

susceptibility of resistant insects or making the susceptible more sensitive. As a result, they have particular utility in overcome metabolic resistance, a common form of resistance mediated by increased levels of detoxifying enzymes. Piperonyl butoxide (PBO) is a well-known synergist capable to interact with phase 1 metabolic enzymes, esterases and P450s, and its synergistic effects have been demonstrated against a wide range of insecticides. Starting from the current knowledge on PBO, a range of novel PBO analogues have been synthesized and evaluated for their inhibition efficacy against esterase FE4 and the cytochrome CYP6CY3 from resistant *Myzus persicae*, to elucidate the relationship between synergist chemical structures and these enzymes, and to synthesize novel potent inhibitors. Similar studies have been performed with *Bemisia tabaci* and can be applied to any insect pest where the enzymes responsible for resistance have been identified. This work has been performed in the framework of the European project 'EcoSyn' (Ecofriendly synergists for insecticide formulations), which aims to optimise the use of synergists in agriculture and public health. Candidate inhibitors emerging from the *in vitro* analysis here presented will be tested *in vivo* in laboratory bioassays and field trials against resistant populations, taking into account also possible effects against non-target insects like pollinators.

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### **Studies on contact and ingestion toxicity of extracts from wild hop *Humulus lupulus* (L.) against *Sitophilus granarius* (L.) (Coleoptera, Curculionidae)**

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Hop, *Humulus lupulus* (L.) is a high-climbing, perennial vine, utilized in the brewing industry. An interesting perspective in insect control is the use of natural products of plants. In this work is evaluated the biological activity of wild hops extracts against *Sitophilus granarius* (L.), a serious pest of stored grains. Plant extracts were obtained by extraction with solvents having different polarity (methanol, acetone and hexane) and by hydro-distillation. Bioassays tested were topical application of extracts and essential oil (EO) on pronotum of *S. granarius* adults and flour discs treated with extracts for effects on nutritional indices and antifeedant activity. Contact toxicity bioassay showed that extracts and EO were toxic for *S. granarius*. Mortality raised with the increase of dose and reached 100% for all solvent extracts at the dose of 75 µg/adult and at 109.37 µg/adult for EO. The highest toxicity was observed for EO, which had a LD<sub>50</sub> and LD<sub>90</sub> values of 13.3 and 40.2 µg/adult after 24 h of application, respectively, decreasing to 11.8 and 36.8 µg/adult after 48 h. Nutritional studies showed that extracts had significantly effects on growth rate, food consumption and food utilization. The greatest deterrence, 57% and 74% after 3 and 5 days, respectively, was observed for methanol extract. The highest mortality upon ingestion was 52% for the acetone extract, at the concentration of 750 µg/disc, 5 days after the treatment. This preliminary study indicates that wild hop is a source of biological substances that are toxic on insects by contact and ingestion.

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### **Exclusion nets for the control of fruit pests in NW Italy**

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In the last years, many chemical products have disappeared from the European market, launching

new challenges for the control of plant pests and pathogens. In the light of the good results achieved with the Alt'Carpo system, exclusion nets represent a promising alternative strategy for plant protection. In the frame of the LIFE+ SU.SA.FRUIT project (LIFE13 ENV/HR/000580), experimental trials were carried out in an apple and a peach orchard in the province of Cuneo (NW Italy). Four nets, three anti-hail photo-selective nets (red, yellow, pearl; mesh 2.4×4.8 mm) and a specific antidrosophilid net (mesh 0.9×1.0 mm), were tested. In each orchard, three neighbouring plants in the row were covered with the net for a total of three cages per net and 12 cages per orchard. Then, three sets of three neighbouring plants in the row without any coverage were used as control. The exclusion nets were set up at petal fall and removed at the end of the harvest time. During the experimental trials, no insecticides were applied on the encaged plants and on the uncaged plants used as control. The population dynamics of key pests, such as *Cydia pomonella* L. and *C. molesta* (Busck), as well as of emerging invasive pests, such as *Drosophila suzukii* Matsumura and *Halyomorpha halys* (Stål), were assessed inside and outside the cages. Similarly, at the harvest time, apple and peach samples were checked for damage caused by the moths and other pests.

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### **Development of *Hermetia illucens* (Diptera: Stratiomyidae) on vegetable waste**

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*Hermetia illucens* (Diptera Stratiomyidae), also known as black soldier fly (BSF), is a fly of wide interest as alternative source of protein. BSF has a high content of protein (nearly 40%), fatty acids (nearly 30%) and is rich in calcium and phosphorous. Larvae develop on a wide range of decaying organic materials; they can grow up to double their weight and are considered good bioconverter. As the use of this species as alternative source of protein in food or feed is very interesting, and data on its development on vegetable materials are poor, we investigated the performance of BSF on the following substrates: 1) Standard diet; 2) Three selected fruits; 3) Three selected vegetables; 4) Mix of the previous; 5) No-selected vegetables discarded by a market. Significant differences were detected in larval final weight and length of larval period. Larvae from vegetables showed the lower final weight ( $0,158\pm 0,06\text{mg}$ ), while the ones from fruits and vegetable were similar to the control. Larval lifetime was the longest on larvae reared on fruits (54d), and the shortest on standard diet. Mean pupal weights differed significantly among diets. Pupae from standard diet and market waste-mix were heavier ( $155,71\pm 2,37$  and  $148,2\pm 6,62\text{mg}$ ); pupae from vegetables showed the minimum mean weight ( $81,86\pm 2,18\text{mg}$ ). The pupal length from the market mix-vegetables differed significantly from other substrates with higher values. BSF was able to develop on the tested substrates, but the differences in developmental time and final weight of the larvae/pupae have to be considered for mass production as protein source.

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### **Converging strategies in plant manipulating insects: insect-induced effects on plants and possible mechanisms used by leaf-miner insects to manipulate their host-plant**

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Nutritional requirements of animals are multidimensional and change qualitatively and quantitatively over time. In parallel, the nutritional environment is frequently highly variable both