IMPLICATIONS OF INTERCROPPING (SWEET PEPPER - TOMATO) FOR THE BIOLOGICAL CONTROL OF PESTS IN GLASSHOUSES

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ABSTRACT. The effects of intercropping on the distribution of pests were analysed in a cropping system composed of rows of sweet peppers alternating with rows of tomatoes in a 80 m^2 glasshouse. The levels of populations of *Myzus persicae*, *Tetranychus urticae* and *Frankliniella occidentalis* and their predators or parasitoids were compared among the rows. Significant differences in pest, predator and parasitoid density were observed. This was partially attributed to differences in plant suitability influencing the predator-prey balance. Moreover, highly significant differences in pest density were recorded among the rows of the vegetable species which favoured high pest outbreaks. This effect was probably due to negative effects caused by the other plant species on the dispersion of the pest. In fact, glandular trichomes heavily entrapped aphids on tomatoes, which probably greatly affected the pest dispersal in the crop. On the other hand, the fact that spider mites were maintained on the sweet pepper plants at very low levels by predatory mites was certainly a factor which contributed to the low spread of the pest in the crop. These results lead to the conclusion that such intercropping seems to locally limit pest outbreaks, and thus may reduce the amount of biological auxiliaries or pesticides needed to control them in comparison with monoculture.

1. Introduction

Monocultures are the only agrosystems which are developed extensively to provide for the increasing needs of the humanity. However, certain species of phytophagous arthropods have become extremely abundant in such crops. The general instability in monocultures was generally thought to be favoured by less interactions than in a natural system, which can absorb effects of rapid changes in the density of one species (Horn, 1988). By increasing heterogeneity in intensive crops by using an intercropping system, one may wonder if the control of phytophagous arthropods would be improved. In fact, the stability of predator-prey interactions depends on spatial asynchrony in predator

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population development (Nachman, 1991), which can be achieved by a heterogeneous environment (Nachman, 1988). Spatial heterogeneity is also a potentially powerful stabilizing force in host-parasitoid interactions (Holt and Hassell, 1993). Moreover, more abundant entomophagous insects were recorded in tropical intercropping systems than in monocultures (Kennedy *et al.*, 1990). This might be caused by more vital food, shelter and resting site (Risch, 1981).

The aim of this study is to analyse the distribution and development of populations of phytophagous insects, phytophagous mites, their predators and parasitoids in a row intercropping system (sweet pepper - tomato) in a glasshouse. Pest distribution and beneficial arthropod distribution were discussed in terms of effects on pest control.

2. Materials and methods

2.1. CULTURAL CHARACTERISTICS

Tomatoes cv. 2209 (De Ruiter) and sweet peppers cv. Mazurka (Rijk Zwaan) were grown on Grodan® rockwool under natural light in a 80 m^2 glasshouse at Louvain-la-Neuve (Belgium) from 2 February to 15 November, 1992. Tomatoes were stood on the rockwool per group of 2 rows (20 plants per row; rows 1, 2, 5 and 6) alternately with 2 rows of sweet peppers (rows 3, 4, 7 and 8). Row location in the glasshouse occurred following a repetitive process of two rows 60 cm apart followed by a 1.2 m walking path. Plants in the row were spaced at 55 cm and were pruned to a single stem for tomatoes and to a double stem for sweet peppers.

2.2. PEST CONTROL AND POPULATION SAMPLING

Two species of insects (the western flower thrips, *Frankliniella occidentalis* (Pergande), and the green peach aphid, *Myzus persicae* (Sulzer)) and one species of spider mite (the two-spotted spider mite, *Tetranychus urticae* Koch) were observed from mid-March, mid-May and the beginning of April, respectively. Predators provided by Koppert (The Netherlands) were introduced onto the crop to control all these pests, and no pesticides were sprayed on the foliage. Populations of the pests and their predators were estimated on sweet pepper and tomato plants of rows 2 to 7.

2.2.1. Western flower thrips

A total of 80 predatory mites, *Amblyseius cucumeris* (Oudemans) were put on each sweet pepper plant from 11 March to 10 June. They were put on leaves by means of a brush once or twice a week. The amount of individuals per release and plant ranged from 3 to 6. Their populations as well those of the western flower thrips were fortnightly estimated in flowers and on leaf areas from 24 March to 23 October. Per sampling date, 10 flowers were cut at random per row and dissected using a stereomicroscope to count the number of thrips and predators. The foliage was also observed by using a 10 x hand lens on a sample (n=20 per row) of 17 cm^2 leaf areas in the upper third of 20 plants chosen at random. Moreover, the density of necrotic leaf areas caused by the nutrition of thrips on the foliage between 1.3 and 1.5 m in height on the plant was estimated on 2 October (n=20 leaves per row).

2.2.2. Green peach aphids

Two local species of *Hymenoptera*, *Praon volucre* (Haliday) and *Aphidius matricariae* Haliday naturally colonized the crop. Moreover, two introductions of approximately 500 adults of the predatory midge, *Aphidoletes aphidimiza* (Rondani) were carried out on 24 June and 17 September. Mid-August, mid-September and mid-October, aphids, their predators and parasitoids were counted on the foliage in the upper third of 10 plants per row by using a 10 x hand lens. Per plant, a total of ten 1.3 cm^2 leaf areas were chosen at random. Moreover, the number of adult and immature aphids immobilized by glandular trichome exudates was determined on 10 tomato leaves randomly selected per row.

2.2.3. Spider mites

Predatory mites, *Phytoseiulus persimilis* Athias-Henriot were applied by means of a brush on tomato and sweet pepper plants of rows 3, 4, 5 and 6. Sweet pepper rows 3 and 4 received 30 and 75 predators, respectively on 1 July, whereas tomato rows 5 and 6 received a total of 360 and 300 predators, respectively on 24 July, 20 August and 2 September. Spider mite and predatory mite density on leaf area was estimated fortnightly in the third upper part of the 10 middle plants of each row. On tomato, 2 leaflets were cut at random per plant; their area was calculated, and the numbers of individuals of both mite species present on their underside were counted under a stereo-microscope. On sweet pepper, however, mite density was directly calculated by averaging the numbers of individuals observed by means of a 10 x hand lens on 1.3 cm^2 leaf areas (n=10) chosen at random per plant.

2.3. STATISTICAL ANALYSIS

The analysis of the inter-row spatial pattern of the pests, their predators and parasitoids was made per sampling date using a 1-factor fixed analysis of variance (ANOVA) model with a fixed row effect: multiple comparisons by contrasts were made to determine which row significantly differed regarding to arthropod density. Prior to analysis, data were transformed by natural logarithm (ln (x+1)) to be normalized and to stabilize the variance.

3. Results

3.1. WESTERN FLOWER THRIPS

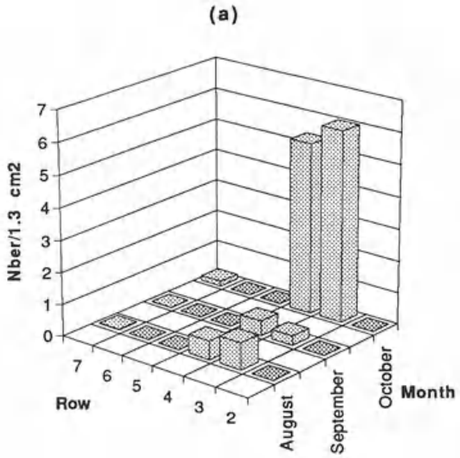
High thrips densities occurred on sweet peppers and not on tomatoes. Nevertheless, thrips individuals successfully reached the tomato rows: a total of 14 adults (no immatures) were found in the 320 tomato flowers which were dissected (711 thrips in the sweet pepper flowers). But only one larvae on the foliage and very few leaves with feeding marks of thrips (<0.0001 necrotic areas per 20 cm^2 leaf area) have been observed on the tomatoes, whereas on sweet peppers, I observed 5.8 ± 7.4 and 0.7 ± 1.4 necrotic areas per 20 cm^2 leaf area on rows 4 and 5, and on row 7, respectively at the beginning of October. On sweet peppers, the necrotic areas caused by thrips nutrition were as dense in row 4 as in row 5, but they were less dense than those on row 7 ($P = 0.005$). No significant difference in thrips density on the leaves was recorded among the three rows. Predatory mites, however, were denser in row 7 than in the two other rows from mid-August, which could explain lower damage.

3.2. GREEN PEACH APHIDS

High aphid colonization occurred on sweet peppers, whereas only dying colonies were observed on tomato leaves; there were a few adults and immatures either disturbed in their movement or immobilized by tomato trichome exudates which hardened on their legs, or stuck dead on trichomes. The high numbers of entrapped aphids were observed on the two tomato rows which stood alongside sweet pepper rows 3 and 4 (Figure 1). These two sweet pepper rows were heavily infested by aphids: on mid-October, there were 6.0 ± 3.3, 5.0 ± 4.2 and 0.2 ± 0.2 aphids per 1.3 cm^2 in row 3, 4 and 7, respectively. The aphid density on row 7 significantly differed from those on rows 3 and 4, whereas there was no difference between rows 3 and 4 where intolerable aphid densities were reached as the plants were covered by honeydew.

3.3. SPIDER MITES

Plants of the six analysed rows were attacked by spider mites, but significant differences in spider mite density were recorded among the rows. Tomato rows 5 and 6 supported very high pest densities, whereas the sweet pepper rows supported very low ones (Figure 2). Surprisingly, there were low spider mite densities on row 2. Infestation started there several weeks after the one on the other rows. Spider mites firstly established in rows 3, 4 and 5 where higher mite densities were observed in the tomato row than in the sweet pepper rows from



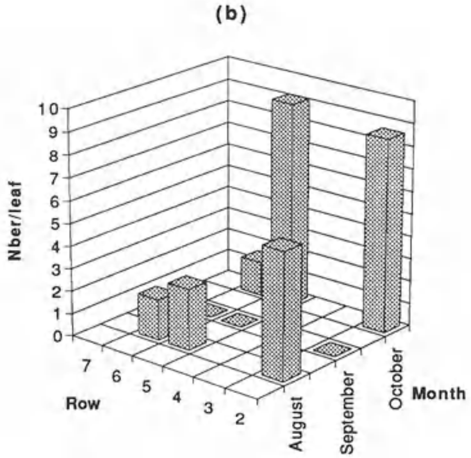


Figure 1. (a) Number of alive aphids, *M. persicae* on the leaf areas in the tomato (▣) and sweet pepper (◻) rows, and (b) of aphids entangled by tomato trichome exudates per leaf.

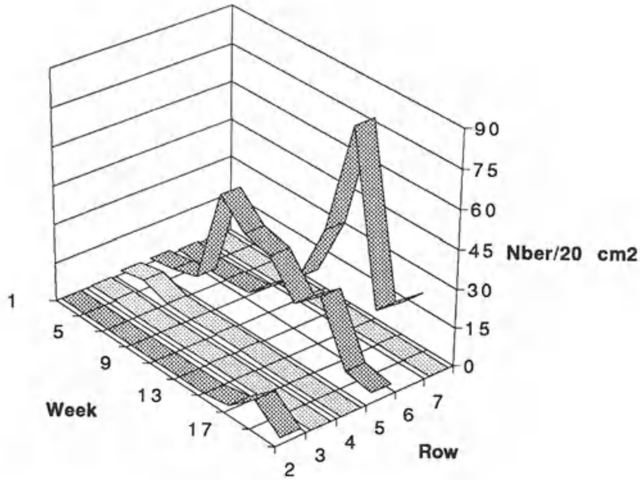


Figure 2. Mean number of spider mites, *T. urticae* on the leaf areas in the tomato (▣) and sweet pepper (◻) rows from 2-7 to 6-11-92.

mid-July. Afterwards, infestation spread into rows 6 and 7, and high pest densities were achieved on tomato row 6 from the end of August. I observed maximum values of spider mite density of 35 ± 39 and 88 ± 80 per 26 cm^2 leaf area in rows 5 and 6, respectively. In the sweet pepper rows, however, there was a maximum of 0.7 ± 1.4 spider mites per 20 cm^2 leaf area. Only from the end of October, spider mite density was greater in tomato row 2 (maximum 11 ± 13 spider mites per 20 cm^2 leaf area) than in the sweet pepper rows. The distribution and development of the predatory mite, *P. persimilis* followed a similar pattern of that of the prey.

4. Discussion and conclusion

The occurrence of differences in pest population between the two plant species was expected, partially caused by the degree of suitability of the two plant species for the pest development, reproduction and longevity (e.g., Van de Vrie *et al.*, 1972), partially by the fact that tomato trichomes deter foraging activity of natural enemies of pests, e.g. *P. persimilis,* thereby affecting the balance between the beneficial arthropod and the pest (Nihoul, 1993a,b).

The original result concerns the effect of each plant species on the distribution of the pests because of row intercropping. Sweet pepper rows, on which spider mites were very well controlled by predatory mites, seemed to reduce the speed and the extent of the pest spread over the crop. On the other hand, tomato rows by affecting aphid distribution were certainly the cause of the localization of high pest populations on restricted sweet pepper rows. Finally, it could be that the population of *A. cucumeris*, the predator of thrips, was affected through interspecific relations (habitat modification, disturbance) by the aphid, thus influencing the thrips population in accordance with the aphid population levels.

In conclusion, in an intercropping system, the plant species which is either the least suitable for the pest because of having a defence mechanism or the most favourable for stable predator-prey interactions with low pest levels, might protect other plants species by concentrating the pest in a certain part of the crop where it can economically be destroyed. Less and more locally applied chemicals or predators might thus be expected, if compared to a monoculture. Further experiments comparing intercropping with monoculture must be done to confirm this hypothesis.

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