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LEGUMES FOR ORGANIC CROPPING SYSTEMS

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Abstract

A field experiment which focuses on the yield performance of both durum wheat and sunflower included in a two-year rotation between wheat/subterranean clover and sunflower was carried out in an organic farm in Central Italy. Three factors were included in the experiment according to a factorial design: a) two different previous crop sequences (four years of alfalfa, four years of annual crops); b) three fertilization levels (without and with animal manure incorporated at 15 or 40 cm depth); c) three durum wheat genotypes (Appulo, Arcangelo and Daunia cvs). The results obtained show that a previous alfalfa meadow allows the succeeding crops (wheat and sunflower) to achieve an appropriate and stable grain yield (about 4 and 3 t ha^{-1}, respectively) even without organic manure for two consecutive cycles. When the durum wheat follows an annual crop sequence, grain yield appears unstable and the different levels of organic fertilizer determine a negative effect in the first cycle and a positive effect in the second cycle. The reseeding capability of sunflower was reduced by animal manure treatments and, consequently, the subclover biomass and its nitrogen content were generally lower in fertilized plots. Anyway, subclover biomass, which was ploughed in after reseeding as a green manure for sunflower, proved to be effective in stabilizing sunflower grain yield, especially in plots without any organic fertilization.

Keywords: cropping system, alfalfa, subclover, durum wheat, sunflower.

Introduction

The interest in organic farming is increasing in Italy, both as a consequence of the EU Reg. No. 2092/91 and because there is an increasing consumer demand. Despite this trend the majority of organic farms do not have livestock and need to depend on both stockless rotation and/or external farming inputs, although mixed farming is the preferred system in organic agriculture (Nauta et al., 1999). Legumes are fundamental components of organic cropping systems and they can positively influence the structure and functioning of the agroecosystem (Caporali and Onnis, 1992; Pierce & Rice, 1988). In a Mediterranean environment both alfalfa (*Medicago sativa* L.) and subclover (*Trifolium subterraneum* L.) are particularly suited to make rotations less dependent from auxiliary energy inputs. Several study have shown that crop yield and product quality are usually improved when alfalfa is grown as a preceding crop (Caporali e Onnis, 1992; Campiglia et al., 1999). Subclover can be used for improving the agroecological performance of cash-crop sequences, like the two-year rotation between a winter cereal (wheat) and a summer crop (sunflower), which is the most common cropping sequence, followed in the arable land in Central Italy (Caporali et al., 1993).

The aim of this study was to evaluate the effect of legumes, like alfalfa as a preceding crop and subclover as living mulch on wheat, on the yield performance of wheat - sunflower rotation arranged in an innovative cropping system pattern.

Material and Methods

The experiment was carried out between September 1995 and August 1999 on a large organic farm located at Bomarzo (12°41'E, 42°26'N) in the upper valley of the Tevere river (Central Italy). The main soil characteristics (0-30 cm depth) at the start of the experiment were: 24% clay, 29% silt, 47% sand, pH 8.35, organic matter 1.82%. Annual precipitation was 638, 1109, 820, 738, 788 mm in 1995, 1996, 1997, 1998 and 1999, respectively. An innovative cropping system particularly suitable for a Mediterranean environment (2-year rotation between a durum wheat/subterranean clover intercropping and sunflower) was adopted for two consecutive cycles (Fig. 1). In this cropping system, subterranean clover operates as a living mulch in the winter cereal, as a cover crop after durum wheat harvesting and clover reseeding, and finally as a green manure for the subsequent sunflower crop (Caporali *et al.*, 1993). Three durum wheat cultivars (Appulo, Arcangelo and Daunia) with different resistance to lodging were factorially combined with three treatments of organic fertilization after both a sequence of 4 annual crops and a 4-year alfalfa ley. The trial was arranged in a split-plot layout with 3 replicates with the durum wheat cultivar in the main plots, fertilization treatments in the subplots and the crop preceding sequence as a third, non-randomized factor including the other two. Subplot size was 576 m^2 (80 m length x 7.2 m width). Each wheat cultivar was intercropped with subterranean clover cv. Mount Barker in paired alternated rows (2 wheat rows followed by a clover strip 30 cm width), spaced 12.5 cm apart. Seeding rates were 500 seeds m^{-2} for durum wheat and 25 kg ha^{-1} of seed for clover. The fertilization treatments included: (i) poultry manure (10 t ha^{-1}, containing 280 kg total N), incorporated at 40 cm depth by means of a mouldboard plough, (ii) poultry manure (10 t ha^{-1}, containing 280 kg total N), incorporated at 10 cm depth by means of a disk harrow and (iii) control (no fertilization), ploughed at 40 cm depth. The same fertilization treatments were applied prior to the subsequent sunflower crop. Sunflower cv. Romsum HS 90 was sown in rows spaced 50 cm apart at a seeding rate of 6.5 seeds m^{-2}. Wheat and sunflower yield (biomass and grain) was determined at harvest, and subclover biomass just before subclover plowing in. Plant material was dried at 70°C until constant weight. Treatments means were compared by a Fisher LSD protected test at $P \leq 0.05$.

Results and Discussion

Results concerning wheat yield and biomass, subclover self-reseeding capacity, subclover biomass and its nitrogen content, and sunflower yield are showed in table 1. Alfalfa as a preceding crop showed generally a positive effect on wheat grain yield in plots without any organic fertilization in both the first and the second cycle. The positive effect of alfalfa as a preceding crop was also evident in the sunflower crop, where the increase in grain yield was 21% and 11% in the first and second cycle, respectively, in comparison with the annual crop sequence treatment. When organic manure was applied, wheat grain yield was unstable after alfalfa because of the lodging of the wheat plants caused by a likely high level of nitrogen in the soil (data no showed). This was evident both in the first and second cycle with poultry manure incorporated both at 10 and 40 cm depth. Anyway, the organic manure treatment was effective in increasing wheat grain yield in the second experimental cycle and wheat biomass in both cycles. The subclover reseeding capacity was strongly reduced by organic fertilization in comparison with no manure treatments both in the first and second cycle. As a consequence of this scanty subclover re-establishment, the biomass plowed in, as a green manure and its nitrogen content were generally lower in the fertilized plots. Subclover biomass ploughed in as a green manure for sunflower resulted effective in stabilizing sunflower grain yield, as shown by the fact that a fertilization main effect was not recorded at list in the second cycle (tab. 1). At present the alternative cropping system described above has been implemented with success in working farms located in Central and Southern Italy where the rainfall is about 800 and 600 mm for year respectively. So we assume that this cropping system has the potential to be used in many Mediterranean environments where a long fellow period follows a winter cereal. This cropping system is particularly suitable for mixed farms where the legume biomass can be utilized as forage for animals and in organic farms where the legumes can represent an important source of nitrogen.

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Table 1 - Durum wheat, subclover and sunflower yield performance in the first and second cycle of the wheat/subclover **-** sunflower rotation. Only significant effects are reported in the table.

		1st cycle				2nd cycle			
	Preceding crop	No manure	Manure 15 cm depth	Manure 40 cm depth	average	No manure	Manure 40 cm depth	Manure 40 cm depth	Average
Wheat grain yield [t ha^{-1}]	Annual crop sequence	3.60	3.30	3.16	-	3.47	4.12	4.33	-
	Alfalfa	3.96	3.03	3.95	-	3.99	3.91	3.21	-
	LSD (P ≤ 0.05)		0.61				0.82		
Wheat biomass [t ha^{-1}]	Average	10.38	11.52	12.30	-	10.17	13.29	13.66	-
	LSD (P ≤ 0.05)		1.14				1.74		
Subclover seedlings [n m^{-2}] (after self-reseeding)	Average	722	109	72	-	1794	659	538	-
	LSD (P ≤ 0.05)		156				254		
Subclover biomass [t ha^{-1}]	cv Appulo	1.89	2.07	2.50	2.15	-	-	-	-
	cv Arcangelo	3.25	2.41	2.36	2.67	-	-	-	-
	cv Daunia	3.25	3.44	2.58	3.09	-	-	-	-
	LSD (P ≤ 0.05)		0.68		0.40				
	average	-	-	-		3.62	2.20	2.28	-
	LSD (P ≤ 0.05)						0.36		
Subclover nitrogen [kg ha^{-1}]	cv Appulo	47.18	52.40	60.50	53.36	107.32	63.85	57.13	-
	cv Arcangelo	94.58	61.85	64.28	73.57	101.12	48.20	70.05	-
	cv Daunia	81.28	78.63	66.70	75.54	93.93	50.48	58.30	-
	LSD (P ≤ 0.05)		18.78		10.84		20.60		
Sunflower grain yield [t ha^{-1}]	cv Appulo	3.51	3.20	3.60	-	-	-	-	2.39
	cv Arcangelo	2.86	2.24	3.81	-	-	-	-	2.01
	cv Daunia	2.85	3.51	4.24	-	-	-	-	2.35
	LSD (P ≤ 0.05)		0.47						0.19
	average	3.07	3.31	3.88					
	LSD (P ≤ 0.05)		0.27						
Sunflower grain yield [t ha^{-1}]	Annual crop sequence	-	-	-	3.09	-	-	-	2.13
	Alfalfa	-	-	-	3.75	-	-	-	2.37
	LSD (P ≤ 0.05)				0.22				0.15

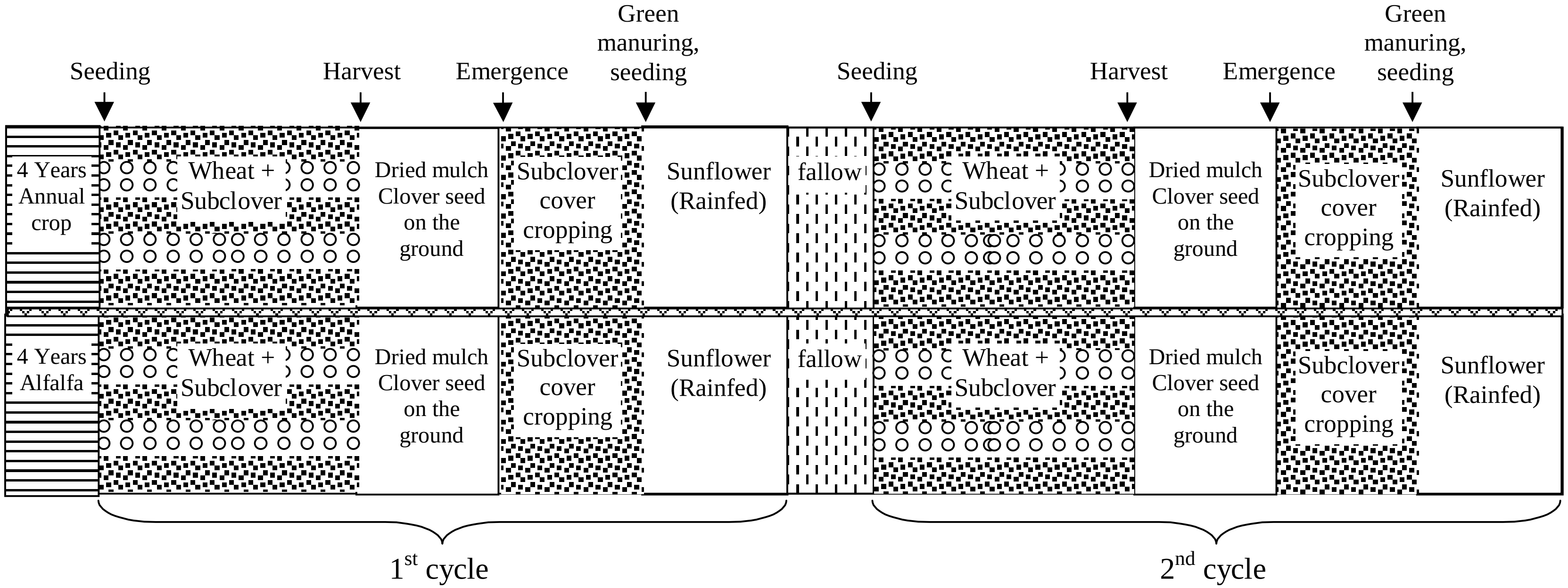

Figure 1 – Experimental layout according to its development in temporal sequence.