Phytology

Fusarium soil isolate shows increased IAA production under variable culture parameters

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Abstract

The current study reports the effect of various culture parameters on the indole acetic acid (IAA) by non-pathogenic *Fusarium* sp. isolated from an agricultural field of Murshidabad district in West Bengal, India. Auxin is one of the principal plant growths promoting substances that influences the overall growth developmental processes in angiosperms. The *Fusarium* sp. was isolated by soil dilution plate technique on selective pentachloronitrobenzene (PCNB) medium. The isolate was identified and subsequently characterized by the routine morphological studies. Various physiological parameters viz., growth media, carbon and nitrogen sources, incubation temperature and pH of the culture medium were taken into account for determining their effect on IAA production and subsequent optimization of the culture conditions. IAA production was found to be highest in CD broth and Asthana and Hawker's broth equally (380 µg/ml). Among the carbohydrate and nitrogen sources used, maltose (390 µg/ml) and sodium nitrate (390µg/ml) respectively were found to be most conducive for IAA production. Interestingly, in acidic pH-4, IAA production was completely ceased. Maximum IAA production was recorded at pH-7 (400 µg/ml) while optimum temperature for IAA production was found as 27^0 C (390 µg/ml). Though the isolate was found quite promising in producing IAA in wide ranges of temperature and pH. This IAA producing *Fusarium* isolate could turn out to be a potential candidate for improving agricultural output.

Keywords: Auxin, Culture medium, *Fusarium*, Carbon, Nitrogen, pH, Temperature etc.

Introduction

Indole acetic acid is one of the most important physiologically active auxins. IAA is a common product of tryptophan metabolism by variety of microorganisms including Plant Growth Promoting Fungi (PGPF). Similar to plant growth promoting rhizobacteria (PGPR), some nonpathogenic rhizospheric fungi were reported to promote plant growth upon root colonization and were functionally designated as 'plant growth promoting fungi' (Hyakumachi, 1994) [1]. They were potentially applied in agriculture as biostimulator, biofertilizer and/or biocontrol agents. As biostimulator, they were reported to synthesize hormones such as indole acetic acid (IAA) and gibberellin (GA) and transport these in plants (Leitaoa & Enguita, 2016) [13]. Production of indole acetic acid (IAA) by soil microbes is an important feature for improvement of plant growth. The beneficial soil microbes are known to induce plant growth by a variety of mechanisms, viz., phytohormones production, HCN production, siderophore production, ammonia production and antagonism activities. Microorganisms isolated from rhizosphere of plant roots have been shown to be quite potential in synthesizing phytohormones in significant amounts as a part of their metabolism. Among the phytohormones, auxin stimulates the overall growth and development of plants. It has marked effects on initiation of roots and better development of root hairs, thus effectively increases the absorptive surface of plant roots for uptake of water and nutrients. The hormone can be synthesized endogenously by the plants themselves but also by diverse soil microorganisms including bacteria (Idris *et al*., 2007; Shahab *et al*., 2009) [10,17], fungi (Stein *et al*., 1985; Hasan, 2002) [18,8] and algae (Finnie and Van Staden, 1985; Prasanna *et al*., 2010) [5,16]. Tryptophan is the key precursor for biosynthesis of IAA in plants and microorganisms, and application of exogenous tryptophan increases IAA production. Root exudates in the form of rhizodeposition are the main sources of tryptophan in soil. Several biosynthetic pathways for IAA production exist, sometimes in parallel in the same organism (Davies, 1995) [4]. There are four intermediate pathways for production of IAA from tryptophan: (i) via formation of indole-3-pyruvic acid and indole-3- acetic aldehyde which was reported in majority of microorganisms such as bacteria and phytopathogenic fungi; (ii) via tryptamine formation; (iii) via indole-3-acetamide formation as in A. tumefaciens and Rhizobium; and (iv) via acetonitrile formation (Fig. 1).

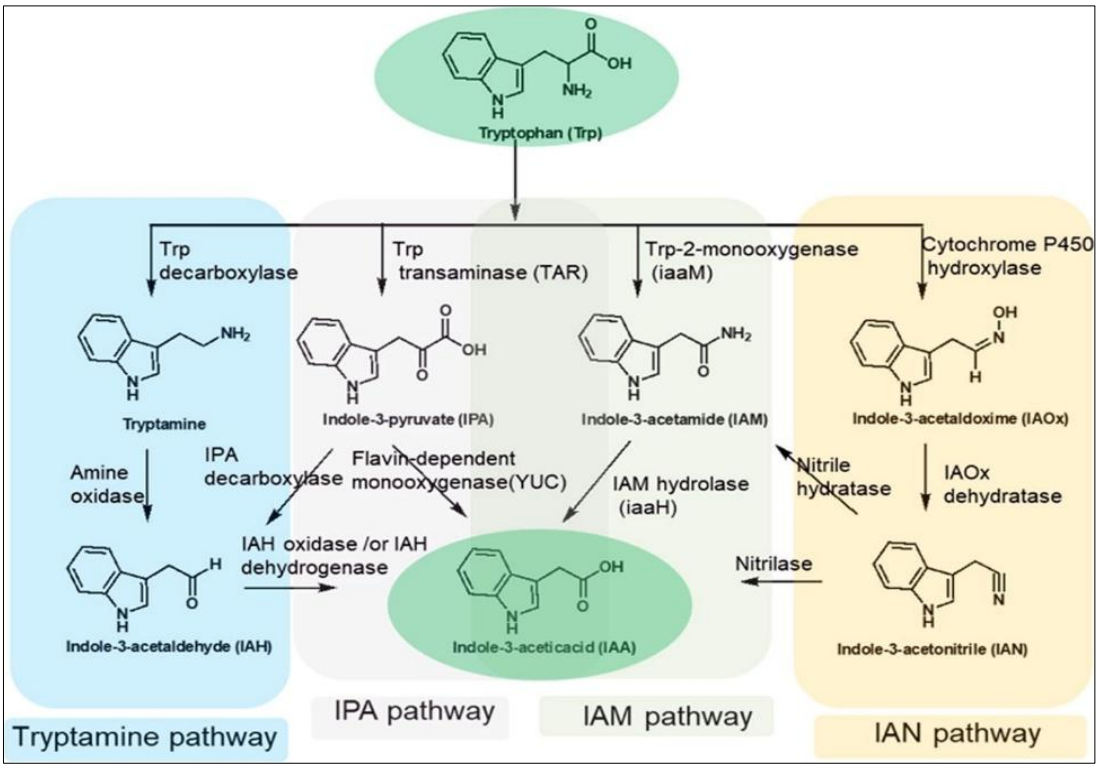

Fig 1: Modes of Trp. Dependant IAA production by microbes *(Image Credit: Menon, et al., 2022)* [15]

Tryptophan independent biosynthesis of IAA was found in *Azospirillum* (Costacurta and Vanderleyden, 1995) [2], *Anabaena* (Prasanna *et al*., 2010) [16]. The genus *Fusarium* represents one of the important groups of filamentous fungi belonging to Ascomycotina phylum which is abundant in soils as free-living saprophytes, pathogens, endophytes, and known to produce a range of mycotoxins that can adversely affect livestock and humans. *Fusarium* species produce three types of spores: banana-shaped 3-4 celled macroconidia, 1-2 celled microconidia and unicellular thick-walled chlamydospores.

The non-pathogenic isolates of *Fusarium* with potential plant growth promoting attributes can be explored to increase crop productivity. This will eventually reduce the rampant use of chemical fertilizers in agricultural fields and minimize their detrimental effects on ecosystems. The objective of the present work was to evaluate the efficiencies of *Fusarium* soil isolate for production of IAA in varying cultural parameters. The optimization of IAA production by the *Fusarium* species in respect to different culture conditions viz., media, temperature, pH, carbon and nitrogen sources will eventually prove to be of immense importance to agriculture.

Materials and Methods

Collection of soil sample

Soil sample at a depth of 6 cm was collected from an agricultural field of Rakhaldaspur village located in Raninagar block-2 (near Indo-Bangaladesh boader region) of Murshidabad district in West Bengal. The agricultural field was placed in close vicinity of Padma River and cultivated for various crops throughout the year where no *Fusarium* diseases were reported previously. Soil sample was collected from the rhizospheric regions of rice plants as the fungus was reported to be present abundantly in the root regions.

Isolation and characterization of *Fusarium* spp.

Fusarium sp. was isolated directly from the soil by dilution plate technique. 1 g of soil from each agricultural field was mixed in 10 ml sterile water separately to prepare the crude soil suspension. From the crude suspension, $1/10^{th}$ and $1/100^{th}$ dilutions were prepared and were subsequently inoculated on potato sucrose agar (PSA) medium [composition (g/l): potato extract 200, sucrose 20, agar 20, pH 6] supplemented with pentachloronitrobenzene (0.1%) and chloramphenicol (0.01%) for selective growth of *Fusarium* spp. The plates were incubated at 28^0C for 5-7 days until visible sign of colony growth occurred. Later on, the fungal isolates were grown on Czapek's Dox (CD) agar medium [composition (g/l): sodium nitrate 2, di potassium hydrogen phosphate 1, magnesium sulphate 0.5, potassium chloride 0.5, ferrous sulphate 0.01, sucrose 30, agar 15, pH 6] and potato carrot agar (PCA) medium [composition (g/l): grated potato 20, grated carrot 20, agar 15, pH 6] to characterize the *Fusarium* isolates in terms of their growth, colony morphology, sporulation and pigmentation. Pathogenicity tests were also performed to prove the nonpathogenic nature of the isolate by calculating percentage of germination of seeds and vigor index.

Assay of Indole Acetic Acid (IAA) production

The *Fusarium* isolate was tested for their ability to produce IAA in CD broth amended with L-tryptophan (1000 ppm) and incubated at 28°C for 14 days. One ml each of culture filtrate and uninoculated broth (control) were mixed with 2 ml of Salkowski's reagent and incubated at room temperature for 25 min. The intensity of pink color developed by the reaction was measured immediately at 530 nm (Gordon & Weber, 1951) [6]. Amount of IAA produced was calculated using the standard curve prepared with known concentration of pure IAA.

Study of effect of different tryptophan concentrations on IAA production

The promising *Fusarium* isolate was grown CD broth supplemented with three different concentrations of tryptophan viz., 1000 ppm, 1500 ppm and 2000 ppm at 28°C with a control set having no tryptophan. After 14 days of incubation, concentration of IAA in the culture broth was estimated using Salkowski's reagent. At the same time, mycelial dry weights of the soil isolates were also determined to draw a correlation between growth and IAA production.

Study of effect of different culture media on IAA production

The IAA producer was further selected to study the effect of various culture media on its IAA production. Eight different broth media, viz., Potato Dextrose broth, Potato Carrot broth, Czapek's Dox broth, Yeast Extract Mannitol broth, Sabouraud's broth, Nutrient broth, Richard's broth, and Asthana & Hawker's broth were prepared, and supplemented with tryptophan (1000 ppm). The *Fusarium* isolate was inoculated in the media and incubated for 14 days at 28°C. IAA production was estimated following Salkowski's method and growth was determined by measuring mycelial dry weights.

Study of effect of various carbohydrate and nitrogen sources on IAA production

Different sets of modified (without carbohydrate) CD broth were prepared supplemented with 3% of the respective carbohydrate source viz., dextrose, maltose, sucrose, lactose, mannitol, sorbitol. Likewise, modified (without nitrogen source) CD broths were prepared supplemented with 0.2% of the respective nitrogen source viz., sodium nitrate, sodium nitrite, peptone, ammonium sulphate, glycine and asparagine. Each of the media was supplemented with tryptophan (1000 ppm), inoculated with 5 mm mycelial disc of the selected fungal isolate and incubated for 14 days at 28°C. IAA production was estimated by Salkowski's reagent and mycelial dry weights were also recorded as a measurement of growth.

Study of effect of different pH and temperature on IAA production

Different sets of CD broth were prepared and pH range from 4-10 was adjusted using dilute HCl or NaOH. The broth sets were supplemented with tryptophan (1000 ppm) and the selected *Fusarium* isolate was inoculated in the broth medium and incubated for 14 days at 28°C. For the study of effect of temperature, the fungal isolate was inoculated in four CD broths and incubated at four different temperatures viz., 14°C, 27°C, 32°C and 37°C. IAA production was estimated by Salkowski's reagent and mycelial dry weights were also recorded as a measurement of growth.

Results

Isolation and characterization of *Fusarium* spp.

On selective peptone PCNB agar medium the several fungal colonies with similar morphology had appeared. The fungal isolate, designated as KUSF2303 was selected for further study, based on initial screening with respect to several parameters viz., conidia formation, pigmentation, growth potential etc. The isolate developed white, circular, compact, irregular margin and was fast growing, produce yellow brown pigment on PDA and CDA media but no pigment on PCA medium (Fig.2). Macroconidia were moderately abundant, straight, slender, short sized (10-15 µm X 2.0-2.25 µm). No. of septa were 3, apical cell was extremely tapering and the basal cell was acute (Fig.3). Microconidia were also moderately abundant, elliptical, pyriform, slightly curved; medium sized (5.25-8.50 µm X 1.75-2.0 µm) with number of septa ranges from 0-1. Conidiogenous cells were monophialides. Chlamydospores were absent even after 4 weeks of growth on both PCA and SNA media. Based on Leslie and Summerell *Fusarium* Laboratory Manual (2006) [14], the isolate was identified as a *Fusarium* sp.

Fig 2: Colony morphology of SF2303

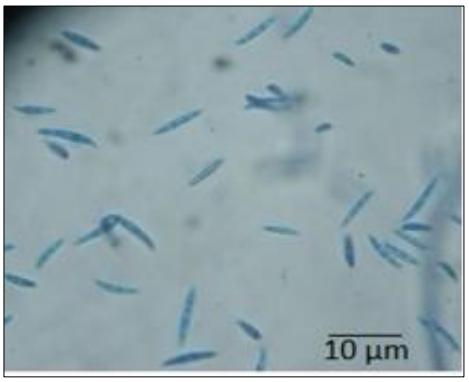

Fig 3: Conidia morphology of SF2303

Fig 4: IAA production by SF2303 in different trp. conc.

Effect of different tryptophan concentrations on IAA production

Since soil microorganisms biosynthesized IAA both via tryptophan dependent and independent pathways, IAA production of the *Fusarium* isolates was assayed by growing them in CD broth with or without tryptophan. The isolate could produce IAA in absence of tryptophan, although concentrations of IAA produced in absence of tryptophan were lesser than that produced in presence of tryptophan (Fig.4). IAA production by the *Fusarium* isolates increased with increase in tryptophan concentration (Table 1), although increased tryptophan concentration did not affect the growth of the isolates. The isolate SF2303 was found to be most potent producing maximum IAA (490 µg/ml in presence of 2000 ppm tryptophan).

Table 1: IAA production of the *Fusarium* isolates at varying tryptophan concentrations*

Sl no	Isolate no.	Control		Tryptophan concentration (ppm)					
				1000		1500		2000	
		Mycelial dry wt. (g)	IAA production (µg/ml)	Mycelial dry wt. (g)	IAA production (µg/ml)	Mycelial dry wt. (g)	IAA production (µg/ml)	Mycelial dry wt. (g)	IAA production (µg/ml)
1.	SF2303	0.313	40	0.345	390	0.323	450	0.347	490

**data taken after 14 days of incubation in CD broth*

4.2.1.2. Effect of culture media on IAA production

Isolate SF2303 was tested for its production of IAA in eight different culture media in presence of the tryptophan. Maximum IAA production (380 µg/ml) was observed in Czapek's Dox broth and in Asthana & Hawker's Broth, and minimum IAA production (170 µg/ml) was found in Potato Carrot broth (Table 2; Fig. 5). In both cases, IAA production was directly related to mycelial growth.

Table 2: IAA production of SF2303 in different culture media

Sl. No.	Culture media	Mycelial dry wt. (g)	IAA production (µg/ml)
1.	Potato Dextrose Broth	0.288	250
2.	Potato Carrot Broth	0.087	170
3.	Czapek's Dox Broth	0.319	380
4.	Yeast Mannitol Broth	0.277	340
5.	Sabouraud's Broth	0.295	330
6.	Nutrient Broth	0.188	180
7.	Richard's Broth	0.301	260
8.	Asthana & Hawker's Broth	0.312	380

**data taken after 14 days of incubation*

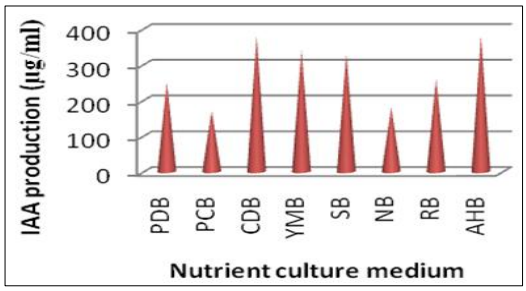

Fig 5: IAA production in different media

4.2.1.3. Effect of carbohydrate and nitrogen sources on IAA production

Isolate SF2303 was tested for its IAA production in modified CD broths containing any of the seven carbohydrates or six nitrogen sources in presence of the tryptophan. Maximum IAA production was observed in broth containing maltose or sucrose as carbohydrate source and sodium nitrate as nitrogen source (Table 3; Fig. 6). Minimum IAA production was found in broth containing starch or glutamine. In all cases, IAA production was directly related to growth of the fungal biomass.

Table 3: IAA production of SF2303 in presence of various carbohydrate and nitrogen sources

Sl no	Carbohydrate source	Mycelial dry wt. (g)	IAA production (µg/ml)
1.	Dextrose	0.315	350
2.	Sucrose	0.325	380
3.	Sorbitol	0.233	270
4.	Mannitol	0.214	250
5.	Lactose	0.236	240
6.	Maltose	0.279	390
7.	Starch	0.021	50
8.	Control	0.009	-
Nitrogen source			
1.	Peptone	0.230	280
2.	Sodium nitrate	0.320	390
3.	Sodium nitrite	0.296	380
4.	Glycine	0.298	370
5.	Asparagine	0.267	220
6.	Glutamine	0.258	200
7.	Control	0.018	-

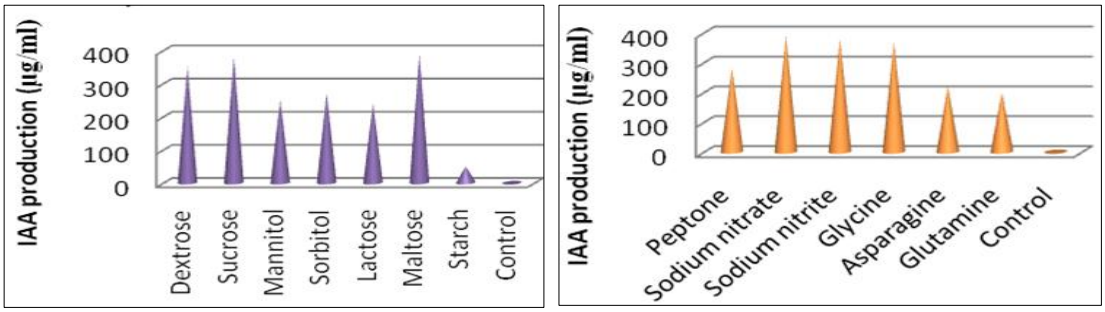

Fig 6: Effect of carbohydrate (upper) and nitrogen (lower) sources on IAA production of SF2303

4.2.1.4. Effect of different temperature and pH on IAA production: Isolate SF2303 was tested for its IAA production in CD broths in presence of tryptophan incubated at different temperatures and in varying pH range. Maximum IAA production was observed in culture incubated at 27°C and in broth having neutral pH (Table 4; Fig. 7). In these conditions, the isolate also showed maximum growth. Hence, IAA production was directly proportion to the growth of the fungal biomass.

Table 4: IAA production of SF2303 at varying temperature and pH

Growth conditions		Mycelial dry wt. (g)	IAA production (µg/ml)
Temperature (˚C)	14	0.288	310
	27	0.320	390
	32	0.311	350
	37	0.237	280
pH	4	-	-
	5	0.116	200
	6	0.299	360
	7	0.314	400
	8	0.291	370
	9	0.298	350
	10	0.274	300

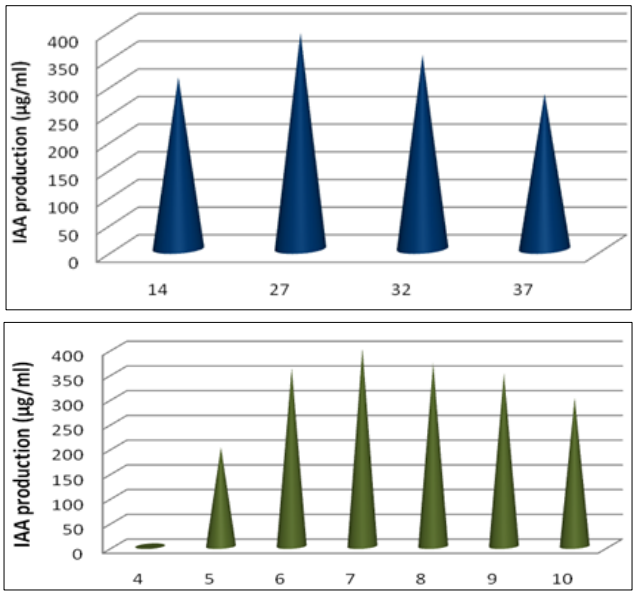

Fig 7: Effect of temperature (upper) and pH (lower) on IAA production of SF2303

Discussion

F. oxysporum isolated from rhizosphere and rhizoplane of melochia (*Corchorus olitorius*), sesame (*Sesamum indicum*) and soyabean (*Glycine max*) produced IAA (100-140 µg/ml) when grown in 1% peptone and 1% glucose-Czapek's medium at 28°C for 7 days (Hasan, 2002) [8]. *F. delphinoides* isolated from chickpea rhizosphere showed tryptophan dependent IAA production (Kulkarni *et al*., 2011) [12]. Significantly, with the increase in tryptophan concentrations, all the *Fusarium* isolates were found to produce IAA in higher amount and isolate SF2303 produced highest IAA (490 µg/ml) in presence of L-tryptophan (2000 ppm)

In *Klebsiella* SN 1.1 low level (12.6 ppm) of IAA production was recorded without tryptophan addition and IAA production increased with an increase to 0.2% (v/v) tryptophan concentration (Chaiharn & Lumyong, 2011) [3]. Since the *Fusarium* isolates produced IAA both in presence and absence of tryptophan, tryptophan-dependant as well as tryptophan-independent pathways of IAA biosynthesis may exist in these isolates (Prasanna *et al*., 2010) [16].

Studying the effects of various culture parameters on IAA production of the *Fusarium* isolate SF2303, highest IAA production was found in Czapek's Dox broth and Asthana & Hawker's broth medium (Table 2). Among the carbohydrate and nitrogen sources used, maltose and sodium nitrate respectively were found to be most stimulatory in IAA production (Table 3). Temperature 27°C and pH 7 were found to be most favorable for IAA production (Table 4). Plant growth promoting *Streptomyces* sp. VSMGT1014 isolated from rice rhizosphere produced maximum IAA at 30°C and pH 8 (Harikrishnan *et al*., 2014) [7]. In all cases, IAA production was directly related to growth of the organism. IAA production in *A. niger* was studied (Bilkay et. al. 2010) [1] for 5-15 days and maximum production was observed on day 6. Maximum IAA production and growth were observed at 25 °C. It was observed that IAA production was maximized at pH 6.0. Islam and Datta (2015) [11] reported that soil borne *Fusarium* isolates produced considerable amount of IAA in culture filtrates and promoted the growth of gram and cucumber seedlings.

Conclusion

Commercial production of IAA by soil microbes could help in boosting agriculture. In presented study an attempt has been made to isolate the most potential IAA producing *Fusarium* species. The culture medium and conditions were optimized for the IAA producing isolate in order to increase IAA production. This work proved that with careful selection of nutritional and physical factors, the yield of IAA can be enhanced. In the current study, the increase in IAA production was quite satisfactory which will be helpful for cost effective production of the plant growth regulator in commercial scales. As the soil isolate is a nonpathogenic one, it could eventually emerge as a promising candidate in agricultural sector as a potential biofertilizer.

References

1. Bilkay IS, Karakoc S, Aksoz N. Indole-3-acetic acid and gibberellic acid production in *Aspergillus niger*. Turkish Journal of Biology. 2010;34(1):313-318.
2. Costacurta A, Vanderleyden J. Synthesis of phytohormones by plant-associated bacteria. Critical Reviews in Microbiology. 1995;21(1):1-18.
3. Chaiharn M, Lumyong S. Screening and optimization of indole-3-acetic acid production and phosphate solubilization from rhizobacteria aimed at improving plant growth. Current Microbiology. 2011;62(1):173-181.
4. Davies PJ. The plant hormones: their nature, occurrence and functions. In: Davies PJ, editor. Plant hormones:

physiology, biochemistry and molecular biology. Dordrecht: Kluwer Academic Publishers, 1995, p1-12.
5. Finnie JF, Van Staden J. Effect of seed weed concentrate and applied hormones on in vitro cultured tomato roots. Journal of Plant Physiology. 1985;120:215-222.
6. Gordon SA, Weber RP. Colorimetric estimation of indoleacetic acid. Plant Physiology. 1951;26(1):192.
7. Harikrishnan H, Shanmugaiah V, Balasubramanian N. Optimization for production of indole acetic acid (IAA) by plant growth promoting *Streptomyces* sp. VSMGT1014 isolated from rice rhizosphere. International Journal of Current Microbiology and Applied Sciences. 2014;3(8):158-171.
8. Hasan HAH. Gibberellin and auxin production by plant root fungi and their biosynthesis under salinity-calcium interaction. Rostlinna Vyroba. 2002;48(3):101-106.
9. Hyakumachi M. Plant-growth-promoting fungi from turfgrass rhizosphere with potential for disease suppression. Soil Microorganisms. 1994;44:53-68.
10. Idris EE, Iglesias DJ, Talon M, Borriss R. Tryptophan-dependent production of indole-3-acetic acid (IAA) affects level of plant growth promotion by *Bacillus amyloliquefaciens* FZB42. Molecular Plant-Microbe Interactions. 2007;20(6):619-626.
11. Islam R, Datta B. Indole acetic acid production by *Fusarium* spp. and their growth promoting effects on gram and cucumber seeds. International Journal of Innovative Research and Advanced Studies. 2015;2(2):1-4.
12. Kulkarni GB, Sajjan SS, Karegoudar TB. Pathogenicity of indole-3-acetic acid producing fungus *Fusarium delphinoides* strain GPK towards chickpea and pigeon pea. European Journal of Plant Pathology. 2011;131(3):355.
13. Leitao AL, Enguita FJ. Gibberellins in *Penicillium* strains: challenges for endophyte-plant host interactions under salinity stress. Microbiological Research. 2016;183:8-18.
14. Leslie JF, Summerell BA. The Fusarium laboratory manual. Ames (IA): Blackwell Publishing, 2006.
15. Menon BRK, *et al*. Halogenases for biosynthetic pathway engineering: Toward new routes to naturals and non-naturals. Catalysis Reviews, 2020, 1-59.
16. Prasanna R, Joshi M, Rana A, Nain L. Modulation of IAA production in cyanobacteria by tryptophan and light. Polish Journal of Microbiology. 2010;59(2):99-105.
17. Shahab S, Ahmed N, Khan NS. Indole acetic acid production and enhanced plant growth promotion by indigenous PSBs. African Journal of Agricultural Research. 2009;4(11):1312-1316.
18. Stein A, Fortin JA, Vallee G. Enhanced rooting of *Picea mariana* cuttings by ectomycorrhizal fungi. Canadian Journal of Botany. 1985;68:492-498.