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Reviewing *Trichoderma* Species as Most Potent Fungal Partner in Biocontrol of Plant Pathogen by in Vitro and Field Studies: A Special Reference to Collar Rot of Chickpea

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ABSTRACT:

Chickpea (Cicer arietinum L.) is an important legume crop of rabi season in arid and semi-arid regions of Indian subcontinent and other parts of world. The pathogen Sclerotium rolfsii is the prime cause of collar rot of chickpea. It is more prevalent in all major growing area of chickpea and lead to significant loss of chickpea production. Trichoderma spp. Is widely authenticated biocontrol agent against collar rot causing pathogen Sclerotium rolfsii. The use of Trichoderma spp. attracts consideration of researchers to discover more and more prominent species and strains of Trichoderma. Their volatile and non-volatile constituents are also reviewed in this review. Trichoderma recompense to the control of collar rot in order to be relevant eco-friendly fungus to control collar rot.

INTRODUCTION:

The need for food is rising as a result of the world's growing population. However, the implementation of plant protections and agronomic practices determines a great deal of what happens in terms of food production success or failure. It is believed that between 25 % and 30% of production losses are caused by biotic and abiotic stresses (Abdul-Kader, 2019).

Abiotic and biotic stresses substantially reduce overall production and productivity and seriously jeopardize global food security. In contrast to phytopathogens, insects, and weeds, which are examples of biotic stresses, abiotic stressors include things like temperature, precipitation, wind, soil nutrients, and water availability. Crops are significantly impacted by these field-based stresses. In addition to decreasing agricultural productivity and efficiency, abiotic stresses also make plant disease more common. Harvest levels will need to be raised by a factor of two in order to meet the anticipated increase in food demand until 2050.

Reduce agricultural losses caused by biotic and abiotic factors hence has to happen immediately. To protect crops from a variety of plant diseases, chemical pesticides are frequently employed in conventional agriculture. More than 95% of the world's pesticide market is now made up of chemical pesticides, which also stop a 50% loss in agricultural productivity. In agriculture, a wide range of chemicals are used to reduce the harmful effects of biotic and abiotic stresses, with a focus on vegetable production. Although it has been demonstrated over the last few decades that the use of chemical pesticides reduces crop loss, concerns regarding the possibly adverse consequences of synthetic agrochemicals are becoming more widespread internationally (Abdel-Kareem, 2018).

Draw attention to the many vitamins, amino acids, and carbohydrates that veggies offer and how important they are to a human diet. Approximately 15% of the world's vegetable crop is produced in India, making it the second most productive country behind China. Even while these agrochemicals help farmers grow more

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vegetables, they build up in the plant and may eventually cause health problems for consumers. The adverse effects of chemical treatments extend to soil health, microbial diversity, and ultimately soil pollution. Concerns about the environment and public health are being raised globally by the ongoing use of these pesticides, thus it is imperative that we move to a safer alternative approach for treating plant diseases.

Chickpea (*Cicer arietinum* L.) is a vital leguminous crop that is produced all over the world because of its nutritional value and economic significance. But a number of biotic and abiotic stresses constantly pose a threat to it. The most harmful one is collar rot, which is brought on by the soil borne fungus *Sclerotium rolfsii*. Collar rot weakens the roots of the chickpea plant, causing it to wilt, develop more slowly, and yield far less than usual. In the past, collar rot has been effectively controlled with chemical fungicides; however, this approach has been criticized for posing risks to human health, the environment, and pathogen resistance. Therefore, there is a pressing need for research on long-term, ecologically friendly methods of preventing collar rot in chickpeas (M. Srivastava, 2020).

Host, Disease, Pathogen and Antagonist:

As the world's population grows, more crops must be produced. Chickpeas will definitely be in high demand because of their high protein content. The major disease known as "chickpea collar rot" affects chickpeas and is mostly brought on by biotic and abiotic stress. It results in large losses in terms of quantity and quality. We try to provide a summary of studies done in India and abroad on the "Biocontrol potential of *Trichoderma* species for the management of collar rot of chickpea caused by *Sclerotium rolfsii*. A brief overview has been provided on the many facets of this investigation.

The most significant sign of the disease, according to Nyvall (1989), is the development of white mycelium on the stem bases, leaf litter, and soil surface surrounding the afflicted plant. A few centimeters above the ground, mycelia may climb the stem and ascend into the air. Sclerotia form on damaged plant material and can range in size from a mustard seed to a dark brown spherical.

According to Anahosur (2001), infected leaves droop and wilt, the stem develops dark brown lesions in the collar region. In addition, he saw and recorded the presence of white mycelial growth with dark brown sclerotial structures, which resembled mustard seeds, on the wilted plants.

Humid soil conditions are more conducive to the growth of diseases such as collar rot, which turns a plant's collar yellow and begins to decay (Hind, 2005). The mycelial threads of dried tap root are white. Seedlings that looked like rape seeds were found when the seedlings were pulled up. There are clusters of the illness in the field (Ahmed, 2021). The description of the symptoms of chickpea collar rot by (Nene et al., 2012). The field may have dead, yellowish plants scattered throughout, which is a sign of collar rot.

The chickpea disease known as collar rot, which is transmitted via the soil, kills seeds and seedlings within the first forty-five days of a crop's life, according to study published by Ramesh et al. in 2014. The symptoms of chickpea collar rot have been recognized by Reddi et al. (2014) as yellowing leaves, drooping branches, the emergence of white mycelial growth in the collar region, and sclerotia that resemble mustard seeds. Sparse cross walls, thin cell walls, and a hyaline appearance are characteristics of *S. rolfsii* asexual (anamorphic) hyphae. This fungal species generates hyphae in at least two different types. First, there is the large, straight, coarse kind that ranges in width from 2 to 9 meters and length from 150 to 250 meters. The hyphae, which have a diameter of 1.5-2.5 m, exhibit irregular development and lack clamp connections, which leads to frequent branching in a distinct shape. One frequently observes thin hyphae penetrating the substrate.

The growth of hyphae culminates in the production of sclerotia (0.3-3.0 mm in diameter) when they group together as a compact mass during the course of 4–7 days. Mullen (2001) observed that sclerostial bodies smooth out and colour from white to brown and even black. Aycock (1966) reported that the sclerotia first become white but soon turn dark brown. Fluid that is colourless to slightly yellow is frequently secreted by young sclerotia. A small rind, hard texture, and occasional pitting characterise mature sclerotia. Though the majority are spherical, some sclerotia are somewhat flattened or merge with others to form irregular sclerotia. (Obosah, 2021) The outer melanized rind, the cortical layer, and the medulla comprise the three layers of mature sclerotia. According to Aycock (1966), *S. rolfsii* does not generate any spores or asexual fruiting structures.

Both hosts and cultivated specimens hardly ever reach the teleomorphic stage. The surface of the hymenium is

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where *A. rolfsii* basidia form, and each basidium produces four haploid basidiospores. Patchy, little appressed hymenium growths emerge. The size of the hyaline basidiospores is 1-2 m by 5-12 m, but the clavatebasidia measure 4-6 m by 7-14 m (Aycock 1966). 44 isolates of *S. rolfsii* collected from different parts of India were categorised by Ansari and Agnihotri (2000) based on the morphological appearance and organisation of the sclerotia on semi-synthetic medium. There were differences observed between the 26 Indian isolates of *Sclerotium rolfsii* that Sharma et al. (2012) studied in terms of colony morphology, mycelial growth rate, sclerotial formation, teleomorph production, sclerotial size, and sclerotial color. Also seen in the group was mycelial incompatibility.

In vitro antagonist evaluation against *S. rolfsii* was conducted by Manu (2012). The results showed that the isolates of *T. harzianum* (GKVK) (81.11%), *T. viride* (57.7%), and *T. harzianum*-55IIHR (56.33%) had the highest levels of mycelial growth inhibition, while *P. fluorescens* (0%), and *B. subtilis* (0%), had the lowest levels of inhibition.

Researchers Singh et al. (2013) assessed the capacity of three rhizosphere microorganisms, fluorescent *P. aeruginosa*, *T. harzianum*, and *Mesorhizobium spp*., to cooperate and trigger antioxidant systems in chickpea in reaction to the threat posed by *S. rolfsii*.

In order to combat the fungus *Sclerotium rolfsii*, which causes collar rot in chickpeas, Sab et al. (2014) investigated the bioefficacy of eight antagonists. *Pseudomonas fluorescence* and *Bacillus subtilis* showed the lowest levels of mycelial inhibition when compared to the other bio agents. *Trichoderma harzianum*-55 IIHR demonstrated the highest amount of inhibition at 70%, while *Trichoderma harzianum* NBAII showed the second-highest level of inhibition at 63%.

The effectiveness of eight antagonists against *S. rolfsii*, the fungus that causes collar rot in chickpeas, was studied by Jabbar et al. in 2014. The dual culture method and the toxic food approach were employed as techniques. Out of the eight bio-agents that were tested, *Trichoderma harzianum*-55 IIHR showed the highest level of inhibition against *S. rolfsii*. Subsequently, *T. harzianum* NBAII (63%) and *Pseudomonas fluorescens* (0%) came next. Chickpeas are a significant pulse crop; therefore, collar rot may be a problem. To combat this problem, bio-agents might be used as part of an integrated disease management plan.

Researchers Nagamma and Nagaraja (2015) examined the effectiveness of bio-control agents against *Sclerotium rolfsii*, the fungus that causes collar rot disease in chickpeas, in a setting that mimics in vitro settings. They assessed the ability of nine distinct bacteria to stop *Sclerotium rolfsii* from growing using the dual culture method. Every bacterium was looked at separately. *Trichoderma harzianum* exhibited the highest percentage of mycelial growth inhibition (71.67 %), with *Trichoderma viride* following closely behind with 63.33 percent.

Seven species of the genus *Trichoderma* showed in vitro antagonistic potential, according to research by Ali and Javaid (2015) using a dual culture approach that involved growing pathogenic and antagonistic fungi side by side on the growth medium in the same Petri plate. Among these species are *T. viride Pers*., *T. harzianum Rifai*, *T. koningii* , *Trichoderma viride*, *Trichoderma harzianum*, *Trichoderma koningii*, and *Trichoderma pseudokoningii* were introduced, and as a result, there was a 40–68% decrease in the number of dangerous fungal species. With *T. viride* exhibiting the best antagonistic behaviour and *T. harzianum* following closely after, the two species reduced the pathogen's development by 68% and 57%, respectively. El-Katny, 2021 Furthermore revealed was the percentage decrease in the quantity of sclerotia generated by *S. rolfsii* as a result of its contact with many distinct species of Trichoderma. *T. viride* has the most potential to function as an antagonist against *S. rolfsii*, according to the results of this investigation.

T. viride showed higher growth inhibition (83.33%) than *T. harzianum* and *P. fluorescens* when tested against *S. rolfsii* Sacc., the causative agent of collar rot and root rot in pigeon pea, according to a 2017 study by Salvi et al. Comparing the three pathogens revealed this to be the case. (Howell, CR, 2022).

In order to determine the impacts of *Trichoderma* isolates, Swathi et al. (2018) assessed their bioactivity in plant tissue culture. A control of more than fifty percent was obtained for chickpea collar rot when the following isolates were added to the soil: Th4 (64.4%), T22 (60.2%), Tckp (60.2%), T14 (56.0%), T15 (56.0%), Th2 (52.3%), Th3 (52.3%), and Trice (51.4%). The isolates Th4 (60.2%), Tv3 (52.3%), T2, and Trice (51.4%) were the next highest percentages of disease inhibition, with isolate T12 having the highest percentage (63.4%). Isolate T12 had the highest percentage of disease inhibition when used as a seed treatment.

The incidence of dry root rot in chickpea in Madhya Pradesh's Vindhya Plateau zone (Bhopal, Raisen, Sagar, Seshore, and Vidisha) was studied by Singh and Agarwal (2002). They found that between 8% and 20% of the population was affected by *R. bataticola* cases. The results of a 2003 study by Prajapati et al. showed that cultivars with bold seeds were more prone to *R. bataticola*-caused dry root rot. Researchers Huang and Erickson (2007) found that seedling blight caused by *R. solani* Ag-4 led to a decrease in the severity of root rot and the rate at which it spread under greenhouse conditions with increasing inoculum concentrations. Even under identical settings, it was demonstrated that this was the case. Singh and Sirohi (2003) did an examination of chickpea disease and found that the districts of Una (4.86%) and Sirmour (3.04%) had the greatest frequency of dry root rot. *R. bataticola* was reported to be present in 60.0% of the plants in the Gulbarga district's chickpea fields by Gurha and Trivedi (2008). Every location in the state of Karnataka that grows chickpeas was included in their study (Benhamou N., 2020)

Collar rot:

The *Sclerotium rolfsii*, or *C. rolfsii* A widespread, omnivorous, polyphagous kind of soil-based fungus is called Sacc. Not to mention, it is infamously damaging. The identification of this bacterium as the cause of tomato blight was originally made by Rolfs in 1892. The fungus's classification as a *S. rolfsii* species was established by Saccardo in 1911. In 1915, Shaw and Ajrekar identified the pathogen from rotting potatoes and published the first account of the root rot that the infection produced in India at the time. Mundkar (1934) was able to isolate the optimal stage of *S. rolfsii*. The year 1985 saw the discovery of collar rot in chilli plants in the Vidarbha area of Maharashtra, which was caused by *Sclerotium rolfsii* (Wangihar, 1985).

According to Nene (1985), the chickpea industry in India is thought to be significantly impacted by this sickness. The presence of organic materials that have not broken down near the soil's surface and an increase in soil moisture are two factors that contribute to this phenomenon. It damages seedlings severely, with the exception of irrigated crops, where it can happen at any time as long as temperatures stay over a specific threshold—but only if they are warm enough. There are a lot more diseases associated with chickpeas than with paddy (Burelle N.K., 2021)

Trichoderma:

Greek words for "hair" (thrix) and "skin" (derma) are the source of the term *Trichoderma*. Fungal filaments are formed by free-living, asexually reproducing *Trichoderma*. This organism makes an excellent model for a biocontrol agent due to its wide distribution, ease of isolation and culture, rapid multiplication on a wide variety of substrates, mycoparasitical behaviour, strong opportunistic invasion, a virulent plant symbiont, competition with plant pathogens for food and space, prolific spore production, and potent antibiotics, antifungal compounds, secondary metabolites, and enzymes. According to Klubicek et al. (2002), these characteristics make these fungi ubiquitous and thriving in the ecosystem.

Occurrence of *Trichoderma:*

The biocontrol agent *Trichoderma* is found in almost all types of soil, both tropical and temperate. All temperature zones are home to it, and it may be found in many types of soil, including agricultural soil, as well as soil from woods, prairies, salt marshes, and deserts. At every latitude, it also colonises plant detritus such as bark, roots, litter, rotting or decorated wood, and other decomposing materials. Domsch et al. (1980) discovered that *Trichoderma* accounted for as much as 3% of all fungal propagules in a range of forest soils.

Discovery of *Trichoderma:*

Trichoderma was first proposed as a genus by German Persoon (1794). This was about two hundred years ago. *Trichoderma viride*, *T nigroscens*, *T aureum*, and *T roseum* were the four species of *Trichoderma* that Persoon proposed. In 1928 Thakur and Norris isolated it for the first time in Madras, India. On the potential bioactive properties of the *Trichoderma* genus, Weindling first published a paper in 1932.

Culture characteristics of *Trichoderma:*

Rapid growth is a defining characteristic of *trichoderma* colonies, which can range in colour from white to several shades of green (or stay a light green or white tinge in certain species). The colonies' colour might also stay the same. There was a landscape with shades of brown, amber, and gold on the opposite side of the colony. It is uncommon to see exudates. Only a few specific species of *Trichoderma* emit a coconut-like odour, according to Persoon (1794). The researchers also found that light was necessary for the sporulation process to occur. Aerial mycelium in *Trichoderma* is rather rare, and when it does occur, the pigmentation is almost always yellow. *Penicillium (*Link) and *Fusarium (*Link), on the other hand, exhibit a wide range of diagnostic characteristics in their cultures. The distinctive yellow colouring of *Longibrachiatum* sets it apart from other parts. One feature of *Trichoderma* colonies that frequently shows up is zonation in the conidial development. In contrast to, say, potato dextrose agar or oat meal agar, where conidial formation was significantly more common, he found that when comparing media with different concentrations of dextrose, maize meal agar with 2% dextrose allowed for clearer views of conidial aggregation. When he contrasted the three categories of media with one another, this was found. In oat meal agar and maize meal agar containing dextrose, respectively, the solubility of pigments produced by *Trichoderma* species was reduced. Cultures of *T. atroviride* and *T. viride* treated with 6-pentyl-pyrone, an antifungal drug, release a pleasant coconut aroma. Another species that produces it is *T. harzianum,* to which it is closely related.

Colony development was somewhat impeded when exposed to light and darkness alternately, as opposed to light being introduced to them very infrequently. This was in contrast to the times when colonies were sporadically exposed to light. It was also observed that *T. aureoviride* isolates cultured on MEA under a regimen of 12 hours darkness/12 hours cool white fluorescent light generated a more or less vivid yellow pigment after a week. This pigment was most prominently seen in the colony reverse. This was carried out in the circumstances mentioned in the preceding sentence. Cultures exposed to low light levels did not create any noticeable pigment during the incubation period. Lieckfeldt et al. (2001) state that the aerial mycelium of *T. aureoviride*, which is composed of small hyphae and produces concentric rings of high conidial production as well as a uniform lawn throughout the colony, is its most significant cultural trait.

Molecular characterization:

Due to the high degree of morphological resemblance amongst *Trichoderma* isolates, it has been demonstrated that they are particularly challenging to identify at the species level. Nine groups were categorised by Rifai (1969) using the term "species aggregate." Previously unknown species were found in two or more of these categories. In an attempt to distinguish between species that have similar characteristics, Gams and Bissett (1998) created morphological "sections". They were nonetheless able to uphold Rifai's (1969) concept of species and accept homologous forms as a result. Approximately 50% of the *Trichoderma spp.* retrieved by morphological evaluation alone was misidentified, according to studies conducted by Kubicek et al. (2011). Following recent changes to the sections on *Longibrachiatum* and *Trichoderma*, respectively, and associated teleomorphs, the *Trichoderma* taxonomy now includes molecular methods (Samuels et al., 2002). These approaches have been used to the study of fungal taxonomy and have led to the reevaluation of many genera, indicating the utility of the tool that they are used as biocontrol agents. The study that Sherriff and colleagues conducted. Through the use of rDNA sequencing, scientists have been able to distinguish between several *Trichoderma* spp. And its strain. Both *T. viride* and *T. harzianum* underwent molecular characterization based on rDNA markers and a PCR RAPD profile study conducted by Chakraborty et al. (2011). By utilising ITS-PCR and RAPD, we looked at the genetic composition of 19 isolates of *T. harzianum* and *T. viride*. The isolates were obtained from soil samples obtained from forest regions, agricultural areas, and the rhizosphere soil of plantation crops in North Bengal. A total of six distinct primers were employed to assess the genetic similarities between the *T. viride* and *T. harzianum* isolates. A considerable degree of genetic variation was found among the eight distinct groups of isolates, as shown by the RAPD profiles. The similarity coefficient ranged between 0.67 and 0.95, based on the dendrogram's values. ITS1 and ITS4 primers were used to perform ITS-PCR on the rDNA region, and the results for each isolate were 600 base pairs long. As of 2020, Katan J.

As of right now, it is standard procedure to forgo using single gene sequences to identify *Trichoderma* isolates. This is because it has been demonstrated that ITS1 and/or ITS2 are carried by paralogous copies in a number of plants and fungi. Concepts of phylogenetic species were developed in part because to the work of Taylor et al. (1999), which was based on five or more gene trees. One approach to developing a trustworthy taxonomy that accurately reflects the connections created throughout evolutionary history is to combine phenotypic traits with genetic techniques. There exist 77 different species of *Trichoderma*, despite the fact that Druzhinina et al. (2011) were only able to identify 70 of them. 96 *Trichoderma* strains that were isolated from a range of substrates were identified at the species level through sequence analysis of the rDNA cluster's internal transcribed spacer regions 1 and 2 (ITS1 and 2), using ex-type strains and taxonomically established isolates of *Trichoderma* as references (Kubicek et al., 2003). On 78 of these specimens, positive identifications were made: 37 were identified as *T. harzianum*/*T. hamatum*, 16 as *T. virens*, 8 as *T. spirale*, 3 as *T. koningii*, 2 as *Hypocreajecorina* (anamorph: *T. reesei*). One useful method for identifying the species of a fungal strain that has been isolated is ribosomal DNA, or rDNA. These rDNA, which show a mosaic of conserved and distinct genomic areas, are exceedingly stable and were initially discovered by Hibbett (1992). With up to 200 copies per haploid genome, they can also be found in tandem repeats. The 5.8S, the 28S Large Sub Unit (LSU), and the 18S Small Sub Unit (SSU) genes make up each tandem repeat. Primers derived from Internal Transcribed Spacer (ITS) regions have also been effectively applied to distinguish between closely related fungal species. In the realm of molecular identification, the approach of taxon selective amplification of ITS sections is becoming more and more popular. Most of the work done to create primers for identifying *Trichoderma* species was focused on the internal transcribed spacer (ITS) region of ribosomal genes. They found that the ITS region of the rDNA could be amplified with success using the genus-specific ITS-1 and ITS4 primers. Primers were also utilised to make amplified products that had a size of 600 base pairs. They found an amplified rDNA segment in *Trichoderma* throughout their analysis, which had a base pair (bp) range of around 500 to 600. The *Trichoderma* variation identified in the ITS region of the rDNA was made public thanks to the ITS PCR method (Ospina and others, 1999).

The ability of *Trichoderma* spp. to inhibit the growth of diseases:

Numerous plant illnesses that are transmitted through the soil can hurt a variety of plants, however *Trichoderma* has been shown to be an efficient bio agent to shield them from the damage. Two things have demonstrated this: concurrent in vitro discoveries and evidence of antagonistic potentiality in vitro. A number of soil-borne plant diseases have been demonstrated to be inhibited by compounds produced by *Trichoderma spp*., according to published studies. *Trichoderma* produces volatile and non-volatile antibiotics that have an effect on *R. solani* and other forms of fungus, as found by Dennis and Webster (1971a–c). Ethanol and acetaldehyde concentrations vary among *Trichoderma* species, as does their rate of carbon dioxide production. It was demonstrated by Hutchinson and Cowan (1972) that these variations explain variations in the proportion of gaseous metabolite-induced suppression of the target fungus. The age of the antagonist and the medium's pH have little effect on *T. harzianum's* ability to produce antibiotics, according to Upadhyay and Mukhopadhyay (1983). Following 15 days of exposure, the vapour impact of *T. harzianum* was most inhibitive to *S. rolfsii* on day 6, and it then gradually decreased until it was insignificant on day 15. It has been shown that *T. viride* inhibits *F. oxysporum* f. sp. *lycopersici* growth by 44.8%, 78.8%, and 20.0%, respectively, when a dual culture, volatile compound production, and no volatile substance production are used. Regardless of whether *T. viride* generated volatile chemicals or not, this was the case.

***Trichoderma* spp. Bio priming:**

Thanks to the application of bioagents to seeds, farmers and growers now have an alternative to using chemical fungicides to preserve seeds and stop illnesses caused by seed-borne pathogens. While chemical seed treatments have demonstrated their value, it is important to remember that biological seed treatments, which employ live microorganisms, have the potential to yield even greater results. (Brian R. Kerry, 2020) As with chemical seed protestants, biological seed treatment may have a more restricted application range because of its differential reactivity to host and environmental conditions. For this reason, it is even more important to store and apply biological seed treatment under the right conditions. While certain biocontrol agents may colonies the rhizospheres and continue to benefit the plant even after the seedlings have emerged, the bulk of biocontrol agents that are applied to seeds expire before the seedlings emerge. In order to combat infections in seeds and seedlings brought on by diseases including *Pythium spp*., *Rhizoctonia solani*, *S. rolfsii*, *Mycosphaerella phaseolina*, and *Fusarium spp*., effective biological control agents have been created. Studies conducted in greenhouses showed that *T. harzianum* was successful in preventing damping off in bean, tomato and aubergine plants, even in the presence of *R. solani* in the soil.

Researchers Shahid et al. (2014) were able to gather a range of *Trichoderma* strains from bean crops in the state of Uttar Pradesh that had wilted. *T. harzianum* was shown to be the most efficient *Trichoderma* species against *Fusarium* when used as a seed treatment, out of the seven that were studied. It led to an increase in germination, the length of the roots and shoots, and the vigour of the seedlings when compared to the untreated control.

Better plant growth traits and germination percentages in a pea crop were seen as a result of study by Devendra et al. (2014) employing an antagonistic seed treatment. At a concentration of 10 gm/kg, the combination of *T. harzianum* and *P. flurosence* had the highest germination rate. *P. flurosence* came next, at 89.8%, followed by *T. harzianum*, *P. flurosence*, and *T. virens* at 88.5%. The germination percentage for the untreated control group was 76.2%. The effects on germination, seedling establishment, dry weight, and vigour in the chickpea genotype Radhey of pre-sowing seed treatment with the *Trichoderma* strains *T. harzianum* (Th. Azad) and *T. viride* (01PP). Radhey chickpea seedlings germinated at a rate of 92% when treated with *T. harzianum* (Th. azad) and 90% when treated with *T. viride* (01 PP). The highest values for the following parameters were noted for each treatment: vigour index I (1597.12 cm), vigour index- II (109.48 cm), dry weight (1.19 cm), shoot (4.97 cm), seedling (17.36 cm), and root (12.38 cm), respectively, as compared to the control (12.19 cm). Rai and Basu (2014) evaluated eight different types of bio-primed okra seeds in an experiment using *T. viride* and *P. fluorescence*. After being treated with *T. viride* in their first and second years of development, the plants of the Arka Anamika variety grew to 108.21 cm and 112.25 cm in pod length, whereas the plants of the Lalu variety reached 19.01 cm and 19.21 cm in pod length and 16.64 mm and 16.85 mm in pod diameter.

Conclusion:

Chickpea (*Cicer arietinum* L.) is an important legume crop of rabi season in arid and semi-arid regions of Indian subcontinent. Different in vitro and field studies clearly indicated that chick pea collar rot pathogen (*Sclerotium rolfsii*) potentially controlled by different *Trichoderma* spp. As potential biocontrol agents *Trichoderma* spp. results of a significant reduction in collar rot pathogen. The findings of present review will be beneficial in controlling the collar rot of chickpea induced by *Sclerotium rolfsii*. The ecofriendly Trichoderma spp. was discovered to have upper hand benefits in the control of collar rot caused in chickpea.

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Conflict Of interest:

We solemnly declare that there is no conflict of interest to publish this manuscript.

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