Effects of Transgenic Insect-Resistant Chickpea Plants on Non-Target Insects

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RATIONALE

The application of biotechnological tools holds a great potential for alleviating some of the major constraints to crop productivity in developing countries. Genetic transformation provides a complementary means for the genetic enhancement of field crops, in general, and enhancing resistance to insect pests in particular. However, the promise has been dimmed by the perceived safety of the transgenic organisms. This includes safety to human health and the environment.

In order to ensure a sustainable deployment of transgenic insect-resistant plants, it is crucial that they are compatible with other control methods, including biological control. It is therefore, necessary that the novel plants are studied for their effects on natural enemies prior to their large-scale deployment.

The proposed project aims at developing methods for testing the extent to which the insect-resistant transgenic chickpeas affect the non-target beneficial insects in its production systems. The information generated through this project will provide a sound decision-making ability on the deployment of transgenic chickpea plants that are being developed at ICRISAT and the Pulse Network under the auspices of Indo-Swiss Collaboration in Biotechnology (ISCB).

OBJECTIVES

- Develop methods (laboratory, semi-field) for testing the impact of insecticidal proteins from genetically modified plants (Bt, ASAL) on
selected beneficial insects. [Campbellis chlorideae and Coccinella septempunctata have been selected as important natural enemies of the pest insects (Helicoverpa armigera, aphids)].

- Assess the impact of pure transgene products (Bt, ASAL) and transgenic chickpea plants on the selected arthropod natural enemies when attacking pest insects containing the transgenic proteins.
- Application of the risk-assessment approach for non-target arthropods developed at FAL to transgenic insect-resistant chickpeas.

EXPECTED OUTPUTS

- Availability of established methods which can be used in the future for testing and assessing the effects of transgene products on hymenopteran parasitoids of lepidopteran larvae and coccinellid predators.
- Data that will allow for a better understanding of risks that genetic transformations can pose on arthropod natural enemies.
- Scientific publications that will provide information on the effects of (a) Bt and ASAL on H. armigera and the natural enemies C. chlorideae and C. septempunctata, and (b) ASAL on aphids and C. septempunctata.
- FAL risk-assessment approach for insect-resistant transgenic chickpeas has been developed.

SUMMARY OF THE ACHIEVEMENTS OF THE FIRST PROGRAM PHASE

adapted from the summary provided by the project partners

To protect chickpea from the attack of pest insects, i.e. Helicoverpa armigera and aphids, attempts are being made within the ISCB to genetically modify plants to express genes which encode for insecticidal proteins. To ensure a sustainable deployment of transgenic insect-resistant plants, it is important that they are compatible with other methods of pest control, including biological control. In addition, international regulations require that the ecological consequences of a large scale deployment of transgenic crops, including the effects on non-target organisms, are assessed prior to commercialization. The proposed project aimed at developing methods to test the extent to which insect-resistant transgenic chickpeas will affect non-target beneficial insects in its production systems.

The project focused on two insecticidal proteins, Bacillus thuringiensis (BT) toxins targeting H. armigera, and Allium sativum leaf lectin (ASAL) that targets aphids. ASAL was purified from plant material grown on an experimental farm at Bose Institute and was provided to both FAL and ICRISAT for insect bioassays.

Experiments with ASAL conducted both at Bose and FAL revealed that this lectin is highly toxic to the target pest, the aphid Aphis craccivora. This is in contrast to reports from other lectins including snow drop lectin (Galanthus nivalis agglutinin, GNA), which only causes sublethal effects on aphids. Immunological studies revealed that both ASAL and GNA bind to midgut tissue from A. craccivora. Direct feeding bioassays showed that ASAL-feeding decreased longevity in larvae of an important aphid predator, the ladybird beetle Coccinella septempunctata. The fact that ASAL shows high activity towards the target pest, but has little effect on the non target predator species makes it an interesting compound to deploy in further studies.

At ICRISAT, dose-response curves of H. armigera to different Bt-toxins were
established. In addition, a technique to rear the *H. armigera* parasitoid *Campoletis chloridae* under laboratory conditions was developed.

In the field, maximum parasitization of *H. armigera* larvae by *C. chloridae* was recorded during September and December. Parasitization efficiency of *H. armigera* larvae differed among host plants. High levels were recorded on cotton, pearl millet and groundnut, moderate levels on pigeonpea and sorghum, and low levels on chickpea.

Studies with *C. chlorideae* attacking *H. armigera* larvae revealed that several life table parameters of parasitoids are negatively affected when the host larvae have been exposed to Bt toxin (Cry1Ab or Cry1Ac) dissolved in artificial diet prior and/or after parasitization. These effects are not unexpected since the *H. armigera* larvae are themselves affected by the Bt-treatment. The ASAL at 0.1% in the artifical diet, on which the *H. armigera* larvae were reared before and/or after parasitization, did not produce significant adverse effects on the survival and the development of the parasitoid.