Restating the role of Alfalfa Integrated Pest Management in Argentina

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ABSTRACT

The current concepts within the Integrated Pest Management (IPM) framework stem from the contributions by Stern and collaborators (1959), professors of California University, developed precisely for alfalfa crop. At that time, they designed the integration of chemical control with the biological control of the spotted alfalfa aphid. IPM, based on fast and reliable sampling methods, with economic thresholds determined through field research, and the use of selective insecticides that effectively control the target arthropod species but have minor or no impact on beneficial wildlife, is proposed as a sound strategy to reduce economic loss risks without compromising environmental health. IPM integrates concepts from the economic theory and mainly concepts and hypotheses stemming from the ecology theoretical framework, such as the theory of island biogeography (MacArthur and Wilson, 1967); the theory of natural enemies (Doutt & DeBach, 1964); and the resource concentration hypothesis (Root, 1973).

In Argentina, a key IPM workshop was held in 1978, organized by FAO at INTA-Pergamino Experimental Research Station (INTA-FAO, 1978). However, from 1960 to 1985 successful strategies were designed for IPM in cotton by Barral & Zago (1983), leading to a substantial decrease of the number of pesticide applications from almost 15 to 3 through the entire season, an achievement that received international recognition. Following the 1978 workshop, the development of IPM programs were started for wheat, corn, soybean and alfalfa. At that time, the INTA-National Program of Plant Protection had been established and led by R. Parisi (Pergamino), and supported by researchers across the country, such as J. Aragón (Marcos Juárez); J. Ves Losada (Anguil); E. Botto (IMyZA) and J.M. Imwinkelried (Rafaela). They conducted life table and key issues analyses to identify the main natural mortality factors of alfalfa pests with the advice of D. Harcourt (Agriculture Canada). These projects set up the bases for a new approach within the IPM strategy: the conservation of natural enemies. Any activity undertaken on the crop should first be assessed as to how it may affect predators, parasitoids or entomopathogens. Keeping this in mind, for the control of lepidopteran larvae such as those of *Colias lesbia*, *Rachiplusia nu*, *Spodoptera frugiperda, Anticarsia gemmatalis* or *Helicoverpa gelotopoeon,* it was recommended to use *Bacillus thuringiensis* formulations or diamide insecticides, which are known to be selective on natural enemies. When aphids are to be controlled, low dosage of pirimicarb was recommended. Nevertheless, since alfalfa is intended for grazing or cutting, perhaps a low cost option is to anticipate the practice without chemical intervention. On the other hand, a successful program for releasing species of *Aphidius* was developed across the cereal and alfalfa production region in the 1980's.

Unfortunately, as it may occur in many other countries, IPM is poorly adopted. However, farmers who practice the IPM philosophy take advance of difference in control costs by decreasing pesticide sprays. Because alfalfa is a perennial crop, this pasture provides a relatively stable environment during several years, on which beneficial organisms can strive in more diverse and abundant communities (Zumoffen et al., 2010). No doubt, the agricultural landscapes containing alfalfa may benefit from this biocontrol ecosystem service, receiving enemies of shared key pests.

Monitoring alfalfa fields not only aims to key pests but also to keep records of its natural enemies as follows: Trichogrammatidae and Scelionidae as parasitoid of Lepidoptera or Hemiptera eggs; Aphidiinae and Microgastrinae as aphids or larvae parasites, respectively; Ichneumonidae and Braconidae as parasitoid of larvae and pupae; Chalcidoidea and Encyrtidae poliembrionic wasps, as well as Tachinidae, key parasitoids on *Rachicplusia nu*; Tettigoniidae, long horned grasshoppers, as predators of aphids and soft-body bugs; Carabidae as predators mainly in soil; several predators of thrips and Lepidopteran eggs, such as larvae and

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nymphs of genus *Orius, Geocoris, Nabis, Reduviidae* and *Podisus;* some Diptera, which are generalist predators, like Asilidae or Dolichopodidae; or Syrphidae and Coccinellidae, in the form of adults or immature, as specific predators of aphids. Also, there are Chrysopidae predators as larvae and adults, same as Staphylinidae. *Solenopsis* ants also are important predators. Besides, *Balaustium* mite is a common predator in alfalfa fields. There are several species of spiders representing families such as Araneidae, Thomisidae, Oxyopidae, Salticidae, Lycosidae and Clubionidae. Additionally, under certain environmental conditions, entomopathogenic viruses and fungi (like *Nomuraea rileyi*) can reach epizootic levels on *Spodoptera* spp. and *Rachiplusia nu* and then controlling a very high percentage of the populations.

As an example of the potential of the IPM approach, from 19 alfalfa fields at Rafaela INTA Agricultural Experimental Station, between November 2014 and April 2015, only four fields were totally treated (with 4.8, 11.3 and 11.5 *S. frugiperda* larvae / sweepnet, and 7.8 *C. lesbia* larvae / sweepnet); and three were partially treated (with 9.5 and 7.2 *S. frugiperda* larvae / sweepnet and 7.6 *H. gelotopoeon* larvae / sweepnet). In contrast, it is well known that the dairy farmers of the region apply at least one insecticide spray per summer season just for defoliating larvae.

A question may arise regarding how soybean and corn fields may benefit from alfalfa fields in a region. The spillover or movement of subsidized natural enemies from alfalfa is likely to be an important process affecting insect herbivore populations in surrounding crops. Since natural enemies start to build up population density in early spring, these can pass on flight or by wind to neighbouring fields.

As in any other crop, IPM in alfalfa needs constant revision. All IPM programs, as they are explained on methodological bases, must target the main pests, which are in a dynamic process. For many years, the main defoliators were *R. nu* and *C. lesbia*. However, perhaps *S. frugiperda* has become comparatively more important in the last ten years, due to temperature increase that has favored its earlier development in the growing season.

As previously mentioned, aphids -as key pest of alfalfa- were targeted with several approaches. Firstly, a program of classical plant breeding was established resulting in several alfalfa varieties exhibiting tolerance or antixenosis. Secondly, conservation of ladybug beetles and parasitoids in the field has been crucial for keeping aphid populations at low densities. During July 2018, an unusual density of alfalfa blue aphid (*Acyrthosiphon kondoi*) was present on the entire alfalfa growing region of Central Argentina, where more than 600 aphids / stem were recorded. Perhaps, such extraordinary infestation may have been the consequence of planting seeds with narrow genetic diversity. Indeed, the increase of aphids that brake resistance of previously resistant cultivars is favored by parthenogenesis, an asexual process by which the offspring is an exact replicate of the parent. This scenario resembles what could has happened some years ago when *A. kondoi*-Raf.1990 biotype was detected as a result of the high selection pressure imposed on the aphid population when a very few cultivars were seeding on more than 50% of the region.

Another interesting debate is referred to the need of *Bt*-alfalfa to solve pest problems: Is it really necessary? There are many arguments against the real need of *Bt*-alfalfa. Even though Lepidopteran larvae are a problem, they can be managed in several ways, including anticipating harvest. But one thing should be kept in mind: if farmers failed to adopt refuges in *Bt*-maize and *Bt*-soybean, it could hardly be expected that farmers will adopt refuges in *Bt*-alfalfa. The important issue to discuss is the constant selection pressure exerted by *Bt* gene on insect populations, particularly because alfalfa a perennial crop and so selection pressure will act for more than four years in every field. Besides, *Cotesia ayerza* (Hymenoptera: Braconidae), a gregarious parasitoid of *C. lesbia*, begins its unnoticed control since the end of winter (August) of each year. While the host is considered a summer pest, should we expect to find *C. ayerza* in *Bt*-alfalfa fields? Or concerns about local extinctions are reasonable?

Alfalfa IPM in Argentina is far from reaching an ideal situation. There is a complexity in the dairy production system, where the person in charge of dairy cattle and the milking process coexists with the production of the pastures and the feed stuff. Generally, pest control rests on the use of pesticides. However, IPM and its economic feasibility have already been demonstrated (Imwinkelried et al., 1992). On the other hand, when law prohibits pesticide use in periurban areas there is a potential contribution of alfalfa as a buffer zone to mitigate social conflicts.

Finally, as shown above, there is evidence that alfalfa crops provide stable environments that harbors a community of beneficial insects, like predators and parasitoids, and other organisms like dung beetles, providing real ecosystem services. No doubt then, the conservation of natural enemies of key pest must be the strategy to enhance and promote an alfalfa IPM philosophy in Argentina.

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