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Tafgor Induced Changes in the Growth and Plant Growth Promoting Traits of Bacteria Isolated from Tomato Crop Field

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A B S T R A C T

The persistence of tafgor pesticide and their residues in tomato crop fields could cause adverse impact on the non-target organisms. With this view, the present study was initiated to observe the impact of tafgor on the bacteria prevalent in tomato crop field soil. Bacteria are important component in the soil ecosystem as they play a vital role in nutrient cycling and promote the growth of plants. In this study, the effect of Tafgor pesticide on the growth of *Bacillus licheniforms, Bacillus cereus* and *Paenibacillus polymyca* and their plant growth promoting traits like indole-3-acetic acid (IAA) production and siderophore production were assayed. The findings of this study reveal that tafgor significantly decreased the bacterial growth and consequently reduced the IAA and siderophore production. Thus, the usage of tafgor could alter the bacterial diversity and interfere with the nutrient cycle and plant growth, which may affect the crop yield and quality.

***Key words*:** Tafgor, *Bacillus sp. Pseudomonas polymyca,* Indole-3-acetic acid (IAA), Siderophore

The minimization of pesticide impact on non-target organisms like bacteria, fungi, insects are of prime concern. Only 5% of the pesticides applied reach the target pest, rest of it contaminates the soil and water bodies. The constant leaching of these pesticide residues contaminates the environment, causing multifaceted toxicity to the biota [1]. Tafgor is a systemic organophosphorus insecticide applied in tomato, onion, chilli, cauliflower, okra, mango, brinjal, cabbage crop fields to kill sucking and caterpillar pest bug, stem borer, shoot fly, beetles, thrips, aphids, mites etc., long term application of dichloropropane-dichloropropene, fosthiazate and chloropicrin reduces the bacterial biomass in the agricultural field [2]. Bacteria are known to produce phytohormones, which play an important role in various physiological processes [3]. Several bacteria like (*Pseudomonas fragi, Bacillus cereus, Rhizobium, Bacillus aerius, Bacillus amyloliquenfaciens, Azotobacter,* fluorescent *Pseudomonas, Mesorhizobium, Azospirillum brasilense, Serratia spp, Enterobacter sp, Bacillus subtilis, Methylobacterium genus, Pseudomonas fluorescens, P. chlororaphis, Sphingomonas sp.* produce siderophore and IAA [4-12]. Keeping in this view, the present study was initiated to study the impact of Tafgor pesticide on the growth of tomato crop field soil bacteria and to assay the production of IAA and siderophore.

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MATERIALS AND METHODS

Determination of growth curve of bacteria in minimal salt medium under Tafgor pesticide stress

100 µl (21 × 10^{-9} cfu / ml) of 48 hours of *Bacillus licheniforms* nutrient broth culture was inoculated into conical flask containing 100 ml of sterilised minimal salt medium and Tafgor pesticide was added (15 ppm and 30 ppm) separately and kept in the orbital shaker at 150 rpm at 30°C for 96 hours in triplicates. Simultaneously, control was maintained without addition of pesticide in minimal salt medium containing bacteria. 3 ml of sample was withdrawn and the optical density at initial, 4^{th}, 8^{th}, 16^{th}, 24^{th}, 48^{th}, 72^{nd} and 96 hours OD was read at 620 nm using colorimeter. Simultaneously, colony forming units on nutrient agar plates of each test and bacterial control were recorded from 100 µl of 10^{-9} dilution factor. Same procedure was followed for *Bacillus cereus* and *Paenibacillus polymyca*.

Impact of Tafgor pesticide on IAA production by Bacillus licheniforms, Bacillus cereus and Paenibacillus polymyca

Indole-3-acetic acid synthesized by bacterial strains was quantitatively evaluated by the method of Gordon and Weber [13] and later modified by Brick *et al.* [14]. Selected bacteria strains were grown in Luria Bertani (LB) broth. Luria Bertani broth (100 ml) having fixed concentration of tryptophan (100 mg/ml) and supplemented with 15 ppm and 30 ppm of recommended rate of each pesticide was inoculated with 1 ml culture of *Bacillus licheniforms* bacterial isolates (cfu/ml) and was incubated for seven days at 28 ± 2°C with shaking at 120 rpm. Simultaneously, control was maintained without addition of pesticide containing bacteria. After seven days, 5 ml of

culture of each treatment was centrifuged (9,000 rpm) for 15 minutes and an aliquot of 2 ml supernatant was mixed 100 µl of orthophosphoric acid and 4 ml of salkowsky reagent (2% 0.5 M $FeCl_3$ in 35% per-chloric acid) and incubated at 28±2°C in darkness for 1 hour. The absorbance of developed pink colour was read at 530 nm. IAA concentration in the supernatant was determined using a calibration curve of pure IAA as a standard. Cfu also was determined simultaneously. Same procedure was followed for *Bacillus cereus* and *Paenibacillus polymyca*.

Impact of Tafgor pesticide on siderophore production by Bacillus icheniforms, Bacillus cereus and Paenibacillus polymyca [15]

Siderophore production was studied by inoculating *Bacillus licheniforms* in conical flask containing 1200 ml succinate medium (K_2HPO_4 6.0, KH_2PO_4 3.0, $MgSO_4$ 0.2, $(NH_4)_2SO_4$ 1.0 and succinic acid 4.0 gm L^{-1}, pH 7.0) and supplemented with 15 ppm and 30 ppm of Tafgor pesticide. *Bacillus licheniformis* was inoculated and incubated in succinate medium for 24 – 72 hours at 28°C with constant shaking at 120 rpm on rotary shaker. Simultaneously, control was maintained without addition of pesticide. After incubation, the fermented broth were centrifuged at 10, 000 rpm in cooling centrifuge at 4 ºC for 10 minutes and cell free supernatant was then mixed with 0.5 ml CAS (Chrome Azurol Solution) solution and 10 µl shuttling solution (sulfosalicyclic acid). The optical density was read in the spectrophotometer at absorbance 630 nm. The percentage of siderophore units was estimated as the proportion of CAS color shifted using the formula [(Ar-As) / Ar] × 100, were Ar is the A630 nm of reference sample (medium + CAS assay solution + shuttle solution) and As is the A630 nm of the sample (supernatant + CAS assay solution + shuttle solution). Colony forming units (cfu) also was determined simultaneously. Same procedure was followed for *Bacillus cereus* and *Paenibacillus polymyca*.

Statistical analysis

The data obtained were subjected to one way and two-way ANOVA using version SPSS 16.0.

RESULTS AND DISCUSSION

The growth curve of bacteria displayed in (Fig 1-9), reveal that the lag phase, log phase and decline phase lasted till 16 hours, 56 hours and 24 hours in terms of optical density (OD) respectively, irrespective of the species and tafgor pesticide concentration. Dose-dependent decline in bacterial population in terms of optical density (Table 1-2) and colony forming units (cfu) (Table 3-4) was evinced in bacteria exposed to Tafgor, irrespective of the species.

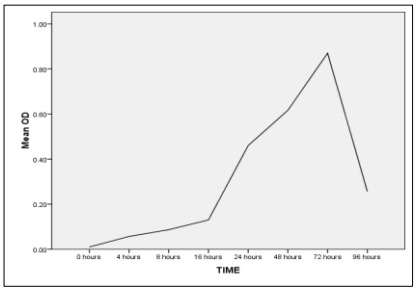

Fig 1 Growth curve (OD) of *Bacillus licheniforms* in minimal salt medium control

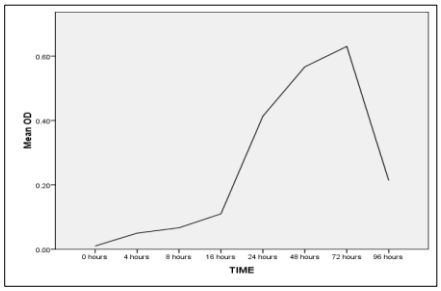

Fig 2 Growth curve (OD) of *Bacillus licheniforms* in minimal salt medium containing 15 ppm of Tafgor pesticide

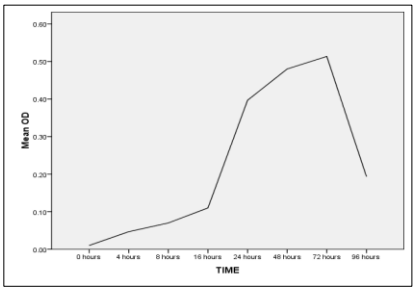

Fig 3 Growth curve (OD) of *Bacillus licheniforms* in minimal salt medium containing 30 ppm of Tafgor pesticide

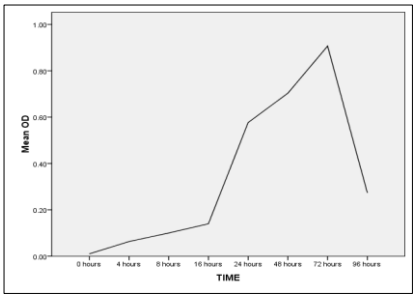

Fig 4 Growth curve (OD) of *Bacillus cereus* in minimal salt medium control

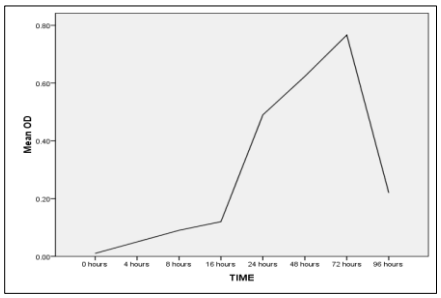

Fig 5 Growth curve (OD) of *Bacillus cereus* in minimal salt medium containing 15 ppm of Tafgor pesticide

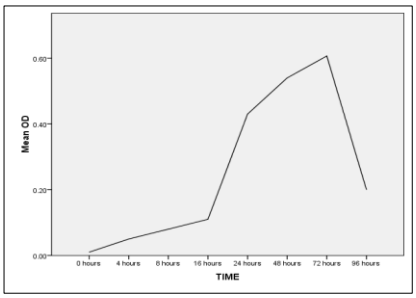

Fig 6 Growth curve (OD) of *Bacillus cereus* in minimal salt medium containing 30 ppm of Tafgor pesticide

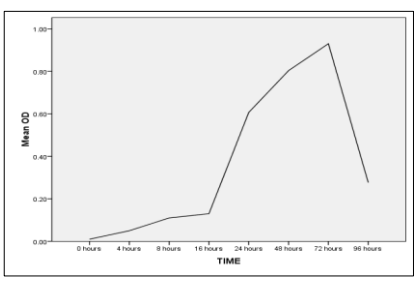

Fig 7 Growth curve (OD) of *Paenibacillus polymyca* in minimal salt medium control

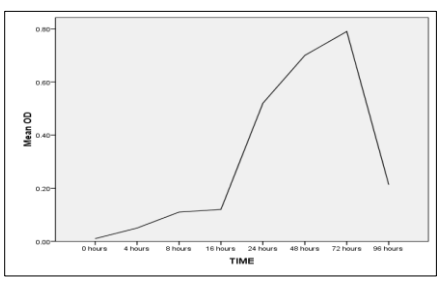

Fig 8 Growth curve (OD) of *Paenibacillus polymyca* in minimal salt medium containing 15 ppm of Tafgor pesticide

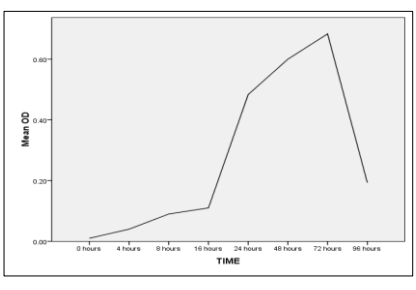

Fig 9. Growth curve (OD) of *Paenibacillus polymyca* in minimal salt medium containing 30 ppm of Tafgor pesticide

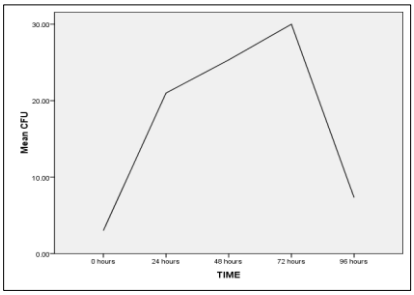

Fig 10 Growth curve of *Bacillus licheniforms* in minimal salt medium control (X 10^{-9} cfu /ml)

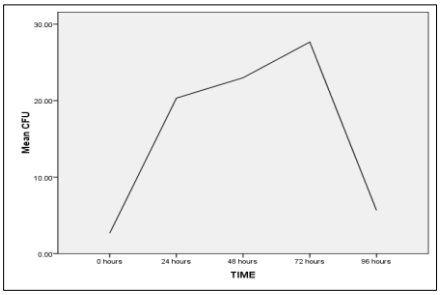

Fig 11 Growth curve of *Bacillus licheniforms* in minimal salt medium with Tafgor pesticide (15 ppm) (X 10^{-9} cfu /ml)

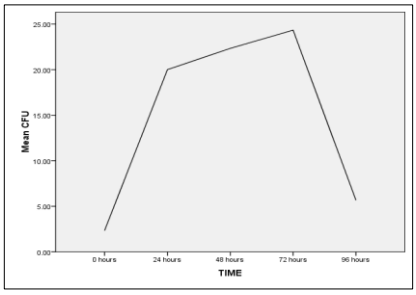

Fig 12 Growth curve of *Bacillus licheniforms* in minimal salt medium with Tafgor pesticide (30 ppm) (X 10^{-9} cfu /ml)

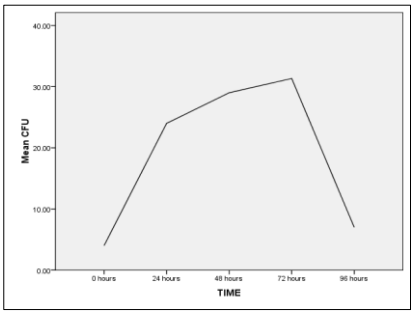

Fig 13 Growth curve of *Bacillus cereus* in minimal salt medium control (X 10^{-9} cfu /ml)

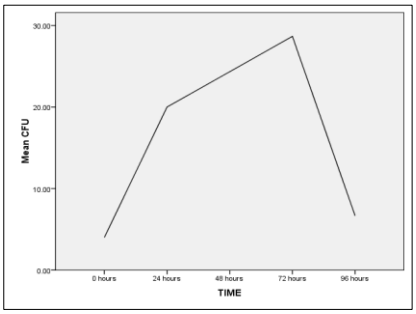

Fig 14 Growth curve of *Bacillus cereus* in minimal salt medium with Tafgor pesticide (15 ppm) (X 10^{-9} cfu /ml)

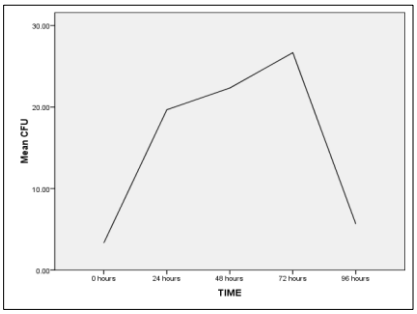

Fig 15 Growth curve of *Bacillus cereus* in minimal salt medium with Tafgor pesticide (30 ppm) (X 10^{-9} cfu /ml)

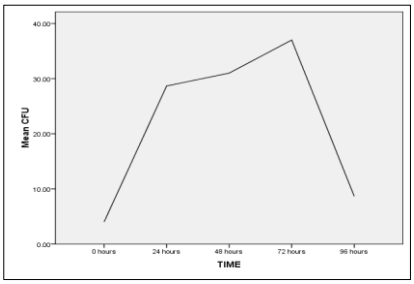

Fig 16 Growth curve of *Paenibacillus polymyca* in minimal salt medium control (X 10^{-9} cfu /ml)

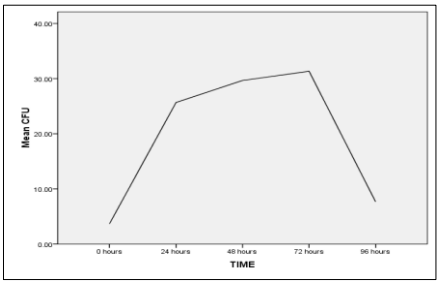

Fig 17 Growth curve of *Paenibacillus polymyca* in minimal salt medium with Tafgor pesticide (15 ppm) (X 10^{-9} cfu /ml)

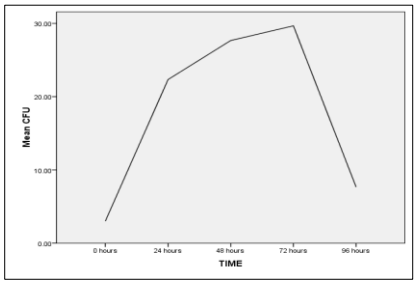

Fig 18 Growth curve of *Paenibacillus polymyca* in minimal salt medium with Tafgor pesticide (30 ppm) (X 10^{-9} cfu /ml)

Table 1 Variation in the growth (OD) of bacteria on exposure to Tafgor pesticide in minimal salt medium

Treatment	*Bacillus licheniforms*	*Bacillus cereus*	*Paenibacillus polymyca*
Control	0.3108^{a}	0.3467^{a}	0.3646^{a}
15 ppm	0.2575^{b}	0.2962^{b}	0.3142^{b}
30 ppm	0.2275^{c}	0.2533^{c}	0.2763^{c}
F value	1.710E3***	1.886E3***	4.848E3***
P	0.001	0.001	0.001

n = 3, Values are mean, ***Significant at P < 0.001, In a column, figures having dissimilar letters differ significantly according to Duncan New Multiple Range Test (DMRT)

Table 2 Growth of bacteria on exposure to Tafgor pesticide in minimal salt medium

Time	*Bacillus licheniforms*	*Bacillus cereus*	*Paenibacillus polymyca*
0 hours	0.0100^{h}	0.0100^{h}	0.0100^{h}
4 hours	0.0511^{g}	0.0544^{g}	0.0467^{g}
8 hours	0.0744^{f}	0.0900^{f}	0.1033^{f}
16 hours	0.1167^{e}	0.1233^{e}	0.1200^{e}
24 hours	0.4233^{c}	0.4989^{c}	0.5367^{c}
48 hours	0.5544^{b}	0.6222^{b}	0.7011^{b}
72 hours	0.6711^{a}	0.7600^{a}	0.8011^{a}
96 hours	0.2211^{d}	0.2311^{d}	0.2278^{d}
F value	2.287E4***	2.682E4***	9.124E4***
P	0.001	0.001	0.001

n = 3, Values are mean, ***Significant at P < 0.001, In a column, figures having dissimilar letters differ significantly according to Duncan New Multiple Range Test (DMRT)

Table 3 Variation in the growth (cfu) of bacteria on exposure to Tafgor pesticide in minimal salt medium

Treatment (×10^{9} cfu/ml)	*Bacillus licheniforms* (×10^{9} cfu/ml)	*Bacillus cereus* (×10^{9} cfu/ml)	*Paenibacillus polymyca* (×10^{9} cfu/ml)
Control	17.3333^{a}	19.0667^{a}	21.8667^{a}
15 ppm	15.8667^{b}	16.7333^{b}	19.6000^{b}
30 ppm	15.0000^{c}	15.5333^{c}	18.0667^{c}
F value	58.688***	242.111***	176.214***
P value	0.001	0.001	0.001

cfu- Colony forming units, ***Significant at P < 0.001, n = 3, Values are expressed as mean, In a column, figures having dissimilar letters differ significantly according to Duncan New Multiple Range Test (DMRT)

Irrespective of the bacterial species and tafgor concentration, the growth curve of bacteria depicted in (Fig 10-18, Table 3-4) exhibited similar growth pattern in terms of cfu

(lag phase: 24 hours; log phase: 48 hours and decline phase: 24 hours).

Table 4 Variation in the population of bacteria exposure to Tafgor pesticide in minimal salt medium

Time	*Bacillus licheniforms* (×10^9 cfu/ml)	*Bacillus cereus* (×10^9 cfu/ml)	*Paenibacillus polymyca* (×10^9 cfu/ml)
0 hours	2.7778^{e}	3.7778^{e}	3.5556^{e}
24 hours	20.4444^{c}	21.2222^{c}	25.5556^{c}
48hours	23.5556^{b}	25.2222^{b}	29.4444^{b}
72 hours	27.3333^{a}	28.8889^{a}	32.6667^{a}
96 hours	6.2222^{d}	6.4444^{d}	8.0000^{d}
F value	3.010E3***	5.771E3***	5.025E3***
P	0.001	0.001	0.001

cfu- Colony forming units, ***Significant at P < 0.001, n = 3, Values are expressed as mean, In a column, figures having dissimilar letters differ significantly according to Duncan New Multiple Range Test (DMRT)

Table 5 Impact of Tafgor pesticide IAA production by *Bacillus licheniforms*, *Bacillus cereus* and *Paenibacillus polymyca*

Treatment	Indole-3-Acetic Acid (µl/ml)		
	Bacillus licheniforms	*Bacillus cereus*	*Paenibacillus polymyca*
Control	0.7033 ± 0.00333^{a}	0.7333 ± 0.00333^{a}	0.8867 ± 0.00333^{a}
15 ppm	0.4867 ± 0.00333^{b}	0.5033 ± 0.00333^{b}	0.4067 ± 0.00333^{b}
30 ppm	0.2833 ± 0.00333^{c}	0.3050 ± 0.00500^{c}	0.2633 ± 0.00333^{c}
F value	3.970E3***	3.090E3***	9.592E3***
P	0.001	0.001	0.001

n = 3, values are mean ± Standard Error, ***Significant at P < 0.001, In a column, figures having dissimilar letters differ significantly according to Duncan New Multiple Range Test (DMRT)

Table 6 *Bacillus licheniforms*, *Bacillus cereus* and *Paenibacillus polymyca* population on the 7 days of Tafgor pesticide exposure of IAA production

Treatment (×10^9 cfu/ml)	*Bacillus licheniforms* (×10^9 cfu/ml)	*Bacillus cereus* (×10^9 cfu/ml)	*Paenibacillus polymyca* (×10^9 cfu/ml)
Control	17.3333 ± 0.33333^{a}	19.3333 ± 0.33333^{a}	18.6667 ± 0.33333^{a}
15 ppm	11.6667 ± 0.33333^{b}	13.3333 ± 0.33333^{b}	10.6667 ± 0.33333^{b}
30 ppm	10.3333 ± 0.33333^{c}	12.3333 ± 0.33333^{c}	9.3333 ± 0.33333^{c}
F value	124.333***	129.000***	229.333***
P value	0.001	0.001	0.001

cfu- Colony forming units, *** Significant at P < 0.001, n = 3, Values are expressed as mean ± Standard Error, In a column, figures having dissimilar letters differ significantly according to Duncan New Multiple Range Test (DMRT)

From the (Table 5), it is evident that IAA produced by *Bacillus licheniforms* significantly (F = 3.970E3; P < 0.001) declined on exposure to tafgor (control: 0.7033 ± 0.00333; 15 ppm: 0.4867 ± 0.00333; 30 ppm: 0.2833 ± 0.00333). Production of IAA by *Bacillus cereus* significantly (F = 3.090E3; P < 0.001; control: 0.7333 ± 0.00333; 15 ppm: 0.5033 ± 0.00333; 30 ppm: 0.3050 ± 0.00500) reduced on exposure to tafgor. Similar response was evinced with respect to *Paenibacillus polymyca* (control: 0.8867 ± 0.00333; 15 ppm: 0.4067 ± 0.00333; 30 ppm: 0.2633 ± 0.00333; F = 9.592E3; P < 0.001). Simultaneously, significant (F = 124.333, P < 0.001) decline in the *Bacillus licheniforms* population was evinced during IAA production (control: 17.3333 ± 0.33333 × 10^9 cfu / ml; 15 ppm: 11.6667 ± 0.33333 × 10^9 cfu / ml; 30 ppm: 10.3333 ± 0.33333 X10^9 cfu / ml). Similar response was elicited by *Bacillus cereus* (control: 19.3333 ± 0.33333 × 10^9 cfu / ml; 15 ppm: 13.3333 ± 0.33333 × 10^9 cfu / ml; 30 ppm: 12.3333 ± 0.33333 X10^9 cfu / ml; F = 129.000; P < 0.001) and *Paenibacillus polymyca* (control: 18.6667 ± 0.33333 × 10^9 cfu / ml; 15 ppm: 10.6667 ± 0.33333 × 10^9 cfu / ml; 30 ppm: 9.3333 ± 0.33333 × 10^9 cfu / ml; F = 229.333; P < 0.001) (Table 6).

Table 7 Impact of Tafgor pesticide Siderophore production by *Bacillus licheniforms*, *Bacillus cereus* and *Paenibacillus polymyca*

Treatment	Siderophore production (%)		
	Bacillus licheniforms	*Bacillus cereus*	*Paenibacillus polymyca*
Control	0.8133 ± 0.00333^{a}	0.8633 ± 0.00333^{a}	0.8767 ± 0.00333^{a}
15 ppm	0.4467 ± 0.00333^{b}	0.5267 ± 0.00333^{b}	0.4367 ± 0.00333^{b}
30 ppm	0.3367 ± 0.00333^{c}	0.4167 ± 0.00667^{c}	0.3167 ± 0.00333^{c}
F value	5.606E3***	2.437E3***	7.824E3
P	0.001	0.001	0.001

n = 3, values are mean ± Standard Error, ***Significant at P < 0.001, In a column, figures having dissimilar letters differ significantly according to Duncan New Multiple Range Test (DMRT)

Table 8 *Bacillus licheniforms*, *Bacillus cereus* and *Paenibacillus polymyca* population on the 7 days of Tafgor pesticide exposure of Siderophore production

Treatment (×10^9 cfu/ml)	*Bacillus licheniforms* (×10^9 cfu/ml)	*Bacillus cereus* (×10^9 cfu/ml)	*Paenibacillus polymyca* (×10^9 cfu/ml)
Control	10.6667 ± 0.33333^{a}	11.3333 ± 0.33333^{a}	10.3333 ± 0.33333^{a}
15 ppm	8.6667 ± 0.33333^{b}	10.3333 ± 0.33333^{b}	7.6667 ± 0.33333^{b}
30 ppm	7.3333 ± 0.33333^{c}	8.6667 ± 0.33333^{c}	6.3333 ± 0.33333^{c}
F value	25.333***	16.333**	37.333***
P value	0.001	0.01	0.001

cfu- Colony forming units, *** Significant at P < 0.001 and P < 0.01, n = 3, Values are expressed as mean ± Standard Error, In a column, figures having dissimilar letters differ significantly according to Duncan New Multiple Range Test (DMRT)

On exposure to tafgor pesticide, bacterial production of siderophore significantly declined, irrespective of all species (*Bacillus licheniforms:* control: 0.8133 ± 0.00333; 15 ppm: 0.4467 ± 0.00333; 30 ppm: 0.3367 ± 0.00333; F = 5.606E3; P < 0.001, *Bacillus cereus:* control: 0.8633 ± 0.00333; 15 ppm: 0.5267 ± 0.00333; 30 ppm: 0.4167 ± 0.00667; F = 2.437E3; P < 0.001, *Paenibacillus polymyca:* control: 0.8767 ± 0.00333; 15 ppm: 0.4367 ± 0.00333; 30 ppm: 0.3167 ± 0.00333; F = 7.824E3; P < 0.001). Moreover, the decrease in siderophore production was found to be dose-dependent. As the concentration of Tafgor increased, production of siderophore by bacteria decreased (Table 7). Furthermore, the population of Tafgor pesticide exposed bacteria significantly reduced during siderophore production, which could be the possible cause for significantly reduction in siderophore. (*Bacillus licheniforms:* control: 10.6667 ± 0.33333 × 10^9 cfu / ml; 15 ppm: 8.6667 ±

0.33333 × 10^9 cfu / ml; 30 ppm: 7.3333 ± 0.33333 × 10^9 cfu / ml; F = 25.333; P < 0.001, *Bacillus cereus:* control: 11.3333 ± 0.33333 × 10^9 cfu / ml; 15 ppm: 10.3333 ± 0.33333 × 10^9cfu / ml; 30 ppm: 8.6667 ± 0.33333 × 10^9cfu / ml; F = 16.333; P < 0.01, *Paenibacillus polymyca:* control: 10.3333 ± 0.33333 × 10^9 cfu / ml; 15 ppm: 7.6667 ± 0.33333 × 10^9 cfu / ml; 30 ppm: 6.3333 ± 0.33333 × 10^9 cfu / ml; F = 37.333; P < 0.001) (Table 8).

Dose dependent inhibition of bacterial population observed in this study is in agreement with the findings of Shetti and Kaliwal [16], who have also observed similar dose-dependent inhibitory effect on Imidacloprid on soil bacteria both under laboratory and field conditions. Further, they have also evinced that the toxic effect of Imidacloprid disappeared after a period of 28 days of application in the field. In agreement with the present findings, Shetti *et al.* [17] have also reported dose-dependent inhibition of growth of *Escherichia coli* due to Imidacloprid exposure in minimal salt medium. Imidacloprid induced toxicity in aquatic bacteria *Vibrio fischeri* [18]. Shetti and Kaliwal [19] have reported significant decrease in the growth of *Bacillus weihenstephanensis* exposed to imidacloprid (10^{-7} to 10^{-3} M) for a period of 96 hours in terms of optical density. In consistent with the present findings, Ahemad and Khan [20] have also evinced that pesticides (metribuzin, glyphosate, imidacloprid, thiamethoxam, hexaconazole, metalaxyl and kitazin) elicited dose-dependent decline in the production of siderophore, IAA, 2,3-dihydroxy benzoic acid and exo-polysaccharides by *Mesorhizobium sp.*As evinced in this study, Mohite [21] have also reported that *Bacillus megaterium, Lactobacillus acidophilus, Lactobacillus casei, Bacillus cereus* and *Bacillus subtilis* produce IAA.

Similarly, Ali *et al.* [22] have also observed that the bacterial strain *Bacillus, Pseudomonas, Escherichia, Micrococcus, Staphylococcus* genera produce IAA. In the opinion of Patten and Glick [23], the role of bacterial IAA is to stimulate plant growth and suppress diseases. Several growth and environmental conditions do influence the production of IAA by bacteria [24]. The present finding is in good accord with the observations of Ghosh *et al.* [25] who have also reported that bacteria like *Bacillus subtilis, Bacillus megatericus* and *Pseudomonas aerogenosa* produce siderophore. Siderophore producing bacteria (*E. coli, Pseudomonas fluorescence, Rhizopus sp.* and *Aspergillus flavus*) have been reported by Kannahi and Senbagam [26].

As observed in this study, Kumar *et al.* [27] have isolated siderophore producing *Bacillus sp* and *Enterobacter sp.* from soil. Similarly, Ahemad and Khan [28] have reported that adverse impact of pesticides on *Pseudomonas putida* strain isolated from rhizosphere soil samples of *Brassica compestris*. As the concentration of pesticides increased (fipronil, pyriproxyfen, imidacloprid and thiamethoxam) there was progressive decrease in the production of siderophore and IAA. In agreement with the findings, Chennappa *et al.* [29] have reported that production of IAA by *Azotobacter vinelandii, A. tropicalis, A. armeniacus and A. salinestris* isolated from paddy crop field soil was reduced due to pendimethalin, chloropyrifos, glyphosate and phorate exposure. Present findings collaborate with the observation of Aswathi *et al.* [30] who have evinced that *Pseudomonas fluorescens* evinced maximum tolerance to imidacloprid at lower concentration of imidacloprid (0.01%), pendimethalin (0.2%) and carbendazim (0.05%). Furthermore, *Pseudomonas fluorescens* produced siderophore and IAA.

The results are in confirmity with Panomkhum *et al.* [31] have reported that application of thiamethoxam in the Cassava cullivar Rayong decreased the bacterial population. On contrary, they have reported that the bacteria exhibited the ability to produce IAA and siderophore even in the presence of thiamethoxam. IAA and siderophore production by bacteria enhanced in the presence of organic fertilizer. Similar observations have been evinced by Tripti *et al.* [32] who have reported that pesticides reduced IAA production by *Burkholderia sp.* isolated from agricultural field soil at Dhanbad region, Jharkhand in a dose-dependent manner. The report of Swarupa and Kumar [33] were also similar, who have demonstrated that bacteria could use Chlorpyrifos as a sole source of carbon. The results are in accordance with those of Kumar [34] who have observed dose-dependent decline in siderophore production by *Pseudomonas fluorescens* as exposure to 25 and 200 ppm of pesticides like acephate, glyphosate, monocrotophos and phorate. The results obtained reveal that tafgor influences the growth and IAA and siderophore production by soil bacteria, which could affect the plant growth and also bacterial diversity.

CONCLUSION

The application of tafgor pesticide in the tomato crop field soil could elicit deleterious effect on soil microbial activity. This study focuses on the impact of tafgor at 15 ppm and 30 ppm on the growth of *Bacillus licheniformis, Bacillus cereus* and *Paenibacillus polymyca* and plant growth promoting traits of these bacteria like IAA and siderophore production. The results obtained revealed that tafgor significantly decreased the growth of bacteria in a dose-dependent manner. Consequently, significantly reduced the production of IAA by these bacteria. Thus, the persistence of tafgor and its residues could reduce the bacterial biodiversity and also effect the plant growth.

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