Effects of Select Surfactants on Soil Enzyme Activity

Mullings, N* and F. Eivazi, Cooperative Research Programs and the Department of Agriculture and Environmental Sciences, Lincoln University, Jefferson City, MO 65102

Abstract

Surfactants (surface-active agents) facilitate and accentuate the emulsifying, dispersing, spreading, and wetting properties of liquids. Surfactants are used in industry to reduce the surface tension of liquid and to solubilize compounds. For agricultural pest management, surfactants are an important component in herbicide and insecticide formulations that enhance adhesion of active ingredients to plant surfaces. Surfactants often directly contact soils, however, little is known about the behavior and fate of these chemicals in soil ecosystems. It is hypothesized that surfactants, upon entry into soil, may affect various chemical, physical and biological properties, and potentially affect microbial activity. The objective of this study was to determine the effects of surfactants on enzymes involved in nutrient cycling in the soil. In our study we used three surfactants: Activator-90, Agridex, and Thrust; three herbicides: Gly-4 (glyphosate), Atrazine, and Basagran (bentazon). Treatments examined were surfactant only, herbicide only, and surfactant + herbicide combination. A greenhouse experiment was conducted using a silt loam Wrengart silt loam (fine-silty, mixed, superactive, mesic Fragic Oxyaquic Hapludalfs). Each pot (4000 g soil) was fertilized according to soil test recommendations. Pots were arranged in a randomized complete block design. Field corn (Zea mays) was used as the test crop and allowed to grow for seven weeks. Soil C/N ratio and enzymes, acid phosphatase, β-glucosidase, arylsulfatase, β-glucosaminidase, and dehydrogenase activities were determined in soil after corn harvested. Results show that C/N increased with the addition of all treatments when compared to controls. Results showed variations in the enzyme activities with some inhibition and some being enhanced by the treatments. Results suggest that surfactants reaching field soils may play a role in altering diversity of the soil microbial community which in turn affects the enzyme activity.

Introduction

Soil enzymes play an important role in biochemical processes in the soil and play a substantial role in maintaining soil health (Singh and Singh, 2005). The enzymatic activity is mainly of microbial origin. Additions of chemicals such as surfactants and herbicides may alter microbial activity by impacting sorption sites in the soil, increasing solubility of pesticides, increasing toxicity and even serve as a source of carbon for the microbial community. Degradation of chemicals such as surfactants and herbicides by biochemical reactions and enzyme mediated processes is critical to reducing the negative impacts of these chemicals on the environment. Degradation can be heavily influenced by the environmental conditions present and the chemical nature (Ying, 2006). Understanding the effects of surfactants on enzyme activities which are involved in the nutrient cycling is worth investigating.

Objective

The objective of the study was to investigate the changes in microbial population, and enzyme activities if any, due to surfactant treatments applied.

Materials and Methods

Soils samples were taken from pots which were used to grow corn and were treated with different treatments of surfactants and herbicides (see Table 1).

Total organic carbon and total nitrogen determined with combustion using a LECO TrueSpec carbon/nitrogen analyzer (LECO Corporation, St. Joseph, MI, USA).

Acid phosphatase activity was determined using a method developed by Eivazi and Tabatabai (1977).

The method of Tabatabai and Bremner was used for assaying arylsulfatase activity (1970).

Beta-Glucosidases activity was estimated by a method described by Eivazi and Tabatabai, (1990).

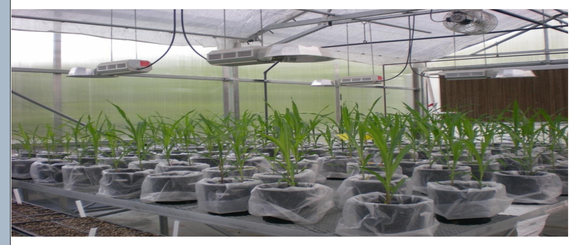
Beta-glucosaminidase and dehydrogenase were measured using methods described in Methods of Soil Analysis, (Tabatabai, M.A. 1994).

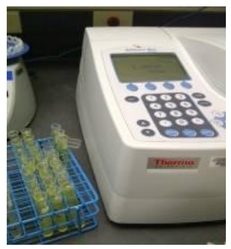
Table 1. Treatment application rates per pot

Surfactant and Herbicide	Control	Surfactant	Surfactant x 2	Herbicide
Activator-90 and Gly-4	0	0.02 ml	0.04 ml	0.0065 ml
Agridex and Atrazine	0	0.02 ml	0.04 ml	0.0167 ml
Thrust and Basagran	0	0.01 g	0.02 g	0.0083 ml

Combination of each surfactant and herbicide was also added as an additional treatment.

Plants growing in the greenhouse

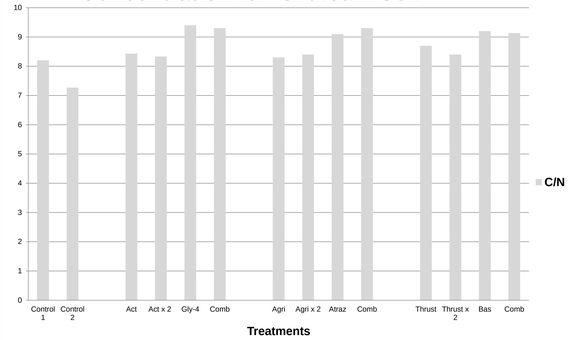




Yellow color intensity measured in a spectrophotometer.

Results and Discussion

Graph 1. Carbon/Nitrogen Ratio Concentration for Silt loam Soil



Effect of Select Surfactants, Herbicides & Surfactant + Herbicide Combination on Enzyme Activity in Silty Clay Loam

TRT	Phos	Sul	β-amin	β-Gluc	Dehy
Ctrl	52.66 f	55.39 c	1.77 a	3.1 cde	-4.99 g
Act.	48.9 fg	34.5 d	2.59 a	3.6 cde	-8.44 g
Act. x2	32.16 h	16.9 e	1.33 a	3.1 cde	-5.21 g
Gly 4	111.3 d	98.4 a	4.37 a	11.52 a	20.84 h
Act. + Gly 4	53.78 f	98.8 a	7.36 a	3.6 cde	13.8 cd
Agr.	118.2 d	61.3 bc	6.63 a	4.89 c	29.54 b
Agr. x 2	174.5 a	22.28 e	3.68 a	1.26 e	5.81 ef
Atra.	16.1 i	55.60 c	6.62 a	1.08 e	-9.60 g
Agr. + Atra.	162.1 b	20.24 e	2.40 a	2.2 cde	0.86 f
Thr.	101.2 e	103.2 a	6.82 a	7.91 b	42.7 a
Thr. x2	39.9 gh	23.87 e	2.56 a	1.51 de	9.7 de
Bas.	140.8 c	70.6 b	4.66 a	3.6 cde	15.02 c
Bas.+Thr.	116.8 d	55.2 c	7.98 a	4.35 cd	11.7 cd

Act=Activator-90; Act x 2=Activator-90 doubled; Gly-4=glyphosate. Agr.=Agri-Dex; Agr. x 2=Agri-Dex doubled; Atra.=atrazine. Thr.=Thrust; Thr. x 2=Thrust doubled; Bas=basagran (bentazon).Phos=Phosphatase; Sul=Sulfatase; b-ami=b-glucosaminidase; b-glu=b-Glucoside; Dehy=Dehydrogenase * Different letters indicate significant difference means within enzyme class at (P<0.05) according to LSD test.

Effect of Select Surfactants, Herbicides & Surfactant + Herbicide Combination on Enzyme Activity in Silty Loam

TRT	Phos	Sul	β-ami	β-Gluc	Dehy
Ctrl	113.2 fg	90.9 d	2.07 a	34.49 a	6.06 a
Act.	116.5 fg	29.5 fg	2.46 a	21.61 b	2.2 bc
Act. x2	56.08 h	13.18 h	1.36 a	8.90 de	0.5 cd
Gly 4	309.4 c	81.9 de	5.10 a	18.56 bc	3.9 ab
Act. + Gly 4	106.1 g	103.0 c	6.99 a	21.34 b	-0.4 cd
Agr.	291.3 d	70.77 e	5.23 a	22.11 b	-0.62 d
Agr. x 2	286.9 a	18.2 gh	3.68 a	10.14 d	0.9 cd
Atra.	64.21 h	77.27 e	6.06 a	11.62 d	-3.47 e
Agr. + Atra.	317.2 c	29.96 g	2.42 a	10.55 d	-0.1 cd
Thr.	252.5 e	130.4 a	7.58 a	11.45 d	-1.6 de
Thr. x2	120.9 f	39.72 f	2.35 a	3.53 e	-0.74 d
Bas.	340.9 b	117.6 b	4.40 a	13.37 cd	0.1 cd
Bas. + Thr.	396.6 a	90.16 d	8.14 a	10.62 d	-1.45 de

Act=Activator-90; Act x 2=Activator-90 doubled; Gly-4=glyphosate. Agr.=Agri-Dex; Agr. x 2=Agri-Dex doubled; Atra.=atrazine. Thr.=Thrust; Thr. x 2=Thrust doubled; Bas=basagran (bentazon).Phos=Phosphatase; Sul=Sulfatase; b-ami=b-glucosaminidase; b-glu=b-Glucoside; Dehy=Dehydrogenase * Different letters indicate significant difference means within enzyme class at (P<0.05) according to LSD test.

Results and Discussion

C/N ratio tends to increase with addition of all treatments compared to the control. As C/N ratio increase so does enzymatic activity within the soils due to an increase in microbial activity. C/N ratio for herbicide alone and combination treatments are higher than treatments with surfactants only.

In general, enzyme activity was enhanced more in silt loam soil than silty clay loam.

Surfactant, Activator 90 appeared to have the most inhibitory effect on enzymatic activities within soils as compared to control.

Acid phosphatase displayed the greatest amount of enzymatic activity within soils, dehydrogenase displayed the most inhibition, whilst β-glucosidase and β-glucosaminidase fluctuated between treatments.

Atrazine application significantly decreased the activities of acid phosphatase, β-glucosidase, and dehydrogenase in both soils, however, combination of Atrazine + Agridex increased the acid phosphatase activity while significantly inhibiting the other enzyme activities in soils.

Enzymatic activity indicated that surfactant alone treatments applied at the recommended rates increase enzyme activity. Surfactant herbicide combinations indicated that surfactant additions to herbicides created synergistic effects (e.g. Basagran+Thrust & Act. 90 + Gly 4) working together to increase enzyme activity. However not all surfactants when added to herbicides may have synergistic effects (e.g. Atrazine + Agridex).

Conclusions

The application of surfactants regardless of rates, herbicides and combination treatments caused variable changes in enzyme activities. Further long-term studies are needed to determine the full extent of changes in the microbial community and other soil properties after several years of annual applications of herbicides and surfactants. We cannot determine from this study whether those changes would lessen with the seasons.

References

Ying, GG. (2006). Fate, behavior and effects of surfactants and their degradation products in the environment. Environment International, volume 32, pages 417-431.

Singh & Singh. (2005). Evaluation of some adjuvants for improving glyphosate efficacy. J. ASTM Intern volume 4 pages 1-10.

Acknowledgements

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