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RESEARCH ARTICLE

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EFFECT OF DIFFERENT LAND USE ON SOIL RESPIRATION IN WINTER

ABSTRACT:

The effect of different land uses on soil respiration was investigated in winter 2009 in black locust, grassland, apple orchard (apple trees and grass) and walnut areas in Seyitler Village, Artvin, Turkey. Soil respiration was measured in December by the soda-lime (NaOH, KOH) technique. Mean daily soil respiration ranged from 0.29 to 1.26 g C m^{-2} d^{-1}. Mean daily soil respiration in black locust was greater than the other areas. Soil respiration was different in the investigated four vegetation types. Established difference was non significant and correlations were negative among soil respiration, soil moisture and soil temperature. These results show that black locust has higher soil biological activity compared to the other areas in this season.

KEY WORDS:
Soil moisture, soil respiration, soda-lime, vegetation.

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INTRODUCTION:

Increasing atmospheric CO_2 concentrations and global climate change have created a strong need for data and information on the global carbon cycle in terrestrial ecosystems. One of the main pathways of fluxes in the global carbon cycle is soil respiration. Soil respiration is the release of CO_2 from soil to the atmosphere. Soils release nearly 75-80% of CO_2-C to the atmosphere annually by soil respiration (Raich and Potter, 1995). Almost 10% of the atmosphere's CO_2 passes annualy through soils. This is eleven times more than the current rate of CO_2 released from fossil fuel combustion (Raich *et al*., 2002).

There are two main sources of soil respiration: root respiration and soil microbial respiration (Hanson *et al*., 2000; Kulkarni *et al*., 2007). Kucera and Kirkham (1971) reported 40% of total soil flux was due to root respiration, while Dugas *et al*. (1999) estimated 90%, Norman *et al*. (1992) estimated 15-70% and Hanson *et al*. (1993) estimated 50%.

Soil respiration is a sensitive indicator of several essential ecosystem processes, including metabolic activity, persistence and decomposition of plant residue and conversion of soil organic carbon to atmospheric CO_2 (Rochette *et al*., 1992; Tufekcioglu *et al*., 2001). In addition, Parkin *et al*. (1996) pointed out that soil respiration is a good indicator for soil quality. Soil respiration is strongly influenced by soil moisture and soil temperature (Singh and Gupta, 1977; Kowalenko *et al*., 1978; Raich and Potter, 1995; Raich and Tufekcioglu, 2000). Rochette *et al*. (1992) observed that soil respiration in moist soil was 2 to 3 times greater than that in dry soils. Soil respiration varies with vegetation type, management practices, environmental conditions and land use type (Raich and Tufekcioglu, 2000; Frank *et al*., 2006). However, analyzing published soil respiration data, Raich and Tufekcioglu (2000) found no predictable significant ($P<0.05$) differences in soil respiration between cropped and vegetation-free soils, between grassland and cropped soils or between forested and cropped soils. Estimates of soil respiration have been made in a variety of ecosystems and summarized in reviews by Schlesinger (1977), Singh and Gupta (1977), Raich and Schlesinger (1992) and Raich and Tufekcioglu (2000). Despite the considerable information on soil respiration in different parts of the world, there have been few soil respiration studies done in forest and adjacent grassland ecosystems in Turkey (Tufekcioglu and Kucuk, 2004)

In this study, the effect of different land use on soil respiration was investigated in black locust, grassland, apple orchard (apple trees+grass) and walnut areas in Seyitler Village, Artvin, Turkey during winter 2009.

MATERIAL AND METHODS:

The study site is located at Seyitler area in Artvin, Turkey. The site location has eastern aspect and gentle slope (5-10%) with elevation 530 m above sea level. Mean annual temperature, precipitation and relative humidity at the site are 12°C, 700 mm and 62%, respectively. Soils are somewhat poorly drained and loamy-clay mollisols. Soil respiration levels were measured in black locust, grassland, apple orchard (apple trees+grass) and walnut areas in Seyitler Village, Artvin, Turkey in winter of 2009.

Black locust (*Robinia pseudoacacia* L.) stands and apple (*Malus domestica* Borkh.) orchards and walnut trees (*Juglans regia* L.) were around 15-20 years old and established by planting. Dominant grass species in the grassland sites are smooth brome (*Bromus inermis* Leyss.), *Agrostis tenuis* L., timothy (*Phleum pratense* L.), Kentucky bluegrass (*Poa pratensis* L.) and *Festuca* spp. Similar grass species were also found as understory in apple orchards. Grasses in grassland and apple orchard sites were cut annually for forage production. Soil respiration rates were measured in four randomly selected locations in each of the three plots per site (each 20x20 m) in December using the soda-lime method in 2009 (Edwards, 1982; Raich *et al*., 1990). The soda-lime method may underestimate actual soil respiration rates at high flux rates (Ewel *et al*., 1987; Haynes and Gower, 1995).

However, the method distinguishes higher and lower flux rates and, therefore, it is an appropriate method for comparing sites. Buckets 20 cm tall and 27.5 cm in diameter were used as measurement chambers. One day prior to measurements, plastic rings with the same diameter were placed over the soil and carefully pushed about 1 cm into the soil. All alive plants inside the plastic rings were cut to prevent aboveground plant respiration. Carbon dioxide was absorbed with 60 g of soda-lime contained in 7.8 cm diameter by 5.1 cm tall cylindrical tins. In the field, the plastic rings were removed, measurement chambers were placed over the tins of soda-lime, and the chambers were held tightly against the soil with rocks. After 24 h the tins were removed, and the contents oven dried at 105^{o}C for 24 h and then weighed. Blanks were used to account for carbon dioxide absorption during handling and drying (Raich *et al*., 1990). Soda-lime weight gain was multiplied by 1.69 to account for water loss (Grogan, 1998). Soil temperature was measured at a 5 cm soil depth adjacent to each chamber in the morning. Gravimetric soil moisture was determined by taking soil samples at 0-5 cm depth and drying them at 105^{o}C for 24 h on the day that the soda-lime tins were removed from the plots. Statistical comparisons were made using SPSS. ANOVA was used to compare soil respiration rate, soil temperature, and soil moisture content among sites. Paired comparison among sites was determined using the Least Significant Difference test at P= 0.05.

RESULTS AND DISCUSSION::

Mean soil respiration ranged from 0.29 to 1.26 g C m^{-2} d^{-1} (Table 1, Fig. 1). Mean soil moisture ranged from 27.34 to 59.41 percent (Table 1, Fig. 2). Soil temperature varied between 5.5-7.5^{o}C. (Table 1, Fig. 3) Soil respiration in black locust was greater than the other areas. Soil respiration, soil moisture and soil temperature values were different in vegetation types. But this difference has no significance as a statistical (P>0.05). But our results included only December month measure. The reason of our result may be only one month measures (in December) and measurement fault. Winter season consist of three months (December, January, and February). There was no significant correlation among soil respiration, soil moisture and soil temperature. These values are within the ranges reported by Kucera and Kirkham (1971), Coleman (1973), Singh and Gupta (1977), Jurik *et al*. (1991), Lessard *et al*. (1994), Hudgens and Yavitt (1997), Raich and Tufekcioglu (2000), Tufekcioglu *et al*. (2001), and Tufekcioglu and Kucuk (2004).

Table 1. Mean, maximum and minimum values of soil respiration, soil temperature, and soil moisture in the study area

Parameters	Vegetation type			
	Black locust plantation	Apple orchard (grass+apple trees)	Walnut plantation	Grasslands
Soil respiration (g C m^{-2} d^{-1})	0.78 (0.32-1.26)	0.66 (0.44-1.18)	0.60 (0.29-1.15)	0.61 (0.29-1.06)
Soil moisture (%)	36.61 (29.19-59.41)	38.88 (25.95-41.20)	31.36 (27.34-46.98)	38.90 (36.26-40.55)
Soil temperature (^{0}C)	6 (5-7)	6.33 (6-7)	6.67 (6-7.5)	6.17 (5.5-6.5)

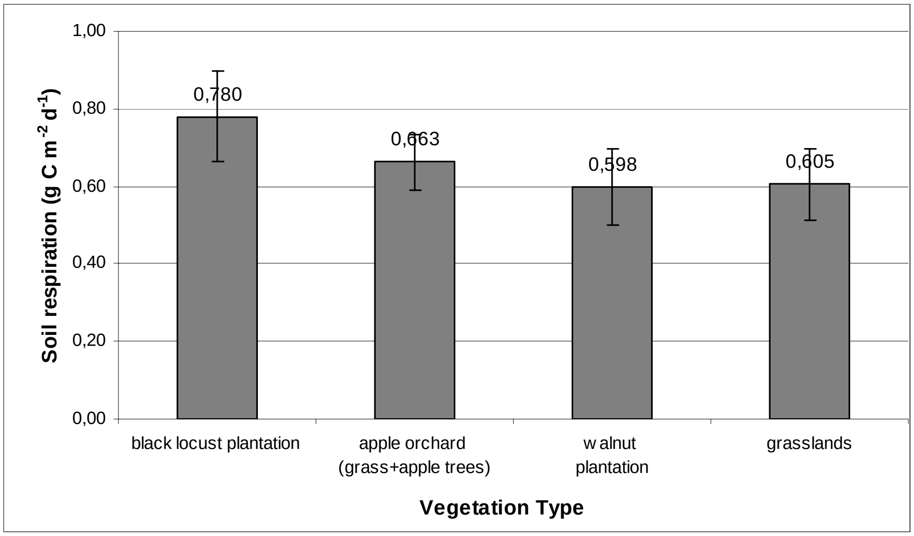

Fig. 1. Changes of soil respiration of different vegetation types in winter

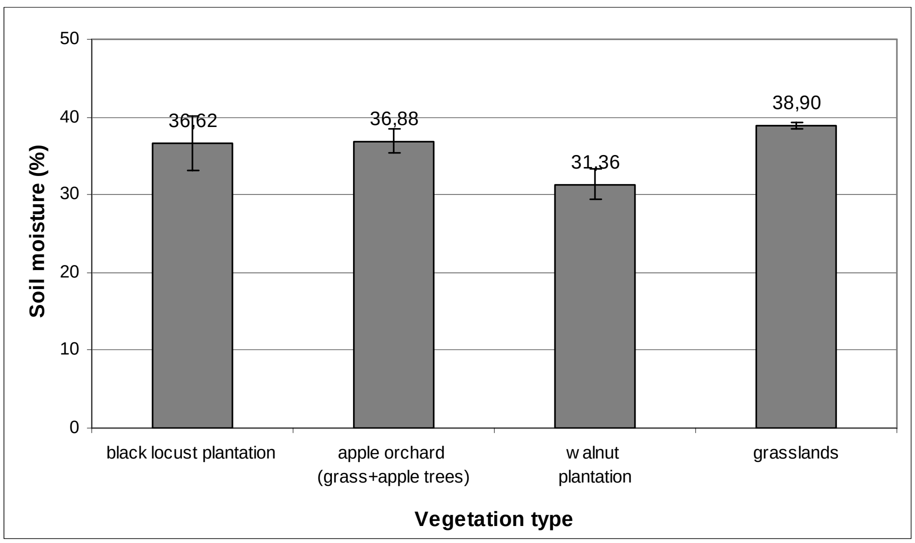

Fig. 2. Changes of soil moisture of different vegetation types in winter

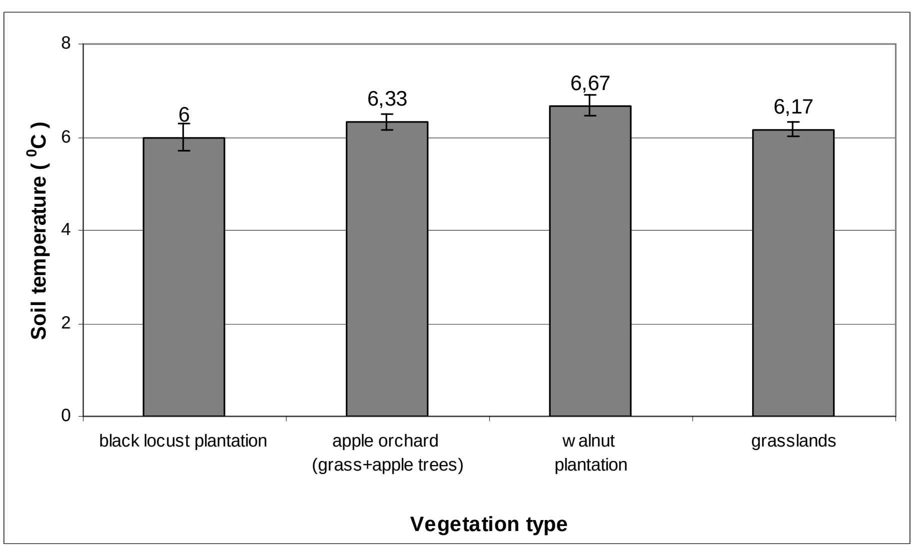

Fig. 3. Changes of soil temperature of different vegetation types in winter

During winter, the soil temperature was low. This pattern corresponded with the annual patterns of temperature and moisture under Mediterranean climate: high temperature associated with low moisture in summer and low temperature associated with high moisture in winter; both are significant determinants of soil respiration in temperate latitudes (Raich and Tufekcioglu, 2000; Tufekcioglu *et al*., 2001). If one of these two factors is too limiting, it becomes the control factor and the other factor has little effect on the rate of soil respiration. Similar pattern was observed by Qi and Xu (2001) in a coniferous forest in the Sierra Nevada Mountains, USA. Holt *et al*. (1990) and Rey *et al*. (2002) also found lower soil respiration rates in summer due to drought. Similarly, Kowalenko *et al*. (1978) reported that temperature was limiting during the winter and spring and that moisture was limiting during the summer and fall on soil respiration in field soils of Canada.

These results show that black locust has higher soil biological activity compared to the other sites in this study. For This reason may be due to the effect of microbial activities of nitrogen bacteria in black locust areas. Because nitrogen-binding bacteria in black locust roots have increasing effect of soil respiration

The black locust plantation proved higher rates of soil respiration than the walnut plantations and grasslands and apple orchards. These higher rates of soil respiration are evidence for the high rates of biological activity and carbon cycling through the soil in black locust plantation compared to, apple orchards walnut population and grassland sites. The present results indicated that temperature was limiting soil respiration during the winter season.

REFERENCES:

Coleman DC. 1973. Soil carbon balance in a successional grassland. Oikos, 24: 195-199.

Dugas WA, Heuer ML, Mayeux HS. 1999. Carbon dioxide fluxes over bermudagrass, native prairie and sorghum. Agric. Forest Meteorol., 93(2): 121-139.

Edwards NT. 1982. The use of soda-lime for measuring respiration rates in terrestrial systems. Pedobiologia, 23: 321-330.

Ewel KC, Cropper WC, Gholz HL. 1987. Soil CO_2 evolution in Florida slash pine plantations. I. Changes through time. Can. J. Forest Res., 17: 325-329.

Frank AB, Liebig MA, Tanaka DL. 2006. Management effects on soil CO_2 efflux in northern semiarid grassland and cropland. Soil Till. Res., 89: 78-85.

Grogan P. 1998. CO_2 flux measurement using soda-lime: Correction for water formed during CO_2 adsorption. Ecology, 79: 1467-1468.

Hanson PJ, Edwards NT, Garten CT, Andrews JA. 2000. Separating root and soil microbial contributions to soil respiration: A review of methods and observations. Biogeochemistry, 48: 115-146.

Hanson PJ, Wullschleger SD, Bohlman SA, Todd DE. 1993. Seasonal and topographic patterns of forest floor CO_2 effects from an upland oak forest. Tree Physiol., 13: 1-15.

Haynes BE, Gower ST. 1995. Belowground carbon allocation in unfertilized and fertilized red pine plantations in northern Wisconsin. Tree Physiol., 15: 317-325.

Holt JA, Hodgen MJ, Lamb D. 1990. Soil respiration in the seasonally dry tropics near Townsville, North Queensland. Soil Biol. Biochem., 28: 738-745.

Hudgens DE, Yavitt JB. 1997. Land-use effects on soil methane and carbon dioxide fluxes in forest near Ithaca, New York. Ecoscience, 4: 214-222.

Jurik TW, Briggs GM, Gates DM. 1991. Soil respiration of five apsen stands in Northern Lower Michigan. Am. Midl. Nat., 126: 68-75.

Kowalenko CG, Ivarson KC, Cameron DR. 1978. Effect of moisture content, temperature and nitrogen fertilization on carbon dioxide evolution from field soils. Soil Biol. Biochem., 10: 417-423.

Kucera CL, Kirkham DR. 1971. Soil respiration studies in tallgrass prairie in Missouri. Ecology, 52: 912-915.

Kulkarni NS, Jaiswal JV, Bodhankar MG. 2007. Influence of agro-waste amendment on soil microbial population in relation to plant growth response. J. Environ. Biol., 28: 623-626.

Lessard R, Rochette P, Topp E, Pattey E, Desjardins RL, Beaumon G. 1994. Methane and carbon dioxide fluxes from poorly drained adjacent cultivated and forest sites. Can. J. Soil Sci., 74: 139-146.

Norman JM, Garica R, Verma SB. 1992. Soil surface CO_2 fluxes and the carbon budget of a grassland. J. Geophys. Res., 97: 18845-18853.

Parkin TB, Doran JW, Franco-Wizcaino E. 1996. Field and laboratory tests of soil respiration. In: “Methods for Assessing Soil Quality (Doran JW, Jones AJ. eds)”. Madison, Wisconsin. Soil Sci. Soc. Am. J., 49: 231-245.

Qi Y, Xu M. 2001. Separating the effects of moisture and temperature on soil CO_2 efflux in a coniferous forest in the Sierra Nevada Mountains. Plant Soil, 237: 15-23.

Raich JW, Bowden RD, Steudler PA. 1990. Comparison of two static chamber techniques for determining carbon dioxide efflux from forest soils. Soil Sci. Soc. Am. J., 54: 1754-1757.

Raich JW, Schlesinger WH. 1992. The global carbon dioxide flux in soil respiration and its relationship to vegetation and climate. Tellus, 44: 81-99.

Raich JW, Potter CS. 1995. Global patterns of carbon dioxide emissions from soils. Global Biogeochem. Cy., 9: 23-26.

Raich JW, Tufekcioglu A. 2000. Vegetation and soil respiration: Correlations and controls. Biogeochem., 48: 71-90.

Rey AE, Pegoraro V, Tedeschi I, Parri P, Jarvis G, Valentini R. 2002. Annual variation in soil respiration and its components in a coppice oak forest in Central Italy. Global Change Biol., 8: 851-866.

Rochette P, Desjardings L, Gregorich EG, Pattey E, Lessard R. 1992. Soil respiration in barley (Hordeum vulgare L.) and fallow fields. J. Soil Sci., 72: 591-603.

Schlesinger WH. 1977. Carbon balance in terrestrial detritus. Ann. Rev. Ecol. Sys., 8: 51-81.

Singh JS, Gupta SR. 1977. Plant decomposition and soil respiration in terrestrial ecosystems. Bot. Rev., 43: 449-528.

Tufekcioglu A, Kucuk M. 2004. Soil respiration in young and old oriental spruce stands and in adjacent grasslands in Artvin, Turkey. Turk. J. Agric. For., 28: 429-434.

Tufekcioglu A, Raich JW, Isenhart TM, Schultz RC. 2001. Soil respiration within riparian buffers and adjacent crop fields. Plant Soil, 229: 117-124.

تأثير استخدامات التربة المتعددة على تنفس التربة فى فصل الشتاء

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تم دراسة تأثير الاستخدامات المتعددة للتربة على التنفس فى فصل الشتاء فى مزارع نبات الخرنوب، الأرض النجيلية ، مزارع التفاح ومزارع عين الجمل فى قرية سيتلر بمقاطعة أرتفن بتركيا. تم قياس التنفس فى التربة فى ديسمبر بواسطة تقنية هيدروكسيد الصوديوم وهيدروكسيد البوتاسيوم وقد تراوح معدل تنفس التربة اليومى بين 0.29 إلى 1.26 $gm^{-2}d$. وكان معدل تنفس التربة فى مزارع الخرنوب أكبر من المناطق الأخرى وكانت الفروق غير معنوية فى تنفس التربة، رطوبة التربة ودرجة حرارة التربة فى المناطق المختلفة تحت الدراسة. وهذه النتائج تدل على أن نبات الخرنوب يتميز بنشاط بيولوجى للتربة إذا ما قورن بالمناطق الأخرى.

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