THE ADVANTAGES OF MIXING DELTAMETHRIN AND ORGANO-PHOSPHOROUS INSECTICIDES FOR THE PROTECTION OF STORED CEREALS -A REVIEW OF RECENT TRIALS.

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SUMMARY

Deltamethrin (DTM) is a pyrethroïd which can either be used alone or combined with other insecticides for the protection of stored cereals. Its characteristics are different from other insecticides already marketed for the protection of grain. - It has a residual activity that generally lasts more than a year. - It is highly effective against *Rhizopertha dominica, Sitotroga cerealella, Corcyra cephalonica, Prostephanus truncatus* and *Trogoderma granarium*. However, weevils and, more particularly, *Sitophilus zeamais,* are the first insects to reappear in grain treated with deltamethrin. - Its effect is increased by the use of piperonyl butoxide (PB), whereas organo-phosphorous compounds (OP's) used to protect grain often have their activity slowed by this synergist. - Deltamethrin is not particularly susceptible to temperature variations and has a slightly negative thermodependency. - It has been noted that pests which have become resistant to OP's remain susceptible to DTM and that certain malathion resistant species show an increased susceptibility to deltamethrin. - The addition of piperonyl butoxide to a combination of deltamethrin and chlorpyriphos methyl (CPM) in a water based solution increases the biological efficiency on *S. zeamais,* but this improvement is only slight; the mortality percentages with and without this synergist are approximately the same after a 12 month storage period and thus does not justify the use of PB in mixed products. This mixture may be made up using different proportions adapted to local conditions and the anticipated storage period but, generally speaking, it remains approximately 0.5 ppm of deltamethrin + 5 ppm of organo-phosphorous compounds for protection periods of 9 or more months in hot countries and 0.125 ppm + 1.25 ppm of CPM or pirimiphos methyl (PMM) when used preventively in temperate countries for a 6 month protection period. A wide range of DTM/OP ratios have been tested, up to a 1/100 ratio, with the exclusive aim of reinforcing the insecticide activity directed against *R. dominica,* using very low doses of deltamethrin. The 1/20 and 1/10 ratios are those most often used; when used in fields, these permit the elimination of *P. truncatus*. Laboratory tests using CPM in a water based solution show that a ratio of 1/5, and even 1/1, are those that provide the longest protection period against attacks from *S. zeamais*.

The combination of DTM + OP widens the spectrum of destroyed pests and gives an insecticide activity at least equal to that of each product taken separately and at twice the dosage level.

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Key words: deltamethrin (DTM), organo-phosphorous compounds (OP's), combination, *Sitophilus zeamais*, *Rhizopertha dominica, Sitotroga cerealella*, storage period, half life, DTM/OP ratio.

Losses after harvesting have always been a major problem in tropical countries. The size of these losses is compounded by the fact that the concerned pests find themselves in optimal temperature and humidity conditions. In terms of contact insecticides, the O.P.'s are highly efficient against certain species, such as the *Sitophilus* weevil, but are insufficient when used against lesser grain borers such as *Rhizopertha dominica* (F.) and *Prostephanus truncatus* Horn. In addition, their effectiveness against *Sitotroga cerealella* (Oliv.), *Corcyra cephalonica* (Stn.), *Trogoderma granarium* Everts and *Callosobruchus* type bruchid beetles is short term. Although the main pests are *Sitophilus* spp., organo-phosphorous compounds cannot ensure the protection of the main edible cereal crops in tropical regions, such as maize, *sorghum* and millet, for more than six months in regions where other pests are present (Arcozzi and Contessi, 1986 (1); Duguet and Liang Quang, 1988 (2)).

The pyrethroïds, and deltamethrin (DTM) in particular, are available in a number of countries in the form of new insecticides for the protection of food products. Deltamethrin is a complete insecticide with a wide spectrum of activity that includes a very long residual effect that, in certain cases, can last a number of years. But these two qualities are obtained using doses that have a production cost greater than that of the OP's. We carried out tests to find out what advantages could be obtained by combining DTM + OP's,analysing the advantages of this combination when compared to the seperate use of products from one or the other of the families.

2. CHARACTERISTICS OF DELTAMETHRIN AND ORGANO-PHOSPHOROUS (OP's) COMPOUND COMBINATIONS IN TERMS OF INSECTICIDE EFFICIENCY

2.a Physical factors concerning the medium and the residual insecticide activity

A number of factors need to be taken into account in the choice of the most efficient dosage level to be used on the cereal stock to protect it against the most resistant species: the residue threshold level inflicting complete mortality; the required protection period; the interactions between the different active ingredients to be combined. One of the most important points to be respected is the incorporation of a sufficient quantity of deltamethrin to protect the cereal against the widest range of potential pests, with the exception of *Sitophilus* spp. which is susceptible to the OP combined with the deltamethrin. Temperature and moisture content variations have little effect on the efficiency of deltamethrin (Samson and Russel on maize (1986) (14)). A model should nevertheless be built up around the OP's degradation speed as this is the most critical combination factor in terms of the physical conditions of the medium. For example, if a deltamethrin dosage level of 0.50 ppm is considered sufficient to destroy all tropical species attacking stored cereals, with the exception of *S. oryzae* and *S. zeamais*, it is possible to combine it with OP doses varying from 1 to 10 ppm to create an effective mix (the DTM/OP ratio shall thus be 1/2 to 1/20 respectively). By taking the lower hypothesis of a 1/2 ratio, whilst accounting for the OP degradation speed and its residual activity on *Sitophilus* spp.,the residual activity will be short in humid tropical climate conditions, offering an activity of between 2 and 4 months depending on the quality of the chosen OP and the physical conditions during the storage period. In the second case (upper hypothesis: 1/20 ratio), the residual activity will be much longer. A period exceeding one year may elapse before the residual dose falls under the *Sitophilus* spp. lethal threshold level. The degradation speed (or the more commonly used insecticide activity inhibition speed) must be precisely known (for OP's in particular), and will depend on: the moisture content of the grain during storage; the type of grain; the temperature (generally expressed as the total of the maximum divergences to the external area most exposed to reinfestation), etc... On the basis of these explanatory variables or parameters, it is possible to evaluate with a fair degree of precision where the degradation curve of the product mixture crosses the lower lethal dosage threshold for *Sitophilus* spp. This 99% lethal dose must be modulated in function of temporary climatic conditions which may be an important variation factor for the OP's. In theory it is possible to draw 2 curves using experimental confirmation data - one giving the reduction of residual insecticide activity in time; the other giving the LD 99 fluctuation of the species that are the least susceptible to the two products in the mixture - that will cross at a point that determines the total protection period and the theoretical date at which surviving insects may reappear. However, the model is fairly complex to construct as it needs to account for significant interactions between the products, particularly the synergy of the pyrethroïd, and the PB where this latter is included in the mixture, as this synergy may develop over a certain period. It is also necessary to take chosen formula and the application method into account as these are often the parameters having the greatest influence and are the most difficult to control and evaluate.

2.b The possible synergy between deltamethrin and organo-phosphorous compounds

In 1985, the Roussel-Uclaf Research and Applied Biology Centre demonstrated, using *S. oryzae*, that combinations giving 70% LD 50 using 30% deltamethrin (DTM) + 70% OP's offered a supposed synergy resulting from the physiological action, this being different from that provided by the two insecticide families. Zhang Guo-Liang in Zhejiang (1986) (Fig. 4) confirmed the Roussel-Uclaf results using *S. oryzae*. This synergy, obtained by topical application, has not yet been able to be measured with the same degree of detail when used on grain. It is difficult to quantify this synergy on grain in normal storage conditions. However, two results bear noting: the recent Australian results by Wellcome (1987) on *S. oryzae, R. dominica, T. castaneum* and those by one of the authors carried out in 1988 on *S. zeamais* which show that the mortality percentages of combinations are greater than those given for each of the products taken separately at twice the dosage level (Fig. 5).

2.c The reaction of OP resistant species

The way these two insecticide families act is different. Carter *et al* (1975) found, whilst working on a strain of malathion resistant rice weevils, that they were more susceptible to pyrethroïds than the susceptible strain of the same species. Bengston (1983) (11) noted that the resistance of local strains of *S. oryzae, T. castaneum* and R. dominica to OP's in Australia did not effect the toxicity results of deltamethrin. Picollo de Villar et al. (1987) (21) found that a malathion resistant local breed of *T. castaneum* in Argentina was ten times more susceptible to deltamethrin than a same species not resistant to OP's. Thus, generally speaking, insects resistant to OP's are susceptible to deltamethrin.

2.d Interactions of piperonyl butoxide with a combination of deltamethrin and an organo-phosphorous compound

2.d.1. Short-term studies

Fleurat-Lessard and Serrano (1987) carried out a number of paper filter tests using *S. zeamais*. These experiments used three doses of CPM, PMM and etrimfos which were combined with three increasingly large doses of PB and then to three doses of deltamethrin (PB doses corresponding to a 1/10 ratio of DTM/PB); representing a total of 189 studied cases. These tests showed that the PB had a retardant effect on the OP's being tested several days after treatment of the paper filters. Counts were made after a 4 hour insect/grain contact; this retardant effect lasted for a 4 day contact period, after which the effects once again became comparable with those obtained when using an OP by itself (Fig. 6). The synergy of the 1/10 DTM/PB ratio has already been demonstrated by Coulon (1978) (22) on *S. granarius*; it also obtained a multiplication coefficient of 4 on wheat. Most laboratory tests carried out on different insects gave values varying between 3 and 5.5, with the exception of *R. dominica* where the coefficient was only 2 (Roussel-Uclaf and the Shanghai Grain Research Institute, comm. pers).

2.d.2 Long term laboratory studies

A long term study was carried out by one of the authors in 1988 on maize and *S. zeamais*, observing the interaction between deltamethrin, CPM and PB in a water based solution. The three components were combined together using four doses of each component, one of these doses being nil. This represented 64 specimen samples at the beginning of the test. Each batch of maize contained some 20 insects below the grain surface and 25 adult *S. zeamais*. Mortality inspections were carried out every month: 24 hours, 7 days, 14 days, 28 days and 2 months after treatment by adding 25 adult *S. zeamais* to the previously infested maize in the petri dishes. The following practical results were obtained: - In the tropical conditions simulated in the laboratory (30°C and 90% moisture content), the deltamethrin is not highly synergised by the PB when used on maize. For example: at a minimum of 6 months after application, the 0.5 ppm dose is not significantly potentialised if one adds 5, 10 or 20 ppm of PB whereas, theoretically, laboratory tests give this 1/10 ratio synergised dose the same level of efficiency as 2 ppm of deltamethrin when used alone, this latter dose known to have a long term level of efficiency. Thus, water based solutions applied on grain do not offer a synergy coefficient of 4 for a PB/DTM ratio of 10 after a certain storage period. - The antagonistic effect of PB on the chlorpyriphos methyl is still apparent, even after 7 days of contact with the insect infested grain at a minimum of 6 months after treatment. This negative effect is increased when the PB is increased from 5 to 10 ppm, but ceases at 20 ppm and one can even note an improved CPM mortality at this dose (Fig. 5). More importantly than the PB/CPM ratio, the quantity of PB per kilogramme of grain should be considered and this observation merits being confirmed with other combinations to see if it is a generalised effect with OP's. - In the binary combination of deltamethrin and CPM, the highest mortality percentages are obtained using the highest doses of deltamethrin and the lowest dose of CPM, being 1.25 ppm in the presented test (Fig. 7). - By comparing the mortality percentages of the ternary mixture of deltamethrin + CPM + PB with those obtained using a binary mixture of deltamethrin + CPM, we have observed a slight improvement in ternary results after a 12 month conservation period (Fig. 7). The PB has a low synergising effect on deltamethrin combined with CPM when the targeted insect is *S. zeamais*, the species least susceptible to DTM. These results demonstrating that there is little point in using PB in water based combinations have been confirmed by tests carried out in Australia by Wellcome (1988 pers.comm.) and by Roussel Uclaf in Bouaké, Ivory Coast, by Peruzzi (1987). - The effect of combinations on *S. zeamais* descendances is total (leading to 100% adult mortality) when using the highest doses of deltamethrin. It prevents reinfestation through the appearance of a new generation. The combination only works on adults and larvae that are not hidden inside the grain. - The dose combination that prevents all grain reinfestation, with or without synergist, 12 months after application of the insecticide on the grain, is the mixture of 2 ppm of deltamethrin with only 1.25 ppm of CPM, being a ratio of 1/0.625 DTM/CPM. However, 0.5 and 1 ppm doses of deltamethrin combined with even very low doses of CPM completely prevent the survival of *S. zeamais* on the grain, being a DTM/OP ratio that can be as low as 1/2.5. - With the 1/100 DTM/OP ratios used in certain formulas with malathion, the role of the deltamethrin is protect the grain against *R. dominica*, being the most susceptible species and when used at 1/20 or 1/10, the combination also destroys *P. truncatus*, an increasingly important pest destroying maize in tropical Africa. Laboratory studies in simulated tropical conditions shows the importance of 1/5 and 1/1 ratios with CPM on the mortality rate of adult pests and the prevention of future generations. When the level of insecticide efficiency is equal, cost begins to play a role in the choice of the DTM/OP ratio. The synergy offered to the deltamethrin by the PB and the retardant effect of the OP insecticide action when used at a dosage level under 20 ppm of PB, appears to reduce the point of using PB in the combinations. But tests need to be carried out in this field using other

OP's and in experimental conditions where the time factor is perfectly controlled.

2.d.3 Silo tests

One of the authors tested the behaviour of DTM + PMM/ CPM/ fenitrothion/ etrimfos on different food products stored in village granaries at Bouaké, Ivory Coast. The climatic conditions in Bouaké have an important effect on results. Conditions were particularly dry at the beginning of the storage period during the months of December, January and February which meant that insects did not develop. There was a great deal of rain from March to September which favoured the proliferation of insects and fungal growth; the latter playing an important part in the degradation of insecticides. The combinations showed good results with efficiency periods varying according to the OP being used and the initial dose. The PMM and CPM had an activity period exceeding 9 months on *Sitophilus zeamais*; fenitrothion lasted 7 months (Fig. 8). Deltamethrin behaves differently depending on the food product being treated. In terms of equal quantities of active ingredients, the best level of protection is obtained, in descending order, on maize, paddy rice, husked rice, sorghum, ground-nuts and, finally, cowpea. 1/10 combinations gave similar results but with protection over longer periods (Fig. 9). Combinations of DTM with PMM and CPM are more efficient when thoroughly mixed than when applied in layers every 15 centimetres. Surface treatment of grain in a village granary can offer the same level of protection as a layer by layer treatment (Fig. 10). Protection of stored food products in hot countries is a subject that has been well researched, as optimal conditions are present for the development of all grain pests and because there are very high weight losses. In temperate countries, the insects only become active when the temperature of the grain exceeds 12°C which reduces the overall annual loss; the OP's are entirely satisfactory in these circumstances as the main pest is a *Sitophilus* and there are no *R. dominica* or *T. granarium*. The combination of DTM + OP's nevertheless remains advantageous as at equal levels of efficiency, its cost price is either lower or equal to that of OP's used alone. As the quantities of active ingredients in combinations are used at less than half the normal doses, the residual quantities of insecticides in the grains are much lower than the tolerance levels. H. Hamel (1990) in Yugoslavia and then M. Boselli (1990) (Fig. 11) in Italy demonstrated the mortality equivalence on *S. oryzae*, *S. granarius* and *R. dominica* between DTM + PB at a dose of 0.5 + 5 ppm, PMM at 8 ppm and CPM at 10 ppm as opposed to DTM + CPM combinations at doses of 0.125 + 1.25 ppm during maintenance treatment over a 6 month period.

CONCLUSION

Deltamethrin is an insecticide with a sufficiently wide spectrum of activity to be used alone at a dose of 2 ppm against *S. zeamais* to protect maize and other cereals in tropical climates, using either a powder or water based emulsion formula. However, in order to reduce the production cost for treating stored grain, a combination with an OP, PMM or CPM or even fenitrothion provides an increased level of efficiency against *Sitophilus* spp, essentially due to the OP content, and offers an efficient product against pests with a lower susceptibility to OP's, especially *R. dominica*, *P. truncatus*, *S. cerealella*, *C. cephalonica*, due to the effect of low dosage application of deltamethrin. The choice of the deltamethrin and OP doses in the mixed formula depends on the pests to be treated, the required protection period and the climatic conditions in the storage areas. The PB slightly improves the deltamethrin and CPM combination, but its presence cannot be economically justified; however, its use may be worthwhile in preventing the reappearance of highly resistant insect strains. The combination of doses as low as 0.5 ppm of deltamethrin and 1.25 ppm of CPM is sufficient to prevent insect reinfestation and multiplication over a 12 month period of adult *S. zeamais* regularly placed on the treated grain (1/2.5 DTM/OP ratio). Standard combination: a minimum of 0.5 ppm of deltamethrin plus 5 ppm of OP's may be used as a base reference, knowing that it offers a complete level of efficiency against all grain pests (a 1/10 DTM/OP ratio). Tests should be carried out in each climatic situation in order to determine the proportions best adapted to local requirements which may vary around the base ratio. Laboratory tests in simulated tropical conditions will demonstrate the combinations needed to provide protection periods lasting from 9 to 12 months; these tests will also allow measures to be taken against the rapid appearance of either OP or pyrethroïd resistant species. We propose the following pivotal balances for testing: - In hot climates: 0.5 ppm of DTM + 5 ppm of OP's. Using PMM, this combination will offer a 12 month protection, 9 months with CPM and 6 months with fenitrothion. If malathion is used, 10 ppm will be needed for 6 months. Using a 0.25 ppm DTM dose is worthwhile for combinations providing 4 to 6 month protection. - In temperate climates: for a preventative treatment, use 0.125 ppm of DTM + 1.25 ppm of CPM or PMM for a 6 to 9 month protection. The dose needs to be raised to 5 ppm if fenitrothion is

used and 7.5 ppm if malathion is used in order to maintain the efficiency period. Doses need to be multiplied by two for curative treatments.

BIBLIOGRAPHY

(1) Luigi ARCOZZI and Alberto CONTESSI - 1986 - Prova di efficacia di K-Othrine Grains CE (P.A. deltamethrin sinergizato con piperonilbutossido) in confronto a malathion et pirimiphos-methyl su crumento tenero infestato de *Sitophilus granarius* L. et *Rhizopertha dominica* F. in nuove acquisizione sulla protezione dei cereali immagazzinati. Incontro de aggiornamnto tecnico BOLOGNA - 4th November 1986. 27-38

(5) J. COULON - 1983 - Sensibilité comparée de *Sitophilus granarius* et *Tribolium confusum* à diverses substances utilisables dans la désinsectisation de céréales stockées, p 135-147.IN "La conservation des céréales en France", Les A.T.P. de l'INRA, 1, INRA publishers, Versailles. 172 p.

(6) J. COULON - 1983 - Effets de la température sur l'efficacité de quelques insecticides. Etudes de laboratoire sur l'activité à 15, 20 et 25°C de quelques substances applicables à *Sitophilus granarius*, p 123-124, In "La conservation des céréales en France", Les A.T.P de l'INRA, 1; INRA publishers, Versailles, 172 p.

(7) J.COULON - 1980 - Propriétés physicochimiques et biologiques des insecticides utilisables sur céréales stockées In "La desinsectisation des céréales stockées". BTI N° 349, 297-310.

(8) A. GAUDUCHON and P. DUCOM 1985. Vitesse de mortalité des émergents de *Sitophilus granarius* L. provenant de grains traités avec deux insecticides de contact: influence sur le contrôle phytosanitaires. in "Compte-rendu du premier symposium du CILDA" Paris 1985, 73-81.

(9) J.S. DUGUET - 1985. Contribution à l'étude de la deltaméthrine en remplacement des organophosphorés et des fumigants pour la protection des céréales et des légumineuses stockées. N° ordre: 383. Thesis, INP de Toulouse, 315 p.

(11) M. BENGSTON, R.A.H. DAVIES, J.M. DESMARCHELIER, R. HENNING, W. MURRAY, B.W. SIMPSON, J.T. SNELSON, R. STICKA and B.E. WALLBANK - 1983 - OrganophoSphorothioates and synergised synthetic pyrethroïds as grain protectants on bulk wheat. Pestic. Sci. 14. 374-384.

(14) P.R. SAMSON - R.J. PARKER - 1986. Effect of grain moisture on the biological activity of protectants on maize p. 540-546. In E. DONAHAYE, S. NAVARRO Editors Proc. 4th Int. working Conf. on stored product protection, Tel Aviv, 668 p.

(15) R.M. NOBLE - D.J. HAMILTON - W.J. OSBORNE - 1982 - Stability of pyrethroïds on wheat in storage. Australia. Pest. Sci.n 13, 246-252.

(16) J.M. DESMARCHELIER - 1977. Selective treatments including combinations of pyrethroïd and organophosphorus insecticides for control of stored products coleoptera at two temperatures. J. stored Prod. Res. 13, 129-137.

(17) M. BENGSTON - L.M. COOPER - R.A.H. DAVIES - J.M. DESMARCHELIER - R.H. HART - M.P. PHILLIPS - 1983. Grain protectants for the control of malathion-resistant insects in stored *Sorghum*. Pestic. Sci., 14. 385-398.

(18) D.J. WEBLEY - 1985. Use of pesticides for central storage of grain, in Pesticides and humid Tropical Grain Storage Systems - ACIAR Proceeding N°14, 327-334.

(20) G.D. GLYNNE JONES - 1983 - *The use of piperonyl butoxide to increase the susceptibility of insects* which have become resistant to pyrethroïds and other insecticides. Inter. Pest. Control, 14-15.

(22) J. COULON and P. BARRES - 1979 - Résultats obtenus avec quelques pyréthrinoïdes appliqués au charançon du blé. INRA Laboratoire de Phytopharmacie. Bull. CILDA N°9, 8-20.

Documents used (articles revealed in seminar reports or directly written by their authors).

(2) J.S. DUGUET and LIANG QUANG - 1988 - Evaluation de l'éfficacité sur paddy de la deltaméthrine utilisée en pulvérisation et en poudrage sur support balle de riz, contre les ravageurs du paddy dans la

Province de Guangdong (China). Agro. Tro.

(3) A. Von BERG and A. BILIWA - 1987 - Lutte contre le grand capucin du maïs, *Prostephanus truncatus* Horn (*Coleoptera Bostrytchidae*) dans les greniers traditionnels du Sud Togo sur maïs spathé. Rapport du Service de la Protection des Végétaux BP 1263 Lomé/Togo.

(4) E. GABRIEL 1988 - Etude de la toxicité des pesticides de contact sur diverses espèces d'insectes ravageurs des denrées entreposées. Approche d'une méthode de dosage biologique des insecticides sur le grain - published by the Fac. des Sci. Agro. de l'Etat, B.5800 GEMBLOUX, 128 p.

(10) F. FLEURAT-LESSARD, J.M. THIERRY, B. FUZEAU - 1985 - L'activité acaricide de quelques spécialités insecticides à base de deltaméthrine utilisées pour le traitement direct des grains. INRA Centre de Recherches at Bordeaux.

(12) A.M. MUSHI - N.B. NYAKUNGA and D. MARENGA - 1984 - Field evaluation of different insecticides for control of the larger grain borer, *Prostephanus truncatus* (Horn) under hot and humid conditions in Eastern Tanzania. Report 2, Ministry of Agriculture Pest Control Services, Arusha, Tanzania. 15 p.

(13) G.M. MWIINGA - A. MAINGA - 1986 - Zambia. Report on the "use of methacrifos and deltamethrin as storage insecticide" trial. M.I.S.T., TTC Food Storage Officer, Mr. Makulu. 14 p.

(19) R. WOHLGEMUTH - R. HARNISCH - R. THIEL - H. BUCHOLZ - A. LABORIUS - 1987. Comparing tests on the control and long term action of insecticides against stored pests under tropical climate conditions. GTZ. gmbh postfach 5180 D-6236 Eschborn 1, FRG. 273 p.

(21) M.I. PICOLLO DE VILLAR - E. WOOD - E. SECCACINI - ZERBA - E. MARTELLI, 1987. Susceptibilidad exaltada a piretroides en una cepa de *Tribolium castaneum* resistente a malathion. Possible mecanismo. Rapport Centro de investigaciones de plagas et insecticidas. Zufriategui 4280 - V. Martelli - Argentina.

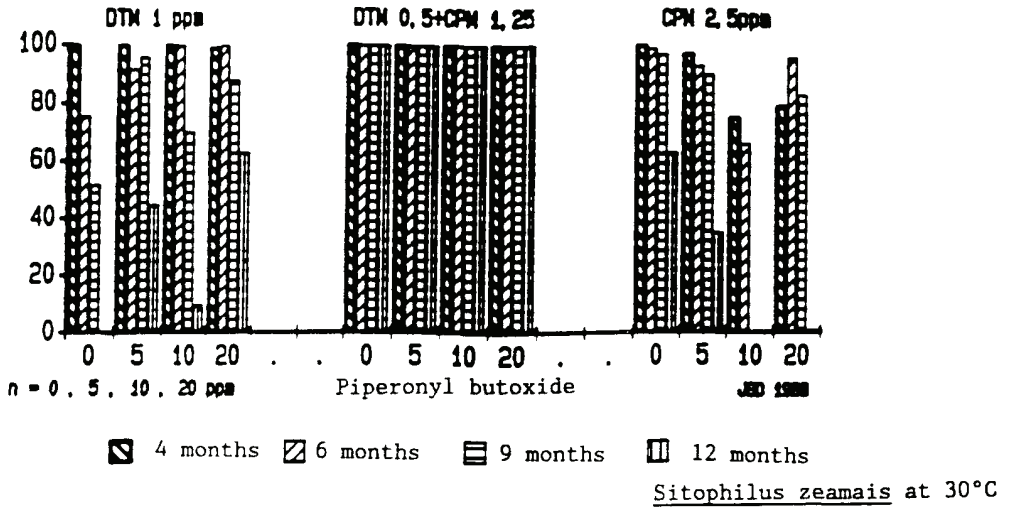


Fig. 5: Mortality percentage using deltamethrin at 1 ppm + n.PB, chlorpyriphos m. at 2.5 ppm + n.PB and a combination of chlorpyriphos at 1.25 ppm + deltamethrin at 0.5 ppm + n.PB.

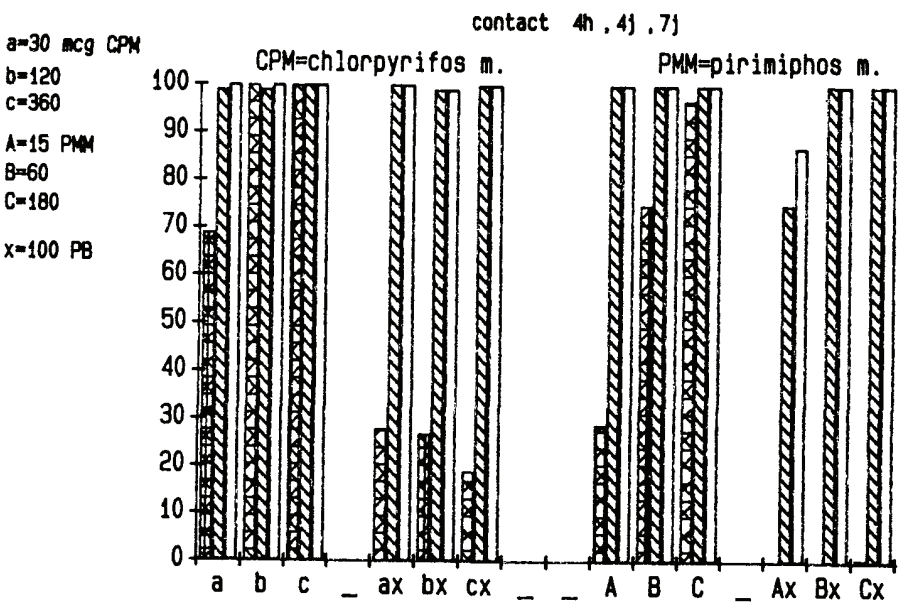
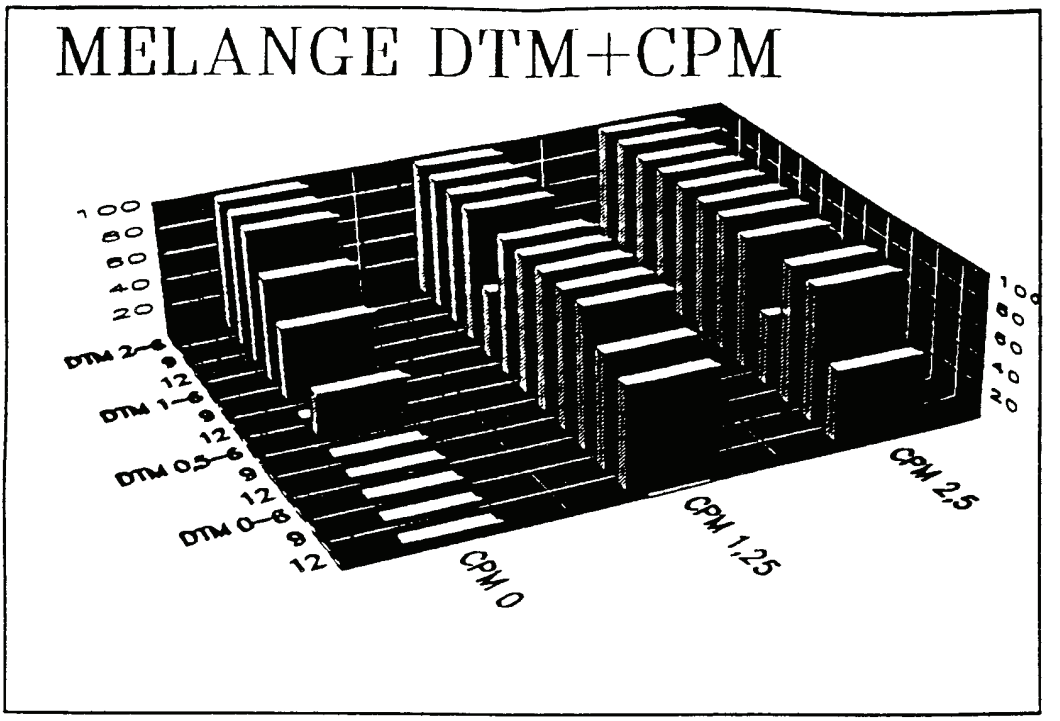


Fig. 6: Synergist (PB) retardant effect observed using chlorpyriphos methyl (CPM) and pirimiphos methyl (PMM) after a 4 hour, 4 day and 7 day contact period with S. zeamais on filter paper.



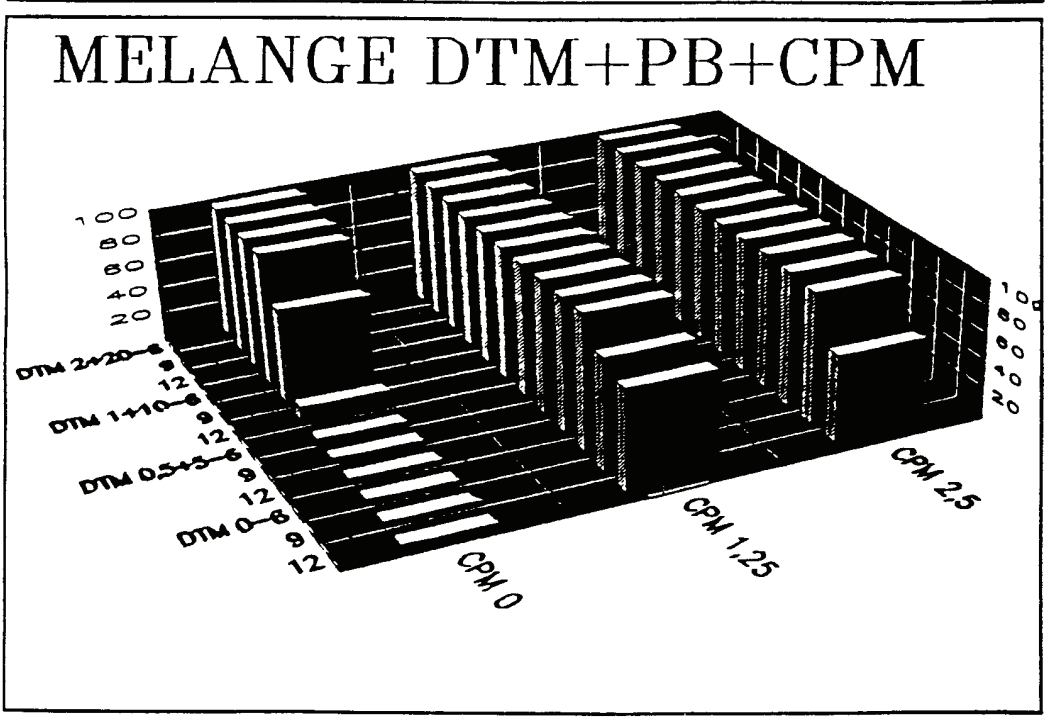


Fig. n° 7 : Mortality of S. zeamais stated 7 days over the artificial infestation of the treated maize with DTM + PB + CPM combinations (T=30°C Aw+0,8 +0,2) 6, 9 or 12 months after the treatment

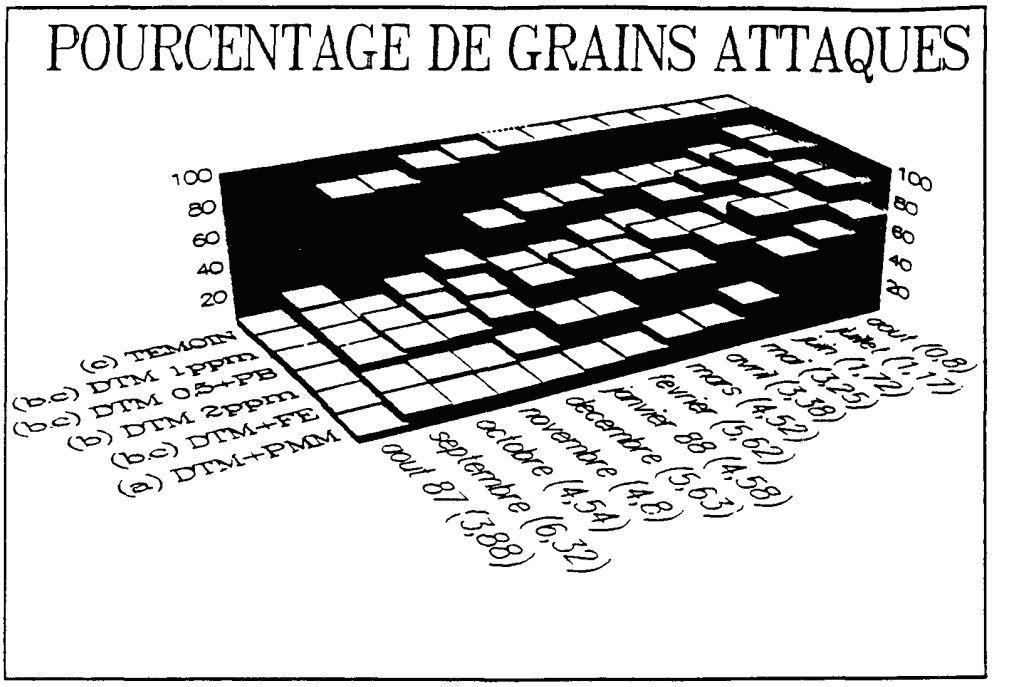


Fig. 8: Relative importance of the quantity of grain attacked by S. zeamais in the wheat lots treated on harvesting with pyrethroïd (DTM) + organo-phosphorous compounds (FE = fenitrothion, PMM) insecticide mixtures in function of the length of the conservation period (tests carried out in Bouaké, Ivory Coast).

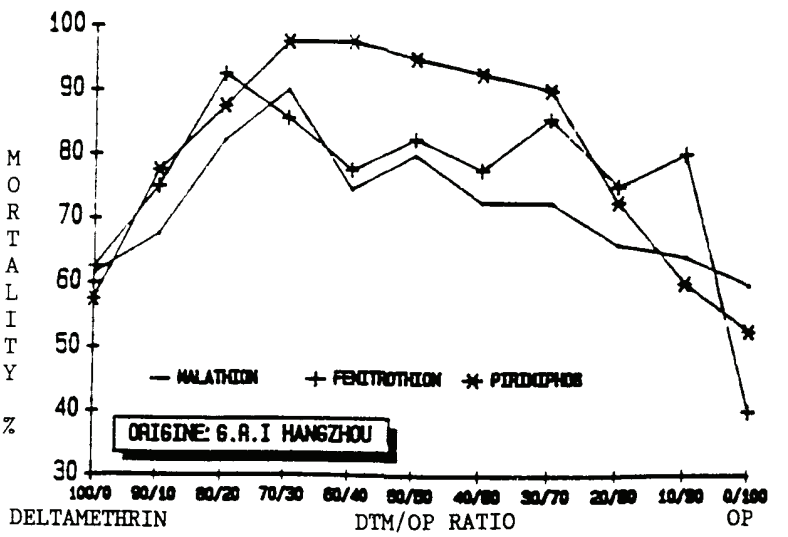


Fig. n°4: Efficiency of deltamethrin + OP combinations over the entire range of possible mixture ratios.

LES POSSIBILITES DU MELANGE DELTAMETHRINE-ORGANOPHOSPHORES POUR LA PROTECTION DES STOCKS DE CEREALES

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RESUME

Le spectre des insecticides organophosphorés (OP) persistants, comme le Chlorpyriphos-méthyl, le Pirimiphos-méthyl, l'Etrimfos, le Malathion et le Fénitrothion est complémentaire de celui de la deltaméthrine (DMT). Pour résumer, les OP sont efficaces à faible dose sur *Sitophilus spp.* mais pas sur *Rhyzopertha dominica*, même à forte dose. Ce sont les parasites les plus courants. L'association d'un OP et de la deltaméthrine apparaît, en première analyse, comme ayant un intérêt à faible dose. Des études, entreprises principalement sur le terrain, montrent que :

1) Il y a une synergie entre les OP et la deltaméthrine. Ceci a été vérifié, soit au cours d'applications dans les pays tropicaux, soit au cours du traitement des grains en grandeur réelle.

2) Le Pypéronyl butoxyde (PB) a une action de synergie sur la deltaméthrine, mais, au-dessus de 20 ppm, il retarde et diminue les effets des OP. L'efficacité d'un mélange de DTM + OP + PB n'est pas supérieure à celle d'un mélange DTM + OP aux mêmes doses.

3) Le rapport de la quantité d'OP à celle de DTM des formules du commerce dépend de différents éléments qui sont : le temps de protection du grain nécessaire ; la présence de certaines espèces de ravageurs et le type de grain à protéger : maïs, blé, riz paddy, sorgho, etc.

Ces éléments jouent un rôle vital dans le choix du dosage efficace de l'OP. Pour obtenir une protection sur 9 mois contre *S. zeamais* en utilisant une association OP-Deltaméthrine, la courbe de dégradation de l'OP dans le grain soit se trouver au-dessus du seuil d'efficacité de l'OP donné pour cette espèce. Le rapport OP/DTM pour une protection de 9 mois variera entre 50 et 100 en utilisant le malathion qui possède une demi-vie de 15 jours à 3 mois, entre 10 et 20 en utilisant le fénitrothion et le chlorpyriphos-méthyl dont la demi-vie sur le grain varie de 3 à 6 mois et, entre 5 et 10 en utilisant le pirimiphos-méthyl et l'étrimfos (demi-vie : 6 à 9 mois). Les interactions entre le DTM et l'OP modifient favorablement ces données. Les essais sur le terrain sont essentiels pour prendre en compte tous ces facteurs.