CONTROL OF CLEONUS (*TEMNORHINUS MENDICUS*) WITH SOIL INSECTICIDES IN LOCALISATION DURING SOWING AND SEED DRESSING IN SUGAR BEET - SECOND CONTRIBUTION

GIOVANNI CAMPAGNA, MASSIMO ZAVANELLA

Servizio agronomico CO.PRO.B. - Via Mora, 56 - Minerbio 40061 Italy

SUMMARY

An investigation is reported regarding some environmental controlled tests and on field trials with soil insecticides used in localisation during sowing and/or as seed dressing. The trials aimed to evaluate the degree of control of cleonus after the very interesting results obtained in a previous contribute. The heavy losses caused to beet crops from the gradual coming out of the weevil during spring, can be avoided with soil insecticides. In-checking the degree of the control of sugar beet weevil by usage of traditional and new soil insecticides, we noted that fipronyl had the best results. Fipronyl used both as seed dressing and in localised application during sowing, allowed a high control of this harmful insect.

The use of thiametoxam on seed determined inappetence, but with this soil insecticide is possible to obtain good efficacy too. The use of soil insecticides made unnecessary the utilization of other insect-killers, thus reducing the environmental impact and the waste of money, and improve the managing of the crop.

SOMMAIRE - LE CONTROLE DU CLEONE (*TEMNORHINUS MENDICUS*) PAR DES INSECTICIDES DE SOL UTILISES DE FACON LOCALISEE PENDANT LA SEMAISON ET COMME ENROBEMENT DE LA SEMENCE DE LA BETTERAVE SUCRIERE

Cette étude concerne certaines expériences en milieu contrôlé et essais sur le terrain avec des insecticides de sol utilisés localement lors des semis et/ou comme enrobage des semences. Les essais étaient destinés à évaluer le degré de contrôle du cléone mendiant après les résultats très intéressants obtenus lors d'une contribution précédente. Les lourdes pertes causées sur les cultures de betterave à partir de la sortie progressive du charançon au cours du printemps peuvent être évitées grâce aux insecticides de sol. En vérifiant le degré de contrôle du charançon de la betterave à sucre par l'usage d'insecticides de sol traditionnels et nouveaux, nous avons observé que le Fipronyl présentait les meilleurs résultats. Utilisé à la fois comme enrobage des

semences et en application localisée lors des semis, le Fipronyl a permis un contrôle élevé de cet insecte nuisible. L'utilisation du Thiametoxam sur les semences a déterminé une inappétence, mais il est également possible d'obtenir une bonne efficacité avec cet insecticide de sol. L'usage d'insecticides de sol a rendu inutile l'utilisation d'autres insecticides, réduisant ainsi l'impact sur l'environnement et le gaspillage financier, et améliorant la gestion de la culture.

ZUSAMMENFASSUNG - DIE KONTROLLE DES RUBENRUBLERS DURCH DIE BODENINSEKTIZIDE, DIE LOKALISIERT WAHREND DER SAAT UND IM PILLENSAAT VERWENDET WERDEN

Diese Untersuchung befasst sich mit Umweltprüfungen und Freilandversuchen zu Bodeninsektiziden vor Ort während der Aussaat und/oder bei der Saatgutbehandlung. In den Versuchen sollten die Möglichkeiten zur Bekämpfung des Cleonus bewertet werden, nachdem in einer vorangegangenen Studie bereits einige sehr aussagekräftige Ergebnisse erzielt worden waren. Die gravierenden Ernteeinbußen beim Rübenanbau durch das allmähliche Ausschlüpfen des Rüsselkäfers im Frühling können durch den Einsatz von Bodeninsektiziden verhindert werden. Bei der Untersuchung der Wirksamkeit der Bekämpfung des Spitzsteißrüsslers mit herkömmlichen und neuen Bodeninsektiziden erwies sich Fipronyl am effektivsten. Durch die Anwendung von Fipronyl sowohl als Saatgutbehandlungsmittel als auch lokal während der Aussaat konnte der Schädling sehr gut bekämpft werden. Die Verwendung von Thiamethoxam bewirkte eine Fressunlust für das Saatgut, mit diesem Bodeninsektizid konnten jedoch ebenfalls gute Ergebnisse erzielt werden. Werden Bodeninsektizide verwendet, erübrigt sich der Einsatz anderer Insektenbekämpfungsmittel. Die Umweltbelastung wird verringert, Kosten werden eingespart, und der Ernteertrag lässt sich genauer vorhersagen.

INTRODUCTION

In the modern conception of sustainable agriculture, studies of the control of cleonus on sugar beet concentrate in particular on biological control agents, including fungal agents such as *Beauveria bassiana* or potential entomophages and parasites, including the use of nematodes from the genera *Steinernema* and *Heterorhabditus*, which are particularly active towards curculionid beetles (Curto and Boselli, 1996; Akalach and Wright, 1997; Boselli *et al.*, 1997; Tacconi *et al.*, 1998).

During its initial development stages, sugar beet is a fairly delicate crop due to its slow growth. For this reason soil insecticides are used to protect the entire root and leaf systems of young seedlings from insect attack, although their high capacity for subsequent recovery makes it possible to minimise production damage. Limited doses of fipronyl used on sugar beet as a seed dressing or in localised application during sowing is shown to be highly effective towards cleonus (Campagna and Zavanella, 2002). At the same time it affords long-term control of a large number of parasites due to the high persistency of the active ingredient and its metabolites in the soil and within the plant tissues (PAN, 2000). Due to its effectiveness and only moderate toxicity for humans, fipronyl has become one of the most widely used insecticides in the fields of agriculture, veterinary medicine and public health over the past few years. At a world level, however, its use for the purposes of sustainable agriculture is under discussion and it is generally considered necessary to appraise its suitability on a case by case basis. For example, application of fipronyl is not considered eco-compatible in rice paddies due to its high persistence and the risks of bioaccumulation of some of its metabolites in adipose tissues in organisms in the food chain. Furthermore, its broad action spectrum would be liable to cause serious harm to aquatic organisms and useful entomofauna. By contrast, its use as a soil insecticide is considered sustainable thanks to its high efficacy at very limited dosages and its low mobility within the soil.

The aim of this second contribution was to further evaluate the degree of efficacy towards cleonus of fipronyl in localised application at sowing and as a seed dressing with very low dosages compared with the other most widely used soil insecticides, as well as that of tiametoxam applied as a seed dressing, a new second-generation neonicotinoid insecticide with high systemicity and capable of offering long-duration protection of the crop from insects with piercing-sucking and masticating mouthparts (Campagna *et al.*, 2002). Furthermore, we also aimed to verify specific action towards cleonus, in particular that of fipronyl, in different soil types and soil moisture conditions, and the persistence of action and appearance of symptoms in the laboratory and in the field.

MATERIALS AND METHODS

The experimental trials were carried out in the laboratory and in the field on medium texture and clay soils in the province of Bologna in 2002. Adult cleonus were obtained by capturing them in the field during the spring. Trap bottles were positioned along the insect migration routes from plots where sugar beet damage had been reported the previous year. Once captured, the cleonus adults were fed with sugar beet leaves in special rearing boxes before carrying out the series of trials during the days following capture, the period in which field control towards this harmful insect is performed.

LABORATORY TRIALS

<u>Control units</u>: plastic cups of capacity 1 litre.

<u>Test cases</u>: a comparison was made of samples of leaves of sugar beets sown in the field with about 1.6 seed units/ha (15.9 seeds/sq.m), without soil insecticide and with soil insecticide using imidacloprid and fipronyl according to the methods given in Table 1.

<u>Introduction of cleonus adults and feeding</u>: at different stages of development of the sugar beet grown in the field, leaves were taken from 12 plants for each individual trial and placed in the control units together with 4 cleonus adults.

<u>Distribution schema</u>: the control units replicated 4 times were subdivided into

randomised blocks and placed in the room at 14-18°C and 60-70 % relative humidity, in low light conditions.

Measurements and observations: following the introduction of cleonus adults, the degree of feeding and the state of vitality of the insects were evaluated daily, distinguishing living mobile insects from those that were paralysed or dead.

FIELD TRIALS

Control units: areas of surface area 1 m^2 containing 10 sugar beet plants in the field delimited with nets to prevent the insects from escaping.

Test cases: Primera variety sugar beet sown in the field with about 1.6 seed units/ha (15.9 seeds/sq.m) in medium texture and clay soils, using soil insecticides according to the methods given in tables 2 and 3.

Method of performing trials: on a medium texture soil, the test cases were differentiated into a further two methods of performance in addition to the normal field method. These were: one completely dry regime and one with irrigation commencing during the first stages of development of the crop, with 2 irrigations each of 10 mm before the rains that fell during the second dekad of April, and another 2 irrigations of 10 mm during the third dekad of April.

Introduction of cleonus adults: 5 cleonus adults were introduced into each control unit in different locations, experimentation cycles and stages of sugar beet development.

Measurements and observations: following the introduction of cleonus adults into the control units, the degree of leaf feeding (estimate of % of defoliation) by the insects and their state of vitality were evaluated every 3 days, distinguishing living mobile insects from those that were paralysed or dead. When the crop was harvested during the second dekad of August, a count was made of damaged sugar beet roots and superficial and deep bites caused by the larvae during the summer period.

Production control: upon harvesting the sugar beets, root samples were taken for analytical control of quantitative and qualitative parameters.

RESULTS

The following results were obtained during the test cycles performed in the laboratory and in the field during 2002.

LABORATORY TESTS (TABLE 1 – FIGS. 1-2-3-4)

From a study of the degree of efficacy of fipronyl (localised application at a dosage of 80 g/ha) as a function of rainfall, which occurred from the 2-4 leaf stage onwards (Fig. 1), it emerged that the soil insecticide initially displayed a lower degree of action following the almost complete absence of rain. The insects kept in conditions of low light and temperatures of between 14° and 18° C and fed with sugar beet leaves collected in the field at different stages of development initially displayed a lower degree of mortality and immobilization due to the smaller quantity of leaf system ingested daily and probably also due to the low concentration of active ingredient, which does not display leaf systemicity. The efficacy increased gradually as the sugar beets developed and with the rains that fell frequently and abundantly prior to the four-leaf development stage, a stage at which sugar beet leaf damage generally begins to appear in the field with greater frequency. The degree of mortality then stabilised at maximum values with a slight fall 75 days after sowing, coinciding with the onset of foliage coverage. The symptoms of intoxication and immobilization followed by mortality occurred with greater rapidity from the point at which the cleonus adults were fed with sugar beet at the 4 leaf stage onwards (Fig. 2), whereas it was slower with sugar beets at the 2 leaf stage, a stage at which it had not yet rained in the field, and with sugar beets at the start of foliage coverage, when the concentration of fipronyl within the tissues of the most developed leaves was lower.

>From the study of the degree of efficacy of the different combinations of imidacloprid and fipronyl (Table 1 – Fig. 3), a slowly increasing progression of symptoms was observed up to about 4 weeks. This was observed in cleonus adults fed in relatively low temperature conditions (but conditions nonetheless frequently recorded during the spring). However, the efficacy was shown to be proportional to the increasing dosages of the most active insecticide, fipronyl. A higher degree of inappetence and consequently lower action towards these insects was observed when feeding with leaves of sugar beet grown with imidacloprid + fipronyl as a seed dressing. The degree of efficacy obtained with the different soil insecticide combinations is shown in Fig. 4, where complete action was obtained with fipronyl applied in localisation. However, even with fipronyl applied as a seed dressing at just 15 and 7.5 g/seed unit, it was possible to achieve a high degree of mortality compared to the same dosages applied as a mixture with imidacloprid.

FIELD TRIALS – MEDIUM TEXTURE SOIL (TABLE 2 – FIGS. 5-6-7-8-9-10-11-12-13)

In the field trials carried out on medium texture soil where the cleonus adults were introduced at different times from the cotyledon stage onwards, it was possible to observe severe damage in sugar beet plants not treated at the cotyledon/2-leaf stage (Fig. 5-6) and the early appearance of the insects. During the initial stages, this can lead to complete leaf destruction in unprotected sugar beets. However, good protection is provided by all soil insecticides, including imidacloprid and tiametoxam, which rapidly give rise to a certain degree of inappetence in the cleonus adults, even though the insects continue to feed at a slower rate. This is particularly evident with imidacloprid, in contrast with fipronyl which does not produce inappetence and the cleonus adults feed normally during the first few days following introduction. Nonetheless, the insects display symptoms of intoxication followed by death within a relatively short space of time (Fig. 7), again depending on environmental conditions which mainly influence their degree of mobility. Tiametoxam has shown a good degree of efficacy, intermediate between imidacloprid and fipronyl in terms of both efficacy and defoliation.

As regards a comparison between the degrees of action towards the cleonus adults in the control units in different soil moisture regimes, namely completely dry, normal soil/climatic conditions and irrigation, the following was observed (Figs. 8-9-10-11): all the soil insecticides displayed a higher degree of efficacy in a dry regime and less under irrigation compared to field conditions, although this was less evident with thiametoxam.

As regards the control of root damage caused by the larvae during the summer period, we observed (Fig. 12) complete control of cleonus by fipronyl applied as a seed dressing at a dosage of 15 g and slightly more limited control with the lower dosage of 7.5 g/seed unit, applied alone or as a mixture with imidacloprid. Thiametoxam showed a good degree of control, in any case higher than imidacloprid, which although not displaying a high degree of action nonetheless reduced attacks by an average of almost 50% compared to the untreated control. A high degree of action with fipronyl was also observed towards the adult cleonus introduced late with sugar beets at the start of the foliage covering stage (Fig. 13). The action of fipronyl very probably extended not only to the adults but also to the larvae beginning trophic activity on the sugar beet roots, since although the adults died within a fairly short space of time, the higher temperatures recorded during the period and the greater vitality of the insects meant that they were able to deposit numerous eggs following introduction into the control units and prior to the onset of symptoms of intoxication.

FIELD TRIALS – CLAY SOIL (TABLE 3 – FIGS. 14-15-16)

During investigations with the most extensive soil insecticide combinations conducted on clay soil with sugar beet sown at a later stage in mid-March (Table 3 and Figs. 14-15), it was possible to observe that all the soil insecticides used in localised application or as a seed dressing displayed a certain degree of control of leaf damage caused by these curculionid beetles, including the less effective benfuracarb and carbosulfan which were taken as reference. Least damage was inflicted in the case of fipronyl used at the highest dosage as a seed dressing or in localised application, in spite of the damage caused prior to the onset of symptoms of intoxication and subsequent death. Intermediate behaviour relative to imidacloprid and fipronyl was displayed by thiametoxam, which together with a certain degree of inappetence gave rise to symptoms of intoxication in relatively short timeframes on the majority of the population of cleonus introduced into the control units, resulting in a good degree of efficacy. Excellent action was displayed by fipronyl at all dosages and with all distribution methods, apart from the smallest dosage of 7.5 g in a mixture with imidacloprid, which showed lower mortality compared to the same dosage of fipronyl applied alone. This was due to the partial inappetence caused by imidacloprid which resulted in ingestion of a smaller quantity of insecticide by the insects.

From the trial carried out on the roots at the time of sugar beet harvesting (Fig. 16), we can observe the excellent efficacy of the highest dosages of fipronyl, which acted directly on the cleonus adults but probably also on the larvae given the late introduction of insects already at the oviposition stage and with sugar beet plants at the 12-14 leaf stage. A good control action by tiametoxam was also observed.

PRODUCTION ANALYSIS (FIG. 17)

From a production analysis of the sugar beet roots damaged by cleonus, performed upon harvesting the crop by weighing and comparing samples with healthy sugar beet, we were able to observe a reduction in polarization and weight and therefore in sucrose production of up to 50% or more in the case of the most severe attacks. Furthermore, against a small reduction in alpha-amino nitrogen, there was a significant increase in the other two quality components, potassium and sodium, and in particular the invert sugar content, resulting in a considerable reduction in the industrial quality of sugar beet.

Figs. 1-2 – Evolution of the efficacy of fipronyl in relation to rainfall and sugar beet growing. Laboratory trials: insects kept in conditions of low light, temperature between 14° and 18° C and fed with sugar beet leaves collected in field (80 g/ha of fipronyl in localization during sowing)

Tab. 1 – Figs. 3-4 – Laboratory trials: insects fed with sugar beet leaves collected in field.

Tab. 2 – Figs. 5-6-7 – Field trials: medium texture soil

Figs. 8-9-10-11 – Efficacy in different soil moisture regimes: completely dry, normal conditions and with irrigation (31-03-2003 10 mm and 05-04-2003 10 mm before rainfall; 23-04-2002 10 mm and 28-04-2002 10 mm)

Tab. 2 – Figs. 12-13 – Field trials: medium texture soil

Tab. 3 – Figs. 14-15-16 – Field trials: clay soil

CONCLUSIONS

At the end of this further study of cleonus control using soil insecticides in localised application at sowing or as a seed dressing, we can confirm that fipronyl has a high efficacy of action even at the lower dosages of 7.5 g/unit (100,000 seeds), although this represents a limit which in unfavourable conditions of use may constitute incomplete action towards major cleonus attacks. A good degree of efficacy was displayed by tiametoxam, which was able to protect the sugar beets from leaf attacks by cleonus and caused an inappetence effect in the insects, albeit to a lesser extent than imidacloprid. Furthermore, it caused severe symptoms of intoxication in a relatively short timeframe and although it did not produce complete mortality it allowed root damage to be considerably reduced. A milder, insufficient action was observed with the use of imidacloprid and more specifically the other traditionally used soil insecticides.

As regards the different soil moisture regimes, we observed a greater final degree of action on the part of the soil insecticides in dry conditions, with the partial exception of tiametoxam which appeared less dependent on rainfall. In particular, fipronyl, classified as non-systemic, displayed a smaller degree of initial action following the low rainfall, probably due to the lower concentrations of product in circulation in the sugar beet leaf tissues. This was also observed with highly developed sugar beets, since the cleonus adults had to ingest a greater quantity of leaves before displaying symptoms of intoxication followed by death in a timeframe proportional to the insect's degree of vitality and hence greater trophic capacity, which is influenced directly by temperature. However, the persistence of the insecticide associated with a high degree of biological action remained high over time, assuring an excellent degree of protection of the crop in different soils and for the entire life cycle of the adult phase of cleonus, which is notoriously long due to the gradual nature of the insects' emergence from the ground during spring. Furthermore, at the highest dosages of use it remained active against extremely late attacks by insects capable of ovipositing before commencing trophic activity.

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