http://dx.doi.org/10.26750/jru.1021

A Study on Microbial Population under the Effect of some Pesticides in Different Soil Orders and Moisture Contents

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Abstract

The present study was designed to determine the effects of glyphosate, mancozeb and diazinon with three different soil orders and two soil moisture contents and their combinations on some soil microbial population in a pot experiment. The main results obtained at the last periods (4th and 5th samplings) of the study demonstrated as: glyphosate showed significant decrease in total actinomycetes and increased total bacteria, proteolytic bacteria and fungi. Mancozeb significantly decreased proteolytic bacteria and fungi. Diazinon significantly increased total bacteria and proteolytic bacteria. Agholan soil showed the greatest reduction in proteolytic bacteria, fungi and actinomycetes. Debaga soil significantly increased proteolytic bacteria. Girdarasha soil increased proteolytic bacteria, fungi and actinomycetes. 50% soil moisture content revealed significant increase in total bacteria and proteolytic bacteria. 100% soil moisture content showed significant increase in actinomycetes. The interaction between P1S2 increased total bacteria and actinomycetes. The interaction P1S3 increased proteolytic bacteria and fungi. The combination P2S3 caused significant reduction in fungi and actinomycetes. The combination P2S2 revealed significant reduction in fungi and actinomycetes. The interaction P2S3 showed the greatest increase in proteolytic bacteria. The combination P3S1 reduced actinomycetes. The interaction P3S2 increased total bacteria and proteolytic bacteria. The combination P3S3 increased proteolytic bacteria. The combination CS1 showed decreasing effect on proteolytic bacteria; CS2 showed decreasing effect on total proteolytic bacteria; CS3 increased actinomycetes and decreased proteolytic bacteria. The combination P1W1 increased total bacteria and fungi, whereas P1W2 increased actinomycetes and proteolytic bacteria. The combination CW2 reduced proteolytic bacteria and actinomycetes. The interaction S1W1 decreased fungi, whereas, S1W2 reduced total bacteria and fungi. The interaction S3W1increased total bacteria; the interaction S3W2 caused the highest increasing in actinomycetes. The combinations: P1S2W1 increased total bacteria and actinomycetes; P1S2W2 increased actinomycetes; P1S3W1 increased total bacteria and fungi. The interaction P2S3W2

e-ISSN (2522-7130) p-ISSN (2410-1036)

increased actinomycetes. The interactions: CS3W1 caused significant increase in actinomycetes; and CS3W2 showed significant increase in actinomycetes.

Keywords: Microbial population, Pesticides, Soil order, Moisture content.

Introduction

The increasing world population demands a continually growing supply of food and food products. Because of the relative lack of new areas suitable for agriculture, the performance of the existing agricultural areas has to be substantially enhanced. Pesticides such as insecticides, molluscicides, nematicides, rodenticides, avicides, piscicides, herbicides, plant growth regulators, defoliants, fungicides, algicides, etc. have been extensively used in agrochemical practice to protect plant against different pests. Although these pesticides are intended to be used at low concentrations, their application may cause contamination of soil, resulting in chemical and biological disturbance of this environment (1). Pesticides affect microorganisms by reducing their numbers, biochemical activity, diversity and changing microbial community structure. However, it is difficult to make a general conclusion regarding the impact of pesticides on soil microorganisms because a number of factors such as soil structure and texture, pH, organic matter content, temperature and moisture affect the behavior of these agrochemicals in soil (2 and 3). Pesticide is a general term that includes a variety of chemical and biological products used to kill or control pests such as rodents, insects, fungi, weeds and etc. (4). The active portion of a pesticide known as the active ingredient is generally formulated by the manufacturer as emulsifiable concentrates or in solid particles (dust, granules, soluble powder, or wettable powder). Soil microorganisms are extremely important among non-target organisms since they are a key component of soil ecosystems, dominating the cycling of nutrient elements and playing a major role in maintaining soil quality through transformation and decomposition of organic matter in the soil and helping plants utilize soil nutrients to grow and thrive, as well as helping soil to store water and nutrients and filter pollutants (5). Microorganisms are found in large numbers in soil usually between 10^1 and 10^{10} microorganisms.g^{-1} of soil with bacteria and fungi being the most prevalent (6 and 7). In 2001, (8) observed that some organophosphorus insecticides had no inhibitory effect on the development of soil microorganism groups. While, no detectable adverse effects were caused by some pesticides tested by (9) when they assessed the effect of those pesticides on non-target soil microorganisms, total count and growth rate. The excessive use, abuse or repeated application of some pesticides like glyphosate or diazinon in Kurdistan Region may alter the diversity and population of microorganisms in soil environment. Due to insufficient knowledge and few studies on pesticide effects on soil microbial population in the study area, present investigation was designed.

Materials and methods

A/ Soil sample collection

Soils of different orders including Entisols, Vertisols and Inceptisols were collected in May 2011 from three different agricultural fields in Erbil province including Agholan, Debaga and Girdarasha (Figure 1).

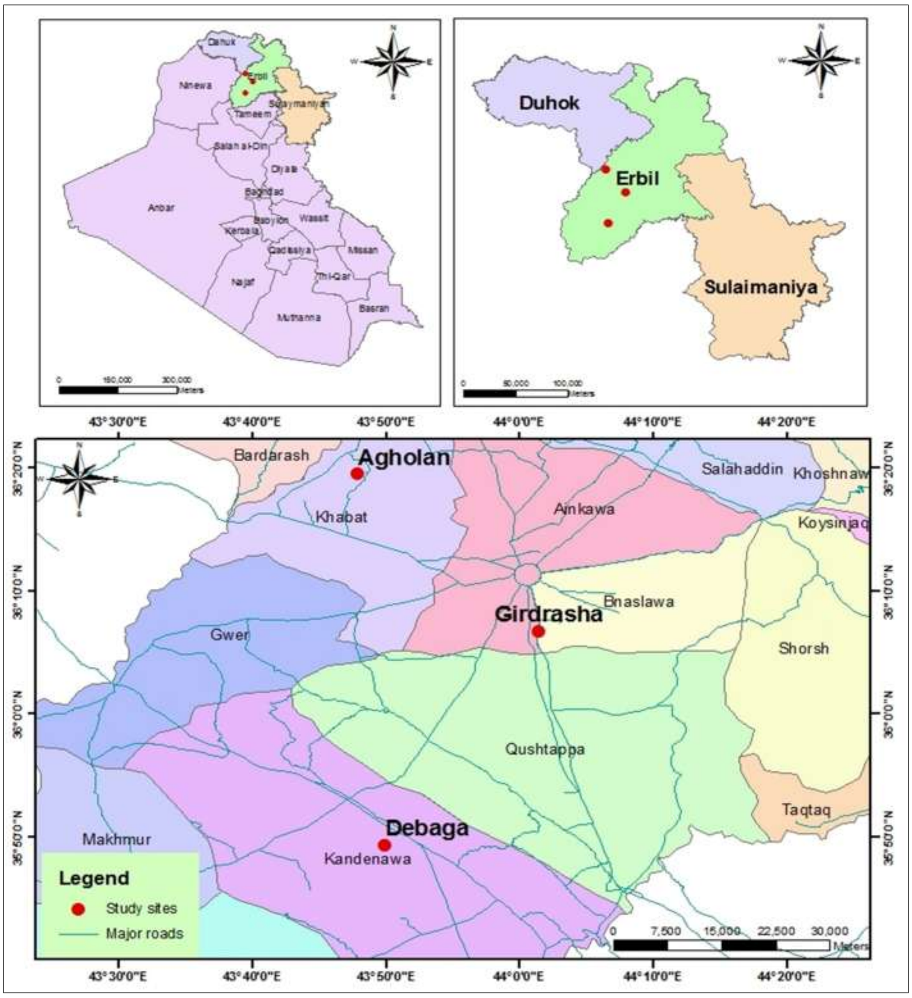

Figure 1: Map showing: Iraq, Erbil and the studied aria.

The soils of these three locations were not used for agricultural purposes for a period of time and had no previous history of pesticide use. Samples were collected from the upper layer of the soils (0-30 cm depth) at a random pattern around each field according to (10). The soil samples were brought to the greenhouse of the College of Science. Samples from each soil order were separately screened from gravels and stones, pulverized, air-dried and sieved by 2-mm sieve. Four portions from each soil order was separately weighted and placed on 57 cm2 of nylon-covered floor in dry and cool condition inside the greenhouse, and kept out from sunlight exposure.

B/ Pesticide preparation

The most abundant and usable pesticides in Kurdistan Region including glyphosate herbicide (48%), mancozeb fungicide (80%) and diazinon insecticide (10%) were selected according to the yearly report of plant protection in the Department of Plant Protection in

Erbil/General Directorate of Agriculture during 2010-2011 and used for the present study. These pesticides were prepared at their commercial recommended doses according to their active ingredients (a.i.) as described by (11). Each pesticide was placed in a sprayer (the amount of spraying water for each pesticide was as 60 liters/donum) and ready for application.

C/ Soil treatment by pesticides

The first portion from each soil order was sprayed by glyphosate; the second portion by mancozeb; the third portion by diazinon; while the last portion from each soil order was left without pesticide treatment. The soil portions were mixed to obtain a homogenous distribution. Then the pesticide-treated soils were sealed and left for an overnight at room temperature.

D/ Pot experiment layout

A factorial experiment (4×3×2) was conducted in the greenhouse of the College of Science/University of Salahaddin using Completely Randomized Design (CRD) with three replications under twenty-four combined treatments (Table 1). For this purpose 72 pre-labelled and similar plastic pots (average diameter 15 cm and height 17 cm) were used and each filled with 4 kg pesticide-treated soil and a sample was taken from each pot. The pots were provided by a below-container to collect the irrigation water and return-back to the pots. Then the pots were covered with filter papers. The pots were irrigated daily by tap water at 50% and 100% moisture content daily and the loss of water were compensated by weighting each pot daily. This experiment last for two months with five sampling periods at biweekly intervals at variable climatic condition (Table 2).

Table 1: Pot experimental design.

No. of treatments		***Pesticide***	***Soil order***	***Moisture content***	***Combined treatments***	***Replications***
1	P1S1W1	Glyphosate	Agholan	50%	Glyphosate.Agholan.50%	3
2	P1S1W2			100%	Glyphosate.Agholan.100%	3
3	P1S2W1		Debaga	50%	Glyphosate.Debaga.50%	3
4	P1S2W2			100%	Glyphosate.Debaga.100%	3
5	P1S3W1		Girdarasha	50%	Glyphosate.Girdarsha.50%	3
6	P1S3W2			100%	Glyphosate.Girdarasha.100%	3
7	P2S1W1	Mancozeb	Agholan	50%	Mancozeb.Agholan.50%	3
8	P2S1W2			100%	Mancozeb.Agholan.100%	3
9	P2S2W1		Debaga	50%	Mancozeb.Debaga.50%	3

10	P2S2W2			100%	Mancozeb.Debaga.100%	3
11	P2S3W1		Girdarasha	50%	Mancozeb.Girdarsha.50%	3
12	P2S3W2			100%	Mancozeb.Girdarsha.100%	3
13	P3S1W1	Diazinon	Agholan	50%	Diazinon.Agholan.50%	3
14	P3S1W2			100%	Diazinon.Agholan.100%	3
15	P3S2W1		Debaga	50%	Diazinon.Debaga.50%	3
16	P3S2W2			100%	Diazinon.Debaga.100%	3
17	P3S3W1		Girdarasha	50%	Diazinon.Girdarsha.50%	3
18	P3S3W2			100%	Diazinon.Girdarsha.100%	3
19	CS1W1	Control (no pesticide)	Agholan	50%	Control.Agholan.50%	3
20	CS1W2			100%	Control.Agholan.100%	3
21	CS2W1		Debaga	50%	Control.Debaga.50%	3
22	CS2W2			100%	Control.Debaga.100%	3
23	CS3W1		Girdarasha	50%	Control.Girdarasha.50%	3
24	CS3W2			100%	Control.Girdarasha.100%	3

Table 2: Climatic condition during the study.

Parameters	***1st sampling 9/6/2011***	***2nd sampling 24/6/2011***	***3rd sampling 9/7/2011***	***4th sampling 24/7/2011***	***5th sampling 8/8/2011***	***Mean***
Maximum temperature (ºC)	37.0	36.7	37.0	44.6	41.2	39.3
Minimum temperature (ºC)	24.4	26.4	28.6	33.3	30.0	28.54
Dry temperature (ºC)	31.1	31.5	33.3	38.9	35.1	33.98
Humidity (%)	29	31	23	20	29	26.4
Wind velocity ($m.sec^{-1}$)	1.0	1.4	2.5	3.9	1.5	2.06
Wind direction	320	240	220	40	320	228
Maximum wind velocity ($m.sec^{-1}$)	3	4	7	14	6	6.8

From: Directorate of Meteorology and Seismology in Erbil.

E/ Preparation of culture media

For counting of total soil bacteria, nutrient agar was prepared by adding 28 g of powdered medium into distilled water and bringing the volume to 1L and pH adjusted to 7.0±0.2. Then mixing thoroughly and gently heating and bringing to boiling in flasks. The medium was then autoclaved for 15 min at 15 psi and 121°C (12). Nutrient gelatin agar was used for counting of total soil proteolytic bacteria. It was prepared by adding the following components [agar 15 g; gelatin 15 g; peptone 4 g and yeast extract 1 g] to distilled water and bringing the volume to 1L and the pH of the medium was adjusted to 7.0±0.2. Then mixing thoroughly and gently heating and bringing to boiling in flasks and then autoclaved (12). For counting of total soil fungi, potato dextrose agar was prepared by adding 39 g of powdered medium into distilled water and bringing the volume to 1L. Then mixing thoroughly and gently heating and bringing to boiling in flasks. The medium was then autoclaved. Then 0.2 mg Chloramphinicol was added (13). Starch casein agar was used for counting of total soil actinomycetes. It was prepared by adding and thorough mixing of the following components [starch 10 g; casein 3 g; KNO_3 2 g; NaCl 2 g; K_2HPO_4 2 g; $MgSO_4.7H_2O$ 0.05 g; $CaCO_3$ 0.02 g; $FeSO_4.7H_2O$ 0.01 g and agar 15 g] with 1L distilled water and the pH of the complete medium was adjusted to 7.0±0.2. The mixture then brought to gentle heating and boiling in flasks and then autoclaved. Before pouring the medium into petri plates containing soil suspensions, 50 mg rifampcine as a bactericide and 50 mg cycloheximide as a fungicide were added (12).

F/ Microbiological analysis

Standard plate method was used for counting the studied microbial groups. Total number of bacteria and total proteolytic bacteria was estimated in a gram of dry soil using the incubation period 24-48 hours at 30-35°C. Normally the number of colonies within the range (30-300) was taken in to account (12 and 14). For total number of fungi, the plates were incubated for 5-7 days at 23±2°C (15). Total number of actinomycetes was estimated by spread plate method and the plates were incubated for 2 weeks at 30°C as described by (12).

G/ Statistical analysis

Data was analysed statistically using SPSS version 11.5 and Microsoft Office Excel 2010 and the means were compared using Revised Least Significant Differences (R.LSD) at the level of significant of 0.05.

Results

Glyphosate showed the highest total bacterial population at 24h and 8 weeks after application (table 3), but during the 4th sampling both glyphosate and diazinon produced the same increasing effect on soil total bacteria. During the 2nd and 3rd sampling the highest bacterial population was found in control treatment. Agholan soil showed the highest values (22.53×10^5±11.191 and 11.82×10^5±3.875) of total bacteria at 24h and 2 weeks after treatment, while Girdarasha soil gave the highest values (14.50×10^5±1.691 and 20.67×10^5±6.649) of soil total bacteria 4 and 8 weeks after treatment. Soil moisture content of 100% showed highest total bacterial population at 24h after treatment, while, 50% soil moisture content showed the highest total bacterial population during the 3rd, 4th and 5th sampling periods. The combination P1S1 showed the highest total bacterial population at 24h after treatment. The combinations CS1, P3S2 and P1S2 during the 2nd, 3rd and 4th sampling periods showed the highest total bacterial population. At the end of the study the combination of P1S3 showed the highest total bacterial population. The combined treatments P1W2, CW2 and P3W1 showed the highest total bacterial count during the 1st, 2nd and 3rd sampling periods and the combination P1W1 showed the highest total bacterial count at the last sampling periods. The combined treatment S1W2 at 24h and 2 weeks after treatment gave the highest total bacterial count; the combinations S2W1 during the 4th sampling and S3W1 during the 3rd and 5th sampling showed the highest total bacterial count. The combinations of P1S1W2, CS1W2 and P1S2W1 revealed the highest count of total bacteria at 24h, 2 and 6 weeks after treatment and the combination of P1S3W1 showed the highest count of soil total bacteria at 4 and 8 weeks after treatment. According to (table 4), glyphosate showed the highest count of soil total proteolytic bacteria at 24h, 4 and 6 weeks after treatment, and diazinon showed the highest count of total proteolytic bacteria during the last sampling periods. Girdarasha soil showed the highest total proteolytic bacterial count, but Agholan soil showed the lowest soil total proteolytic bacteria during the 3rd, 4th and 5th sampling periods. 100% soil moisture content revealed highest soil total proteolytic bacterial count at 24h after treatment, but 50% soil moisture content showed the highest total proteolytic bacteria 4 and 8 weeks after treatment. The combined treatment P1S3 showed the highest total proteolytic bacterial population during the 1st, 3rd and 4th sampling periods and the combinations of CS1 and P3S3 during the 2nd and 5th sampling periods showed the highest total proteolytic bacterial count. The combination of P3W2 showed the highest total proteolytic bacterial count at the beginning of the study, while the combinations of CW2, P3W1 and P1W2 revealed the highest total proteolytic bacterial count during the 2nd, 3rd and 4th sampling periods. The combined treatment S3W2 at the beginning and S3W1 during the 3rd sampling showed the highest total proteolytic bacterial population. Glyphosate in Girdarasha soil with 100% soil moisture content (P1S3W2) showed highest total proteolytic bacterial count during the 1st sampling probably. In the 2nd sampling the highest population of proteolytic bacteria was found in the combination of CS1W2. In the 3rd sampling the combination P1S3W1 showed the highest total proteolytic bacterial count. According to the data shown in (table 5), glyphosate revealed the highest fungal population during the studied periods except for the 2nd sampling. At the end of the study, mancozeb significantly decreased total fungi. Girdarasha soil showed the highest total fungi count during the 2nd, 3rd and 5th sampling periods. 100% soil moisture content showed the highest total fungi count during the 2nd and 3rd sampling periods, while 50% soil moisture content showed the highest total fungi count at the end of the study. Glyphosate in Girdarasha soil (P1S3) showed the highest total fungi count during the studied periods except for the 1st sampling in which Glyphosate in Agholan soil (P1S1) showed the highest count. The combination of P2S1 caused significant reduction in total fungi at the end of the study. During the 3rd and 5th samplings, the combined treatment P1W1 showed significant increase in total fungi, but P2W2 showed the least fungal population during the 5th sampling. During the last sampling period the combined treatment S3W1 significantly increased total fungal population, but both the combinations S1W1 and S1W2 caused significant decrease in total fungi during this period. The combination P1S3W1 during the 3rd and 5th sampling periods showed significant increase in total fungi. The combination of CS1W2 showed significant increase in total fungi during the 2nd sampling. All the treatments caused high reduction in actinomycetes population during the 2nd sampling period except for glyphosate treatment (table 6) and more reduction was observed during the 3rd and 4th sampling periods with higher reduction in control; glyphosate caused significant reduction in soil total actinomycetes during the 3rd sampling period. Debaga soil showed the highest actinomycetes population at the beginning of the study and Girdarasha soil increased total actinomycetes at the end of the study, organic matter of both Debaga and Girdarasha soils were increased during the studied period (table 7). Agholan soil caused significant reduction in soil total actinomycetes during the last sampling. 100% soil moisture content showed the highest total actinomycetes during the 1st, 2nd and 5th sampling periods. The combined treatments CS2, P3S3 and CS3 showed the highest soil total actinomycetes population during the 1st, 2nd and 5th sampling periods. The combined treatments P1S2 and CS3 showed significant increasing in total actinomycetes at the last sampling period. During the 1st sampling the combined treatment CW2 showed the highest actinomycetes population. The combination of P1W2 showed the highest actinomycetes population during the 2nd and 5th sampling periods. The combination of P1W1 revealed the lowest soil total actinomycetes during the 2nd sampling. During the 2nd and 5th sampling periods, Girdarasha soil with 100% soil moisture content (S3W2) showed the highest total actinomycetes population. The combinations of P1S3W2 and CS3W2 during the 2nd and 5th sampling respectively revealed the highest actinomycetes population. The combinations of P1S2W1, P1S2W2, P2S3W2, CS3W1 and CS3W2 showed significant increasing in total actinomycetes during the last sampling.

Table 3: Effects of different treatments on soil total bacterial population$\times 10^{5}.g^{-1}$ dry soil during five sampling periods (Mean±S.E.).

Treatments	**1st sampling 9/6/2011 (24h after application)**	**2nd sampling 24/6/2011 (2 weeks after application)**	**3rd sampling 9/7/2011 (4 weeks after application)**	**4th sampling 24/7/2011 (6 weeks after application)**	**5th sampling 8/8/2011 (8 weeks after application)**
P1 (Glyphosate)	40.69±7.148 a	4.69±1.101 c	10.56±2.787 b	11.00±2.822 a	21.29±3.221 a
P2 (Mancozeb)	7.15±1.422 b	7.40±2.240 b	8.30±1.770 c	9.04±1.957 b	12.91±2.241 b
P3 (Diazinon)	10.43±2.389 b	8.62±1.121 b	13.28±2.610 a	11.40±1.290 a	13.03±3.013 b
C (Control)	7.05±1.250 b	20.20±3.766 a	13.49±0.811 a	6.43±0.920 c	8.84±1.423 c
S1 (Agholan)	22.53±1.191 a	11.82±3.875 a	8.00±1.190 c	6.59±0.971 c	9.06±2.624 c
S2 (Debaga)	9.59±1.903 c	10.03±2.583 b	11.72±2.118 b	12.06±1.948 a	12.33±1.271 b
S3 (Girdarasha)	16.88±4.699 b	8.84±1.207 b	14.50±1.691 a	9.75±1.560 b	20.67±3.649 a
W1 (50% Moisture content)	8.61±2.302 b	9.74±1.818	12.47±1.838 a	10.48±1.553 a	17.92±4.700 a
W2 (100% Moisture content)	24.05±4.602 a	10.72±4.520	10.34±1.192 b	8.45±1.165 b	10.12±1.357 b
P1S1	62.53±3.387 a	7.04±0.000 fg	8.38±0.318 fg	4.91±0.088 e	5.78±0.693 f

P1S2	9.07±2.409 cde	3.03±1.053 h	5.65±0.351 hi	16.59±7.080 a	15.03±2.685 bcd
P1S3	50.46±40.854 b	11.04±0.163 cd	17.66±3.075 a	11.49±0.816 bc	43.05±11.678 a
P2S1	5.98±3.991 de	2.05±0.712 h	4.51±1.095 i	8.37±2.807 cd	9.66±1.595 ef
P2S2	8.37±1.694 cde	13.49±3.187 bc	9.42±2.831 ef	8.38±1.518 cd	11.92±4.956 cde
P2S3	7.10±2.945 de	6.65±1.506 g	10.96±3.443 de	10.38±3.678 c	17.17±4.311 b
P3S1	14.55±14.078 c	7.46±1.376 g	6.75±0.121 gh	8.84±0.771 cd	15.58±5.968 bc
P3S2	10.60±3.185 cd	9.96±2.027 de	18.16±3.464 a	14.65±0.131 ab	10.20±0.681 def
P3S3	6.14±1.141 de	8.43±2.145 g	14.93±1.777 b	10.71±2.610 c	13.32±0.893 bcde
CS1	7.04±0.260 de	37.75±9.865 a	12.38±1.426 cd	4.24±1.161 e	5.21±0.966 f
CS2	10.31±1.451 cd	13.62±4.271 b	13.67±0.461 bc	8.61±1.023 cd	12.19±1.012 bcde
CS3	3.80±0.325 e	9.23±2.466 def	14.43±2.340 b	6.44±0.867 de	9.14±1.980 ef
P1W1	18.41±5.721 b	4.99±1.172 de	12.58±2.666 a	13.66±3.435 a	29.97±8.171 a
P1W2	62.97±10.680 a	4.39±1.452 e	8.55±1.632 b	8.34±1.790 bcd	12.60±4.414 bc
P2W1	6.24±2.337 c	11.53±3.871 bc	9.20±2.604 b	8.26±2.308 cd	15.47±3.935 bc
P2W2	8.06±1.955 c	3.26±0.963 e	7.39±2.840 b	9.83±1.635 abc	10.36±1.759 bc
P3W1	2.30±1.146 c	8.78±1.051 c	14.47±4.950 a	12.57±1.537 ab	16.76±2.079 b
P3W2	18.56±5.371 b	8.45±2.269 cd	12.09±2.855 a	10.23±2.143 abc	9.31±2.388 bc
CW1	7.51±2.392 c	13.64±2.465 b	13.64±1.694 a	7.45±1.224 cd	9.49±1.657 bc
CW2	6.59±1.368 c	26.75±5.889 a	13.34±0.632 a	5.41±1.304 d	8.20±2.638 c
S1W1	9.73±3.636 c	7.37±2.961 c	8.22±1.035 c	7.80±1.536 c	11.81±4.930 b
S1W2	35.32±10.764 a	16.26±13.846 a	7.79±2.346 c	5.38±1.037 d	6.30±1.660 c
S2W1	9.83±2.696 c	10.76±2.116 b	12.18±2.190 b	14.50±3.280 a	13.82±2.041 b
S2W2	9.34±2.097 c	9.29±2.719 b	11.27±1.801 b	9.62±1.725 bc	10.85±1.380 b

e-ISSN (2522-7130) p-ISSN (2410-1036)

S3W1	6.28±1.070 c	11.08±0.949 b	17.02±2.363 a	9.16±2.245 c	28.13±6.718 a
S3W2	27.47±7.332 b	6.60±1.600 c	11.98±1.879 b	10.35±2.466 b	13.20±2.718 b
P1S1W1	29.14±4.367 b	0.007±0.000 n	8.70±0.251 h	4.99±0.120 jkl	6.47±0.844 kl
P1S1W2	95.92±14.240 a	0.008±0.000 n	8.06±0.459 hi	4.82±0.121 kl	4.09±0.000 l
P1S2W1	16.48±0.311 c	4.08±0.000 kl	5.30±0.300 k	23.67±7.131 a	17.71±1.339 cde
P1S2W2	1.66±0.064 gh	1.08±0.067 m	6.00±0.000 jk	9.51±0.181 fgh	12.34±2.010 ghi
P1S3W1	9.61±1.060 d	10.88±0.062 fg	23.74±0.292 a	12.31±0.118 cde	65.73±4.216 a
P1S3W2	91.32±8.258 a	11.20±0.000 ef	11.59±0.372 fg	10.68±0.363 defg	20.37±0.000 cd
P2S1W1	1.99±0.000 gh	2.76±0.000 lm	6.60±0.246 ijk	11.17±1.990 def	8.06±1.270 ijkl
P2S1W2	9.97±2.644 d	1.34±0.000 m	2.41±0.000 l	5.56±0.424 ijkl	11.25±0.000 ghij
P2S2W1	6.68±0.964 defg	22.68±0.000 b	6.59±1.268 ijk	9.90±0.177 efgh	16.87±1.614 def
P2S2W2	10.07±0.989 d	4.31±0.000 jkl	12.25±0.688 defg	6.86±0.414 ijk	6.96±0.000 jkl
P2S3W1	10.04±0.000 d	9.16±0.000 fg	14.41±0.668 c	3.70±0.000 l	21.48±0.000 c
P2S3W2	4.15±0.000 defgh	4.15±0.000 kl	7.52±0.063 hij	17.06±0.721 b	12.85±0.866 fgh
P3S1W1	0.47±0.000 h	8.84±1.701 gh	6.63±0.188 ijk	9.61±0.656 fgh	26.55±6.509 b
P3S1W2	28.63±2.543 b	6.08±0.000 ijk	6.87±0.137 hijk	8.07±0.424 ghi	4.62±0.377 l
P3S2W1	4.41±0.000 defgh	6.94±0.000 hi	23.62±0.661 a	14.78±1.185 bc	9.52±1.359 hijk
P3S2W2	16.78±0.000 c	12.99±3.161 de	12.69±0.319 cdefg	14.52±0.718 bc	10.88±0.229 ghij
P3S3W1	2.00±0.000 gh	10.58±1.954 fg	13.15±0.547 cdef	13.32±1.775 cd	14.21±0.951 efg
P3S3W2	10.28±2.428 d	6.29±0.000 ij	16.70±3.430 b	8.10±0.000 ghi	12.43±0.307 ghi
CS1W1	7.30±0.000 def	17.88±0.630 c	10.95±0.506 g	5.40±0.480 jkl	6.17±1.663 kl
CS1W2	6.78±0.000 defg	57.61±5.861 a	13.81±0.871 cde	3.08±0.000 l	4.24±0.421 l
CS2W1	11.76±0.000 cd	9.35±0.123 fg	13.21±0.726 cdef	9.63±0.000 fgh	11.17±1.290 ghij

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CS2W2	8.86±0.000 de	17.89±0.124 c	14.13±0.316 cd	7.59±0.000 hij	13.20±1.758 fgh
CS3W1	3.48±0.000 fgh	13.69±0.243 d	16.77±0.605 b	7.30±1.247 hijk	11.12±1.119 ghij
CS3W2	4.13±0.000 defgh	4.76±0.000 jkl	12.09±3.459 efg	5.57±0.000 ijkl	7.16±1.299 jkl

Table 4: Effects of different treatments on soil total proteolytic bacterial population×10^5.g^{-1} dry soil during five sampling periods (Mean±S.E.).

Treatments	1st sampling 9/6/2011 (24h after application)	2nd sampling 24/6/2011 (2 weeks after application)	3rd sampling 9/7/2011 (4 weeks after application)	4th sampling 24/7/2011 (6 weeks after application)	5th sampling 8/8/2011 (8 weeks after application)
P1 (Glyphosate)	6.32±2.017 a	2.68±0.292	5.50±1.621 a	5.38±1.410 a	5.94±1.320 b
P2 (Mancozeb)	3.49±0.713 c	1.63±0.345	4.49±1.712 b	3.07±0.553 b	6.64±1.405 ab
P3 (Diazinon)	4.29±1.828 b	5.98±1.165	4.88±1.678 ab	4.52±1.411 a	7.95±1.316 a
C (Control)	2.48±0.421 d	9.82±2.226	2.45±0.494 c	2.57±0.937 b	1.15±0.420 c
S1 (Agholan)	3.86±1.483	7.14±2.551	2.31±0.623 c	1.63±0.474 c	3.26±0.475 b
S2 (Debaga)	4.10±0.655	3.71±1.031	4.59±1.267 b	4.21±0.741 b	5.91±1.304 a
S3 (Girdarasha)	4.47±1.593	4.23±1.090	6.10±1.464 a	5.81±1.122 a	7.08±1.678 a
W1 (50% Moisture content)	3.55±0.755 b	3.63±0.800	5.53±1.208 a	4.13±0.917	6.56±1.181 a
W2 (100% Moisture content)	4.74±1.253 a	6.42±1.667	3.13±0.690 b	3.64±0.742	4.28±0.919 b
P1S1	4.58±0.208 c	0.09±0.000 b	2.94±0.008 cd	1.31±0.161 fg	3.36±0.924 cd
P1S2	4.16±1.054 c	2.25±0.084 b	3.39±1.002 cd	6.13±1.189 bc	7.17±2.318 abc
P1S3	10.23±2.292 a	9.79±1.609 b	10.18±2.346 a	8.71±0.399 a	7.29±2.148 ab
P2S1	1.56±1.004 fg	1.34±0.784 b	0.27±0.058 e	3.29±1.510 defg	3.27±0.299 d
P2S2	4.66±0.694 c	1.15±0.502 b	6.14±1.335 b	3.48±1.028 def	6.48±0.890 abcd
P2S3	4.26±0.654	2.40±0.097	7.05±2.888	2.43±0.790	10.16±2.23

	c	b	b	efg	2 a
P3S1	6.19±2.194 b	3.73±0.688 b	3.95±0.586 c	0.93±0.410 h	4.31±1.350 bcd
P3S2	4.46±0.817 c	6.99±1.889 b	6.65±2.214 b	5.10±1.469 cd	9.31±0.742 a
P3S3	2.21±1.764 ef	7.22±1.981 b	4.04±1.803 c	7.51±2.322 ab	10.22±1.829 a
CS1	3.13±0.260 d	23.51±2.306 a	2.06±0.011 d	0.98±0.149 g	2.12±1.071 e
CS2	3.11±0.323 de	4.44±0.128 b	2.16±0.012 d	2.15±1.230 fg	0.69±0.330 e
CS3	1.20±0.167 g	1.51±0.600 b	3.13±0.955 cd	4.58±1.209 cde	0.66±0.025 e
P1W1	6.98±0.546 a	3.91±0.442 b	5.95±1.292 b	4.80±1.069 ab	8.07±1.913
P1W2	5.67±1.428 b	1.45±0.930 b	5.06±1.448 b	5.96±1.307 a	3.81±0.718
P2W1	3.14±1.325 cd	2.09±0.245 b	5.32±1.106 b	2.97±0.948 bc	7.78±2.554
P2W2	3.84±0.815 c	1.17±0.567 b	3.66±2.079 c	3.17±0.786 bc	5.50±1.431
P3W1	1.36±1.147 f	5.91±1.650 b	8.08±1.928 a	5.92±1.473 a	8.76±1.847
P3W2	7.21±2.615 a	6.05±2.014 b	1.68±0.350 d	3.12±1.372 bc	7.13±2.141
CW1	2.73±0.681 de	2.62±1.006 b	2.77±0.860 cd	2.85±1.971 bc	1.63±0.786
CW2	2.23±0.598 e	7.01±14.435 a	2.13±0.616 d	2.29±0.652 c	0.68±0.201
S1W1	2.93±1.780 d	1.94±0.935	2.94±1.088 d	2.03±0.930	4.18±0.544
S1W2	4.80±2.551 b	2.35±3.173	1.67±0.600 e	1.23±0.269	2.35±0.453
S2W1	4.56±0.892 b	3.41±0.640	5.05±2.393 b	3.72±1.260	6.61±1.915
S2W2	3.63±1.031 c	4.00±1.120	4.12±1.274 bc	4.71±0.903	5.21±1.985
S3W1	3.17±1.335 cd	5.55±1.885	8.60±1.922 a	6.64±1.779	8.89±2.768
S3W2	5.78±2.986 a	2.91±0.907	3.60±1.464 cd	4.97±1.498	5.27±1.816
P1S1W1	7.79±0.514 c	0.002±0.000 b	2.93±0.314 fghij	1.14±0.180	4.28±1.868
P1S1W2	1.37±0.158 hi	0.004±0.000 b	2.95±0.131 fghij	1.47±0.121	2.43±0.766
P1S2W1	7.22±0.	3.33±0.062	2.39±0.300	4.94±0.357	9.49±2.800

	187 c	b	ghijk		
P1S2W2	1.11±0.640 ij	1.16±0.671 b	4.39±1.299 efg	7.32±0.604	4.85±0.487
P1S3W1	5.94±0.312 d	8.40±2.363 b	12.53±0.467 a	8.31±0.415	10.43±2.216
P1S3W2	14.52±0.381 a	3.18±0.368 b	7.83±0.86 b	9.11±0.906	4.14±1.164
P2S1W1	0.55±0.064 ij	2.13±0.000 b	0.21±0.000 l	4.80±0.844	3.57±1.929
P2S1W2	2.56±0.078 gh	0.56±0.064 b	0.33±0.063 kl	1.78±0.545	2.97±1.594
P2S2W1	3.96±0.361 ef	1.65±0.119 b	4.81±0.483 def	2.45±0.471	7.37±1.960
P2S2W2	5.35±0.989 d	0.65±0.124 b	7.48±0.313 bc	4.51±0.000	5.59±1.401
P2S3W1	4.92±0.000 de	2.50±0.481 b	10.94±0.486 a	1.64±0.119	12.39±3.577
P2S3W2	3.61±0.694 fg	2.30±0.399 b	3.16±0.189 fghi	3.22±0.300	7.93±1.608
P3S1W1	0.09±0.000 j	4.42±0.981 b	5.54±1.199 cde	1.34±0.060	5.66±0.363
P3S1W2	12.39±0.795 b	3.04±0.687 b	2.37±0.000 ghijk	0.52±0.061	2.96±0.846
P3S2W1	3.64±0.446 efg	4.10±0.182 b	11.86±0.481 a	6.57±0.948	8.57±2.327
P3S2W2	5.27±0.554 d	9.88±0.496 b	1.43±0.319 ijkl	3.63±0.539	10.05±0.658
P3S3W1	0.44±0.257 ij	8.20±1.893 b	6.84±0.547 bcd	9.84±4.496	12.05±1.843
P3S3W2	3.97±0.944 ef	5.24±0.202 b	1.23±0.583 ijkl	5.19±1.998	8.39±0.184
CS1W1	2.39±0.151 fg	1.20±0.567 b	3.07±0.632 fghij	0.83±0.000	3.19±0.535
CS1W2	2.87±0.151 fg	15.81±6.450 a	1.04±0.067 jkl	1.13±0.059	1.05±0.130
CS2W1	3.43±0.566 fg	4.57±1.269 b	1.15±0.545 ijkl	0.92±0.414	1.02±0.469
CS2W2	2.78±1.023 fg	4.31±0.000 b	3.18±0.063 fghi	3.38±0.414	0.36±0.053
CS3W1	1.37±0.215 hi	2.11±0.000 b	4.09±0.424 efgh	6.79±0.238	0.68±0.230
CS3W2	1.03±0.447 ij	0.91±0.000 b	2.18±0.000 hijkl	2.37±0.179	0.63±0.236

Table 5: Effects of different treatments on soil total fungal population×10^5.g^{-1} dry soil during five sampling periods (Mean±S.E.).

Treatments	1st sampling 9/6/2011 (24h after application)	2nd sampling 24/6/2011 (2 weeks after application)	3rd sampling 9/7/2011 (4 weeks after application)	4th sampling 24/7/2011 (6 weeks after application)	5th sampling 8/8/2011 (8 weeks after application)
P1 (Glyphosate)	8.11±2.353 a	20.74±5.599 b	10.95±2.026 a	10.02±1.881 a	15.65±4.522 a
P2 (Mancozeb)	2.20±0.366 b	3.43±0.482 d	5.89±1.736 c	2.33±0.037 b	1.66±0.434 c
P3 (Diazinon)	2.25±0.657 b	11.90±3.467 c	6.28±1.614 c	2.69±0.235 b	4.67±1.176 b
C (Control)	3.60±0.798 b	32.66±9.769 a	7.63±1.204 b	8.57±2.281 a	4.59±1.309 b
S1 (Agholan)	5.40±1.907	20.41±9.393 a	6.38±1.394 c	4.45±0.909	3.07±0.686 c
S2 (Debaga)	3.01±0.736	11.80±3.157 b	7.84±1.473 b	6.54±1.876	6.67±2.194 b
S3 (Girdarasha)	3.72±1.228	19.33±4.501 a	8.85±1.769 a	6.71±2.516	10.19±4.004 a
W1 (50% Moisture content)	4.31±1.181	13.02±3.573 b	7.23±1.282 b	5.75±1.525	8.55±2.794 a
W2 (100% Moisture content)	3.77±1.089	21.34±6.083 a	8.15±1.256 a	6.05±1.547	4.74±1.453 b
P1S1	14.00±0.020 a	15.52±0.913 cd	9.51±1.793 c	4.70±0.956 c	5.37±0.061 cde
P1S2	1.76±0.463 c	11.77±0.962 de	8.77±0.472 c	11.40±0.949 a	15.34±5.322 b
P1S3	8.59±2.753 ab	34.93±8.224 a	14.55±4.035 a	13.96±2.345 a	26.24±7.775 a
P2S1	2.37±1.267 c	2.16±0.819 f	3.87±1.672 ef	5.55±0.327 b	0.82±0.168 g
P2S2	2.28±0.188 c	3.75±0.450 f	10.79±2.431 b	1.18±0.053 c	1.97±0.473 g
P2S3	1.94±0.518 c	4.37±0.003 e	3.00±0.538 f	0.26±0.157 c	2.19±0.122 fg
P3S1	1.95±0.529 c	3.79±0.745 f	7.97±0.493 d	4.24±0.424 c	3.84±1.219 ef
P3S2	2.80±1.837 bc	11.74±0.522 d	3.30±0.867 ef	2.12±0.109 c	4.32±0.797 de
P3S3	2.01±1.544 c	20.16±4.291 c	7.57±0.729 d	1.70±0.143 c	5.86±0.405 cd
CS1	3.26±0.652	30.15±15.9	4.15±0.670	3.30±0.122	2.26±0.203

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	bc	88 b	e	c	fg
CS2	5.20±2.138 bc	19.94±5.279 c	8.49±1.043 c	11.48±0.202 a	5.06±0.387 cde
CS3	2.33±0.525 c	17.86±3.328 cd	10.27±0.625 b	10.93±0.589 ab	6.46±0.405 c
P1W1	8.88±3.873	15.10±7.122 c	11.31±4.196 a	10.80±3.708	20.04±8.257 a
P1W2	7.34±3.477	26.39±8.611 b	10.58±1.667 b	9.24±1.824	11.26±3.848 b
P2W1	1.88±0.404	3.55±0.421 d	5.62±1.565 d	2.15±1.564	2.28±0.704 de
P2W2	2.51±0.640	3.30±0.984 d	6.16±3.543 d	2.51±1.701	1.04±0.248 e
P3W1	3.21±0.943	8.97±3.494 c	4.68±1.126 e	3.78±0.236	5.88±2.138 c
P3W2	1.30±0.605	14.82±6.271 c	7.88±3.032 c	1.59±0.928	3.46±0.939 d
CW1	3.28±0.323	24.45±9.857 b	7.30±1.394 c	6.27±2.839	6.00±2.454 c
CW2	3.92±1.726	40.85±17.685 a	7.97±2.278 c	10.87±3.557	3.18±0.744 d
S1W1	5.11±3.033	17.03±0.953	6.18±1.788 c	4.88±0.136	2.77±0.948 d
S1W2	5.68±2.779	23.78±1.770	6.58±2.418 c	4.01±0.137	3.37±1.112 d
S2W1	2.77±0.719	6.66±0.282	6.01±1.112 c	6.55±0.316	8.42±0.414 b
S2W2	3.24±1.404	16.94±0.457	9.67±2.578 a	6.54±0.253	4.93±1.820 c
S3W1	5.05±2.108	15.37±0.457	9.50±3.325 a	5.82±0.364	14.46±0.671 a
S3W2	2.38±1.184	23.29±0.795	8.19±1.806 b	7.60±0.397	5.91±0.419 c
P1S1W1	14.02±4.752	16.44±3.070 efgh	11.30±0.000 cd	3.75±0.000	5.43±0.000 de
P1S1W2	13.98±7.753	14.61±6.494 fghi	7.72±0.000 gh	5.66±0.000	5.31±0.000 def
P1S2W1	1.29±0.498	2.15±0.000 i	4.05±0.600 jk	12.35±0.000	20.66±0.000 b
P1S2W2	2.22±1.281	21.40±0.000 def	13.50±0.000 b	10.46±0.000	10.02±3.045 c
P1S3W1	11.34±5.923	26.71±7.462 cd	18.59±0.000 a	16.31±2.309	34.01±0.000 a
P1S3W2	5.83±2.986	43.16±1.397 bc	10.52±0.000 cde	11.62±4.2.90	18.46±0.000 b
P2S1W1	1.10±0.637	2.98±0.000	5.54±0.000	5.22±1.809	0.98±0.000

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		i	i		g
P2S1W2	3.64±1.011	1.34±0.000 i	2.19±0.000 l	5.88±0.000	0.65±0.061 g
P2S2W1	2.09±0.000	3.30±0.714 i	8.36±0.000 fg	1.12±0.530	2.44±0.574 fg
P2S2W2	2.46±1.051	4.20±1.305 hi	13.23±0.000 b	1.23±0.473	1.50±0.475 g
P2S3W1	2.46±1.049	4.37±1.202 hi	2.94±0.000 kl	0.10±0.0593	3.41±0.417 defg
P2S3W2	1.42±0.442	4.38±0.000 hi	3.05±0.503 kl	0.42±0.240	0.98±0.315 g
P3S1W1	1.42±0.000	4.53±0.000 hi	3.04±0.502 kl	8.48±4.655	2.62±0.908 efg
P3S1W2	2.48±0.159	3.04±1.298 i	12.91±0.752 c	0.009±0.000	5.06±1.947 def
P3S2W1	4.63±2.421	6.52±0.000 ghi	4.16±0.000 ijk	1.03±0.593	5.12±0.591 def
P3S2W2	0.96±0.554	16.96±0.000 defg	2.43±1.275 l	3.21±1.736	3.52±0.000 defg
P3S3W1	3.56±1.796	15.87±0.000 defg	6.84±0.911 h	1.84±0.118	9.91±2.010 c
P3S3W2	0.47±0.000	24.45±1.277 def	8.30±0.000 gh	1.56±0.230	1.81±0.184 g
CS1W1	3.91±2.258	44.17±6.612 b	4.82±0.000 ij	2.08±0.000	2.06±0.000 fg
CS1W2	2.61±1.506	76.14±0.000 a	3.48±0.670 kl	4.51±2.132	2.46±0.948 efg
CS2W1	3.06±1.061	14.66±2.576 efgh	7.44±0.545 gh	11.68±5.087	5. 44±0.680 d
CS2W2	7.34±3.068	25.22±5.350 de	9.53±1.707 ef	11.28±5.327	4.67±0.000 def
CS3W1	2.88±1.219	14.53±1.338 efgh	9.64±4.842 def	5.04±1.841	10.51±3.356 c
CS3W2	1.81±1.043	21.19±8.505 def	10.89±0.000cd	16.81±8.159	2.41±0.968 fg

Table 6: Effects of different treatments on soil total actinomycetes population×10^4.g^{-1} dry soil during five sampling periods (Mean±S.E.).

Treatments	1st sampling 9/6/2011 (24h after application)	2nd sampling 24/6/2011 (2 weeks after application)	3rd sampling 9/7/2011 (4 weeks after application)	4th sampling 24/7/2011 (6 weeks after application)	5th sampling 8/8/2011 (8 weeks after application)
P1 (Glyphosate)	2.29±0.576	2.55±0.558	1.6±0.693 a	1.7±0.347 a	9.39±3.299

e-ISSN (2522-7130) p-ISSN (2410-1036)

	c	b			b
P2 (Mancozeb)	5.04±1.028 b	2.36±0.425 b	0.2±0.181 b	1.7±0.345 a	6.06±2.871 d
P3 (Diazinon)	5.58±0.605 ab	3.2±0.558 a	0.5±0.370 b	2.1±0.007 a	6.75±1.451 c
C (Control)	6.27±1.435 a	2.65±0.486 b	0.1±0.086 b	0.3±0.344 b	10.03±3.306 a
S1 (Agholan)	4.27±0.845 b	2.32±0.430 b	0.7±0.457	1.6±0.342	3.23±0.532 c
S2 (Debaga)	5.4±1.185 a	2.74±0.336 a	0.3±0.172	1.3±0.377	9.49±2.477 b
S3 (Girdarasha)	4.72±0.898 ab	3.01±0.516 a	0.8±0.497	1.6±0.339	11.47±2.597 a
W1 (50% Moisture content)	3.48±0.639 b	2.38±0.274 b	0.8±0.406	1.2±0.306	7.05±1.903 b
W2 (100% Moisture content)	6.11±0.747 a	3.0±0.401 a	0.4±0.202	1.7±0.234	9.07±2.004 a
P1S1	3.15±1.371 fg	1.78±0.809 c	1.6±1.630	2.1±0.007	4.45±1.524 f
P1S2	1.43±0.786 h	2.24±0.088 c	0.5±0.519	1.0±1.045	19.62±0.005 a
P1S3	2.3±1.003 gh	3.62±1.469 b	2.6±1.484	2.1±0.021	4.12±2.034 f
P2S1	3.3±2.087 fg	2.18±0.053 c	0.009±0.000	2.1±0.005	2.0±0.119 g
P2S2	4.23±0.055 ef	3.18±1.122 b	0.5±0.542	2.0±0.004	2.09±0.020 g
P2S3	7.58±1.166 b	1.72±0.569 c	0.008±0.000	2.1±1.040	14.08±5.201 b
P3S1	5.01±0.498 de	1.7±0.113 c	1.1±1.089	2.07±0.015	2.63±0.519 g
P3S2	6.58±0.617 bc	3.39±0.814 b	0.009±0.000	2.1±0.011	10.3±0.065 c
P3S3	5.17±1.838 de	4.5±0.160 a	0.5±0.526	2.1±0.014	7.34±1.159 d
CS1	5.61±2.999 cd	3.63±1.448 b	0.009±0.000	0.007±0.000	3.84±1.265 f
CS2	9.37±2.018 a	2.14±0.016 c	0.3±0.257	0.009±0.000	5.94±1.133 e
CS3	3.82±1.338 ef	2.19±0.080 c	0.008±0.000	1.0±1.031	20.32±0.128 a
P1W1	1.24±0.3.283 d	1.76±0.3.949 d	2.8±0.899 a	1.4±0.689	8.21±0.571 c
P1W2	3.35±0.6.653 c	3.33±0.8.821 a	0.4±0.358 b	2.1±0.001	10.58±0.452 a

P2W1	3.93±1.5.054 [c]	2.16±0.0677 [cd]	0.007±0.000 [b]	1.4±0.688	4.28±0.230 [e]
P2W2	6.14±1.3.413 [b]	2.56±0.9.254 [bc]	0.4±0.361 [b]	2.1±0.015	7.84±0.572 [c]
P3W1	4.60±0.7.588 [c]	3.45±0.8.200 [a]	0.4±0.351 [b]	2.1±0.006	6.52±0.205 [d]
P3W2	6.57±0.5.344 [b]	2.94±0.9.045 [ab]	0.7±0.726 [b]	2.1±0.007	6.99±0.250 [d]
CW1	4.15±1.6.012 [c]	2.14±0.0225 [cd]	0.006±0.000 [b]	0.007±0.000	9.19±0.554 [b]
CW2	8.38±1.8.001 [a]	3.17±0.9.557 [a]	0.2±0.172 [b]	0.7±0.688	10.87±0.482 [a]
S1W1	2.53±0.720	1.77±0.280 [c]	0.8±0.815	1.6±0.520	2.63±0.275 [d]
S1W2	6.01±0.895	2.87±0.764 [ab]	0.5±0.545	1.6±0.524	3.83±1.003 [c]
S2W1	4.53±1.449	2.63±0.523 [b]	0.3±0.260	1.0±0.591	9.18±3.868 [b]
S2W2	6.27±1.987	2.84±0.496 [ab]	0.4±0.258	1.6±0.518	9.79±3.689 [b]
S3W1	3.38±1.093	2.72±0.540 [b]	1.3±0.955	1.0±0.592	9.33±3.880 [b]
S3W2	6.05±1.174	3.29±0.946 [a]	0.3±0.268	2.1±0.006	13.6±3.659 [a]
P1S1W1	1.78±0.000	0.97±0.000 [e]	3.3±0.188	2.1±1.202	2.92±0.000 [g]
P1S1W2	4.52±0.237	2.59±0.000 [b]	0.0009±0.000	2.1±0.000	5.97±0.000 [ef]
P1S2W1	0.65±0.159	2.15±0.000 [bc]	1.0±0.060	0.0008±0.000	19.61±0.000 [a]
P1S2W2	2.22±0.000	2.33±0.000 [bc]	0.0008±0.000	2.1±0.000	19.62±0.000 [a]
P1S3W1	1.3±0.499	2.15±0.000 [bc]	4.0±0.233	2.1±0.000	2.09±0.000 [g]
P1S3W2	3.3±0.635	5.09±0.000 [a]	1.1±0.062	2.1±1.208	6.15±0.000 [ef]
P2S1W1	1.21±0.000	2.13±0.000 [bc]	0.0005±0.000	2.1±0.000	1.88±0.000 [g]
P2S1W2	5.39±0.000	2.23±0.000 [bc]	0.0006±0.000	2.1±1.212	2.12±0.000 [g]
P2S2W1	4.17±0.000	2.06±0.000 [bcd]	0.0005±0.000	2.0±1.178	2.07±0.000 [g]
P2S2W2	4.28±0.000	4.31±1.243 [a]	1.1±0.063	2.0±1.182	2.11±0.000 [g]
P2S3W1	6.41±0.000	2.29±0.000 [bc]	0.0007±0.000	0.0008±0.000	8.88±0.000 [cd]

P2S3W2	8.74±0.000	1.15±0.000 [de]	0.0008±0.000	2.1±1.201	19.28±0.000 [a]
P3S1W1	4.51±1.507	1.81±0.000 [bcde]	0.0008±0.000	2.1±0.000	3.14±0.000 [g]
P3S1W2	5.51±1.589	1.59±0.000 [cde]	2.2±0.126	2.1±0.000	2.11±0.000 [g]
P3S2W1	5.96±0.000	4.2±0.000 [a]	0.0007±0.000	2.1±1.185	10.24±0.000 [bc]
P3S2W2	7.19±0.000	2.58±0.000 [b]	0.0006±0.000	2.1±1.197	10.36±0.000 [b]
P3S3W1	3.33±0.000	4.34±1.160 [a]	1.1±0.061	2.0±0.000	6.18±0.000 [ef]
P3S3W2	7.01±2.698	4.66±0.000 [a]	0.0007±0.000	2.1±1.199	8.5±0.000 [de]
CS1W1	2.61±0.000	2.18±0.000 [bc]	0.0008±0.000	0.0008±0.000	2.57±0.514 [g]
CS1W2	8.61±0.301	5.08±0.000 [a]	0.0008±0.000	0.0007±0.000	5.1±0.342 [f]
CS2W1	7.35±0.000	2.12±0.000 [bc]	0.0007±0.000	0.0007±0.000	4.81±0.677 [f]
CS2W2	11.39±0.000	2.16±0.000 [bc]	0.5±0.030	0.0007±0.000	7.07±2.606 [e]
CS3W1	2.48±0.000	2.11±0.000 [bc]	0.0007±0.000	0.0008±0.000	20.19±0.000 [a]
CS3W2	5.16±0.000	2.27±0.000 [bc]	0.0007±0.000	2.1±0.000	20.45±0.000 [a]

Discussion

Glyphosate showed the highest total bacterial population at 24h and 8 weeks after application and similar observations were reported by (16) and (17) and this is probably because glyphosate decomposition resulted in increasing of microbial activity (18) so glyphosate can be quickly used by microorganisms as a source of energy, carbon and nitrogen which result in stimulation of the activity and functional diversity of cultivable portion of heterotrophic soil microbial community (19 and 20); but during the 4^{th} sampling both glyphosate and diazinon produced the same increasing effect on soil total bacteria as the same findings of (21) and (22) as well as observations of (23) when diazinon increased bacterial population by 16.4% after 30-60 days of soil application. Agholan soil showed the highest total bacteria at 24h and 2 weeks after treatment and this may due to the highest organic matter and total nitrogen contents of this soil which utilized by bacteria as a source of energy. Soil moisture content of 50% showed the highest total bacterial population during the 3^{rd}, 4^{th} and 5^{th} sampling periods and this may refer to the environmental temperature during these periods (table 2). The combination P1S1 showed the highest total bacterial population at 24h after treatment which may be due to non-biological degradation of pesticides by organic matter, so the behavior and fate of glyphosate is greatly influenced by this process which is depend on some factors such as clay mineral composition, pH, exchangeable cations, moisture, temperature and type pesticide (24). The combination

e-ISSN (2522-7130) p-ISSN (2410-1036)

P1W1 showed the highest total bacterial count at the last sampling periods and this increasing response to glyphosate may be due to soil moisture (25). The combined treatment S1W2 at 24h and 2 weeks after treatment gave the highest total bacterial count and this may refer to the type and amount of organic matter and type of microbial population in addition to sufficient moisture content in Agholan soil which preferred the growth and replication of bacteria. The combinations S2W1 during the 4th sampling and S3W1 during the 3rd and 5th sampling showed the highest total bacterial count, and this may agree with the statement of (26) who stated that water has a strong attraction to soil colloidal particles; microorganisms and plants that depend upon each other's biological functions for survival are inhibited by the lack of water, where there is little water in the soil there is an abundance of air which can limit the accumulation of organic matter by accelerating decomposition and remaining the low level of soil colloids. According to table 5, glyphosate showed the highest count of soil total proteolytic bacteria at 24h, 4 and 6 weeks after treatment, and diazinon showed the highest count of total proteolytic bacteria during the last sampling periods. Similar observations were recorded by (21); (23); (27) and (28). The increasing in total proteolytic bacterial population during pesticide treatment indicates that this group of bacteria is capable of degrading the studied pesticides and uses them as a source of carbon and energy (29). The lowest number of total proteolytic bacteria was recorded in control during the study and similar conclusions were given by (30). Girdarasha soil showed the highest total proteolytic bacterial count, but Agholan soil showed the lowest soil total proteolytic bacteria during the 3rd, 4th and 5th sampling periods and this may refer to the amount and type of organic matter of the studied soils. 100% soil moisture content revealed highest soil total proteolytic bacterial count at 24h after treatment, but 50% soil moisture content showed the highest total proteolytic bacteria 4 and 8 weeks after treatment and probably this may refer to the proper moisture content which resulted in increasing total proteolytic bacteria during the first days of treatment in comparing with the soils containing lower moisture content which increased total proteolytic bacteria subsequently (table 2). The combinations of CS1 and P3S3 during the 2nd and 5th sampling periods showed the highest total proteolytic bacterial count, however the statements of (28) and (23) who described that total proteolytic bacterial population was increased in silt loam soil after diazinon treatment seem to confirm the fact with the combination of P3S3. The combined treatment S3W2 at the beginning and S3W1 during the 3rd sampling showed the highest total proteolytic bacterial population and this may refer to the texture of Agholan soil which absorb more water and reduced oxygen in the pores thus proteolytic bacterial population was reduced. Glyphosate in Girdarasha soil with 100% soil moisture content (P1S3W2) showed highest total proteolytic bacterial count during the 1st sampling probably because glyphosate used as a source of nutrient, carbon and energy in the presence of sufficient moisture in a fertile soil as described by (31). In the 3rd sampling the combination P1S3W1 showed the highest total proteolytic bacterial count and this may refer to degradation of the studied pesticides and utilized by such group of bacteria or according to explanation mentioned by (32) that increasing moisture content in loam soil reduce adsorption of pesticides to soils and the pesticide may undergo several processes of degradation, hydrolysis, leaching and volatilization and produce less effect. According to the data shown in (table 5), glyphosate revealed the highest fungal population during the studied periods except for the 2nd sampling and this also concluded by (16); (17); (25); (33) and (34) who observed that fungal population increased in response to glyphosate so its application at field rate stimulate microbial population and activity. At the end of the study, mancozeb significantly decreased total fungi in accordance with the results of (17), (35) and (36) in which a significant decline in the number of soil fungi occurred during fungicide treatment and this is due to the effect of fungicide on the reduction of growth of hyphae and their division as well as on the decrease in the activity of enzyme responsible for the decomposition of the fungicide thus an increase in organic matter in soil occur and resulted in increasing microbial activity (37). Girdarasha soil showed the highest total fungi count during the 2nd, 3rd and 5th sampling periods, probably, because the higher organic matter content of this soil supply carbon and energy to soil microbes and provide sites for microbes to colonize and decompose organic pollutants. 100% soil moisture content showed the highest total fungi count during the 2nd and 3rd sampling periods, while 50% soil moisture content showed the highest total fungi count at the end of the study and this may refer to proper humidity during this period (table 2). The combination of P2S1 caused significant reduction in total fungi at the end of the study and the observations of (36) who observed that mancozeb in soil with decreased organic matter content result in decreasing soil fungi so Debaga soil containing the least amount of organic matter among the studied soils. During the 3rd and 5th samplings, the combined treatment P1W1 showed significant increase in total fungi, but P2W2 showed the least fungal population during the 5th sampling as obtained by (36) who found that fungicide concentration and soil moisture contribute to the decline in the number and activity of soil fungi. Both the combinations S1W1 and S1W2 caused significant decrease in total fungi during this period; (37) stated that fungi find the upper layers of soil conducive for growth and they are only able to grow when there is adequate oxygen in the soil water; when the pH of soil is acidic, fungi overcome bacterial growth and when the soil is low in nitrogen, fungi are able to produce more protoplasm than bacteria on the limited nitrogen; fungi can also grow under less moist conditions than bacteria; Agholan soil contains more clay and has less pore size which becomes poorer in oxygen, as well as it has higher pH value and nitrogen content in comparing with Debaga and Girdarasha soils which may be the possible cause of reduced fungal population. The combination P1S3W1 during the 3rd and 5th sampling periods showed significant increase in total fungi and similar finding of (36) who found that herbicide with moisture content and organic matter result in increasing soil fungi. All the treatments caused high reduction in actinomycetes population during the 2nd sampling period except for glyphosate treatment (table 6) and more reduction was observed during the 3rd and 4th sampling periods with higher reduction in control and this may refer to competition between bacteria and fungi with actinomycetes for their food sources, but diazinon showed the higher population of actinomycetes during the 2nd sampling while lower than the 1st sampling and similar observation was given by (21) and (23) when diazinon decreased actinomycetes population; glyphosate caused significant reduction in soil total actinomycetes during the 3rd sampling period and similar observations were given by (39) and this may be due to the inhibition of aromatic amino acid synthesis in soil microorganisms which exhibit short or long-term effects on soil biological processes (25) or may refer to susceptibility of actinomycetes population to the products of soil-pesticide interactions which could have a microbicidal property; at the last sampling period the highest actinomycetes population was observed in control as the same observation of (16) when they noted an increase in actinomycetes population in control at the end of 60 days of glyphosate treatment. Debaga soil showed the highest actinomycetes population at the beginning of the study and Girdarasha soil increased total actinomycetes at the end of the study, probably, because actinomycetes can metabolize most naturally occurring organics and require less nitrogen than most bacteria for cell growth, thus actinomycetes tend to metabolize the more resistant forms of organic matter; after the normal bacteria and fungi metabolize the readily biodegradable components, the actinomycetes are able to continue to metabolize the residual organics (38). Agholan soil caused significant reduction in soil total actinomycetes during the last sampling as the same observations given by (21) when actinomycetes population decreased in clay-loam soil. 100% soil moisture content showed the highest total actinomycetes during the 1st, 2nd and 5th sampling periods, probably, because when sufficient water is available, faster dilution of pesticides might be expected and fewer effects on soil microorganisms expressed (40). The combined treatments P1S2 and CS3 showed significant increasing in total actinomycetes at the last sampling period possibly because glyphosate was degraded completely at the end of the 60th day of application and increased soil phosphorus and nitrogen content which became sources of energy and nitrogen for actinomycetes and in the latest combination there was no pesticide application which made soil more preferable for their growth. During the 1st sampling the combined treatment CW2 showed the highest actinomycetes population because there was no pesticide treatment and the moisture was available. The combination of P1W1 revealed the lowest soil total actinomycetes during the 2nd sampling probably because glyphosate concentration was higher in 50% and made more negative effect, or due to a microbial competition for nutrient and energy source during the 1st, 2nd and 3rd samplings between bacteria, proteolytic bacteria and fungi in one side (tables 3, 4 and 5) and actinomycetes on the other side thus actinomycetes population was lower during these periods. The combinations of P1S2W1 showed significant increasing in total actinomycetes during the last sampling, (32) stated that increasing moisture content in loam soil reduce adsorption of pesticides to soils and the pesticide may undergo several processes of degradation, hydrolysis, leaching and volatilization and reduced their effects.

Conclusion

Glyphosate and diazinon showed more positive effects on soil microbial population counts than mancozeb. More increasing effect on soil microbial population was shown by girdarasha soil. 100% soil moisture content showed more significant effects on soil microbial population. Different significant effects on soil characteristics were shown by the interactions between pesticides-soil orders, pesticides-soil moisture contents, soil orders-soil moisture contents and pesticides-soil orders-soil moisture contents.

References

1. Cserháti, T.; E. Forgács; Z. Deyl; I. Miksik and A. Eckhardt. 2004. Chromatographic determination of herbicide residues in various matrices. Biomed. Chro. 18: 350-359.
2. Li, G. 1983. Residue and toxicity problems associated with pesticides use in Taiwan. Tropical Agriculture Research Center, Ministry of Agriculture, Forestry and Fishers. Japan.
3. Cycon, M; Z. Piotrowska-Seget and J. Kozdrój. 2010. Responses of indigenous microorganisms to a fungicidal mixture of mancozeb and dimethomorph added to sandy soils. Int. Biodeterio. Biodeg. 64: 316-323.
4. Dömötörová, M. and E. Matisová. 2008. Fast gas chromatography for pesticide residues analysis. J. Chro. A. 1207: 1-16.
5. Fragoeriro, S.I. 2005. Use of fungi in bioremediation of pesticides. Ph.D. Thesis. University of Cranfield.
6. Topp, E. 2002. Bacteria in agricultural soils: diversity, role and future perspectives. Canadian J. Soil Sci. 83: 303-309.

e-ISSN (2522-7130) p-ISSN (2410-1036)

7. Černohlávková, J. 2007. Effects of persistent organic pollutants on soil microorganisms. Rigorous Thesis. Masaryk University Faculty of Science.
8. Digrak, M. and F. Kazanici. 2001. Effect of some organophosphorus insecticides on soil microorganisms. Turk J. Biol. 25: 51-58.
9. Atlas, R.M.; D. Pramer and R. Bartha. 1978. Assessment of pesticide effects on non-target soil microorganisms. Soil Biol. Biochem. 10(3): 231-239.
10. USAID. 2008. Soil testing. Perennial Crop Support Series. Jalalabad, Afghanistan. Publication No. 2008-001-AFG. February 8.
11. Hill, D.S. 2008. Pests of Crop in Warmer Climates and their Control. Springer Netherlands. XII Edition.
12. Atlas R.M. 2005. Handbook of Media for Environmental Microbiology. Second Edition. Taylor & Francis Group, LLC. New York.
13. Cheesbrough, M. 1992. Introduction to Mycology. Medical Laboratory Manual for Tropical Countries. 11: 372-39.
14. Harley, J.P. and L.M. Prescott. 1996. Laboratory Exercises in Microbiology. Third Edition. McGraw-Hill. U.S.A.
15. Aneja K.R. 2003. Experiments in Microbiology, Plant Pathology and Biotechnology. Fourth Edition. New Age International Publishers.
16. Choudhari, S.E.; C.D. Deokar; A.M. Navale and R.B. Sonawane. 2010. Studies on effect of weedicides on microbial population in soil and yield of soybean. Int. J. Plant Pro. 2(2): 186-188.
17. Khudhur, S.M. 2011. Impact of some pesticides on soil pollution. M.Sc. Thesis, University of Salahaddin-Erbil.
18. Eser, F.; H. Sagliker and C. Drici. 2007. The effects of glyphosate isopropylamine and metalaxyl on the carbon mineralization of olive trees soil. Turk J. Agric. For. 31: 297-302.
19. Mijangos, I.; J.M. Becerril; I. Albizu; L. Epelde and C. Garbisu. 2009. Effects of glyphosate on rhizosphere soil microbial communities under two different plant compositions by cultivation-dependent and -independent methodologies. Soil Biol. Biochem. 41: 505-513.
20. Sobral, J.K.; W.L. Araujo; R. Mendes; A.A. Kleiner and J.L. Azevedo. 2005. Isolation and characterization of endophytic bacteria from soybean (*Glycine max*) grown in soil treated with glyphosate herbicide. Plant Soil. 273: 91-99.
21. Barakah, F.N.; M.I. Ababutain and A.M. Heggo. 2007. Effect of lannate and diazinon pesticides on some soil microorganisms. Alexaneria Sci. Exch. J. 28(1): 38-53.
22. Shittu, O.B.; A.K. Akintokun; P.O. Akintokun and M.O. Gbadebo. 2004. Effect of diazinon application on soil properties and soil microflora. Proceedings of the International Conference on Science & National Development, 25th-28th.
23. Singh, J. and D.K. Singh. 2005. Bacterial, *Azotobacter*, actinomycetes, and fungal population in soil after diazinon, imidacloprid, and lindane treatments in groundnut (*Arachis hypogaea L.*) fields. J. Environ. Sci. Health Part B, 40:785-800.
24. Schnitzer, M. and S.U. Khan. 1975. Soil Organic Matter. Elsevier. Vol. 8.
25. Locke, M.A.; R.M. Zablotowicz and K.N. Reddy. 2008. Integrating soil conservation practices and glyphosate-resistant crops: impacts on soil. Pest Manag. Sci. 64 :457-469.
26. Moore, R.C. 2009. The soil guy: caring and sharing organic gardening - compost, equipment, ideas and training. Thunder Data Systems. www.thunderdatasystems.com
27. Roger, P.A.; I. Simpson; R. Oficialc; S. Ardales and R. Jimenez. 1994. Effects of pesticides on soil and water microflora and mesofauna in wetland ricefields: a summary

of current knowledge and extrapolation to temperate environments. Australian J. Exp. Agric. 34: 1057-1068.

28. Digrak, M. and F. Kazanici. 2001. Effect of some organophosphorus insecticides on soil microorganisms. Turk J. Biol. 25: 51-58.

29. Karnatak, A.K. and D.C. Karnatak. 2008. Impact of pesticides on bacteria and fungi in rice ecosystem. Pantnagar J. Res. 6(2): 210-214.

30. Digrak, M. and S. Özçelik. 1998. Effect of some pesticides on soil microorganisms. Bull. Environ. Contam. Toxicol. 60:916-922.

31. Al-Mehmar, A.; Z. Al-Nasir and M.J. Hijaz. 2011. Pesticide Toxicity and Testing. Practical Part. Dimashq University Publisher. 357pp. (In Arabic)

32. Al-Mehmar, A.; Z. Al-Nasir and M.J. Hijaz. 2009. Pesticide Toxicity and Testing. Theory Part. Al-Rawdha Publisher. 384pp. (In Arabic)

33. Ingham, E.R. and D.C. Coleman. 1984. Effects of Streptomycin, Cycloheximide, Fungizone, Captan, Carbofuran, Cygon, and PCNB on soil microorganisms. Microbial Ecol. 10: 345-358.

34. Ayansina, A.D. and B.A. Oso. 2006. Effect of two commonly used herbicides on soil microflora at two different concentrations. African J. Biotech. 5(2): 129-132.

35. Shukla, A.K. and R.R. Mishra. 1996. Response of microbial population and enzymatic activities to fungicides in potato field soil. Proc. Indian Nat. Sci. Acad. 62(5): 435-438.

36. Mandic, L.; D. Dukic and S. Dordevic. 2005. Soil fungi as indicators of pesticide soil pollution. Proc. Nat. Sci. 109: 97-102.

37. Smith, M.D.; D.C. Hartnett and C.W. Rice. 2000. Effects of long-term fungicide applications on microbial properties in tallgrass prairie soil. Soil Biol. Biochem. 32: 935-946.

38. McKinney, R.E. 2004. Environmental Pollution Control Microbiology. Marcel Dekker, Inc.

39. Omar, S.A. and M.A. Abdel-Sater. 2004. Microbial populations and enzymatic activities in soil treated with pesticides. Water, Air Soil Poll. 127(1-4): 49-63.

40. Roger, P.A. 1990. Microbiological aspects of pesticide use in wetland ricefields. Paper 21 presented at the Workshop "Environmental and health impacts of pesticide use in rice culture" March 1990. International Rice Research Institute. Philippines. IRRI SB207W6E5 1990.

e-ISSN (2522-7130) p-ISSN (2410-1036)