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Factors Affecting Biodegradation of the Insecticides by Cyanobacterial Strains, Isolated from Soil Contaminated with Pesticides

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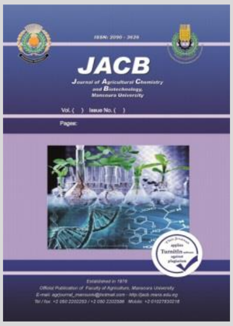

ABSTRACT

This research aim to study the effect of some factors (concentration of insecticide, temperature and pH levels) affecting biodegradation of insecticides by cyanobacteria. The superior isolates out of twelve cyanobacterial isolates, which isolated from soil contaminated with insecticides were *Nostoc muscorum* and *Anabaena oryzae*. Results indicated that an increase in dry weight and N_2 fixation was recorded with increasing chlorpyrifos concentration from 0 up to150 ppm. These results were noted with *Anabaena oryzae*. On the other hand, there was an increase in the average of dry weight and N_2 fixation with increasing the concentration of carbofuran from zero up to 80 ppm. The highest nitrogen content was recorded in *Nostoc muscorum.* The biodegradation of the pesticide (chlorpyrifos and carbofuran in liquid cultures) by cyanobacterial isolates was evidenced by complete discoloration of cyanobacterial growth at 12 days of incubation. The fixed nitrogen and dry weight of *Anabaena oryza*e and *Nostoc muscorum* grown at different concentrations of chlorpyrifos (0, 50, 100, 150 and 200) and different temperature degrees (20,25,30 and 35°C) as well as different pH levels (5, 6, 7 and 8) were determined. Results indicated that the maximum uptake of chlorpyrifos by *Anabaena oryzae* and *Nostoc muscorum* was recorded at 30°C and pH 7.0. Moreover, the maximum removal of carbofuran by *Anabaena oryza*e and *Nostoc muscorum* at different concentrations (0, 40, 80 and 120) was recorded at 25°C and pH 7.0

***Keywords*:** cyanobacteria, insecticide, temperature, pH

INTRODUCTION

The pesticides are considering the most important factor in agrochemical when the need for controlling of agricultural pests. This leads to protect food production from agricultural pests while, these pesticides contaminate the environment. Biological ways for several beneficial microorganisms, including cyanobacteria, is involved in decreasing the chemical remains (Subashchanhrabose *et al.*, 2013). The different periods for degradation of chlorpyrifos in soil are affected by many factors such as initial concentration, soil moisture, temperature, and pH (Racke *et al.*, 1994; Awasthi and Prakash, 1997). The important factors of chlorpyrifos degradation are microbial degradation and other chemical factors on soil (Getzin 1981; Racke *et al.*, 1988). The degradation of carbamate nematicides can develop rapidly in soils with a pH higher than 6.5. If the microbial populations have established themselves in the soil, they might last for up to two years in soils with a low pH and for longer than five years in soils with a high pH (Arbeli and Fuentes 2007). The cyanobacterial removal ability increases with an increase in the optimal temperature or initial temperature or carbofuran concentration (Roriz *et al.* 2009). The ellipse plots showed that the degradation potential of carbofuran was greatly affected by changes in pH or temperature. The reduction in carbon forane increases with increasing temperature. After reaching the optimum temperature, biodegradability decreases with increasing temperature. The degradation efficiency of carbofuran is up to 95% as follows: carbofuran concentration 92.50 mg/L, temperature 27.50°C and pH 7. The biodegradation of chlorpyrifos by *Ps. desmolyticum* NCIM 2112, the optimum pH and temperature for degradation were found to be 7.0 and 30 °C, respectively. *Ps. desmolyticum* NCIM 2112 reduces chlorpyrifos to non-toxic metabolites such as 2-pyridinol and phosphorothioate (Rokade and Mali 2013). The bioremediation of chlorpyrifos in soil using the *Bacillus cereus* Ct3 strain isolated from cotton plant soil. *Bacillus cereus* Ct3 tolerates chlorpyrifos up to 125 mg/L and reaches 88% of chlorpyrifos in 8 days at pH 8. *Bacillus cereus* Ct3 tolerates temperatures of around 30-40 °C (Farhan *et al.* 2021). Cyanobacteria can remove many contaminants from water. Cyanobacterial biodegradation processes can occur extracellularly; intracellular; or a combination of both, where initial degradation occurs extracellularly and fragments are subsequently degraded intracellularly (Touliabah *et al.* 2022). Therefore, the aim of this study was to evaluate insecticides concentration, temperature and pH affecting biodegradation of the insecticides (chlorpyrifos and carbofuran) by cyanobacterial strains, isolated from soil contaminated with pesticides.

MATERIALS AND METHODS

Source of soil samples

Soil samples were collected from different locations at Kafr Elsheikh Governorate cultivated with rice and contaminated with insecticides. The collected soil samples were used as a source of cyanobacterial isolates. Some chemicals and physicals analyses of soil (Piper 1950 and

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Jackson 1958) were previously presented by Abou Elatta *et al.* (2023).

Preparation of cyanobacterial inoculum

Liquid cultures of cyanobacterial isolates were prepared using Modified Watanabe liquid medium with incubation at 28-30ºC under continuous illumination (2500 lux) for 21 days.

Total nitrogen determination

Using the micro-kjeldahl method according to Jackson (1958), total nitrogen was determined in 100 ml broth culture from cyanobacteria.

Insecticides used

Chlorpyrifos (Bestban 48%) and carbofuran (Feurdan 10%) were used in this investigation. Chlorpyrifos is O,O-diethyl O-3,5,6- trichloro-2- pyridyl phosphorothi oate (TCP). Carbofuran is N-Methyl carbamate. Some chemical characteristics of chlorpyrifos according to Venkta Mohan *et al.,* (2004). Also, chemical characteristics of carbofuran according to Chowdhury *et al.* (2014) are presented in Abou Elatta *et al.,* (2023) and Afify *et al.,* (2023b). These insecticides were obtained from Sigma - Co., USA.

Statistical analysis

Treatments differences modified L.S.D. compared with 5% and Duncan's , follow the procedure outlined by Steel and Torrie (1980).

RESULTS AND DISCUSSION

Twelve cyanobacterial isolates were obtained from a soil sample contaminated with insecticides in Kafr Elsheikh Governorate. These twelve isolates were found to be belonging to four genera (*Anabaena*, *Nostoc*, *Oscillatoria* and *Chroococcus*). Scientific names are presented in Afify, *et al.* (2023a).

Effect concentrations of insecticides

1. Determination of cyanobacterial growth

Biodegradation ability of pesticides by cyanobacteria can be evidenced by measuring the growth and nitrogen fixation of cyanobacteria. The results presented in Table (1) show great variation in the biomass production of different cyanobacterial species. During incubation period (7, 14, 21 days), the highest amount of biomass produced by cyanobacteria was recorded for *Anabaena oryzae* followed *Nostoc muscorum*. On the other hand, as the chlorpyrifos concentration increased from 0 to 150 ppm in the same incubation period, the biomass values increased and then decreased at 200 ppm. *Anabaena oryzae* reached the highest significant dry weight (Sarnaik *et al*., 2006 and John *et al*., 2014). A similar study was conducted by Yang *et al*. (2005) they found that 76.2% degradation of chlorpyrifos (100 mgl^{-1}) by *Alcaligenes faecalis* DSP3 was achieved after 18 days of culture. *Bacillus pumilus* C2A1 degraded 89% of 1000 mgl^{-1} chlorpyrifos in 15 days. Moreover, the obtained data indicate that there are mostly gradual increases in cyanobacterial biomass (dry weight) with increasing incubation period, where the highest cyanobacteria dry weights were recorded with all strains between 14-21 days of incubation period.

Table 1. Effect of different chlorpyrifos concentrations on dry weight (g/100 ml culture) of cyanobacterial strains at different incubation periods.

Concentration of chlorpyrifos (ppm)	Control			50			100			150			200		
Cyanobacterial strains	Incubation Time(days)			Incubation Time(days)			Incubation Time(days)			Incubation Time (days)			Incubation Time (days)		
	7	14	21	7	14	21	7	14	21	7	14	21	7	14	21
Nostoc muscorum	48n	65h	91b	55k	80c	95b	60n	68j	98b	64jk	70f	105b	41b	32d	23ij
Nostoc paludosum	31t	57k	65h	39p	65i	74f	50r	58o	81e	58lm	63k	88c	35c	23ij	21kl
Nostoc entophytum	42q	55l	62i	45n	62j	73f	49rs	66k	79f	51o	68g	84d	31d	22jk	19mn
Nostoc pruniforme	24x	40r	79c	31s	46n	76e	52q	64l	85c	54n	67gh	89c	27ef	18n	15o
Nostoc viride	33s	62i	72f	38p	69h	81c	44t	72i	85c	47p	64jk	88c	24hi	19mn	12q
Nostoc verrucosum	28u	46o	60j	35q	49m	70gh	42u	76g	81e	45q	66hi	85d	27ef	21kl	20lm
Nostoc rivulare	26v	40r	58k	28t	46n	61j	32z	48s	65kl	37r	55n	66hi	28e	13pq	10r
Anabaena oryzae	52m	74e	98a	55k	80c	99a	62m	85c	102a	65ij	89c	108a	50a	35c	25gh
Anabaena qelatinicola	30t	45op	76d	32rs	48m	78d	42u	49rs	83d	45q	55n	85d	22jk	15o	12q
Anabaena variabilis	27uv	44p	65h	36q	52l	71g	41u	56p	82de	44q	57m	85d	26fg	14op	13pq
Chroococcus minor	26v	51m	65h	33r	53l	69h	35x	62m	74h	38r	70f	76e	23ij	12q	6t
Oscillatoria brevis	23x	34s	67g	29t	43o	81c	38v	58o	83d	48p	59l	89c	15o	9rs	8s

Means followed by different letter(s) during 21 days of incubation time and concentration of chlorpyrifos are significantly different

The results in Table (2) show that dry weight of cyanobacterial isolates increased with increasing the incubation time. On the other hand, during the same incubation period, dry cell weight increased as the carbofuran concentration increased from 0 to 80 ppm and then decreased at a concentration of 120 ppm. *Nostoc muscorum* had highest dry cell weight with all carbofuran concentrations at all incubation times. Significant differences in dry weight were recorded depending upon the pesticide type and the applied dose as well as the type of cyanobacteria. For example, *Anabaena variabilis* tolerates arosine, alachlor, butachlor and 2,4-dichlorophenoxyacetate insecticides, but with increasing the concentration of these insecticides, the growth of cyanobacteria (*Nostoc punctiforme, Nostoc calcicola, Anabaena variabilis, Gloeocapsa* sp. and *Aphanocapsa* sp.) decreased and arosine exhibited the highest toxicity (Singh and Datta, 2006).

2. Determination nitrogen fixation by cyanobacteria

The results presented in Table (3) show that all tested cyanobacterial strains gradually increase nitrogen fixation (mg N/100 ml culture) with increasing the incubation time, reaching much high fixed nitrogen at 21st day. Moreover, it was noticed that highest amount of fixed nitrogen was recorded for *Anabaena oryzae*. Otherwise, over the same incubation period, the average N_2 fixation increases as the chlorpyrifos concentration increases from 0 to 150 ppm and then decreases at a concentration of 200 ppm (Sarnaik *et al*., 2006; John and Shaike 2015). *Anabaena oryzae* was found to have the highest significant nitrogen content. This increase is due to the microbial catabolic ability to break down chlorpyrifos (John *et al*. 2014; Singh *et al*. 2004). Therefore, it is important to determine the effectiveness at which cyanobacterial isolates fix atmospheric nitrogen, as previous studies of the effects of many pesticides on cyanobacterial growth and activity have shown that the effects are dose-dependent. While low doses increased synthetic pigments, high doses decreased cyanobacterial growth, photosynthetic pigments and enzyme activities and increased oxidative stress in *Nostoc* and *Anabaena* cyanobacterial species (Kumar *et al*., 2008 and Kumar *et al*., 2013).

Table 2. Effect of different carbofuran concentrations on dry weight (g/100 ml culture) of cyanobacterial strains at different incubation periods.

Concentration of carbofuran (ppm)	Control			40			80			120		
Cyanobacterial strains	Incubation Time(days)			Incubation Time(days)			Incubation Time(days)			Incubation Time(days)		
	7	14	21	7	14	21	7	14	21	7	14	21
Nostoc muscorum	58j	67e	93a	65k	82d	95a	68lm	92d	105a	43a	32d	23gh
Nostoc paludosum	33q	55k	65fg	39r	75g	84c	56q	83h	95c	35c	23gh	21ij
Nostoc entophytum	46n	51l	62i	55m	66k	74gh	59p	78i	94c	31d	22hi	19kl
Nostoc pruniforme	22u	40p	71d	36t	49o	71i	50s	61o	91d	27ef	18l	15m
Nostoc viride	31r	63hi	75c	39r	68j	82d	47t	74j	92d	24g	19kl	12no
Nostoc verrucosum	28s	42o	58j	37st	47p	73h	46t	65n	87fg	27ef	21ij	20jk
Nostoc rivulare	26t	32qr	48m	38rs	48op	62l	47t	56q	69l	28e	13n	10p
Anabaena oryzae	52l	64gh	88b	55m	80e	89b	65n	89e	103b	40b	31d	22hi
Anabaena qelatinicola	31r	45n	66ef	42q	68j	78f	55qr	64n	89e	22hi	15m	12no
Anabaena variabilis	28s	41op	55k	37st	62l	73h	54r	67m	86g	26f	16m	13n
Chroococcus minor	26t	52l	62i	33u	53n	65k	38u	60op	71k	23gh	11op	8q
Oscillatoria brevis	22u	33q	57j	30v	41q	61l	46t	69l	88ef	15m	10p	7q

Means followed by different letter(s) during 21 days of incubation time and concentration of carofuran are significantly different

Table 3. Mean amounts of fixed-nitrogen (mg N/100 ml-culture) by cyanobacterial strains with different concentrations of chlorpyriphos

Cyanobacterial strains	Concentration of chlorpyriphos ppm														
	Zero			50			100			150			200		
	Incubation Time(days)			Incubation Time(days)			Incubation Time(days)			Incubation Time(days)			IncubationTime(days)		
	7	14	21	7	14	21	7	14	21	7	14	21	7	14	21
Nostoc muscorum	2.33k-p	5.25c-h	9.71a	2.46j-m	5.54d-g	9.89a	2.87l-n	6.54d-h	10.16a	4.97j-n	7.34e-h	10.46ab	1.87cd	1.21d	1.06d
Nostoc paludosum	2.25l-p	4.14d-l	5.55c-f	2.32k-m	4.41g-i	9.65ab	2.91l-n	4.63h-m	9.88ab	4.01l-o	5.43h-l	9.91a-c	1.71cd	1.16d	1.02d
Nostoc entophytum	2.11m-p	3.45g-n	5.06c-i	2.33k-m	4.51g-i	9.35ab	2.33n	6.03e-i	9.45ab	3.43m-o	7.01f-i	9.55a-d	1.33cd	1.14d	0.35d
Nostoc pruniforme	2.24l-p	3.58g-n	5.98b-d	2.39k-m	4.64g-i	8.14a-c	2.49n	4.74g-l	8.55a-c	3.39no	6.23g-k	9.34a-d	1.39cd	1.12d	0.14d
Nostoc viride	2.31k-p	4.16d-l	5.81b-e	2.44j-m	4.36g-j	6.78c-e	2.64n	5.02g-k	6.98c-f	4.21l-o	5.86h-l	7.88d-g	1.24cd	1.16d	0.98d
Nostoc verrucosum	2.12m-p	3.35h-o	4.35d-j	2.35k-m	4.21g-k	5.22e-h	2.55n	5.11f-k	6.42d-h	3.35no	5.61h-l	6.52f-j	1.35cd	1.11d	0.42d
Nostoc rivulare	1.41op	2.26l-p	4.27d-k	2.12lm	3.38h-l	5.61d-g	2.26n	5.24f-k	6.31e-h	4.11l-o	6.22g-k	7.81d-g	1.12d	1.08d	0.77d
Anabaena oryzae	3.25i-p	5.35c-g	9.81a	3.31h-m	5.45d-g	9.92a	3.37k-n	6.58d-g	10.31a	4.24l-o	8.89b-e	10.81a	3.16bc	4.35b	6.54a
Anabaena qelatinicola	2.46j-p	3.89e-m	7.42b	3.11i-m	5.25e-h	7.96bc	3.53k-n	6.01e-i	8.56a-c	4.11l-o	6.45f-j	9.06a-e	1.11d	1d	0.26d
Anabaena variabilis	1.35p	3.61f-n	6.46bc	1.41m	3.96g-l	7.27cd	2.41n	4.01j-n	8.26b-d	2.68o	5.06j-n	8.27c-f	1.41cd	1.26cd	1.07d
Chroococcus minor	1.91m-p	2.83j-p	4.18d-l	2.41klm	3.25ijklm	4.85f-i	2.81mn	4.14i-n	5.15f-k	3.41m-o	4.35k-o	5.35i-m	1.36cd	1.15d	0.25d
Oscillatoria brevis	1.87n-p	2.84j-p	4.34d-j	3.25ijklm	5.25efgh	6.61c-f	3.64k-n	5.72e-j	7.31c-e	4.25l-o	6.85f-j	7.81d-g	1.25cd	1.05d	0.54d

Means followed by different letter(s) during 21 days of incubation time and concentration of chlorpyrifos significantly different

The results in Table (4) show that nitrogen fixation by cyanobacteria with different carbofuran concentrations gradually increased as the experiment progressed, with the significant highest nitrogen fixation by cyanobacteria being recorded during 14-21 days of incubation. It was determined that nitrogen fixation and excretion capacity of all different strains were recorded the highest nitrogen fixation value with *Nostoc muscorum* culture after 21 days. This increase is due to microbial degradation of carbofuran when organisms such as cyanobacteria, bacteria and fungi use pesticides as source of caron and energy. Microbial degradation occurs rapidly in soil conditions suitable for microbial activity. These factors include temperature, pH, humidity, aeration (oxygen source) and fertility. The degree of absorption also affects microbial degradation, as most pesticides must be in solution to be absorbed and metabolized by bacteria. Frequent use of pesticides is also an important factor affecting this deterioration (Harrison, 1990).

Nostoc muscorum and *Anabaena oryzae* were found to be the superior cyanobacterial isolates, which isolated from soil contaminated with insecticides. Both isolates were tested for their ability to degrade insecticides under different temperature degrees and pH levels. The obtained results are presented below:

Table 4. Effect of different carbofuran concentrations on nitrogen fixation (mg N/100 ml culture) of cyanobacterial strains.

Cyanobacterial strains	Concentration of carbofuran ppm											
	Control			40			80			120		
	Incubation Time(days)			Incubation Time(days)			Incubation Time(days)			Incubation Time(days)		
	7	14	21	7	14	21	7	14	21	7	14	21
Nostoc muscorum	3.25h-o	5.35d-f	9.81a	4.31f-j	6.45c-e	9.92a	5.24k-o	8.89b-e	10.91a	3.16a-c	4.35a	3.54ab
Nostoc paludosum	2.51j-p	4.14e-l	5.53de	3.32h-k	4.45f-i	8.65ab	4.61k-p	6.43g-k	9.81-c	2.11b-d	1.16d	1.02d
Nostoc entophytum	2.13m-p	3.35g-n	5.32d-f	3.33h-k	4.53f-i	8.35ab	3.53n-p	5.01k-p	9.5a-d	1.31cd	1.14d	0.35d
Nostoc pruniforme	2.25l-p	3.48f-m	5.67de	3.39h-k	4.61e-i	8.14a-c	3.49op	6.13h-k	9.34a-d	1.49cd	1.12d	0.19d
Nostoc viride	2.49j-p	4.26d-k	5.82c-e	3.44h-k	4.39fg-j	7.78b-d	4.81k-p	5.46j-n	7.88d-h	1.28cd	1.06d	0.91d
Nostoc verrucosum	2.33k-p	3.36gh-n	4.32d-j	2.95i-k	4.23g-j	6.22d-f	3.35op	5.62j-m	6.56fg-k	1.35cd	1.1d	0.41d
Nostoc rivulare	1.45n-p	2.26l-p	4.22d-l	2.62i-k	3.38h-k	5.61e-g	4.11l-p	6.24g-k	7.83d-h	1.12d	1.0d	0.76d
Anabaena oryzae	3.13h-p	5.25d-g	8.81ab	3.46h-k	5.54e-g	9.89a	4.97k-p	7.34e-j	10.46ab	1.87b-d	1.21d	1.06d
Anabaena qelatinicola	2.46j-p	4.89d-h	7.52bc	3.11h-k	4.25g-j	8.96ab	4.71k-p	6.15h-k	8.06cd-g	1.61cd	1.3cd	0.86d
Anabaena variabilis	1.85m-p	4.61d-i	6.16cd	2.41jk	4.96e-h	7.77b-d	3.68m-p	5.16k-p	8.37c-f	1.49cd	1.16d	1.07d
Chroococcus minor	1.21p	2.73i-p	4.18e-l	2.41jk	4.25g-j	4.15g-k	3.48op	4.15l-p	5.25kl-o	1.36cd	1.1d	0.55d
Oscillatoria brevis	1.37op	2.14m-p	4.14e-l	2.25k	4.21g-k	5.61e-g	3.25p	5.85i-l	7.71d-i	1.25cd	1.05d	0.53d

Means followed by different letter(s) during 21 days of incubation time and concentration of carofuran are significantly different

Effect pH on the growth of cyanobacterial strains in presence of different concentrations of chlorpyrifos and carbofuran.

The fixed nitrogen and dry weight of cyanobacterial strains grown at different concentrations of chlorpyrifos are presented in Table (5). Among the isolated cyanobacteria *Anabaena oryzae* and *Nostoc muscorum* were found to have the highest dry weight at 150 ppm chlorpyrifos concentration. This increase was attributed to the ability of microbes to degrade chlorpyrifos (John *et al*. 2014; Singh *et al*. 2004). Strains were selected and grown in nutrient medium with different pH levels, and the most suitable pH for all cyanobacterial isolates tested was found to be pH 7.0. The results for the removal of chlorpyrifos in the acidic and alkaline conditions showed maximum removal at pH 7.0. Our observations are based on the maximum removal (mg/L) of chlorpyrifos pH 7.0 (Fang *et al*., 2008). The significant maximum biodegradation of chlorpyrifos by bacteria has been reported in the neutral pH or alkaline range (Singh *et a*l. 2003; Yang *et al*. 2005; Xu *et al*. 2007; Fang *et al.* 2008; Thengodkar and Sivakami 2010). Rokade and Mali (2013) reported that the optimum pH value for degradation is 7.0.

Table 5. Effect different pH values on dry weight (mg/100ml-culture) of cyanobacterial strains at different concentrations of chlorpyrifos

Cyanobacterial strains and concentration of chlorpyrifos (ppm)	Incubation Time(7 days)				Incubation Time(14 days)				Incubation Time(21 days)			
	pH values											
	5	6	7	8	5	6	7	8	5	6	7	8
Anabaena oryzae	5uv	28n	42f	40g	55k-m	65g	74cd	68f	80kl	91f	98de	92f
Anabaena oryzae +50 ppm	11st	31lm	45de	36ij	46no	57jk	70e	58ij	73no	85ij	99d	97e
Anabaena oryzae +100 ppm	13s	32l	52c	38h	54lm	65g	75c	71e	77lm	82k	102c	87h
Anabaena oryzae +150 ppm	22pq	34k	65a	46d	69ef	80b	89a	73d	93f	98de	108a	99d
Anabaena oryzae +200 ppm	8tu	23p	38h	36j	41p	52m	55lm	53m	58s	62r	75mn	63r
Nostoc muscorum	6u	18r	28n	21q	29t	36r	45o	39pq	37u	50t	71o	65q
Nostoc muscorum +50 ppm	10t	26o	45de	35jk	38q	46o	60h	54m	65q	69p	75mn	71o
Nostoc muscorum +100 ppm	17r	35jk	40g	37hi	45o	54m	68f	58j	70op	84j	91f	89g
Nostoc muscorum +150 ppm	18r	40g	54b	44e	56kl	65g	70e	59hi	74n	86hi	105b	101c
Nostoc muscorum +200 ppm	3v	21q	30m	26o	33s	41p	52m	49n	58s	65q	79l	71o

Means followed by different letter(s) in the same incubation time are significantly different

Results in Table (6) showed the effect of different pH levels on dry weight of cyanobacterial strains growing on different concentrations of carbofuran 0,40,80 and120 ppm. The highest dry weight was observed with *Nostoc muscorum* and *Anabaena oryzae* at concentrations from zero to 80 ppm. Therefore, the efficiency of cyanobacteria strains in nitrogen fixation and dry weight was evidence by the biodegradation of carbofuran. *Nostoc muscorum* and *Anabaena oryzae* were selected and grown in nutrient media containing different pH, and the maximum removal of carbofuran was recorded at pH 7.0. The significant high maximum biodegradation of carbofuran by bacteria has been reported in the neutral pH or alkaline range (Singh *et al*. 2018).

Effect temperature on the growth of cyanobacterial strains with different concentrations of chlorpyrifos and carbofuran

The efficiency of *Anabaena oryzae* and *Nostoc muscorum* in biodegradation of chlorpyrifos insecticide was tested at different temperature degrees (*i.e.* 20, 25, 30 and 35ºC). Data in Table (7) indicated that the significant maximum uptake of chlorpyrifos was recorded at 30°C. After estimating the average dry weight of cyanobacterial strains added to different concentrations of chlorpyrifos (0, 50, 100, 150 and 200 ppm), the highest dry weight was recorded for *Anabaena oryzae* and *Nostoc muscorum*. This increase is due to the ability of cyanobacteria to degrade chlorpyrifos. Therefore, the efficiency of the cyanobacterial isolates concerning dry weight was evidence by the biodegradation of chlorpyrifos. The strains were selected and cultivated in a nutrient medium with different temperatures to find out the most suitable degree for the biocracking process, and the best temperature was 30ºC. Rokade and Mali (2013) described the biodegradation of chlorpyrifos by *Ps. desmolyticum* NCIM 2112 and the best temperature for degradation was 30°C.

Table 6. Effect different pH values on the dry weight (mg/100ml-culture) of cyanobacteria strains growing on different concentrations of carbofuran

Cyanobacterial strains and concentration of carbofuran (ppm)	Incubation Time(7 days)				Incubation Time(14 days)				Incubation Time(21 days)			
	pH											
	5	6	7	8	5	6	7	8	5	6	7	8
Anabaena oryzae	7n	25k	41e	30no	45j	55h	74gh	67k	81e	89hi	98ef	92h
Anabaena oryza + 40	21l	33g	44d	36m	49i	57g	71hi	68jk	74gh	81k	96fg	87i
Anabaena oryzae + 80	32gh	44d	66b	45j	69d	80b	89c	85d	93b	98ef	108b	99e
Anabaena oryzae + 120	8n	22l	31h	26o	39l	42k	59l	53m	68jk	72lm	79k	74l
Nostoc muscorum	9n	28j	38f	31n	46j	66e	75g	69ij	77f	80k	91h	85j
Nostoc muscorum + 40	10n	29ij	45d	34m	48i	69d	80e	74gh	85d	89i	95g	91h
Nostoc muscorum + 80	38f	57c	74a	64f	76c	85a	95a	89c	94ab	103d	115a	106c
Nostoc muscorum + 120	13m	21l	30hi	26o	23p	31n	45o	39p	48n	55o	69n	71m

Means followed by different letter(s) in the same incubation time are significantly different

Table 7. Effect of different temperature degree on dry weight (mg/100ml-culture) of cyanobacteria strains added to different concentrations of chlorpyrifos

Temperature degree	20°C			25°C			30°C			35°C		
Cyanobacterial strains and concentration of chlorpyrifos (ppm)	Incubation Time(days)			Incubation Time(days)			Incubation Time(days)			Incubation Time(days)		
	7	14	21	7	14	21	7	14	21	7	14	21
Anabaena oryzae	55p	69l	84f	58mn	75i	89e	78op	105f	120d	53p	82j	97d
Anabaena oryzae +50ppm	63mn	75i	95c	69jk	85g	104c	86l-n	110e	125c	62o	85i	99c
Anabaena oryzae +100ppm	66m	81g	98b	75i	86g	108b	88k-m	120d	130b	71lm	92f	105b
Anabaena oryzae +150ppm	72jk	90d	110a	86fg	89e	111a	90jk	125c	135a	77k	98cd	108a
Anabaena oryzae +200ppm	31s	33s	55p	32r	48p	62m	37s	74p	82o	24t	39r	49p
Nostoc muscorum	45q	59o	74ij	48p	65l	79h	68q	85n	91j	63o	72lm	87h
Nostoc muscorum +50ppm	56p	62n	78h	58n	68k	72j	77p	86mn	99h	68n	73l	90g
Nostoc muscorum +100ppm	60no	69l	88e	65l	80h	99d	85n	89kl	103g	70mn	81j	92f
Nostoc muscorum +150ppm	71k	85f	96c	72j	88ef	108b	88k-m	94i	109e	72lm	85i	95e
Nostoc muscorum +200ppm	21t	43r	59o	37q	52o	71j	44r	68q	76p	36s	46q	63o

Means followed by different letter(s) in the same incubation time are significantly different

The data in Table (8) indicated that insecticide (carbofuran) removal by *Anabaena oryzae* and *Nostoc muscorum* was studied at temperatures (20, 25, 30 and 35ºC). The results showed that significant maximum degradation of carbofuran was observed at 25°C. After estimating dry weight of cyanobacterial strains added to different concentrations of carbofuran (0, 40, 80 and 120) the highest dry weight was achieved by *Nostoc muscorum* and *Anabaena oryzae.* This increase is due to the ability of cyanobacteria to degrade carbofuran. Temperature influences both algal biomass composition and productivity. The cyanobacterial strains were cultivated in a nutrient medium with different temperatures to screen the suitable degree and the best temperature was 25ºC. These results are in agreement with those achieved by Umar Mustapha, *et al.* (2020). An optimization method using surface response method was used to analyze the effects of four different factors (pH, nitrogen source, temperature and initial carbofuran concentration) and their effects on carbofuran degradation. Carbofuran is effectively degraded up to 95% as follows: carbofuran concentration 92.50 mg/L, temperature of 27.50 °C.

Table 8. Effect of different temperature degrees on dry weight (mg/100ml-culture) of cyanobacteria strains added to different concentrations of carbofuran

Cyanobacterial strains and concentration of carbofuran (ppm)	Temperature											
	20°C			25°C			30°C			35°C		
	Incubation Time(days)			Incubation Time(days)			Incubation Time(days)			Incubation Time(days)		
	7	14	21	7	14	21	7	14	21	7	14	21
Anabaena oryzae	45n	59l	74g	68r	85k	95i	58o	80j	92f	53k	82h	91f
Anabaena oryzae +40ppm	53m	65j	85e	76op	100g	98h	69m	78kl	94e	62j	85g	93e
Anabaena oryzae +80ppm	62k	80f	100b	80mn	115d	125b	76l	89g	105b	77i	96d	101b
Anabaena oryzae +120ppm	20s	23r	35o	37t	64s	72q	27s	48p	41q	22p	33o	41m
Nostoc muscorum	56m	69i	85e	78no	104f	120c	68m	85h	99d	53k	82h	96d
Nostoc muscorum +40ppm	62k	75g	95c	83l	110e	125b	79jk	99d	101c	62j	85g	99c
Nostoc muscorum +80ppm	72h	90d	110a	90j	125b	135a	82i	91f	111a	77i	98c	108a
Nostoc muscorum +120ppm	31q	33p	55m	37t	74p	82lm	32r	48p	62n	24p	39n	49l

Means followed by different letter(s) in the same incubation time are significantly different

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العوامل المؤثره على التكسير الحيوى لمبيدات الآفات بواسطة سلالات السيانوبكتيريا المعزوله من الأراضى الملوثه بمبيدات الآفات

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الملخص

يهدف هذا البحث إلى دراسة تقييم العوامل المؤثره على قدرة السيانوبكتيريا المحلله لمبيدات الآفات حيث تم الحصول على إثنى عشره عزله من السيانوبكتيريا من الأراضى الملوثه بمبيدات الآفات من محافظة كفر الشيخ وعند تقدير تأثير بعض العوامل وخاصة تركيزات مختلفه من مبيدين من مبيدات الآفات (الكلوروبيروفوس والكاربوفيوران) بعد ذلك دراسة تأثير درجة الحراره ودرجة الحموضه على أكفأ عزلتين من السيانوبكتيريا فى تحليل المبيدات عند تركيزات مختلفه من الكلوروبيروفوس والكاربوفيوران *Nostoc muscorum* and *Anabaena oryzae* وقد أظهرت النتائج زياده فى الوزن الجاف وكذلك النتروجين المثبت عند زيادة فترة التحضين وذلك بزيادة تركيز المبيد الكلوروبيروفوس 150 جزء فى المليون مع سلالة *A. oryzae* . من ناحية أخرى زيادة الوزن الجاف والنتروجين المثبت عند تركيز مبيد الكاربوفيوران 80 جزء فى المليون مع سلالة السيانوبكتيريا *N. muscorum* . بصفة عامة سجلت السلالتين التكسير الحيوى لكلا المبيدين حتى اليوم الثانى عشر من التحضين. وبالنسبه لتأثير درجة الحراره ودرجة الحموضه سجلت أفضل درجة الحراره 30 ^{o}م ودرجة حموضه 7 مع المبيد الكلوروبيروفوس ولكن درجة حراره 25^{o} م ودرجة حموضه 7 مع المبيد الكاربوفيوران على التوالى .