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Original Research Article

How Lime Dust Does Affect Carbon Mineralization of *Eucalyptus camaldulensis* Soil?

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Abstract: *Eucalyptus camaldulensis* is a well adapted perennial plant to changes in the environmental conditions. The objective of this reseach was to exhibit how soil carbon mineralizaton of *Eucalyptus* growing into lime factory garden are affected by the additions of its unwashed and washed leaf and shoot (containing half of total soil organic carbon) from lime dust under the same laboratory conditions (45 days and 28 °C). Leaf, shoot and soil of *Eucalyptus* were sampled from two different sites with (lime factory garden) and without (campus of Osmaniye Korkut Ata University) lime dust in Osmaniye. Carbon mineralization of soils was determined with CO_2 respiration method. The high cumulative $C(CO_2)$ values was observed in soil added unwashed *Eucayptus* leaf and shoot of the lime factory while the lowest value was at soil no added of lime factory. This finding showed that lime added with unwashed leaf and shoot of *Eucalyptus* improved and favorable conditions for microbial activity into 45 days. Carbon mineralization ratio (%) of no added campus soil was the highest than both no added lime factory soil ($P = 0.003$) and the other additions ($P = 0.000$ for all of them). It might be explained with stifling effect of added carbon amount of organic matter originating from *Eucalyptus* leaf and shoot on soil microorganisms.
Keywords: carbon, *Eucalyptus camaldulensis*, lime dust, lime factory, mineralization.

INTRODUCTION

Eucalyptus is a fast-growing and widely planted genus of trees in the world and also used as an afforestation species because of its short rotation forestry practices [1]. These properties of the plant have received considerable attention with regard to its impacts on soil properties, which is highly relevant to the sustainable productivity of *Eucalyptus* plantations [2, 3]. There are many different studies on *Eucalyptus* plantations and their soil microorganism and their activities [4-7]. Soil respiration is one of the important constituents of ecosystem respiration [8, 9], and minor changes in soil respiration may strongly affect soil carbon mineralization [10]. Therefore, it is significant to obtain good estimates of soil respiration and to follow environmental changes. Soil microbial communities and their activities are increasingly used to assess ecosystem responses to environmental stress compared to higher organism [11, 12] as they have intimate relations with their surroundings due to their high surface to volume ratio [13]. Soil respiration is impressed by root biomass, microbial biomass, litter amount, soil organic carbon, soil nitrogen, cation exchange capacity, soil bulk density, soil porosity, soil pH and site topography [14, 15].

The environment pollution with alkaline dust from cement plants affects to the plants, animals and soil. The CaO content of the cement dust is 42.5% and strongly alkaline. Alkalization of soils are expressed as changes in the species composition, the growth and bioproduction of trees and plant communities, considering the direct effect of cement dust [16]. Lime and cement dust has essentially affected on air pollution, crops, orchards and soil [17, 18]. Depending on the chemical composition of the alkaline emissions, their deposition in ecosystems may change soil pH levels, contents of carbon, major elements and soil microorganisms [19, 20]. The microbial activity and C mineralization in the soil is commonly utilized to characterize the microbiological status of soil [21] and to determine the effects of different contamination sources [22-25].

In this study, we wanted to exhibit effects of lime dust on organic carbon mineralization in the soils added unwashed and washed leaf and shoot *of Eucalyptus camaldulensis* Dehn. (Myrtaceae) growing on both lime factory garden and Osmaniye Korkut Ata

University campus in the eastern Mediterranean region, Turkey.

MATERIALS AND METHODS

Study sites and preparation of plant and soil samples

The two sites are selected at Fakıuşağı in Osmaniye. Mean annual precipitation and mean annual temperature of Osmaniye are 808 mm and 18.2°C, respectively. These two data are approximately based on 27 years. First site is within the lime factory, 1.5 km far from Osmaniye Korkut Ata University campus. Second site is within the university campus and selected because of being clean area from lime dust.

In March 2014, each of five samples from soil (upper 0-20 cm), leaf and shoot of eucalypt tree were taken from the garden of lime factory. Plant leaf and shoots of eucalypt were collected from the upper third of the tree crown at each site [26]. The other samples were also collected from the university campus at the same way. After removing recognizable plant debris, each of five samples were air-dried separetely and sieved through a 2-mm mesh sieve. The surface of the eucalypt leaves and shoots were covered with lime powder in the garden of Factory. Plant samples were separated into leaf and shoot and washed thoroughly to remove adhering lime deionised water for only first site. These samples were called as washed and unwashed samples in all of the the text. These washed and unwashed plant materails were oven dried at 70°C to a constant weight and then ground.

Sample analysis and carbon mineralization measurements

The soil texture was determined with a Bouyoucos hydrometer [27], field capacity (%) with a vacuum pump at 1/3 atmospheric pressure [28], and pH with a WTW Inolab 720 pH-meter in 1:2.5 soil-water suspension [29]. The soil $CaCO_3$ content (%) was measured with a Scheibler calcimeter [30], organic carbon content of soil and plant leaves and shoots (%) by the Anne method, and organic nitrogen content of soil and two plant parts (%) by the Kjeldahl method [31].

Soil C mineralization experiment was established using a design with two factors: i) additions [four additions of unwashed leaf (1), shoot (2) and washed leaf (3) and shoot (4)] and ii) sites (lime factory garden and university campus ares). Soils were placed in the incubation vessels for carbon mineralization, and ground leaf and shoot samples (unwashed and washed) were added. Both unwashed and washed leaves and shoots of *Eucalyptus* were added at the half amount of soil carbon content (2%) to the lime factory and campus soil. No plant parts (leaf and shoot) was added to *Eucalyptus* soil in the control treatment. Three replicates were used for each factor. The final moisture contents of both soils were adjusted to 80% of their own field capacity before incubation at 28°C over 45 days [32]. Free carbondioxide derived from microbial activities was absorbed in 40 ml of saturated $Ba(OH)_2$ solution in beakers, placed in the center of the soils in closed incubation vessels, and then transposed to an incubator. The carbondioxide amount was measured once every 3 days by titrimetric method [33]. Empty vessels were used as blanks. The ratio (%) of carbon mineralization of all treatments was counted by dividing the cumulative amount of $C(CO_2)$ produced in 45 days into total organic carbon.

Statistical analysis

Repeated measures (general linear model) analysis was performed to determine the differences in carbon mineralization over incubation time between 2 sites (lime factory garden and university campus), 2 plant parts (leaf and shoot), 2 practices (unwashed and washed). Three replicates were used for each combined soil for statistical comparisons. Data were analyzed by a series of analyses of variance [34]. Results were given as mean ± standard error (S.E.) in both tables and figures. Statistically significant value was accepted as $P \leq 0.05$.

RESULTS

Campus and lime factory soils had some different physical and chemical properties (Table 1). Both soils were loam textured (L) and no significant differences between two from the point of view of field capacity, pH level, carbon content (%, $P > 0.05$). $CaCO_3$ content (%) of lime factory soil was statistically higher than campus soil ($P = 0.000$). Nitrogen content (%) of campus soil was higher than lime factory soil at 0.002 significance level. C/N ratio of campus soil was 11.2 and significantly lower than lime factory soil (15.6, $P = 0.001$). *Eucalyptus* leaf carbon, leaf and shoot nitrogen contents (%) of campus was statistically higher than the lime factory ($P = 0.003$, $P = 0.000$, and $P = 0.000$, respectively) whereas its shoot carbon was not different between two sites ($P > 0.05$, Table 1).

There were not significant differences between unwashed and washed *Eucalyptus* leaf and shoot at the lime factory in terms of carbon contents (%, $P > 0.05$). But nitrogen content (%) of *Eucalyptus* leaf and shoot significanly changed between unwashed and washed samples [$P = 0.000$ and $P = 0.004$, respectively (Table 2)].

Cumulative $C(CO_2)$ respired of campus soil added *Eucalyptus* leaf and shoot decreased when it compared no added soil at the end of the incubation period ($P = 0.036$ and $P = 0.001$, respectively). There was also significant difference between campus soil added *Eucalyptus* leaf and shoot ($P = 0.014$). The highest value was no added campus soil with 15.8 mg $C(CO)_2$/100 g oven dried soil at the end of 45 days. *Eucalyptus* leaf added soil was second with 14.4 mg $C(CO)_2$/100 g. Third was *Eucalyptus* shoot added soil with 12.6 mg $C(CO)_2$/100 g (Fig. 1).

Cumulative $C(CO_2)$ value of no added lime factory soil was significantly lower than soil added unwashed leaf, washed and unwashed shoot (P = 0.000, P = 0.002 and P = 0.000, respectively). Lime factory soil added washed leaf was also significantly lower than soil added unwashed leaf and shoot of *Eucalyptus* during the incubation period (P = 0.000 and P = 0.007, respectively). There was an important difference between lime factory soil added unwashed leaf and washed shoot (P = 0.015, Fig. 2).

Carbon mineralization ratios (%) of campus and lime factory soils added washed and unwashed leaf and shoot of Eucalyptus and no added campus and lime factory soils were shown significant and different results (Fig. 3).

The high carbon mineralization ratios were observed in no added campus and lime factory soils of *Eucalyptus*. But no added campus soil had the highest ratio from both no added lime factory soil (P = 0.003) and the other plant part additions (P = 0.000 for all of them). No added lime factory soil was also significantly different from the others except for unwashed leaf addition of same soil (P < 0.005). The lowest ratio of carbon mineralization was shown in campus soil added leaf and shoot (P < 0.005, Fig. 3).

Table 1: Some physical and chemical properties (mean ± S.E.; *n* = 3) of *Eucalyptus camaldulensis* Dehn. campus and lime factory soil

Characteristics	Sites		
	Campus	Lime Factory	Significance between sites
Sand [2–0.02 mm (%)]	40.1 ± 3.95	42.5 ± 2.91	0.651
Silt [0.02–0.002 mm (%)]	24.3 ± 3.63	25.2 ± 4.90	0.900
Clay [<0.002 mm (%)]	35.6 ± 0.84	32.3 ± 2.00	0.212
Texture type	Loam (L)	Loam (L)	-
Field capacity (%)	23.9 ± 0.57	22.8 ± 1.62	0.385
pH	7.79 ± 0.28	7.90 ± 0.12	0.751
$CaCO_3$ (%)	10.5 ± 0.27	20.6 ± 0.35	0.000
C (%)	1.97 ± 0.05	2.03 ± 0.03	0.409
N (%)	0.18 ± 0.003	0.13 ± 0.006	0.002
C/N	11.2 ± 0.30	15.6 ± 0.45	0.001
Leaf C (%)	46.6 ± 0.91	34.0 ± 1.66	0.003
Shoot C (%)	38.9 ± 1.33	42.1 ± 1.66	0.205
Leaf N (%)	1.58 ± 0.024	0.79 ± 0.01	0.000
Shoot N (%)	0.67 ± 0.003	0.44 ± 0.02	0.000

Table 2: Carbon and nitrogen contents (%, mean ± S.E.; *n* = 3).) of unwashed and washed *Eucalyptus camaldulensis* Dehn. leaf and shoot sampled from lime factory

Elements	Parts	Unwashed	Washed	Significance between sites
C (%)	Leaf	34.0 ± 1.66	36.5 ± 0.00	0.205
	Shoot	42.1 ± 1.66	47.2 ± 3.31	0.243
N (%)	Leaf	0.79 ± 0.01	1.28 ± 0.008	0.000
	Shoot	0.44 ± 0.02	0.55 ± 0.005	0.004

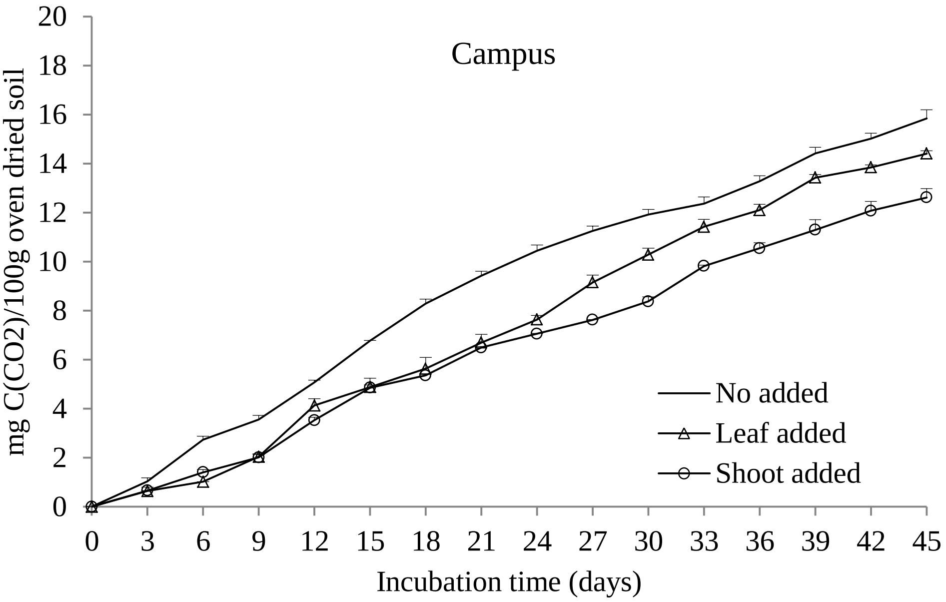

Fig-1: Cumulative C mineralized (mean ± S.E.; *n* = 3) in no added, *Eucalyptus* leaf and shoot added campus soils of Osmaniye Korkut Ata University, at different incubation time (45 days)

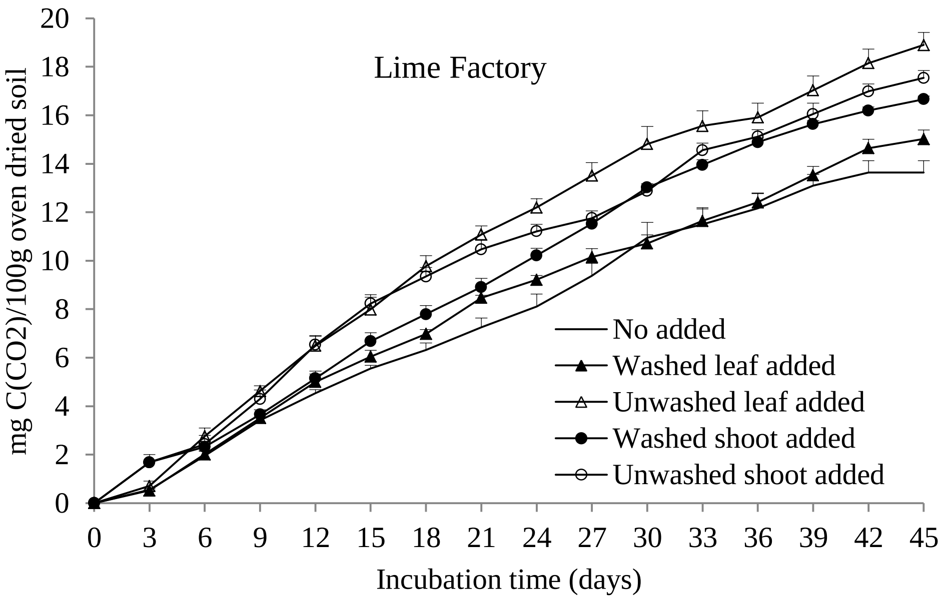

Fig-2: Cumulative C mineralized (mean ± S.E.; n = 3) in no added, washed and unwashed Eucalyptus leaf and shoot added soils of lime Factory, at different incubation time (45 days)

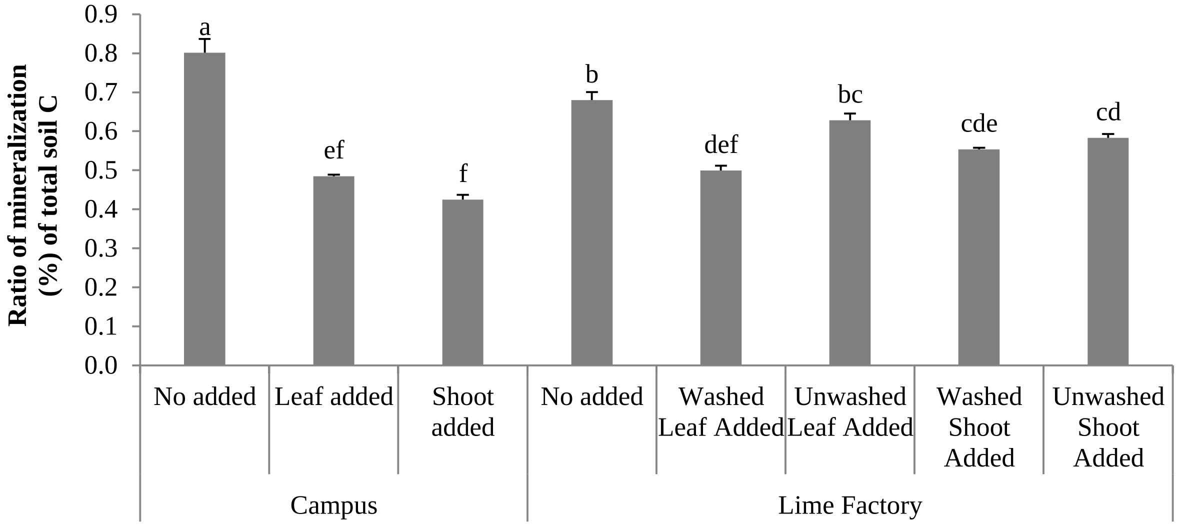

Fig-3: Ratio of mineralization (Rm) of the organic carbon of no added and all additions (with own organic matter of soils) in Campus of Osmaniye Korkut Ata University and Lime Factory soils (mean ± S.E.; n = 3), at the end of incubation period (45 days). Different letters denote significant differences between both sites at P ≤ 0.05 level

DISCUSSION

No added campus soil was significantly higher than soil added *Eucalyptus* leaf and shoot during incubation period (45 days). Leaf and shoot addition of *Eucalyptus* were not perceived as a new organic carbon source by soil microorganisms. On the contrary, these additions to the soil suppressed the soil carbon mineralization. This result exhibited that soil microorganims live in a balanced environment and do not require to additional organic matter source. The incorporation of organic matters into soils may not only accelerate soil organic carbon mineralization but also retard it [35, 36].

The highest cumulative $C(CO_2)$ value was observed in soil added unwashed *Eucayptus* leaf of the lime factory while curve of the lowest carbon mineralization was at soil no added of lime factory. Especially $C(CO_2)$ values of lime factory soil added unwashed leaf and shoot showed significant increasing. These results were so important in terms of observing effects of both lime additions sourced from leaf and shoot and extra organic matter. This result might be explained that lime dust is used as available and readily mineralizable organic matter source for soil microorganisms. Presence of lime dust derived from lime factory on the surface of *Eucalyptus* leaf and shoot was probably stimulated microbial growth and activity because of carbon addition of Ca carbonate. $CaCO_3$ content of lime factory soil was 20.6% and classified as very limy [37]. Microbial biomass carbon and C mineralization increased with lime at almost all sampling times and decreased with sample depth [38, 39]. Differences in microbial biomass carbon were most significant when comparing the control with any of the three different liming rates [39]. In summary, our finding showed that lime added with unwashed leaf and shoot of *Eucalyptus* immediately improved and sustained favorable conditions for microbial activity into 45 days. Like no added lime factory soil, soil added washed leaf was also significantly lower than soil added unwashed leaf and shoot of *Eucalyptus*. In this situation, it might mention that leaf washing process was decreased effect of lime on soil carbon mineralization.

The highest carbon mineralization ratio (%) was no added campus soil of *Eucalyptus*. The second was also no added lime factory soil. There was a significant difference between two no added soil. The other additions of both campus and lime factory soils were generally lower than both no added soils. It was observed that carbon mineralization ratios significantly affected from especially plant part additions at half amount of soil carbon content (2%) in both site soils. It might be mentioned that added carbon amount of organic matter originating from *Eucalyptus* leaf and shoot created stifling effect on soil microorganisms in the evaluation of carbon mineralization ratios. The quality and quantity of different organic matter added to soil determines the rate of decomposition and dynamics of mineral C [5, 40, 41].

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REFERENCES

1. Westoby JC; Introduction to World Forestry. Blackwells, UK, Oxford, 1989; 228-230.
2. Evans J; Plantation Forestry in the Tropics. UK: Oxford University Press, 1992; 403-404.

3. Turnbull JW; Eucalypt plantations. New Forest, 1999; 17: 37-52.
4. Rhoades C, Bınkley D; Factors influencing decline in soil pH ın Hawaiian Eucalyptus and Albizia plantations. Forest Ecology and Management,1996; 80: 47-56.
5. Aggangan RT, O'Connell AM, McGrath JF, Dell B; The effects of Eucalyptus globulus Labill. leaf litter on C and N mineralization in soils from pasture and native forest. Soil Biology and Biochemistry, 1999; 31: 1481-1487.
6. Behera N, Sahani U; Soil microbial biomass and activity in response to Eucalyptus plantation and natural regeneration on tropical soil. Forest Ecology and Management, 2003; 174: 1-11.
7. Chen F, Zheng H, Zhang K, Ouyang Z, Li H, Wu Q; Soil microbial community structure and function responses to successive planting of Eucalyptus. Journal of Environmental Sciences, 2013; 25: 2102-2111.
8. Granier A, Ceschia E, Damesin C, Dufrene E, Epron D, Gross P, Lebaube S, Dantec VLE, Goff NLE, Lemoine D, Lucot E, Ottorini JM, Pontaıller JY, Saugier B; The carbon balance of a young beech forest. Functional Ecology, 2000; 14: 312-325.
9. Janssens IA, Lankreijer H, Metteucci G; Productivity overshadows temperature in determining soil and ecosystem respiration across European forests. Global Change Biology, 2001; 7: 269-278.
10. Raich JW, Schlesinger WH; The global carbon dioxide flux in soil respiration and its relationship to vegetation andclimate. Tellus, 1992; 44: 81–99.
11. Lewis DE, White JR, Wafula D, Athar R, Tamar DT, Williams HN, Chauhan A; Soil Functional Diversity Analysis of a Bauxite-Mined Restoration Chronosequence. Microbial Ecology, 2010; 59(4): 710-723.
12. Banning NC, Gleeson DB, Grigg AH, Grant CD, Andersen GL, Brodie EL, Murphy DV; Soil microbial community successional patterns during forest ecosystem restoration. Applied and Environmental Microbiology, 2011; 77: 6158-6164.
13. Kara O, Bolat I; Impact of Alkaline Dust Pollution on Soil Microbial Biomass Carbon. Turk Journal of Agriculture and Forestry, 2007; 31: 181-187.
14. La Scala N, Marques J, Pereira GT, Cora JE; Carbon dioxide emission related to chemical properties of a tropical bare soil. Soil Biology and Biochemistry, 2000; 32(10):1469-73.
15. Xu M, Qi Y; Soil-surface CO2 efflux and its spatial and temporal variations in a young ponderosa pine plantation in northern California. Global Change Biology, 2001; 7: 667-677.
16. Mandre M; Physiological and biochemical responses of coniferous trees to alkaline dust impact. In: Mandre M. Dust Pollution and Forest Ecosystem, A Study of Conifers in an Alkalized Environment. Tallinn: Institute of Ecology publication, 1995; 44-65.
17. Stern AC; Air pollution. Measurement, monitoring and surveillance of air pollution, 3rd ed. Academic Press, New York, 1976; 13-15.
18. Dubey A; Studies on the Air Pollution around Cement and Lime Factories. Journal of Environment and Earth Science, 2013; 3: 191-195.
19. Ulukanli Z, Digrak M; Alkaliphilic Micro-organisms and Habitats. Turkish Journal of Biology, 2002; 26: 181-191.
20. Klose S, Makeschin F; Chemical properties of forest soils along a fly ash deposition gradient in eastern Germany. European Journal Forest Research, 2004; 123: 3-11.
21. Nannipieri P, Greco S, Ceccanti B; Ecological significance of the biological activity in soil. In: Bollag JM and Stotzky G, eds. Soil biochemistry. Vol. 6. Marcel Dekker, New York, USA, 1990; 293-355.
22. Chander K, Brookes PC; Effects of Zn, Cu, and Ni in sewage sludge on microbial biomass in a sandy loam soil. Soil Biology and Biochemistry, 1993; 25: 1231-1239.
23. Brookes PC; The use of microbial parameters in monitoring soil pollution by heavy metals. Biology Fertility of Soils, 1995; 19: 269-279.
24. Aka H, Darici C; Carbon and nitrogen mineralization of lead treated soils in eastern Mediterranean region. Soil and Sediment Contamination, 2004; 13: 255-265.
25. Aka Sagliker H; Effects to soil carbon mineralization of the different doses of trifluralin at the different temperature conditions. European Journal of Soil Biology, 2009; 45: 473-477.
26. Madgwick HAI, Mead DJ; Variation in nutrient concentrations within Pinus radiata trees and their relationship to tree size. New Zealand Journal Forestry Science, 1990; 20: 29-38.
27. Bouyoucos GS; A recalibration of the hydrometer for mohing mechanical analysis of soil. Agronomy Journal, 1951; 43: 434-438.
28. Demiralay I; Toprak Fiziksel Analizleri. Ataturk Universitesi Ziraat Fakultesi Yayınları, Erzurum, 1993: 63-85.
29. Jackson ML; Soil Chemical Analysis. Prentice-Hall Inc, Englewood Cliffs, 1958; 55-78.
30. Allison LE, Moodie CD; Carbonate. American Society of Agronomy, 1965; 9-15.
31. Duchaufour P; Precis de Pedologie. Masson et C1e, Paris, 1970; 1-50.
32. Schaefer R; Characters et evolution des activites microbiennes dans une chaine de sols hidromarphes mesotrophiques de la plaine d' Alsace. Revue d' Ecologie et de Biologie du Sol, 1967; 4: 567-592
33. Benlot C; Recherches sur les Activites Biochimiques dans les Successions de sols Derives de Cendres Volcaniques sous Climat Tropical

Humide (Zaire-Indonesie). ENS Lab., Paris, 1977; 1-65.
34. Kleinbaum DG, Kupper LL, Muller KE, Nizam A; Applied Regression Analysis and Other Multivariable Methods. Duxbury Press, California, 1998; 25-45.
35. Kuzyakov Y, Friedel JK, Stahr K; Review of mechanisms and quantification of priming effects. Soil Biology and Biochemistry, 2000; 32: 1485-1498.
36. Hamer U, Marschner B; Priming effects in different soil types induced by fructose, alanine, oxalic acid and catechol additions. Soil Biology and Biochemistry, 2005; 37: 445-454.
37. Kacar B; Toprak Analizleri. Nobel Akademik Yayıncılık, Ankara, 2012.
38. Bezdicek DF, Beaver T, Granatstein D; Subsoil ridge tillage and lime effects on soil microbial activity, soil pH, erosion, and wheat and pea yield in the Pacific Northwest, USA. Soil Tillage Research, 2003; 74: 55-63.
39. Fuentes JP, Bezdicek DF, Flury M, Albrecht S, Smith JL; Microbial activity affected by lime in a long-term no-till soil. Soil & Tillage Research, 2006; 88: 123–131.
40. Dilly O, Munch JC; Ratios between estimates of microbial biomass content and microbial activity in soils. Biology Fertility of Soils, 1998; 27: 374-379.
41. Ahn MY, Zimmerman AR, Comerford NB, Sickman JO, Grunwald S; Carbon Mineralization and Labile Organic Carbon Pools in the Sandy Soils of a North Florida Watershed. Ecosystems, 2009; 12: 672-685.