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Evaluation of Physicochemical Component and Microbial Populations of Diuron Treated Soil in Yola, Adamawa State, Nigeria

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Abstract

This study was aimed at assessing the effect of different concentrations of diuron on physicochemical component and microbial population of soils in Yola. A sample of soil treated with different concentrations of diuron were obtained at 0, 2, 4 and 6 weeks after treatment. The physicochemical properties and the microbial component and populations of the sampled soils were assessed using a standard procedure. The results showed that the different concentrations of diuron had no significant effect on all the physicochemical components of the soil especially at 0 week after application (WAT) except at 4th WAT on the pH, organic carbon, organic matter and percentage of total nitrogen of the soil; and CA^{++} content at 6th WAT. Also, the bacterial and fungal populations, the different concentrations of the herbicide had no significant effect. The *Rhizopus* species of fungi was found present in all the soils samples treated with especially the highest concentrations of the herbicide while *Aspergillus* species was only found in the control soil sample and that of the lowest concentration of diuron. In conclusion, the different concentrations of diuron only have a significant effect on the pH, organic carbon, organic matter and % of total nitrogen of soils at 4th WAT. On the bacterial and fungal populations, however, the herbicide's concentrations have no significant effect.

Keywords: Physicochemical properties. Soil, Herbicide, Diuron, *Aspergillus* species, Microbial.

Introduction

The quality and fertility of soil and behavior of chemical herbicides in the soil are determined to a large extent by the physicochemical components of the soil. The components of soil that include: pH, electrical conductivity, texture, moisture, temperature, organic matter, available nitrogen, phosphorus and potassium are what constitute the physicochemical component of soil. The pH of soil serves as an important indicator of balanced available nutrients in soil (Kinyangi, 2007). It also helps in indicating the need to maintain equilibrium between soil nutrients; and ensures that minerals like Fe, Mn, Zn and Cu become more available in acidic soil than that of the alkaline (Deshmukh, 2012). The plants, animals, available nutrients, cation exchange capacity and organic matter contents of soil are also determined by the soil pH. The texture of soil determined the soil-water relation, aeration, root penetration and generally affect the nutrient status

of the soil; while the moisture content of soil helps in determining the absorption of soil nutrients by plants (Yennawar, 2013). The electrical conductivity, which is the easiest and fastest way by which the health status of soil could be assessed, is used in estimating the soluble salt concentration in the soil (Wagh *et al.*, 2013). The organic matter content of soil determines the vulnerability of the soil to soil erosion and the usefulness of the soil for agricultural practices. It also helps in increasing the water retention capacity, air and water flow of soils; and serve as food source to soil microbes (Brady, 1996). Therefore, the knowledge of the physicochemical properties of soil is of great importance to agriculturalists as it provides an information on the suitability of the soil for cultivation of any kind of crops.

The microbial components of soils that involved bacteria, fungi, actinomycetes play a very vital roles in nutrient recycling, breaking down of crop residues and stimulating plant growth; and serve as an important indicator for soil health, soil pollution and restoration of ecology (Wu *et al.,* 2016). Soil microbes like bacteria help to increase and supply nitrogen directly to plant as they have the ability to take and set nitrogen from the atmosphere. Also, due to enzymatic activities of soil microbes, there is an increase in phosphorus and other mineral content of soils; and help in transformation of minerals like iron into absorbable form to plants.

The introduction of herbicides was mainly for the purpose of reducing cost of crop production and increase in yield output of crops. However, the use of these herbicides in crops fields is accompanied by some of effects on plants and especially soil microbial and physicochemical components. The application of nicosulfuron and atrazine was reported to impact negatively on some beneficial soil microbes as it significantly reduces their population (Chen *et al.*, 2021). Also, the use of herbicides like acetochor and 2,4-D at different concentrations resulted in the reduction of bacterial, fungal and actinomycetes contents of the treated soils (Tyagi *et al.,* 2018). Some of the herbicides, however, were reported to promote the increase in populations of the soil microbes. For instance, the use of Bispyribac-Na and Pendimenthalin were found to significantly increase the population of actinomycetes when compared with that of weed free and weedy check controls (Dubey *et al.*, 2018). Herbicides were also reported to affect the physicochemical components of soils treated with it. The application of herbicides like dimethylammonium acetate resulted in the significant increase in physicochemical properties of soil that include electrical conductivity and exchangeable acidity as well as some soil minerals such as Ca, Mg, Na, K, Cu and Zn (Sebiomo and Banjo, 2021). Also, an increase in total nitrogen, organic matter and phosphorus content of soil as a result of over application of glyphosate was reported by Nigussie *et al.* (2019). Although, the effect of these herbicides on both soil microbes and physicochemical components is dependent upon the soil type, concentration used, time of application and herbicide type (Handy et al., 2022), however, some were reported to have no significant effect on the physicochemical properties of soils (Ilusanya *et al.*, 2018;

Tudararo-Aherobo and Ataikiru, 2021). There was very little or no literatures on the effect of diuron in Yola, Adamawa State, Nigeria. This explains why this study was undertaken.

Materials and Methods

Study Area

The study was carried out at the Modibbo Adama University, Yola, Adamawa State, Nigeria in 2021 rainy seasons. The study area is situated in the North Eastern part of Nigeria and lies between Latitude 9° 20"00" and 9° 21'30" N of the equator and between Longitude 12° 29'00" E and 12° 30'30" E of the Greenwich meridian. It lays in the northern Guinea Savanna ecological zone; with mean annual rainfall of 278.6 mm. The length of the rainy season ranges from 120-210 days mostly between the months of May and October. The average annual temperature of the study area is 31.5° C. The relative humidity peak of 71% is usually in the month of August and September.

Experimental Design

Randomized Completely Block Design (RCBD) was used for the study. The size of the experimental plot was 25 x 6.5 m^2. The field layout consisted of five (5) blocks; each of which was replicated three times bringing it to a total of 15 blocks. The block had 2 x 1.5 m^2 in size. The intra blocks gap was 0.5 m while the inter blocks gap was 1m.

Application of Treatments

The treatments which consisted of four concentrations of diuron that include: 0.5, 1.0, 1.5 and 2.0 g/ha were applied once using a 16 litres knapsack sprayer. During the treatment's application, a polythene/leather was used in covering blocks so as to avoid drifting of treatments to unintended blocks.

Data Collection

Soil Sample Collection: The samples of the treated soil were collected from a depth of about 0-15 cm with the help of soil auger and were transferred into a black polythene bags and thoroughly mixed. The soil sample collection was carried out at 1, 2 and 3 weeks after application of treatments.

Preparation of Soil Samples Collected for Analysis

The soil samples collected from each of the treatment replicates were made free of large stones and plant debris using 2.0 mm wire mesh sieve; and were kept in labelled sample bottles.

Isolation of Bacteria

Preparation of Media

Nutrient agar was used for the isolation of the soil bacteria. About 28 g of the nutrient agar powder was suspended in one liter of distilled water. The suspension was heated to boiling point so as to dissolve it completely. The dissolved medium was then autoclaved at the temperature of 121°C for 15 minutes. At the completion of the autoclaving process, the beaker containing the medium was cooled to a temperature of about 40-45°C. The medium was then poured into a sterile petri dish under sterile conditions and allowed to solidify. After its solidification, the medium was placed in hot air oven at lower heating setting for few minutes so as to remove any moisture present before its usage.

Isolation and Enumeration of Bacteria

About 10 g of the soil sample was taken and sieved properly so as to remove any foreign particles and added to 100 ml of sterilized distilled water to make a dilution of 10^{-1}. Ten (10) ml of the aliquot was taken from this dilution and added to 90 ml of sterilized distilled water thereby making a dilution of 10^{-2}. In the same way, the soil sample was serially diluted (six fold series). One (1) ml of the aliquot was taken from dilution 10^{-5} and spread evenly with cotton swap on the prepared nutrient agar. This was allowed to set and then incubated at 37 °C for a period of 24 hours. The counting of the bacterial colony was done at the end of the incubation period.

The pure culture of the bacteria was obtained by sub-culturing each of the colonies observed. A sterile wire loop was used to pick a colony and streak on the surface of a freshly prepared nutrient agar. This was incubated at 37 °C in an inverted position for 24-48 hours. The obtained pure culture was stored in a refrigerator at 4 °C pending further analysis and identification.

Identification and Characterization of the Pure Bacterial Isolates

The individual bacterial colonies were identified through the morphological and biochemical techniques using the taxonomy scheme of Bergey's Manual of Determinative Bacteriology. The cultural characterization of the bacterial colonies isolated was carried out by observing the colonies for color, shape, edge, elevation and surface appearance displayed on the nutrient agar whereas the biochemical tests such as catalase test, motility test and oxygen-relation, methyl Red tests, fermentation of sugars, Gram's reaction, coagulate test was carried out for the identification (Cheesbrough, 2005).

Isolation of Fungi

Preparation of Media

Patotoe Dextrose Agar (PDA) was used in isolating the fungi. The medium was prepared by suspending 39 g of the powder in 1000 ml of distilled water. This was mixed while boiling to dissolve the suspension completely. It was then be sterile by autoclaving it at the temperature of 121°C for 15 minutes. The medium was then be poured into a sterile petri dish under sterile conditions and allowed to solidify.

Isolation and Enumeration of Fungi

The method of serial dilution was used for the isolation and enumeration of the fungi. The dilution of the soil sample was carried out in two replicates; and each replicate was diluted six times and labelled as 10-1 until 10-6. About 50 g of the soil sample was added to 100 ml of 85 % sodium chloride (NaCl) solution and was thoroughly shaken to mix the solution. The solution then was diluted to a series of prepared vials containing 9 ml of 85 % NaCl solution. About 9 ml of the soil-NaCl solution was transferred to the first vial by using a pipette. Subsequently, another 9 ml of the solution from the first vial was transferred to the second vial and the steps continued until the last vial. About 0.1 ml of the solution in each vial was pipetted into the already prepared PDA plate that contain streptomycin (1 mg/100 ml). The solution was then spread on the plate by using a hockey stick and incubated at room temperature for seven (7) days. The colony of the fungi that appeared on the plate after the incubation period was counted and expressed as colony forming units per gram (cfu/g) by dividing the number of colonies formed by volume plated and multiplying it by dilution factor. Pure culture of each of the colonies was obtained through sub-culturing. The sub-culturing was done by picking each of the colonies with sterile wire loop and culture on a freshly prepared PDA plate. This was again incubated for another seven days. The obtained pure culture was then used for identification.

Identification and Characterization of the Pure Fungal Isolates

The pure fungal isolates were identified and characterized based on the colony features (color, shape and size of hyphae); and microscopic appearances (nature of hyphae, and type of conidia) by using a compound microscope with digital camera using lactophenol cotton blue-stain slide mounted with a small portion of the mycelium (Gaddeyya *et al*., 2012).

Determination of Soil Physicochemical Properties

The following soil physicochemical properties were determined in this study: i.e. moisture content, pH, organic carbon, organic matter, electrical conductivity and cation/anions exchange capacity.

Determination of Moisture Content

The soil moisture content was determined by oven drying method. About 10 g of the soil sample was taken. The weighed soil sample was then oven dried at 105°C for 24 hrs. Dry weight of the sample was taken till it showed its constant weight. The loss in weight corresponds to the amount of water present in the soil sample. The formula below introduced by Joel and Amajuoyi (2009) was used to calculate the percentage of moisture content in the soil sample:

Moisture content (%) = Loss in weight on drying (g) ÷ Initial sample weight (g) x 100.

Determination of Soil pH

The pH of the soil samples was measured in water suspension (1:2.5) as described by Jackson (1967). About 20 g of the air-dried soil sample was measured and placed in a beaker and to this 50 ml of water was added. The mixture was stirred with glass rod for a period of about 10 minutes and allowed to stand for 30 minutes. The pH meter (ELMETRON, CPI-501, Poland) was calibrated using standard buffer solution of pH 4.0, 7.0 and 10.0. Then electrode of the pH meter was inserted into the supernatant solution and the pH reading was taken.

Determination of Organic Carbon and Organic Matter

The soil sample organic carbon composition was determined according to the method described by Walkey and Black (1934). About 1 g of finely grounded soil sample was passed through 0.5 mm mesh sieve without loss was taken into 500 ml conical flask and to it, 10 ml of 1 N potassium dichromate and 20 ml concentrated H_2SO_4 was added with measuring cylinder. The contents were shaken for a minute and allowed to stand for 30 min. Then 200 ml of distilled water, 10 ml orthophosphoric acid and 1 ml diphenylamine indicator were added. The solution was titrated against 0.5 N ferrous ammonium sulfate till the colour changes from blue-violet to green. The blank titration was carried at the beginning without soil. The result was calculated by the following formulas:

Organic carbon % = N x (V1– V2) ÷ S x 0.39 x mcf

Where: N = Normality of ferrous ammonium sulfate (FAS)

V1 = Vol.of 0.5 N FAS required to neutralize 10 ml of 1 N $K_2Cr_2O_7$, that is, blank reading (ml).

V2 = Volume of 0.5 N FAS needed for titration of soil sample (ml)

S = Weight of air-dry sample (g) 0.39 = 0.003 x 100 % x 1.31 (0.003 is the milli-equivalent weight of carbon (g). It is assumed that only 77% of the organic matter is oxidized and a fraction of 100/77 = 1.31

Organic matter (%) = Organic carbon (%) x 1.724

1.724 = average content of carbon in soil organic matter is equal to 58 %

Determination of Cation Exchange Capacity

The soil cation exchange capacity (CEC) was determined according to the method described by Raman and Sathiyanarayanan (2009). About 1.3 g of soil samples was measured into centrifuge tube. About 11 ml of 1 N sodium acetate solution was added into the centrifuge tube. It was then be shaken well and centrifuged. The supernatant liquid was decanted. About 11 ml of isopropyl alcohol was added into the centrifuge tube. The centrifuge tube was shaken well and centrifuged. The supernatant liquid was decanted. About 11 ml of 1 N ammonium acetate solution was added into the centrifuge tube. The centrifuge tube was shaken well and centrifuged. The supernatant liquid was then poured into the 100 ml flask. The solution in the 100 ml standard measuring flask was made up to 100 ml. The flame photometer was calibrated with standard sodium solution. The prepared

solution was then injected into the instrument and the reading was taken. CEC value was then determined by the formula introduced by Herk (2012).

CEC, $cmol_{(+)}\ kg^{-1}$ soil = 10*Na concentration in meq L^{-1} ÷ Mass of sample (g)

Determination of Electrical Conductivity

The electrical conductivity (EC) of the soil samples was determined as described by Jackson (1967). About 20 g of the air-dried soil sample was poured into a beaker and to this 50 ml of water was added. The mixture was stirred with glass rod for 10 min and was allowed to stand for 30 minutes without any disturbances. The soil was allowed to settle down and the EC value was measured by inserting an electrical conductivity meter (SCHOTT handy lab LF11, Germany) in to the supernatant solution.

Results

The Physicochemical Properties of Soil treated with different Concentrations of Diuron sampled at Weeks after Treatment (WAT). As shown in Table 1, at 0 WAT, the different concentrations of diuron recorded a statistically similar Mg^{++} content with 1.5 L/ha having the highest (1.20 cmol/kg) that was only significantly different with the lowest (0.30 cmol/kg) recorded by the control soil. The Mg^{++} content of the control soil was statistically similar to that of the different concentrations of diuron except 1.5 L/ha that had the highest. Similarly, the highest K^{++} (0.19 cmol/kg) was recorded by soil treated with concentration 1.5 L/ha and was at par with that of the highest concentration of diuron that had 0.53 cmol/kg. The control soil sampls recorded K^{++} (0.06 cmol/kg) content that was only significantly different to that of concentration 1.5L/ha which had 0.19 cmol/kg (Table 1).

At 4 WAT, the OC (12.40 g/kg), OM (21.38 g/kg) and %TN (0.12 cmol/kg) compositions of soil treated with 0.5 L/ha of diuron were significantly the highest, but was statistically at par with that of 2.0 L/ha which had 10.84 g/kg (OC), 18.69 g/kg (OM) and 0.11 cmol/kg (%TN). The control soil samples recorded OC, OM and %TN that was only significantly similar with that of 1.0 L/ha, which had the lowest, and 1.5 L/ha. The pH of soils treated with the different concentrations of diuron was significantly similar. However, the control soil samples had a pH of 6.58 that was only significantly different with the highest (6.94) recorded on soil samples applied concentration 1.5 L/ha of diuron (Table 1).

The physicochemical properties of soil samples analyzed at 6 WAT were not significantly different. The control soil samples, however, had the highest Ca^{++} (5.50 cmol/kg) content that was only significantly different with that of concentrations 0.5 (1.40 cmol/kg) and 2.0 L/ha (2.07 cmol/kg) (Table 1).

Fungal Species Isolated from Action Diuron Treated Soils.

A total of four (4) different fungal species were isolated from the soils treated with action diuron and its control. These include: *Aspergilus flavus*, *Madurella grisea*, *Aspergilus versicolor* and *Rhizopus* species (Table 2). The *A. flavus* and *M. grisea* were isolated from the

control soil sample of the 2, 4 and 6 WAA sampling periods; *A. versicolor* was isolated from soil treated with concentration 0.5 L/ha of action diuron at all the sampling periods; *Rhizopus* sp. was isolated from soils treated with concentrations 1.0 to 2.0 L/ha of action diuron at all the sampling periods except at concentration 1.0 L/ha where *Stachybotrys chartarum* was isolated at the 6 WAA sampling period (Table 2).

Effect of Different Diuron Concentrations and Sampling Duration on Soil Bacterial and Fungal Populations

The comparison of the bacterial and fungal populations recorded at 0, 2, 4 and 6 WAT showed that the bacterial (68.95 $x10^4$) and fungal (257.67 $x10^4$) population recorded at 0 WAT were significantly the highest while the lowest bacterial (32.91 $x10^4$) and fungal (55.23 $x10^4$) populations recorded at 2 and 4 WAT respectively was significantly similar to that of the other WAT, but different to that of the highest both recorded at 0 WAT (Table 3).

The interactions between diuron concentrations and sampling duration had no statistical significant difference on both the bacterial and fungal populations (Table 3).

Discussion

Almost all the physicochemical properties of soils sampled at 0, 2, 4 and 6 weeks after treatment (WAT) were not significantly different at different concentrations of diuron, except Mg^{++} and K^{++} at 0 WAT, pH, OC, OM and %TN at 4 WAT; and Ca^{++} at 6 WAT that had a significantly different values. The effect of the different concentrations of diuron was not significant on the various soil physicochemical component at 2 WAT except at 4 WAT on the pH, organic carbon, organic matter and percentage of total nitrogen due to the fact that the effect of the herbicide is not such that is immediate, but a gradual one. However, at 6 WAT, the diuron was observed to have a significant effect only on Ca^{++}. This shows that the effect of the herbicide on the soil physicochemical properties has a maximum peak that once is attained, it reduces with increase in period of application. Similarly, a significant effect of different concentrations of glyphosate on physicochemical component of soil that include total nitrogen, organic matter and phosphorus was also reported by Nigussie *et al*. (2019). Also, Tahar *et al*. (2017) found a significant effect of hymexazole on electrical conductivity and total carbon of soils treated with different concentrations of the herbicide when compared with that of the control soil.

Four (4) different species of fungi were isolated from soils treated with different concentrations of diuron and that of the control. Of these four different fungal species, the *Rhizopus* species of fungi was found in most of the soil sampled especially the ones treated with the highest concentrations of diuron; while the *Aspergillus* species of fungi were found only in the control soil samples and that of the lowest concentration of diuron used. This was an indication that the *Rhizopus* species of fungi could withstand high concentrations of diuron than *Aspergillus* species. The study by Adomako and Akyeampong (2016) similarly reported the absent of some fungal species from the genera that include Aspergillus, Mucor

and Penicillium in soils treated with different concentrations of paraquat, glyphosate and 2,4-D amine, but present in the control soil samples.

The different concentrations of diuron had no statistical difference in their effect on soil bacterial and fungal populations. The bacterial population of the control soil sample was, however, higher than that of concentration 1.0 kg/ha of diuron that had the lowest. This showed that the different concentrations of diuron had effect on the bacterial population. Study by Sebiomo *et al.* (2011) similarly reported the reduction in bacterial population of soils treated with glyphosate, atrazine, primeextra and paraquat. The fungal population recorded on the control soil was significantly similar with that of the different concentrations of diuron. This contradict the report of Sebiomo *et al.* (2011) who reported a significant reduction in population of fungi in soils treated with the different concentrations of the above-mentioned herbicides. This could be due to differences in herbicides type, nature of the soil and duration of application as these greatly affect the effect of herbicides on soil component. The bacterial and fungal populations of soil sampled prior to treatment was observed to be higher than that of the treated soils sampled different weeks after treatment.

Conclusion

The different concentrations of diuron have no significant effect on the physicochemical component of soil in Yola except on pH, organic carbon, organic matter and percentage of total nitrogen especially at 4th week after its application. Similarly, the different concentrations of the herbicide have no significant effect on both the bacterial and fungal populations of the soils.

Table 1: The Physicochemical Properties of Soil treated with different Concentrations of Diuron sampled at 0, 2, 4 and 6 WAT during 2021 Trial

		Physicochemical Property													
WAT	Conc (L/ha)	pH	EC (ds/m)	%MC	OC (g/kg)	OM (g/kg)	%TN (cmol/kg)	Ca^{++} (cmol/kg)	Mg^{++} (cmol/kg)	K^{++} (cmol/kg)	Na^{++} (cmol/kg)	TEB	TEA	ECEC	PBS
0	Con	7.33a	0.19a	8.67a	10.21a	17.60a	0.10a	0.60a	0.30b	0.06b	0.20a	1.16a	2.27a	3.42a	32.33
	0.5	7.05a	0.28a	7.33a	11.21a	19.32a	0.11a	0.60a	0.80ab	0.06b	0.21a	1.67a	2.00a	3.67a	44.93
	1.0	7.02a	0.44a	8.33a	11.74a	20.23a	0.12a	0.73a	0.90ab	0.06b	0.19a	1.88a	2.07a	3.95a	47.00
	1.5	6.96a	0.39a	8.67a	10.01a	17.25a	0.10a	0.40a	1.20a	0.19a	0.21a	2.06a	2.47a	4.53a	45.87
	2.0	7.13a	0.56a	11.17a	11.34a	19.55a	0.11a	0.63a	0.53ab	0.10ab	0.19a	1.46a	2.53a	3.99a	36.62
	SE±	0.09	0.06	0.85	0.44	0.76	0.00	0.06	0.12	0.01	0.02	0.14	0.10	0.17	2.49
2	Con	7.33a	0.19a	8.67a	10.21a	17.60a	0.10a	0.60a	0.30a	0.06a	0.20a	1.16a	2.27a	3.42a	32.33a
	0.5	7.24a	0.23a	9.33a	10.91a	18.80a	0.11a	0.77a	0.80a	0.04a	0.19a	1.80a	1.93a	3.73a	47.58a
	1.0	6.74a	0.46a	6.33a	10.54a	18.17a	0.11a	0.67a	0.57a	0.07a	0.22a	1.52a	2.20a	3.72a	40.70a
	1.5	6.81a	0.60a	9.00a	9.84a	16.97a	0.10a	0.47a	0.93a	0.15a	0.23a	1.78a	2.40a	4.18a	42.67a
	2.0	7.13a	0.56a	11.17a	11.34a	19.55a	0.11a	0.63a	0.53a	0.10a	0.19a	1.46a	2.53a	3.99a	36.62a
	SE±	0.10	0.07	0.86	0.42	0.72	0.00	0.06	0.10	0.02	0.01	0.12	0.10	0.17	2.23
4	Con	6.58b	0.23a	8.33a	9.18bc	15.82bc	0.09bc	1.97a	1.77a	0.03a	0.29a	4.05a	2.67a	6.72ab	60.26a
	0.5	6.84ab	0.23a	7.67a	12.40a	21.38a	0.12a	2.03a	2.23a	0.09a	0.42a	4.79a	3.00a	7.79a	61.54a
	1.0	6.64ab	0.40a	7.67a	7.21c	12.44c	0.07c	2.03a	2.17a	0.01a	0.36a	4.57a	2.93a	7.50ab	60.79a
	1.5	6.94a	0.17a	8.00a	8.94bc	15.42bc	0.09bc	2.40a	1.13a	0.01a	0.24a	3.79a	2.33a	6.12b	61.79a
	2.0	6.69ab	0.19a	8.67a	10.84ab	18.69ab	0.11ab	2.57a	0.67a	0.09a	0.51a	3.82a	3.13a	6.96ab	54.98a
	SE±	0.05	0.04	0.31	0.58	1.01	0.01	0.22	0.26	0.02	0.04	0.16	0.13	0.20	1.39
6	Con	6.99a	0.09a	11.17a	12.57a	21.67a	0.12a	3.50a	0.60a	0.22a	0.42a	4.74a	3.00a	7.74a	61.30a
	0.5	6.52a	0.11a	9.50a	10.31a	17.77a	0.10a	1.40b	2.43a	0.38a	0.45a	4.66a	2.93a	7.59a	62.00a
	1.0	6.31a	0.09a	8.83a	10.94a	18.86a	0.11a	2.47ab	1.87a	1.09a	0.85a	6.28a	3.13a	9.41a	65.75a
	1.5	6.75a	0.10a	8.50a	11.67a	20.12a	0.12a	2.47ab	0.93a	0.19a	0.46a	4.05a	4.00a	8.05a	51.96a

2.0	6.92a	0.07a	9.17a	10.01a	17.26a	0.10a	2.07b	1.30a	0.22a	0.43a	4.03a	2.87a	6.89a	58.54a
SE±	0.11	0.01	0.43	0.46	0.78	0.00	0.24	0.26	0.16	0.09	0.32	0.27	0.35	2.49

Table 2: Fungal Species Isolated from Soils Treated with Action Diuron

	Concentration (L/ha)/Organism				
Sampling Period (WAT)	0.0	0.5	1.0	1.5	2.0
2	A. flavus M. grisea	A. versicolor	Rhizopus sp.	Rhizopus sp.	Rhizopus sp.
4	A. flavus M. grisea	A. versicolor	Rhizopus sp.	Rhizopus sp.	Rhizopus sp.
6	A. flavus M. grisea	A. versicolor	S. chartarum	Rhizopus sp.	Rhizopus sp.

Table 3: Effect of Different Diuron Concentrations and Sampling Duration on Soil Bacterial and Fungal Populations

	Microbial Organism	
Treatment	Bacteria ($x10^4$)	Fungi ($x10^4$)
Concentration (kg/ha) - (A)		
0.5	44.76ab	110.48a
1.0	38.48b	105.59a
1.5	46.82ab	91.77a
2.0	42.92ab	125.47a
Control	59.67a	106.48a
SE±	5.53	15.19
Sampling Duration (Week) - (B)		
0	68.95a	257.67a
2	32.91b	63.01b
4	37.49b	55.23b
6	46.77b	55.91b
SE±	4.95	13.59
Interaction		
A x B	NS	NS

Means in the same column with the same letter(s) are not significantly different at p≤0.05.

Key: NS = No significant difference

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