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COMPARING INSECTICIDES AND DISTRIBUTION TECHNIQUES AGAINST RED PALM WEEVIL

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ABSTRACT

The Red Palm Weevil (RPW), *Rhynchophorus ferrugineus* (Olivier, 1790) is the major pest for both amenity and economic palms all over the world. RPW inflicts severe economic losses and several techniques have been proposed to lower its population below the economic threshold. Chemical control on healthy (symptomless) palms are the only suitable approach to control RPW infesting *Phoenix canariensis* because of its preventive and protective actions (2P).

Different techniques permit to distribute insecticides. Six different active ingredients were tested: Imidacloprid, Thiametoxam, Dimethoate and Abamectin by tree injection, and Clothianidin and Azadirachtin through tree injection and soil application. The research was performed over a total of 111 *Phoenix* palms, namely eighty-nine *P. canariensis* plus twenty-two *P. dactylifera* in different countries (Italy, Malta and Syria). Treatments were carried out in homogeneous plots testing different insecticides and distribution techniques in order to evaluate distinctive protective and preventive effects for each active ingredient. We compared uptake dynamics, side effects and effectiveness along with the fallouts of phytosanitary treatments in urban centres and commercial palm plantations, insecticide phytotoxicity, cost effectiveness of the different distribution methods.

Keywords: Red Palm Weevil, Canary Palm, Date Palm, Arecaceae, active ingredient.

RESUME

Le charançon rouge (CR), *Rhynchophorus ferrugineus* (Olivier, 1790), est le ravageur clé du palmier dattier et des palmiers d'ornement sur lesquels il occasionne des dégâts économiques importants. De nombreuses techniques ont été mises au point pour réduire quantitativement la présence de cet insecte. Les traitements chimiques réalisés sur les palmiers sains (asymptomatiques) s'avèrent être la seule solution appropriée dans le cas de *Phoenix canariensis* étant donné qu'ils ont une efficacité préventive et de protective (2P).

Plusieurs techniques peuvent être employées pour distribuer des insecticides et nous allons décrire ici notre expérience concernant six substances actives : l'imidaclopride, le thiametoxam, le diméthoate et l'abamectine, utilisés par injection, et la clothianidine et l'azadirachtine utilisées par injection et aussi par application directe au sol. Cette étude a été effectuée sur un total de 111 palmiers du genre *Phoenix* (89 de l'espèce *canariensis et* 22 de l'espèce *dactylifera*) dans différents pays (Italie, Malte et Syrie). Le traitement a été réalisé sur des parcelles homogènes en testant différents insecticides et techniques de distribution afin d'évaluer les effets spécifiques de protection et de prévention pour chaque substance active.

Nous avons comparé la dynamique de l'absorption, les effets secondaires et l'efficacité et nous avons également pris en compte les conséquences des traitements phytosanitaires sur les palmiers en milieu urbain et dans les vergers commerciaux, les problèmes de phytotoxicité, les avantages et coûts des différents modes de distribution.

Mots-clés : Charançon rouge, Palmier de Canarie, Palmier datier, *Arecaceae*, Substance active.

INTRODUCTION

The action threshold to control RPW infestation on cultivated palms is related to the plant use and management. Amenity palms as *Phoenix canariensis* (PC) are grown in South Europe and Mediterranean shores as long-lived urban trees. Twenty-meters tall plants of about one century life span were common in historic downtown of many Cities in Italy, France and Spain, before the unwanted RPW introduction.

Such plants with high landscape and social value were (and some still are) unique, impossible to substitute in the urban panorama.

Pest lethality is a further key factor while assessing a RPW control strategy; it is strictly connected with the infested palms inability to recover from weevil and associated microorganisms damages because of their peculiar stipe anatomy.

Plant uniqueness and pest lethality key factors both concur to require a nearly zero action threshold suggesting Preventive and Protective (2P) means of control.

None of the suggested alternative means of control such as wide area mass trapping, SIT, biological control by nematodes or fungi, early detection by sound or vibration detection, physical barriers or phytosanitation can help RPW control while infesting PC. This is both because they cannot lower the pest population below a nearly zero action threshold, and because they do not prevent the pest from infesting and killing the palms.

Actually, none of those control means are protective and preventive and the pest can inflict *year-by-year additive* losses to the palm population and, thus, exterminate the palms over a ten-twenty time span.

Chemical preventive control is, thus, the only rationale to control RPW population while infesting PC, eventually in association with tree surgery or entomopathogenic fungi in IPM strategy.

This study focuses on the proper means to distribute several insecticides to control Red Palm Weevil while infesting *P. canariensis* in urban area; some comparative data obtained from *P. dactylifera* were added. The trial was intended for preventive and protective control of RPW and, thus, carried out on asymptomatic palms.

MATERIALS AND METHODS

Plot description

Italy

Eighteen, about forty-five years old, PC were treated by imidacloprid or dimethoate in IAM-B garden near Valenzano (Bari). Ten *P. canariensis* about one hundred years old and growing in a private garden near Santo Spirito (Bari) were injected with imidacloprid. Eighteen palms growing near Monteruscello plus nine near Pozzuoli (Naples), all about forty years old and in private gardens, were treated by abamectin, clothianidin and azadirachtin. All the palms involved in Italian trials were regularly attended with usual cultural cares and regular watering; leaf pruning was biennial.

Syria

Twelve *P. dactylifera* were injected in Aleppo and further ten in Lattakia (Syria). Those palms were all amenity trees shading a public square and a private garden, respectively. They were about fifty-years old plants, barely attended with any given watering.

Malta

Twenty-eight PC about forty years old plus further six palms about one hundred years old, all growing in “San Anton Gardens” area (Triq Birbal, Attard) were injected by imidacloprid. All Maltese palms were regularly attended with regular cultural cares and regular watering; leaf pruning was biennial.

All the chosen plants were untreated and asymptomatic at time zero of experiences. Tree-injection was given by a patented method & tool, purposely developed for large stem Arecaceae (AA.VV., 2009).

Active ingredients (a.i.) & formulations

Six a.i., namely Dimethoate, Imidacloprid, Thiametoxam, Abamectine, Clothianidin and Azaridactin A were delivered into the palms by injection. Each a.i. was directly poured as commercial formulation into the injector. The proper formulation amount was calculated on the basis of the part of the stipe to protect and on its water content, detected as described in

Porcelli *et al.* (2009a). Being the data almost homogeneous for the chosen plants we found a dose from 16 to 120 ml of formulation per palm, depending on a.i. concentration and pest lethality. Moreover, gently pressurized (0,1-0,3 Bar) tap water helped the insecticide transfer into the palm tissues (Porcelli *et al.,* 2009b).
Further Clothianidin and Azaridactin A were also delivered by direct soil distribution in water solution.
Residue analyses were obtained sampling from basal leaves petioles after the first treatment. Further insecticide distributions were given every one or two months depending on the active substances. Trials in IAM-B started in 2008 and are still running while other trials near Bari were made in 2009-2011, in Naples trials lasted from 2009 to 2010. Malta and Syria were involved in 2009. Data are given in ppm by HPLC/GC-MS analysis in officially recognized laboratory. The samples were taken at Days After Treatment (DAT) as declared on each graph. Each residue value is an arithmetic mean among data obtained from each palm into the plot.

RESULTS AN DISCUSSION

Active ingredient uptake dynamic

Dimethoate

Almost all the tree experience of dimethoate injections (tab. 1 & fig. I: 1-3) have shown the same a.i. uptake dynamic. To be specific dimethoate is quite fast in peaking its maximum residue at 3 DAT. Later the curve lowers but some residues are still perceivable at 60 DAT. Since the curve lowers, we infer that palm shall uptake the a.i. in two days or less. Experiences in Lattakia and Aleppo (Syria, tab. 1 & fig. I) show a logistic-like a.i. residue curve that may be due to differences in *P. dactylifera* stipe structure in comparison (Tomlinson, 1961) to that of *P. canariensis*. A well-known phytotoxic effect, blackening of leaf midribs, occurred frequently in case of year-long repeated treatments.

Imidacloprid

Even Imidacloprid residue curve has almost the same behaviour (tab. 1& fig. I: 4-6). Very interestingly, the a.i. has a latency period of about fifteen days at relatively low level. After that residues increase during the following fifteen days to a peak, thus slowly lowering. The a.i. has still a rather high level to 60 DAT (tab. 1& fig. I: 4-5) or 75 DAT (tab. 1& fig. I: 6). The persistence of the a.i. is remarkable also because the general residue level. Any phytotoxic effect was observed.

Table 1 - General uptake dynamic data of the active ingredients tested by tree-injection. Second column reports a.i., place of the trial, dose of formulation per palm (DAT: Days After Treatment).

Dynamique générale d'absorption des matières actives évaluées par injection dans le stipe. La matière active, le localité de l'essai et la dose de formulation appliquée par palmier sont données en seconde colonne (DAT : Jours après traitement).

1	Dimethoate Italy (IAM-B) 20 ml/palm	0.506	0.419	0.236	0.016			
	DAT	3	15	30	60			
2	Dimethoate Italy (Bari S. Spirito) 20 ml/palm	0.540	0.519	0.221	0.014			
	DAT	3	15	30	60			
3	Dimethoate Syria (Lattakia and Aleppo)	2.300	2.080	0.300	0.100	0.060	0.001	
	DAT	3	15	30	60	75	90	
4	Imidacloprid Italy (IAM-B) 20 ml/palm	0.011	0.012	0.032	0.021			
	DAT	3	14	30	60			
5	Imidacloprid Italy (Bari S. Spirito) 20 ml/palm	0.015	0.018	0.039	0.024			
	DAT	3	14	30	60			
6	Imidacloprid Malta (Triq Birbal, Attard) 20 ml/palm	0.011	0.012	0.032	0.021	0.016		
	DAT	3	14	30	60	75		
7	Thiametoxam Syria (Lattakia and Aleppo) 20 ml/palm	0.001	0.123	0.140	0.001			
	DAT	3	14	30	60			
8	Abamectin Italy (Naples) 100 ml/palm	0.027	0.018	0.018	0.020	0.015	0.013	0.017
	DAT	1	3	8	10	14	24	35
9	Clothianidin Italy (Naples) 15 gr/palm	0.860	0.840	0.840	0.800	0.620	0.560	0.38
	DAT	1	3	8	10	14	24	35
10	Azadirachtin Italy (Naples) 120 ml/palm	1.080	0.960	0.300	1.920	1.260	0.420	0.2
	DAT	1	3	8	10	14	24	35

Thiametoxam
Experience in Syria with thiametoxam reports a “late peaking dynamic” similar to that of imidacloprid (tab. 1& fig. I: 7). In this case the peak is almost symmetrical and about 60 DAT long. Unfortunately residues are very low at start and at the end of the curve, thus describing a not so promising behaviour.
The late peaking dynamic given by both neonicotinoids should be due to the blocking of pesticide and to the consequent late, slow release of the a.i. into the plant. Any phytotoxic effect was observed.

Abamectin
This a.i. is a natural fermentation derivative and uptakes quickly reaching its maximum at first DAT (tab. 1& fig. I: 8). Later residues lower considerably also because of the low lethality of the Avermectins B1a&b mixture. The decreasing curve has two peaks at 10 and 35 DAT. Any phytotoxic effect was observed.

Clothianidin
This further neonicotinoid does not show the late peaking dynamic of Imidacloprid and Thiametoxam while injected into the palm stipe (tab. 1& fig. I: 9). Uptake is fast and the peak is on the first DAT. Residues go gradually down to 35 DAT, with still consistent residue. On the contrary soil distribution shows a quite fast loss of residues that are below the analytic sensitivity starting from 8 DAT (tab. 2& fig. I: 11). Any phytotoxic effect was observed.

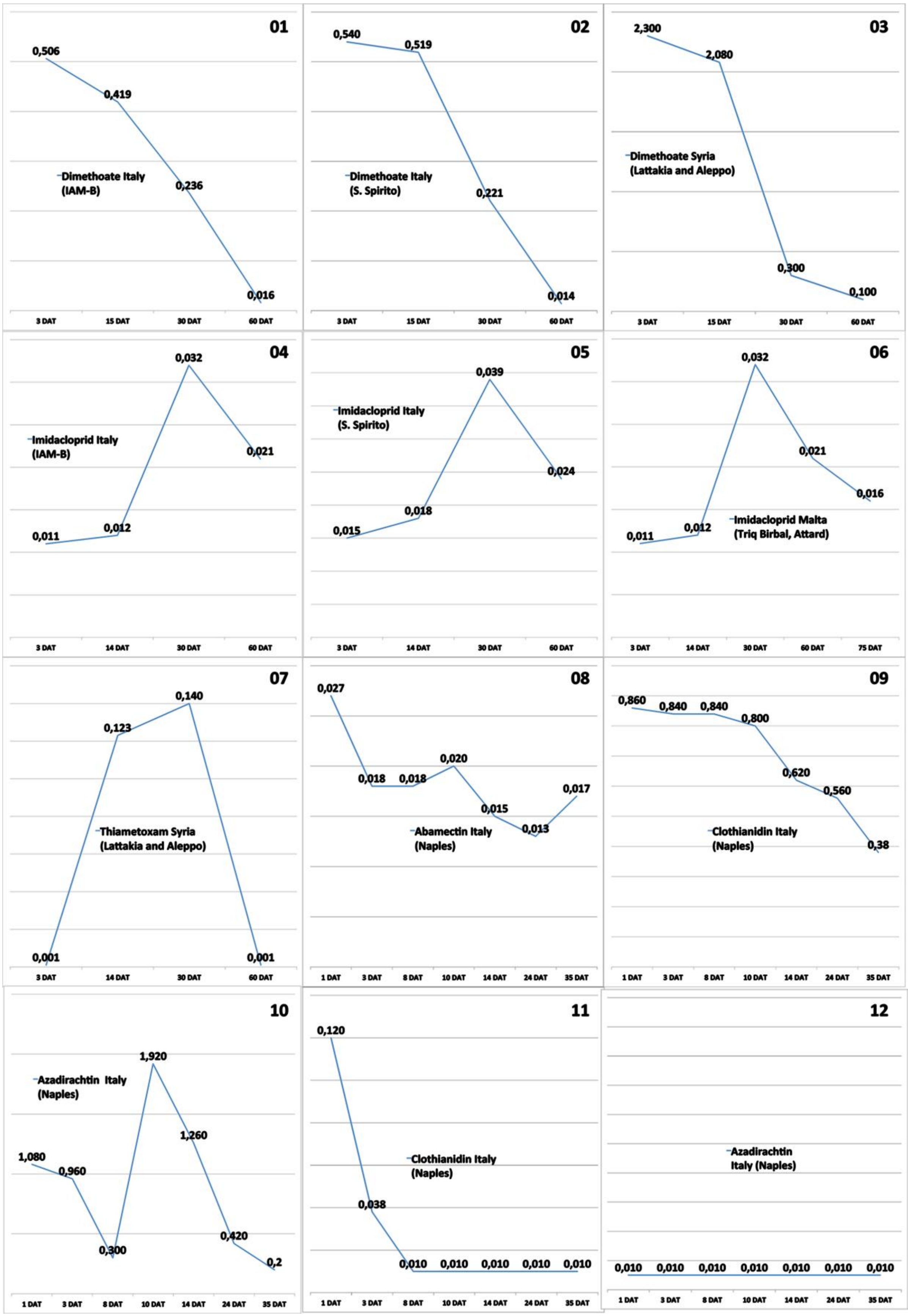
Table 2 - General uptake dynamic data of the a.i. tested by soil application. Second column reports a.i., place of the trial, dose of formulation per palm (DAT: Days After Treatment).

Dynamique générale d’absorption des matières actives évaluées par application au sol stipe. La matière active, le localité de l’essai et la dose de formulation appliquée par palmier sont données en seconde colonne (DAT : Jours après traitement).

11	Clothianidin Italy (Naples) 30 g/palm	0,860	0,840	0,840	0,800	0,620	0,560	0,38
	DAT	1	3	8	10	14	24	35
12	Azadirachtin Italy (Naples) 400 ml/palm	1.080	0.960	0.300	1.920	1.260	0.420	0.2
	DAT	1	3	8	10	14	24	35

Azadirachtin
This a.i. has an unusual behaviour, once injected. Residues are at middle level at first DAT, and then they lower considerably at 8 DAT. Later, at 10 DAT, residues show an impressive peak then lowering to a very low minimum at 35 DAT (tab. 1& fig. I: 10). In soil distribution the a.i. was below the analytical limit (tab. 2& fig. I: 12). Any phytotoxic effect was observed.

Figure I- General uptake dynamic data of all the tested a.i. Nos. from 1 to 10 refers to tree-injection while 11-12 refer to uptake dynamic of soil treatments.
Dynamique générale d'absorption des matières actives évaluées : Graphes 1 à 10 : injections dans les stipe et Graphes 11 et 12 : application au sol.



CONCLUSION

Chemical Prevention and Protection (2P) of large stipe palms from RPW require envenoming the plants long enough by an effective single a.i. treatment. This shall be in order to lower the number and the cost of yearly pesticide distribution to 2-5.

Within this frame the pesticide uptake dynamic appears to be a key factor in choosing the proper means of control (Abdul Raheem, 2008; Ćialic, 2009).

The dimethoate, a well-known cytotropic molecule in spray distribution, peaks quite fast and with high residues quantity if placed by our patented tree-injection method. Nevertheless, active ingredient persistence lasts not enough to guarantee consistent protection over time but for 1-2 months.

Imidacloprid, as injected, shows long enough persistence and effective residues. We estimate a single Imidacloprid distribution to protect a palm for 2-3 months.

Abamectin has low residues concentration that decrease relatively fast. Thiametoxam and azadiracthin also maintain a brief lapse of effectiveness and low lethality to RPW larvae. Clothianidin is fast peaking but does not maintain a residue level high and long enough to guarantee the protection from the pest. We do not consider these four a.i. effective enough to protect and prevent palms from RPW infestation

Soil distributions show a considerably low attitude, in case of clothianidin, or the complete failure, in case of azadirachtin, to transfer the a.i. to palms. Not to speak about the inequity between the very large amounts of a.i. lost in water by percolation. The pesticide drifts suggest avoiding soil distribution, absolutely, thus preferring tree-injection as a more effective means to deliver pesticide in palms. Moreover, in tree-injection the a.i. is sealed into the plant, thus guaranteeing the best RPW control paired with the high environmental safety attitude.

Finally, we believe that a palm purposely developed tree-injection method, and non a generic application of modified dicot technique (Abad & Gallego, 1978; Abdallah & Al-Khatri, 2000; El-Ezaby, 1997; Helburg *et Al.*,1973), will offer the best available combination of favourable feature to deliver a pesticide against RPW infestation.

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