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INVESTIGATION OF ALKALI PHOSPHATASE ENZYME ACTIVITY OF GAZIANTEP AGRICULTURAL SOILS

Erdihan TUNÇ[1], Yunus KÖNEZ[1], Ömer ÇELİK[2], Mustafa DEMİR[1]

[1] University of Gaziantep, Faculty of Arts & Science, Department of Biology, 27310 Şehitkamil, Gaziantep, Turkey

[2]Muş Alparslan University, Faculty of Applied Sciences, Department of Herbal Production, Muş, Turkey

* Corresponding author: tunc@gantep.edu.tr

ABSTRACT

This study was carried out to determine the alkaline phosphatase (ALP) enzyme activity and the effects of some soil properties on ALP enzyme activity in the soils of agricultural production areas in Gaziantep province. In the study, soil samples were taken from 24 dry farming plots, 12 irrigated farming plots and 9 fallow farming plots. In addition to ALP enzyme activity in soil samples, soil pH, EC, SOM, lime, soil texture, phosphorus (P) and potassium (K) contents were determined. As a result of the study, it was determined that the soils were slightly alkaline, unsalted and very calcareous. These soils, which are deficient in organic matter (SOM) content, were found to be rich in P and K. However, the mean ALP enzyme activity was found to be 334.12 ± 123.83 µg p-NP.gr. As a result, the order of ALP enzyme activity according to land use was determined as fallow > irrigated agriculture > dry agriculture. There was no significant relationship between ALP enzyme activity and general soil properties. In this study, it was concluded that it is possible to increase the SOM content of soils only by using appropriate organic fertilizers.

Keywords: Alkaline phosphatase enzyme, soil, agriculture, Gaziantep

1. INTRODUCTION

Enzymes are catalytic proteins produced during the metabolic activities of living beings and so soil enzymes originate from soil-dwelling microorganisms, soil animals and plants [1,2,3]. The greatest source of soil enzymes is microorganisms in the soil [2,3,4,5,6]. Soils are home to many living things [3,4,5,6,7] as well as an environment for many physical, chemical and biological activities. Cycles of macronutrients such as carbon (C), nitrogen (N), phosphorus (P) and sulfur are especially important for the quality and sustainability of ecosystems [8,9,10]. Intracellular and extracellular enzymes are involved in the reactions of organic substances in the mineralization process [11,12]. It is important to determine soil enzyme activities to obtain information about the quality and sustainability of the ecosystem [13,14].

In a study investigating the role of phosphatases in P mineralization and environmental factors [15], it was reported that phosphatases catalyze the hydrolysis of both esters and anhydrides of phosphoric acid, thereby leading to the release of inorganic P to plants and microorganisms. It has been established that the activity of soil enzymes is negatively affected by the effect of heavy metals on soil microorganisms [16]. It has been reported that 60% to 95% of the phosphorus taken up by plants is returned to the soil, but this ratio ranges from 18-38% in mowed pastures[17].

In the study reporting that organic P in soils is important for determining the bioavailability and mobility of P dynamics in soil plant systems [18], it was suggested that a comprehensive understanding of the biological, chemical and physical properties and processes that govern this determine is required. In the study that found that deficiency of P, one of the most limiting macronutrients in terms of agricultural productivity, is a common situation worldwide [19]. Phosphorus (P) cycle enzymes in the study [20] found that the cycling of phosphorus (P) in soils occurs through phosphatases. In the study carried out to determine the phosphomonoesterase, phosphodiesterase and phosphotriesterase enzyme activities [21], it was found that the alkaline phosphatase enzyme activity in the soil fluctuated between 200 and 625 µg p-NP.gr. In the study conducted on pastures, corn fields and oak forests [22], it was found that acid phosphatase enzymes are produced by bacteria, fungi, yeast, protozoa, mycorrhizal fungi and plant roots in the soil, while alkaline phosphatases are only produced by bacteria, fungi and worms . A study in West Texas (USA) [23] found that enzyme activities are higher in silty and sandy clay silt soils than in fine sandy silt soils. In a study examining the effects of plowing [24], it was reported that the enzyme activities of phosphatase and arylsulfatase were significantly positively related to organic carbon.

In the study [25], it was found that P is important in the nutrition of plants as it is involved in the physiological and biochemical processes of all living things. It has been reported that the increase in alkaline phosphatase activity in winter is due to the desorption and reactivity of phosphatase released from dying soil microorganisms and phosphatase previously accumulated in the soil [26]. In a study investigating the microbiological characteristics of the corn-grown agricultural land in Şanlıurfa [27], it was found that the ALP enzyme activity in the soil ranged from 7.04 to 82.4 µg p-NP.gr top-1.s-1. In a study conducted to investigate the erosion potential of agricultural soils in Gaziantep [28], it was determined that the erosion risk of these soils is high. Accordingly, the amount of organic matter was found to be low. A total of 40 soil samples were taken in the study in which the total C and N contents of Gaziantep agricultural soils were investigated [29]. In the study, positive significant relationships were found between lime and pH and sand, and between silt and sand and clay. The average SOM content of the soils was found to be 1.42%. In the study conducted on the agricultural soils of the Barak Plain [30], it was determined that the K values of the agricultural soils were high and varied between 35 and 72 ppm. In another study conducted in Gaziantep agricultural soils [31], it was reported that these soils with high lime content have high K content. In the study [32] in which agricultural land use and land cover dynamics were examined by using remote sensing and geographic information systems (GIS) between 1984-2019 in Araban district, it was determined that the areas planted for peanut and olive dry farming increased. It has been reported that the irrigated agricultural areas have decreased.

2. MATERIALS and METHODS

2.1. Soil Sample Collection and Preparation

In Gaziantep, most of which is developed from limestone bedrock, 55.38% of the soils are chromic combisol, 23.09% colluvial, 8.13% cambisol, 7.37% basaltic bedrock and 1.28%. The other two are composed of other soil types such as regosol, Terra rossa and Terra fusca [30]. In Gaziantep, where mostly dry agriculture is practiced, irrigated agriculture production is increasing rapidly in order to meet the needs of the increasing population.

It has been reported that irrigated farming practices and agricultural lands have increased especially in the last 30 years. Olive and wheat are produced in Gaziantep, mainly pistachio production [32]. Soil samples taken from 45 different locations, 24 from dry farming, 12 from irrigated farming and 9 from fallow farming areas, were affected by placing them in plastic bags. Then it was brought to Gaziantep University Soil Ecology laboratory and prepared for analysis. 45 samples were sieved (2 mm mesh) and air dried for soil chemical analysis. The alkaline phosphatase enzyme activity in soil is determined by the colorimetric method based on the spectrophotometric measurement of p-nitrophenyl at 410 nm, which is formed as a result of incubation of soil samples with p-nitrophenyl phosphate for 1 hour at 37°C. A substrate [10,15, 33] was found in pH 11 buffer solution. The pH was determined potentiometrically in a CaCl2-solution (0.01 M) using a Hanna pH electrode (model HI 83140) [34], followed by determination of the electrical conductivity (EC) [35]. The CaCO3 content was measured by the Scheibler method [36] using the Eijkelkamp model M1.08.53.D calcimeter. Soil organic C content (Corg, syn. SOM) was measured by after[37]. Soil structure analysis of the soils in the study area was made according to [38]. Phosphorus (P) was determined by the NaHCO3 method [39]. K contents were determined in ammonium acetate solution [40].

3. STATISTICAL ANALYSES

Normality tests were applied to the obtained data and Pearson correlation test was applied to the data that was found to be normal, and Spearman's correlation test was applied to the data that was found to be non-normal. In the analysis of variance of data with three or more variables, One Way ANOVA was used for normal data and Kruskal-Wallis H test was used for abnormal data. Paired Samples T test was used for variance analysis of data with two different variables, and Mann-Whitney U test was used for abnormal data. SPSS Ver 25 and MiniTab 19 applications were used for statistical analysis. The significance level value (p) in analysis of variance is 0.05. Microsoft Excel 2016 application was used to compile the data and determine the basic statistical data.

4. RESULTS & DISCUSSIONS

It was determined that the average soil pH of Gaziantep agricultural soils was 7.62±0.14 (Figure 1a). According to the average soil pH, the pH of the studied soils was found to be in the slightly alkaline class. This result is consistent with previous studies on agricultural soils in Gaziantep [8,41,42]. According to EC (dS/m) values, all of the studied soils were found to be salt-free. However, the findings of this study showed that the detected EC values were in the range of 0.03 to 0.12 dS/m (Figure 1b).

In terms of average EC values, it is consistent with the results of another study [30] that investigated the risk of erosion in natural areas [31] and agricultural soils of the Barak Plain. In a previous study that investigated plant species that could be beneficial in preventing erosion in Gaziantep. It has been determined that the average SOM content of Gaziantep agricultural soils is low. The mean value of SOM contents varying between 0.13% and 2.96% was found to be 1.42±0.70% (Figure 1c).

This result is similar to the results of previous studies [2,3,9,28,29,30,31,32] carried out in Gaziantep agricultural soils, and is lower than the SOM content reported in the study [28] in which the erodibility factor of agricultural soils was determined in Gaziantep. The study showed that the SOM contents of the soils were mostly in the low class (n=25; 55.56%).

However, 26.67% of the soils were found to be in the very little (n=12) class and 17.78% in the middle (n=8) class. In this study, it was determined that the lime contents ranged between 1.50% and 27.0% and the average was 15.64±8.74% (Figure 1d). In this respect, it has been found that Gaziantep agricultural soils are in the very calcareous class in terms of average lime content. Although this result is lower than the lime contents reported in previous studies [9] in agricultural areas in the region, it is similar to the lime values found in the study [28] in which the erodibility factor of agricultural soils in Gaziantep was determined. In this study, soils in the very calcareous class (n=29) constitute 64.44% of all soil samples. In particular, the clay contents (Figure 1e) determined in this study were lower than the results of previous studies [9], while the silt (Figure 1f) contents were higher. However, the contents of clay, silt and sand [3] in pistachio orchards with low SOM content in Karkamış were similar to the contents in our study.

In terms of soil texture, 26.67% of the samples were clay loam (n=12), 15.56% clayey (n=7) and loamy (n=7), 11.11% sandy loam (n=7) 5) and silty clay (n=5), 8.89% silty loam (n=4), 6.67% sandy loam (n=3) and 4.4% silty clay loam (n=2) was found to be in the structure. This result shows that the texture of agricultural soils has a lot of variability (Figure 1e,f,g). Similar to the results of previous studies [9], the average plant usable P content of agricultural soils in this study was found to be 22.09±3.59 ppm. This result shows that the amount of P available to the plant in Gaziantep soils is sufficient (Figure 1f).

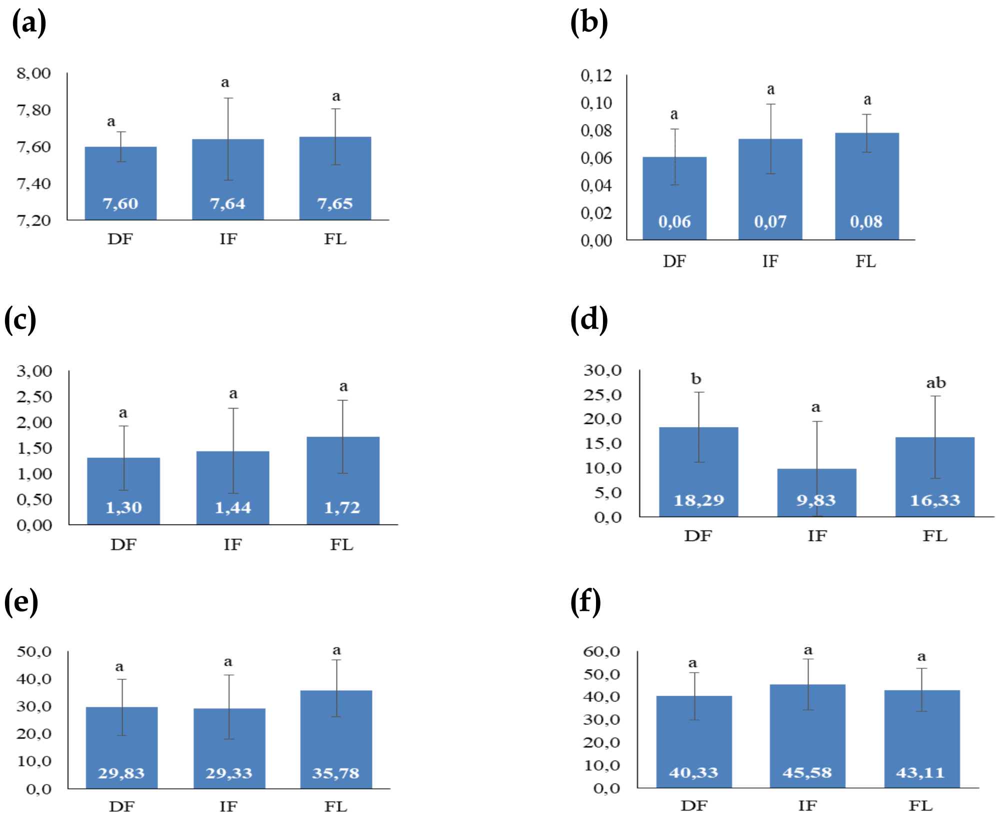
However, it was determined that 80.00% of agricultural soils contain P at medium level and 20.00% at high level. In this study, it was determined that the amount of K available to the plant in the soil was sufficient(Figure 1i). However, the average potassium content is 200.68±43.50 ppm.

It is similar to the results of another study [9] carried out in agricultural areas in Gaziantep. However, according to the classification of soils according to their K content [14], it has been determined that 8.89% of the soils are in the medium class, 4.44% in the sufficient class, and 86.67% in the high class.

In this study, the highest values in terms of soil pH:7.65±0.15, EC:0.08±0.01 dS/cm, SOM:respectively 1%, clay:72±0.71, P: 22.89±2.93 ppm and K:217.06±30.89 ppm were found in fallow agricultural areas.

In addition, the highest value in terms of silt (45.58±11.17%) was found in irrigated farming areas, and the highest value of sand (29.79±12.08%) was found in dry farming areas. However, the lowest pH:7.6±0.08, EC:0.06±0.02 dS/cm, SOM:1.30±0.63%, silt:40.33±10% and K:187.92±49.34 ppm contents of the soils.

Although the ALP activity in the soil varies between 139.12 and 570.77 µg p-NP.gr top-1.s-1, the average ALP enzyme activity is 334.12±123.83 µg p-NP.gr (Figure 4).



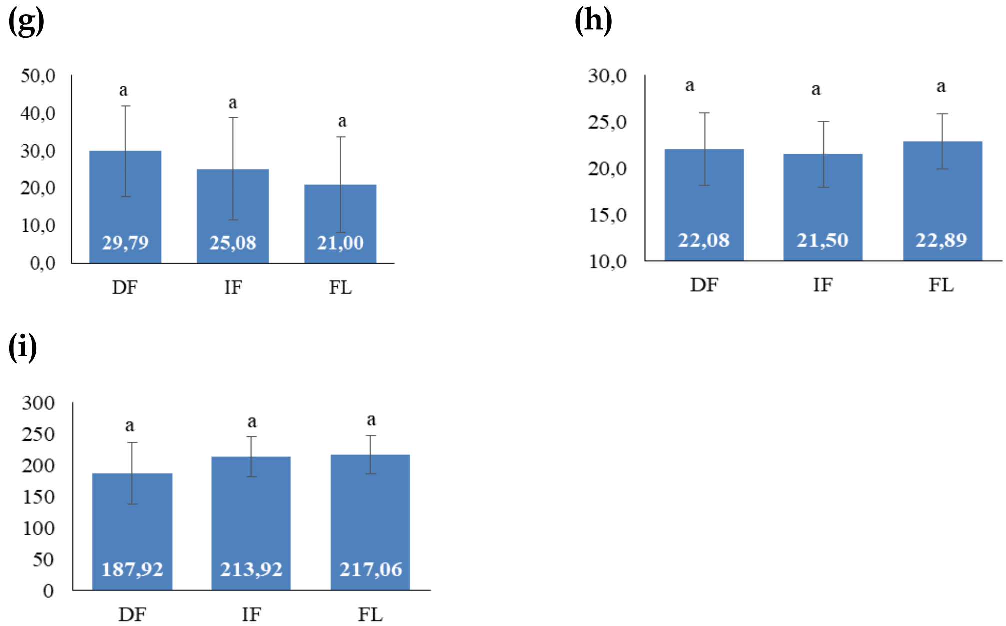
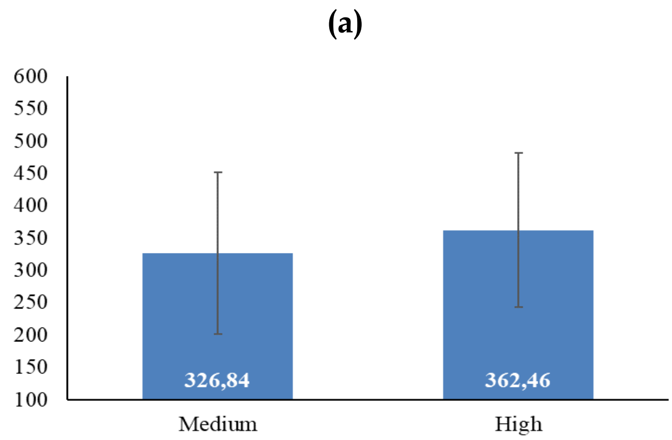


Figure 1. Selected general soil properties and changes in nutrients depending on land use; (a) Soil pH, (b) EC, (c) SOM, (d) Lime, (e) Clay, (f) Silt, (g) Sand, (h) P, (i) K. (DF :Dry farming, IF: Irrigated farming, FL: Fallow); Group averages in homogeneous subsets according to the Post Hoc Duncan test).

The results of the analysis showed that the average ALP enzyme activity of neutral soils and slightly alkaline soils in terms of soil pH was similar to each other. While the ALP enzyme activity of neutral soils (n=7) is 340.16±124.36 µg p-NP.gr , the ALP enzyme activity of slightly alkaline soils (n=37) is 332.98±125 .42 µg p-NP.gr (Figure 2a).

Statistical analysis studies revealed that there were no significant differences between neutral soils and slightly alkaline soils in the classification of soils according to their pH values ($p>0.05$). As confirmed by regression analyzes between soil pH and ALP enzyme activity (Figure 2b), the inability to detect significant differences between soils included in both soil pH classes indicates that ALP enzyme activity does not change depending on soil pH (p>0,). 05).



(b)

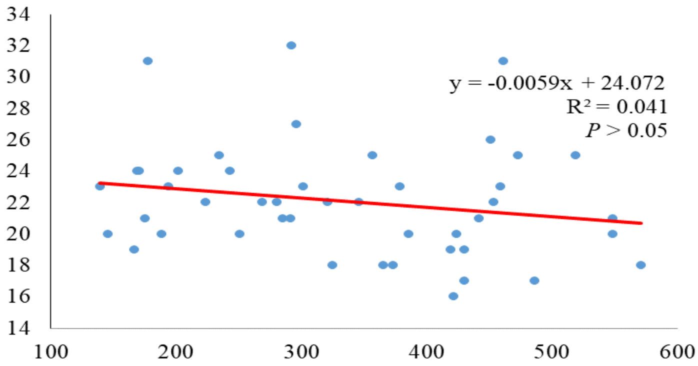
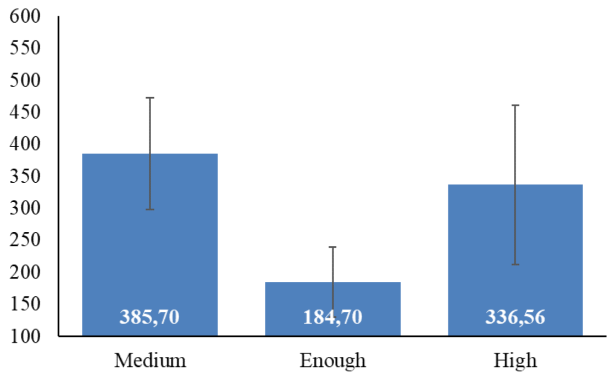


Figure 2. Average alkaline phosphatase enzyme activity of soils according to phosphorus (ppm) classification (a) and regression graph (b).

(a)



(b)

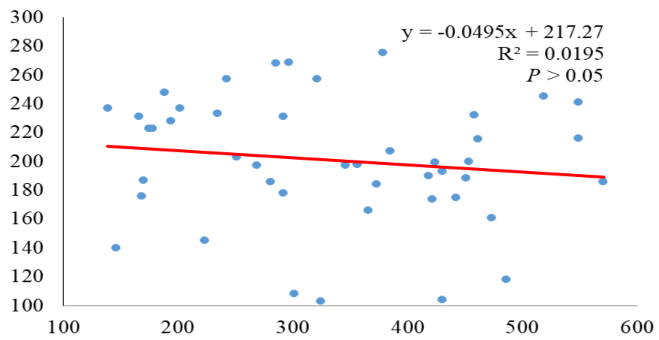


Figure 3. Average alkaline phosphatase enzyme activity of soils according to potassium (ppm) classification (a) and regression graph (b).

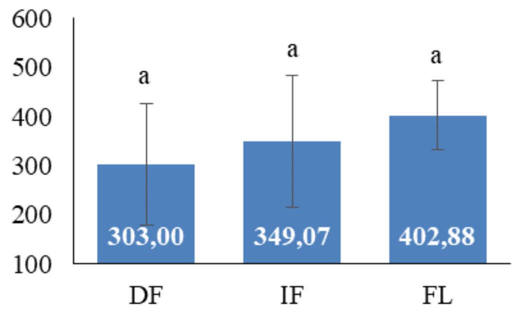


Figure 4. Changes in ALP enzyme activity due to land use(DF: Dry farming, IF: Irrigated farming, FL: Fallow)

As a result, the order of ALP enzyme activity according to land use was determined as fallow > irrigated agriculture > dry agriculture (Figure 4). There was no significant relationship between ALP enzyme activity and general soil properties.

5. CONCLUSIONS

In this study, which determined the ALP enzyme activity of agricultural soils in Gaziantep, which generally has highly calcareous and gypsum soils and is located in a transition zone between Mediterranean and continental climates, 65% of the soils are very calcareous soil class, while 85% are light react alkaline. This situation is one of the most important factors limiting the uptake of nutrients by plants from the soil. Again, it was found that the average SOM content of these soils, 85% of which are in the very few and few classes, is low.

Achieving sufficient SOM levels for nutrient cycling in soils not only has a positive impact on soil quality and fertility, but also on the cycling of macro plant nutrients such as C, N, P, S.

In this study, it was determined that the ALP enzyme activity, which is one of the important indicators of the P cycle in alkaline soils, is low due to climatic reasons, agricultural practices and soil structure.

Although no significant correlations could be found between the general characteristics of the selected soil and ALP enzyme activity in Gaziantep soils, which is located in a region with low rainfall and arid, high lime contents and low SOM contents are thought to play a role in the low ALP enzyme activity, as shown by previous studies.

For this purpose, it is recommended that the agricultural lands of the region be fertilized correctly, especially with organic fertilizers, and for this purpose, training should be given to the farmers. Since this study is the first to investigate the effect of ALP enzyme activity of agricultural soils and selected physicochemical properties of soils, it is expected to form the basis for future studies.

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