



Original article

Effects of trifluralin on soil carbon mineralization at different temperature conditions

Hüsniye Aka Sağlıker^{a,b,*}^a University of Çukurova, Yumurtalık Vocational School, 01670 Yumurtalık, Adana, Turkey^b University of Osmaniye Korkut Ata, Faculty of Science and Arts Department of Biology, 80000 Fakuşağı, Osmaniye, Turkey

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ABSTRACT

Trifluralin is a herbicide intensively used in Turkish cotton agriculture. The recommended field dose [(RFD), 480 g active ingredient l⁻¹], 2 × RFD, 4 × RFD and 6 × RFD of this herbicide were added to virgin (previously no trifluralin applied) and cotton field soils (previously trifluralin applied) from a district (Yumurtalık, Adana) under Mediterranean climate conditions in order to determine their effects on soil microbial activity as measured by carbon mineralization at the different temperature conditions (20 °C, 25 °C and 30 °C). C mineralization of all samples was determined by the CO₂ respiration method over 30 days (20 °C, 25 °C and 30 °C at constant moist). The ratio (%) of carbon mineralization at all doses of cotton field soil at 30 °C was significantly higher than all other field dose–temperature combinations ($P < 0.001$). Based on these results, trifluralin is used as a carbon source by soil microorganisms. The herbicide trifluralin was degraded completely in the cotton field but a small fraction remained in the virgin field. This result can be explained by the cotton field soil having both more active microbial populations and more microorganisms adapted to the trifluralin applications than the virgin field.

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1. Introduction

Turkey is one of the largest cotton growing countries [8]. Cotton is very susceptible to weed competition [3] which is a key factor causing crop losses in Turkey. Herbicides are intensively used in cotton [31]. Trifluralin (α, α, α -trifluoro-2,6-dinitro-*N,N*-dipropyl-*p*-toluidine) has been used almost in all cotton fields in Turkey since 1970s. It keeps the crop free from weeds in early crop stages by controlling annual grass weeds and certain small-seeded broad leaved weeds [23,29,30,33]. The average half-life in the field is 45 days on most soils and less than 10% of applied trifluralin remains 1 year after application [33]. Some researchers studied trifluralin degradation in various types of agricultural soil under aerobic and anaerobic conditions and found that breakdown was highly dependent on soil type [7]. In a soil used for the disposal of various pesticides (diuron, trifluralin, carbofuran), only trifluralin was still detected after many years [18]. Residues of organic contaminants including toxaphene, DDT, trifluralin, hexachlorocyclohexanes, polychlorinated biphenyls, polycyclic aromatic hydrocarbons

(PAHs) and nonylphenol were measured in 32 cotton field soils collected from South Carolina and Georgia in 1999. Toxaphene, trifluralin, DDT and PAHs were the major contaminants found in these soils. Trifluralin was detected in all the soils at concentrations ranging from 1 to 548 ng/g dry weight [19].

Soil respiration is affected in a complex way by the temperature, moisture, soil properties, quality and quantity of decomposing organic substrates [22,27]. Soil respiration strongly depends on temperature [12,32]. The range of diurnal fluctuations in litter and topsoil depends on many factors and can reach 25–30 °C [6].

The low cost of trifluralin has led to a more intensive use of this herbicide in Turkey. Some farmers have practiced the herbicides trifluralin on their own field at 2 fold of the recommended field dose (RFD) and even as mixtures of 2 or 3 different herbicides for obtaining better crop in Turkey. These applications might create unwanted side effects on non-target organisms within the time in the soil. The presence of trifluralin in soil may cause changes to the microbial population and activity of a soil [16]. When glyphosate and trifluralin were compared with each other from the point of view of soil C mineralization, it is possible to conclude that soil microorganisms are capable of using glyphosate as a carbon source in the soil [15].

The aim of this investigation was to comparatively evaluate the effects of RFD and 2, 4 and 6 folds of RFD of trifluralin on the microbial activity of virgin and cotton field soils under different

* Corresponding author. University of Osmaniye Korkut Ata, Faculty of Science and Arts, Department of Biology, 80000 Fakuşağı, Osmaniye, Turkey. Tel.: +90 328 8251818; fax: +90 328 8250097.

E-mail addresses: crocus@cu.edu.tr, hasaglikler@osmaniye.edu.tr

temperature conditions (20 °C, 25 °C and 30 °C) by measuring carbon mineralization in a district (Yumurtalık, Adana) of the Eastern Mediterranean region, Turkey. Temperature responses of C mineralization rates have been extensively investigated in numerous fields and laboratory experiments [11,21,22].

2. Materials and methods

Yumurtalık, a district of Adana city, is situated on the Eastern Mediterranean region of Turkey (Fig. 1). The economy of this district mainly depends on agriculture, and 31,000 ha of land are being used as agricultural fields. The soils of these agricultural fields are periodically cultivated with cotton, maize, peanut, sunflower, watermelon and wheat.

There were two different plots in the district characterized by semiarid Mediterranean climate conditions (mean annual precipitation of 833 mm and mean annual temperature of 19.3 °C). One of the plots was at the agricultural field of Yumurtalık Vocational School of Çukurova University. This field soil was selected because of not containing herbicides and fertilizers and being an unapplied virgin area. The other plot contained the herbicide trifluralin being an applied cotton field in Yumurtalık. The precipitation and temperature data of Yumurtalık are based on 42 years [2]. The virgin and cotton field soils were classified as Haplic Xerorent Subgroups and Typic Xerorthent, respectively.

Five superficial soil samples from the upper 10 cm of both virgin and cotton fields were collected from each of four corners and the middle of these plots due to its shape in April 2007. Five samples taken from each of these two plots were mixed, homogenized and then considered as a composite and representative sample. After removing recognizable plant debris, these composite samples were air-dried and sieved through a 2 mm mesh sieve. The salt of

trifluralin (Trading name: Fer-Tref 48 EC; Production firm: Fertel; 480 g active ingredient l⁻¹) was added to the soil at the RFD (16 mg kg⁻¹), 2 × RFD (32 mg kg⁻¹), 4 × RFD (64 mg kg⁻¹) and 6 × RFD (96 mg kg⁻¹). The other values related to the herbicide were presented below. Rate calculations of trifluralin were based on volume weight (1.42 g cm⁻¹ for virgin field, 1.46 g cm⁻¹ for cotton field) and prospectus of this chemical (2 l ha⁻¹, 480 g active ingredient l⁻¹). To measure normal soil microbial activity in both virgin and cotton fields, a control soil which was not added trifluralin was included.

Doses	Herbicide additions (mg kg ⁻¹)	Total C added to soil from herbicide (mg kg ⁻¹)	Total N added to soil from herbicide (mg kg ⁻¹)	C:N ratios
No added trifluralin	–	–	–	–
RFD	16	42	23	1.83
2 × RFD	32	84	46	1.83
4 × RFD	64	168	92	1.83
6 × RFD	96	252	138	1.83

Soils were placed in 750 ml incubation vessels for the carbon mineralization. Herbicide was added in 5 ml of distilled water to soil samples. The final moisture contents of soils were adjusted to 80% of own field capacity before incubation [28]. The CO₂ produced from microbial respiration was absorbed periodically in 40 ml saturated Ba(OH)₂ solution in small tubes, which were placed on the top of the soil in incubation vessels. The incubation vessels were closed. Empty vessels were used as blanks. The CO₂ produced as a result of microbial respiration was measured every 3 days by titration with oxalic acid [4]. Incubation was carried out in a dark

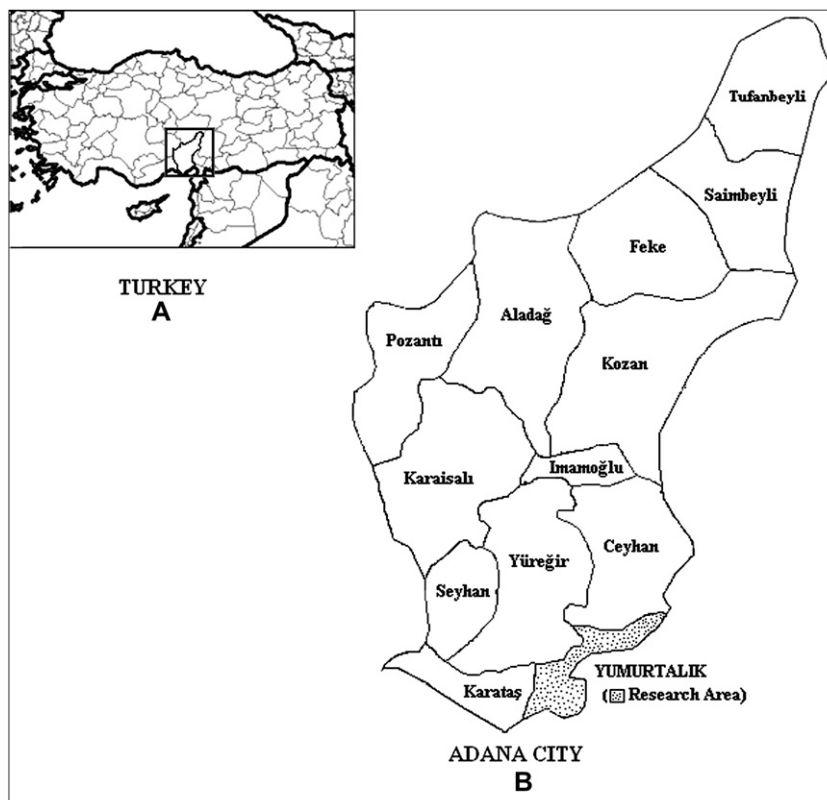


Fig. 1. (A) Location of Adana City in Map of Turkey. (B) Location of Yumurtalık (District) in Map of Adana City.

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