PN-ABM-443
79474

January 1989

Title: Bioproduction of Modified Atmospheres in Small Grain-Storage Containers for Insect Control

C7-062

Grant No. DPE-5544-G-SS-7024-00.

A Progres Report for the Second Period.

July- December 1988

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APR 21 1989

Bioproduction of Modified Atmospheres in Small Grain-Storage Containers for Insect Control

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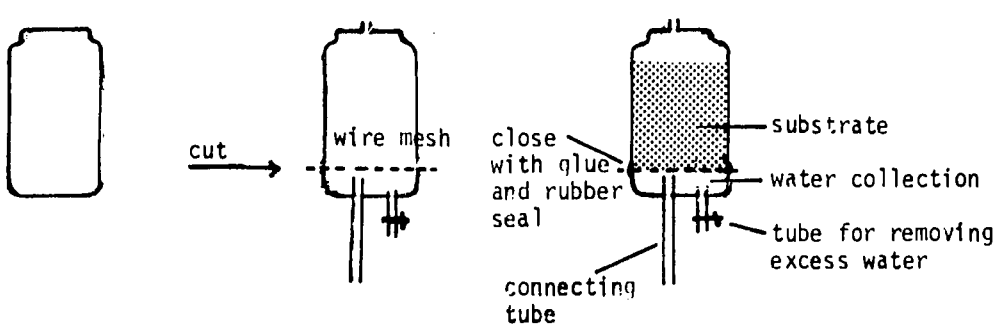
Progress Report No. 2 (January 1989).

A. Israel

During the second period of our work we concentrated on studying the dynamics of CO_2 migration produced in a biogenerator into a plastic bin filled with corn grain. This led to the development of a practical model which will serve as a simulative prototype for our biogenerator - grain bin system.

1. Biogenerator: The same cans described in our first report were used in the present studies. A schematic drawing of such a bin is given in Fig. 1.

Fig. 1: A scheme describing the cans used as a biogenerator



2. Grain bin: Plastic bins capable of holding 20kg corn grain each were used (Fig. 2). Three plastic tubes were inserted at three heights in each bin, thus enabling us to measure the air composition in the bottom, middle and surface layer of the grain. Corn was used as

the test grain and, in order to avoid CO_2 accumulation due to insect activity, the corn was treated, prior to the studies, with Phostoxin. The initial moisture content (MC) of the corn was 13.0%.

3. Substrates: Based on the results reported previously (Progress Report No.1, July 1988), we decided to use peanut shells and wheat bran as the choice substrates. The materials were wetted to 25-28% MC and allowed to equilibrate for 14 days at 5°C before use. Lots of 300 g of each substrate were placed separately in plastic cans which were than connected to the grain bin (one can to each bin). Studies were carried out in triplicate in a controlled temperature room (26±1°C); CO_2 and O_2 were measured using a Gas-Analyzer and Oxymeter, respectively. The intergranular relative humidity (RH) was measured using Hygrotest 6400 (Testoterm, Germany) equipped with a probe inserted to the bottom of each bin. The MC of the corn was calculated from the RH values using the commonly used conversion charts. In order to measure the MC of the substrates without opening the biogenerator, a separate set of biogenerators was placed alongside the trial bins and samples of each substrate were taken periodically and analyzed for MC.

Results and Discussion: Table 1 shows the changes in the gas composition inside the generators and the grain bins. A sharp increase in the CO_2 level occurred in the peanut shells biogenerator and within 48 h the concentration of CO_2 inside the grain bins rose to 10-11%. In the bran biogenerators the CO_2 rose gradually to a maximum level (12%) at 6 days of storage. The accumulation of CO_2 was concomitant with a decrease in the O_2 level. The MC values of the corn grain remained unchanged throughout the studies (Table 2), thus indicating that CO_2 migration was not followed by humidity migration from the biogenerator to the grain bins.

These findings indicate strongly that we were able to establish a "biogenerator - grain bin system" in which the CO_2 which was produced, migrated satisfactorily to the lower bin. The different CO_2

accumulation pattern found to exist in the substrates used encourages us to use both substrates in the same biogenerator. Hence, the CO_2 will start accumulating immediately (due to the peanut shells) and continue to rise (due to the wheat bran).

The objectives for the next period are as follows:

1. To determine the CO_2 production in the substrates as related to the MC of the materials. This could lead us to choose a substrate with higher levels of moisture, which could yield enhanced CO_2 concentrations.

2. To integrate the biogenerator - grain bin model with insect mortality. For this purpose, insects of three selected common grain pests will be introduced into the bins and the lethal effect in their natural environment - as a function of CO_2/O_2 ratio and storage period will be established.

3. Based on the results presented here, we intend to start our farm-scale studies using 100-kg lots of corn. These studies will be undertaken in Israel and Costa Rica using the biogenerator installation developed by us and the substrates which have been shown to be promising in Israel (peanut shell and wheat bran) and Costa Rica (sugar cane).

Fig. 2: A general view of the "biogenerator - grain bin" model.

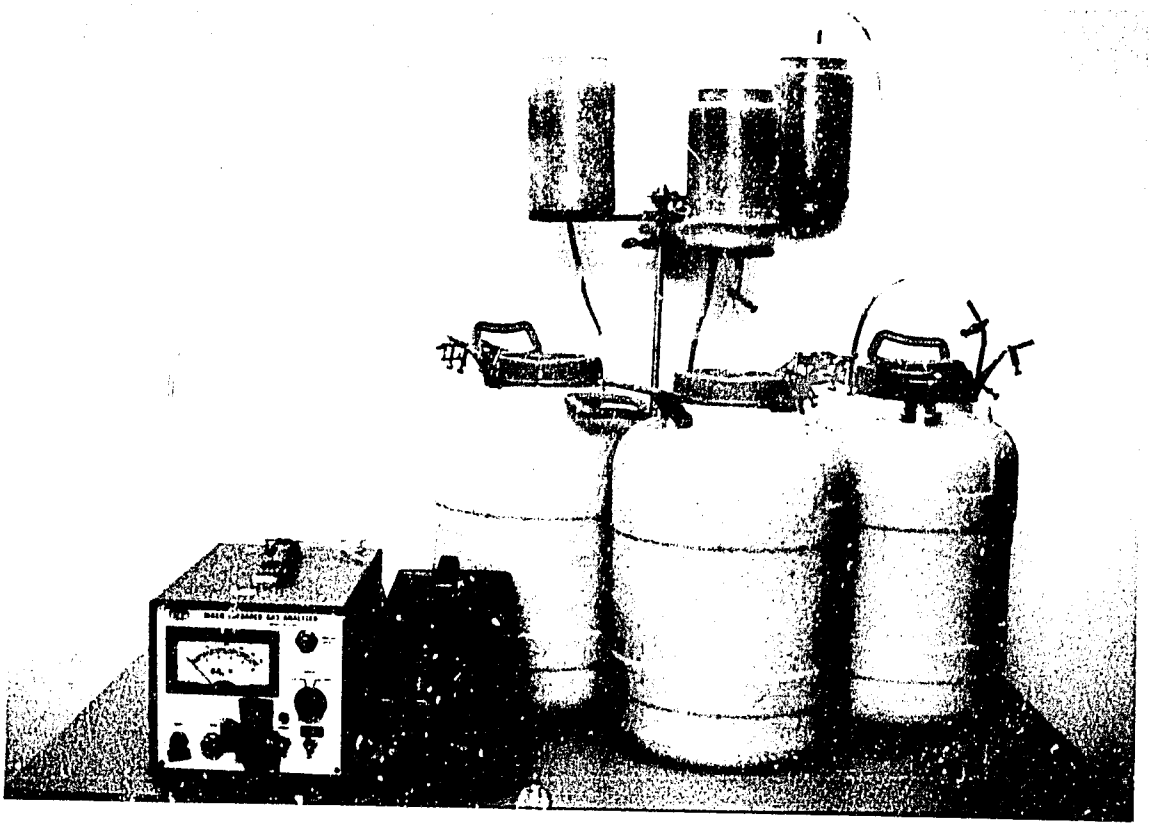


Table 1 - Changes in concentrations (%) of O_2 and CO_2 (average of three replicates ± S.E.) in biogenerators and corn bins stored for 17 days at 26±1°C.

			Days of storage											
			2		3		6		8		11		17	
			CO_2	O_2	CO_2	O_2	CO_2	O_2	CO_2	O_2	CO_2	O_2	CO_2	O_2
Wheat bran	Biogenerator		0.6	20.6	1.8	19.7	15.1	6.9	14.0	8.2	13.5	8.2	12.7	9.4
		S.E.	0.06	0.03	0.2	0.1	0.7	0.7	0.8	0.9	1.4	0.9	1.2	1.5
	Surface Layer		0	20.7	0	20.7	12	9.7	11.5	11.0	9.1	13.1	9.2	13.8
		S.E.	-	0.05	-	0.05	-	0.1	-	0.4	0.3	0.6	0.5	0.05
	Middle		0	20.8	0	20.7	12	9.3	11.5	10.7	9.5	12.6	9.1	13.4
		S.E.	-	0.05	-	0.1	-	-	0.5	0.8	0.4	0.8	0.05	0.1
	Lower Layer		0	20.8	0	20.7	11.2	10.1	11.2	10.9	9.3	13.0	8.9	13.6
		S.E.	-	0.05	-	0.05	0.7	0.8	0.2	0.6	0.7	0.9	0.2	0.2
Peanut shells	Biogenerator		19.0	5.8	14.3	8.4	10.4	11.9	9.1	12.7	8.3	13.7	6.2	15.5
		S.E.	0.2	0.3	0.4	0.4	0.6	0.6	0.3	0.5	0.5	0.5	0.3	0.15
	Surface Layer		10.6	12.1	10.5	12.0	7.9	14.8	6.8	15.2	5.0	14.8	3.5	18.0
		S.E.	0.4	0.2	0.2	0.7	0.9	0.7	0.5	0.4	0.6	1.4	0.5	0.5
	Middle		11.3	11.2	10.8	11.6	7.9	14.6	7.1	15.0	5.1	14.8	3.7	17.8
		S.E.	0.3	0.3	0.1	0.6	0.9	0.6	0.5	0.5	0.5	1.5	0.6	0.5
	Lower Layer		11.3	11.3	11.1	11.5	7.5	14.5	7.0	15.1	5.1	14.7	3.7	17.8
		S.E.	0.3	0.4	0.6	0.7	0.6	0.6	0.5	0.6	0.5	1.4	0.5	0.5
Control	Surface Layer	S.E.												
	Middle	S.E.	0	20.8	0	20.8	0	20.8	0	20.6	0	20.7	0	20.7
	Lower Layer	S.E.												

Table 2 - The moisture contents (%) of the corn grain (average of three replicates ± S.E.) during the trial period.

		Days of Storage		
		3	8	17
Wheat bran		13.04	13.0	12.9
	S.E.	0.1	0.1	0.05
Peanut shells		12.9	12.9	12.9
	S.E.	0.1	0.07	0.05
Control		13.0	13.0	13.0
	S.E.	0.1	0.1	0.1

INSECT CONTROL PROJECT USING CO_2 FROM BIOGENERATORS

II REPORT

(ACTIVITIES FROM JULY TO DECEMBER 1988)

Dr. Miguel Mora, CIGRAS, Costa Rica.

During this period, work was done in three activities:

1. Tests for application of CO_2 to different recipients utilized by grain producers for storage of grain. Insect control and hermeticism of these recipients.
2. Tests with different substrata for CO_2 biogeneration.
3. Tests on the effect on volume and CO_2 concentration measurement variation due to differences in temperature.
4. Survey to learn about postharvest grain handling systems, autoconsumption and grain marketing between producers.

TESTS WITH STORAGE CONTAINERS

Objectives

The objectives established for these tests were the following ones:

1. To design an try out a appropriate metodology to fill with CO_2 and realize necessarily measurements, in two commonly used recipients for the storage of grains at farm level.
2. To measure CO_2 losses in each kind of recipient using two types of sealing (hermeticism) in each one.

3. To measure CO_2 quantity needed to obtain a predetermined gas concentration (40 and 80% CO_2 in this case) on the containers and kind of grain (maize) tested.
4. To test the effect of different CO_2 treatments, under the present experimental conditions, on Sitophilus zeamais mortality.

Metodology

Recipients

We used the two most commonly utilized recipients in the Centralamerican area for grain storage at farm level. One of these containers is the known as "oil drum", a structure of 55 gallons made of fairly heavy metal and very well sealed since its initial purpose is transportation of liquids. The other container tested is the "silo familiar" (family bin) which is made locally using galvanized metal sheets. The use of this type of bin is widely spread in several countries within and out the Centralamerican area. It is built with different capacities, usually from 0.5 to 3 t. In our case for easier handling, we use bin with capacity to hold near 310 kg of maize.

Since in this work hermeticism of recipients is of fundamental importance, both types of structures were tested using two ways of sealing them, simulating ways used for small farmers.

Some drums have only two small openings of 2 and 7 cm in diameter that can be close very tightly, while others have their top side completely open. In these test we used the firsts drums very well closed and the second ones with only a double sheet of polyethylene firmly tight around the top opening. In the construction of these small bins, in some cases the edges are only bent one upon the other and hammered, while in some other cases this type of joint is reinforced by welding it with stannum. Bins with both types of constructions were tested here.

Grain used and site of testing.

The recipients were fill up to near 5/6 their total capacity using 13.2% m.c white endosperm maize from a lot belonging to the Consejo Nacional de Producción (National Council of Production) CNP, gubernamental institution responsible of maintain grain supply in the country. The grain was taken from a terminal plant called La China and, for facility of transportation, the test were carry out in this same place were we also have the collaboration of some personal and workshop services from the CNP.

Treatments

For these test we used commercially available CO_2 applied to the grain to obtain initial concentrations of 40 and 80%. Besides, in some cases, extra CO_2 was added daily to maintain the initial level and in other treatments this extra applications were not done.

For the evaluation of treatments, mortality of insects in each deposit of grain was determined. Insects used were Sitophilus zeamais from cultures kept on maize at CIGRAS and CNP. The grain of both cultures were mixed first one with the other and then mixed with non infested grain (1:3) for dilutions purposes and to supply new grain for oviposition of insects remaining alive. Samples for testing were prepared placing 40 g of grain and 30 adult insects in small cloth bags. In each recipient were placed three bags, one near the top another in the middle and the third one near the bottom.

We also carry out a control treatment for the insect mortality, where no CO_2 applications were done. However it was necessary to do this test at different time than the others, because of shortage of recipients.

Measurements.

Concentration of CO_2 and O_2 was measured at the beginning of the test and then every 24 hours, at the top center and bottom sections of the recipients. In order to take the gas samples each container have four small pieces of copper tube welded at the walls. Each tube was about 15 cm long and 5 mm in diameter. Three of these were use for the actual taken of samples and, since the containers were hermetically closed, the fourth one was use to blow air to an initially empty bag left inside the recipient, allowing in this way to maintain the internal volumen while extracting gas through the others tubes.

The analysis made to the grain itself were moisture content by the oven method, truth density by displacement of toluene, apparent density and mold and insect damage.

To evaluate the efect of treatments on insects, we counted the number or live and dead adults after 5 days of storage. The grain of these samples have been left in incubation for 30 days to evaluate the mortality of other stages of development of the insects.

Hermeticism tests.

Since hermeticism of recipients is so important for the effectiveness or this method of insect control with CO_2, this characteristic was evaluated in different ways: a) by the daily loss of CO_2 concentration in those recipients were we were trying to maintain the initial concentration; b) by the daily rate loss of CO_2 in those recipients were no more gas was added; c) by extra tests made specifically for this purpose. This last tests were done by measuring CO_2 loss, in each type of recipient, from an inicial concentration of 80%. Readings were taken every hour in bins and every 2 hours in drums until concentration reached 30% or less and up to a maximum of 10 hours of readings.

Repetitions

Only one repetition was use for test in the bins were no CO_2 was added after the initial filling, but all other tests were done with two repetitions.

Results

Volumen of CO_2 needed.

Actual quantity of grain added to drums was near 115 kg an to bins was near 235 kg. Volumen of pure CO_2 needed to reach 40 was near 140 l in the closed drum and 160 l for the open drum Volumen needed to reach 80% CO_2 was near 330 l for the close drum, 400 l for the open drum, 600 l for the welded bin and 750 for the bent joints bin.

Above quantities are a first approach to determine need of gas generation to reach an insect lethal concentration of CO_2 in containers tested. In those figures are included the effect of gas absorption, leaks and the filling of the space left on top of grain.

Some additional information to consider when calculating needs of gas is the total free space in the containers. Since the grain had a apparent density of 0.74 kg/l and a true density of 1.25 kg/l, considering the total capacity of the containers and the grain added to each one, we have that in drums there was a empty space of near 114 l and in the bins of 230 l. Calculated needs for pure CO_2 for a 40% concentration are of 45 l for drums and 92 l for bins. Double is needed for 80%. Relating these figures with actual CO_2 volumen used in tests, results that it was needed about three times the calculated volumen to reach a given concentration.

Effect of CO_2 concentration.

Effect of initial CO_2 concentration was completely dependent of the type of recipient utilized . An initial concentration of 40% of CO_2 was enough to kill all insects if a completely hermetic recipient is used as it is the sealed drum (Figure 1). On the contrary, an initial concentration of 40% is not enough to have a good control when the drums were just covered with polyethylene and a concentration of 80% was necessary here to kill most adult insects. We never had good insect control in the bins. The best treatment with bins was using a sealed bin without replacement of the CO_2 lost. This is not logical since level of CO_2 was null in this silos by the following day while in the other the gas loss rate was slower (Figure 2). We do not have any explanation for these last results right now except that it was necessary to put to much gas at the beginning in this bins to reach an initial concentration of 80% which could have affected the insects.

Effect of the type of recipient.

As it was mentioned and is logical, there is a close relationship between the effect of the initial CO_2 concentration and the type of recipient used. With no doubt the best recipient is the sealed drum were a single application of CO_2 to reach 40% was enough to kill all adult insects. The second best one is still the drum even when only covered by polyethylene. This system could be even better if we choose a more appropriated material to cover the structure and a better way to do this. Silos tested are

not good to apply this type of control.

The results obtained in each recipient is of course dependent of it gas tightness. As mentioned, the best results in insect control were found in drums and, as can be see in Figure 2, the rate of CO_2 concentration drop is much lower in these drums than in bins.

One very important conclusion from results obtained is the fact of the so poor capacity of bins to retain CO_2. These gives as result the poor insect control obtained in bins. Importance of these result is increased by the great interest shown in some countries to spread as much as possible the use off these structures.

Hermeticism de los recipients.

Lowest gas losses were found in sealed drums followed by losses in closed drums. By far highest losses were found in not welded bins were all CO_2 is lost in a few hours. Data obtained up to now have some inconsistence in relation to rate of losses but not on relative losses between container. Some more work should be done about rate of CO_2 loss.

CO_2 GENERATORS TESTS

Objectives

1. To evaluate CO_2 production capacity of biogenerator tested, using different types of organic materials and forms of preparation of these materials.
2. To carry out additional test related to biogenerators functioning such as hermeticism of materials used to make gas collector and the effect of temperature upon gas volumen and CO_2 concentration measurement.

Metodology

Treatments.

In testing generation of CO_2, there were 30 treatments evaluated, formed by different combinations of 6 types of material, 4 ways of physical preparation, 2 water adding ways and some additional test adding yeast to some of the original treatments (Table 1). The generators were as described in former report, that is, made with a 1 gallon plastic main deposit connected to a gas collector. In this case we changed the gas collector for bags as described later. Generators were place in an air conditioned room with a temperature, during the tests, of 23 ± 2 °C.

Measurements.

Effect of treatments were evaluated by the total volumen of gas produced and its proportion of CO_2 and O_2. Temperature was recorded continuously. Additional test to correct these readings were done.

Tests to correct readings of gas volumen and composition.

Not having on hand information about the effect of temperature on changes in volumen, a apparatus was built for this purpose. This apparatus have a glass chamber with a flexible bag inside that was partially filled with gas at different concentrations of CO_2. The glass chamber was filled with water at 20 °C or less and, as temperature was increased due to ambient effect, changes in volumen by water displacement for expansion of gas inside the bag were measured a different temperatures. Data was corrected for water volumen changes due to changes in temperature. We also did some tests for CO_2 concentration readings changes due to temperature changes.

Results

Effect of treatments

Table 1 shows the quantity and weighted average composition, from different readings, of gas produce in each treatment. Before these tests are finished and statistical analysis is carry out, there are some major observations that can be done.

1. Although not shown on table, many treatments produce complete unacceptable odors. This is the case of maize alone and with yeast and most green materials.
2. Mixture of some material, as maize and sorghum, helps some in gas production and avoids greatly bad odors.
3. Sugar cane is an excellent substrate by itself. Addition of water in a ratio of 1:1 is better than with 1.5 parts of water. In this occasion one replicate was lost because of problems with the gas container.
3. Addition of yeast (3.5 g/kg) to sugar cane is by far the best treatment. This treatment not only produced more gas than any other one but also have the highest proportion of CO_2 and is odorless. Another characteristic is that gas is produced very rapidly (within 24 hours) while in the others several days are needed to have gas production.

In relation to the practicability of using sugar cane and yeast to generate CO_2, both are readable available most of everywhere. If necessary in some cases, sugar cane is easily cultivated for a purpose as the present. Yeast is also easily obtained, cheap and easy to transport to places were is not available.

Correction of gas volume and concentration by temperature.

In Table 2 are shown some factors to correct volume reading made at differente temperatures and at different concentration level. This are only preliminary results and more work should be done if there is no other source of information about this matter.

If no automatic correction of CO_2 concentration reading for

temperature is available, this factor should also be considerer. Initial trials showed diferences of up to 14% in readings made at 20 and 28 C. Concentration level also seems to interact with temperature affecting readings.

Other results.

One very important result of the work done with the biogenerator was the identification of a container practically impermeable to CO_2.

Since at the beginning of this work we did not have any suitable container to be use to hold the gas been produced by the biogenerator, we tried many materials for this purpose. Some of these were different types of containers made of regular polyethylene, polyvinyl chloride (PVC), rubber and polyethylene tereftalate (PET). This last material is fairly new an known to have low permeability to CO_2, however we had complete unacceptable losses in all cases including the PET where about 18% CO_2 concentration is lost within 24 hours independently of initial concentration. It is possible to make PVC containers as the ones needed here but since this does not seem to be practical, we used the already available ones. We finally tried out a special bag use to pack food and made with plastic layers and one aluminum layer. This was the only container within tested ones that was strong and practically impermeable to CO_2. The only draw back was its short availability in the country but we finally got enough to run the tests.

FARM GRAIN HANDLING SYSTEM

Objectives

1. To estimate proportions and ways grain is stored and used at farm level.
2. To know the producers opinion about the type of problems and their effects on principal grains they handled

Metodology.

Initially, we prepared a survey with nationwide cover, based on relative production of each region and place and, at the end, farmers selection complete at random from available rolls. Collateral effects of a hurricane passing near the country destroyed part of grain plantation and specially damaged roads of access to production areas. Because of this problems a less planed survey is been conducted by filling out form with information of any grain producer available. This work is been done with the help of CNP's personnel localized in the same grain production areas. In this way, 115 farmers have been interviewed during this period.

Results

Selected average result obtained up to now are presented here but is very important to be aware that they come from very partial data specially from one region of the country. Previous results obtained in other projects proved existence of different problems and posharvest systems in other areas. FOLLOWING RESULTS ARE MAINLY A SAMPLE OF THE TYPE OF RESULTS WE WILL BE OBTAINING WITH THE PRESENT SURVEY.

1. Total number of forms filled out are 114 but 100 come from region Chorotega and 14 from the Huetar region.
2. Only the white endosperm maize and common beans are stored at farm level at important quantities and frequencies.
3. From total numbers of grain producers interviewed, 66% stored maize and 56 % stored beans.
4. In relation to ways of storage, hermetic drums were mentioned 53 % of total occasions. Other storage ways mentioned are non insect protective systems as regular bags, grain loose on the floor, etc.
5. In relation to insect damage, 45% of farmers that stored grain had problems in white maize and 57% in beans.
6. Stored grain is use for animal or human consumption and for seeds but not for future sales. Maximum storage time is usually from 6 months to 1 year.

ACTIVITIES FOR I SEMESTER 1989

1. Test to confirm advantages of materials as sugar cane and ripe banana fruit to produce CO_2. Try some materials similar to these.
2. Test effect of air injection to biogenerator chamber.
3. Effect of temperature on gas production.
4. Laboratory insect control tests using gas from biogenerators.
5. Test for production of larger volumes of gas.
7. Field trials for insect control using biogenetors.
6. Work on hermeticism of grain containers.
8. Finalize farm survey.
9. Visit to ARO group.

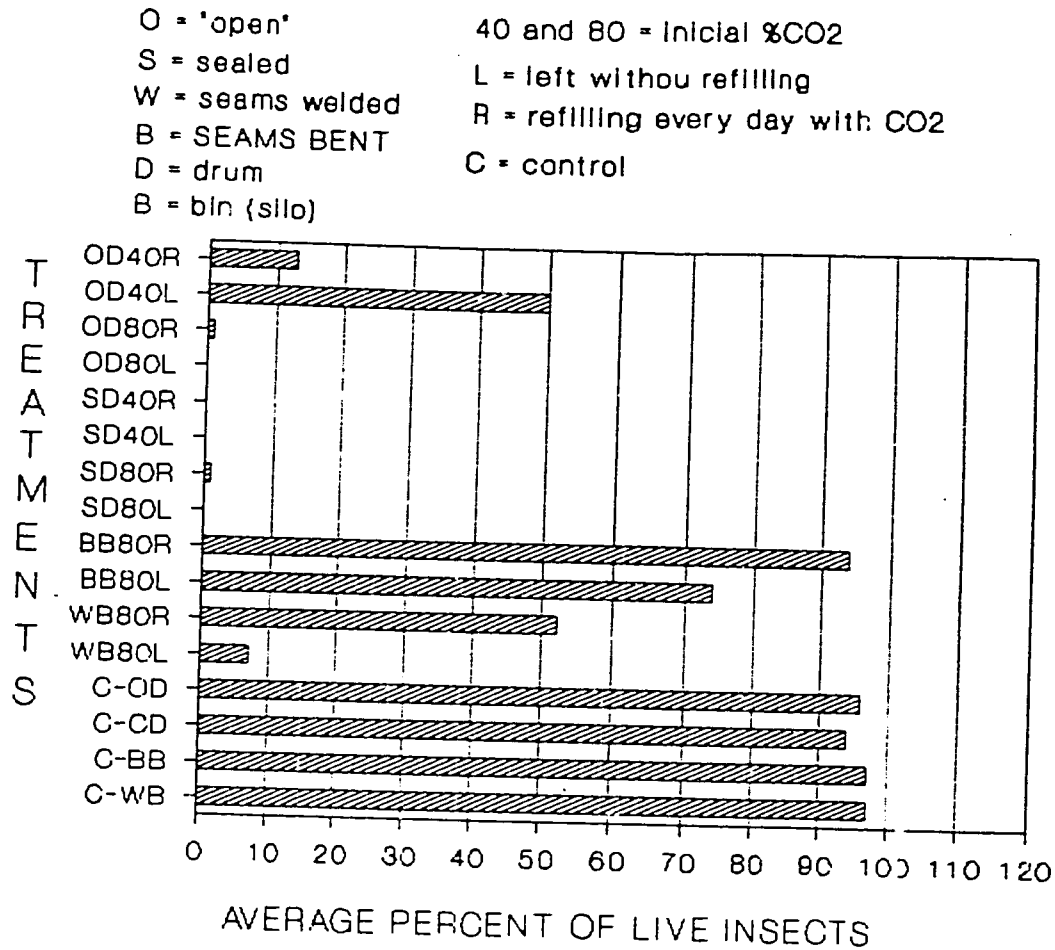


Fig. 1. Average percent of live S. zeamais after 7 days treatment with CO2.

B = BIN D = DRUM

S = SEALED, O = "OPEN", B = BENT SEAMS, W = WELDED SEAMS

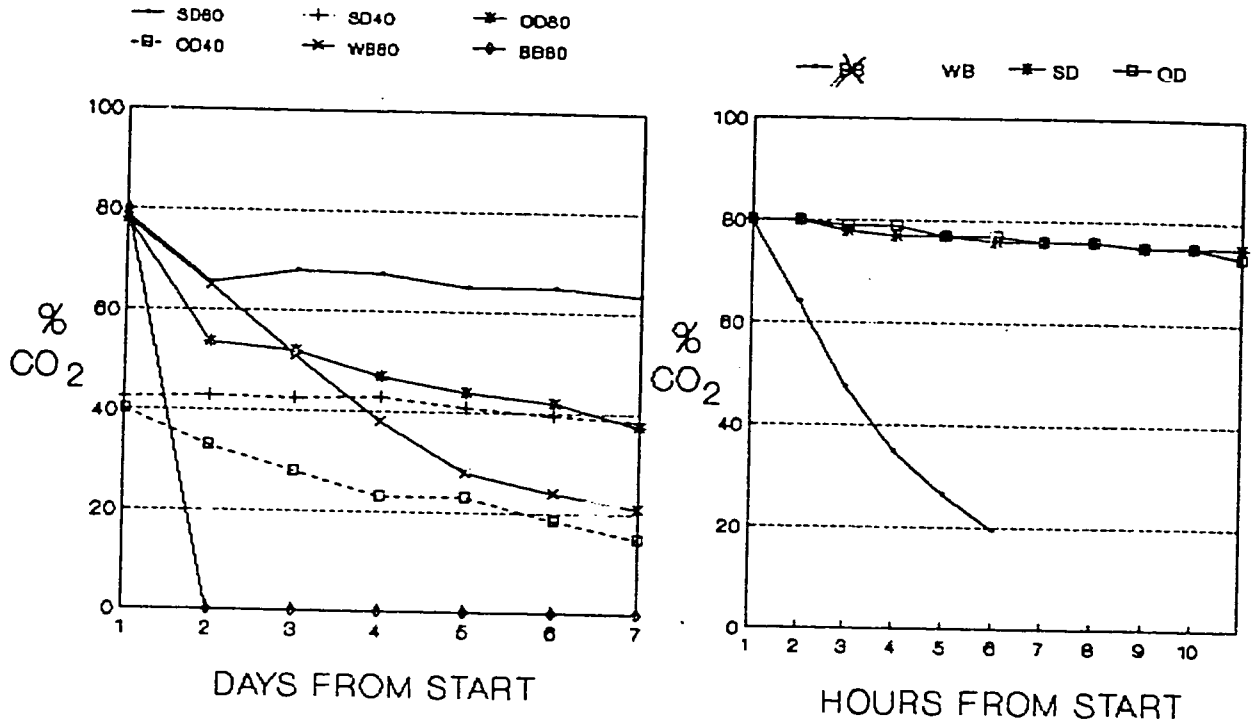


Fig. 2. Rate of CO2 loss in different containers during tests with insects (left) and in separated tests (right).

Table 1. Percent of live and dead insects after a CO_2 treatment.

TREAT. NO.	CONT. WAY	% CO_2 CONCENT. INICIAL	KEPT		REP 1 LIVE	REP 1 DEAD	REP 2 LIVE	REP 2 DEAD	CONTROL AVG.
1	DRUM "OPEN"	40	YES	top	3	97	57	43	97
				center	0	100	13	87	
				bottom	0	100	7	93	
2	DRUM "OPEN"	40	NO	t	50	50	84	16	
				c	22	78	92	8	
				b	0	100	57	43	
3	DRUM "OPEN"	80	YES	t	0	100	0	100	
				c	0	100	3	97	
				b	0	100	0	100	
4	DRUM "OPEN"	80	NO	t	0	100	0	100	
				c	0	100	0	100	
				b	0	100	0	100	
5	DRUM SEALED	40	YES	t	0	100	0	100	97
				c	0	100	0	100	
				b	0	100	0	100	
6	DRUM SEALED	40	NO	t	0	100	0	100	
				c	0	100	0	100	
				b	0	100	0	100	
7	DRUM SEALED	80	YES	t	0	100	0	100	
				c	3	97	0	100	
				b	0	100	0	100	
8	DRUM SEALED	80	NO	t	0	100	0	100	96
				c	0	100	0	100	
				b	0	100	0	100	
9	BIN "BENT"	80	YES	t	97	3	N.D.	N.D.	
				c	84	16	N.D.	N.D.	
				b	100	0	N.D.	N.D.	
10	BIN "BENT"	80	YES	t	93	7	86	14	
				c	56	44	77	23	
				b	57	43	73	27	
11	BIN "WELDED"	80	YES	t	60	40	N.D.	N.D.	94
				c	58	42	N.D.	N.D.	
				b	37	63	N.D.	N.D.	
12	BIN "WELDED"	80	NO	t	17	83	10	90	
				c	7	93	0	100	
				b	8	92	0	100	

"OPEN" = WITH TOP SIDE COVERED WITH POLYETHYLENE
"BENT" = WITH JOINTS MADE BY BENDING EDGES OF METAL SHEETS.
"WELDED" = WITH JOINTS WELDED WITH STANNUM.

Table 2. Resumed biogenerator results. Two weeks test at ambient t

TREAT. No.	MATERIAL	FORM	WATER	TTL. VL. & AVG. CO2 & O2 VOL. (l)	% CO2	% O2
1	MAIZE	WHOLE	IMMERGED	15.1	72.0	7.0
2	MAIZE	WHOLE	IMMERGED	20.5	69.2	5.6
3	MAIZE	WHOLE	WETTED	11.5	66.2	5.6
4	MAIZE	WHOLE	WETTED	9.3	61.3	4.5
5	MAIZE	BROKEN	IMMERGED	7.2	50.3	4.6
6	MAIZE	BROKEN	IMMERGED	4.2	50.8	3.0
7	MAIZE	BROKEN	WETTED	2.7	36.4	1.5
8	MAIZE	BROKEN	WETTED	5.8	52.2	1.7
9	SORGHUM	WHOLE	IMMERGED	4.9	55.4	2.0
10	SORGHUM	WHOLE	IMMERGED	6.0	58.1	2.4
11	SORGHUM	WHOLE	WETTED	5.4	66.9	3.9
12	SORGHUM	WHOLE	WETTED	9.3	60.9	3.7
13	SORGHUM	BROKEN	IMMERGED	3.4	35.0	10.0
14	SORGHUM	BROKEN	IMMERGED	0.0	N.D.	N.D.
15	SORGHUM	BROKEN	WETTED	3.9	41.3	6.5
16	SORGHUM	BROKEN	WETTED	3.6	43.8	6.0
17	M + 20% S*	WHOLE	IMMERGED	14.0	62.1	2.8
18	M + 20% S	WHOLE	IMMERGED	10.9	62.0	3.0
19	M + 20% S	WHOLE	WETTED	4.0	32.3	6.0
20	M + 20% S	WHOLE	WETTED	6.1	49.8	5.1
21	M + 50% S	WHOLE	IMMERGED	9.8	60.9	3.0
22	M + 50% S	WHOLE	IMMERGED	8.4	60.6	1.4
23	M + 50% S	WHOLE	WETTED	6.9	56.3	2.3
24	M + 50% S	WHOLE	WETTED	6.2	56.1	2.3
25	M + 20% S	BROKEN	IMMERGED	5.7	41.0	1.9
26	M + 20% S	BROKEN	IMMERGED	5.1	41.0	2.0
27	M + 20% S	BROKEN	WETTED	5.7	50.0	4.5
28	M + 20% S	BROKEN	WETTED	5.7	47.1	3.1
29	M + 50% S	BROKEN	IMMERGED	4.3	50.0	2.6
30	M + 50% S	BROKEN	IMMERGED	3.6	47.3	1.7
31	M + 50% S	BROKEN	WETTED	0.0	N.D.	N.D.
32	M + 50% S	BROKEN	WETTED	0.4	30.0	0.0
33	BANANA LEAF	CUTTED	IMMERGED	0.0	N.D.	N.D.
34	BANANA LEAF	CUTTED	IMMERGED	0.5	40.0	0.0
35	BANANA LEAF	CUTTED	WETTED	0.5	15.0	0.0
36	BANANA LEAF	CUTTED	WETTED	0.0	N.D.	N.D.
37	BANANA LEAF	MASHED	IMMERGED	3.5	22.5	4.3
38	BANANA LEAF	MASHED	IMMERGED	3.6	25.6	3.6
39	BANANA LEAF	MASHED	WETTED	4.2	43.7	1.1
40	BANANA LEAF	MASHED	WETTED	0.9	50.0	0.0
41	BANANA STEAM	CUTTED	IMMERGED	3.5	10.0	17.0
42	BANANA STEAM	CUTTED	IMMERGED	2.6	10.0	17.0
43	BANANA STEAM	CUTTED	WETTED	0.9	16.3	5.0
44	BANANA STEAM	CUTTED	WETTED	0.7	25.0	0.0
45	BANANA STEAM	MACERADO	IMMERGED	1.8	19.0	8.0
46	BANANA STEAM	MACERADO	IMMERGED	2.6	40.7	0.6
47	BANANA STEAM	MACERADO	WETTED	3.1	37.7	1.1
48	BANANA STEAM	MACERADO	WETTED	2.7	26.3	1.6
49	RIPE BANANA	CUTTED	IMMERGED	3.4	40.4	9.0
50	RIPE BANANA	CUTTED	IMMERGED	17.3	76.3	4.9
51	RIPE BANANA	CUTTED	IMMERGED	6.1	81.5	3.6
52	RIPE BANANA	CUTTED	IMMERGED	8.1	82.2	4.3
53	SUGAR CANE	CUTTED	IMMERGED1	10.3	78.7	3.9
54	SUGAR CANE	CUTTED	IMMERGED1	14.8	79.6	5.6
55	SUGAR CANE	CUTTED	IMMERGED2	25.4	76.7	4.1
56	SUGAR CANE	CUTTED	IMMERGED2	2.1	60.9	3.3
57	MAIZE	BROKEN	IMMERGED **	16.9	53.8	3.1
58	SORGHUM	BROKEN	IMMERGED **	5.0	60.0	5.0
59	SUGAR CANE	CUTTED	IMMERGED **	32.0	90.4	6.0

* M = maize, S = sorghum. ** 0.4% yeast. N.D. No data.

Table 3. Correction factors for CO_2 mixtures volumen variation due to temperature changes. Based on a value of 1 for for readings obtained at 25 C.

TEMP. C	CO_2 CONCENTRATION LEVEL		
	100%	66%	33%
20	1.02	1.03	1.04
21	1.02	1.03	1.03
22	1.01	1.02	1.02
23	1.01	1.01	1.01
24	1.00	1.01	1.01
25	1.00	1.00	1.00
26	1.00	0.96	0.99
27	0.99	0.99	0.99
28	0.99	0.98	0.98
29	0.98	0.98	0.97
30	0.98	0.97	0.97

UNIVERSIDAD DE COSTA RICA
VICERRECTORIA DE ADMINISTRACION
OFICINA DE ADMINISTRACION FINANCIERA
SECCION DE EJECUCION Y CONTROL

FONDO RESTRINGIDO #183

COMBATE DE INSECTOS CON CO2

SITUACION PRESUPUESTARIA

CODIGO	CONCEPTO	PRESUPUESTO 1988	GIRADO DEL PERIODO	COMPROMISOS 31/12/88	DISPONIBLE PRESUPUESTO
11	SERVICIOS ESPECIALES				
07	Cuota Patronal C.C.S.S.	30,987.50	24,871.78	3,334.54	2,781.18
08	Décimo Tercer Mes	27,905.50	22,398.06	3,002.88	2,504.56
09	Cuota Patronal JAP-UCR	8,375.00	6,722.10	901.23	751.67
10	Servicios Especiales	335,000.00	268,884.13	36,049.07	30,066.80
11	Cuota Patronal Banco Popular	1,675.00	1,344.43	180.24	150.33
14	Fondo Pensiones Magist. Hac.	1,675.00	1,344.43	180.24	150.33
12	SERVICIOS NO PERSONALES				
03	Seguro Riesgos Profesionales	301.50	------	------	301.50
09	Fletes y Transport.p/Exter.	145,840.00	------	------	145,840.00
10	Gastos Viaje dentro pais	56,475.00	32,405.00	------	24,070.00
12	Mant.Reparac.Maquinar.y Equipo	109,380.00	27,600.00	------	81,780.00
19	Otros Servicios	15,000.00	10,000.00	------	5,000.00
20	Servicios Administrativos	187,760.00	98,696.47	------	89,063.53
21	MATERIALES Y SUMINISTROS				
01	Productos Alimenticios	5,000.00	866.75	------	4,133.25
03	Reactivo y Utiles de Laborat.	245,000.00	256.25	------	244,743.75
04	Combustibles y Lubricantes	44,000.00	8,890.80	------	35,109.20
06	Product.de papel carton e imp.	5,000.00	1,150.65		3,849.35
07	Herramientas, Instrum.y Otros	0.00	392.70	------	(392.70)
08	Repuestos y Accesorios	8,000.00	48,683.10	------	(40,683.10)
09	Utiles y Mater.de Oficina	3,000.00	0.00		3,000.00
11	Material de Construcción	10,000.00	9,601.20	------	398.80
15	Otros Materiales y Suministros	15,000.00	32,905.10	------	(17,905.10)
22	MAQUINARIA Y EQUIPO				
07	Equipo para Laboratorio	600,000.00	445,000.00	------	155,000.00
11	Otros equipos	60,000.00	------	------	60,000.00
		1,915,374.50	1,042,012.95	43,648.20	829,713.35

SITUACION FINANCIERA

INGRESOS:		
Ingresado 1988: RI #698863	1,070,906.00	
TOTAL DE INGRESOS		1,070,906.00
Menos:		
GIRADO DEL PERIODO	1,042,012.95	
COMPROMISOS AL 31-12-88	43,648.20	
TOTAL DE EGRESOS		1,085,661.15
SUPERAVIT O DEFICIT		(14,755.15)

DIRECTOR
OFICINA DE ADMINISTRACION FINANCIERA

UNIVERSIDAD DE COSTA RICA
Oficina
Administración
Financiera