# CROP PROTECTION

# Imidacloprid Impact on Arthropods Associated with Canopy of Common Beans

Flávio Marquini, Marcelo C. Picanço, Raul N.C. Guedes and Paulo S.F. Ferreira

[1]Depto. Biologia Animal, Setor de Entomologia, Universidade Federal de Viçosa, 36571-000, Viçosa, MG

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## Impacto do Imidaclopride em Artrópodes Associados ao Dossel do Feijoeiro

RESUMO - O presente trabalho objetivou verificar o efeito temporal e espacial da aplicação do inseticida imidaclopride na comunidade de artrópodos associados ao dossel do feijoeiro (*Phaseolus vulgaris*). Cerca de dois hectares de feijoeiro foram divididos em duas partes. Ambas receberam as mesmas práticas culturais, exceto pela aplicação do inseticida. Imidaclopride 700 GrDA (147 g i.a/ha) foi aplicado aos 20 dias de idade das plantas. Foram traçados três transectos abrangendo as áreas pulverizadas e não-pulverizadas. Cada transecto foi composto por nove pontos amostrais eqüidistantes 10 m. Amostrou-se a parte aérea das plantas antes da aplicação e aos 3, 8, 14, 22, 29 37 e 44 dias após a aplicação do imidaclopride. Verificou-se efeito temporal do inseticida em algumas guildas de artrópodos, mas o efeito espacial da aplicação do inseticida foi verificado apenas para *Empoasca kraemeri* Roos & Moore, onde a dispersão da área não-tratada mascarou o efeito do inseticida sobre a área tratada. O inseticida afetou as populações de *Thrips tabaci* (Lind.)*, Caliothrips brasiliensis* (Morgan) e *E. kraemeri*, mantendo-as em baixos níveis até 22 dias após a aplicação. Imidaclopride também preveniu o incremento de Collembola, não apresentando, porém, efeito significativo sobre insetos mastigadores, *Frankliniella* sp., *Liriomyza* spp. e *Bemisia tabaci* (Genn.). Imidaclopride foi seletivo, não afetando predadores e parasitóides comumente associados às pragas do feijoeiro.

PALAVRAS-CHAVE: Insecta, neonicotinóide, impacto ambiental, *Phaseolus vulgaris*

ABSTRACT - The present work aimed at assessing the temporal and spatial effect of applying the insecticide imidacloprid on the arthropod community associated with the canopy of common beans (*Phaseolus vulgaris*). About 2 ha of bean field was divided into two adjacent fields subjected to the same crop management practices except for insecticide application. Imidacloprid 700 GrDA (147 g a.i./ha) was applied to 20-day old plants. Three transects were extended from the mid-part of the sprayed area to the mid-part of the non-sprayed area. Nine sampling points 10 m apart were established in each transect. Arthropods were sampled from the plant canopy before and 3, 8, 14, 22, 29 37 and 44 days after insecticide application. There was a strong temporal effect of the insecticide on some arthropod guilds, but the spatial effect of the insecticide application was only noticeable in *Empoasca kraemeri* Roos & Moore whose dispersion from the non-sprayed area masked the insecticide effect on the treated area. The insecticide decreased the *Thrips tabaci* (Lind.)*, Caliothrips brasiliensis* (Morgan), and *E. kraemeri* populations until 22 days after its application. Imidacloprid also prevented population increase of springtails (Collembola), but it did not significantly affect plant-chewing insects nor *Frankliniella* sp., *Liriomyza* spp. and *Bemisia* (Genn.). Imidacloprid was selective in favor of the most common bean pest predators and parasitoids.

KEY WORDS: Insecta, neonicotinoid, environmental impact, *Phaseolus vulgaris*

Fields of common beans are frequently subjected to a number of potential insect-pests in tropical areas. Among the chewing insects, leafminers, bean leaf beetles, and soybean loopers are the most important, while thrips, green leafhoppers, whiteflies, and stink bugs are the main sap sucking pests of common beans in Brazil (Magalhães & Carvalho 1988, Zucchi *et al.* 1993, Vieira *et al.* 1998).

Common beans insect pest populations are commonly maintained below their economical damage thresholds by the action of predators and parasitoids. *Orius* spp. (Heteroptera: Anthocoridae), *Anthicus* spp. (Coleoptera: Anthicidae) and *Crematogaster* sp. (Hymenoptera: Formicidae) are the most common predators, while eulophids and ichneumonids are among the most frequent parasitoids reported attacking pests of common beans (Magalhães & Carvalho 1988, Coll & Bottrell 1995). Other arthropods commonly found associated with the bean canopy may not directly affect the pest populations, but they can be of great importance for the arthropod community structure. Some of them such as springtails (Hexapoda) are generally regarded as potential bioindicators of ecological stress factors (Sphar 1981, Frampton 1997).

One of the main tactics used by common bean producers against insect-pests is the use of insecticides. A large range of compounds is used with this objective, but neonicotinoid imidacloprid has been widely used by common bean growers (Andrei 1999). This systemic insecticide acts by interfering with the chemical signal transmission after ingestion and/or contact by binding to the nicotinergic acetylcholine receptor in the insect nervous system (Abbink 1991, Muchembled 1991, Elbert *et al.* 1998). Imidacloprid is reported to have a low residual effect and to be selective for intented targets, but selectivity studies have been carried out for very few species and the overall community effects of this compound have not been studied yet. Imidacloprid is also reported to be repellent to birds and mammals (Boyd & Boethel 1998, Wamhoff & Schneider 1999).

Despite the benefits of insecticide use against insect pests, its effects span a far broader range of organisms leading to community stress in different ecosystems, including the agroecossystem (Jepson *et al.* 1989, Pedigo 1989, Waage 1989). Insecticide resistance and pest-population resurgence and replacement are just a few examples of ecological backlashes of insecticide use in agriculture (Pedigo 1989, Waage 1989). The period for recolonization of a sprayed area is one of the most important subjects in studies of insecticide impact in arthropod communities, as well as the spread of insects from non-treated and treated areas, both potentially influencing the evolution of insecticide resistance and pest eruption. The dispersion of insects from nearby areas can potentially influence the recolonization of the sprayed area (Jepson 1989, Carlson *et al.* 1992). Therefore, we aimed with the present work to assess the temporal and spatial effect of imidacloprid application in the arthropod community associated with the canopy of common beans (*Phaseolus vulgaris* L.).

## Material e Methods

The field experiment was carried out from December 1998 to February 1999 at Coimbra County, Minas Gerais, Brazil. The experimental field was located on the left side of the road linking the counties of Coimbra and Ervália, at km 2. The soil type of the area is "podzólico vermelho-amarelo distrófico fase terraço", according to the Brazilian Classification (Leppsch *et al.* 1985, Resende *et al.* 1988). This soil is poor in nutrients with moderate depth and low water permeability.

Tillage operations were carried out as described by Kluthcouski *et al.* (1988) and the crop management practices were followed throughout the cultivation period (Zimmermann *et al.* 1988). The variety "Vermelho 2157", colored beans, with undetermined growth habit, type IIb and a 90 day cycle (Viera *et al.* 1998) was used in the 1.9 hectare area of the experiment. Plants were spaced 0.5 m between rows and 14 seeds were sown per linear meter. The cultivation was carried out following a low input system, without irrigation and fertilization. The herbicide Robust$^{Ò}$ CE (fluazifop-*p*-buthyl 20% + fomesafen 25%; Syngenta Proteção de Culturas Ltda; São Paulo, SP) was applied 15 days after sowing. The average rainfall (mm) in the experimental area was 384.9.

A water dispersible granular formulation of imidacloprid (Confidor® 700 GrDA; Bayer S/A, Santo Amaro, SP) was applied at the rate of 147 g a.i./ha in half of the experimental area using manual knapsack sprayers (Costal Manual PJH; Jacto; Pompéia, SP) equipped with a hollow cone hydraulic nozzle (JD 14-2) at high volume (350 l/ha) and 3 bar pressure. The plants were sprayed when they reached 20 days old to prevent the infestations of green leafhopper and thrips from reaching the economic damage level of two insects per plant. Three transects were extended from the mid-part of the sprayed area to the mid-part of the non-sprayed area. Each transect was a replicate and occupied an area of 90 x 50 m. Nine sampling points 10 m apart from each other were established in each replicate. Each sampling point contained 25 rows 10 m long, encompassing an area of 125 $m^2$.

Arthropods were sampled from the plant canopy before and 3, 8, 14, 22, 29, 37 and 44 days after insecticide application. They were sampled by beating one plant apex per sampling point in a white tray (35 x 29 x 5 cm). This technique was used because it allows fast collection of a wide diversity of species associated to beans. Insects were collected, sorted by morphspecies, counted and properly mounted. The number of leafminer mines was assessed in one mid-canopy leaf in three different plants at each sampling site (Miranda 1997). Specimens were identified by comparison with reference collections of the Entomological Museum of the Federal University of Viçosa or by specialists whenever necessary. Voucher specimens were depositated at the University Museum for future reference.

Abundance of arthropod species and groups were subjected to regression analysis ($P < 0.05$) using time after insecticide spray and distance to the intersection between sprayed and non-sprayed areas as independent variables. These analyses were carried out using the non-linear curve fitting procedure of the System of Statistical and Genetics Analysis (SAEG) from the Universidade Federal de Viçosa (Euclides 1983). The standard errors of the means were also estimated for each treatment to allow a descriptive comparison between the regression curves estimated for sprayed and non-sprayed areas, which were considered significantly different if there was no superposition of standard error of the means for sampling points at the same time and distance from the intersection for each area.

## Results

Seventy three arthropod morphspecies (11 phytophagous chewing insect-species, 21 phytophagous sap-sucking species, 25 predaceous species, 11 parasitoids, four detritivorous and one leafminer species) were collected in the common bean canopy in our experiment (Table 1 and 2).

The response pattern of arthropods associated with the bean canopy to imidacloprid was affected by time after spraying ($F = 88.60$; $df_{error} = 20$; $P < 0.0001$). However, only the green leafhopper, *Empoasca kraemeri* Roos & Moore (Homoptera: Cicadellidae), was significantly affected by the distance to the intersection between sprayed and non-sprayed areas ($P < 0.0001$; $R^2 \geq 0.35$). The arthropod community as a whole and especially the phytophagous were strongly affected by the insecticide, showing drastic population decrease on the third day after spraying (Fig. 1A and 1B). From the third day to the 22nd day after imidacloprid spraying there was a steady increase in the arthropod populations of the sprayed area, reaching levels comparable to the non-sprayed area after this period (Fig. 1A and 1B). A similar pattern was also observed for sap-sucking insects (Fig. 2A).

Imidacloprid drastically affected Collembola (Hexapoda) populations preventing their increase during the bean cultivation cycle (Fig. 2B). Collembola abundance reached a maximum 10 to 15 days after the start of the experiment in the non-sprayed area (Fig. 2B). The abundance of *Thrips tabaci* (Lind.) and *Caliothrips brasiliensis* (Morgan) (Thysanoptera: Thripidae) was also maintained at lower levels by imidacloprid up to nearly 20 days after its application (Fig. 3A and 3B), unlike *Frankliniella* sp. (Thysanoptera:

Table 1. Phytophagous and detritivorous arthropods associated with the canopy of common beans (Coimbra - MG, December 1998 to February 1999).

| Order | Family | Species | Abundance (nº specimens collected) | Developmental phases collected[1] | Group of ecological niche[2] |
|---|---|---|---|---|---|
| Acari | Xylobatidae | *Brasilobates bipilis* Perez-Iñigo & Baggio | 600 | A | III, IV, V |
| Coleoptera | Bruchidae | *Acanthoscelides obtectus* (Say) | 400 | A | V |
| | Chrysomelidae | *Cerotoma arcuata* Oliv. | 10,400 | A | IV, V, VI |
| | | *Chrysodina* sp. | 100 | A | IV,V, VI |
| | | *Colaspis* sp. | 300 | A | IV, V, VI |
| | | *Diabrotica speciosa* (Germ.) | 1,600 | A | IV, V, VI |
| | | *Systena* sp. | 400 | A | IV, V, VI |
| | Lagriidae | *Lagria villosa* Fabr. | 1,000 | A | VII |
| Collembola | | sp.1, sp.2, sp.3 | 1,400 | A | VII |
| Diptera | Agromyzidae | *Liriomyza* spp. | 2,400 | L, A | VIIIVI |
| Heteroptera | Alydidae | *Alydus* sp. | 200 | A | III, IV, V |
| | Miridae | *Ceratocapsus* sp. | 100 | A | III, IV, V |
| | | *Collaria oleosa* (Distant) | 200 | A | III, IV, V |
| | | *Garganus gracillentus* (Stål) | 300 | A | III, IV, V |
| | | *Halticus bractatus* (Say) | 1,300 | A | III, IV, V |
| | | *Horciasinus signoreti* (Say) | 100 | A | III, IV, V |
| | | *Hyaliodocoris insignis* (Say) | 200 | A | III, IV, V |
| | | *Phytocoris subvittatus* ( Stål) | 100 | A | III, IV, V |
| | | *Prepops* sp. | 100 | A | III, IV, V |
| | | *Prepops zetterstedti* ( Stål) | 300 | A | III, IV, V |
| | | *Proba vittiscutis* ( Stål) | 200 | A | III, IV, V |
| | | *Piezodorus guildinii* (West.) | 1,600 | A | V |
| | Pentatomidae | *Acrosternum impicticorne* ( Stål) | 300 | A | V |
| | | *Basasa* sp. | 200 | A | V |
| | Pyrrhocoridae | *Dysdercus* sp. | 100 | A | V |
| Homoptera | Aleyrodidae | *Bemisia tabaci* (Gemm.) | 16,100 | A | III |
| | Aphididae | *Aphis craccivora* Koch | 300 | N, A | III |
| | Cicadellidae | *Empoasca kraemeri* (Ross & Moore) | 111,700 | N, A | III, IV |
| Lepidoptera | Hesperiidae | *Urbanus proteus* L. | 100 | L | IX |
| | Noctuidae | *Pseudoplusia includens* Walker | 7,700 | L | IX |
| Orthoptera | Gryllidae | *Grillus assimilis* (Fabr.) | 200 | N, A | I |
| Thysanoptera | Thripidae | *Caliothrips brasiliensis* (Morgan) | 185,600 | A | III, IV, V |
| | | *Frankliniella* sp. | 129,800 | A | III, IV, V |
| | | *Thrips tabaci* (Lind.) | 199,100 | A | III, IV, V |

[1]Developmental phases: N = nymphs; L = larvae; A = adult

[2]Groups by ecological niche: I, II, III, IV, V - represent arthropods associated with stem (I), roots (II), leaf veins (III), flowers (IV) and fruits (V), respectively; VI, VII, VIII, IX - represent sap-sucking (VI), detritivorous (VII), leafminers (VIII) and defoliators (IX), respectively.

Table 2. Predators and parasitoids associated with the canopy of bean plants (Coimbra - MG, December 1998 to February 1999).

| Order | Family | Species | Abundance (n. specimens collected) | Developmental phases[1] | Group[2] |
|---|---|---|---|---|---|
| Aranea | Araneidae | *Alapida veniliae* (Keyserling) | 20,300 | A | PD |
| | | *Argiope argentata* Fabr. | | A | PD |
| | | *Neoscona* sp. | | A | PD |
| | Linyphiidae | *Dubiaranea* sp. | | A | PD |
| | Miturgidae | *Cheiracanthium inclusum* (Hentz) | | A | PD |
| | Oxyopidae | *Oxyopes salticus* (Hentz) | | A | PD |
| | Salticidae | sp.1, sp.2,sp.3 | | A | PD |
| | Tetragnathidae | sp.1 | | A | PD |
| | Thomisidae | *Misumenops* sp. | | A | PD |
| Coleoptera | Anthicidae | *Acanthinus* sp. | 400 | A | PD |
| | | *Anthicus* sp. | 3,800 | A | PD |
| | Carabidae | *Lebia concina* Brullé | 1,300 | A | PD |
| | | *Callida pallidipennis* Chaudain | 100 | A | PD |
| | Coccinellidae | *Cicloneda sanguinea* (L.) | 400 | L, A | PD |
| | | *Coleomegila maculata* (De Geer) | 100 | A | PD |
| | | *Eriops connexa* (Germar) | 100 | A | PD |
| | | *Hyperaspis* sp. | 100 | A | PD |
| Dermaptera | Forficulidae | *Dorus luteipes* Eschs. | 100 | N, A | PD |
| Heteroptera | Anthocoridae | *Orius insidiosus* Say | 6,100 | N, A | PD |
| | Lygaeidae | *Geocoris* sp. | 600 | A | PD |
| | Nabidae | *Nabis* sp. | 2,600 | N, A | PD |
| | Reduviidae | *Repipta* sp. | 500 | A | PD |
| Hymenoptera | Braconidae | sp.1 | 100 | A | PT |
| | Chalcididae | sp.1 | 100 | A | PT |
| | Encyrtidae | sp.1, sp.2 | 1,700 | A | PT |
| | Eulophidae | sp.1, sp.2 | 12,500 | A | PT |
| | Ichneumonidae | sp.1, sp.2, sp.3 | 2,000 | A | PT |
| | Pteromalidae | sp.1, sp.2 | 100 | A | PT |
| | Trichogrammatidae | *Trichogramma* sp. | 1,900 | A | PT |
| | Formicidae | *Crematogaster* sp. | 16 %[3] | A | PD |

[1]Developmental phases: N = nymphs; L = larvae; A = adult
[2]Groups by ecological niche: PD = predators; PT = parasitoids
[3]Frequency (number of samples containing the species/total number of samples x 100)

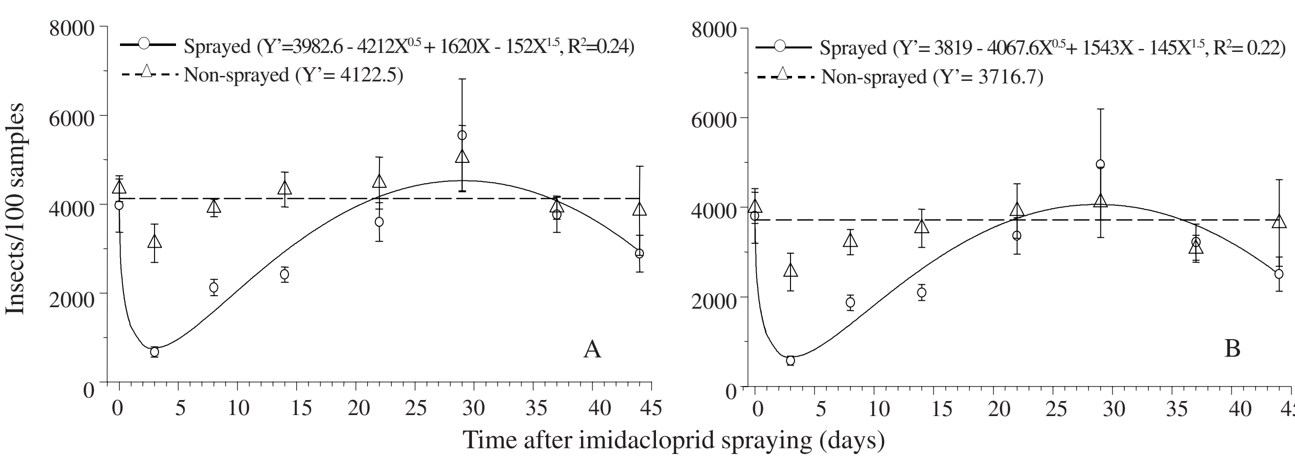


Figure 1. Total number of arthropods (A) and phytophagous insects (B) collected in the canopy of common beans as a function of the time after imidacloprid spraying ($P < 0.001$). Symbols represent the mean of 27 replicates. Vertical bars indicate standard errors of the mean.

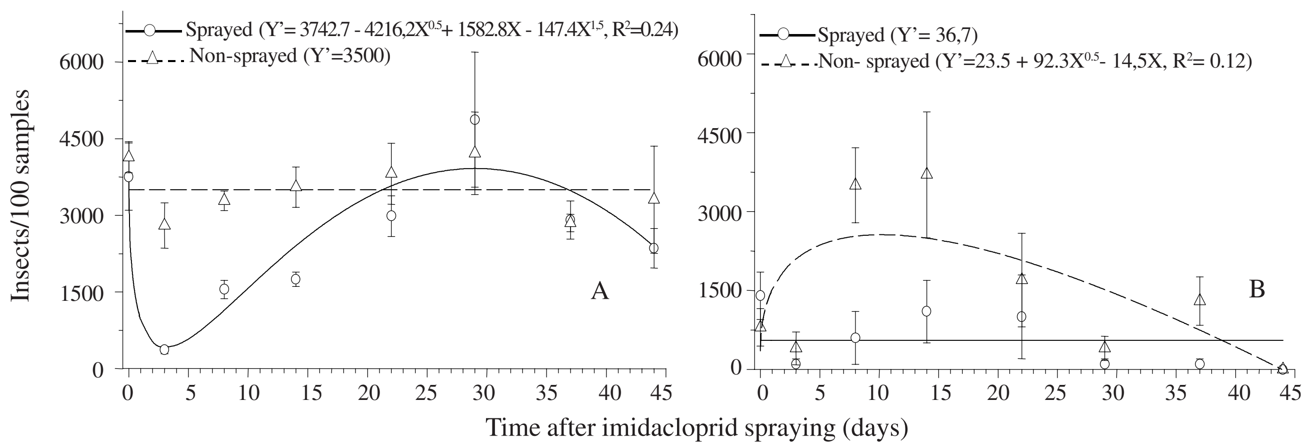


Figure 2. Total number of sap-sucking insects (A) and springtails (Collembola) (B) collected in the canopy of common beans as a function of the time after imidacloprid spraying (P < 0.001). Symbols represent the mean of 27 replicates. Vertical bars indicate standard errors of the mean.

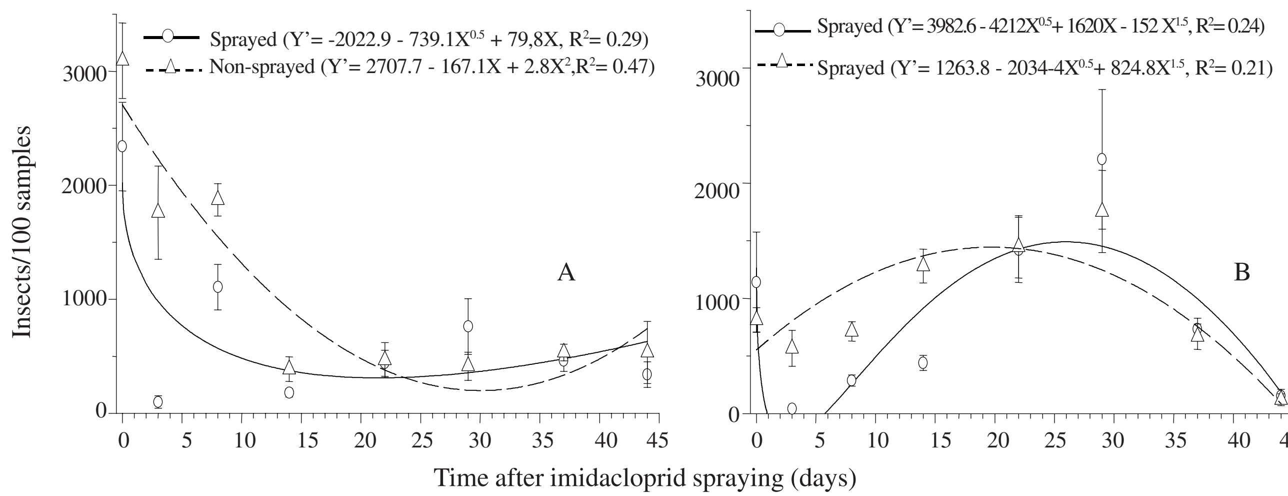


Figure 3. Abundance of *T. tabaci* (A) and *C. brasiliensis* (B) associated with the canopy of common bean plants as a function of the time after imidacloprid spraying (P < 0.001). Symbols represent the mean of 27 replicates. Vertical bars indicate standard errors of the mean.

Thripidae) which was not affected by imidacloprid. The insecticide also did not affect the leafminer *Liriomyza* spp. (Diptera: Agromyzidae), the bean leaf beetle *Cerotoma arcuata* (Oliv.) (Coleoptera: Chrysomelidae), the stink bug *Piezodorus guildinii* (West.) (Heteroptera: Pentatomidae), the soybean looper *Pseudoplusia includens* (Walker) (Lepidoptera: Noctuidae), the whitefly *Bemisia tabaci* (Genn.) (Homoptera: Aleyrodidae), and natural enemies collected on this crop.

The green leafhopper *E. kraemeri* was significantly affected by imidacloprid which reduced its population growth (Fig. 4A and 4B). The insecticide showed a residual effect on *E. kraemeri* which extended for over 30 days. This effect was stronger at farther distances from the intersection between both areas (i.e., 20 to 40 m from the intersection).

## Discussion

One of the main objectives of insecticide impact investigations is the assessment of the primary target community of the insecticidal action and its recovery from this environment stressor. Our study carried out such assessment for the arthropod community associated with the canopy of common beans in a tropical area when exposed to the application of the neonicotinoid imidacloprid. We assessed not only the complex of herbivores and their predators and parasitoids associated with the bean plant canopy, but also other potentially important elements of the arthropod community which are used as bioindicators of insecticidal action, such as epigeal springtails and some ant species (Frampton 1994, De Bruyn 1999, Peck *et al.* 1999).

The range of species significantly affected by imidacloprid was restricted mainly to two thrips species, *T. tabaci* and *C. brasiliensis*, the green leafhopper *E. kraemeri*, and Collembola. These are among the most abundant taxa observed in our investigation, which may have contributed to the higher insecticidal effect suppressing or containing their populations and favoring the detection of such effects when

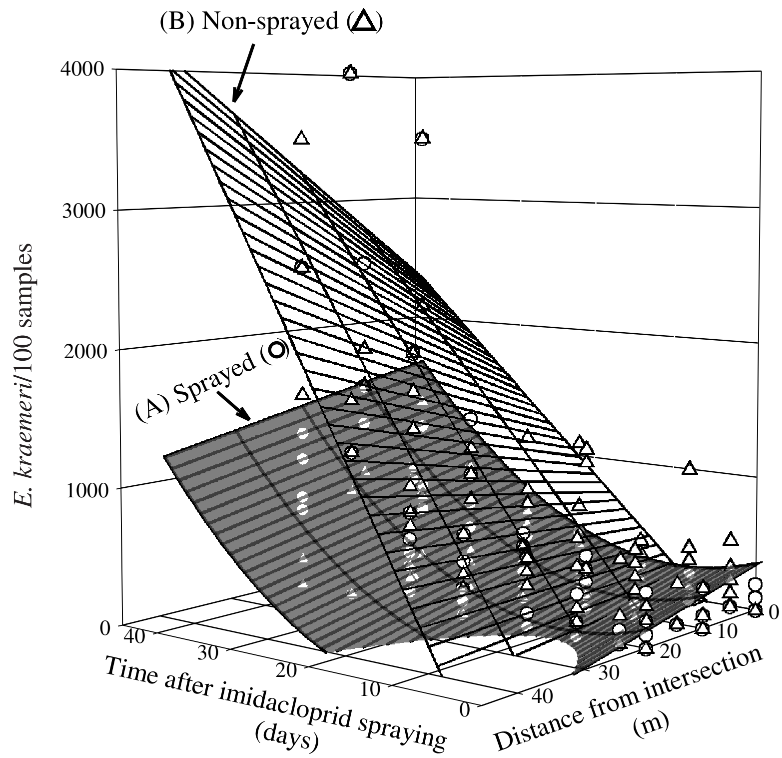


Figure 4. Abundance of *E. kraemeri* associated with the canopy of common bean plants of sprayed (A) and non-sprayed (B) areas as a function of the time after imidacloprid spraying and the distance from the intersection between both areas ($P < 0.001$). Symbols represent the mean of three replicates. Vertical bars indicate standard errors of the mean. (A: $y = 349.4 - 21.9x + 1.2x^2 - 11.0z$ ($R^2 = 0.46$) and B: $y = - 361.7 + 61.0x + 15.8z + 1.4xz$ ($R^2 = 0.35$), were x = time after imidacloprid.

general insect species groups and/or guilds were analyzed. Furthermore, *E. kraemeri*, *T. tabaci* and *C. brasiliensis* are among the primary pest-targets for control with imidacloprid in common beans in Brazil (Andrei 1999).

Imidacloprid impact was particularly strong soon after its application and lasted for 14 to 30 days depending on the taxa. This comes as no surprise since the imidacloprid formulation used in our study has a short photolytic half-life (126 min according with Wamhoff & Schneider, 1999). Its field efficiency against sap-sucking insects usually does not extend over 30 days, as reported by Orozco *et al.* (1995), and its effect containing the growth of Collembola populations reinforces the potential of this taxa as bioindicator of environmental stress by insecticides (Frampton 1994, 1997). However, caution is necessary when using Collembola as bioindicators of insecticidal impact because they may not properly represent the arthropod community in question due to their overall high susceptibility to some insecticides (Sphar 1981), which may lead to an overestimation of the insecticide community effect.

The distance between sprayed and non-sprayed areas was of importance only for *E. kraemeri*. Greater distances from the intersection between both areas showed greater differences in leafhopper abundance. This may be due to the dispersal ability of this leafhopper which seems relatively limited establishing an abundance gradient in the transects with the highest density at the mid-part of the non-sprayed area and lowest density at the mid-part of the sprayed area (Jepson 1989, Carlson *et al.* 1992).

Chewing insects such as the soybean looper (*P. includens*) and insect predators and parasitoids were not affected by imidacloprid, that has also been reported elsewhere (e.g., Boyd & Boethel 1998). However, the alleged efficiency of imidacloprid against a broad range of insect-pests, such as defoliators, thrips, and whiteflies (Orozco *et al.* 1995, Elbert *et al.* 1998), was not observed in our investigation, probably due to the environmental conditions of our experiment, which was carried out in a tropical area during the rainy season. Despite this particularity, imidacloprid was shown not to affect whiteflies and the thrips *Frankliniella* sp (Zhao *et al.* 1995, Horowitz *et al.* 1998). In our study we observed significant effect of imidacloprid on two thrips, *T. tabaci* and *C. brasiliensis*, but not on *Frakliniella* sp., that is curious and deserves further attention. The relative restricting effect of imidacloprid in the arthropod community associated with the bean canopy may partially impair its use in the study region, but the environmental benefit of this trait is interesting and may favor its use against *E. kraemeri, T. tabaci,* and *C. brasiliensis* in pest management programs in tropical common bean fields.

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