The role of intercropping on insects diversity in dryland field crops in a Mediterranean site

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***Abstract* - This work aims to evaluate the effect of crop type and density on insects' community in the Mediterranean region. In winter of 2004, four 35m x 10m blocks (replicates) were delimited and 24 equidistant 2m x 3m plots were marked. Seven crop types (barley, vetch, turnip, barley-vetch, barley-turnip, vetch-turnip and barley-vetch-turnip) at three densities were randomly established within each block. Fifteen crop shoots per plot were randomly collected in May to evaluate insect's abundance and diversity. Our results suggest that intercrop has a positive effect on abundance of most examined groups of insects and diversity, specifically when vetch is incorporated in the mixture. Changes in abundance of aphids, trips and ants are also discussed connected with vetch presence.**

INTRODUCTION

The range of component practices of cultural pest management that involve increasing diversity is considerable (New, 2005). Likewise, the range of benefits from such enhancement to agricultural biodiversity and its functions are also very diverse (Altieri, 1991; Altieri & Nicholls, 1999). Some of these cultural practices are the intercropping or the use of monoculture of multiple crops in an area (Letourneau & Altieri, 1999). This work aims to evaluate the role of intercropping on the abundance and diversity of herbivorous insects and their natural enemies. Despite several studies have shown that crop diversity strongly affected the population dynamics of some specialist herbivores (Bach,1979) few studies have compared the effect that the combination of three crop species differing in functional type have on the abundance and diversity of insects in the Mediterranean region.

MATERIAL AND METHODS

This study was carried out in Montblanquet (UTM 31T CF3495), NE of Spain. The climate at the study site is mediterranean with a mean annual temperature and precipitation of 13ºC and 450 mm, respectively. To analyze the effect of crop type and density on abundance, richness and diversity of insects we selected a commercial field, which had been managed for more than one decade following the guidelines of Organic Farming. The 50x150 m field was located in the bottom of a narrow valley (600 m above sea level). Field boundaries were colonized by dense herbaceous grasslands dominated by *Brachypodium phoenicoides and* hedges dominated by *Rubus ulmifolius* and *Prunus spinosa.* Some trees (*Quercus faginea*, *Acer campestris and A. opalus*) and shrubs from natural oak woodlands also grow in the boundaries.

In winter of 2004 four 35m x 10m blocks (replicates) were marked. In each block, 24 equidistant 2m x 3m plots were delimited. Seven crop types were sown; three sole crops: barley (*Hordeum distachion*), vetch (*Vicia sativa*), and turnip (*Brassica napus*), and four polycultures: barley-vetch, barley-turnip, vetch-turnip and barley-vetch-turnip. All crop types were sown at three densities (high, medium and low). The different crop types and densities were randomly assigned to each plot within each block. Thus, a complete combination of seven crops at three densities within each block was obtained.

In May 2005 fifteen crop shoots were randomly collected in each plot. All insects were removed and transferred to 70% alcohol and sorted at the family level. Trips, ants and aphids were sorted out by species because of their particular importance. The abundance of insects was estimated by the number of individuals of each plot. Diversity, estimated by means of Shannon's diversity index (H'), evenness (J') and family richness were calculated according to Magurran (1988). The effect of crop type and density on abundance, richness, diversity and evenness of insect communities was analysed by two-way analysis of variance, with crop type at seven levels, and density at three levels. Differences among crops and densities were analysed using DMS method. The significant degree was $p<0.05$. Number of individuals was transformed using $\log_{10}(x+1)$ to achieve normality and homoscedasticity of residuals. A non-parametric Kruskal-Wallis test was used when transformed data were not normalised. Analyses were carried out using the SPSS Statistical Package (2002).

RESULTS

In total, 2055 individuals from 10 orders and 25 families of insects were identified. The number of individuals ranked from 1 to 128 per plot. Mean abundance ranked from a minimum value of 6, 33± 4, 7 indiv plot^{-1} in barley plots to a maximum value of 21. 50 ± 16, 7 indiv plot^{-1} in barley-vetch plots (Table 1).

The two-way ANOVA show that insects abundance ($F = 4.4$, df = 6, $p = 0.001$), diversity ($\chi^2 = 15.38$, df = 2, $p = 0.017$), group richness ($F = 2.67$, df = 7, $p = 0.015$) and evenness ($\chi^2 = 18.85$, df = 6, $p = 0.004$) differ significantly among crop types. However, no significant differences were found among densities within each crop type ($p \le 0.05$).

Table1. Diversity (H'), evenness (J') and family richness in the different crop types. Data (Mean ±ES) with different letter within a column are significantly different ($p \le 0.05$).

Treat	H'	Richness	J'	Abundance
V	1,87^{a} ± 0,54	7,56^{a} ± 1,39	0,57^{a} ± 0,38	10,38^{a} ± 6,7
B	0,78^{b} ± 0,17	5,33^{b} ± 0,52	0,37^{b} ± 0,32	6,33^{b} ± 4,7
T	1,28^{ab} ± 0,19	6,83^{ab} ± 0,76	0,48^{ab} ± 0,13	13,92^{a} ± 13,3
B+V	1,57^{a} ± 0,58	7,92^{a} ± 1,29	0,60^{a} ± 0,26	21,50^{a} ± 16,71
B+T	1,25^{ab} ± 0,29	6,42^{ab} ± 0,95	0,51^{ab} ± 0,15	10,67^{ab} ± 10,7
T+V	1,84^{a} ± 0,5	8,13^{a} ± 1,80	0,57^{a} ± 0,15	13,75^{a} ± 8,5
B+V+T	1,48^{a} ± 0,45	7,25^{a} ± 0,43	0,58^{a} ± 0,16	20,64^{a} ± 13,50

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Lowest mean species diversity was found in barley plots, 0.78 $\pm$ 0.17 bits ind^{-1}. In the other crop types, there were a wide range of diversity values, which ranged from 1.25 $\pm$ 0.29 bits.Ind^{-1} in barley-turnip plots to 1.87 $\pm$ 0.54 bits. Ind^{-1} in vetch monoculture plots. Richness and evenness follow a similar pattern than diversity. The comparison of means show that mean family richness, diversity, evenness and abundance were significantly higher in crops with vetch than in barley monoculture (Table 1). The most abundant groups of insects were herbivorous and omnivorous, such as trips (O.Thysanoptera), aphids (O.Hemiptera F. Aphididae) and ants (F.Formicidae) comprising 76% of all individuals and 35 species. Among 889 individuals and 14 species of aphids, the three most common were *Aphis craccivora* (45%), *Rhopalosiphum maidis* (34%) and *Brevicoryne brassicae* (10%) colonising almost exclusively in sole and intercrops with vetch, barley and turnip respectively. A total of 328 trips from 15 species were recorded. The most commonly trapped trips were *Trips* sp. (70%) mainly on vetch, vetch-turnip and vetch-barley plots. Among 77 individuals and 7 species of ants, the two most frequent were *Tetramoriom caespitum* (43%) and *Lasius cf.grandis* (27%). While 87% of individuals of *T. caespitum* were found in barley-vetch-turnip plots, all of *L. cf. grandis* individuals appeared in plots with vetch.

Table 2. Number of species (S) and abundance (A) of aphids, ants and trips in the different crop types.

Treat	Aphids		Ants		Trips	
	S	A	S	A	S	A
V	7	21	3	16	12	96
B	5	38	0	0	8	19
T	6	49	1	1	7	27
BV	6	368	4	14	8	90
BT	6	57	0	0	8	17
TV	8	71	4	7	9	50
VBT	7	285	5	39	7	29
Total	14	889	7	77	15	328

DISCUSSION AND CONCLUSIONS

Diversity, evenness and family richness of insects' communities were higher in intercrops than in sole crops, except for vetch monoculture, that is as diverse as intercrops. Moreover crop density is irrelevant for such communities. These results support the hypotheses that crop diversification (by adding species) enhances abundance and structure of herbivorous insect's communities (Altieri, 1999). However, Koricheva (2000) remarks that plant diversity effects on invertebrate abundance were mostly indirect and mediated by changes in plant biomass and cover.

The higher abundance and diversity of herbivorous insects in plots with vetch can be related to the higher amount of food resources (flowers and extra floral nectarines) and more structural crop complexity. The potential benefits of vetch enhancing beneficial biodiversity could be reduced because of vetch also facilitate some insect pest populations like trips and aphids. Furthermore, vetch favours ant populations and consequently enhances aphids' dissemination. This pattern is supported by the positive relationship between *Lasius* cf. *grandis* and aphids in vetch plots.

In mediterranean climate, cereal (barley) monoculture clearly impoverishes insect communities and consequently several functions as natural pest control and pollination may be reduced. To minimize the undesired effects of cereal monocultures, the design of spatial and temporal combinations of crops in an area including vetch would be advisable because of its positive effect on maintaining insect abundance and diversity in the agroecosystem.

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