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PESTICIDE EFFECT ON QUALITATIVE OCCURRENCE AND SURVIVAL OF SOIL BLUE-GREEN ALGAE IN LABORATORY CONDITION

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Abstract: In the present exploration, stock solutions of Furadan (carbofuran, 3% G) and Rogor (dimethoate, 30%) pesticides were prepared and added to the BG-11 culture media to obtain the desired concentration of 100, 250, 500 and 1000 ppm. 10 g proportion of air dried soil was taken in sterilized BG-11 medium (with different concentration of various pesticides) and incubated at 28 ± 2^{0}C under 16/ 8 hours light/ dark cycles with 2- 5 K Lux light intensity. The algal forms appearing in the culture flask were identified by using standard monographs after 30 days of incubation. A sum of 19 Cyanophyceae species appeared in the composite soil of the control flask belonging to 14 genera and 6 families. The occurrence of blue-green algae remained almost unaffected even in the presence of Furadan and Rogor pesticides at 100 ppm dose in the test soil. The survival percentage of blue-green algae was reduced upto 50% at 500 ppm of Furadan while 10.52% survivability was noticed with Rogor only at 500 ppm dose level. The organophosphate, Rogor, was comparatively more toxic than carbamate, Furadan against tested blue-green algae. However, higher concentration of these pesticides significantly affects the survival showing high algicidal potential. The result of the present study revealed that indiscriminate use of these pesticides may cause adverse effects on the nitrogen fixing blue-green algae in crop fields, which has a direct effect on total productivity. The sensitivity of different Cyanophyceae to pesticide application was found more predominantly in sheath less heterocystous and unicellular forms than the heterocystous ensheathed and non-heterocystous ensheathed forms.

Keywords: Blue-green algae, Furadan, Rogor, Pesticides, Survival.

INTRODUCTION

The blue-green algae (cyanobacteria) are photosynthetic and aquatic. This name is convenient for talking about organisms in the water that make their own food, but does not reflect any special relationship with algae. Cyanobacteria are relatives of the bacteria, not eukaryotes, and it is only the chloroplast in eukaryotic algae to which the cyanobacteria are related. They belong to Domain Bacteria, according to 6-Kingdom system and Kingdom Monera as per 5-kingdom system (Ashok, 2016). In recent years, the practice of utilizing blue-green algae as an efficient source of biofertilizer for various crops have been advocated and adopted in India. Reduction of chemical fertilizers input upto 30% by supplementing with blue-green algae as a significant finding when conservation of energy is contemplated (Roger and Kulasooriya, 1980; Venkataraman, 1981; Rai *et al.*, 2000). In agriculture, introduction of fertilizer responsive crop varieties has necessitated the use of enormous amounts of pesticides during production and storage. The use of more pesticides have hazardous implications on the flora and fauna including fishes all over the world (Prakash and Verma, 2014; Verma and Prakash, 2018; Kaur and Mishra, 2019; Prakash and Verma, 2020). Agrochemicals are indispensable for life systems and their number has grown phenomenally in recent times (Kapoor and Arora, 2000). A variety of pesticides like organochlorines, organophosphates, carbamates and synthetic pyrethroids are now in use (Das, 2008; Kumar *et al.*, 2000).

It has been noticed under field conditions, the destruction of blue-green algal populations by pesticide application intended to control the insects and pests of the various agricultural crops. Ironically, these agrochemicals also damage wide variety of beneficial micro-organisms because of their long persistence in the environment (Rajendran *et al.*, 2006; Islam *et al.*, 2007). Therefore, pesticides used in routine applications in crop fields have adverse ecological effects in addition to those usually intended. Owing to this, the present investigation is undertaken to study the effect of commonly used pesticides on occurrence and survival of blue-green algae in laboratory conditions. Such investigations are useful in awakening the farmers to adopt better farm management practices that in turn will reduce the chemical fertilizer input and problem of environmental degradation.

MATERIALS AND METHODS

Pesticides used

In the present exploration, the effect of commercially used pesticides *namely* Furadan (carbofuran, 3% G) and Rogor (dimethoate, 30%) belonging to carbamate and organophosphate groups respectively, were studied on the survivability of soil blue-green algae. These pesticides are generally used to control suckingbugs, lepidopterous and nematode pests and mites that occur in maize, wheat, sugarcane, cotton, onion, vegetable and oil yielding crops. The carbamate and organophosphate pesticides are used as contact and stomach action pre-emergence systemic pesticides that altered the cholinesterase reversible activity. The pesticide application rates recommended to control various crop pests are 1.0 kg/ha carbofuran (Furadan) and 0.7 liter/ha dimethoate (Rogor) that provides a range of 5- 10 ppm in the agricultural crop field.

Experimental Set up

Commercial grade pesticides carbamate, Furadan (Union Carbide Ltd.) and organophosphate, Rogor (Rallis India Ltd.) were used. Stock solutions of these pesticides were prepared for experiments in the sterilized media and added to the BG-11 (Rippka *et al.*, 1979) culture media to obtain the desired concentrations (100, 250, 500 and 1000 ppm). The pH of all the media was adjusted to 7.5.

10 g proportions of air dried soil was taken in sterilized 50 ml of the BG-11 medium (with different concentrations of various pesticides). After addition of nutrient solution to the culture, samples were agitated to ensure uniform distribution of the pesticides. For each concentration, triplicates were set up and incubated at 28 ± 2^{0}C under 16/ 8 hours light/ dark cycles with 2-5 K Lux light intensity from white fluorescent tubes. The algal forms appeared in the culture flask after 30 days of incubation were identified using standard monographs of Prescott (1951), Desikachary (1959) and Anand (1990). The survival percentage of the blue-green algae was calculated in laboratory cultures on the basis of the number of species present in the respective treatments by taking survival in the control flask as 100%.

RESULTS AND DISCUSSION

Altogether 19 blue-green algal taxa appeared in the composite soils of the control flasks belonging to 14 genera, 6 families and 3 orders (table 1). Taxonomical characterization was made by using standard literature of Desikachary (1959).

Table 1: Taxonomic enumeration of blue-green algae appeared in control flask.

Sl. No.	Order	Family	Genus	Species
1.	Chroococcales	Chroococcaceae	*Chroococcus*	*C. minutus*
2.			*Gloeocapsa*	*G. kuetzingiana*
3.			*Aphanothece*	*A. pallida*
4.	Nostocales	Oscillatoriaceae	*Oscillatoria*	*O. okeni*
5.				*O. animalis*
6.			*Phormidium*	*P. fragile*
7.			*Lyngbya*	*L. polysiphoniae*
8.		Nostocaceae	*Cylindrospermum*	*C. musicola*
9.			*Nostoc*	*N. punctiforme*
10.				*N. paludosum*
11.				*N. linckia*
12.				*N. calcicola*
13.			*Anabaena*	*A. oryzae*
14.				*A. fertilissima*
15.			*Aulosira*	*A. aenigmatica*
16.		Scytonemataceae	*Scytonema*	*S. subtile*
17.		Rivulariaceae	*Calothrix*	*C. javanica*
18.	Stigonematales	Stigonemataceae	*Hapalosiphon*	*H. welwitschii*
19.			*Westiellopsis*	*W. prolifica*

Amongst the 19 blue-green algal species appeared in the control flask, 7 species were non-heterocystous and 12 heterocystous. *Nostoc punctiforme*, *Anabaena fertilissima*, *Hapalosiphon welwitschii* and *Westiellopsis prolifica* were present abundantly in the test soils. These are well known to fix atmospheric nitrogen in pure culture (Nayak *et al.*, 1996) and therefore indicating the richness of beneficial blue-green algal species.

The effect of commonly used pesticides, Furadan and Rogor on the qualitative occurrence and survivability of the blue-green algae at various concentrations was studied and the results depicted in the table 2. The results revealed that the occurrence of blue-green algae remained almost unaffected even in the presence of Furadan and Rogor pesticides at 100 ppm dose in the test soil. However, their quantitative occurrence was decreased to a considerable extent (table 3).

Further increase in the pesticide dose level, proportionate decrease in their occurrence was noted. At 500 ppm dose level of Furadan, most of the unicellular and filamentous forms of the blue-green algae could not grow in the test soils. Exceptions to this result were: *Gloeocapsa kuetzingiana, Lyngbya polysiphoniae, Scytonema subtile* and *Calothrix javanica*, which possess well-defined sheath around their cells or trichomes. None of the other tested blue-green algal forms could tolerate 1000 ppm concentration of Furadan (table 2).

The effect of Rogor was quite specific on the occurrence of blue-green algal forms. Even at 100 ppm, qualitative and quantitative occurrence of heterocystous and non- heterocystous blue-green

Table 2: Qualitative occurrence of soil blue-green algae in the presence of Furadan and Rogor pesticides at the end of 30 days

Sl. No.	Blue-green algal species	Control	Furadan (ppm)				Furadan (ppm)			
			100	100	250	500	1000	250	500	1000
1.	*Chroococcus minutus* (Kuetz.) Nag.	+	+	+	+	-	-	+	+	-
2.	*Gloeocapsa kuetzingiana* Nag.	+	+	+	+	-	-	+	+	+
3.	*Aphanothece pallida* (Kuetz.) Rabenh.	+	+	+	-	-	-	+	-	-
4.	*Oscillatoria okeni* Ag. ex Gomont	+	+	+	+	-	-	+	+	-
5.	*O. animalis* Ag. ex Gomont	+	+	+	+	-	-	+	+	-
6.	*Phormidium fragile* (Meneghini) Gomont	+	+	+	-	-	-	+	-	-
7.	*Lyngbya polysiphoniae* Fremy	+	+	+	+	+	-	+	+	+
8.	*Cylindrospermum musicola* Kuetz. ex Born. et Flah.	+	+	+	-	-	-	+	-	-
9.	*Nostoc punctiforme* (Kuetz.) Hariot.	+	+	+	+	-	-	+	-	-
10.	*N. paludosum* Kuetzing ex Born. et Flah.	+	+	+	+	-	-	+	+	-
11.	*N. linkia* (Roth) Bornet ex Born. et Flah.	+	+	+	+	-	-	+	-	-
12.	*N. calcicola* Brebisson ex Born. et Flah.	+	+	+	+	-	-	+	-	-
13.	*Anabaena oryzae* Fritsch	+	+	+	-	-	-	+	-	-
14.	*A. fertilissima* Rao, C. B.	+	+	+	-	-	-	+	+	-
15.	*Aulosiraa enigmatica* Fremy	+	+	+	+	-	-	+	+	-
16.	*Scytonema subtile* Mobius	+	+	+	+	-	-	+	+	+
17.	*Calothrix javanicade* Wilde.	+	+	+	+	+	-	+	+	+
18.	*Hapalosiphon welwitschii* W. et G. S. West	+	+	+	-	-	-	-	-	-
19.	*Westiellopsis prolifica* Janet	+	+	+	+	-	-	+	-	-
Total number of blue-green algal species appeared		19	19	18	19	13	02	00	10	04
Percentage (%) survival		100	100	94.73	100	68.42	10.52	00	52.63	21.05

(+ Present, - absent)

Table 3: Quantitative occurrence and survival percentage of blue-green algal species in the culture at different concentrations of Furadan and Rogor pesticides.

Pesticide	Concentration (ppm)	Blue-green Algae			
		Heterocystous		Non- heterocystous	
		Total number of species	Percentage survival	Total number of species	Percentage survival
Control	**Without Pesticide**	16	100	03	100
Furadan	100	16	100	03	100
	250	15	93.7	03	100
	500	08	50	02	66.6
	1000	03	18.7	01	33.3
Rogor	100	16	100	03	100
	250	11	68.7	02	66.6
	500	02	12.5	00	00
	1000	00	00	00	00

algae was decreased considerably. These algal species were almost completely eliminated from the soils in presence of 500 ppm. With further increase in the pesticide concentration, almost all the blue-green algal forms did not grow in the culture. Only *Lyngbya polysiphoniae* and *Calothrix javanica* tolerated up to 500 ppm to grow. Further increase in pesticide concentration at 1000 ppm, none of the blue-green algal species could grow.

The results obtained regarding the total number of different blue-green algal species appeared in the culture and their survival percentage in presence of various concentrations of pesticides indicated that soil blue-green algae show variable resistance to pesticide treatments. The survival percentage of the blue-green algae was reduced upto 50 percent at 500 ppm of Furadan while only 10.52% survivability was noticed with Rogor at 500 ppm dose level (table 2 and table 3).

Author noticed that organophosphate pesticides have been considered to be hazardous due to their toxicity and longer persistence in the environment. However, higher concentrations of both Furadan and Rogor pesticides greatly affect the survival showing high algicidal potential. According to Lal and Saxena (1980), exposure to organophosphate and organochlorine compounds can inhibit enzyme activity and photosynthesis, alter cell membrane permeability and integrity and interfere with synthesis of DNA, RNA and proteins. Ma *et al.* (2006) revealed the average acute toxicity of the carbamate insecticides to the cyanobacteria and the green algae in the descending order of carbaryl>carbofuran, propoxur, metolcarb>carbosulfan. Wide variations in response to the tested carbamate insecticides occurred among the 8 individual species of cyanobacteria and green algae. These views of previous workers are in close conformity with the findings of the present work on variable response of blue-green algae to pesticides treatments.

It was also seen that with increasing doses of pesticide application in the crop fields *i.e.* more than 100 ppm of Furadan and Rogor, qualitative and quantitative occurrence of heterocystous and non-heterocystous blue-green algae was decreased considerably. Author also found that Rogor was more toxic than Furadan on the basis of survivability of the tested blue-green algae. However, Adhikary (1989) observed that survivability and nitrogen fixation of *Westiellopsis prolifica* was reduced to 72 and 93 percent, respectively in the presence of 100 ppm of Endotaf and concluded that Endotaf is more toxic than the Furadan, Sevin and Rogor pesticides. Similarly, Mohapatra *et al.* (2003) reported that Endosulfan was found to be more effective in reducing the survivability of *Chlorella vulgaris* and *Anabaena doliolum* than dimethoate, Rogor. Das (2008) found that *Calothrix parietina* was more tolerant, while *Anabaena variabilis* was more sensitive to an organophosphate pesticide, Rogor (dimethoate 30 EC).

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