fungus (PGPF) in the not-too-distant future. Some of the approaches presented here show considerable potential, but it's possible that no single approach can boost plant growth in every situation.

Fungus of the genus Trichoderma, specifically Trichoderma longibrachiatum. T. longibrachiatum is not only one of 21 diverse species in the genus Trichoderma, but it also serves as a paradigmatic representative of one of numerous clades within the genus [1]. A soil fungus known as Trichoderma longibrachiatum, it is widespread in warmer regions of the globe [1]. Due to their capacity to release enormous quantities of protein and metabolites, several species from this clade have been utilized inmany sectors.Trichoderma longibrachiatum, a globally distributed filamentous fungus, is the genetically unique agamospecies of the Longibrachiatum group.of the teleomorph Hypocrea genus, order, and family (Dikarya) fungus Trichoderma. Isolated Trichoderma communities often include T. longibrachiatum since it is found in a wide variety of settings, including soil, mushrooms and food-rotting fungus, marine and soil animals, and decaying wood. Indoor conditions with water damage or green mold in mushroom farms seem to be prime breeding grounds. Therefore, T. longibrachiatum has also been found in the sputum and sinuses of otherwise healthy persons. Importantly, it's the only Trichoderma spp. known to infect immunocompromised people, together with the closely related Hypocrea orientalis. This species was demonstrated to effectively manage soil populations of plant-pathogenic nematodes.

Similar to the teleomorph Hypocrea jecorina, T. longibrachiatum has been exploited as a source for the synthesis of enzymes that break down plant material. Notably, between 1984 and 1996, it was misidentified as T. reesei, and to this day, various cellulase preparations derived from T. reesei are offered under the name "T. longibrachiatum." The sequencing of its genome and subsequent comparison with those of other Trichoderma species is thus anticipated to provide insight into the evolutionary transition from environmental opportunist to opportunistic human pathogen, and to supplement the genetic resources for industrial enzyme production.

Reduced agricultural output is a global concern caused by soil salinity. While it is known that the plant-growth boosting fungus Trichoderma longibrachiatum T6 (T6) increases wheat yield and increases plant resistance to parasitic nematodes, whether or not T6 increases plant tolerance to salt stress is less clear. Inoculated wheat seedlings were compared to controls that had not been exposed to the T6 strain. Wheat seedlings were evaluated for their height, root length, and shoot and root weights after 15 days of growth in either 150 mM NaCl or a NaCl-free

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environment. A figure of colonies were re-isolated from the roots of wheat seedlings under salt stress. The relative water content in the leaves and roots, chlorophyll content, and root activity were significantly increased, and the accumulation of proline content in leaves was markedly accelerated with the plant growth parameters, but the content of leaf malondialdehyde under saline condition was significantly decreased. The antioxidant enzymes- superoxide dismutase (SOD), peroxidase (POD), and catalase (CAT) in wheat seedlings were increased by 29, 39, and 19%, respectively, with the application of the strainof T6 under salt stress; the relative expression of SOD, POD, and CAT genes in these wheat seedlings were significantly up-regulated. The possible mechanisms by which T6 suppresses the negative effect of NaCl stress on wheat seedling growth may be due to the improvement of the antioxidative defense system and gene expression in the stressed wheat plants.

Phosphorus is abundant in soils in both organic and inorganic forms; nevertheless, it is unavailable to plants. Accordingly, soil becomes phosphorus (P)-deficient, making P one of the most important nutrient elements limiting crop productivity. To circumvent the P deficiency, phosphate-solubilising microorganisms could play an important role in making P available for plants by dissolving insoluble P. The dissolution of inorganic P by microbial communities including fungi is though common under *in vitro* conditions; the performance of phosphate-solubilising microbes *in situ* has been contradictory. Fungi exhibit traits such as mineral solubilisation, biological control, and production of secondary metabolites. As such, their potential to enhance plant growth when present in association with the roots is clear. The challenge is how to make use of such biological resources to maintain soil health while increasing the crop productivity by providing P to plants through the application of phosphate-solubilising fungi. The present review focuses on the mechanisms of phosphate solubilisation, development and mode of fungal inoculants application and mechanisms of growth promotion by phosphate-solubilising fungi for crop productivity under a wide range of agro- ecosystems, and the understanding and management of P nutrition of plants through theapplication of phosphate-solubilising fungi will be addressed and discussed.

Salt stress is one of the major abiotic stresses that affect plant growth, development, and crop yield [2, 3]. Wheat (Triticum aestivum), the most important cereal crop in the world, is considered to be salt sensitive [4]. Grown under salt conditions, wheat plants often produce a significantly low grain yield with poor quality. Studies have shown that salt stress can induce several morphological, physiological, and metabolic responses of plants, which causes ROS stress and osmotic stress in plants, leading to increased peroxidation of lipid and antioxidant enzyme inactivation [5]. Also, plants grown under salt stress conditions usually synthesize several kinds of soluble compounds including soluble sugars and proteins, which may help adjust osmoticum, retain cell turgor, and stabilize cell structures [6].

At the present time, about 6% of the arable land on the earth is salt affected, especially in arid and semiarid regions [7]. This seriously threatens global agricultural sustainability and food security. Thus, it is critically important to develop effective and practical techniques to alleviate the negative effects of salt stress on plant growth and development. Conventional breeding and transgenic technology have been used to develop new cultivars with improved salt tolerant traits, but breeding salt tolerance has not been successful [8]. The long breeding cycle and low breeding efficiency for the quantitative trait presents challenges. Transgenic technology has the ability to incorporate salt tolerant genes in new plant materials [9, 10, 11], but the effectiveness has been low and also enveloped in controversy [12]. Furthermore, gene loss, high cost, and other regulatory issues are the main bottlenecks for commercial transgenic plants use [13]. A newer attempt is to apply exogenous compounds to

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decrease the negative effect of abiotic stress; this technique has been shown to increase plant tolerance to salt stress, such as using oligochitosan [2], nitric oxide and calcium nitrate [4], chit oligosaccharides [12], and jasmonic acid [14] in wheat, as well as gibberllic acid and calcium chloride in linseed [15], and ascorbic acid in broad bean. These exogenous compounds have been shown to improve the salt tolerance of plants, butexact physiological mechanisms are unknown. A new, innovative technique that has attracted a great deal of attention in recent years is to use plant-growth-promoting bacteria and fungi to induce plant resistance to abiotic stress. It is an effective approach for enhancing planttolerance to salt stress and this approach may playa role in the development of sustainable agricultural systems. *Trichoderma spp.* is one of the important groups of rhizosphere microorganisms, which can impart some beneficial effects on promoting plant growth and development [16, 17]. The Trichoderma species have also been known to be used by plants as biological control agents for controlling different species of plant fungus diseases for decades [16]. [18] have reported that Trichoderma afroharzianum T22 can enhance tomato (Solanum lycopersicum) seedgermination under biotic and abiotic stresses, alleviating oxidative damage in osmotic stressedseedlings. However, the underlying mechanisms responsible for the alleviation of oxidative damage remain to be explored. Little information is available regarding the potential and possible mechanisms of plant-growth-promoting fungi T6 in enhancing the tolerance of wheat to salt stress.

Trichoderma sp. is useful in industry because of their high capacity to secrete large amounts of protein and metabolites. It has been suggested that Trichoderma longibrachiatum could be used as a biocontrol agent for its parasitic and lethal effects on the cysts of the nematode Heterodera avenae. [19] Because *T. longibrachiatum* is a mycoparasite, it has also been investigated for use in combating fungal diseases on agricultural crops. [20] Its enzymatic capacity could potentially be useful in bioremediation, for use in remediation of polycyclic aromatic hydrocarbons (PAHs) and heavy metals. [21] Other industrial uses include using the various cellulases for staining fabrics in the textile industry, increasing digestibility of poultry feed, and potentially in the generation of biofuels. [22] *Trichoderma longibrachiatum* has also been reported in promoting plant growth by increasing nutrient uptake, inhibiting the growth of plant parasites, increasing carbohydrate metabolism, and phytohormone synthesis.

The high level of salinity is one of the major environmental stress factors that cause biochemical alterations in plants, limits plantgrowth, and decreases plant productivity [23, 24]. *Trichoderma* species are one of the most versatile opportunistic plant symbionts which can colonize plant roots [25]. These symbionts are well- known for their remarkable interactions with host plants and their ability to induce broad-spectrum resistance to plant pathogens [16, 26, and 27]. Although, the plant-growth-promoting capability of *Trichoderma* spp. has been previously reported, there is little information concerning plants' systemic responses induced by T6 under salt stress conditions.

[28] Reported that host roots colonized by *Trichoderma* strains enhanced whole-plant tolerance to biotic and abiotic stresses. The enhancement was indicated by increased plants root growth and nutritional status [29], and induced systemic resistance to diseases [16]. In the present study, we found that T6 has a great ability to colonize the roots of wheat seedlings under salt stress, which significantly improved wheat seedlings growth and development under salt stress. The cacao (*Theobroma cacao*) seedlings which were colonized by *Trichoderma hamatum* isolate DIS 219b enhanced seedlinggrowth and development. In a similar study,

[30] found that the plant saplings grown with *T. afroharzianum* T22 produced more biomass than non-inoculated controls in metal contaminated

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soil. Our findings are supported by a number of previous observations where *Trichoderma* spp. has the ability to colonize plant roots, establish symbiotic relationships with a wide range of host plants, and promote plant growth and development [28,31]. Moreover, similar results were reported that *Trichoderma parareesei* increased the tomato lateral root development and growth promotion under salt stress conditions [32].

Plant roots are critical for plant growth and development which is attributed to their function and importance in absorption of nutrients and water from soil [33].

The content of proline was increased in wheat seedling grown with NaCl alone, compared to the control. The previous research indicated that the increased level of proline in plants under salt stress condition may have been due to the activation of proline biosynthesis which enhances protein turnover [15]. Proline is an important nitrogen source that is available for plant recovery

from environmental stress and restoration of growth [34], and it can act as an osmolyte that reduces the osmotic potential of the cell and the uptake of toxic ions [35]. Thus, proline plays a predominant role in protecting plants from osmotic stress [15]. Alleviating effects of oligochitosan on salt stress-induced oxidative damage in wheat leaves might be related to its regulation roles in proline levels. The content of MDA significantly increased in NaCl-stressed wheat seedlings in comparison to the control plants, which is consistent with the findings of [36] in wheat. Thereafter, the content of MDA significantly decreased after wheat seeds were soaked in the suspension of T6 before NaCl stress. Taken together, our results are consistent with data from [37], who demonstrated that wheat seed biopriming with salinity-tolerant isolates of *T. harzianum* Th-14, Th-19, and Th-13 reduced the accumulation of MDA content, whereas, it increased the proline content in wheat seedlings under both salt and non-saline conditions.

It is widely accepted that osmosis molecules, including soluble sugars and proteins, are important indicators in response to abiotic stress [38]. The increased accumulation of glucose and sucrose in plants usually indicates a highly protective mechanism against oxidative damage caused by high salinity in the plant environment [6, 39]. However, most previous studies determined the physiologic role of soluble sugars and utilization by plants.

In plants, the overproduction of ROS is considered a biochemical change under salt stress [40], which is the most important factor responsible for NaCl-induced damage to macromolecules and plants cellular structures [41]. To alleviate the damage associated with the overproduction of ROS, plants have naturally developed a wide range of enzymatic defense mechanisms to detoxify free radicals and thereby help protect themselves from destructive oxidative damage [42, 43]. One of the important protective mechanisms in plants is the enzymatic antioxidant system, which involves the simultaneous action of a number of enzymes including SOD, POD, and CAT [2]. The findings from the present study demonstrate that NaCl stress induced plants produce a higher level of SOD, POD, and CAT activity in wheat seedlings than the control samples. However, the In agreement with the results of [44], who showed that the function of T. harzianum in Indian mustard (Brassica juncea) was to ameliorate NaCl stress by an antioxidative defense mechanism, T6 usage boosted SOD, POD, and CAT activity in wheat seedlings independent of salt content.

It has been shown that the plant-beneficial fungus Trichoderma may significantly alter the expression of certain genes in response to biotic and abiotic stressors [18]. Stressed plants have been shown to have elevated SOD activity, which may be due to an increase in the expression of genes that code for SOD activity [45, 46]. The expression of gene families involved in plant defense against abiotic stressors is upregulated in plants treated with Trichoderma spp., according to a number of prior research [47, 48]. However, there have been no

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comprehensive analyses of the effects of the plant-growth-promoting fungus T6 on the expression of individual genes in wheat seedlings. This involvement of ROS in detoxifying cellular survival and regulating plant acclimation was supported by the activities of ROS-scavenging enzymes in T6-challenged wheat plants [49]. Furthermore, ROS functioned as an important signaling molecule in cellular expansion and maintenance. There have been similar reports indicating increased ROS generation in plants is the consequence of salt, one of the environmental conditions that might alter the normal homeostasis of plant cells. The reactive oxygen species (ROS) molecule plays a crucial role in signaling transduction molecules in response to salt stress [49].

Since grain legumes contain protein, minerals, and other beneficial compounds, they serve as an important element in both diet and feed. Global grain legume intake grew as nutritional knowledge rose [50]. Increased revenue generation and livelihood resilience for small holder farmers may result from greater adaption of these plants as inter-crops with cereals or tuber crops. However, the production level of such leguminous crops is limited by a number of factors, including assaults by pests and pathogens, infertile soils, and changes to the climate. Breeding and molecular approaches have led to the development of superior cultivars. been implemented, yet productivity has not changed in over two decades. As a result of these factors, the United Nations General Assembly has declared 2016 the "International Year of Pulses" in order to bring attention to the importance of pulses in ensuring global food and nutritional security and to raise public awareness of the difficulties inherent to the cultivation and distribution of pulses. Therefore, the focus of this study is on the PGP properties of T6 and the extent to which it has been researched for purposes such as promoting growth, controlling pests and pathogens, buffering the effects of abiotic stress, and improving phytoremediation and biofortification.

Conclusion

In conclusion, the T6 strain of plant-growth-promoting fungus has a significant impact in mitigating the negative consequences of salt stress on the development and growth of wheat seedlings. We used a battery of assays to investigate the potential physiological and molecular processes by which T6 mitigates the suppressive impact of salt stress. Wheat seedlings may be able to withstand salt stress because (i) T6 boosts the activity of the antioxidative defense system and (ii) T6 increases the relative amounts of antioxidant gene expression in stressed plants. The effectiveness of the T6 strain of plant-growth-promoting fungus in interactions with other plant species and other abiotic stressors is a topic that needs to be investigated further. Additional research may be required to identify the T6 signaling molecule responsible for the systemic alterations in antioxidant enzyme and gene expression. understanding of molecular mechanisms behind their action and evaluation at field levels are necessary.

The world that can support only a limited number of people. Unless new sustainable agricultural approaches and technologies are soon developed, food availability in the next 50 years approximately might be a great challenge for the growing population. To address this problem, one of the approaches that might be undertaken is the more widespread use of PGPB, initially in addition to, and possibly eventually instead of, the current use of agricultural chemicals.

The last 30–40 years have seen researchers developed an exhaustive, precise understanding of how PGPF facilitate plants growth so that the more widespread application of these organisms has now become feasible. The latter using bacteriophages in biocontrol while the former shows the activities of PGPF in reduction of stress. However, in order to make this approach a worldwide reality, a number of steps must be undertaken. (1) New and improved techniques for the large-scale growth, storage, shipping, formulation and application of plant growth-promoting bacteria need to be developed. (2) Reasonable, safe, efficacious and consistent

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regulations for the use PGPF need to be developed in all countries of the world so that the technology may readily be transferred from one country to another. Also, unnecessary regulatory hurdles need to be kept to a minimum. (3) Broadly-based campaigns of public education regarding the nature of PGPF need to be initiated so that the public comes to understand that these bacteria are not sources of disease but are natural products playing a positive role. (4) Following additional fundamental work to better understand PGPF and their biochemistry, genetics and physiology, scientists, laymen and regulators need to accept that "optimal" PGPF strains may require some genetic manipulation and that the use of such genetically manipulated strains will not present any new hazards or risks to humans or the environment. (5) It is likely that different crops and varying situations will necessitate the use of PGPF that are either rhizospheric or endophytic. It will be necessary to delineate those situations where either rhizospheric or endophytic PGPF strains are most appropriate so that the mostPlant and PGPF combinations are always successful. The relationship between plants and mychorrhizae improves the development of more than 90% of agricultural plants, thus it's important to learn more about how PGPF work together to maximize plant growth. (7) To prevent a small number of corporations from amassing control over crucial innovations, as much of this technology as feasible should remain in the public domain.

While much more fundamental and practical research has to be conducted, PGPF has been successfully implemented on a modest scale in a number of nations. There is every reason to believe that agricultural practice globally may become both sustainable and highly effective if scientists and the agencies funding their studies put their efforts toward tackling the aforementioned and related concerns.

References

Samuels, Gary J.; Ismaiel, Adnan; Mulaw, Temesgen B.; Szakacs, George; Druzhinina, Irina S.; Kubicek, Christian P.; Jaklitsch, Walter M. *"The Longibrachiatum Clade of Trichoderma: a revision with new species"*. Fungal Diversity; 2012; 55(1): 77–108.

Ma, L. J., Li, Y. Y., Yu, C. M., Wang, Y.,

Li, X. M., Li, N. Alleviation of exogenous oligochitosan on wheat seedlings growth under salt stress. Protoplasma; 2012; 249,

393–399.

Rivero, R. M., Mestre, T. C., Mittler, R., Rubio, F., Sanchez, F. G., and Martinez,

V. The combined effect of salinity and heat reveals a specific physiological, bio- chemical and molecular response in tomato plants. Plant Cell Environ; 2014; 37, 1059–1073.

Tian, X. Y., He, M. R., Wang, Z. L.,

Zhang, J. W., Song, Y. L., He, Z. L.

Application of nitric oxide and calcium nitrate enhances tolerance of wheat seedlings to salt stress. Plant Growth Regul; 2015; 77, 343–356.

Garg, N., and Manchanda, G. ROS gene ration in plants: boon or bane? Plant Biosyst; 2009; 143, 81–96.

International Journal of Life Sciences Biotechnology Pharma Sciences