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The Change of Catalase Enzyme Activity in Soils by The Land Use

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ABSTRACT

Analysing the factors driving the population size and activities of soil microorganisms is important for understanding the soil ecosystem's structure and functioning. For this purpose, the soil enzymes are used as an indicator of soil microbial activity and soil fertility. Although there are many studies on the distribution and activities of various soil enzymes in soils under monoculture or crop alternation conditions, there are only few studies examining the ecological relationship in natural ecosystems, especially by using enzymes. In this study, it was aimed to determine the effect of different land uses on the catalase enzyme activity in soil. For this purpose, the catalase enzyme activities in soil samples taken from 0-5cm and 5-10cm depths in agricultural, forest, and pasture lands in north and south exposures were determined and the effects of different land use, exposure, and soil depth conditions on the enzyme activities were investigated. At the end of the study, it was determined that the catalase enzyme activity significantly differed by the land use and the highest level of catalase enzyme activity in both south and north exposures and at both depth levels was found in forest soils, whereas the lowest level of activity was found in agricultural lands in north exposure and pasture soils in south exposure.

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Introduction

Since the lives of all living organisms on the earth depend directly or indirectly on the plants, the plants are defined as the most important organism group of the world (Yigit et al., 2018; Sevik, 2021). The plants fulfill various economic, ecologic, and social functions in locations, where they grow (Aricak et al., 2019; Ozel et al., 2020; Kalayci Onac et al., 2021; Cesur et al., 2021). Plants' ability to fulfill these functions depends on their healthy growth and development (Yucedag et al., 2018; Yucedag et al., 2019; Turkyilmaz et al., 2020).

As with all morphological, anatomical, and phenological characteristics of plants, plant development is driven by its genetic structure (Hrivnak et al., 2017; Imren et al., 2021) and mutual interactions between environmental conditions (Sevik et al., 2020a,b; Ertugrul et al., 2021). The environmental conditions can be classified as climatic (Cetin et al., 2018a,b; Varol et al., 2021) and edaphic (Kravkaz Kuscu et al., 2018a,b) conditions of the location, where the plant grows (Turkyilmaz et al., 2020; Cetin et al., 2020). Soil, which constitutes the edaphic ones among these conditions, is one of the most important factors influencing plant development. The soil structure and the nutrients in soil play important roles in the development of plants (Kravkaz Kuşcu and Sharaf, 2021). Thus, many studies were carried out on the relationship between plant development and soil characteristics (Zhang et al., 2020; Kravkaz Kuscu, 2020; Adekiya et al., 2020; Yucedag et al., 2021).

In assessing the functions related with fertility and soil protection in a complex soil system, it is important to consider the biological factors (Kravkaz Kuşcu and Sharaf, 2021). Being one of the most important factors influencing the soil structure and fertility, enzymes are the high-molecule catalyzers that are created by organisms but do not need an organism to function. The main responsibility of enzymes is to transform the high-molecule organic matter into simple forms, which can enter the cell and be utilized by the organism. As stated before, enzymes act as catalyzers and their presence solely ensures the faster formation of the reactions (Kravkaz Kuscu, 2014). Being one of the enzymes, catalase is an enzyme dissociating the hydrogen peroxide (H_2O_2), which arises from metabolic

events and respiration of living organisms and is toxic for the cell, into water and oxygen (Çengel, 2004).

It is known that enzymatic reactions are in a close relationship with soil fertility (Kravkaz Kuscu, 2019). However, the studies carried out to date remained at limited levels and there is a very scarce amount of studies carried out on forestry. In this study, it was aimed to determine the effect of different land uses on the catalase enzyme activity in soil. For this purpose, the catalase enzyme activities in soil samples taken from 0-5cm and 5-10cm depths in agricultural, forest, and pasture areas in north and south exposures were determined and it was aimed to reveal the effects of different land use, exposure, and soil depth on the enzyme activities.

Material and Method

Material

In this study, the forest (orman), pasture (mera), and agricultural (tarım) lands that are neighboring to each other and, consequently, have similar characteristics were determined and the areas (agriculture, pasture and forest) to take soil samples in harmony with the objective of this study were chosen in north (Figure 1) and south (Figure 2) exposures. After the preliminary examinations, the soil samples were taken from the areas in exposures mentioned-above.

At the locations, which were found to fit the purpose of the study, the soil samples were taken from 5 different points and at 2 different depth levels. Thus, 60 soil samples were taken from 2 exposures in 3 land uses (agriculture, forest, and pasture) at 2 different depth levels and with 5 repeats. While taking the samples, the pits were prepared in 80cm width, 100cm length, and 30cm depth. The non-deteriorated soil samples with $100cm^3$ volume were taken from 0-5cm and 5-10cm depths. Soil samples were taken in the second half of May, when the precipitation stopped but the soil kept its moisture. The samples were kept in the mobile coolers and transferred to Ankara on the same day and then, by taking the required measures, kept at +4°C until the analyses.

Method

Catalase activity is an indicator of anaerobic organism activities. Catalase enzyme is secreted by many species dissociating toxic H_2O_2, which occurs during the material exchange, into water and oxygen. This procedure is performed by applying H_2O_2 into a soil buffer solution, in which the dissociating oxygen is measured using the gas volumetric method. The reaction occurs as follows;

$2H_2O_2$ ----------> $2H_2O + O_2$
(manometric calculation, volume reading)

Catalase enzyme is present in all anaerobic bacteria and facultative bacteria. Bacterial catalase is an enzyme that is active between pH 3 and 9 values. The pH range, in which it is active at the highest level, is 6.3-7.2, whereas the temperature range is 4-26°C. the catalase activities of soils were determined using Beck's (1971) method that is based on the gasometric measurement of the amount of oxygen arising from the dissociation of hydrogen peroxide.

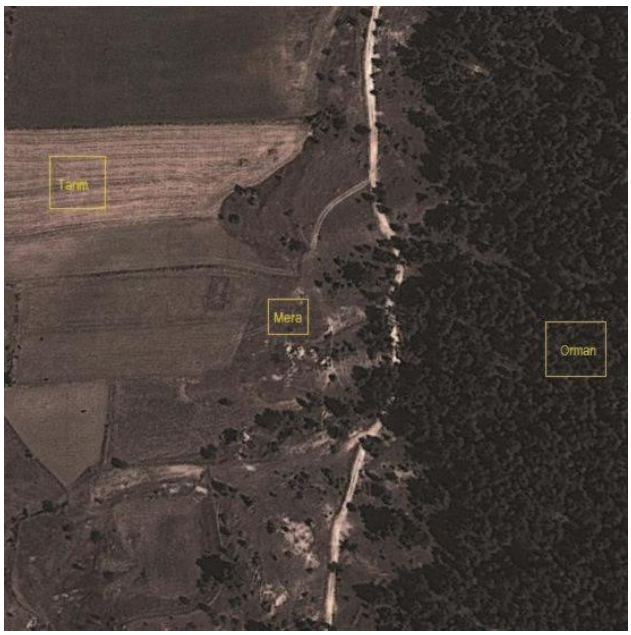

Figure 1. Sampling areas in north exposure

Figure 2. Sampling areas in south exposure

Results and Discussion

Identification, variance analysis and Duncan test results for catalase enzyme activities in various exposures and soil depths are presented below.

Catalase Enzyme Activity of Soils in North Exposure at 0-5 cm Depth

The identification table, the variance analysis and Duncan test results for soils at 0-5 cm depth with north exposure are given in Table 1, 2 and 3, respectively.

Given the identification table, it can be seen that the catalase enzyme activity in forest soils taken from 0-5 cm depth was 2.12 folds of the level determined in agricultural soil and 1.23 folds of the level in pasture soils. As seen in the table, the catalase enzyme activity level is approx. 1.72 folds of the level determined in agricultural soils.

Table 1. Identification table for soils at 0-5 cm depth with north exposure

Catalase Enzyme (ml/5 g)	Average	Std.Dev.	Std.Error	Confidence level of 95%		Minimum	Maximum
				Lower Limit	Upper Limit		
Agriculture	10.9286	1.63169	0.42130	10.0250	11.8322	8.75	14.59
Forest	23.2002	12.23699	3.15958	16.4236	29.9768	8.66	43.38
Pasture	18.7849	6.23128	1.60891	15.3341	22.2357	11.69	29.41
Average	17.6379	9.33753	1.39196	14.8326	20.4432	8.66	43.38

Table 2. Variance analysis results of soils at 0-5 cm depth with north exposure

Catalase Enzyme (ml/5 g)	Sum of Squares	df	Mean Square	F	P
Between Groups	1159.043	2	579.521	9.091	0.001
Within Groups	2677.293	42	63.745		
Total	3836.336	44			

Table 3. Duncan test results of soils at 0-5 cm depth with north exposure

Catalase Enzyme (ml/5 g)	Value	Groups	
Agriculture	10.9286	a	
Forest	18.7849		b
Pasture	23.2002		b

Table 4. Identification table for soils at 5-10 cm depth with north exposure

Catalase Enzyme (ml/5 g)	Average	Std.Dev.	Std.Error	Confidence level of 95%		Minimum	Maximum
				Lower Limit	Upper Lımıt		
Agriculture	9.2823	2.81024	0.72560	7.7260	10.8386	4.78	13.61
Forest	18.8020	6.05570	1.56357	15.4485	22.1556	11.85	30.06
Pasture	11.2554	1.89221	0.48857	10.2075	12.3032	8.20	13.92
Average	13.1132	5.70375	0.85026	11.3996	14.8268	4.78	30.06

Table 5. Variance analysis results of soils at 5-10 cm depth with north exposure

Catalase Enzyme (ml/5 g)	Sum of Squares	df	Mean Square	F	P
Between Groups	757.349	2	378.674	23.594	0.000
Within Groups	674.091	42	16.050		
Total	1431.440	44			

Table 6: Duncan test results of soils at 5-10 cm depth with north exposure

Catalase Enzyme (ml/5 g)	Average	Groups	
Agriculture	9.2823	a	
Pasture	11.2554	a	
Forest	18.8020		b

Given the variance analysis results, it was determined that the catalase enzyme activities in agricultural, forest, and pasture soils with north exposure differed significantly at the error level of 0.001, which indicates a confidence level of 99%. According to the results of the Duncan test, it can be seen that agricultural soils gathered in a group and pasture and forest soils gathered in another group. Accordingly, the pasture and forest soils taken from 0-5cm depth in north exposure were found to have 1.23 folds of difference in terms of catalase enzyme activity level but the difference was found to be statistically non-significant. However, the catalase enzyme activity in agricultural soils was found to be statistically significantly (confidence level of 99%) lower than in forest and pasture soils.

Catalase Enzyme Activity of Soils in North Exposure at 5-10 cm Depth

The identification table, the variance analysis and Duncan test results for soils at 5-10 cm depth with north exposure are presented in Table 4, 5 and 6, respectively.

Given the identification table, it can be seen that the catalase enzyme activity level in forest soils taken from 5-10 cm depth in north exposure was found to be higher than 2 folds of those found in agricultural soil samples. As seen in the table, the catalase enzyme activity in forest soils was calculated to be 1.67 folds of the catalase enzyme activity level in pasture soils. The catalase enzyme activity found in soil samples taken from pasture was approx. 1.21 folds of the level found in agricultural soil samples. Given the results of variance analysis, it was found that the catalase

enzyme activity levels in agricultural, forest, and pasture soil samples taken from 5-10cm depth in north exposure significantly differed at the confidence level of 99.9%.

According to the result of the Duncan test, agricultural and pasture soil samples gathered in a group and forest soils in another group. Given these results, the catalase enzyme activity levels in forest soils taken from 5-10 cm depth in north exposure were higher than in agricultural and pasture soil samples.

Catalase Enzyme Activity of Soils in South Exposure at 0-5 cm Depth

The identification table, the variance analysis and Duncan test results for soils at 0-5 cm depth with south exposure are given in Table 7, 8 and 9, respectively.

As can be seen in the identification table, the catalase enzyme activity level found in the forest soils taken from 0-5cm depth was higher than in agricultural soil samples by 41% and in pasture soil samples by 88%. Besides that, the level found in agricultural soil samples was approx. 33% higher than in pasture soil samples.

According to the variance analysis results, it was determined that the catalase enzyme activities in agricultural, forest, and pasture soil samples taken from 5-10cm depth in south exposure significantly varied at the confidence level of 99.9%.

Given the results of the Duncan test, it can be seen that the agricultural and pasture soil samples gathered in a group and the forest soils in other group. Thus, it can be stated that the catalase enzyme activity in forest soil samples taken from 5-10cm depth in south exposure was higher than in agricultural and pasture soil samples with the confidence level of 99.9.

Catalase Enzyme Activity of Soils in South Exposure at 5-10 cm Depth

The identification table, the variance analysis and Duncan test results for soils at 5-10 cm depth with south exposure are given in Table 10, 11 and 12, respectively..

As seen in the identification table, the catalase enzyme activity level found in forest soil samples taken from 5-10cm depth in south exposure was approx. 2 folds of the level found in pasture soil samples. As can be seen in the table, the catalase enzyme activity found in forest soils was 1.33 folds of the level found in agricultural soil samples. Catalase activity level in agricultural soil samples was found to be 1.48 folds of the level found in pasture soil samples. Given the variance analysis results, it was found that the catalase enzyme activity levels in agricultural, forest, and pasture soil samples taken from 5-10 cm depth in south exposure significantly differed at the confidence level of 99.9%.

According to the results of the Duncan test, it can be seen that each of the catalase enzyme activity levels in agricultural, forest, and pasture soil samples taken from 5-10 cm depth in south exposure gathered in a different group. Accordingly, the catalase enzyme activity values found in agricultural, forest, and pasture soil samples significantly differed from the others.

Table 7. Identification table for soils at 0-5 cm depth with south exposure

Catalase Enzyme (ml/5 g)	Average	Std.Dev.	Std.Error	Confidence level of 95%		Minimum	Maximum
				Lower Limit	Upper Limit		
Agriculture	20.1118	9.30282	2.40198	14.9601	25.2635	7.54	35.53
Forest	28.4405	9.15730	2.36440	23.3694	33.5117	14.34	41.35
Pasture	15.0825	4.48144	1.15710	12.6007	17.5642	10.39	22.99
Average	21.2116	9.57298	1.42706	18.3355	24.0876	7.54	41.35

Table 8. Variance analysis results of soils at 0-5 cm depth with south exposure

Catalase Enzyme (ml/5 g)	Sum of Squares	df	Mean Square	F	P
Between Groups	1365.505	2	682.752	10.753	.000
Within Groups	2666.745	42	63.494		
Total	4032.249	44			

Table 9. Duncan test results of soils at 0-5 cm depth with south exposure

Catalase Enzyme (ml/5 g)	Average	Groups	
Pasture	15.0825	a	
Agriculture	20.1118	a	
Forest	28.4405		b

Table 10. Identification table for soils at 5-10 cm depth with south exposure

Catalase Enzyme (ml/5 g)	Average	Std.Dev.	Std.Error	Confidence level of 95%		Minimum	Maximum
				Lower Limit	Upper Limit		
Agriculture	11.9584	3.25764	0.84112	10.1544	13.7624	7.58	17.13
Forest	15.9653	2.52005	0.65067	14.5697	17.3608	12.33	21.05
Pasture	8.0782	2.15780	0.55714	6.8832	9.2731	4.19	12.35
Average	12.0006	4.18127	0.62331	10.7444	13.2568	4.19	21.05

Table 11. Variance analysis results of soils at 5-10 cm depth with south exposure

Catalase Enzyme (ml/5 g)	Sum of Squares	df	Mean Square	F	P
Between Groups	0.023	2	0.012	20.710	.000
Within Groups	0.024	42	0.001		
Total	0.047	44			

Table 12. Duncan test results of soils at 5-10 cm depth with south exposure

Catalase Enzyme (ml/5 g)	Average	Groups		
Pasture	8.0782	a		
Agriculture	11.9584		b	
Forest	15.9653			c

Conclusion

As a result of the present study, it was determined that the catalase enzyme activity levels significantly varied by the land use in both south and north exposures and at both depth levels. According to the results obtained from the variance analysis and Duncan test, the highest catalase enzyme activity level in both south and north exposures and at both depth levels was found in soil samples taken from the forest, whereas the lowest values were obtained in agricultural soil samples for north exposure and pasture soil samples for south exposure.

The results obtained from the present study are generally in corroboration with the related literature. Wang et al. (2012) reported that the highest level of catalase enzyme activity in areas covered with *Robinia pseudoacacia* and *Platycladus orientalis* and the lowest catalase enzyme activity level in the agricultural areas.

Li et al. (2014) compared the forestation area, natural forest, bush, terrace, deserting rock area, and agricultural areas in terms of catalase enzyme activity level and reported the lowest catalase enzyme activity level in natural forest areas and there was no statistically significant difference between these areas.

Kravkaz Kuşcu (2019) reported that catalase enzyme activity level varied depending on the plant species in soils, where different plant species are grown under different shadow conditions, and that the highest catalase enzyme activity level was found in open areas for *Betula pendula* and the lowest catalase enzyme activity level was found in open area for *Gleditsia triacanthos*. Rodriguez and Truelove (1982) determined that the soil catalase activity level varied depending on the plant species and that the highest level of catalase enzyme activity was found with wheat, soybean, and common vetch, whereas the lower levels were reported for corn and cotton parcels.

It was reported that the catalase enzyme activity decreased in irrigated soils (Okur et al., 2001). Formanek and Vranova (2003) showed that the catalase enzyme activity varied depending on the plant cover and was related with the amount of organic substances, total N, available P and K.

On the other hand, Kızılkaya et al. (1998) asserted that there was no relationship between catalase enzyme activity and organic substance.

Türkmen et al. (2013) stated that the catalase enzyme activity decreased with increasing depth and the highest catalase enzyme activity levels were observed in unprocessed soils. This finding corroborates with the results obtained in the present study.

Plant development is shaped by the plant's genetic structure (Hrivnak et al., 2017) and environmental conditions (Sevik et al., 2019a,b; Turkyilmaz et al., 2019). The environmental conditions influencing the plant development are also related with each other. For instance, sunlight influences the development, form, and morphological and anatomic characteristics of plant (Sevik et al., 2017; Yigit et al., 2018) and it also increases the temperature. The temperature affects the moisture level of soil and moisture influences the microbial activities and enzymatic activities (Kravkaz Kuscu, 2014; Szymańska et al., 2017; Yang et al., 2018; Yigit et al., 2019; Ertugrul et al., 2019). Thus, there are many environmental factors interacting with each other and influencing the soil structure and, consequently, the plant development (Ozkazanc et al., 2019; Aricak et al., 2020; Ozel et al., 2021; Koc, 2021). The climatic factors such as precipitation, temperature, and light (Kilicoglu et al., 2020; Sevik et al., 2021), the edaphic factors such as soil pH, amount of organic matters, and depth (Kravkaz Kuscu et al., 2019; Varol et al., 2019), the factors causing stress such as drought (Topacoglu et al., 2016; Mahmood et al., 2020), frost (Sevik and Karaca, 2016; Joshi et al., 2020), pollution (Mutlu et al., 2016; Mutlu and Aydın Uncumusaoglu, 2016; Mutlu and Kurnaz, 2017; Mutlu and Aydın Uncumusaoglu, 2017; Aydın Uncumusaoglu and Mutlu, 2017; Mutlu and Kurnaz, 2018; Turkyilmaz et al., 2018; Kükrer and Mutlu, 2019; Mutlu, 2019; Ucun Ozel et al., 2020; Emin et al., 2020; Kutlu and Mutlu, 2021; Tokatli et al., 2021), and human-origin factors such as fertilization (Moncada et al., 2021; Soumare et al., 2021), irrigation (Shu et al., 2020; Parkash et al., 2021), and hormone implementations (Guney et al., 2016a,b; Yucedag et al., 2019; Ashokhan et al., 2020) significantly affect each other, plant development, and soil structure. In conclusion, in order to determine the effects of enzyme activities on soil fertility and plant development and to use them purposefully, it is necessary to increase and diversify the future studies to be carried out on this subject.

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