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Original Research

Relationship between Enzyme Activity (Urease-Catalase) and Nutrient Element in Soil Use

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Abstract

This study determined the relationship of urease and catalase enzyme activity and nutrient elements related to the use of soil. We identitified urease and catalase enzymes and calcium (Ca), magnesium (Mg), iron (Fe), zinc (Zn), copper (Cu), and manganese (Mn) as nutrient elements, and total nitrogen (N), phosphorus (P) useful for plants, and exchangeable potassium (K) were identified in soils used for different purposes (agriculture, forest, and pasture), and the relationships between urease and catalase enzymes and these nutrient elements were revealed. Soil samples were taken from 60 points as 2 aspects x3 areas x2 depths x5 recurrences and the analyses were conducted on each sample with 3 recurrences. Duncan's test was carried out and the results were evaluated. The strongest relationships are identified between Mg and Fe (0.854), and Mg and Mn (0.867). The results of the study indicate that the depth factor has an effect only on catalase enzyme activity and Zn, soil use has an effect only on catalase enzyme activity and urease enzyme activity and Ca and Zn among micronutrient elements, and the aspect factor has an effect on all nutrient elements other than Zn – in contrast to other factors.

Keywords: catalase, enzyme activity, nutrient element, soil, urease, catalase

Introduction

Soil is important for forests and landscapes. Enzymes in the soil structure ensure that they are alive in forest areas [1-3]. Enzymes are molecules of protein structure that catalyze biochemical reactions in cells. Enzymes with significant metabolic functions in cells have entered daily and economic life to be used for various purposes [4]. Studies on enzyme activity have been of great interest for many years. However, it made great progress at the beginning of the 1950s as the main research subject in soil microbiology and biochemistry [5].

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Enzymes are classified as:

- Oxidoreductases: xidation reduction reaction (dehydrogenase, catalase, peroxidase).
- Tranferases: the transfer of group of atoms from donor to an acceptor molecule (Aminotransferases, Rhodonese).
- Hydrolases: hydrolitic cleavage of bonds (phosphatase, cellulase, urease).
- Lyases: cleavage of bonds other than hydrolysis or oxidation (aldolase).
- Isomerases: isomarization reaction.
- Ligases: formation of bonds by the cleavage of ATP (acetyl-CoA carboxylase).

Importance of Soil Enzymes

The release of nutrients in soil by means of organic matter degradation, identification of soils, identification of microbial activity, and importance of soil enzymes are sensitive indicators of ecological change [6]. The resources of enzymes in the soil are plants, soil animals, and microorganisms [7]. Most studies conducted on soil enzymes have accepted that the biological characteristics of the soil can be identified by determining the activities of certain enzymes with high amounts in the soil [8]. Inorganic and organic colloids of the soil are absorbed by clay and humin substances. Absorbed enzymes are more resistant to external factors when compared to other enzymes. They can maintain their activities for a long time. Thus, organic residues in the soil, most of which are plantal, are decomposed into micromolecule simple compounds after a series of enzymatic reactions.

The findings obtained from soil enzyme measurements are evaluated periodically as a guide for soil productivity [7]. Soil enzyme activities have a potential to determine the health of living elements of the soil and the total biological activity of the soil. Soil enzyme tests may provide information about the potential of soils in terms of carrying out some biochemical processes.

The height of enzymatic activity is one of the most significant indicators of the characteristics and the quality of a soil [9]. Therefore, determining the relationship between enzymatic activities and external factors can provide significant benefits in many areas – from soil reclamation to the increase in productivity.

Urease and catalase enzymes among the soil enzymes are prominent enzymes that have been the subject of many studies to date. Urease enzyme is an extracellular enzyme that catalyzes carbondioxide and ammonia hydrolysis of the urea, which is retained by organic and inorganic colloids of the soil [10]. Catalase enzyme is an enzyme that is a result of metabolic events and respiratory events of living organisms and that separates cytotoxic hydrogen peroxide (H_2O_2) into water and oxygen [10].

In this study we aimed to identify the relationship between urease and catalase enzymes with some soil nutrient elements, and also soil depth, soil use, and change depending on the aspect of these substances.

Experimental

In the study, areas are adjacent to each other and therefore have the same characteristics; however, uses as forest, pasture, and agricultural land were identified, and areas where soil samples would be taken were determined in accordance with the purpose of the study. As a result of the land works conducted, the areas where soil samples would be taken from two determined sample areas were identified as the southern and northern aspects, and it was decided as a result of the preliminary examinations conducted that samples would be taken from five different points and two different depths from each test area from the areas determined in accordance with the purpose of the study. Thus, soil samples were taken from 60 points as 2 aspects x3 areas (agriculture, forest, pasture) x2 depths x5 recurrences, and the analyses were conducted on each sample with 3 recurrences. Micronutrient elements were determined according to Zbiral [11], and urease-catalase enzyme activity was identified according to Yang et al. [12].

Results and Discussion

The Effect of Soil Depth

As a result of our study, variance analysis was conducted on the data to identify the effect of the depth factor on urease and catalase enzymes and micronutrient elements, and the results were evaluated. The average values obtained and the results of the variance analysis are indicated in Table 1. Because of the fact that there are only 2 depth levels as the depth factor, Duncan's test was not applied to the data.

Table 1. Change of deep-contained enzyme and nutritional elements.

	Urease	Catalase	Ca	Mg	Fe	Zn	Cu	Mn
0-5 cm	0.047	19.206	8,534.647	410.647	17.319	0.427	1.382	13.053
5-10 cm	0.049	11.531	8,472.28	374.299	15.826	0.285	1.408	11.397
F Value	0.023ns	15.334***	0.011ns	0.383ns	0.327ns	7.068*	0.013ns	0.414ns

Table 2. Change of enzymes and nutrients depending on soil use.

	Urease	Catalase	Ca	Mg	Fe	Zn	Cu	Mn
Pasture	0.025	12.295	7,138.38	422.96	16.403	0.313	1.162	13.534
Forest	0.065	21.071	9,894.13	308.913	16.164	0.499	1.594	11.331
Agriculture	0.054	12.74	8477.88	445.545	17.151	0.257	1.429	11.81
F Value	10.553***	8.577**	8.855***	2.176ns	0.051ns	8.522**	1.274ns	0.266ns

When the values in Table 1 are examined, it is seen that the depth factor is only effective on catalase enzyme activity (at 99.9% confidence level) and Zn (at 95% confidence level), and there are not statistically significant differences at least at the 95% confidence level at different depths in terms of other enzyme and nutrient elements.

The Effect of Soil Use

The study was conducted on agricultural, forest, and pasture soils and as a result of the study, the variance analysis was applied to the data to identify the effect of soil use on urease and catalase enzymes and micronutrient elements, and the results were evaluated. The average values obtained and groupings resulting from the results of the variance analysis and the results of Duncan's test are indicated in Table 2.

When the values in Table 2 are examined, it is seen that soil use is only effective on catalase enzyme activity (at 99.9% confidence level), urease enzyme activity (at 99% confidence level), Ca (at 99.9% confidence level), and Zn (at 95% confidence level) among micronutrientelements, and there are not statistically significant differences at least at the 95% confidence level in soil use in terms of other nutrient elements. The results of Duncan's test indicating enzymes with statistically significant differences and the groupings of nutrient elements are provided in Table 2.

When the results of the table are examined, forest soils have the highest values in terms of urease and catalase enzymes and Ca and Zn nutrient elements, and the lowest values are obtained from pasture soils. Although Zn values measured in agricultural soils are higher when compared to the values measured in pasture soils, agricultural and pasture soils are included in the same homogeneous group in terms of Duncan's test.

The Effect of Aspect

The study was conducted on the samples obtained from the soils where the northern and southern aspects were dominant. As a result of the study, the variance analysis was applied to the data to identify the effect of the aspect factor on urease and catalase enzymes and micronutrient elements, and the results were evaluated. The average values obtained and the results of the Variance analysis are indicated in Table 3. Because of the fact that there are only 2 depth levels as the aspect factor, Duncan's test was not applied to the data and the results are indicated in Table 3.

When the values in Table 3 are examined, it is seen that the aspect factor is not effective on catalase and urease enzyme activities, in contrast to other factors; however, it has an effect on all nutrient elements other than Zn. This factor is effective at the 99% confidence level in Cu, and at the 99.9% confidence level in other elements.

Results of Correlation Analysis

Table 4 presents the results of the correlation analysis conducted by means of the SPSS 17.0 program to identify the relationship levels of urease and catalase enzymes, and micronutrient elements with each other, and whether or not these relationships are statistically significant are presented in Table 4.

When the values in Table 4 are examined, it is seen that urease and catalase enzymes are not statistically significantly related to each other. Moreover, it is observed that the urease enzyme is related to Mg and Fe, and this relationship is significant and negative at the 99% confidence level. It is also seen that there is a strong and positive relationship between catalase enzyme and Zn, and this relationship is significant at the 99% confidence level. Furthermore,

Table 3. Exchange of enzymes and nutrients depending on aspect.

	Urease	Catalase	Ca	Mg	Fe	Zn	Cu	Mn
South	0.043	15.753	7,132.713	576.665	23.163	0.345	1.692	20.81
North	0.053	14.985	9,874.213	208.28	9.982	0.367	1.098	3.64
F value	1.301ns	0.122ns	31.480***	119.425***	45.145***	0.157ns	7.846**	184.359***

Table 4. Results of correlation analysis.

	Catalase	Ca	Mg	Fe	Zn	Cu	Mn
Urease	0.227	0.159	**-0.365****	**-0.357****	0.177	-0.038	-0.141
Catalase		0.116	-0.002	0.121	**0.623****	-0.108	0.120
Ca			-0.483**	-0.327*	0.209	-0.049	**-0.605****
Mg				**,854****	-0.012	**0.337****	**0.867****
Fe					0.183	**0.302***	**0.777****
Zn						-0.010	0.163
Cu							0.370**

*Confidence level of 95%, **Confidence level of 99%, ***Confidence level of 99.9%

Ca has a significant and negative relationship with Mg and Mn at the 99% confidence level, and Cu has a weak but positive relationship with Mg, Fe, and Mn. The strongest relationships are identified between Mg and Fe (0.854), and Mg and Mn (0.867).

Conclusions

The results of our study indicate that the depth factor has an effect only on catalase enzyme activity and Zn, soil use has an effect only on catalase enzyme activity and urease enzyme activity and Ca and Zn among micronutrient elements, and the aspect factor has an effect on all nutrient elements other than Zn (in contrast to other factors). Moreover, forest soils have the highest values in terms of urease and catalase enzymes and Ca and Zn nutrient elements, and the lowest values are obtained from pasture soils.

When the literature is examined, it is seen that there are different results related to the subject. Kaptanoglu Berber et al. [13] stated that soil depth is effective on urease enzyme activity. Turkmen et al. [14] stated in their studies that urease enzyme activity changes at different depth levels in pastures reclaimed with different methods, and the average urease enzyme activity in soils obtained from 0-15 cm depth is approximately 42% more when compared to urease enzyme activity in soils obtained from 15-30 cm depth. In the same study, it was identified that the average catalase enzyme activity in soils obtained from 0-15 cm depth is approximately 22% higher when compared to the catalase enzyme activity in soils obtained from 15-30 cm depth. The change of both enzyme activities based on soil depth was found to be statistically significant [14].

Zhao et al. [15] compared urease enzyme activities at different depths of different soils and determined urease enzyme activity by providing samples from 0-10, 10-20, 20-30, and 30-40 cm depths of the soils. It was identified as a result of the study that as the depth in forest soils and parks increases, urease enzyme activity decreases. The change of urease enzyme activity in farm soils, in areas where street afforestation and road afforestation are performed based on the soil depth was found to be statistically insignificant.

Li et al. [16] compared afforested areas, natural forest, bush, meadow, terrace, rocky areas that have become deserts, and agricultural lands in terms of urease enzyme activity and identified that urease enzyme activity determined only in afforested areas was high when compared to others, and there was not a statistically significant difference in other areas.

Wang et al. [17] identified the effect of the type of vegetation on urease enzyme activity in their studies and stated that the highest urease enzyme activity was determined in areas covered with CaraganaKorshinskii, and the lowest urease enzyme activity was found in meadows. We identified that the highest urease enzyme activity level was in forest soils – especially on the southern aspect. It is known that land use is effective on urease enzyme activity. Kaptanoglu Berber et al. [13] state that land use affects certain soil characteristics and thus the structure of the soil, and this affects urease enzyme activity. This situation arises from soil characteristics such as organic matter content and soil compaction.

Udawatta et al. [18] stated that litter variability affects enzyme activities and enzyme activities are higher in these areas. Kizilkaya and Dengiz [19] support this result and indicate that there is a positive correlation between urease enzyme activity and organic matter. However, Kaptanoglu Berber et al. [13] reported in the study they conducted that there was not a statistically significant relationship between organic matter and urease enzyme activity.

As a result of the correlation analysis conducted, we identified that urease and catalase enzymes are not statistically significantly related to each other. Moreover, we determined that urease enzyme is related to Mg and Fe, that this relationship is statistically significant and negative at the 99% confidence level, and that the catalase enzyme has a strong and positive relationship with Zn and this relationship is significant at the 99% confidence level. Furthermore, Ca has a significant and negative relationship with Mg and Mn, and Cu has a weak but positive relationship with Mg, Fe, and Mn. The strongest relationships are between Mg and Fe, and Mg and Mn.

Kuscu [20] identified that catalase and urease enzyme activities have a statistically significant and positive relationship with each other at the 99% confidence level. Moreover, it is stated that urease enzyme is related to pH and phosphorus (P), and that the catalase enzyme is significantly related to potassium (K), organic matter (OM), calcium carbonate ($CaCO_3$), and total nitrogen (N) (apart from urease).

Abujabhah et al. [21] indicated that urease activity increases especially with organic matter, organic carbon, total nitrogen, and exchangeable potassium of the soil. It was identified in the study we conducted that urease enzyme activity has a positive relationship with pH and calcium carbonate ($CaCO_3$) and a negative relationship with phosphorus (P) and potassium (K). However, the relationship between urease, and calcium carbonate ($CaCO_3$) and potassium (K) is not statistically significant. The relationship between urease and pH was found to be statistically significant in some studies [13] and insignificant in others [15]. Hess and Austin [22] stated that pH varies by the type of vegetation and that this affects enzyme activity.

Kızılkaya et al. [23] identified a positive relationship between urease enzyme activity and organic matter, exchangeable potassium (K), and total phosphorus (P) in lands in which Bafra plain rice cultivation is made. Kaptanoğlu Berber et al. [13] reported that the relationship between urease enzyme activity and pH, organic matter (OM), electrical conductivity (EC), and calcium carbonate ($CaCO_3$) is not statistically significant.

Wang et al. [17] indicate that while there is a positive, strong, and statistically significant correlation between urease enzyme activity and organic carbon, total nitrogen (N), and phosphorus (P) useful for plants and exchangeable potassium (K), the relationship between pH and urease is negative and statistically insignificant.

Zhao et al. [15] stated that the relationship between urease enzyme activity and pH, total nitrogen, and C/N rate is statistically insignificant; however, there is a statistically significant and positive relationship between urease and organic matter.

Loeppmann et al. [24] reported that waste addition with high organic matter increases microbial activity in the soil in the first weeks, and as a result of the increase in microbial activity urease activity increased, and after a certain time urease activity out of the root region of the soil decreases.

Wang et al. [17] indicated that while there is a positive, strong, and statistically significant correlation between catalase enzyme activity, and organic carbon, total nitrogen (N), and potassium (K), the relationship between pH and total phosphorus (P) and catalase is statistically insignificant. These results coincide with the results obtained in our study.

However, sometimes, contradictory results can be obtained from the studies conducted. For instance, Yang et al. [12] stated that there is not a significant relationship between urease activity and pH. Kaptanoglu Berber et al. [13] reported that the relationship between pH and urease enzyme activity is statistically insignificant. Zhao et al. [15] indicate that the relationship between pH and urease is negative but statistically insignificant. Kaptanoğlu Berber et al. [13] stated that the relationship between urease and pH is statistically significant. This result also coincides with our study.

Suggestions

As enzyme activities can be used as a soil quality indicator, the studies conducted indicate that enzyme activities can provide information about the past of the soil. Although the number of the studies conducted on enzymes during the literature review seems to be high, when the results obtained are examined, the number of studies conducted in this area is still insufficient to understand enzyme activities. The fact that there are contradictory results among the research findings even in the most basic subjects (for instance, the relationship between urease enzyme activity and catalase) in the studies conducted suggests that the current studies are not sufficient to completely understand complex enzyme activities.

One of the reasons why researchers provide contradictory information can be the multiplicity of the factors affecting enzyme activities. Thus, many factors affect enzyme activities – from soil structure to climate factors and from the amount of organic matter to land use. Including one or more factors in studies and ignoring others may cause misleading results. Therefore, repetition of the studies in controlled environments and keeping factors other than the factors studied constant may provide an easier interpretation of enzymatic activities.

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References

1. SEVIK H., CETIN M. Effects of water stress on seed germination for select landscape plants. Pol. J. Environ. Stud. **24** (2), 689, **2015**.
2. CETIN M. Sustainability of urban coastal area management: A case study on Cide. J. Sustainable For. **35** (7), 527, **2016**.
3. CETIN M. Landscape Engineering, Protecting Soil, and Runoff Storm Water. Chapter 27, in book: InTech-Open Science-Open Minds, Book: Advances in Landscape Architecture-Environmental Sciences, Eds:

Murat Ozyavuz, ISBN 978-953-51-1167-2, Online July 1st, 697, **2013**.

4. KHODAYARI F., CEBECI Z., OZCAN, B.D. Optimization of xylanase and α-amylase production by alkaline and thermophilic Bacillus isolate KH-13. J. Entomol. Zool. Stud. **2**, 295, **2014**.
5. XU Z., YU G., ZHANG X., HE N., WANG Q., WANG S., WANG R., ZHAO N., JIA Y., WANG C. Soil enzyme activity and stoichiometry in forest ecosystems along the North-South Transect in eastern China (NSTEC). Soil Bio. Biochem. **104**, 152, **2017**.
6. URL1. Ohio State University, Class Documents. Retrieved from; http://senr.osu.edu/sites/senr/files/imce/files/course_materials/enr6610/Section02_Graphs.pdf (accessibility on 02.01.**2017**)
7. SHARMA S., KUMAR V., TRIPATHI R.B. Isolation of phosphate solubilizing microorganism (PSMs) from soil. J. Microbiology Biotechn. Res. **1** (2), 90, **2017**.
8. KRAVKAZ KUSCU I.S., KARAOZ M.O. Importance of Soil Enzymes Application in Forestry.Developments in Science and Engineering. St. KlimentOhridski University Press Sofia. ISBN 978-954-07-4137-6, **2016**.
9. SINGH P., MITRA S., MAJUMDAR D., BHATTACHARYYA P., PRAKASH A., BORAH P., PAUL A., RANGAN L. Nutrient and enzyme mobilization in earthworm casts: A comparative study with addition of selective amendments in undisturbed and agricultural soils of a mountain ecosystem. Int. Biodeterior Biodegradation. **119**, 437, **2017**.
10. KLEBANOFF S.J. Oxygen-dependent cytotoxic activity of phagocytes. Advances in Immunopharmacology: Proceedings of the First International Conference on Immunopharmacology, July 1980, Brighton, England. Elsevier, **2016**.
11. ZBIRAL J. Determination of plant-available micronutrients by the Mehlich 3 soil extractant – a proposal of critical values. Plant, Soil and Environ. **62(**11), 527, **2016**.
12. YANG X., LIU J., MCGROUTHER K., HUANG H., LU K., GUO X., HE L., LIN X., CHE L., YE Z., WANG, H. Effect of biochar on the extractability of heavy metals (Cd, Cu, Pb, and Zn) and enzyme activity in soil. Environ. Sci. Pollut. Res. **23** (2), 974, **2016**.
13. KAPTANOGLU BERBER A.S., FARASAT S., NAMLI A. Afforestatıon Effects on Soil Biochemical Properties. Eurasian Journal of Forest Science, **1** (1), 25, **2014**.
14. TURKMEN C., MUFTUOGLU N.M., KAVDIR Y. Variation of some soil quality characteristics in meralard treated by different methods. Journal of Agricultural Sciences **19**, 245, **2013**.
15. ZHAO D., LI F., WANG F. The effects of different urban land use patterns on soil microbial biomass nitrogen and enzyme activities in urban area of Beijing, China. ActaEcologicaSinica **32**, 144, **2012**.
16. LI Q., LIANG J.H., HE Y.Y., HU Q.J., YU S. Effect of land use on soil enzyme activities at Karst area in Nanchuan, Chongqing, Southwest China, Plant Soil Environ. **60** (1), 15, **2014**.
17. WANG B., XUE S., LIU G.B., ZHANG G.H., LI G. Zong ping ren changes in soil nutrient and enzyme activities under different vegetations in the loess plateau area, Northwest China. Catena. **92**, 186, **2012**.
18. UDAWATTA R.P., KREMER R.J., GARRETT H.E., ANDERSON S.H. Soil enzyme activities and physical properties in a watershed managed under agroforestry and row-crop systems, agriculture, Ecosystems and Environment, 1, **2008**.
19. KIZILKAYA R., DENGIZ O. Variation of Land Use and Land Cover Effects on Some Oil Physico-Chemical Characteristics and Soil Enzyme Activity, ISSN 1392-3196, Zemdirbyste-Agriculture, **97** (2), 15, **2010**.
20. KRAVKAZKUSCU I.S. Comparison of enzymes activities in Agricultural-Range-Forest soils in Kastamonu region, Istanbul University, Graduate school of Natural and Applied Sciences, Depaertment of Forestry Engineering, Soil Science and Ecology Doctoral thesis, Istanbul, **2014**.
21. ABUJABHAH I.S., BOUND S.A., DOYLE R., BOWMAN J.P. Effects of biochar and compost amendments on soil physico-chemical properties and the total community within a temperate agricultural soil. Applied Soil Ecology, **98**, 243, **2016**.
22. HESS L.J., AUSTIN A.T. Pine afforestation alters rhizosphere effects and soil nutrient turnover across a precipitation gradient in Patagonia, Argentina. Plant and Soil, **415** (1-2), 449, **2017**.
23. KIZILKAYA R., ARCAK S., HORUZ A., KARACA A. (1998). Effect of soil properties on enzyme activities of Rice soils, Pamukkale University Faculty of Engineering, Journal of Engineering Sciences **4** (3), 797, **1998**.
24. LOEPPMANN S., SEMENOV M., BLAGODATSKAYA E., KUZYAKOV Y. Substrate quality affects microbial – and enzyme activities in rooted soil." Journal of Plant Nutrition and Soil Science **179** (1), 39, **2016**.