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Biotic stress alleviating strategies in chickpea

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ABSTRACT

The third-most important food legume in terms of economic importance worldwide is the chickpea (*Cicer arietinum L.).* Its potential production is frequently constrained by numerous biotic stressors, such as the nematodes, insects *Ascochyta blight, fusarsium* wilt, and botrytis grey mould are the three major fungal diseases that cause significant economic losses, while *Helicoverpa armigera, Aphis craccivora, cowpea weevil* are the three major pre-harvest pest of chickpea. Several biological, chemical, cultural and, agronomical practices are used to control biotic stress, apart from that few modern biotechnological approaches also developed for high yielding and biotic stress resistant varieties. This paper aims to elaborate about different biotic stresses that affect Chickpea plant, their management strategies including traditional chemicals and adaptation of transgenic varieties with their limitations and also enlightened newer ray of hope *i.e.*, plant growth promoting rhizobacteria that holds the ability to combat against biotic stress by mitigating stress ethylene level.

Introduction

Chickpea(*Cicer arientinum L.)* is one of the most significant leguminous cool-season food crops, widely grown in the Asian Pacific region.Chickpea has large levels of all the essential amino acids, except for the Sulphur (Methionine) containing amino acids (Jukanti *et al*., 2012).The main storage carbohydrate is starch, which is followed by dietary fibre, oligosaccharides, and simple sugars like glucose and sucrose. With the addition of other pulses and cereals, chickpeas may have favorable effects on various serious human ailments, including as cardiovascular disease (CVD), type 2 diabetes, and digestive disorders, several cancers too (Lukus *et al.*, 2020).Chickpeas are a significant pulse crop with a wide range of possible nutritional and health advantages. However, yields are frequently modest and unpredictable (Verma *et al*.,2021). A variety of biotic and abiotic stress factors have a negative impact on yield, which is the main cause of yield variability *i.e.*, 20-35% by weeds, 50-100% by disease and 10-90% by insect pest (Rana *et al*., 2016).Major biotic stresses, such as fungi, bacteria, and viruses, insect pests, nematodes, and parasitic weeds, have an impact on chickpea output worldwide. Due to wilt disease, the chickpea crop is seriously damaged in India, Myanmar, Nepal,Iran and Pakistan (Davies *et al.*, 2007). *Fusarium* wilt, a fatal fungal disease, has a detrimental effect on chickpea productivity.Causal organism of fusarium wilt is *Fusarium oxysporum. F. sp. ciceris,* a most common disease in India (Dhawale and Dhale, 2021). Superior cultivars with improved resilience have been able to combat several of the main biotic stresses on chickpeas.There are still a few biotic stresses, nevertheless, for which no resistance has been found. This review focuses on the major biotic stresses affecting chickpea productivity as well as

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modern strategies to manage them.

Biotic stress:

When living things, such as weeds, insect pests, disease-causing agents, nematodes, allelopathic compound and pathogen harm plants it results in biotic stress. During various phases of plant growth, fungi and viruses are most prevalent and significant groupings affecting all areas of the plant (Mahmoud, 2021; Pande *et al.,* 2006).

Chickpea diseases:

Fungal diseases, followed by viral and bacterial illnesses, are the most important disease that contribute to a general decrease in the annual yield of chickpeas. On chickpea 67 fungus, 22 viruses, 3 bacteria, and 80 nematodes have been observed (Kukreja *et al*., 2018), but only small number of these result in economically significant disorders. Diseases like *Fusarium* wilt (*Fusarium oxysporum f. sp. ciceri*), *Ascochyta blight* (*Ascochyta rabiei*), *Botyris grey mould* (BGM) (*Botrytis cinerea*) *etc.* are the major diseases of chickpeas (Rasool *et al*., 2015)

***Fusarium wilt* (*Fusarium oxysporum f. sp. ciceri)*:**

Using 10 chickpea lines as distinguishing factors,revealed the occurrence of four physiological races of *F. oxysporum* which are cicers in India (Ramanamma *et al*., 2020). Later, two further races (0-1) from Spain and another (race 6) from California were identified on the basis of variations in responsiveness on various host, Race 1 was subsequently split into two races, namely Race 1A (from India) and Race 1B/C (from Spain). Syria,Turkey, and United States (California) have also reported races 1B/C.Many soils borne organisms belonging to the genus *Fusarium* were widespread worldwide and were referred to as plant pathogens. Wilted plant caused by *Fusarium* sp.,*Rhizoctonia sp*. and *F. oxysporum* which are Cicers pathogenic strains of chickpea are currently accepted worldwide as the causal agent (Jendoubi *et al*., 2017, Nikam *et al*., 2007).

Pathogen:

A globally distributed fungus called *Fusarium* can be found in soil not only in tropical and temperate climate condition but also occurs in regions including the polar and other environments. *Fusarium* species are among the most persistent species of soil borne fungal pathogen. It produces conidia, chlamydospore, micro and macro conidiospore.

Symptomatology :

The disease known as chickpea wilt was seen in seedling and growing phase of the plant (Lodhi *et al*., 2006). Petioles and rachis droop are symptoms seen as the condition progresses. Base to upward yellowing, leaf dryness and browing in plant vascular bundles, wilting were noticed.The pathogen produces enzyme that break down cell walls and obstruct the plants transport system. This is followed by discoloration of the roots vascular system. Later, the plant begins to yellow, wilt, develop necrosis, and eventually die.In soil plant waste, the pathogen *Fusarium oxysporium* can live and spread through seed. The fungus was revealed to be present in the seed hilum as chlamydospore-like structures.During the study of the pathogen distribution in seed, Basaiah *et al*. (2006) discovered that it was concentrated in the cotyledons and axis, this may be studied via disease cycle (Figure 1). The main source of infection is either mycelia or chlamydospore. While the fungus conidia are short-lived, its chlamydospores can survive until the next harvest season. Even in perfectly healthy plants growing next to infected ones, the pathogen can survive for a long time in the roots and stem (Haobing *et al*., 2015).

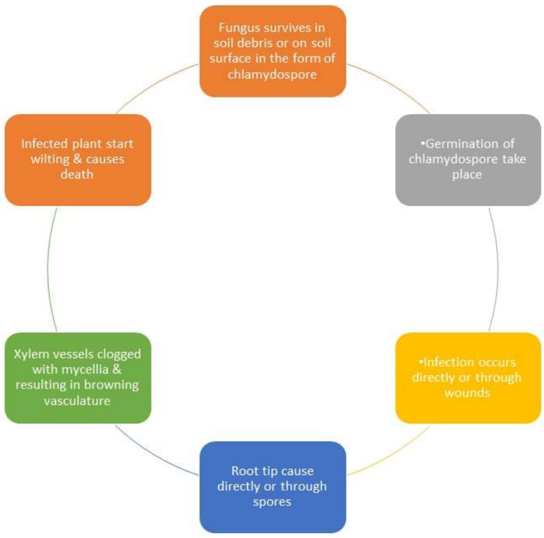

Figure 1: Disease cycle of *F. oxysporum f.sp. ciceris*

Disease management:

***Agronomicalculturalpractices*:**

It is not possible to control the illness by crop rotation since the fungus is soil-borne and seed-borne and can live in soil for extended periods of time even without a host. The use of pathogen-free seeds and avoiding affected fields are thus preventive measures (Gurjar *et al*., 2011). *Fusarium* wilt has also been successfully controlled by bio-control agents that offer an environmental friendly method of eradicating the ailment, such as a non-pathogenic *Bascillus sp.*(Kamali *et al*., 2019) and *Pseudomonas fluorescens* (Pandey *et al*., 2022; Fravel *et al*., 2003). However, the most efficient and environmental friendly way to treat the illness to use wilt resistant chickpea cultivars when they are available (Biratu, 2017).

Usage of chemicals:

In 2000 and 2001, the global use of pesticides exceeded 5.0 billion pounds. Disease control for plants has relied heavily on the use of insecticides (Whipps and Gerhardson, 2007). There was a 1.8% rise in production when output per hectare increased. However, this hasn't always been the case for instance, if farmers use pesticides recklessly or ignorantly, some of the pesticides may contaminate soil and/or groundwater stay in the environment for a long time, and be hazardous to farmers (Dasgupta *et al*., 2007)

Biotechnology tools:

Agriculture and food systems could undergo a transformation, thanks to nanoscale science and nanotechnologies. It has ushered forth a new era of Agronanotechnology. Nanoparticles possess been tested as antifungal medications against fungi as "magic bullets" that are nutrients, fertilizers, fungicides, herbicides, or targeting particular plants to transfer their energy for the intended effectsin plants (Pramanik *et al*., 2021). Different types of nanomaterials like copper (Cu), Gold (Au), Silver (Ag), Zinc (Zn), Titanium (Ti) may one day benefit Nano-agrotechnology by acting as a means of delivering nutrients. The seeds with the required compounds during germination capable of shielding them from the disease since it encourages growth, it will not contain any harmful, restricting, or unfavorable the plant's impact.

***Ascochytablight*:**

The most damaging form of chickpea disease, *Ascochyta blight*, is brought on by the fungus *Ascochyta rabiei*, which only lives on chickpeas. There are many reports of serious losses caused by blight, which reports of yield reductions of up to 100 %.The cause of ascochyta blight in chickpea, *Ascochyta rabiei* can found as both a teleomorph and an anamorph. *A.rabiei* ananamorph, is distinguished by the development of spherical pycnidia, which are black fruiting structures that resemble pears. A large number of hyaline unicellular and spores that have two cells, pycnidiospores, or conidia, grew on brief conidiophores incorporated within a limp that is mucous (Liu *et al*., 2016).

Symptomatology:

All of the plants aerial components are susceptible to developing *Ascochyta blight* symptoms. Brown lesions form at the stem base of newly emerging seedlings due to seed-borne illness. Following that the lesions expand in bulk and encircle the stem, breaking it and plants demise. Many pycnidia appear on the necrotic wound.These plants tend to cluster in patches but they can spread quickly (Figure 2). Depending on threat, plants are attacked at any stage of growth. Younger leaves are infected by *Conidia* and *Ascospore*, which produces tiny, necrotic areas drenched in water that quickly become larger and coalesce. When symptoms spread quickly to all aerial components, such as leaves, petioles, flowers, pods, branches and stem, tissues quickly collapse and the affected organism dies. Infected pod frequently causes seed infection and infection during the pod maturation stage often result inshriveled and infected seed (Foresto *et al*., 2023).

Figure 2*: Ascochyta blight* symptoms on chickpea. a) aerial part infection. b) infected pod

Disease cycle:
A.Rabiei undergoes periods in its life cycle that are both teleomorphic (sexual) and anamorphic (asexual). When both compatible mating types are present on crop debris from an *Ascochyta blight* infection during the winter the teleomorph develops (Singh *et al*., 2022). After successful mating, a *pseudothecium*, a sexual fruiting organism that is initially encased in host tissue is produced, have extensively discussed the condition of *pseudothecium* development on artificially infested chickpea straw in field conditions. Each ascus contains eight, two-celled ascospores, under moist condition mature pseudothecia discharged ascospores into the air (Figure 3). Meiotic recombination creates new pathogen varieties during sexual reproduction, and ascospores aid in the pathogen long distance dissemination (Bayraktar *et al*., 2007; Valetti *et al*., 2021).

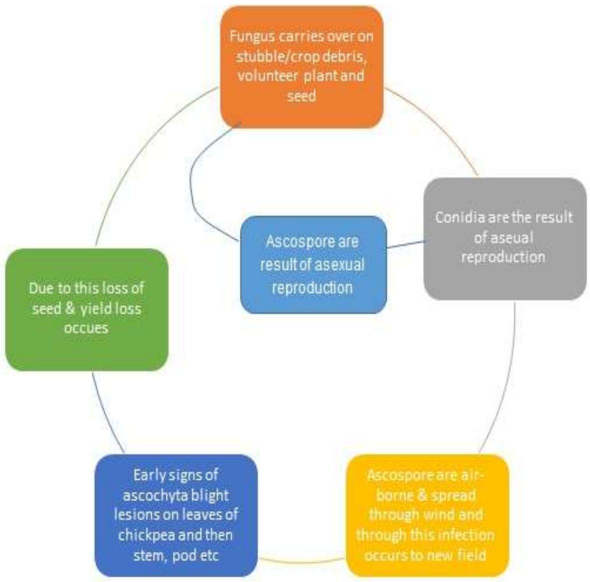

Figure 3: Disease cycle of *Ascochytarabiei*

Disease management:
Agronomicalculturalpractices:
Increased chickpea yields are necessary to feed the world's population, which is constantly expanding. Disease management strategies are therefore crucial. It is feasible to manage disease using variety of well-thought-out tactics (Manjunatha *et al*., 2022). Only chickpeas are susceptible to *A.rabiei*so culture practices like rotating with non-host crops and only growing chickpeas after a gap of three to four years will enable the control of this disease (Gurjar *et al*., 2011). Similar to this, using disease-free seeds and removing infected plant detritus can help lower inoculum level and prevent the spread of severe epidemics (Gan *et al*., 2006).
Modern Biotechnology tools:
Marker-Assisted Selection (MAS) seeks to choose a genetic feature of interest such as productivity, disease resistance, etc. indirectly. Plant breeding uses MAS to increase disease resistance and quality improvement (Kukreja *et al*., 2018). MAS have demonstrated to be effective in selecting for qualities that are challenging to measure. The utilization of molecular markers related to quantitative trait loci (QTLs) that provide resistance has been discovered. DNA based markers also promoted the adoption of uncommon disease resistance sources. These markers shorten the time required to generate resistant cultivars and improve the range of sources for the pyramiding of resistant genes.
Botrytis grey mould (BGM):
The second most significant disease to affect chickpeas is Botrytis Grey Mould (BGM), which is brought on by *Botrytis cinere* has potential to completely destroy chickpea particularly in winter rainfall and high humidity (Pande *et al*., 2006; Nene *et al.,* 2012). The timing of the disease emergence in relation to crop development and the severity of the disease-both of which are significantly influenced by the weather and the pathogen inoculum level.
Pathogen:
Micheli created the genus botrytis in 1929, and since then it has gained widespread recognition as a family of fungi that can cause economically and potentially significant plant diseases. This is especially true for form that cluster together since species forms tend to be concentrated in the temperature around 25°C and they can be found on a range of crop plants at 30º latitude (Manjunatha *et al*., 2019).
Symptomology:
The disease can affect all of the chickpea plant aerial components, with growth tips and flowers being the most vulnerable (Pande *et al*., 2006). BGM symptoms typically emerge after crop canopy closure (Knight and Siddique, 2002). BGM frequently first manifests as stem lesions that have been wet. That start at ground level and spread

along the stem, infecting other stem (Knights and Siddique, 2002). The fungus survives on infected seed, as a saprophyte on decaying plant debris and as soil-borne sclerotia. The disease is often established in new areas by sowing infected seeds. Masses of spore can be produced on infected plants. These fungal spores can be carried from plant to plant by air currents and spread the disease rapidly (Figure 4).

Figure 4: Disease cycle of Botrytis Grey Mould in chickpea

Management of disease

Agronomicalculturalpractices:

Utilizing pathogen-free seed can lower the disease's seed transfer rate. Minimize plant densities, taller cultivars, and altered sowing dates can all help to lower the amount of BGM in chickpeas (Pande *et al*., 2006). Late seeding slows vegetative development, which lessens the likelihood of illness. However,this may also result in a decline in grain yield. Greater crop aeration is made possible by wider row spacing. Lowered relative humidity, leaf wetness, and canopy, which in turn lowers the likelihood of disease (Pande *et al*., 2006), linseed intercropping and wider plant spacing in paired rows (Nene *et al*., 2012) have been shown to improve grain yield while reducing illness.

Useofchemicals:

Fungicide seed treatments, such as iprodione, mancozeb, thiabendazole, triadimefon, triadimenol, vinclozolin, thiram, benomyl, carbendazim, or captan, are successful in lowering seed infection (Pande *et al.* 2002). As soon as the disease first manifests, foliar treatments applied at regular intervals can control especially when combined with a seed-dressing (Pande *et al*., 2006).

Modern Biotechnology tools:

The creation of dependable and effective regeneration and transformation systems is crucial for gene technology to be successful in delivering novel features like BGM resistance in chickpea. Furthermore, cloned and characterized genes are particularly significant in expressing genes with antifungal metabolites. Several antifungal proteins, such as the hydrolytic fungal cell wall disintegrating chitinolytic enzymes prevents *B. cinerea* from growing as a fungus inside of leaf tissue (Kumar *et al*., 2018).

Root rot:

Dry root rot in chickpeas is brought on by *Macrophomina phaseolina* (*Rhizoctonia bataticola*). Australia, Ethiopia, Iran, Pakistan, Bangladesh, Nepal, and a number of other nations have reported it as a severe issue (Singh *et al*., 2022). The disease typically manifests at the flowering and podding stages and is more severe in sandy soils. Just the top of the plant has drooping petioles and leaflets. Tap roots lose their lateral roots and develop black and rotten, among other symptoms (Figure 5). On the tap roots, a whitish mycelium can occasionally be seen clearly. Dead roots are fragile and exhibit bark tearing. When touched, the root's tip is readily broken. When the collar section is cut vertically or with the arid of handles on the exposed woody root parts, little sclerotia can be observed. Both seeds and soil can spread the illness. Several members of the Leguminosae family become good hosts for pathogens. Lack of soil moisture is advantageous for the development of illness (Singh *et al*., 2007).

Management practices

Agronomical practices:

The severity of the disease is lowered by deep ploughs and the removal of infected host detritus from the soil. Conditions of moisture stress should be avoided. To avoid the hot weather when the illness is mature, early maturing types should be sown in the right time frame (Kaul *et al*., 2007).

Figure 5: Root rot disease

Insect pest attack on chickpea

Around the world, it is known that 60 different insect species eat chickpea. Among these, leaf miners and pod borers (*Helicover paspp*.) are the most significant insect pests. The Bruchid weevil (*Liriomyz acicerina*), cutworms (*Agrotis spp*., *etc*.), armyworms (*Spodoptera spp*.) and cowpea aphids (*Aphiscrac civora*) are among the leaf eating pests (Sharma *et al*., 2015).

Pre-harvest pest

Pod borers:*Helicoverpa armigera* (Lepidoptera: Noctuidae)

There are several different crops that are severely economically damaged by *Helicoverpa* species, which are widely distributed geographically. Major crop losses could result from the larvae feeding directly on the seed pod, which results in seed abortion and damage. Major crop losses could result from the larvae feeding directly on the seed pod, which results in seed abortion and damage. *Helicoverpa* favours chickpe as above lupins, canola, Indian mustard, and linseed, just like he does with field peas and faba beans (Grundy *et al*., 2004).The adult moths are grey to brownish in appearance and migrate over great distances in search of host plants.

Black cutworm- *Agroti sipsilon* (Lepidoptera: Noctuidae):

In North India, black cutworm is a pest of chickpea and other crops. During the rainy season, it causes significant harm in places that are inundated; however, in the summer, it may move to a hilly area. The species has different generations every year depending on the weather. On chickpea plants and soil clods, eggs are laid. Up to 2250 eggs can be laid by each female.The entire life cycle, including the egg (3 to 6 days), larvae, and pupae, lasts approximately 60 to 120 days. There are typically six to seven larval instars found.

Practices to minimize infestations:

Deep soil ploughing, hand-picking of large-sized larvae/pupae, shaking of plants to remove insects, weeding, mulching with grass, and sowing at the right time are cultural practices to avoid or reduce lepidopteran insect pest infestations (Dahiya *et al*., 1999), preserving the distance between individual plants, and applying fertilizer.Even though cultural customs they are generally time-consuming and cost-effective to produce a good harvest, but their implementation falls behind contemporary farming.

Since a few decades ago, the majority of the diseases and insect pests of chickpea have been largely controlled by chemical pesticides. Chemical pesticides' primary benefit is their ability to manage infestations, even when applied at an advanced stage of infestation. However, due to its persistent and widespread use, insects are subjected to strong selection pressure, which caused resistance to develop many chemical pesticides. There have been reports of resistance in *H. armigera* against several pesticides, including as carbamates, organophosphates and pyrethroids (Ahmad *et al*., 2001).

Role of PGPR in controlling biotic stress

Stratigies to control fusarium wilt in Chickpea

1. By using biocontrol agent

The most widely used and environmentally benign way of controlling *Fusarium oxysporum* is biological control (Anjajah *et al*., 2003). Rhizobacteria that promote plant development (PGPR) can be used to combat the wilt pathogen (Schmidt *et al*., 2004). These rhizobacteria produce the siderophores pyrolnintrin, phenazin, and phloroglucinol, which suppress and inhibit *Fusarium oxysporum* (Fridlender *et al*., 1993). *Burkholderia, Bacillus, Pseudomonas, Trichoderma* and others exhibit notable inhibition, making them effective biocontrol agents for chickpea wilt (Wani *et al*., 2007). By boosting -1, 3-glucanase enzyme activity and thus suppressing the pathogen growth, *Trichoderma harzianum* and *Bacillus subtillis* block and suppress the disease (Anjajah *et al*., 2003; Moradi *et al*., 2012).

2. By using plant extract ;

The antifungal activity of four plant species' aqueous extracts, including *Azadaracta indica In-vitro* research revealed the presence of *A. Juss., Datura metel* L. var. *quinque cuspida Torr.,Ocimum sanctum* L., and *Parthenium hysterophorus* L. At 100% concentration, *Azadirachta indica* leaf extract fully prevented pathogen spore germination (Singh and Chand 2004). Three weed species *Capparis decidua, Lantana camara* and *Tridax procumbens* have extracts that exhibit antifungal properties when applied to *Fusarium oxysporum* (Kumar *et al*., 2021.) *Datura stramonium* acetone extracts have reportedly been shown to have antifungal effect against a number of fungus, including *Fusarium oxysporum*.

3. By using agronomic practices

Crops that are planted early typically experience greater illness. According to several research, delaying planting and maintaining low temperatures during flowering are both beneficial for disease prevention (Chandra *et al*., 1974). Planting of seed at proper depth can also minimizes the disease incidence. Pigeon pea wilt incidence was significantly reduced by intercropping with sorghum in the first year (down to 55%), and thereafter it steadied at around 20–30%. Chick peas mixed with wheat and berseem produce measurable disease control (Basha *et al*., 2017).

PGPR mediated enzyme production

According to Cappuccino and Sherman (1992), many PGPR produce a variety of cell-degrading enzymes, including amylase, cellulase, pectinase and protease to degrade cell wall of dangerous bacteria, which thus lowers the Stress caused by living things. In addition, the fungus pathogen is diminished by the component of the cell wall is destroyed by the enzymes, for instance, chitinase, 1,3-glucanase, and proteases are made by PGPR.

Phytohormonal modulation:

Several phytohormones, such as cytokinin, gibberellin, abscisic acid, salicylic acid, jasmonic acid, brassinosteroids, auxin, and ethylene, play a crucial role in regulating various plant physiological activities (Orozco-Mosqueda *et al*., 2023). It is noteworthy that numerous plant growth-promoting bacteria (PGPB) possess the ability to synthesize or degrade some of these phytohormones, including cytokinin, gibberellin, salicylic acid, auxin, and ethylene (Delcarmenorozco-mosqueda *et al*., 2023)

Cytokinin:

The effects of cytokinins extend to various plant cell types, influencing functions such as seed germination, apical dominance, root elongation, xylem and chloroplast differentiation, transition to reproductive growth phase, flower and fruit development, leaf senescence, nutritional signaling, and interactions with plant pathogens. It is worth noting that cytokinins play a significant role in promoting plant cell division while simultaneously inhibiting senescence. Interestingly, the ratio of cytokinins to auxins in plants growing in their natural environment determines the degree of shoot and root formation, with higher cytokinin to auxin ratios promoting shoot formation (Maxton *et al*., 2018a).

Salicyclic acid :

Plants treated with PGPB frequently develop systemic, broad-spectrum resistance to a variety of phytopathogenic bacteria and fungi. Before plants engage with phytopathogens, this induced systemic resistance (ISR) primes plant defenses so that plants are more resistant to disease attack in the future. The ISR is frequently connected involves an increase in plant cell lignification and an uptick in the expression of Reactive oxygen species (ROS)-reducing enzymes such peroxidase, catalase, superoxide dismutase.

Auxin :

Auxin produced by PGPB (plant growth promoting bacteria) is traditionally found to be the key method by which bacteria promote plant development. Moreover, the majority of scientific literature focuses on acid (IAA), one of multiple auxins having biological action, hence the terms IAA and auxin are usually used synonymously. IAA stimulates cell division, cell expansion, root bacterial colonisation, differentiation of vascular tissues, and defense against pathogens, elongation of stems and roots, and loosening of root cell walls, among other plant growth features (Maxton 2017a).

PGPR mediated enhanced nutrient availability:

The primary purpose of siderophores, which are metal-chelating agents, is to draw insoluble ferric iron from various habitats (sideros, which means iron, and phores, which means carrier) (Nagoba and

Vedpathak, 2011). In general, it was discovered that the majority of facultatively anaerobic and aerobic bacteria create siderophore in the absence of iron ions (Neilands, 1995). There are three main categories into which siderophores can be divided: hydroxa-mates, catecholates (phenolates), and carboxylates. Because of the insoluble iron form (Fe^{3+}), iron has a limiting effect on plant growth. PGPR known as *Pseudomonas putida* develops symbiotic interactions with plants. Phosphorus is essential for ATP generation and the phosphorylation of photosynthetic proteins and enzymes, two processes involved in plant growth (Zer and Ohad, 2003). *P. putida* increases chlorophyll content in the leaf also enhances antioxidant enzymes activities in chickpea leaves under phosphorus deficiency. The mobility of nutrients including P, Fe, Zn, and Mn is increased by the root exudation of organic acids (Zhang *et al.* 1997). Citric acid, which is widely found among root exudates, mobilises P in soils primarily by ligand exchange, dissolution, and occupation of P sorption sites (Fox *et al.*, 1990; Gerke, 1995).

Nitrogen fixation

One well-known and important critical ingredient for plant growth and development is nitrogen. The global nitrogen cycle, however, contaminates groundwater and raises the danger of chemical leaks. Chemical fertilizer manufacturing is a very energy-intensive process that relies heavily on fossil fuels. High input farming methods that produce high yields have led to environmental issues and resource deterioration. Therefore, during the past few decades, the application of PGPR for environmentally friendly and sustainable agriculture has significantly increased in different parts of the world (Figueiredo *et al.*, 2008). Increased and expanded use of PGPR for bio-fertilization would decrease and reduce the demand for chemical fertilizers and the unfavorable consequences they have on the environment (Maxton *et al.*, 2017c).

Phosphorus availibility

One of the major and important elements that restrict plant growth, along with nitrogen, is phosphorus (Podile and Kishore, 2006). Even in phosphorus-rich soil, the majority of the phosphorus is insoluble and so unavailable to the plants. This issue can be solved using phosphate solubilizing bacteria (PSB), which are widespread in the rhizosphere (Vessey, 2003).In addition to solubilizing inorganic phosphate and converting insoluble phosphates into soluble monobasic and dibasic ions, PSB secretes organic acids and phosphatases that release soil phosphorus that would otherwise remain fixed and make it available to plants (Richardson, 2001)

Nutrient uptake

Mainly sixteen basic elements are needed for living plants to survive. Carbon, hydrogen, and oxygen are three of the sixteen elements that are predominantly obtained from air and water. The other thirteen are typically taken up by plant roots. Each of these fundamental components plays at least one distinct role in the development of plants. As a part of a method to ensuring appropriate plant nutrition and minimizing the harmful impacts of fertilizers on the environment, PGPR has been promised. In order to reduce the demand for fertilizers and minimize the buildup of nitrates and phosphates in agricultural soils, PGPR may boost nutrient uptake from soils. As known, phosphorus and nitrogen are the principal nutrients limiting plant growth and an essential macronutrient needed for plant growth (Podile and Kishore, 2006). In addition, some PGPR encourage the development of roots, which is accomplished by the creation of phytohormones like indole acetic acid (Kloepper *et al.*, 2007)

Conclusion

In this manuscript, we identified that the main obstacles to increasing the production of chickpea crops in India are biotic stressors. To address the problem of the nation's nutritional security, it is vital to reduce the negative effects of these pressures on the pulse crops; productivity and production. Future of chickpea crop is bright because it is also basic food crop. It is a crop that uses few inputs and is adapted to use less water. We have highlighted several biotic stresses that can affect chickpea production, including *Fusarium wilt, Ascochyta blight, Botrytis grey mould, Pod borers* and *Black cutworm*. While several management strategies, including cultural and chemical control measures have been suggested for mitigating the impact of these biotic stresses, *fusarium* wilt is the major disease in chickpea crop and it can be control by using various different strategies such as bicontrol agent, agronomical practices and also using plant extract. The use of resistant varieties has also shown to be an effective approach. Plant breeders have developed several chickpea varieties that are resistant to one or more of these biotic stresses. Therefore, planting resistant chickpea varieties can be an important component of an integrated pest management strategy for controlling biotic stresses in chickpea. By using resistant varieties in conjunction with other management strategies, farmers can improve the resilience of chickpea crops to biotic stresses and achieve higher yields and better quality produce. Apart from this, PGPR mediated strategy is an emerging ray of hope in this scenario that supports plant yield by mitigating stress ethylene level. It is recommended and urged to use PGPR as a method for bioremediation and biocontrol. PGPR offers everything of the best. Potential to serve as a bio-fertilizer that might be effective an ecology that is improved by improvements in productivity. The successful adoption of resistant chickpea varieties coupled with PGPR utilization by farmers will lead to reduced use of chemical pesticides, thus promoting sustainable agriculture and reducing environmental impacts.

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Conflict of interest

The authors declare that they have no conflict of interest.

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