CONTROL OF STORED PRODUCT PESTS WITH CO_2 ON WHEAT IN PLASTIC BAGS

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Abstract

The control of stored product pests in wheat with CO_2 has been studied. The wheat was stored in PVC, PE and PA/PE bags. Dry ice and gas formulations of CO_2 were used. The satisfactory results were obtained at higher concentrations or longer expositions.

The advantage of such a control method is very interesting in the household and for small farmers who will be able to protect their products harmlessly and successfully. At the same time, if less permeable plastic would be used, the treated commodity could be preserved and protected for a longer period of time before the usage.

In order to spread the use of this control method it would be necessary to have available various dimensions of dry ice or small cylinders with CO_2 gas. These studies have to be continued in order to improve and preserve the stored products on small farms in many countries where considerable quantities of commodities are still stored in inapropriate conditions having almost no perspective for a correct control of the pests that infest stored commodity.

Introduction

The presence of the insects on the stored wheat is a significant problem, particularly concerning the storages on the small farms. The powdered formulation of malation has been registered for the control of stored product pests in Yugoslavia in the late sixties (Anon, 1976) and the way of their usage is a very simple one. Some other active ingredients, in some

particularly adapted formulations, can be applied by means of some complicated and expensive wquipments and they are used in grain elevators and warehouses. Namely, among the insecticides there are no adequate ones implying both a low hazardness and toxicity a fast acting and no hazard residues for the control of the insects. According to this carbon dioxide could be used on the small farms in the control of the stored product pests soon, due to its favourable toxicologic characteristics.

The researches with carbon dioxide in the control of the stored product pests, by gas and dry ice, have been studied for decades. In the course of time a lot of data has been gathered, using the same, similar or different methods and parameters (Annis, 1987). As orientational data, providing a satisfactory efficacy to all the insect development stages, a 60% concentration of CO_2 during 4 days at the temperatures above 25°C can be cited (Jay, 1971).

By the application of the dry ice on the flour in transport, in a waggon, (Ronay and Jay, 1982) some satisfactory results were obtained. Nevertheless, the possibility to apply the pelets and the dry ice blocks, under the condition that the sealing is performed in a better way, what would provide a favourable result, is cited.

Except the application of the gasseous CO_2 in a bin, the studies show out the possibility of the fumigation of the goods in bags covered by PVC film (Annis, et al 1984). If the air is displaced from the sack of wheat and it is replaced by CO_2 a skin packing comes out. Using polyethylene / polyester film, an average absorbtion of CO_2 on rice, in the ammount of 69 ml CO_2/kg including the loss through the film, was stated. These results are in accordance with the researches performed in Japan, where an absorbtion of 70 ml CO_2/kg was attained using polyethylene/ polyamyde film (LuQianyu, 1984). As long as the film is not damaged, the products treated in such a way can be kept for a longer period of time since they are protected from the insect attacks and they retain a good quality as well. Utilizing the current knowledge, these researches have been issued in order to achieve the use of the method in practice as soon as possible.

Materials and Methods

The experiments were set in the plastic bags filled 3/4 of their size by wheat. The adhesive tape was used for closing of the bags. The conditions during the time of the experiment were as follows: the temperature 25$\pm$ 2°C

and the relative humidity of 65$\pm$ 5%. The efficacy was read off after the end of the experiments by counting the present insects either by removing of the alive ones from the wheat or by leaving the alive ones in the purpose of getting the offspring. The ofspring was counted after 30 and after 60 days.

a) The experiment in PVC bags

There was 20 kg of wheat in the sacks. The adults of **Sitophilus oryzae (L)** and **S.granarius (L)** were used. 25 insects were put into a jar containing 20 g of wheat. The jar shut by some cloth was put into the bag, then the gas from the cylinder was released and put in. The initial concentration in the sack was 60% of CO_2. The concentration of $CO_2$was measured only on the last day of the experiment .

b) The experiments in PE bags

One experiment was set in the bags containing 15 kg of wheat, naturaly infested by **S.oryzae and S.granarius** and CO_2 from the cylinder was used in it. The concentration was being measured almost all the time of the experiment (6 days). In the sacks containing 3 kg of wheat, 20,30, 40 or 50 g of dry ice was used. The insects engaged in this experiment were **S. granarius, Rhizopertha dominica F** and **Tribolium confusum Du Val.** 25 insects of each species were put either into an empty jar or in the jar with 20 g of wheat, shut by some cloth andthen put into a bag. In the end of the experiment after 24 or 48 hours, the survived insects were left for the purpose of getting the offspring. In another experiment, in the bags containing 15 kg of wheat 200, 300, 400 or 500 g of dry ice was used. In this experiment **S.granarius and T.confusum** were used . The experiment lasted for 14 days and the method was the same as previously described.

c) The experiments in PA/PE bags

The experiments in PA/PE sacks were performed in the same way as the ones in PE sacks, only 3 kg of wheat was always used.

Results and Discussion

a) The experiments in PVC bags

The initial concentration of CO_2 was 60% and after 2 days it was from 22 to 38%. A higher mortality of **S.oryzae** than of **S.granarius** was achieved at this concentrations. This fact resulted with the appearance fo **S. granarius** offspring, though the number of the **S.granarius** adults was a smaller one on the treated than on the untreated wheat. The results obtained

satisfy by no means, since the appearance even of 1 to 3 weevils indicates a necessity of performing the control measures (Table I).

At a day longer exposition (i.e. 3 days) and the same initial concentration, using the same sacks, from 10 to 24% of CO_2 was measured. The mortality of **S.oryzae** was identical to the one in the first experiment whereas more of **S.granarius** died in this one. No offspring of **S.oryzae** but only of **S.granarius** appeared in this case as well. Such a way of control, based on the attending of the offspring, proved to be not an efficient one (Table I).

b,c) The experiments in PE and PA/PE bags

Three or fifteen kg of wheat, highly infested by all the development stages of **S.oryzae** and **S.granarius** were treated by CO_2 released from a cylinder. The filling of the sacks by CO_2 lasted as long as the initial concentrations were from 67 to 75%, what means that the sacks were blow on. Still five measurings afterwards showed gradually decreasing concentrations. The experiment was concluded on the sixth day when the concentrations were 10% and lower ones. In PE sacks (B,C) containing 22 to 30% of CO_2 measured after 24 hours there were lots of the alive and paralysed (slowly moving) insects. By checking of the random samples (3 x 200 g) before the treatment a very high number of the insects in the B (altogether 312 **S. oryzae** and **S.granarius**) and the lowest one in the A were found. By checking of the samples, having the same weight, after the treatment, the alive insects were found in the B and the C. The efficacy of CO_2 relating to the initial population was from 29% to 82%. Though a lot of the insects did not survive, excluding the A, the obtained results were not the best ones. The same samples taken before the treatment checked 30 days after showed more insects than the ones taken after the treatment (Table II). These results indicate that the efficacy on the development stages was not satisfactory one.

The results obtained in PA/PE sacks did not vary much to the ones previously described (Table II). The differences were in higher concentrations of CO_2, a better initial efficacy and much higher insect population but the results achieved when checking the samples 30 days after were even worse than the ones in the PE sacks. According to these results it can be seen that the efficacy was not a satisfactory one.

By applying of the dry ice in the PE and PA/PE bags, some more favourable results were obtained. All insects died in PA/PE bags after 24 hours.

Ronai K.S. and Jay E.G. (1982) Experimental studies on using carbon dioxide to replace conventional fumigants in bulk flour shipments. Assoc. Operative Millers-Bull. 3954-3958

Table I **The results obtained with CO_2 applied as gas at initial concentration of 60%**

Sacks	Exposition (days)	Concentration of CO_2 (%)	Mortality (%)		Progeny after 60 days	
			So	Sg	So	Sg
A	2	38	100	36	-	132
B	2	22	84	60	-	167
C	2	36	100	56	-	125
Con.	2	-	-	-	200	200
A	3	10	100	48	-	200
B	3	14	80	24	-	74
C	3	24	100	88	-	56
Con.	3	-	-	-	200	200

Insects: **S.oryzae, S.granarius, Con. - control**

Table II **The results obtained with CO_2 applied as a gas in the naturaly infested wheat with S.oryzae and S.granarius in PE and PA/PE sacks**

	PE-A	PE-B*	PE-C*	PA/PE-D	PA/PE-E*	PA/PE-F
Initial conc.of CO_2(%)	67	75	75	84	78	67
24^h	57	30	22	64	31	35
48^h	52	26	16	58	30	30
72^h	34	20	12	30	25	11
96^h	16	14	10	32	17	15
144^h	8	10	6	21	15	10
Efficacy %	82	70	29	89	70	42
No of insects before treat.						
Initial Alive	24	294	50	193	17	20
Dead	6	18	2	2	6	25
30 days Alive	262	404	258	836	73	92
No of insects after treat.						
Initial Alive	0	14	8	26	4	4
Dead	11	44	4	232	89	116
30 days Alive	7	127	50	836	110	80

Though a lower concentration (from 52 to 58%) after 24 hours in the PE sacks was measured even here all the **S.granarius** died whereas only a few **R.dominica** and **T.confusum** were paralysed. Since all the insects that were used as control ones were alive, the lack of food cannot be the cause of the dying. In another experiment, using the same type of the sacks, **T. confusum** were put on the flour and **S.granarius** on the wheat. The measurments after 24 hours showed some lower results than in the first experiment and so they were repeated after 48 hours. Since the bearing of the insects could not be distinguished and using the experience of the case when insects lacked food, the experiment was suspended. Meanwhile, by checking the insects in the jars, the highest percentage of mortality of **S.granarius** and **T. confusum** was stated in the applying of the lowest dosage, 20 g, in the both kinds of plastic sacks. It is interesting that lower concentrations were measured at the applying of higher dosages and in accordance to it a lower mortality was registered. Comparing the results of these two experiments, it can nevertheless be presumed that in the first one, besides somewhat higher concentrations, the lack of flour or wheat in the jars influenced the dying of the insect (Table III and IV). By the applying of the dry ice, 200 to 500 g in the PE bags containing 15 kg of wheat, the necessary, higher concentrations were measured during 2 or 3 days and then decreased daily 2 to 4%. Besides the initial high concentrations, these lower ones, during a longer period of time, 14 days, probably influenced the dying of the insects as well. Namely, this method can be compared to the hermetical storage (Table V). There was no offspring of **S.granarius** and **T. confusum**

Conclusion

These researches, showing out some positive results, also show quite a lot of problems which come up during the application. It is difficult to maintain the necessary concentrations of CO_2 in plastic sacks. However, a longer exposition though at low concentrations provided a good efficacy. Probably, by adding of CO_2 several times till the blowing in of the sacks, the concentration of 60 to 70% can be achieved and a satisfactory result can be provided in a shorter time. The most considerable problem is the fragility of the plastic sacks since even by a careful handling some slight damages can appear what influences the loss of the gas.

The results of the experiments evidently show that sometimes a lower concen-

* Paralysed and alive insects during the experiment

Table III **The experiment with dry ice in PE and PA/PE sacks when insects were in jars without food 24^h**

Sacks	Dry ice (g)	Concentration of CO_2 (%)	Mortality (%) S.g.	R.d.	T.c.
PA/PE	20	60	100	100	100
PA/PE	30	66	100	100	100
PA/PE	40	66	100	100	100
PA/PE	50	62	100	100	100
PE	20	58	100	96	100
PE	30	54	100	100	100
PE	40	58	100	100	96
PE	50	52	100	100	100

Insects: **S.granarius, R.dominica, T.confusum**

Table IV **The experiment with dry ice in PE and PA/PE saks when insects were in jars with food 48^h**

Sacks	Dry ice (g)	Concentration of CO_2 % 24^h	48^h	Mortality (%) S.g.	T.c.
PA/PE	20	61	54	85	100
PA/PE	30	45	28	55	32
PA/PE	40	64	60	50	80
PA/PE	50	63	58	45	92
PE	20	57	46	75	80
PE	30	50	29	70	44
PE	50	37	23	45	12

Insects: **S.granarius, T.confusum**

Table V **The results obtained with dry ice in PE sacks at 14 days exposition**

Dry ice (g)	Concentration of CO_2(%)				Mortality (%)	
	24^h	48^h	72^h	396^h	S.g.	T.c.
200	64	58	46	4	100	100
300	58	46	28	6	100	100
400	67	63	58	6	100	100
500	56	38	23	3	100	100

Insects: **S.granarius, T.confusum**

tration is measured at the higher dosages and it results by a lower mortality. Such a reverse proportionality can be the conseqence of a strong pressure on the side-wall of the sack what can cause a considerable loss of CO_2 since the permeability of the film depends on pressure as well. In order to enable the use of CO_2 in practice on small farms, its application ought to be a simple one. Dry ice could be used by means of some attainable equipments for the manufacture of some little weight cubes, which could be thrown into the sack. According to the results of the experiments, about 7 g of dry ice on a kilo of wheat would result satisfactorily. In this case it would also do well to throw in a half of the quantity, applied in the beginning but several times.

The presence of CO_2 in the sacks must be obvious either the sack is blown up or the skin packing arised. In the experiments the small packings were blown up while the big ones deflated a few days after. The skin packing was not realized in the experiments. It the undamaged sacks can be left closed after the treatment since the present CO_2 implies the role of a concervative means, the wheat can be protected from the insect infestation for a longer period of time before its use. These studies have to be continued in order to improve and preserve the stored products on small farms where considerable quantities of commodities are still stored in inappropriate conditions having almost no perspective for a correct control of stored product pests.

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LUTTE CONTRE LES RAVAGEURS DES STOCKS DE DENREES PAR LE CO_2 SUR LE BLE EN SACS EN PVC ET EN PA/PE

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RESUME

On a étudié la lutte contre les insectes des grains avec le gaz carbonique. Le grain était stocké dans des sacs en PVC et en PA/PE. On a essayé le CO_2 sous forme de neige carbonique et de gaz. Des résultats satisfaisants ont été obtenus aux doses les plus élevées et après les temps d'exposition les plus longs.

L'avantage d'une telle méthode d'élimination est d'un grand intérêt au niveau domestique et des petites exploitations qui pourront protéger leurs produits avec succès et sans peine. En outre, si l'on utilise un plastique moins perméable, la denrée traitée pourrait aussi bénéficier d'une protection pendant un temps plus long que de coutume.

Afin d'étendre l'emploi de cette méthode, il serait nécessaire de disposer de diverses tailles de stocks transportables de neige carbonique, ou de petits conteneurs de CO_2 gazeux. Ces études doivent être poursuivies dans le but d'améliorer et de préserver les stocks des petites exploitations dans de nombreux pays où des quantités considérables de denrées sont encore stockées dans de mauvaises conditions et n'ont aucun moyen de lutte contre les déprédateurs qui les infestent.