Weed Development in Sunflower as Affected by Cropping Systems Based upon Different Input Levels[1]

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Abstract

The effect of three cropping systems based upon different input levels (low=L1, intermediate=L2, and high=L3) on the density and structure of sunflower weed communities was evaluated from 1989 to 1991. The three cropping systems, applied to a sunflower-winter wheat two-year rotation, differed for type and/or amount of inputs applied to the crop (hybrid/cultivar, seeding rate, fertilization, irrigation, and weed control method). Weed presence was monitored twice each year (at canopy closure and at late flowering) when the effects of cultural practices were already evident. The density of each weed species was recorded and used for the computation of total weed density and of the Shannon-Wiener diversity index (H'). Both weed density and diversity were always higher in L1 as compared to L2 and L3. Weed presence was low (L1) or negligible (L2 and L3) in the first two years while it increased in the third year. This may be attributable to a seed bank build-up caused by the short length of the rotation cycle or by the lack of chemical weed control (L1) and might lead to future weed control problems especially for the low-input cropping system. The analysis of qualitative data outlined a short-term dynamics in weed communities unrevealed by quantitative data.

Key words: cropping systems, low-input agriculture, sunflower, weed density, weed diversity index .

Introduction

In the recent years weed research carried out on sunflower has mostly been focused on the effects of herbicides on weed control and on crop injury and growth (Wall, 1994); on the evaluation of up-to-date weed control methods such as flaming (Casini *et al.*, 1992) and on the definition of competitive ability and threshold levels for selected weeds

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[1]Research funded by the Italian Ministry for Agriculture (M.I.R.A.A.F.) - P.F. P.A.N.D.A., Publication Series 2, No. 31.

(Durgan *et al.*, 1990; Onofri and Tei, 1994).
As for many other field crops, the definition of cropping systems able to reduce environmental risks as well as to preserve the gross margin of farmers is an ultimate need. Low-input cropping systems are likely to cause shifts in the weed flora spectrum, as it has been observed in cereal-based production systems (Ball and Miller, 1993; Young *et al.*, 1994). To date, scientific information on the effects of alternative cropping systems characterized by different input levels on weed development in sunflower is still lacking. In this kind of research, the qualitative aspects of the weed flora, such as the study of the community structure (i.e. relative composition of weed species) are very important because they may reveal transitions in weed communities due to the intensity of cultural practices (Derksen *et al.*, 1995).
The objective of this study was to investigate on weed development in sunflower consequent to the adoption of low-, intermediate- and high-input cropping systems both from the quantitative (total weed density) and the qualitative (weed flora diversity) points of view.

Materials and methods

A field trial was conducted from 1989 to 1991 on a Typic Xerofluvent located near the river Arno (43°40' lat. N, 10°19' long. E, 2 m a.s.l.). Three cropping systems characterized by different input levels (low, intermediate and high) were compared from 1985 on a sunflower-winter wheat two-year rotation. All phases of the rotation were present each year. The experiment was arranged according to a randomized complete block design with four replications. Each plot had a size of approximately 400 m^2. The main technical differences among the three cropping systems are reported in tab. 1. No chemical weed control was ever applied to L1. On sunflower, a pre-emergence treatment (metobromuron+prometryn: 1.5 + 1.5 $kg \cdot ha^{-1}$) was applied to L2 and L3. On winter wheat, a post-emergence treatment (2,4-D: 2.5 $kg \cdot ha^{-1}$) was applied to L2, while both a pre-emergence (metoxuron: 8 $kg \cdot ha^{-1}$ in 1989 and 1990, and chlorotoluron + terbutryn: 3.5 $kg \cdot ha^{-1}$ in 1991) and a post-emergence (2,4-D: 2.5 $kg \cdot ha^{-1}$) treatments were applied to L3. Sunflower was always late-spring hoed, whatever the cropping system.
Weed surveys were conducted twice each year: at canopy closure (20 June 1989, 5 June 1990 and 26 June 1991) and at late-flowering/early ripening (2 August 1989, 3 September 1990 and 26 July 1991). Both sampling periods were subsequent to all chemical and/or mechanical operations performed, and thus aimed at outlining the effects of the different cropping systems on actual weed flora in two sunflower stages. At each sampling date, weed density was assessed by counting the number of plants of each weed species found in two 1 m^2 squared frame randomly placed onto a 100 m^2 uniform area within each replication. Total weed density (x) was transformed as $\sqrt{(x+0.5)}$ to normalize the distribution, and variance homogeneity was tested by means of the Bartlett test (Gomez and Gomez, 1984).
The structure of weed communities was evaluated by means of the Shannon-Wiener H' diversity index (Mahn and Helmecke, 1979).

The index was computed as:

$$H' = \sum_{i=1}^{S} h_i$$

with $h_i = p_i \cdot \ln(1/p_i)$, where p_i is the relative density of each of the S weed species present (density of the i^{th} species/total weed density, expressed as percent). For each sampling date, a series of three dominance-diversity curves were then constructed by placing the number of weed species - sorted in descending order according to h_i values - on the abscissa, and the corresponding cumulative h_i values on the ordinate.

Results, discussion and conclusions

Each year, the low-input cropping system showed the highest total weed density both at canopy closure and at late flowering (tab. 2). Differences in total weed number between L2 and L3 were always insignificant. While in 1989 and 1990 weeds were relatively rare in all cropping systems, in the last year an appreciable increase in weed number was observed everywhere. However, this increase was more evident for L1, probably because of the seed bank build-up caused by the lack of weed control within the rotation. This may also be an explanation for the absence of weed decline observed for L1 between the two sampling periods, contrarily to what seen in the two previous years and for L2 and L3 in the same year. In a situation where weeds are relatively undisturbed, the allelopathic effect of sunflower on weed species germination (Leather, 1983) may also be enhanced, thus causing greater short-term shifts in size and composition of the weed flora.

The diversity indices of weed communities clearly revealed the impact of cropping intensity on the inner structure of the weed flora. In 1989 as much as fourteen and twelve weed species were found in L1 at canopy closure and late flowering, accounting for a H' of 1.51 and 0.97, respectively. On the contrary, except for L3 at canopy closure (three species, H'=0.27), in all other situations only one weed species was found, thus rendering the diversity index equal to zero. In 1990 the situation was similar to that described above, although positive values of H' were observed for L2 and L3 (fig. 1). Between canopy closure and late flowering a 23% diversity reduction was recorded for L1; this was consistent with the reduction in total weed density, just like it had been observed in the previous year. On the other hand, less pronounced diversity changes were recorded for L2 and L3. As expected from quantitative data, in 1991 all cropping systems showed a higher weed flora diversity (fig. 1). It is interesting to note how the H' value was greater for L3 than for L2 at canopy closure, while the contrary was observed at late flowering. This may be attributed to the highest weed suppression exerted by high-input sunflower in the period between the two surveys, due to lower light transmittance through the canopy as influenced by greener and thicker foliage resulting from higher fertilization and irrigation rates. On the contrary, the micro-environment present in L2 was adequate to a greater number of weed species to survive. These within-communities shifts could not be revealed by the analysis of quantitative data only.

The response of weeds to cropping systems was not always related to the degree of input level applied to sunflower. Although this type of experiment does not allow to draw "absolute" conclusions, it is likely that the application of pre-emergence herbicides (L2 and L3) has influenced the size and composition of weed communities to a greater extent, as clearly evidenced by low total weed number (especially in the first two years) and by the shape of the dominance-diversity curves. However, the analysis of weed communities structure also revealed the existence of an underlying dynamics in the weed flora that can produce changes in the relative importance of weed species even in the short-term and without the application of specific anthropogenic factors. This underlines the need for taking into account both quantitative and qualitative aspects when investigating on the effects on weeds of cropping systems where many complex interactions among cultural practices occur. The increase in the number of weeds observed for L1 during the last trial year must be taken with caution because it may be a symptom of unsustainability of that cropping system in terms of weed control and - possibly - of crop productivity. The shortness of the rotation together with the lack of chemical weed control may hamper L1 crop yields despite the insertion of a strong competitor like sunflower within the rotation cycle. Consequently, *una tantum* herbicide applications might be required for the low-input cropping system in order to maintain weed communities below the damage threshold.

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The work is to be attributed to all authors in equal parts.

Tab. 1. Cultural practices relative to the three cropping systems in the period 1989-91.

Operations	Crops	L1	L2	L3
Main tillage (ploughing)	winter wheat sunflower	25 cm deep 40 cm deep	25 cm deep 40 cm deep	25 cm deep 40 cm deep
Additional tillage	winter wheat sunflower	- hoeing	- hoeing	- hoeing
Fertilization* ($kg \cdot ha^{-1}$)	winter wheat sunflower	160 N, 73 P_2O_5, 0 K_2O 90 N, 46 P_2O_5, 25 K_2O	212 N, 106 P_2O_5, 0 K_2O 180 N, 84 P_2O_5, 330 K_2O	245 N, 123 P_2O_5, 190 K_2O 210 N, 98 P_2O_5, 385 K_2O
Cultivar Hybrid	winter wheat sunflower	Manital/Mec [(1)] Astro	Manital/Mec [(1)] Stromboli	Manital/Mec [(1)] Stromboli
Seeding rate*	winter wheat sunflower	220 $kg \cdot ha^{-1}$ 7 $seeds \cdot m^{-2}$	220 $kg \cdot ha^{-1}$ 8 $seeds \cdot m^{-2}$	220 $kg \cdot ha^{-1}$ 7 $seeds \cdot m^{-2}$
Irrigation* ($m^3 \cdot ha^{-1}$)	winter wheat sunflower	- -	- 1014	- 1983

L1=low-input system, L2=intermediate-input system, L3=high-input system.
[(1)] Manital in 1989 and 1990; Mec in 1991. *Average of the three-year period.

Tab. 2. Total weed density recorded during the trial period.

	$Plants \cdot m^{-2}$	Computed F (and prob. > F)	$Plants \cdot m^{-2}$	Computed F (and prob. > F)
Input level	Canopy closure (20 Jun 1989)		Late flowering (2 Aug 1989)	
L1 L2 L3	24.5 a 0.3 b 1.8 b	19.61 (0.0023)	7.8 a 0.3 b 0.8 b	5.26 (0.0479)
Input level	Canopy closure (5 Jun 1990)		Late flowering (3 Sep 1990)	
L1 L2 L3	21.9 a 2.1 b 1.1 b	38.67 (0.0004)	7.7 a 1.7 b 3.0 b	37.12 (0.0004)
Input level	Canopy closure (26 Jun 1991)		Late flowering (26 Jul 1991)	
L1 L2 L3	90.3 a 9.3 b 10.5 b	12.52 (0.0072)	99.8 a 4.5 b 4.8 b	66.90 (0.0001)

L1=low-input system, L2=intermediate-input system, L3=high-input system.
For each sampling date, values marked by the same letter are not significantly different for $P \leq 0.05$ (LSD protected test).

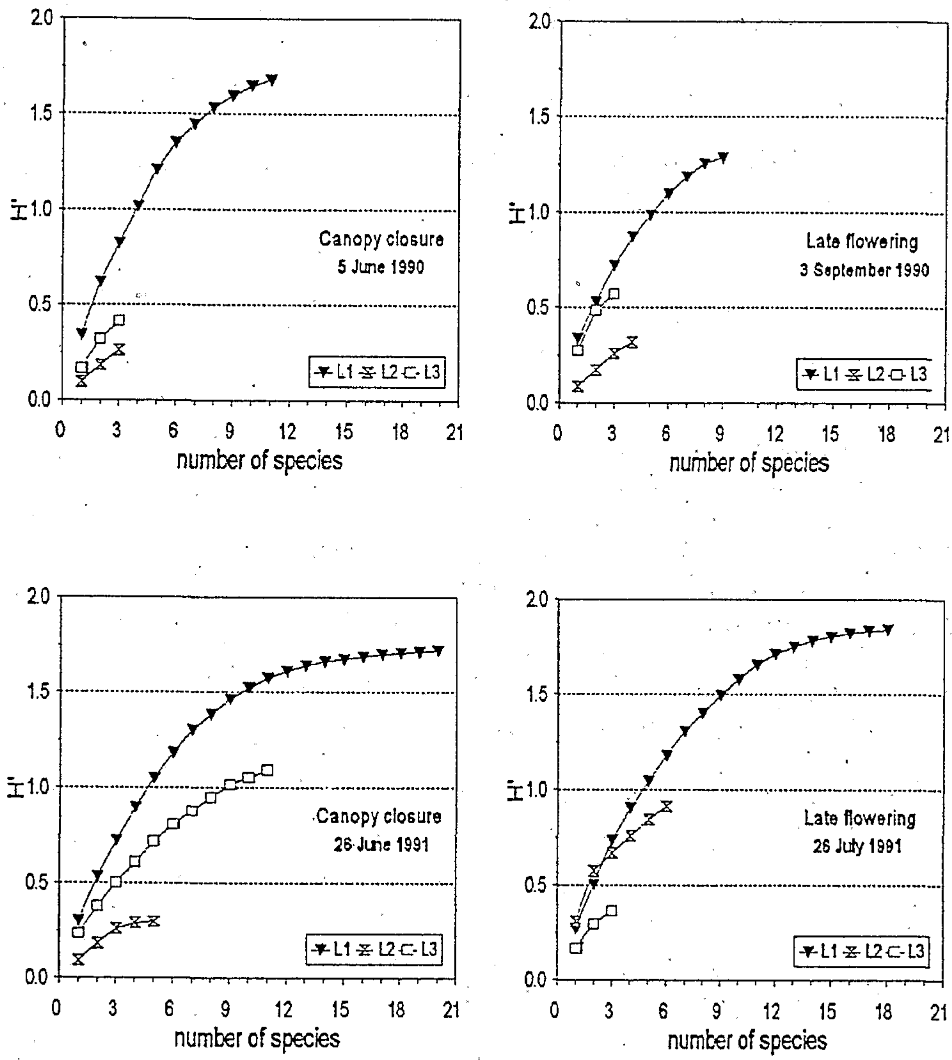

Fig. 1. Dominance-diversity curves of sunflower weed communities in 1990 (above) and 1991 (below). L1 = low-input system, L2 = intermediate-input system, L3 = high-input system.