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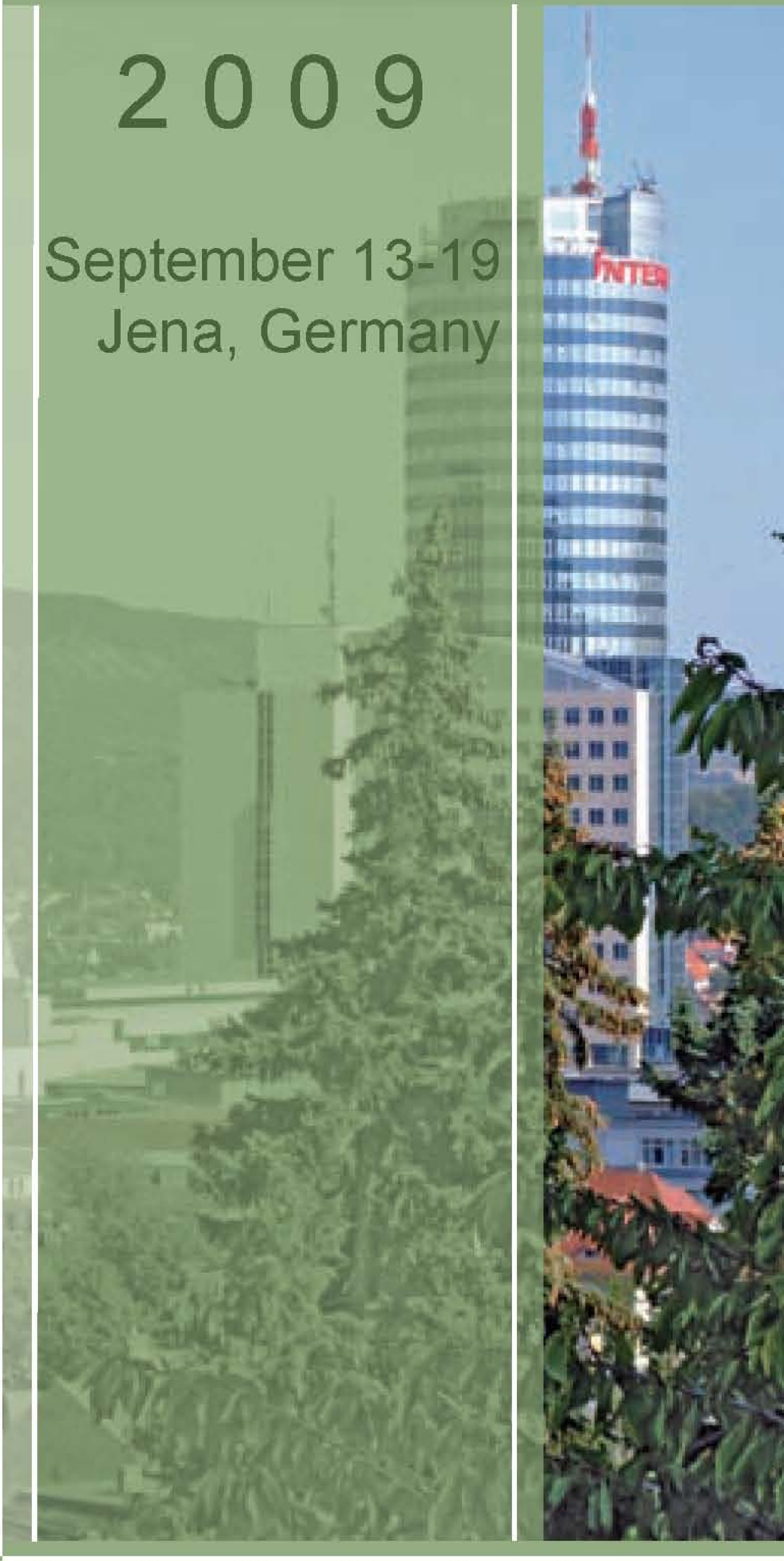

2009

September 13-19
Jena, Germany

ICDC8

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CARBON DIOXIDE FIXATION IN MEDITERRANEAN TREE FRUIT AGRO-ECOSYSTEMS

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ABSTRACT

This study reports the carbon fluxes in the biomass of olive and peach Mediterranean orchards, indicating that proper canopy management coupled with other agricultural techniques could increase the absorption of atmospheric CO_2 and its storage as organic matter in the soil.

INTRODUCTION

At a global scale, agricultural practices account for one-fifth of annual emissions of CO_2, CH_4 and N_2O (Reicosky et al., 2000). Between 1.5 and 3.0 Gt yr^{-1} of CO_2 could be immobilised worldwide in agricultural soils by the implementation of appropriate management practices to increase productivity (IPCC, 1995). These values are equivalent to 47% and 94% of the CO_2 yearly released into the atmosphere, which amounts to 3.2 Gt CO_2 (Lal, 1997). In agro-ecosystems, any increase of the carbon pool as humus derives almost entirely from the biotic pool of carbon inputs. Modern agricultural practices convert the pedosphere, which is normally a carbon sink, into a significant carbon source, with significant repercussions on the total amount of CO_2 in the atmosphere. This is the case in modern fruit orchards, especially in areas where rainfall is infrequent during the growing season and the soil is managed with shallow and repeated tillage. Although not fully understood, CO_2 fixation in fruit orchards is probably higher in comparison to fixation in annual herbaceous crops. This study reports the carbon storage in olive (*Olea europaea* L.) and peach tree (*Prunus persica* L.) orchards under different training systems. We propose that correct utilisation of appropriate agricultural techniques and soil management, important for fruit production and soil preservation, could also contribute to the removal of considerable quantities of atmospheric CO_2.

MATERIALS AND METHODS

Trials were conducted in experimental orchards located in Southern Italy (N 40° 38', E 15° 48') on 1) own-rooted young two-year-old olive plants (cv. 'Coratina') with a density of 156 trees ha^{-1}, on 2) mature 50-year-old olive plants (cv. 'Maiatica'; 555 trees ha^{-1}); and on 3) peach plants (*Prunus persica* L.; Batch 'Springcrest') trained to delayed vase (416 trees ha^{-1}) and transverse Y (1,111 trees ha^{-1}). Considering the short productive cycle of the peach orchards (i.e., ~10 years), the plants at year 1 and 2 were considered young trees whereas those from years 3 to 5 were considered mature trees. At the end of each vegetative season, in all the orchards, dry matter of the whole tree partitioned among the plant organs, fruit yield, senescent leaves and pruning material were evaluated from 30 plants. The determination of isohumic coefficients and root systems biomass was carried out according to Celano et al. (2002). Fixed CO_2 was determined assuming that the carbon content was 50% of the dry matter and, carbon was then converted in CO_2 by the equation 1.0 g carbon = 3.66 g CO_2.

RESULTS AND DISCUSSION

Young trees gradually increased CO_2 fixation during the experimental period (Fig. 1). In a five year period, olive trees fixed 72.9% of CO_2 in the above-ground biomass of the plants and the remaining CO_2 was fixed in root biomass (Fig. 1). During the whole experimental period, the mean value of fixed CO_2 in leaves of young olive trees was 16.4% of the total fixed CO_2 and decreased from 17.9% in year 1 to 9.0% in year 5 (Fig. 1A). In contrast, the mean value of fixed CO_2 in woody parts of young olive plants was 68.9% and increased from 64.9% in year 3 to 71.9% in year 5 (Fig. 1A). Pruning materials could account as carbon loss from the orchard system if removed from the grove and then burned, a conventional practice for some growers. Pruning material left to naturally decompose represents an efficient mean of long-term CO_2 immobilisation (Lal, 1997). The patterns of fixed CO_2 in leaves and pruning material were similar, showing the highest value in year 4 (3.78 and 3.62 t ha^{-1} respectively, Fig. 1A). During the entire experiment, young olive trees stored in the senescent leaves and pruning material about 0.91 t ha^{-1} and 1.83 t ha^{-1} of CO_2, respectively. Leaves and pruning material produced 0.10 and 0.35 t ha^{-1} of humus, derived from their decomposition (Table 1). The carbon from fruit is lost from the orchard system through harvesting. Olive fruits contributed to fix 0.18 to 6.70 t ha^{-1} of CO_2 in year 1 and year 5, respectively (Fig. 1A). In productive olive orchards, where plants have reached maturity, the annual increment of dry matter decreases. In mature olive trees, the mean values of fixed CO_2 in senescent leaves and pruning material were 1.67 and 7.87 t ha^{-1}, respectively (Table 1). The humus derived from the decomposition of senescent leaves and pruning material was 0.18 and 1.51 t ha^{-1}, respectively (Table 1). Results show differences in fixed CO_2 in peach organs between the two training systems (Fig. 1B-C), largely influenced by plant density. In both peach training systems, the largest amount of fixed CO_2 during year 1 was primarily accumulated in the permanent structures of the above-ground biomass (branches and trunk) and considerably less in the root system (Fig. 1B-C). The carbon accumulated in woody biomass (branches, trunk, stump and roots) of trees trained as delayed vase and transverse Y increased every year (Fig. 1B-C). The CO_2 fixed in the leaves of young and mature peach trees trained to delayed vase was 1.60 and 6.00 t ha^{-1}, with a production of 0.16 and 0.66 t ha^{-1} of humus, respectively (Table 1). In peach trees trained to transverse Y, 2.76 and 9.96 t ha^{-1} of the CO_2 fixed in leaves resulted in the production of 0.30 and 1.09 t ha^{-1} of humus respectively (Table 1). During years 3, 4 and 5, the amount of CO_2 in fruit was higher in the transverse Y plants than in the delayed vase plants (Table 1). The choice of an appropriate training system, plant density and the use of sustainable agricultural practices can enhance the soil carbon inputs (Montanaro et al., 2009), promoting the fixation of the atmospheric CO_2 into biomass and humus. Considering that in the Mediterranean area, 16% of the total cultivated land is occupied by fruit tree orchards (Olesen and Bindi, 2002), we can estimate that the CO_2 sequestration could be significant.

Table 1. Carbon content and humus production		Plant organ	Dry matter (t ha^{-1} yr^{-1})	Fixed CO_2 (t ha^{-1} yr^{-1})	Isohumic coefficient	Humus (t ha^{-1} yr^{-1})
Olive orchards	Young	Senescent leaves	0.50	0.91	0.20	0.10
		Pruning material	1.00	1.83	0.35	0.35
		TOTAL	1.50	2.74	-	0.45
	Mature	Senescent leaves	0.91	1.67	0.20	0.18
		Pruning material	4.30	7.87	0.35	1.51
		TOTAL	5.21	9.54	-	1.69
Peach orchards (delayed vase)	Young	Senescent leaves	0.80	1.60	0.20	0.16
		Pruning material	0.33	0.60	0.35	0.12
		TOTAL	1.13	2.07	-	0.28
	Mature	Senescent leaves	3.28	6.00	0.20	0.66
		Pruning material	4.76	8.71	0.35	1.67
		TOTAL	8.04	14.71	-	2.33
Peach orchards (transverse Y)	Young	Senescent leaves	1.51	2.76	0.20	0.30
		Pruning material	0.93	1.70	0.35	0.33
		TOTAL	2.44	4.47	-	0.63
	Mature	Senescent leaves	5.44	9.96	0.20	1.09
		Pruning material	8.52	15.59	0.35	2.98
		TOTAL	13.96	25.55	-	4.07

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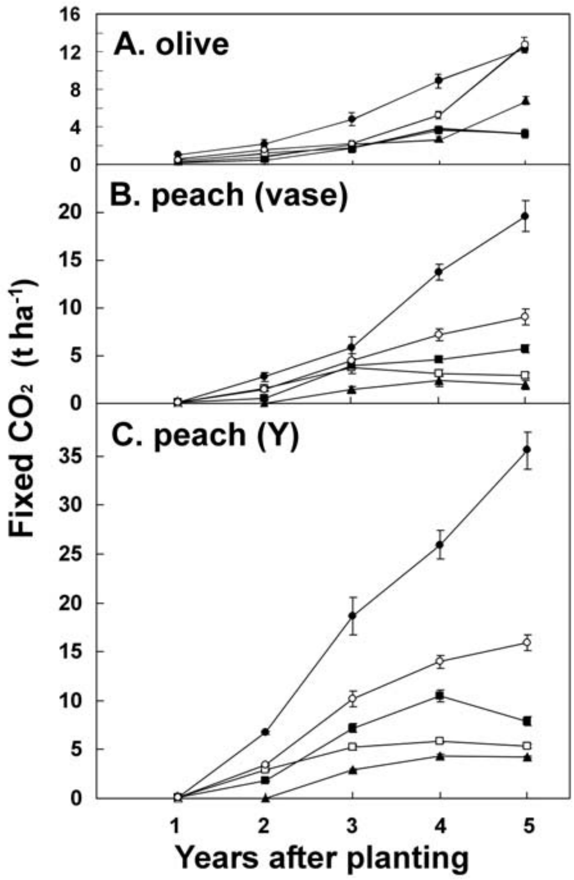

Fig.1. CO_2 fixed (± SE; *n* = 30) in the different organs of olive plants (A), and peach plants trained to delayed vase (B) and transverse Y.