CARBOFURAN SEED COATINGS AS CONTROLLED RELEASE FORMULATION

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SUMMARY

The incorporation of systemic insecticides in seed-coatings is a combined operation (sowing and treatment) which allows to reduce the dose applied per ha and/or increases efficiency time. Carbofuran incorporated in corn coated-seeds, at the rate of 3 mg active ingredient /seed (about 300 g a.i. /ha), reduced markedly the number of wireworms attacks. Incorporation in field bean coated seeds of carbofuran at the rate of 3 mg a.i. /seed reduces up to 98% stem nematode populations in plants 4 months after sowing. As might be expected for a systemic pesticide incorporated to the soil, carbofuran has no effect against pollinators and pest's predators or parasites. The controlled-release effect of all these formulations has been characterized using radioisotopic techniques. In a laboratory test, carbofuran appeared to be released up to 3 times more slowly from coatings than when formulated as commercial microgranules.

RESUME

Enrobage des semences au carbofuran avec une formulation retard

L'incorporation d'insecticides systémiques dans les enrobages de semences est une opération combinée (semis et traitement) qui permet la réduction de la dose appliquée à l'hectare et qui peut augmenter la persistance d'action du pesticide. Le carbofuran incorporé aux enrobages de semences de maïs à la dose de 3 mg/ semence (soit 300 g m.a./ha) a réduit très fortement les attaques de taupins. De même, l'application de 3 mg de carbofuran par semence de féverole a diminué de 98% les populations de nématodes des tiges trouvés dans les plantes 4 mois après le semis. Incorporé au sol, le carbofuran, qui est un insecticide-nématicide systémique, n'a pas d'effet négatif sur les auxilliares et les pollinisateurs. L'effet de libération lente a été caractérisé en

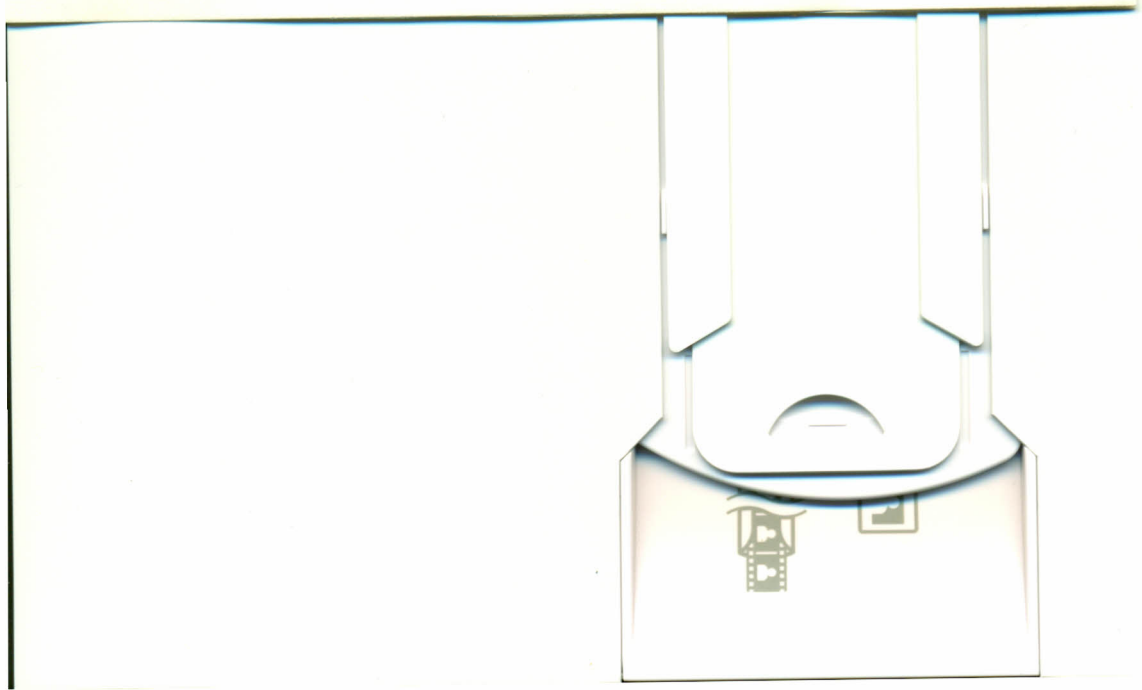
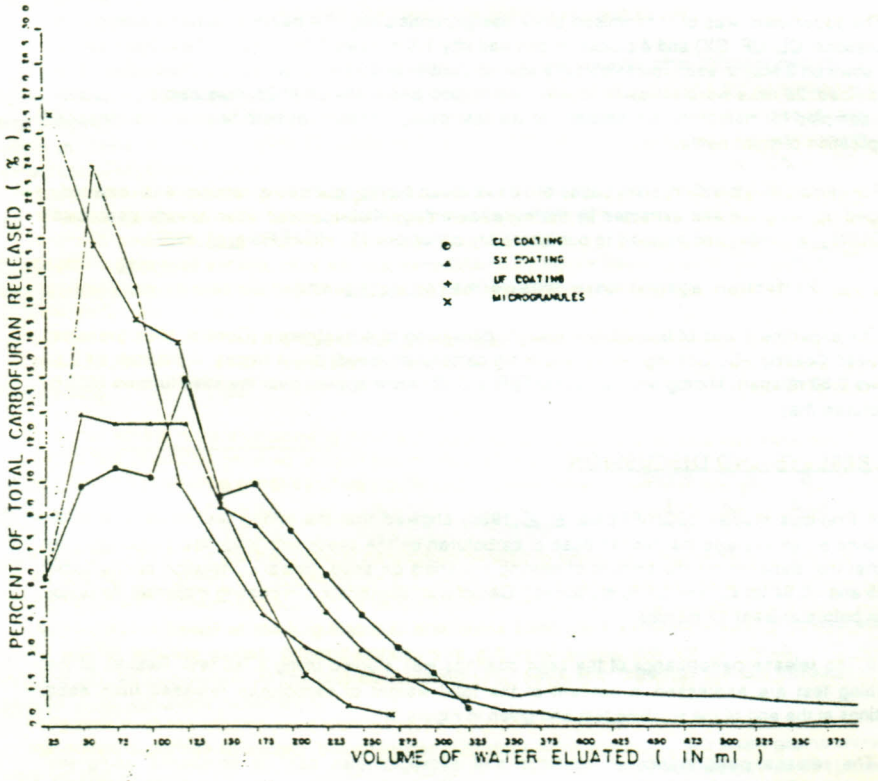


Table I - Composition of seed dressing with controlled release formulations (3 mg carbofuran/seed). The total amount of coating material added to the field bean and corn seeds corresponds to 30% of their own weight.

Formulations		Clays: Bentonite	Vermiculite	Adsorbent: Perlite	Stickers: Versicol S 190®	Vinarol ST®	Mowilith DL 45®	Resin:
Classical (CL)	:	49%	10%	29%	10%	2%	-	-
Urea-formaldehyde (UF) [resin titrating 4% of carbofuran]	:	27%	14%	-	4%	-	9%	46%
Starch xanthide (SX) [resin titrating 12% of carbofuran]	:	50%	10%	17%	5%	-	-	18%

Figure 1 - Percent of carbofuran released from microgranules (CURATER 5 G ®) and seed coatings according to volumes of water eluated in a standard washing test.



2.2. STANDARD WASHING TEST

To evaluate the release performance of the seed coatings, a standard washing test was used (SCHIFFERS,1986). This involved placing 5 seeds on a sand bed of 100 g in a Büchner funnel (7.5 cm diameter x 7 cm), retaining 25 or 30 ml of distillated water in the funnel for 24 hours and then draining off. The eluated volume was noted and 1 ml of the eluate was then mixed with 10 ml of a scintillation mixture (LUMAGEL-LUMAC) to measure the radioactivity by counting. At the end of the test, radioactivity remaining in the seeds and the sand was measured.

To compare controlled release of seed coatings with a commercial granular formulation of carbofuran (CURATER 5 G ®), the standard washing test was also used with a weight of microgranules containing the same amount of chemical than the 5 coated seeds. The amount of carbofuran released from microgranules was also extracted from eluated water and measured by gas chromatography. Some samples of the radioactive eluate were also analyzed by gas chromatography to identify radioactivity as carbofuran.

2.3. FIELD EXPERIMENTS

2.3.1. Portection against field bean aphids and nematodes (Ditylenchus dipsaci)

The experiment was of randomised block design, consisting of 4 treatments (untreated and 3 formulations: CL, UF, SX) and 4 blocks. A plot had fifty 1.5 m rows 0.25 m apart. Field bean seeds were sown on 3 May in each row to obtain a sowing density of 40 seeds per square meter. Each plot was divided: 25 rows were set aside for yield estimation and in the other 25 rows field bean plants were sampled for nematode extractions. At the last date, withering of field bean plants stopped multiplication of stem nematodes.

For nematode extraction, stem bases of 10 field bean plants collected at random were cleaned, chopped up, weighed and extracted by the mixer-centrifugal-flotation technique already described (COOLEN et al.,1984) and adapted to our laboratory conditions (SCHIFFERS et al.,1985).

2.3.2. Portection against corn wireworms (Agriotes sp.)

The experiment was of latin square design, consisting of 4 treatments (Control, Microgranules and Seed Coating -CL Coating- with 3 and 6 mg carbofuran /seed) and 4 blocks. A plot has six 2.5 m rows 0.80 m apart. Microgranules (CURATER 5 G ®) were applied over the seed furrows (600 g carbofuran /ha).

3. RESULTS AND DISCUSSION

Previous studies (SCHIFFERS et al.,1986) showed that the rolling technique is able to distribute on an average the desired dose of carbofuran on the seeds with a variation from seed to another that depends on the amount of coating materials on seed (linear correlation coefficients: +0.85 and +0.94 for CL and UF formulations). Carbofuran degradation in coating materials does not occur before at least 12 months.

The release performance of the seed coatings was studied using a lab test. Results of the washing test are expressed in percent of the total weight of carbofuran released from seed coatings at the end of the washing test and given in Figure 1.

The release performance of coatings and microgranules can be compared using the percentage of the total amount remaining in formulations when microgranules are used up (A%), and volumes of water needed to release 50, 75 and 95% of carbofuran. A release-ratio (Rr) can be

established as " Rr = coatings V_{95}/ microgranulesV_{95} " (Table II).

Table II - Percent of the total amount of carbofuran remaining in coatings when commercial microgranules are used up (A%) and release-ratio values (Rr).

Formulations	A%	Volumes of water needed to release 50% of the total amount of carbofuran	75%	95%	Rr
Microgranules (Curater 5 G)	0%	90ml	120ml	180ml	1.0
CL coating	26%	125ml	200ml	275ml	1.5
UF coating	22%	120ml	210ml	540ml	3.0
SX coating	23%	125ml	175ml	300ml	1.7

The results from this type of evaluation indicate that seed dressing formulations appear to offer a higher retention of active agent than commercial microgranules of carbofuran. Best of them is the UF coating which has an 'A%' equal to 22% and a 'Rr' 3 times greater than the one of microgranules. No significant level of radioactivity was found in sand and seeds.

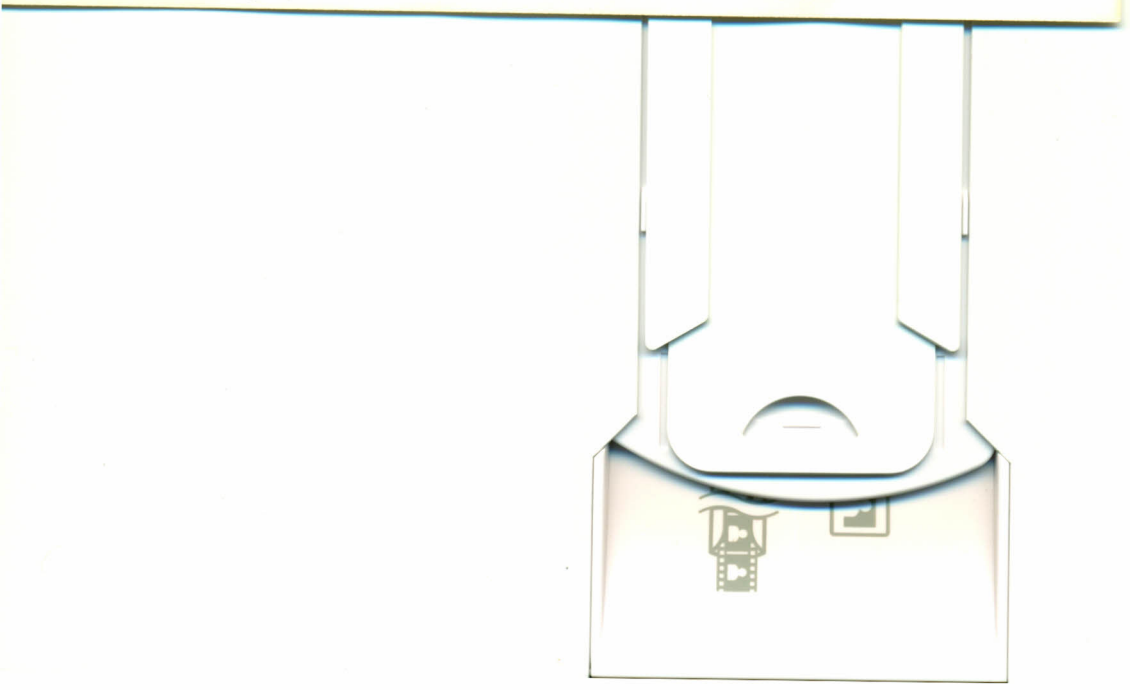
In field experiements, the nematodes infestation of field bean plants after different periods of growth is measured: effects 52, 75, 97 and 117 days after sowing of CL, UF and SX formulations (with 3 mg carbofuran/seed) on the number of stem nematodes per g of field bean plant tissue are shown in Table VI. The efficacy of each nematicide formulation is indicated by comparing percentage of infestation control (C%) at the last extraction date. This is expressed by "C% = 100 - (X/Y.100)", with "X" as the number of D.dipsaci found in treated plants at the last extraction date and "Y" as the number of nematodes found in the untreated plants at this date (Table III).

Table III - Effects of various seed coating formulations (3 mg carbofuran/seed) on number of stem nematodes recovered from yield bean plants at different times after sowing.

Formulations	Average number of D.dipsaci /g stem tissue 52	75	97	117	C %
	days after sowing				
Untreated	3,6 ± 1,5	11,1 ± 1,8	59,6 ± 38,4	266,9 ± 59,3	0
CL coating	0,4 ± 0,3	1,6 ± 0,7	4,6 ± 2,0	19,9 ± 8,7	92,5
UF coating	0,1 ± 0,1	0,4 ± 0,3	2,4 ± 1,6	11,2 ± 6,0	95,8
SX coating	0,5 ± 0,5	1,1 ± 0,6	22,5 ± 3,4	42,1 ± 16,4	84,3

The highest number of stem nematodes was found from the first observation in untreated plants and quickly increased. A good control was achieved during the first 3 months with all formulations of carbofuran. At the last observation (117 days after sowing) the SX formulation allowed some nematode penetration.

Half plots were harvested on 10 September (130 days after sowing). Field bean grains were cleaned and air dried before being weighed. Carbofuran markedly improved yield ($P<0.001$), the thousand grain weight (TGW) and the protein content who were significantly greater than in



untreated plots (Table IV). All values given in Table IV are significantly different ($P<0.05$).

Table IV - Influence of different formulations of carbofuran on the yield, the thousand grain weight (TGW) and the protein content of a field bean crop (cv. Exelle)

Formulations	Yield (g / m2)	TGW (g)	Protein content (%)
	(Averages of 4 repetitions)		
Untreated	402.8 a	320.7 a	24.2 a
CL coating	604.7 b	397.5 b	25.7 b
UF coating	636.4 b	412.9 b	26.1 b
SX coating	563.9 b	387.0 b	25.7 b

a and b : ditribution of means following the NEWMAN and KEULS method for $\alpha = 0.05\%$.

After extraction, residues of carbofuran in flour of harvested grains were determined by a gas-liquid chromatographic method (SCHIFFERS et al.,1985). Residues attained 0.11 ppm or 0.38 ppm for plants treated with a classical (CL) or a urea-formaldehyde (UF) formulation, respectively.

The coating efficacy has been also evaluated against corn wireworms attacks (Table V).

Table V - Influence of different carbofuran treatments on the number of corn plants after attacks by wireworms and on the yield.

Treatments	Number of plants 16 days after sowing (average of 4 repetitions)	104	Yield (starch in g / m2)
Untreated	7.7 a	4.2 a	920 a
Microgranules	11.1 b	6.3 c	1587 c
CL coating(3 mg/seed)	10.7 b	6.7 c	1626 c
CL coating(6 mg/ seed)	11.4 b	6.8 c	1731 c

a and b : ditribution of means following the NEWMAN and KEULS method for $\alpha = 0.05\%$; c : for $\alpha = 0.01\%$.

The number of plants surviving wireworms damage are similar for all treatments and significantly greater than the control. No difference between a half-dose of carbofuran and others treatments.

4. CONCLUSIONS

The controlled-release performance of coating and microgranules formulations has been characterized using radioisotope technique. In a laboratory test, carbofuran appeared to be

released up to 3 times more slowly from coatings than when formulated as commercial microgranules. In another experiment with 14C-carbofuran (SCHIFFERS et al.,1987), it appeared that accumulation of carbofuran and its metabolites occurs in oldest parts of plants and carbofuran release from seed coatings provides a higher proportion of chemical in plant tissues that gives to the active agent a longer time of efficacy.

Carbofuran reduces markedly the number of stem nematodes found in field bean plants 4 months after sowing. 3 mg of carbofuran per seed correspond to 0.9-1.2 kg a.i./ha according to sowing density. The long persistence of nematicide activity for such a quantity of a.i. is obtained by the slow release of carbofuran from seed coatings as characterized in a standard washing test. Seed dressing with the UF formulation provides the best protection against D.dipsaci (95.8% of control 4 months after sowing) and the best yield (+58%). SX formulation has a shorter activity than the others, but the infestation is nevertheless prevented during sensitive blossoming period (until 15 July). Therefore, yields of SX formulation are not significantly smaller than for the other treatments. Residues of carbofuran at harvest were always found below the authorized level (0.50 ppm), but the difference of residues levels between the "CL" and the "UF" formulation illustrates the risk of over prolonging the release period.

Carbofuran applied to corn seeds at the rate of 3 mg a.i./seed, or about 300 g a.i./ha, has a similar efficacy than coatings or microgranules at 600 g carbofuran/ha, that allows a chemical reduction of 50%.

Seed coating can also be used for microorganism incorporation to the soil, and some of them -such as Rhizobium- can be associated with carbofuran (SCHIFFERS et al.,1982).

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