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AID SCIENCE ADVISOR GRANT
UNDERGROUND GRAIN STORAGE PROJECT
GRANT N DPE 5542 G-SS-7030 00
PROJECT NUMBER 7336

SIX MONTH PROGRESS REPORT

PERIOD COVERED
JULY 1 TO DECEMBER 30, 1989

HASSAN II AGRONOMIC AND VETERINARY INSTITUTE

RABAT MOROCCO

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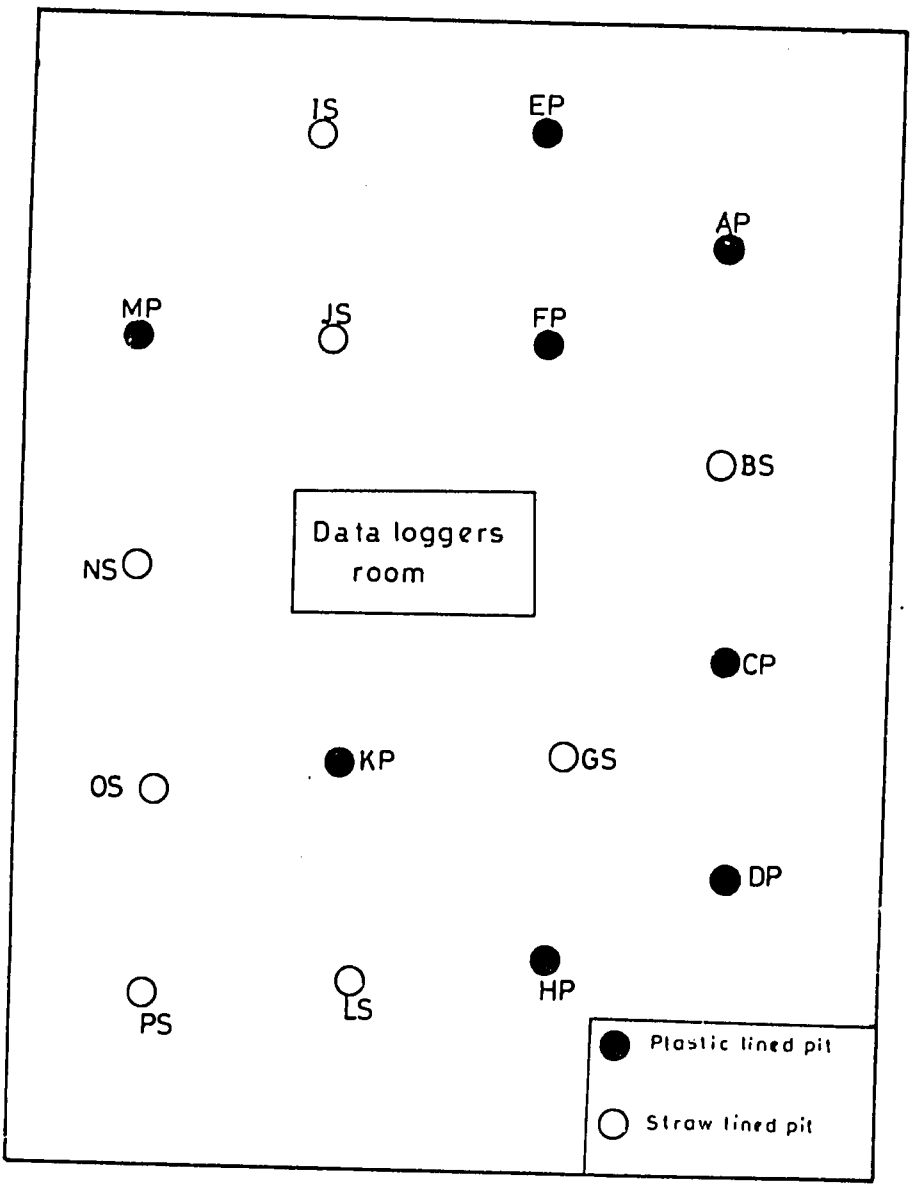
1.0 INTRODUCTION

The present progress report is the fifth one, it presents the complete results on the experiment undertaken at Settat on wheat storage using underground pits in which two types of in side lining are used : straw versus plastic. The following data are given to remind the reader of the important phases of the experiment:

1. December 30th, 1987 : 16 pits were filled with wheat (8 straw + 8 plastic lined) as shown in fig.1.
2. April 5th, 1988 : first opening : 2 straw lined pits (BS and OS) and 2 plastic lined pits (EP & KP).
3. June 30th, 1988 : second opening ; 2 straw lined pits (PS &NS) and 2 plastic lined pits (CP & HP).
4. September 30th, 1988 : third opening ; 2 straw lined pits (GS & IS) and 2 plastic lined pits (AP & MP) were emptied.
5. May 18th , 1989 : last opening ; the last four pits (2 straw lined : JS & LS and 2 plastic lined : DP & FP) were emptied after about 16 months of storage.

The partial results of the first three openings have been presented in the previous progress reports. In addition to the measured data and analysis of the samples taken in the last opening, the present report gives the overall evaluation of the underground storage of wheat in straw lined pits versus plastic

Fig.1: Disposition of the 16 experimental pits in Settat



All the data gathered during the sixteen months of storage (physical, environmental, biological as well as biochemical and chemical) show that the plastic lining insures better storage conditions than the straw lining. The farmers as well as the extension technicians of the Ministry of Agriculture and Agrarian reform at Settat are in favour of the plastic lining.

Two joint seminars between the storage group participants have been organized ; the main objectives were : 1) share the results obtained from the investigations of each participant ; 2) correlate the important factors in multidisciplinary analysis ; 3) outline the important scientific papers that will cover all the aspects of the present research. Some papers will be published in the proceedings of the international seminar on grain storage to be held in Rabat in Novembre 1990.

The achievements obtained this far are being disseminated in the Chaouia plain, the Sais area and the Middle Atlas, where the plastic lining of the underground pits is favorably introduced to improve the quantitative as well as the qualitative underground storage conditions of cereals.

2.0 - RESEARCH ACCOMPLISHMENTS

2.1 Sampling of pits opened

As outlind above, the last opening comprised two straw lined pits (JS & LS) and two plastic lined ones (DP & FP) as illustrated in fig.1. The sampling location are showen in fig.2. They correspond to the position of temperature sensors. The sampling procedures as well as the types of analysis are similar to those defined in the three previous progress reports.

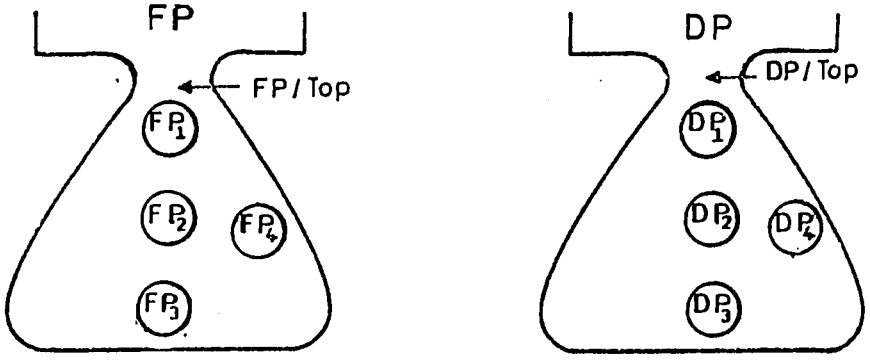
2.2 Research evaluation

As mentioned in the fourth progress report, the thesis defense of Mr. El Ghali Abdellatif, a third cycle student in Agricultural Engineering, has been the second opportunity of the on going research evaluation, the defense has taken place at IAV Hassan II in November 27, 1989. The joint seminars between the storage team members held in February 1990 were another opportunity of multidisciplinary research evaluation of the present project.

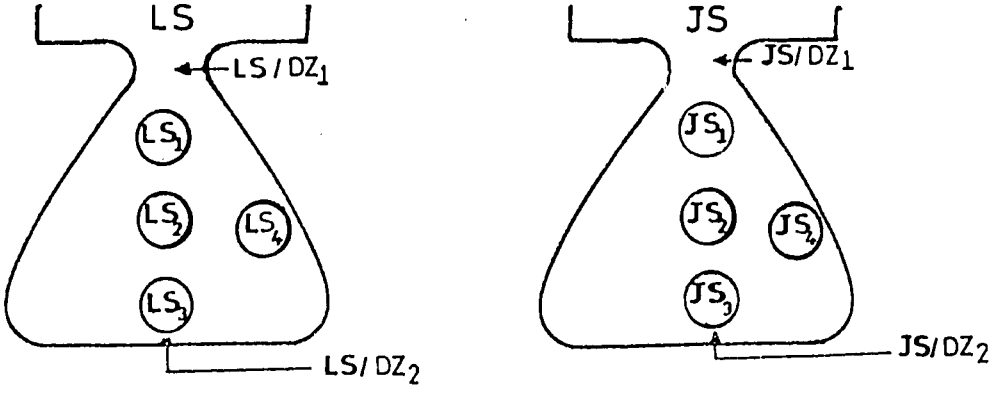
This interdisciplinary evaluation shows that:

1. the storage conditions of grain are very good in the underground pits ;

Fig. 2 : Location of grain samples fourth opening of pits.



Plastic lined pits.



Straw lined pits.

2. the plastic lining preserves better the quality as well as the quantity of grains stored in the underground pits compared to the straw lining (less than 1% of weight loss are obtained in the plastic lined pits against 20% in the average in the straw lined pits) ;

3. the germination potential of the grain decreases significantly storage in straw lined pits where it approches zero after six months of storage.

2.3 Analysis of 16 months of storage

2.3.1. Agricultural Engineering

The Agricultural Engineering Department continued the overall coordination of the present project under the supervision of Dr. H. BARTALI, and Dr. A. DEBBARH. The tasks included: the preparation and the material organization of the pits openings, data monitoring and processing, reports preparation and project evaluation.

Dr. H. BARTALI and Dr. A.DEBBARH are actively involved in the preparation and the organization of the International Conference on grain Storage to be held in Rabat-Morocco in November 1990. Abstracts related to the different themes of the conference have been already sent by participants coming from more than 25 countries representing the five continents of the globe. Five papers related to the present project will be presented in this conference.

2.3.1.1 Data Monitoring

Temperature, relative humidity and carbone dioxide levels in the pits were regularly monitored by the Agricultural Engineering Department during the 16 months of storage. The results have been progressively analysed in the previous reports. The analysis of the data recorded lately is presented in the following.

2.3.1.2. Temperature variation

Temperature data are plotted here in terms of depth; in fact the average of the maximal daily temperatures for each month is distributed for a particular pit over its depth.

Figures 3 to 5 represent temperature profiles in the soil for the sixteen months of storage. It is clearly shown that the gradient becomes slow below the first 20 to 30 cm of the soil; it is ascendant during the cold season and descendant during the hot period; figures 6 to 8 represent monthly maximal temperature distribution over the depth of the plastic lined pit, Figures 9 to 11 represent similar vertical temperature istribution for the straw lined pits. From the comparison of the above figures, the following conclusions can be made :

1. Temperature profiles of the plastic lined

Fig.3 : TEMPERATURE GRADIENT IN THE SOIL.

First semester of storage

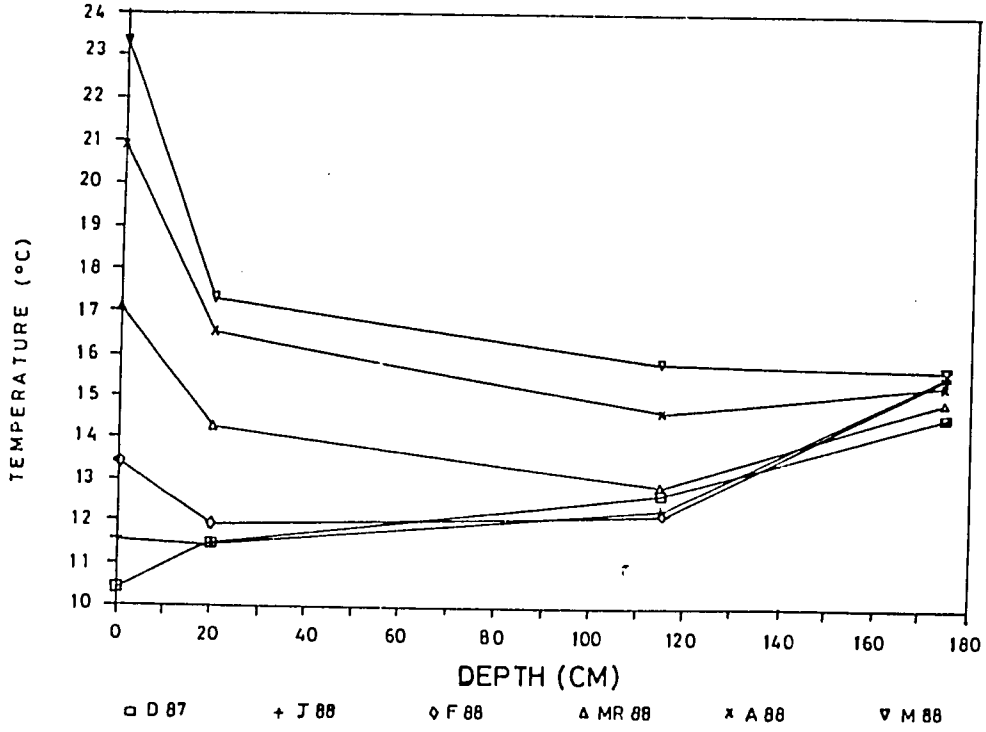


Fig.4 : TEMPERATURE GRADIENT IN THE SOIL.

Second semester of storage

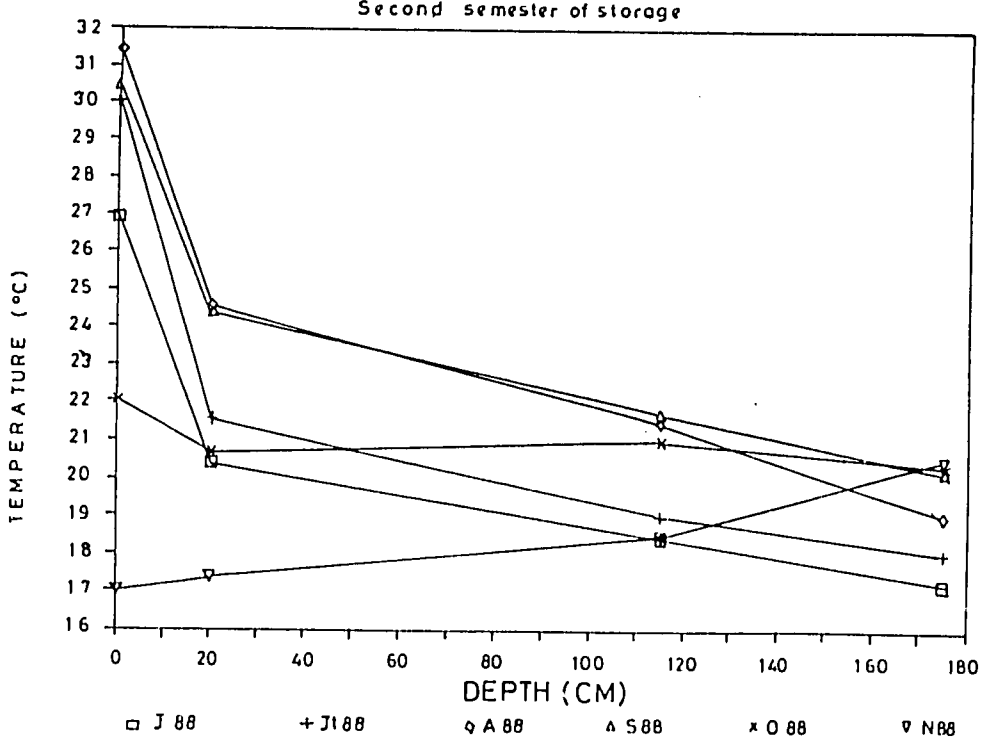
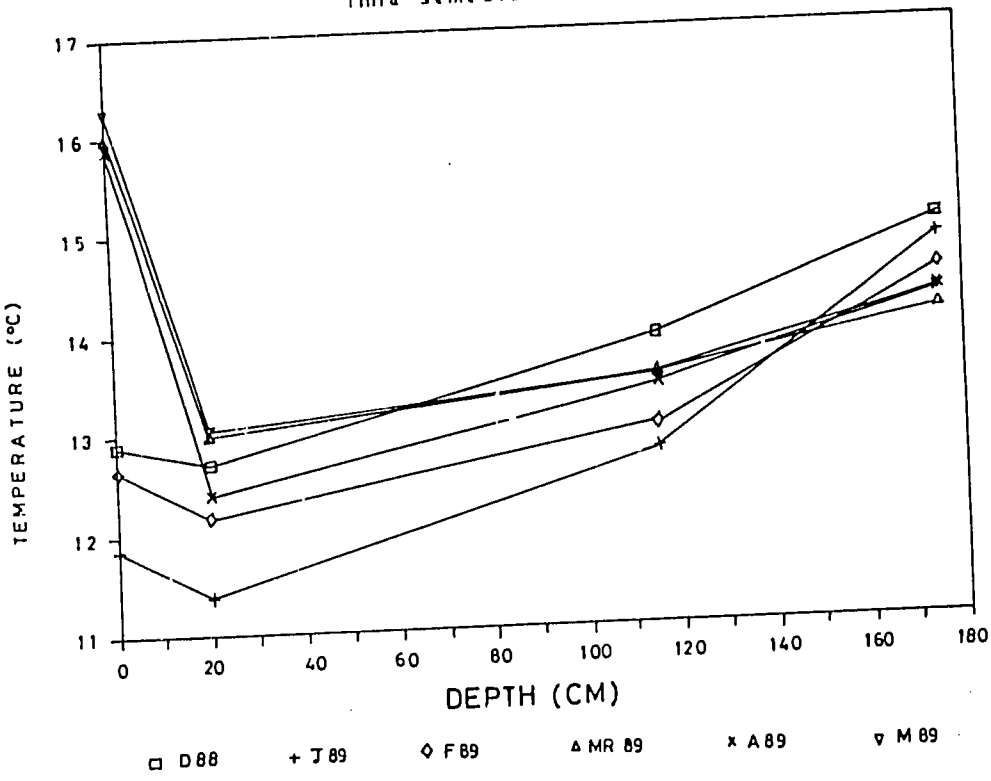


Fig.5 : TEMPERATURE GRADIENT IN THE SOIL.

Third semester of storage



pits look similar to those of the soil, this indicates that the main mechanism of temperature transfert in the plastic lined pit is due to heat conduction. In the grain bulk temperatures are higher than those of the corresponding points in the soil ;

2. The shapes of temperature profiles of the straw lined pits are different from those of the plastic lined ones, in general temperatures are higher in the grain bulk of the straw lined pits than those of the plastic lined pits ;

3. The temperature measured at the top level of the bulk of grains in the straw lined pits is much more higher than that of the soil surface above these pits, the reasons are related to important biological activities at this level (micro-organisms and grain respiration; there might be a certain disponibility of oxygen at this level because the closing of the hole above the stored bulk of grain is not completely sealed).

2.3.1.3. Relative humidity

Because of some technical problems, the sensor of relative humidity placed at the center of one plastic lined pit was not functionning properly. Relative humidity measures were taken for the straw lined pits only. The results have already been discussed in the previous progress report. Table 1 shows the evolution of the relative humidity of the interstitial air and measured by an hygrometer at the center of each pit at the various

Fig.6 : PLASTIC LINED PIT

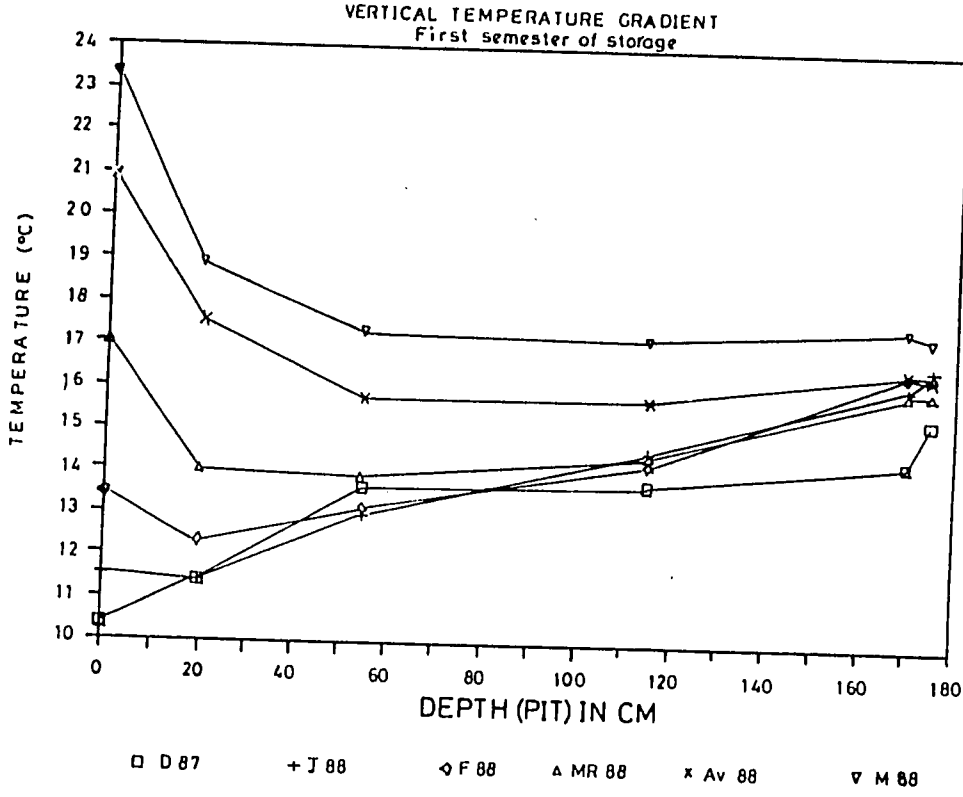


Fig.7 : STRAW LINED PIT

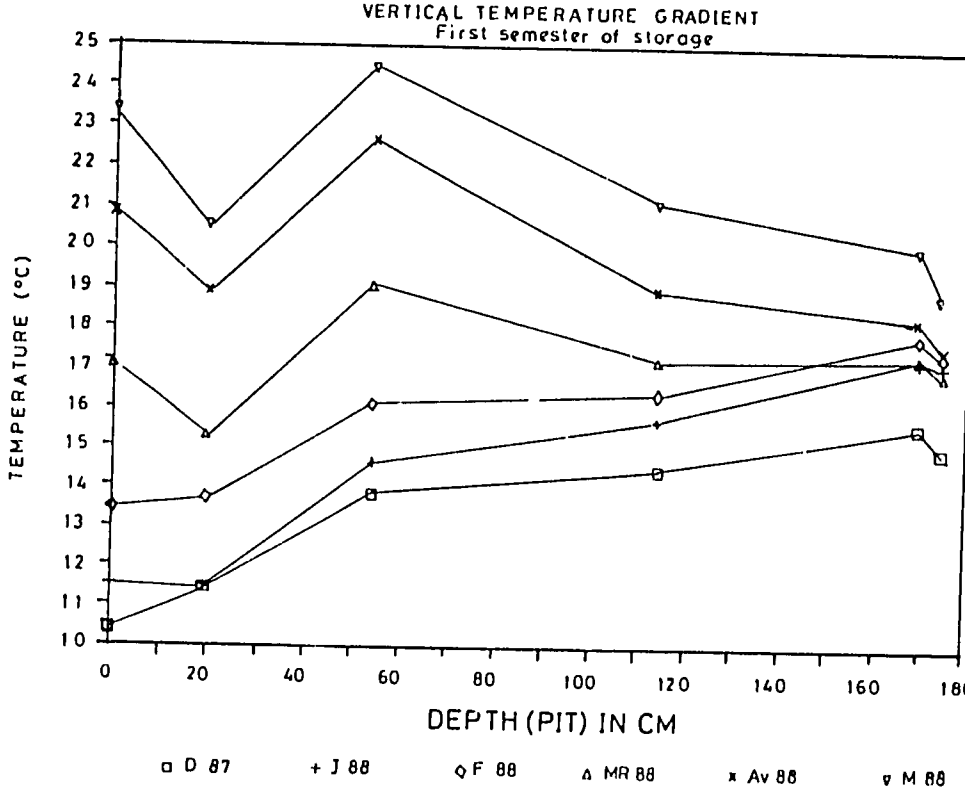


Fig.8 : PLASTIC LINED PIT

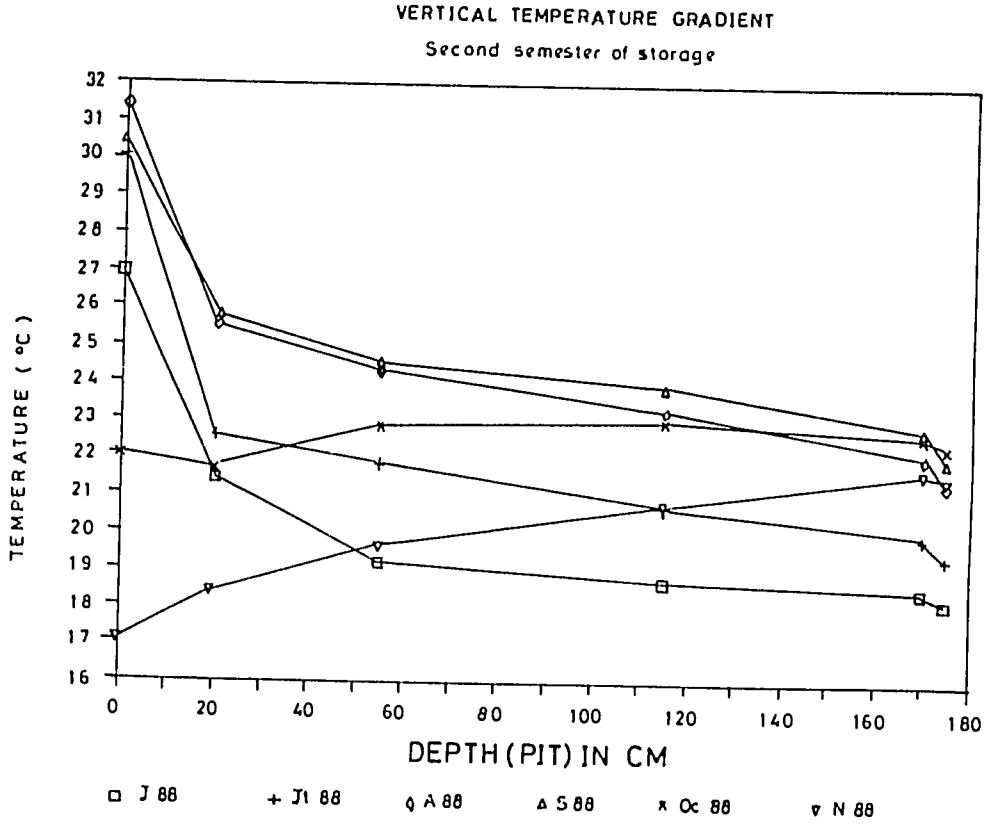


Fig.9 : STRAW LINED PIT

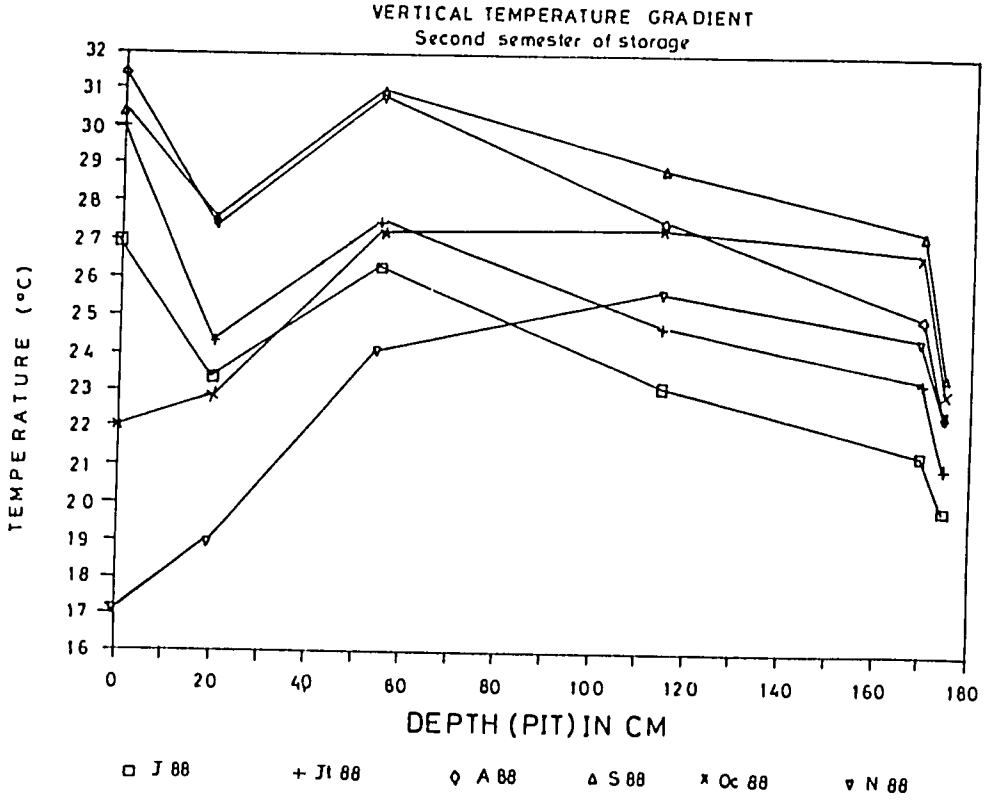


Fig.10 : PLASTIC LINED PIT

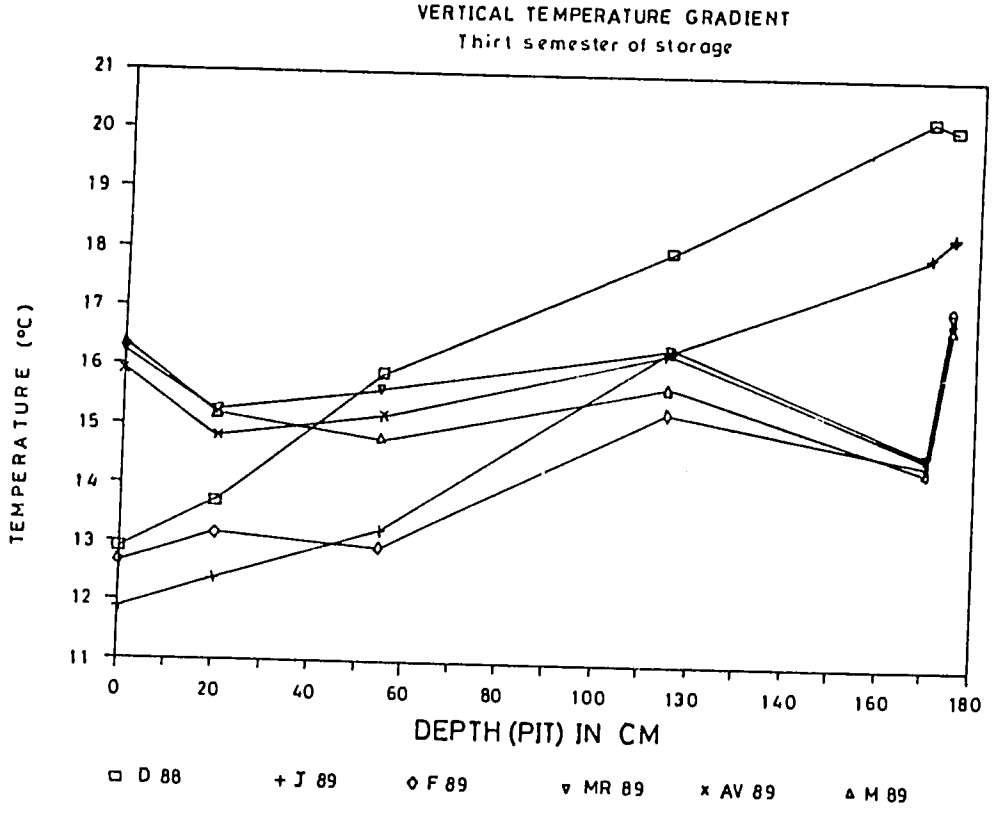
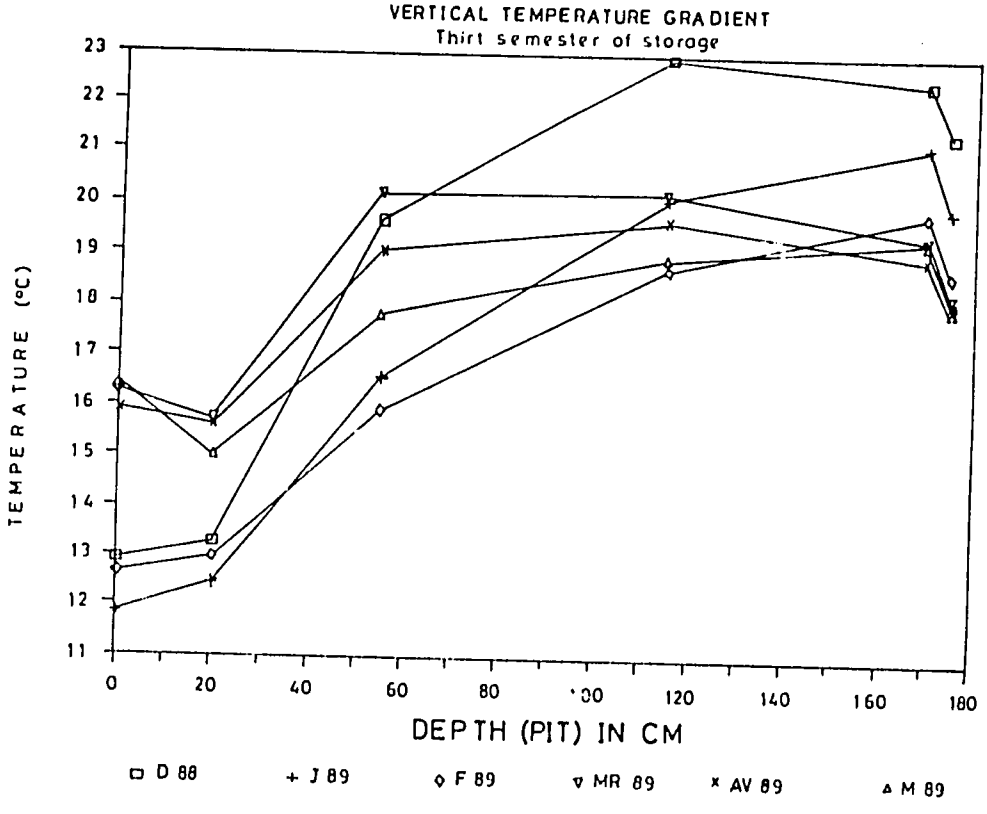


Fig.11 : STRAW LINED PIT



openings. It is clearly seen that the relative humidities inside of the straw lined pits are higher than those inside of the plastic lined pits.

Table 1 : Relative humidity measured inside pits at each opening

Storage period	Plastic lined pits	Straw lined pits
3 months 1st opening	67.50%	80.00%
6 months 2nd opening	65.00 %	75.00%
9 months 3rd opening	64.50 %	80.50 %
16 months 4th opening	66.00 %	89.00 %

2.3.1.4. Carbon dioxide

The corresponding data have been reported and discussed in the previous progress report. The CO_2 level has been found higher in the straw lined pits than in the plastic lined pits (about 4% of differences), this consolidates the hypothesis of greater biological activities inside the bulk of grain stored in the straw lined pits (Fig 12 and 13).

2.3.1.5. Unit weight and moisture content

a. Unit weight

Table 2 shows that the unit weight of wet grain after 16 months of storage has decreased from its initial value of 775.5 g/l to an average value of 674.16 g/l for the straw lined pits while table 3 shows that this decrease is very small (almost negligible) for the plastic lined pits (the average value is

Fig.12: Variation of CO_2 levels at bottom of pit
From 12-30th 1987 to 5-10th 1989

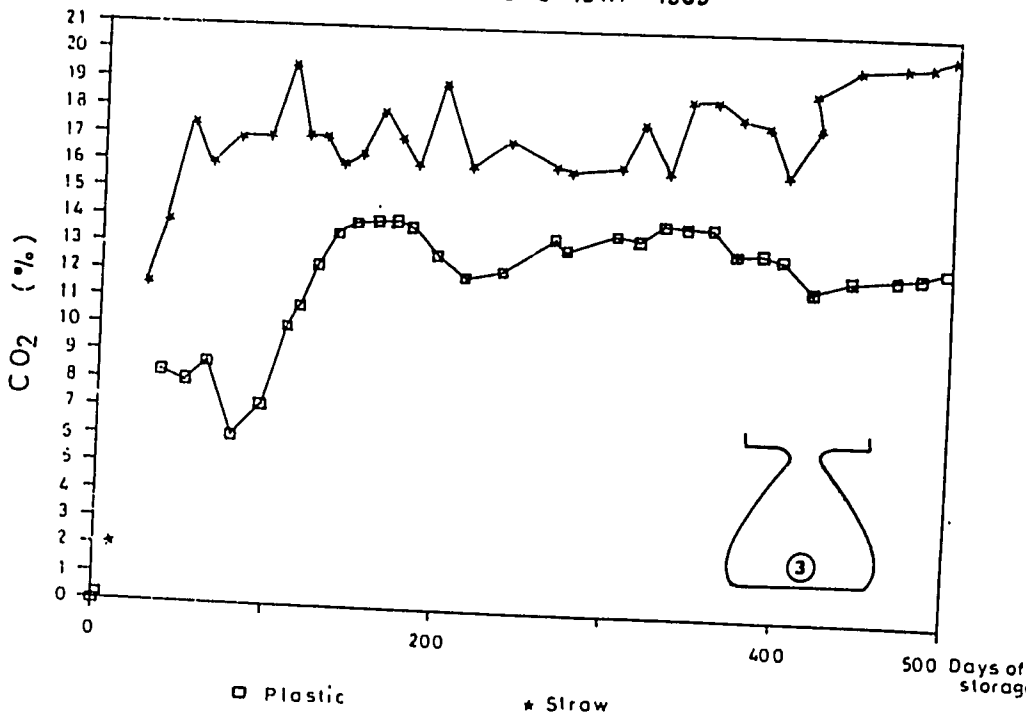
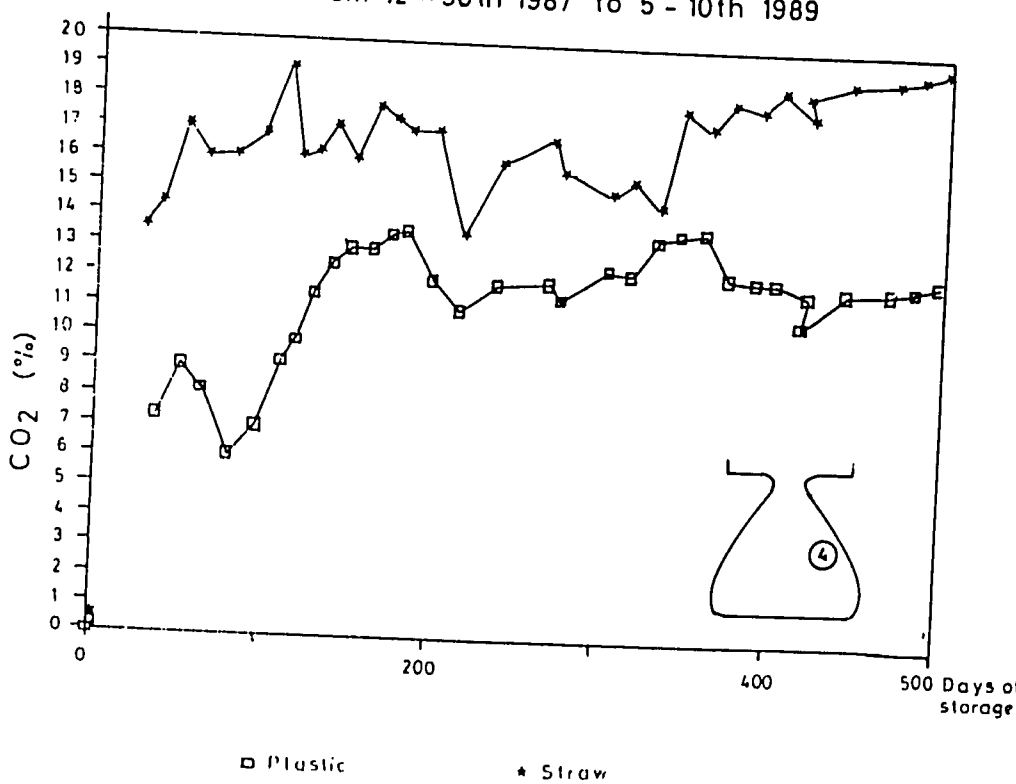


Fig.13: Variation of CO_2 levels at side of pit
From 12 - 30th 1987 to 5 - 10th 1989



around 754.74 g/l).

b. Moisture content

Tables 2 and 3 indicate that the average moisture content of grains stored in the straw lined pits and much more higher than that of the plastic lined pits (17.91 % in the average for the straw lined pits against 12.49% for the plastic lined pits).

c. Damage and waste evaluation

Tables 4 and 5 give the complete data on the percentage of grain damages respectively for straw and plastic lined pits. It is clearly shown that this percentage of damages is much larger for the straw (26.59% in the average) than for the plastic lined pits (9.29% in the average). Table 6 shows that the grains stored in straw lined pits presents large percentage of waste (4.46 %) in addition to various chemical and biochemical changes that are illustrated by the changes of odor and color, those changes have not been observed in the plastic lined pits (see table 7). Tables 8 and 9 give the losses by dry weight method respectively for the straw and plastic lined pits after sixteen months of storage. It is clearly shown that the losses calculated by dry weight method are five to six times higher for the straw than for the plastic lined pits (19.03% a gainst 3.62% in the average). Tables 10 and 11 confirm the observation made thus far that is the losses evaluated after sixteen months of storage are more important in

TABLE 2 - Unit weight and moisture content of grain: straw pit, 16 months of storage

Pit	Sample	Unit Weight of wet grain (g/l)	Moisture content (%)	Unit weight of dry grain (g/l)	Volume of zone in %	Average unit weight of wet grain (g/l)	Average moisture content of grain (%)
LS	LS (DZ 1)	661	18,91	706	8,50	678,10	17,33
	LS1	700	16,71	753	7,80		
	LS2	702	15,85	749	13,20		
	LS3	686	17,26	741	43,30		
	LS4	697	16,36	745	20,90		
	LS (DZ 2)	507	22,68	612	6,30		
	Mean	658,83	17,90	717,67			
	St.Dev.	75,91	2,39	54,45			
JS	JS (DZ 1)	655	18,63	667	8,50	670,23	18,48
	JS1	697	16,34	741	7,80		
	JS2	701	16,25	749	13,20		
	JS3	663	18,41	686	43,30		
	JS4	678	17,40	725	20,90		
	JS (DZ 2)	617	29,66	655	6,30		
	Mean	668,5	19,45	703,83			
	St.Dev.	31,06	5,10	39,82			
					Mean	674,16	17,91
					St.Dev.	5,565	0,81

TABLE 3 : Unit weight and moisture content of grain: plastic pit, 16 months of storage

Pit	Sample	Unit weight of wet grain (g/l)	Moisture content %	Unit weight of dry grain (g/l)	Volume of zone in %	Average unit weight of wet grain (g/l)	Average moisture content of grain (%)
CP	CP (Top)	754	12,60	765	0,94	762,04	12,495
	CP 1	758	12,55	780	10,88		
	CP 2	759	12,42	788	12,09		
	CP 3	762	12,51	784	53,20		
	CP 4	766	12,47	786	22,89		
	Mean	759,80	12,51	780,6			
	St.Dev.	4,49	0,07	9,21			
FP	FP(Top)	739	12,88	773	0,94	747,43	12,476
	FP1	747	12,79	785	10,88		
	FP2	758	12,55	784	12,09		
	FP3	739	12,88	780	53,20		
	FP4	762	12,51	784	22,89		
	Mean	749	12,72	781,2			
	St.Dev.	10,65	0,18	4,97			
					Mean	754,74	12,485
					St.Dev.	10,33	0,013

the straw lined pits. All the above data show that the plastic lining insures better conditions of grain storage in the underground pits with negligible weight losses and no odor and no color changes.

2.3.1.6 Distribution of plastic bags to farmers and survey.

40 plastic bags were confectionned under the supervision of the Department of Agricultural Enginneering in April 1990 and handed out to the farmers in the Settat area prior to their stoarge of the 1989 harvest by the extension service. A questionnaire was established by the Department and was to be filled by the extension to evaluate the feelings and reactions of the farmers after using th . ves the plastic on their own pits. Reactions of farmers after 6 months of storage were very positive.

2.3.2 Plant Pathology

Dr. B. EZZAHIRI

Test for germination and for storage fungi were conducted after 16 months of storage

2.3.2.1 Germination

The results of the germination test are presented in table 12. After 16 months of storage, the grains stored in the

TABLE 4 - Damage evaluation (%) Straw pit, 16 months of storage

Pit	Sample	Decoloration kernel %	Insect attacked kernels %	Shrunken kernels %	Broken kernel %	Germinated kernels %	Kernels with visible mold %	Other damage on kernels %	Total of damaged kernels %	Volume of zone in %	% damage
LS	LS(DZ 1)	—	—	—	—	—	100	—	100	8,50	26,34
	LS 1	4,70	3,60	1,90	0,80	0,08	1,30	3,20	15,58	7,80	
	LS 2	3,50	0,90	2,20	0,70	0	0,90	2,90	11,10	13,20	
	LS 3	4,80	1,20	2,60	0,90	0	1,20	3,80	14,50	43,30	
	LS 4	4,30	1,10	1,80	0,80	0,05	1,10	3,20	12,35	20,90	
	LS (DZ2)	—	—	—	—		100	—	100	6,30	
	Mean	4,325	1,70	2,125	0,80	0,033	34,08	3,275	42,26		
	St.Dev.	0,591	1,27	0,359	0,082	0,039	51,06	0,377	44,757		
JS	JS (DZ1)	—	—	—	—	—	100	—	100	8,50	26,84
	JS 1	4,80	2,50	1,80	0,90	0,09	1,40	3,60	18,69	7,80	
	JS 2	3,90	0,80	1,90	0,70	0	0,90	3,10	11,30	13,20	
	JS 3	4,90	1,30	2,10	1,00	0	1,20	3,90	14,40	43,30	
	JS4	4,50	1,20	1,90	0,80	0,06	1,00	3,30	13,66	20,90	
	JS (DZ2)	—	—	—	—	—	100	—	100	6,30	
	Mean	4,525	1,45	1,925	0,85	0,0375	34,08	3,475	43,01		
	St.Dev.	0,45	0,733	0,126	0,129	0,045	51,06	0,35	44,21		
										Mean	26,59
										St.Dev.	0,35

TABLE 5 - Damage evaluation (%), plastic pit, 16 months of storage

Pit	Sample	Decoloration kernels %	Insect attached kernels %	Shrunken kernels %	Broken kernels %	Germinated kernels %	Kernels with visible mold %	Other damage on kernels %	Total of damaged kernels %	Volume of zone in %	% damage
DP	DP(Top)	3,30	0,60	2,10	0,40	0	0	2,30	8,70	0,94	9,14
	DP 1	4,10	0,50	1,70	0,20	0	0	2,00	8,50	10,88	
	DP2	4,50	1,10	1,50	0,25	0	0	1,40	8,75	12,09	
	DP3	4,40	0,90	1,80	0,45	0	0	2,50	10,05	53,20	
	DP4	3,50	0,50	1,10	0,35	0	0	2,10	7.55	22.89	
	Mean	3,96	0,72	1,64	0,33	0	0	2,06	0,71		
	St.Dev.	0,537	0,268	0,37	0,10	0	0	0,416	0,893		
FP	FP(Top)	3,90	0,70	1,30	0,35	0	0	2,90	9,15	0,94	9,43
	FP1	4,20	0,95	1,95	0,30	0	0	2,50	9,90	10,88	
	FP2	3,20	0,65	2,30	0,45	0	0	1,95	8,75	12,09	
	FP3	3,50	0,80	1,80	0,40	0	0	2,90	9,40	53,20	
	FP4	4,40	0,60	1,35	0,50	0	0	2,80	9,65	22,89	
	Mean	3,84	0,78	1,74	0,40	0	0	2,61	9,36		
	St.Dev.	0,493	0,135	0,42	0,079	0	0	0,404	0,445		
										Mean	9,285
										st.dev.	0,205

TABLEAU 6 - Percentage of waste, odor and color evaluation
Straw Pit, 16 months of storage

Pit	Sample	Percentage of waste	Volume of zone in %	Percentage of waste in pit %	Odor	Color
LS	LS (DZ1)	4,98	8,50	4,42	Odor of mold	Yellow with grey spot
	LS1	4,27	7,80		sliht mold odor	Darker than normal
	LS2	3,76	13,20		"	"
	LS3	4,45	43,30		"	"
	LS4	4,43	20,90		strong mold odor	"
	LS(DZ2)	4,95	6,30			Yellow
	Mean	4,47				
	St.Dev.	0,455				
JS	JS (DZ1)	5,10	8,50	4,50	Odor of mold	Yellow with gry spot
	JS1	4,38	7,80		sliht mold odor	Darker than normal
	JS2	4,05	13,20		"	"
	JS3	4,57	43,30		"	"
	JS4	4,34	20,90		"	"
	JS(DZ2)	4,09	6,30		strong mold odor	Yellow
	Mean	4,56				
	St.Dev.	0,385				
			Mean	4,46		
			St.Dev.	0,06		

TABLE 7 - Percentage of waste, odor and color evaluation plastic pit, 16 months of storage.

Pit	Sample	Percentage of waste	Volume of zone in %	Percentage of waste in pit %	Odor	Color
DP	DP (Top)	3.65	0.94	3.61		Normal
	DP1	3.98	10.88			"
	DP2	3.17	12.09			"
	DP3	3.84	53.20			"
	DP4	3.15	22.89			"
	Mean	3.56				
	St.Dev.	0.38				
FP	FP (Top)	4.15	0.94	3.60	Normal	Normal
	FP1	3.13	10.88		"	"
	FP2	3.36	12.09		"	"
	FP3	3.97	53.20		"	"
	FP4	3.06	22.89		"	"
	Mean	3.53				
	St.Dev.	0.497				
			Mean St.Dev.	3.605 0.007		

TABLE 8 : Loss by dry weight method: straw pit, 16 months of storage

Pit	Sample	Unit weight (g/l)		Moisture content		Loss of dry weight per zone in %	Volume of zone in %	Loss of dry weight in %
		Initial	Final	Initial %	Final %			
LS	LS (DZ 1)	775,52	661	11,76	18,91	21,67	8,50	17,98
	LS1	"	700	"	16,71	14,80	7,80	
	LS2	"	702	"	15,87	13,70	13,20	
	LS3	"	682	"	17,26	17,06	43,30	
	LS4	"	697	"	16,36	14,81	20,90	
	LS (DZ 2)	"	507	"	22,68	48,71	6,30	
		775,52 0,00	658,83 75,91	11,76 0,00	17,97 2,54	21,79 13,49		
JS	JS (JS 1)	775,52	655	11,76	18,63	22,12	8,50	20,08
	JS 1	"	697	"	16,34	14,79	7,80	
	JS2	"	701	"	16,25	14,21	13,20	
	JS3	"	663	"	18,41	20,95	43,30	
	JS4	"	678	"	17,40	18,16	20,90	
	JS (DZ 2)	"	617	"	29,66	36,58	6,30	
		775,52 0,00	668,50 31,06	11,76 0,00	19,45 5,10	21,135 8,21		
							Mean	19,03
							St.Dev.	1,48

TABLE 9 : Loss by dry weight method: plastic pit 18 months of storage

Pit	Sample	Unit weight (g/l)		Moisture content		Loss of dry weight per zone in %	Volume of zone in %	Loss of dry weight in %
		Initial	Final	Initial %	Final %			
DP	DP (Top)	775,52	754	11,76	12,60	3,70	0,94	2,55
	DP 1	"	758	"	12,55	3,13	10,88	
	DP 2	"	759	"	12,42	2,86	12,09	
	DP 3	"	762	"	12,51	2,58	53,20	
	DP 4	"	766	"	12,47	2,02	22,89	
		775,52 0,00	759,80 4,49	11,76 0,00	12,51 0,07	2,86 0,62		
FP	FP(Top)	775,52	739	11,76	12,88	5,92	0,94	4,69
	FP1	"	747	"	12,79	4,80	10,88	
	FP2	"	758	"	12,55	3,13	12,09	
	FP3	"	739	"	12,88	5,92	53,20	
	FP4	"	762	"	12,51	2,58	22,89	
		775,52 0,00	749,00 10,65	11,76 0,00	12,72 0,18	4,47 1,56		
							Mean	3,62
							St.Dev.	1,51

TABLE 10 - Loss evaluation : Thousand Grain Method, Straw Pit, 15 months of Storage

Pit	Sample	Weight of undamaged kernels (g)	Weight of damaged kernels (g)	Total weight (g)	Number of damaged kernels	Loss of dry weight %	Volume of zone in %	Loss of dry weight in the pit %
GS	GNS (DZ1)	0	48,50	48,50	1000	21,67	8,50	8,34
	GNS 1	41,00	6,45	47,45	156	2,32	7,80	
	GNS 2	41,20	6,60	47,80	170	3,23	13,20	
	GNS 3	39,10	7,55	46,65	199	5,35	43,30	
	GNS 4	39,60	6,60	46,20	179	4,22	20,90	
	GNS (DZ2)	0	54,85	54,85	1000	42,71	6,30	
		26,82	21,78	48,58	450,67	13,25		
		20,79	23,26	3,18	425,74	16,14		
IS	IS (DZ1)	0	48,95	48,95	1000	22,12	8,50	7,83
	IS 1	39,85	7,15	47,00	186	3,99	7,80	
	IS 2	40,00	6,20	46,20	173	4,48	13,20	
	IS 3	38,76	7,84	46,60	206	4,54	43,30	
	IS 4	39,10	7,75	46,85	197	3,78	20,90	
	IS (DZ2)	0	56,90	56,90	1000	36,30	6,30	
		26,29	22,47	48,75	460,33	12,54		
		20,37	23,73	4,10	418,17	13,68		
							Mean	8,085
							St.Dev.	0,360

TABLE 11 - Loss Evaluation : Thousand Grain Method
Plastic Pit, 16 months of Storage

Pit	Sample	Weight of undamaged kernels (g)	Weight of damaged kernels (g)	Total weight (g)	Number of damaged kernels	Loss of dry weight	Volume of zone in %	Loss of dry weight in the pit (%)
MP	MP (Top)	40,90	4,90	45,80	113	0,67	0,94	1,81
	MP 1	42,10	4,80	46,90	105	0,296	10,88	
	MP 2	42,00	4,85	46,85	134	3,40	12,09	
	MP 3	40,90	5,05	45,95	126	1,81	53,20	
	MP 4	42,80	5,10	47,90	122	1,74	22,89	
		41,74	4,94	46,68	120	1,58		
		0,83	0,13	0,85	11,29	1,21		
AP	AP (Top)	40,10	4,85	44,95	120	1,36	0,94	2,79
	AP 1	42,00	5,10	47,10	126	1,99	10,88	
	AP 2	41,80	4,70	46,50	117	1,77	12,09	
	AP 3	40,30	5,60	45,90	136	3,64	53,20	
	AP 4	41,90	4,80	46,70	119	1,81	22,89	
		41,22	5,01	46,23	123,60	2,11		
		0,94	0,36	0,84	7,70	0,88		
							Mean	2,30
							St.Dev.	0,693

straw lined pits lost completely their viability, while in the plastic lined pits, a relatively high germination level was maintained.

Table 12 - Percentage germination of durum wheat kernels after 16 months of storage in two types of pits.

Sampling location	% Germination*	
	Plastic	Straw
Top of pit	86	0
15 cm from top (1)	88	0
Center (2)	64	0
Bottom (3)	44	0
Near the edge (4)	68	0

* : Average of 3 subsamples, 100 kernels each (1) to (4) number of sampling location.

2.3.2.2 Test for fungi

The methods utilized were described in a previous report. The kinds and the frequencies of storage fungi in the two types of pits after 16 months of storage compared to 9 months of storage are presented in table 13.

The two species A. glaucus et A. versicolor continue to be dominant after 16 months of storage in both types of pits, with lower frequencies in plastic than in straw lined pits.

Other species present 9 months after storage in both types of pits were not detected after 16 months of storage.

Table 13 - Percentage of surface desinfected durum wheat kernels from which storage fungi grow after 9 and 16 months of storage in plastic lined pits and straw lined

STORAGE FUNGI	% INFECTED			
	Plastic lined pit		Straw lined pit	
	9 mo	15 mo	9 mo	15 mo
Aspergillus candidus	3.8	0	4.7	1,5
A. flavus	0.6	0	0.6	0
A. glaucus	7.3	6.8	36.2	26.6
A. niger	3.1	0.7	2.4	0.1
A. fumigatus	1.4	0	0.5	0
A. ochracens	0.2	0	0.2	0
A. versicolor	3.5	2.4	23.8	27
A. wentii	0.4	0	0.5	0
A. clavatus	0.5	0	1.9	0
Penicillium sp.	5.2	6.5	15.1	5.3

mo: months

2.3.3 Plant Breeding

Mr Z. FATEMI

2.3.3.1 Germination

This test was run in the laboratory of the D.P.V. C.T.R.F. as described in the first progress report.

Table 14 Percentage germination results after 16 months of storage

Type of pits	Sample location	Mean	Standard deviation
STRAW	Real top	0	0
	15 cm from top	0.375	0.517
	Center	0.625	0.916
	Bottom	0.125	0.354
	Near the side	0.500	0.534
	Real Bottom	0	0
PLASTIC	Real Top	27.000	11.314
	15 cm from top	27.250	1.832
	Center	17.350	1.062
	Bottom	13.000	1.604
	Near the side	13.120	2.800

The percentage germination of the seeds from the real top and the real bottom of the straw lining pits was nul.

In order to assess if there is any effect of lining, site or their interaction on seed germination, an analysis of variance was run (table 15). The model used is the same as the one described in the second progress report.

Table 15 Analysis of variance table for germination

Source of variation	Df	SS	MS	F	P
Lining	1	4778.3	4778.3	1101.73	0.0000
Replications	7	31.484	4.4978	1.04	0.4815
Error 1	7	30.359	4.3371		
Site	3	542.05	180.68	143.10	0.000
Lining*site	3	533.67	177.89	140.89	0.000
Error 2	42	53.031	1.2626		
Total	63	5968.9			

The analysis of variance (table 15) shows that the effect of lining, site and their interaction are highly significant.

A contrast analysis was run to do a multiple comparison of means for which the results are summurised in table 16.

Table 16 Pairwise comparisons of percentage germination means

a/ Straw lined pits

Site	Bottom	Top	Side	Center
Percentage germination mean	0.125	0.375	0.500	0.625

b/ Plastic lined pits

Site	Bottom	Side	Center	Top
Percentage germination mean	13.000	13.120	17.350	27.000

The values which do not differ significatly are underlined in table 16. For the straw lined pits, the highest germination was shown by the seed from the center. The germination of the seed from all sites of the straw pits didn't differ significantly.

For the plastic lined pits, the percentage germination didn't differ significantly between the bottom and the side. Elswhere, the differences were significant. Figure 14 show the evolution of percentage germination of the seed from the plastic (a) and the straw (b) lined pits.

In the plastic lined pits, the percentage germination showed a large decrease between 9 and 16 months of storage.

In the straw lined pits, the decrease was really important so that the germination percentages were near 0%.

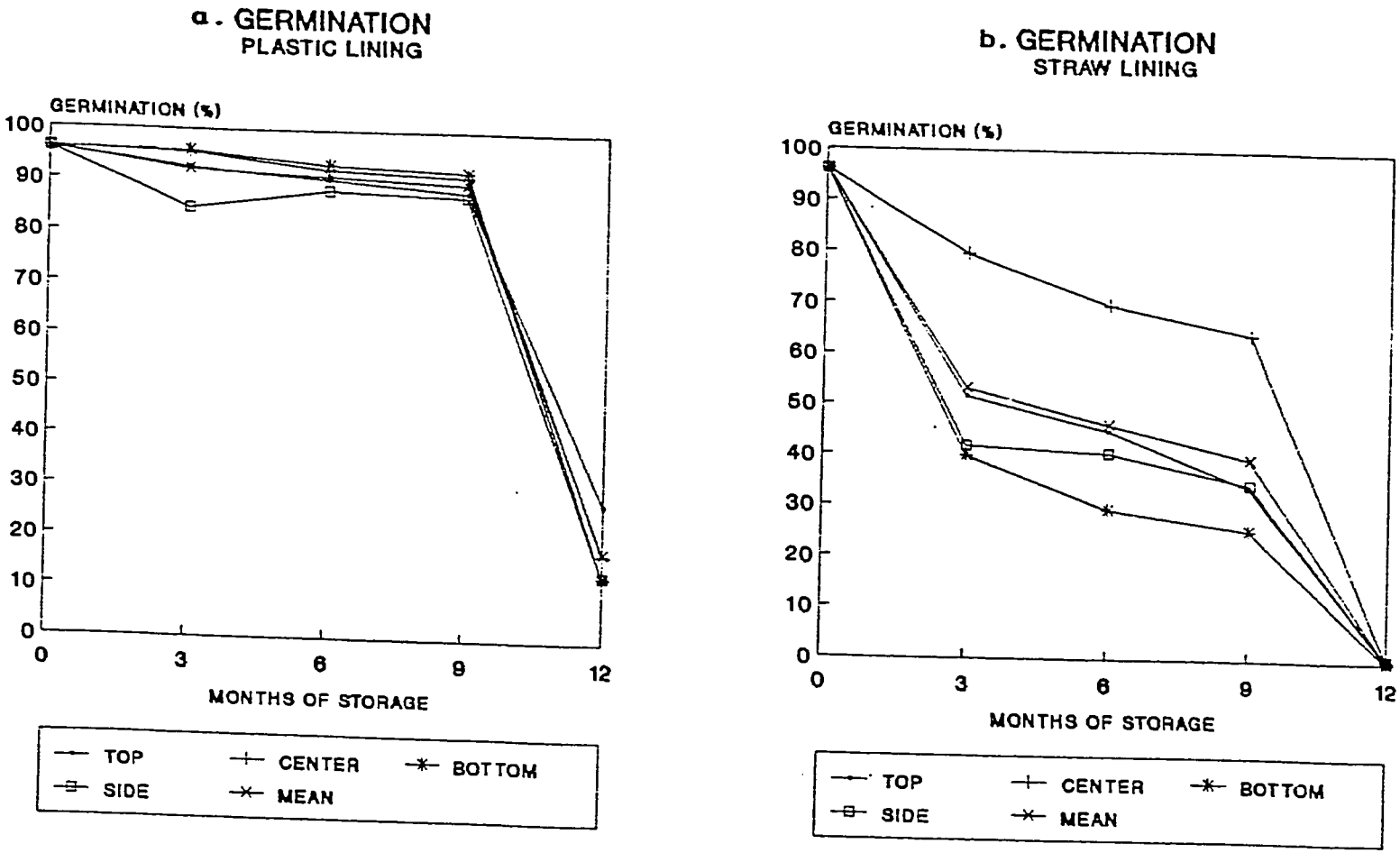


Fig.14: Evolution of Percentage Germination.

2.3.2.2 Early vigor test

This test was run as described in the second report. A summury of the seedling dry weight after 16 months of storage is given in table 17.

Table 17 - Seedling Dry Weight after 16 months of storage (mg)

Type of pits	Sample location	Mean	Standard deviation
Straw	Real Top	0	0
	15 cm from top	0	0
	Center	3.750	2.500
	Bottom	1.250	2.500
	Near the side	2.500	2.887
	Real bottom	0	0
Plastic	Real top	-	-
	15 cm from top	68.750	2.500
	Center	62.500	10.410
	Bottom	50.000	7.071
	Near the side	51.250	8.539

The also, the seedling dry weight from the seed from the real top and the real bottom of the straw lining pits was nul.

The analysis of variance (table 18) shows that the effect of lining, site and their interaction are highly significant.

TABLE 18 Analysis of variance table for seedling dry weight

Source of variation	DF	SS	MS	F	P
Lining	1	25312	25312	450.00	0.0002
Replications	3	81.250	27.083	0.48	0.7182
Error 1	3	168.75	56.250		
Site	3	462.50	154.17	5.29	0.0086
Site*lining	3	550.00	183.33	6.29	0.0042
Error 2	18	525.00	29.167		
Total	31	27100			

A multiple comparison of means by a contrast analysis was done. Those results are summurised in table 19.

Table 19 - Pairwise comparison of seedling Dry weight Means

a/ Straw lined pits

Site	Top	Bottom	Side	Center
Seedling dry weight means	0	1.250	2.500	3.750

b/ Plastic lined pits

Site	Top	Bottom	Side	Center
Seedling dry weight mean	68.750	50.000	51.250	62.500

The seed from the plastic lined pits showed a decrease in vigor between 9 and 16 months of storage. The vigor of the seed from the straw lined pits was not far from 0.

For the straw lined pits, the seedling dry weight means didn't differ significantly. They were really lower than those of the plastic lined pits. For the latters, the mean for the seed from the side and the bottom didn't differ significantly elswhere, the differences were significant. Figure 15 shows the evolution of the seedling dry weight of the seed from the plastic (a) and the straw (b) lined pits.

2.3.3.3 Conclusion

The plastic lining seems, so far, to protect the best the seedling vigor and the germination but after 9 months of storage, this protection didn't seem to be very protective that is the seedling dry weight and the germination were not very satisfactory after 9 months of storage.

2.3.4 Entomology

Mrs K. Bourarach

2.3.4.1 Situation before incubation

Materiel and methods used in this study are similar to those described in our previous studies. Grain samples were is leved. The trash and the broken grains were examined fo detect any

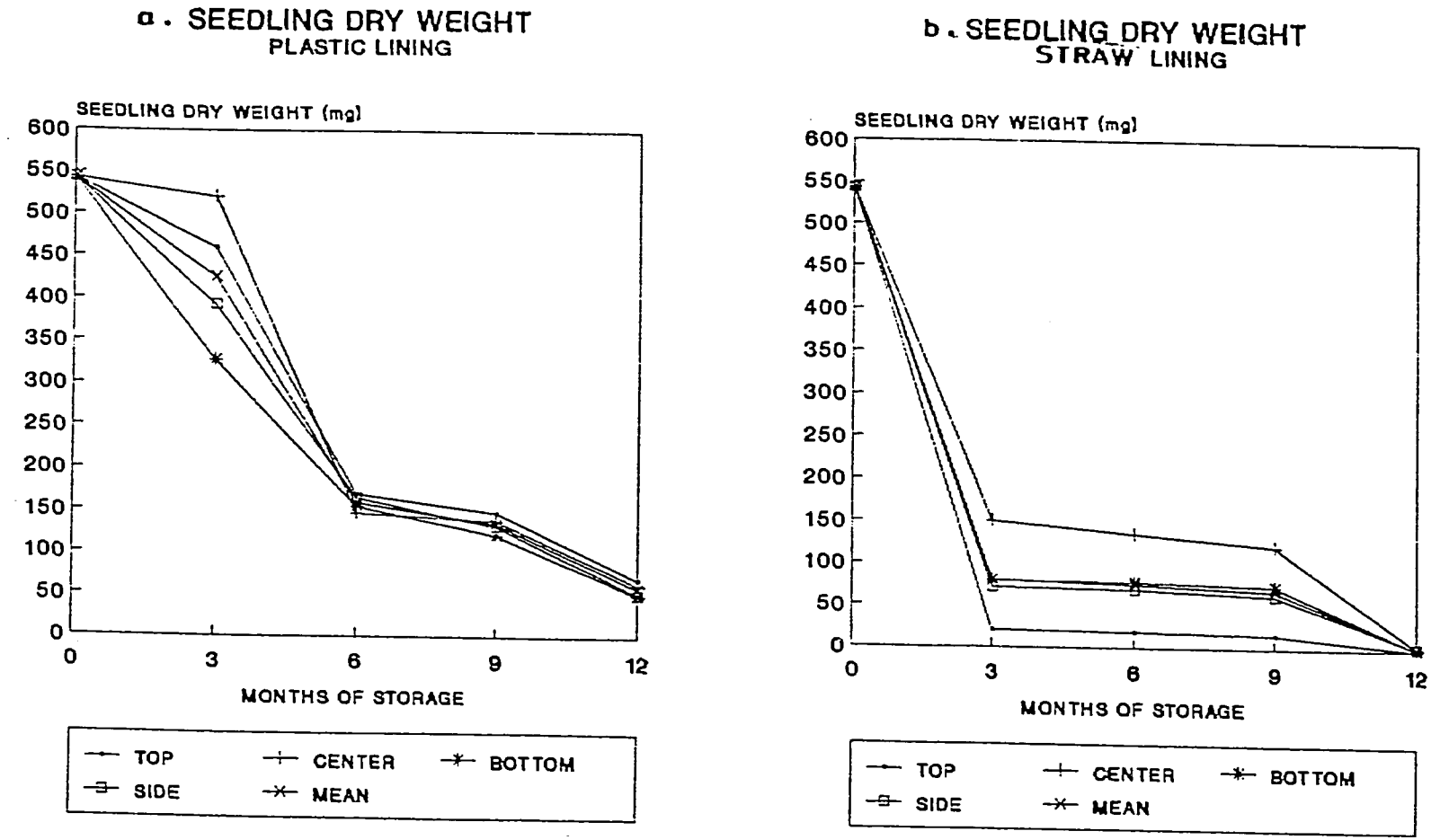


Fig.15 : Evolution of the Seedling Dry Weight.

form of Arthropode presence. The distribution of the different insects found associated with grains in "matmoras" are represented in table 20. Our results show the presence of 2 live Coleoptere species in matmoras tarped with plastic film. These two species are : Sitophilus orizae and Rhizoperta dominica. These were found with an average number of 0.25 and 1, respectively. Dead individuals of the same species were also detected with an average of 2.57 for S. oryzae and 1 for R. dominica. Dead individuals of another specie (S. granarius) were present with an average of 0.5. Samples from plastic "matmora" did not show any live insects. However, one dead adult individual of S. orizae was found.

In straw matmoras, no live or dead insect was detected in the pit JS. However, 2 live and one dead (weevil) were found in the pit LS. These (weevils) belong to S.oryzae et S.granarius. The first species were found with an adult average of 2.25 alive and 0.5 dead. The second species was present with higher adult averages: 21.75 alive and 5 dead. During the opening of this second matmora, a high mite infestation was noticed.

2.3.4.2 Situation after incubation

After the incubation periode, plastic matmora samples showed a low infestation with 3 coleopteres species. These pests present in matmora F.P. were S. oryzae (m = 0.25). S. granarius (n = 0.5) and R. dominica (m = 0.5). In the same matmora and

Table.20 : Pest counts before incubation.

Matmoras with plastic lining							
Sample	INSECTS						Acarians
	Sitophilus.oryzae		Sitophilus.granarius		Rizopertha.dominica		
	Live	Dead	Live	Dead	Live	Dead	
FP_1	0	0	0	0	0	0	—
FP_2	0	0	0	0	0	0	—
FP_3	0	1	0	0	0	0	—
FP_4	0	0	0	0	0	0	—
$\bar{m}$	0	0,25	0	0	0	0	
DP_1	0	1	0	0	1	0	—
DP_2	0	0	0	1	0	0	—
DP_3	0	10	0	1	1	1	—
DP_4	1	0	0	0	2	0	—
$\bar{m}$	0,25	2,75	0	0,5	1	0,25	

Matmoras with straw lining							
Sample	INSECTS						Acarians
	Sitophilus.oryzae		Sitophilus.granarius		Rizopertha.dominica		
	Live	Dead	Live	Dead	Live	Dead	
LS_1	0	0	22	5	0	0	+
LS_2	8	2	28	4	0	0	+
LS_3	1	0	17	7	0	0	+
LS_4	0	0	20	4	0	0	+
$\bar{m}$	2,25	0,5	21,75	5	0	0	
JS_1	0	0	0	0	0	0	—
JS_2	0	0	0	0	0	0	—
JS_3	0	0	0	0	0	0	—
JS_4	0	0	0	0	0	0	—
$\bar{m}$	0	0	0	0	0	0	

before incubation there was only one dead individual of S.orizae. In the second matmora (DP), the same two species S.oryzae and R. dominica found before incubation were detected again after incubation but with higher numbers then those detected before. The average adult number was 7 for S.oryzae, and 1.25 alive and 0.25 dead for R. dominica (table 21).

Examination of samples form (JS) "straw" matmoras did not reveal any insect infestation. L.S. samples were heavily infested with S.granarius. This species was found with an average number of 83.5 alive and 4 dead individual. A high mite infestation was also noticed in these samples.

Insect infestation degree does not depend on the type of matmora, neither on a site of sampling. The insect distribution inside the matmora was heterogenious and does not follow any particular repartition (Table 22).

Concerning losses, there were more weevil-eaten grains or grains without germ in "straw" matmoras than in "plastic" matmoras. No damage of grain cotyledons was noticed in plastic matmoras. In "straw" matmoras grains with damaged cotyledons were present with an average of 8.5 per sample.

2.3.4.3 Discussion and conclusion

One of straw "matmoras" dit not show neither during the

Table.21. Pest counts and damages after incubation.

Sample		DAMAGES								INSECTS NUMBERS						Acarians	
		Grains with holes	Grains with blak spots	Rotten grains	Other damage	Grain without cotyledon	Broken grains	Grains without germes	Small grains	Sitophilus oryzae		Sitophilus granarius		Rizopertha dominica			
										Live	Dead	Live	Dead	Live	Dead		
Matmora with plastic lining	FP_1	3	54	0	0	0	6	6	5	0	0	0	0	0	0	—	
	FP_2	3	26	0	0	0	26	5	18	0	0	2	1	0	0	—	
	FP_3	7	40	34	0	0	7	3	14	0	0	0	0	2	0	—	
	FP_4	6	56	0	0	0	28	0	0	1	0	0	0	0	0	—	
	$\bar{m}$	4,75	44	8,5	0	0	16,75	3,5	9,25	0,25	0	0,5	0,25	0,5	0		
	DP_1	15	52	0	0	0	14	5	36	0	0	0	0	3	0	—	
	DP_2	11	31	0	0	0	10	8	23	0	0	0	0	0	0	—	
	DP_3	27	38	0	0	0	16	3	12	26	0	0	0	7	1	—	
	DP_4	12	54	0	10	0	8	4	21	2	0	0	0	7	0	—	
	$\bar{m}$	16,25	43,75	0	2,5	0	12	5	23	7	0	0	0	4,25	0,25		
Matmoras with straw lining	LS_1	63	36	73	3	1	6	6	10	0	0	106	0	0	0	+	+
	LS_2	119	34	22	0	5	15	7	16	0	0	77	16	0	0	+	+
	LS_3	210	45	85	0	0	10	3	5	0	0	95	0	0	0	+	+
	LS_4	70	63	26	0	0	8	4	22	0	0	56	0	0	0	+	+
	$\bar{m}$	115,5	44,5	51,5	0,75	1,5	9,75	5	13,25	0	0	83,5	4	0	0		
	JS_1	4	28	75	5	0	12	5	16	0	0	0	0	0	0	—	
	JS_2	6	54	248	4	1	11	7	15	0	0	0	0	0	0	—	
	JS_3	47	38	112	0	13	16	11	50	0	0	0	0	0	0	—	
	JS_4	0	30	64	81	56	14	3	8	0	0	0	0	0	0	—	
	$\bar{m}$	14 25	37 5	124 75	22 5	17 5	13 25	6 5	22 25	0	0	0	0	0	0		

Table 22 : Pest counts by level of matmora after incubation.

	Level	Grains with holes	Grains with black spots	Rotten grains	other damages	Grains without cotyle-don	Broken grains	Grains without germes	Small grains	Sitophilus oryzae		Sitophilus granarius		Rizopertha dominica	
										Live	Dead	Live	Dead	Live	Dead
Matmoras with plastic lining	1	9	53	0	0	0	10	5,5	20,5	0	0	0	0	1,5	0
	2	7	28,5	0	0	0	18	6,5	20,5	0	0	1	0,5	0	0
	3	17	39	17	0	0	11.5	3	13	1,3	0	0	0	4,5	0,5
	4	9	55	0	5	0	18	2	10,5	1,5	0	0	0	3,5	0
										Live	Dead	Live	Dead	Live	Dead
Matmoras with straw lining	1'	33,5	32	74	4	0,5	9	5,5	13	0	0	53	0	0	0
	2'	62,5	44	13,5	2	3	13	7	15,5	0	0	38,5	8	0	0
	3'	128,5	41,5	98,5	0	6,5	13	7	27,5	0	0	47,5	0	0	0
	4'	35	46,5	45	40,5	28	11	3 5	15	0	0	28	0	0	0

$$1 = \frac{FP_1 + DP_1}{2} \qquad 1' = \frac{LS_1 + JS_1}{2}$$

opening nor after incubation any insect infestation. This is probably because of :

a. The sample number was not sufficient to give a better idea of the real degree of infestation.

b. The stored grain was initially non infested with insects. The observed high level of CO_2 is due to microorganism fermentation and not to insect or mite activities.

In the second "matmora", there was quite high degree of infestation by Arthropodes which were favored by the climatic conditions during the storage periode. The presence of high biological activity in this second matmoras indicated, the presence of insects and mites.

In plastic "matmoras", only few alive insects were detected when samples were examined after the opening. After incubation the some samples were found to be highly infested. We think that during storage, the plastic film used in "matmora" inactivate insect development, which may become normal when conditions are favorable.

2.3.5 Food Chemistry and Biochemistry

A. KAANANE

This report gives the results relative to the samples taken on 5-10-1989.

2.3.5.1 Methodology

a) Samples

Five samples were taken from each of the four pits that were opened on 5-10-1989 (16 months and ten days of storage). Two pits with straw lining and the other two with plastic lining. The sampling experimental design can be found in other part of this report. It should be noted that all determinations were done in duplicate.

b) Methods of Analysis

Refere to the six months progress report of January-June 1988.

2.3.5.2 Results and Discussion

The results obtained for moisture content, water activity, fat content and total acidity of all samples are shown on table 23. As it can be seen all values are higher in case of pits straw lining than values relative to pits with plastic lining.

Table 23 Moisture content, water activity, fat acidity of different samples of cereals stored in pits with plastic and straw lining after 16 months of storage

* LS, JS - straw lining
* FP, DP - plastic lining

Samples*	Moisture content gH20/100g	Water activity	Fat content %	Fat acidity mg KOH/100g
LS	18.6	0.81	1.73	130
LS1	16.8	0.79	2.01	139
LS2	17.7	0.79	2.17	162
LS3	21.8	0.81	1.57	174
LS4	19.0	0.79	2.75	152
JS	19.2	0.83	1.23	168
JS1	16.3	0.79	1.59	167
JS2	15.9	0.78	2.23	158
JS3	19.8	0.82	2.25	170
JS4	18.5	0.80	2.28	167
FP	14.0	0.72	2.12	34
FP1	13.7	0.69	1.93	42
FP2	14.9	0.75	2.05	42
FP3	16.4	0.76	2.04	42
FP4	14.7	0.73	1.88	47
DP	13.5	0.71	2.04	21
DP1	12.3	0.69	2.15	30
DP2	13.4	0.68	2.24	22
DP3	13.5	0.68	1.99	13
DP4	12.2	0.67	2.30	33

2.3.6 Food Microbiology

Study of molds and mycotoxins

Dr. A. TANTAOUI ELARAKI

In this report, the results related to mycological analysis of the samples taken on May 11, 1989, will be given, and those relative to mycotoxin research in all the samples will be presented.

2.3.6.1 Mycological analysis

As for the perious sets of samples, fungal contamination was assessed by the following :

- percentage of seeds contaminated with molds
- number of molds spores by gram of product.

The techniques used were described in previous reports Table 24 summarizes the results which represent a confirmation of what we had adready observed, i.e. that plastic liners cause a drastic decrease in the number of fungal spores/gram of product. The percentages of seeds contaminated are also lower in "plastified matmoras".

2.3.6.2 Mycotoxin Analysis

All the samples collected from the begining of this investigation were checked for Aflatoxin Bl, Ochratoxin A and Zearalenon.

Extraction and detection prosedures have been described in perious reports.

None of the samples was contaminated with any of the three mycotoxins.

In the final report, we will discuss the overall results of this investigation.

Table 24. Mycological analysis of samples taken on May 11-1989

Disignation of Samples	% of seeds contaminated	Number of Fungal spores/g	Number of molds isolated and stored
JS top	67	$3.74*10^5$	1
JS1	53	$1.30*10^6$	
JS2	32	$1.67*19^9$	3
JS3a	63	$2.93*10^7$	2
JS3b	45	$1.63*10^6$	2
JS3c	39	$1.56*10^6$	
JS4	57	$1.06*10^7$	2
JS bottom	73	$5.50*10^7$	1
LS top	80	$3.40*10^4$	2
LS1	55	$1.19*10^4$	3
LS2	89	$1.62*10^5$	
LS3	57	$3.60*10^5$	2
LS4	39	$2.93*10^4$	2
LS bottom	51	$2.70*10^6$	1
FP top	87	$1.30*10^4$	
FP1	51	$1.10*10^4$	3
FP2	56	$1.66*10^2$	4
FP3	17	$7.20*10^4$	4
FP4	42	$1.18*10^5$	3
DP top	100	$1.70*10^2$	
DP1	70	70	8
DP2	40	53	2
DP3a	34	29	3
DP3b	16	27	1
DP3c	34	34	2
DP4	32	28	

2.3.7 Food Science

Dr. M. BAKHELLA

Mixograph and falling number tests

2.3.7.1 Procedures used: Refer to previous reports

2.3.7.2 Results and discussions

a) Falling number test

In general the latest data collected show once more that wheat samples still are very hypodiastasic with very few exceptions. More comments will be made on these data and the previous ones in the final report.

b) Mixograph results

Discussions on the parameters of the mixograms will be made in the final report. In general the results resemble those of the preceding openings with more indices of serious rheological degradation of samples issued from straw-lined pits.

Table 25 Falling number of wheat stored for 16 months

Sample reference	Falling number (14% m.b)	Sample reference	Falling number (14% m.b)
Straw lining		Plastic lining	
JS (top)	67	FP (top)	820
JS1	586	FP1	762
JS2	716	FP2	409
JS3	68	FP3	279
JS4	66	FP4	424
LS (Top)	749	DP(Top)	271
LS1	879	DP1	314
LS2	867	DP2	333
LS3	70	DP3	249
LS4	494	DP4	795

Acknowledgement

We are grateful to the National Research Institute of Agronomy for performing the falling number test, and to Omar KAANANE - Department of Food Chemistry and Biochmistry, IAV Hassan II for performing moisture determinations on wheat samples.

3.0 NEW RESEARCH FACILITY FOR GRAIN STORAGE

The Agronomic and Veterinary Institute of Rabat has completed the experiment station for storage of grain and legumes in Meknes Dkhissa in another grain producing area of Morocco. This experiment was built by the funds of the project obtained by the Institute from the Ministry of Agriculture and directed by Dr H> Bartali, principal investigator. The station is designed and managed by the Department of Agricultural Engineering of the Institute. The research work will be carried out by the

multidisciplinary team involved in the Science Advisor Project of Settat. Objectives of this research are the evaluation and comparaison of some storage systems adapted to the conditions of Morocco and other developping countries. The facility covers 5 types of storage systems:

-Underground storage improved with plastic lining according to the findings of the research conducted since 1987 under the Science Advisor grant.
-small farmers silos made with reed and lined with pastic and clay
-two appropriate storage units newly tested in Morocco: a clay straw silo and a bulk emergency storage technique.
-a steel silo equipped with mechanical ventilation

Two seminars were organised on grain storage on the site of the experiment station. The first one on November 10 th on the day of the inauguration of the station. The second on April 4 th on the occasion of the first control after 3 months of storage, the topic of this seminar was Techniques of sampling and monitoring of stored grain.

4.0 INTERNATIONAL SEMINARS ON STORAGE

Dr H. Bartali, principal investigator was invited as a key note speaker to the seminar on Post Harvest Systems organised in Abidjan (Ivory Coast) from January 28 to February 2 nd. The seminar was sponsored by the Association of Partially and Entirely

French Speaking Universities and hosted by the School of Agronomy of Abidjan. Dr Bartlai presented a key note paper on Post Harvest Situation in North Africa and a second paper on Underground Storage of Grain showing the research methodology and result from the Science Advisor/IAV project.

International Seminar on Storage Structures

An international seminar on "Storage Structures for Grain, Legumes and their Derivatives" is jointly organised by the Aronomic and Veterinary Institute of Rabat, the Moroccan Association for Land Reclamation, Irrigation and Drainage (ANAFID) in collaboration with the International Commission of Agricultural Engineering (CIGR). The seminar will be held in Rabat Morocco from November 28 to 30 th.

Participants from 22 countries from the five continents have submitted their intention to attend. 5 papers dealing with the research conducted with the Science Advisor Grant on underground grain storage will be presented by the Institute in this seminar. Visits to the research sites on grain storage will be organised for the participants. Attached is a copy of bulletin 1.

5.0 PLANS FOR NEXT SIX MONTHS

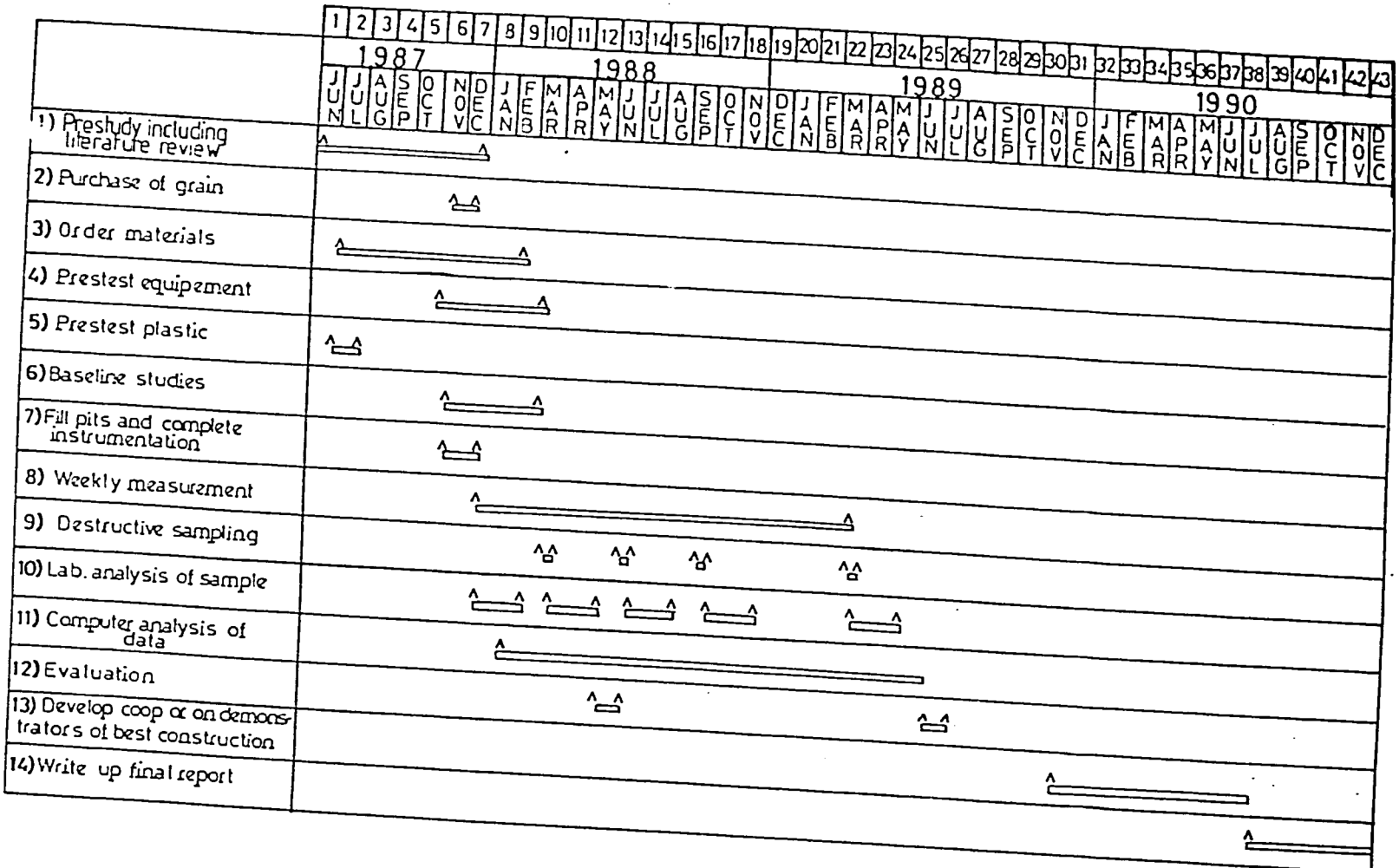
5.1. Preparation of the papers to be presented at the International seminar on grain storage of November 1990 and to be included in the final report.

For this purpose, a series of regular meetings of the research team was initiated in January 1990 by a meeting with Dr SEDRATI, Director of the Institute and founder of the Study and Reserch Group on Grain Storge (GERS).

5.2. Continuation of the extension work for the use of plastic bags through seminars such as those held in the experiment station of Meknes.

5.3. Visit of Dr H. Bartali to USA

As principal investigator, Dr H. Bartali will make a visit to the US in June 1990. The dates of this visit will be determined in concertation with Dr Florence Dunkel, principal coinvestiagtor. Dr Bartali will visit some reseach labs on grain storage and AID.



Gantt chart

^ ^ Completed

SCIENTIFIC PROGRAMME

The seminar will cover various scientific and technical aspects dealing with structures for storage of grain and legumes, t following topics will be examined :

1. General aspects

* Methods for estimating needs for constructing storage units.
* Problems of losses incurred during storage.
* Problems of losses incurred during handling.
* Role of professional bodies (national and international).

2. Aerated above ground storage

* Structures :
  - design of vertical, horizontal bulk or bag storage;
  - emergency storage;
  - use of local materials and appropriate technologies;
  - transit silos;
* Ventilation of stored products.
* Drying of products.
* Handling.
* New design methods.
* New technologies in storage units design.
* Sampling and quality control.

3. Controlled atmosphere and underground storage

* Structures:
  - earth sheltered storage units;
  - insulated underground storage design;
  - hermetically sealed above ground units;
  - plastic or other appropriate liners;
  - large scale underground structures.
* Handling: loading and unloading.
* Control of conservation parameters.
* Sampling, remote control.
* Biological considerations.
* Treatment technics.

4. Economical aspects and study cases :

* Faisability studies of storage constructions.
* Central storage systems.
* On farm storage units.
* Optimization of collecting and storage networks.
* Comparaison of bulk storage and bag storage.

RABAT, LIEU DU SEMINAIRE
RABAT, VENUE OF THE SEMINAR

Rabat, ville imperiale et capitale du Royaume du Maroc dispose de nombreux hôtels de toutes les catégories. Tous les efforts seront faits pour loger chaque participant dans la catégorie de son choix. Rabat étant une ville côtière possède un climat tempéré.
En Novembre, la température moyenne se situe autour de 16°C.

Rabat, the imperial city and capital of the Kingdom of Morocco offers numerous hotels of all classes. Every effort will be made to book each participant in the hotel of his choice.

Rabat being on the atlantic coast has a fairly mild weather. Mean temperature in November is around 16°C.

APPEL AUX COMMUNICATIONS
CALL FOR PAPERS

Les propositions de communications devront être adressées avant le 31 Mars 1990 au Secrétariat du séminaire, sous la forme d'un résumé d'une page dactylographiée au maximum (200 mots).

Elles seront soumises au Comité de lecture qui avisera les auteurs de sa décision avant le 30 Avril 1990.

Abstracts should be submitted to the secretariat of the seminar before March 31st, 1990 in one page typed at most (200 words).

The authors will be notified by the selection committee before April 30th ,1990.

ADRESSE POUR CORRESPONDANCE
SECRETARIAT OF SEMINAR

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SEMINAIRE INTERNATIONAL DE LA 2ème SECTION DE LA COMMISSION INTERNATIONALE DU GENIE RURAL

STRUCTURES DE STOCKAGE DES CEREALES, DES LEGUMINEUSES ET DE LEURS DERIVES

28-30 NOVEMBRE 1990
RABAT - MAROC

INTERNATIONAL SEMINAR OF THE 2nd SECTION OF THE INTERNATIONAL COMMISSION ON AGRICULTURAL ENGINEERING

STORAGE STRUCTURES FOR GRAIN, LEGUMES AND THEIR DERIVATIVES

28-30 NOVEMBER 1990
RABAT - MOROCCO

BULLETIN 1