PN-ABB-109

Jan 20th, 1988

REF : GRANT N° DPE-5542-G-SS-7030-00
Project n° 7336
"Investigation of plastic liners for indigenous underground grain storage structures"

Dear Sir

Please find two copies of the second progress report regarding the AID Grant indicated in reference.

Sincerely.

Dr. El Houssine BARTALI

Principal Investigator

DEH

INSTITUT AGRONOMIQUE ET VETERINAIRE HASSAN

B.P. 6202 - RABAT-INSTITUTS

RABAT - MAROCCO

PN-ABC-108

AID-SCIENCE ADVISOR COUNCIL GRANT

UNDERGROUND GRAIN STORAGE PROJECT

GRANT N DPE-5542-G-SS-7030-00
PROJECT NUMBER 7.336

SIX MONTH PROGRESS REPORT
PERIOD COVERED

JANUARY 1 TO JUNE 30, 1988

HASSAN II AGRONOMIC AND VETERINARY INSTITUTE

RABAT MOROCCO

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1.0. Introduction

Research undertaken at the Agronomic and Veterinary Institute on underground grain storage has been initiated in fall 1986 with an experiment on barley storage in two types of pits installed on campus, one straw and one plastic lined. This experiment was covered in the first progress report and the results for loss evaluation over six months of storage were encouraging since they reached .97% with plastic and 6.27% with straw. The grant obtained from A.I.D Science Advisor in Washington in August 1987 has allowed to pursue this research by extending the investigation to underground storage of wheat and compare the performance of plastic and straw as lining materials in sixteen pits installed on farm in Chaouia. The progress report covered the overall set up of the experiment and introduced the seven Departments of I.A.V involved in the investigation. The experimental pits were filled with wheat on December 30, 1987. The baseline sampling was carried out according to the procedure described in the first progress report. The project is making very satsifactory progress. Brochures presenting the project were prepared in french and english.

2.0. Research accomplishments

2.1 Experiment with wheat on farm

2.1.1 Procedure used in pit opening

2.1.1.1 Identification of the pits opened

The first opening of pits took place on the 5 th of April 1988. Four pits were opened after a period of three months of storage, two plastic and two straw lined. The four pits are identified as F_{11}, F_{15}, P_5 and P_{16} as shown in figure 2. The appellation of the pits has been modified for convenience and the new one is indicated in table 1. The first two pits were intensively equiped and the latter two were partially equiped with instruments. The choice of these pits among the 16 installed was done randomly, except for the pit F_{11} where a relative humidity sensor was installed. This sensor was no longer functioning properly after it has been installed in Chaouia pit. It was decided to open this pit and to fix the sensor for another use in the pits on campus.

2.1.1.2. Location of sampling points

The grain samples were taken on site by the research team. The location and the identification of these samples is shown in figure 1. The locations correspond to the positions of temperature sensors in the grain. All the samples were

analysed according to the flow diagram for sample analysis indicated in the first report. Additional samples were taken from the upper and lower zones of grain in straw pits, respectively named DZ1 and DZ2 as well as from the top of grain bulk in plastic pits as shown in figures 19 and 20. In these areas of pits, grain is more infested and examination of samples focused on insects, molds and damage evaluation only.

2.1.1.3 Participants to the opening operation

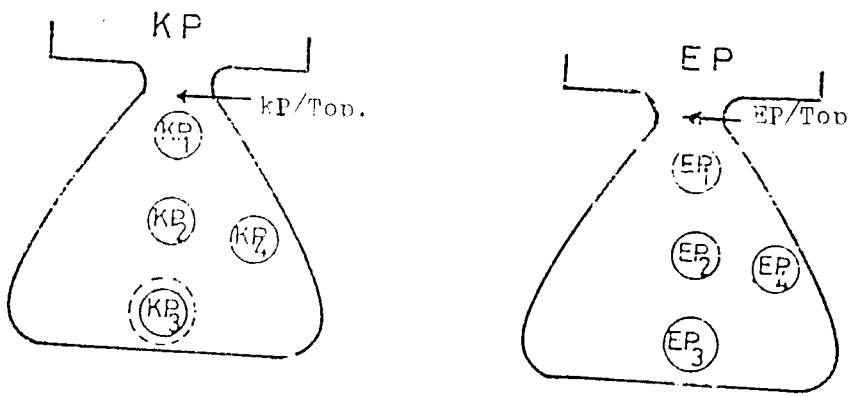
During this opening of pits, in addition to the research team members and graduate students, extension local agency staff in Settat, farmers from the Chaouia region and engineers from a regional cooperative for grain storage were present. They examined the differences in grain quality due to storage in two different conditions: plastic lined and straw lined pits. Dr F. Dunkel, principal coinvestigator in the project also attended this first opening of pits.

2.1.2. Revision of sample analysis procedure

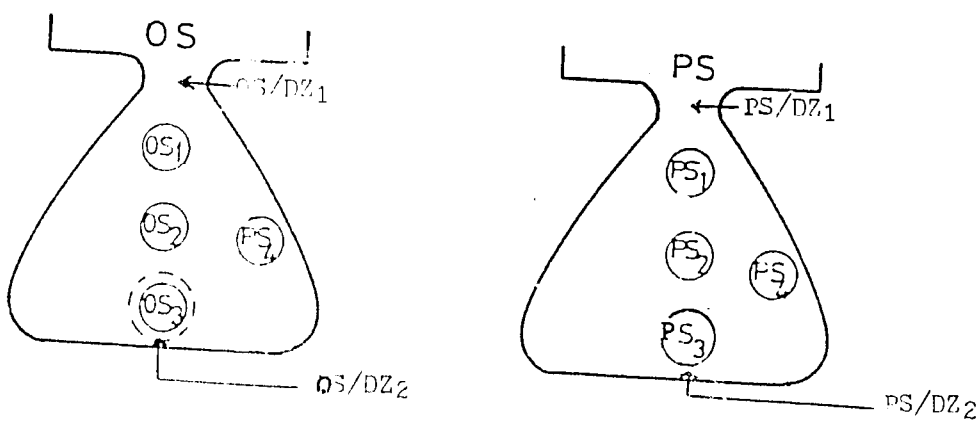
2.1.2.1 Consolidation of damage analysis

The faculty involved in the project have selected some techniciens and graduate students of I.A.V to carry out the analyses and laboratory work related to the research subject. Two graduate students, already selected, Mr Khalid Tlemcani

Fig. 1 Location of grain samples first opening of pits



Plastic lined pits



Straw lined pits

Samples to be analysed in three replicates.

Table 1.

Table of correspondance between first and new appellations of experimental pits in settat

First appellation	New appellation
P 1	AP
F 2	BS
F 3	CP
P 4	DP
P 5	EP
F 6	FP
F 7	GS
P 8	HP
P 9	IS
F10	JS
F11	KP
P12	LS
F13	MP
P14	NS
F15	OS
P16	PS

majoring in agricultural engineering and Mr M. Brahim Abdellah majoring in plant pathology will be defending their M.S theses in Fall 1988. Other students will be selected in the academical year 88-89 such as Mr El Ghali Abdellatif majoring in agricultural engineering. This procedure has a very positif impact on the graduate training of students who benefit from the research environment created by the project.

Regarding the number of replicates per analysis, the research team members decided, on their meeting of April 11 th, 1988 to limit this number to three replicates. These replicates will be made on the samples taken from the bottom levels of a straw pit and a plastic pit (fig. 1).

As far as the procedure for sample analysis is concerned, the following categories of damage will be analyzed on a sample of 300 gr or the standard sample size used in baseline study. Each category of damged grain will be weighed separately. The categories of damaged kernels comprise: broken (Casse), shrunken (mince), decolorated (decolores, including taches noires), germinated (germes), visible mold (moisissure visible), insect holes (trous d'insectes), attacked germ (also insect damage), (germe attacke) and undamaged (grain non endommage).

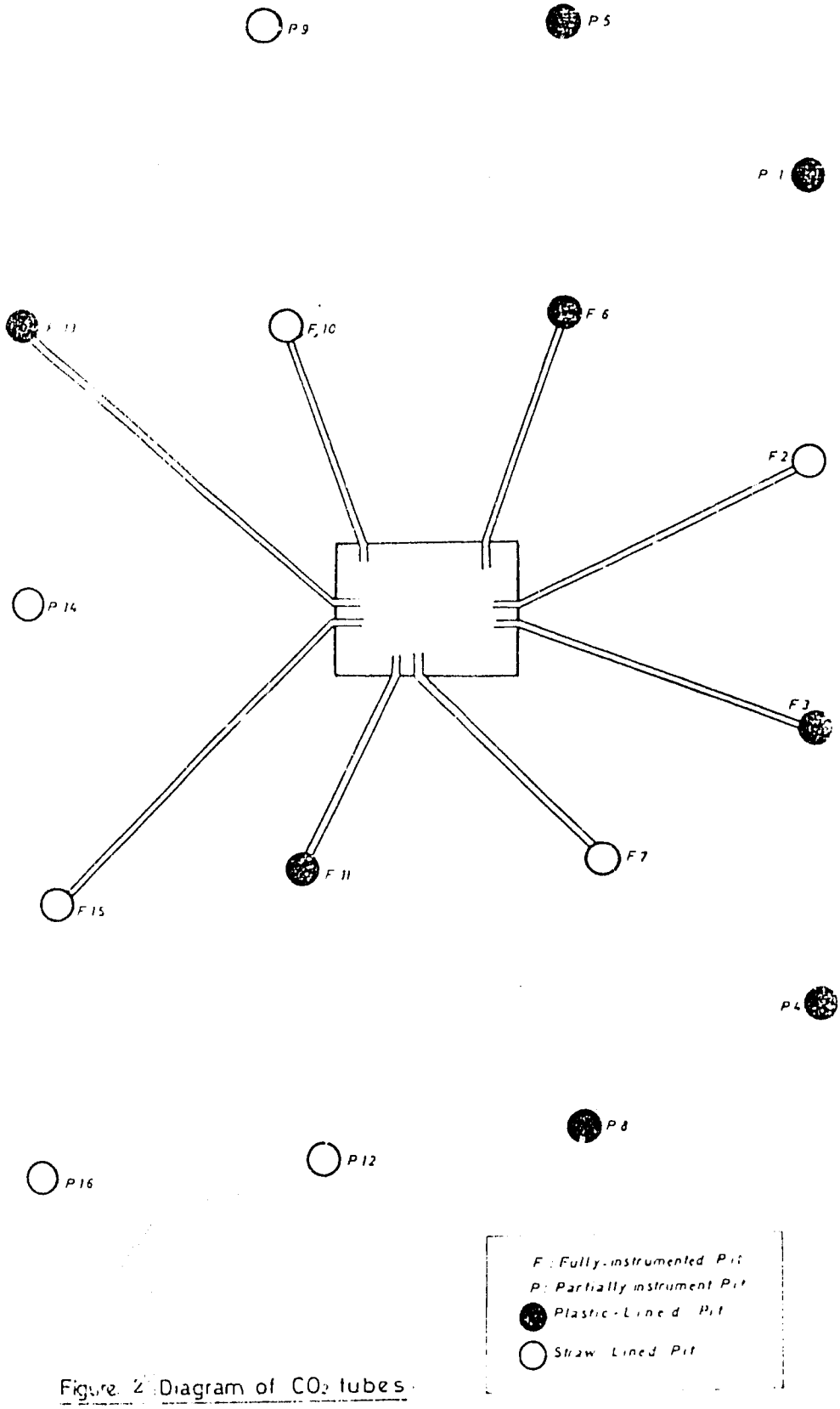


Figure 2 : Diagram of CO_2 tubes

2.1.2. Designation of "emergency treatment"

Some samples taken from the matmoras require "emergency treatment". These include samples for food microbiology, plant pathology, food chemistry and biochemistry and food technology analyses. These samples need within 24 hours after being taken from pits in Settat, to be placed in zero degree temperature.

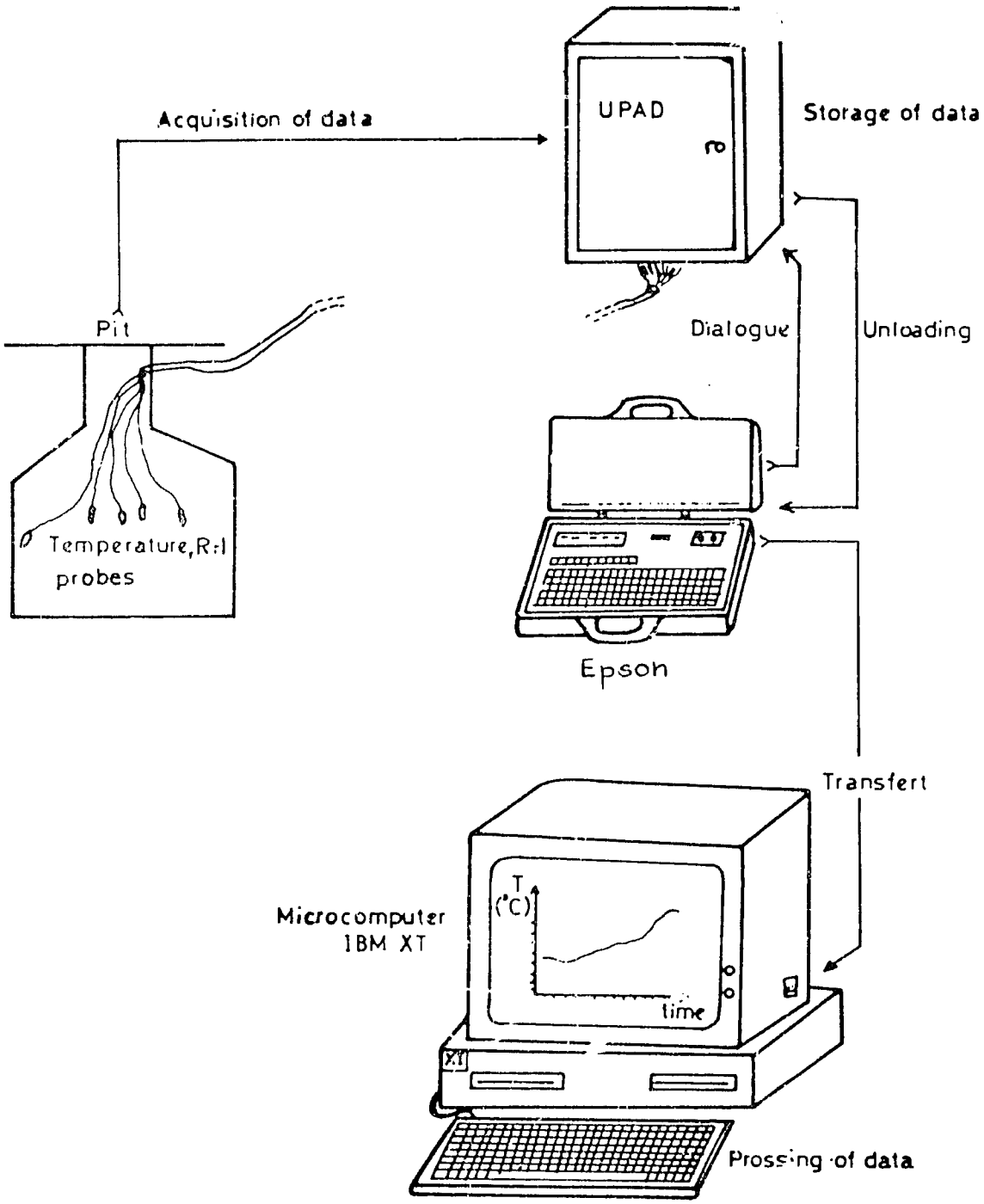
2.1.3. Comparison of base line data with 3 months of storage

2.1.3.1. Agricultural Engineering

The Agricultural Engineering Department has contributed by carrying out on site measurments of data, coordinating and planing the overall research process. Dr H. Bartali with the contribution of Dr H. Debbarh supervised these activities which included:

The preparation for the two pits opening, the regular data acquisition and processing, the determination of damages in the samples taken at each opening, the analysis of the soil on the pits site, the investigation of the stability and mechanical resistance of pits in terms of their size and the equipment of an underground grain storage facility on the Institute campus. On the other hand, ordering of equipment and supplies for each contributing department was continued.

Fig 3. System of acquisition and processing of data .



During the visit that Dr H. Debbarh made in Spring 1988, to the University of Minnesota, in relation to his dissertation, he discussed the grain storage project progress with Drs Dunkel and Sterling and checked some of the equipment ordering such as the microcomputer for the project

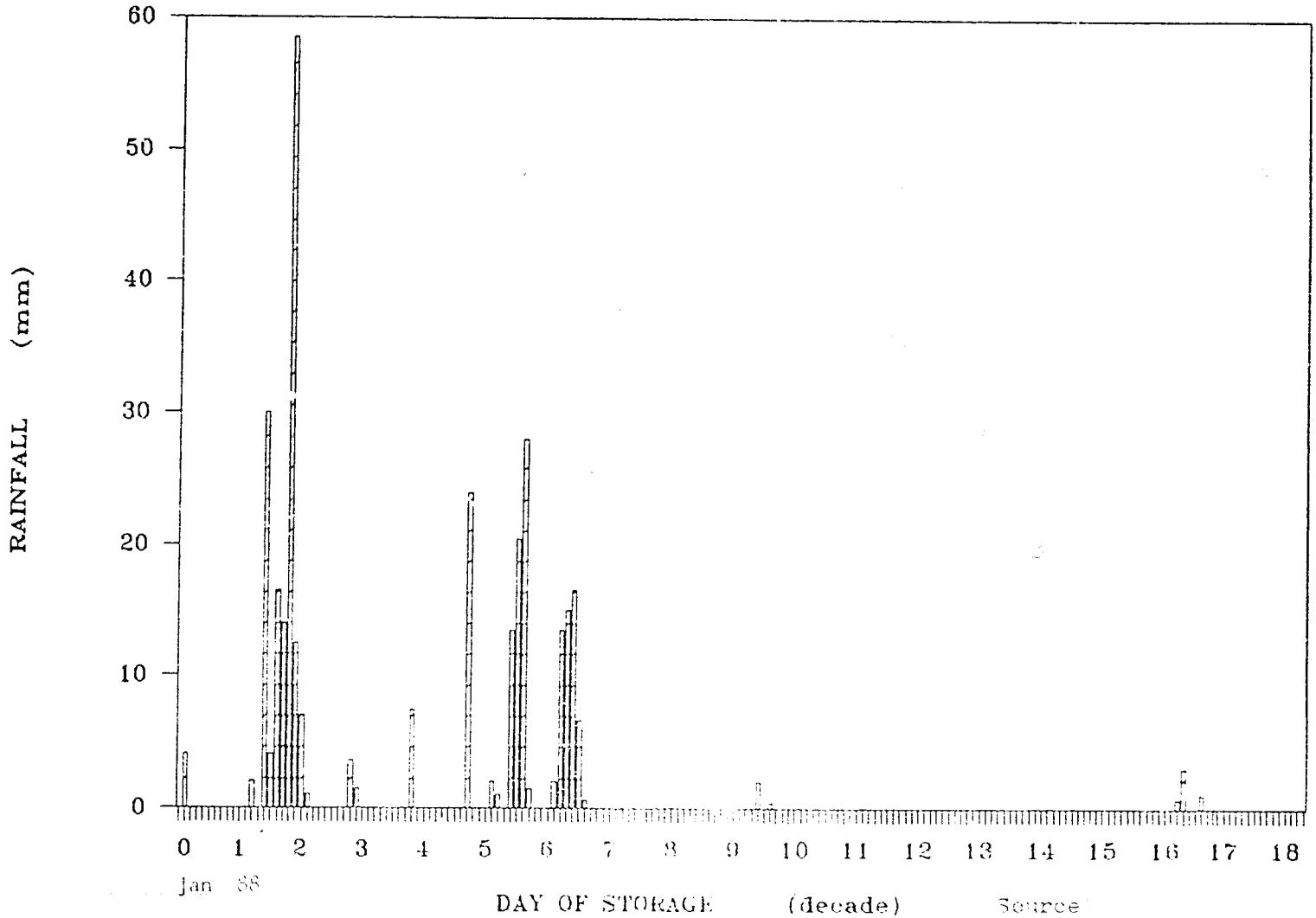
A. Data monitoring

Temperature, relative humidity and carbone dioxide levels within the pits were regularly monitored by the Agricultural Engineering Department. Figure 3 shows the system of acquisition and processing of temperature and relative humidity. An Epson micromputer is used to collect the data from the on farm recording equipment. These data are stored and processed on an IBM XT. The levels of rainfall corresponding to the first six months of storage are shown in figure 4. They were obtained from a nearby meteorologic station of the Research Center on Aridoculture in Settat.

A.1. Temperature variations

The variations of temperature levels recorded over the first six months of storage were used to examine the shape of temperature gradients in the soil of pit and in the grain-soil system in vertical and horizontal directions for the two types of lining. The results are respectively shown in figures 6 and 7, 8 and 9, 10 and 11. Temperatures in straw

Fig 4. *RAINFALL IN SITE OF EXPERIMENT*



pits are higher than the ones in plastic pits. Pastic sheets represent an obstacle to humidity and oxygen migration into grain. The relative disponibility of these two factors in straw pits allow respiration of insects and fungi to take place and to increase temperature of grain. This is particularly noticible around temperature sensor # 1 where temperature in straw pits reaches 26.5 C. This sensor is located in a region of pit more exposed to surface water infiltration through upper straw layer. Temperature figures also reveal the effect of soil on grain temperature. Curves obtained for sensors 1 and 5; 4 and 6 and 3 and 7 have a similar shapes. Temperature at the bottom is more stable compared to temperature at the top of pit. This is due to the above soil layer which has a damping effect on temperature fluctuations. Straw pits present a relatively large temperature gradient in vertical direction. This gradient induces movment of air and heat inside wheat and increases humdity of grain at some locations of pit.

A.2. Relative humidity

A sensor (type Vaissala) measured the variations of relative humidty of intersticial air at the center of a straw pit (JS). These variations are shown in figure 5. Another sensor installed at the center of a plastic pit (KP) failed to operate properly a few days after it was installed in January 1988. This sensor was removed at the first opening.

Fig 5. *STRAW LINED PIT*

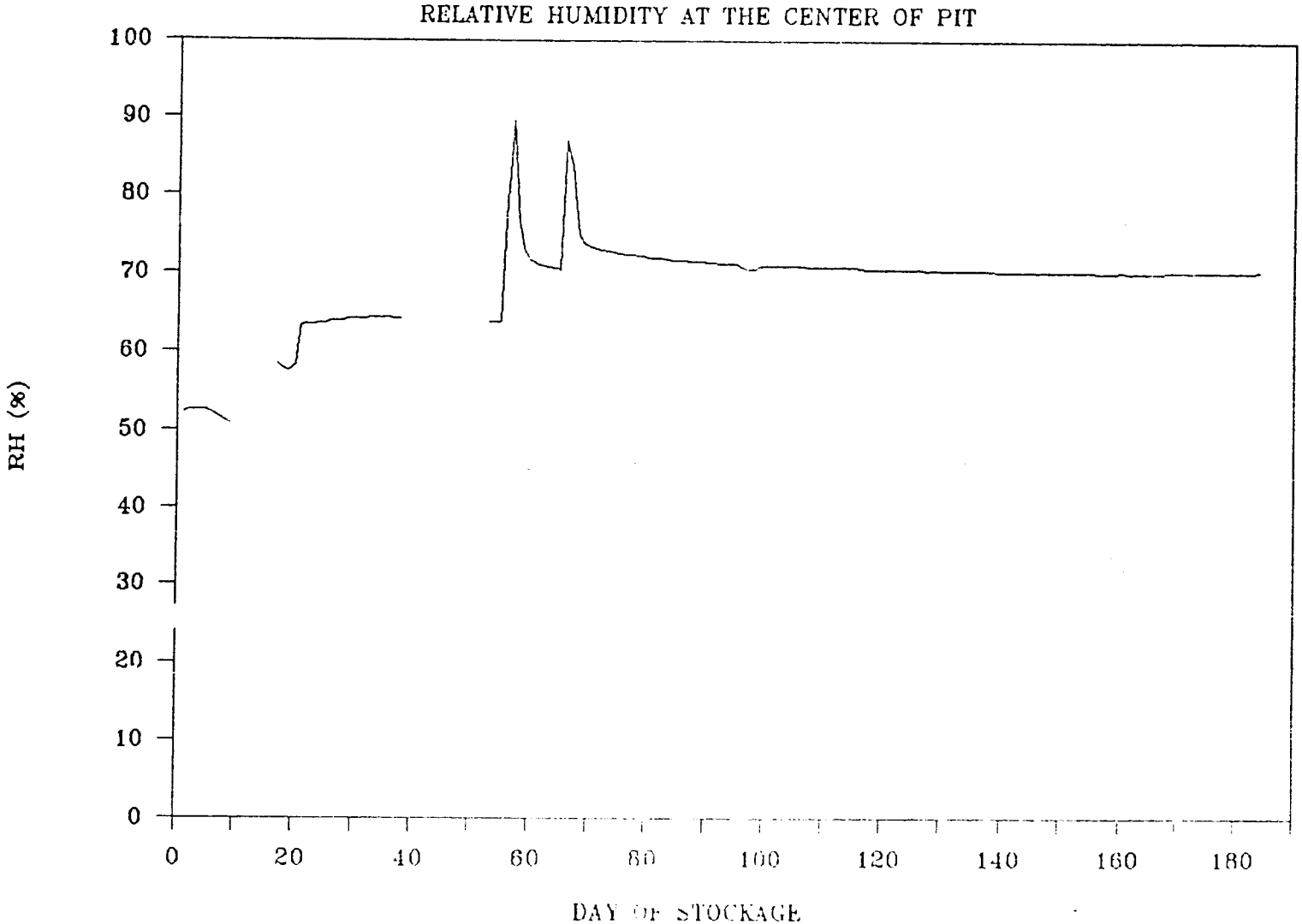


Fig 6. *STRAW LINED PIT*

TEMPERATURE GRADIENT IN SOIL

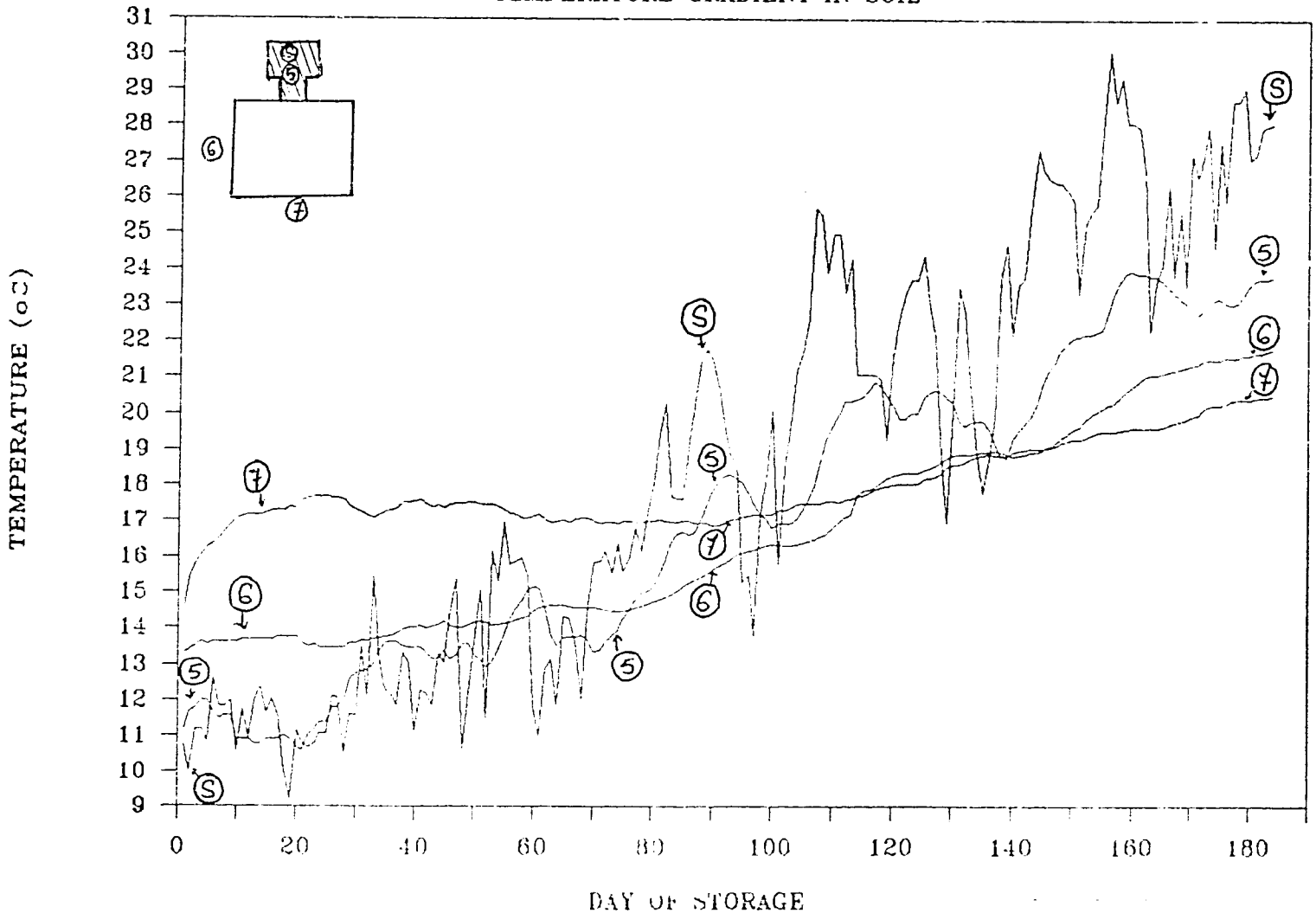


Fig 7. *PLASTIC LINED PIT*

TEMPERATURE GRADIENT IN SOIL

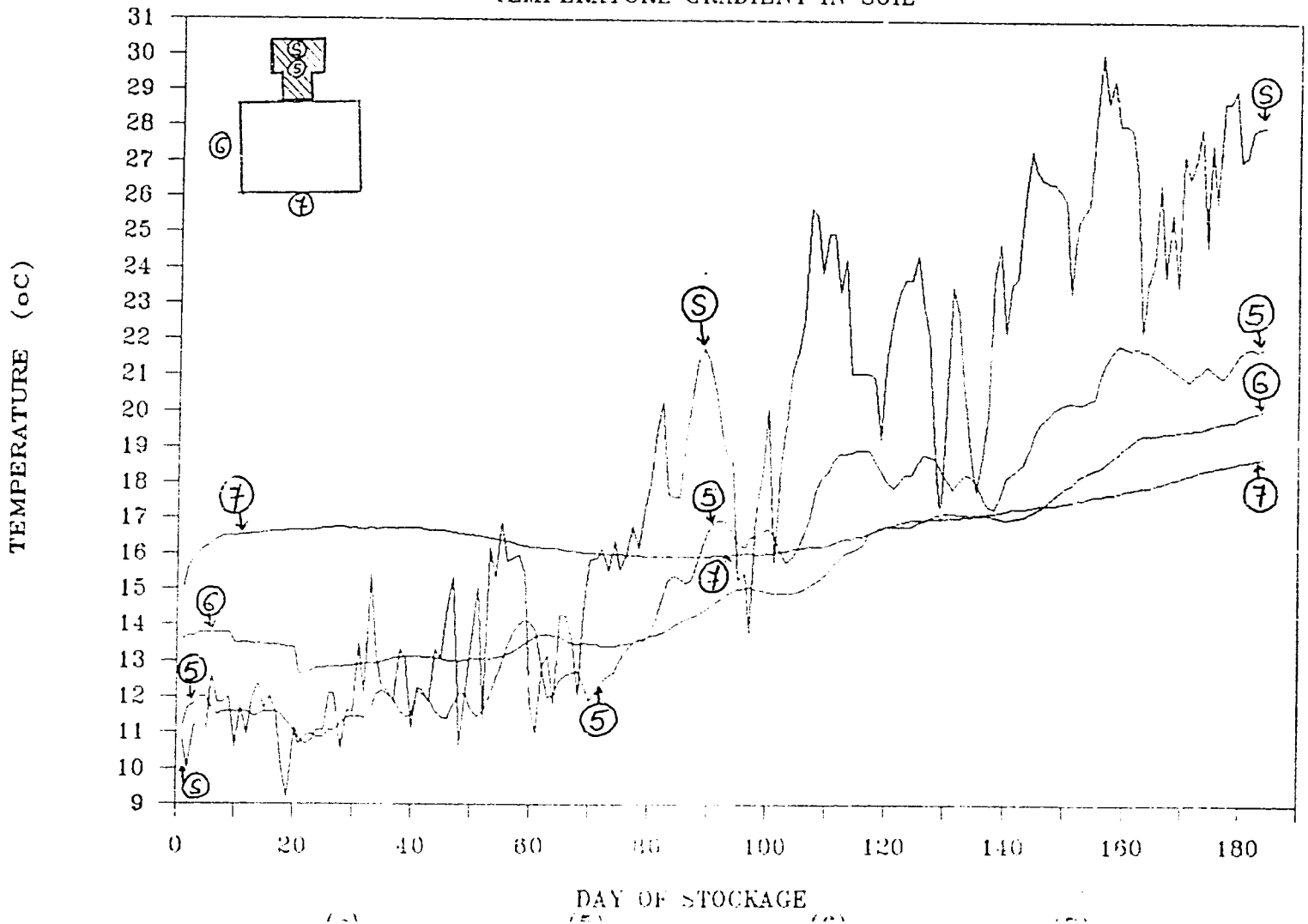


Fig 8. *STRAW LINED PIT*

VERTICAL TEMPERATURE GRADIENT

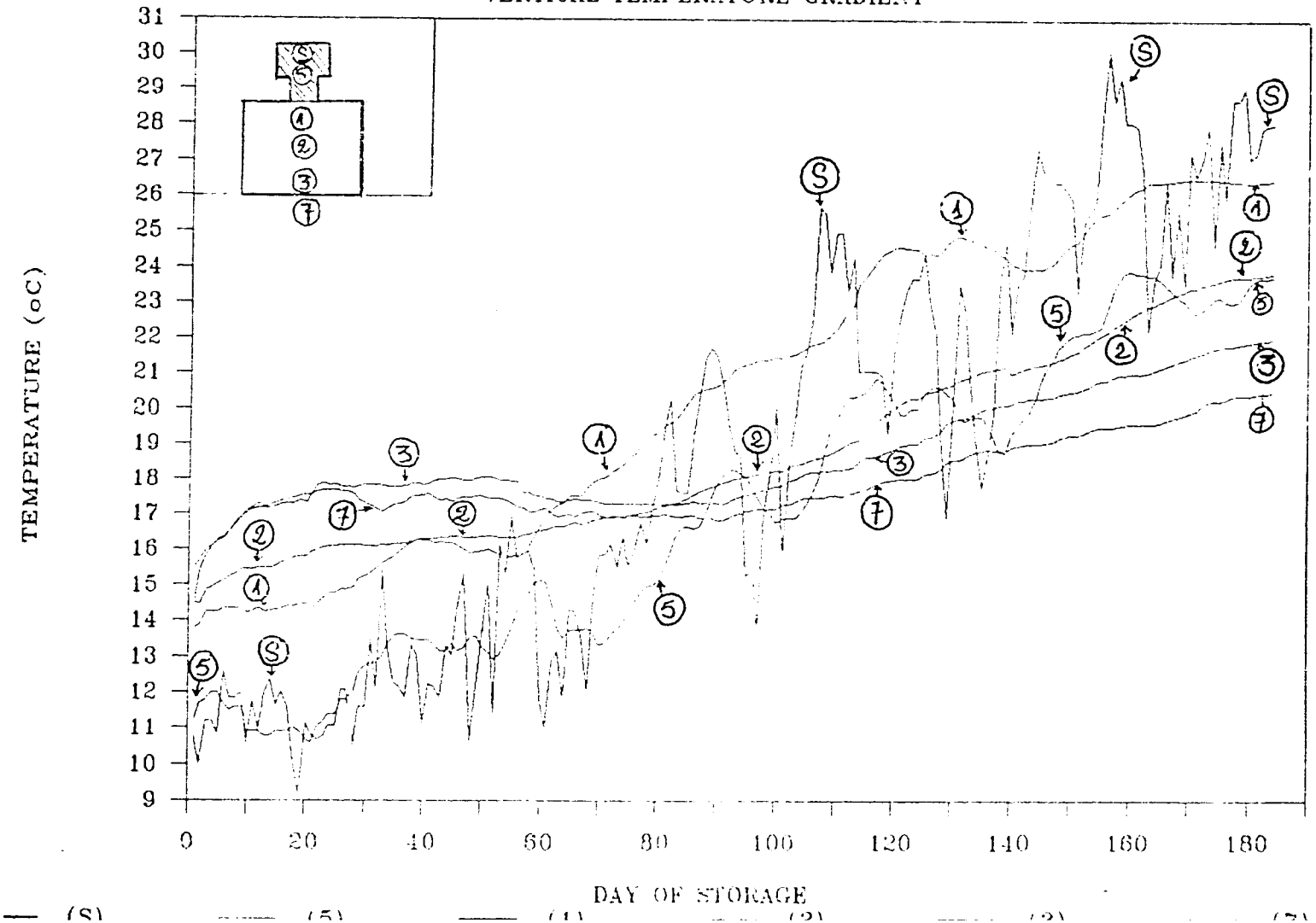


Fig 9. *PLASTIC LINED PIT*

VERTICAL TEMPERATURE GRADIENT

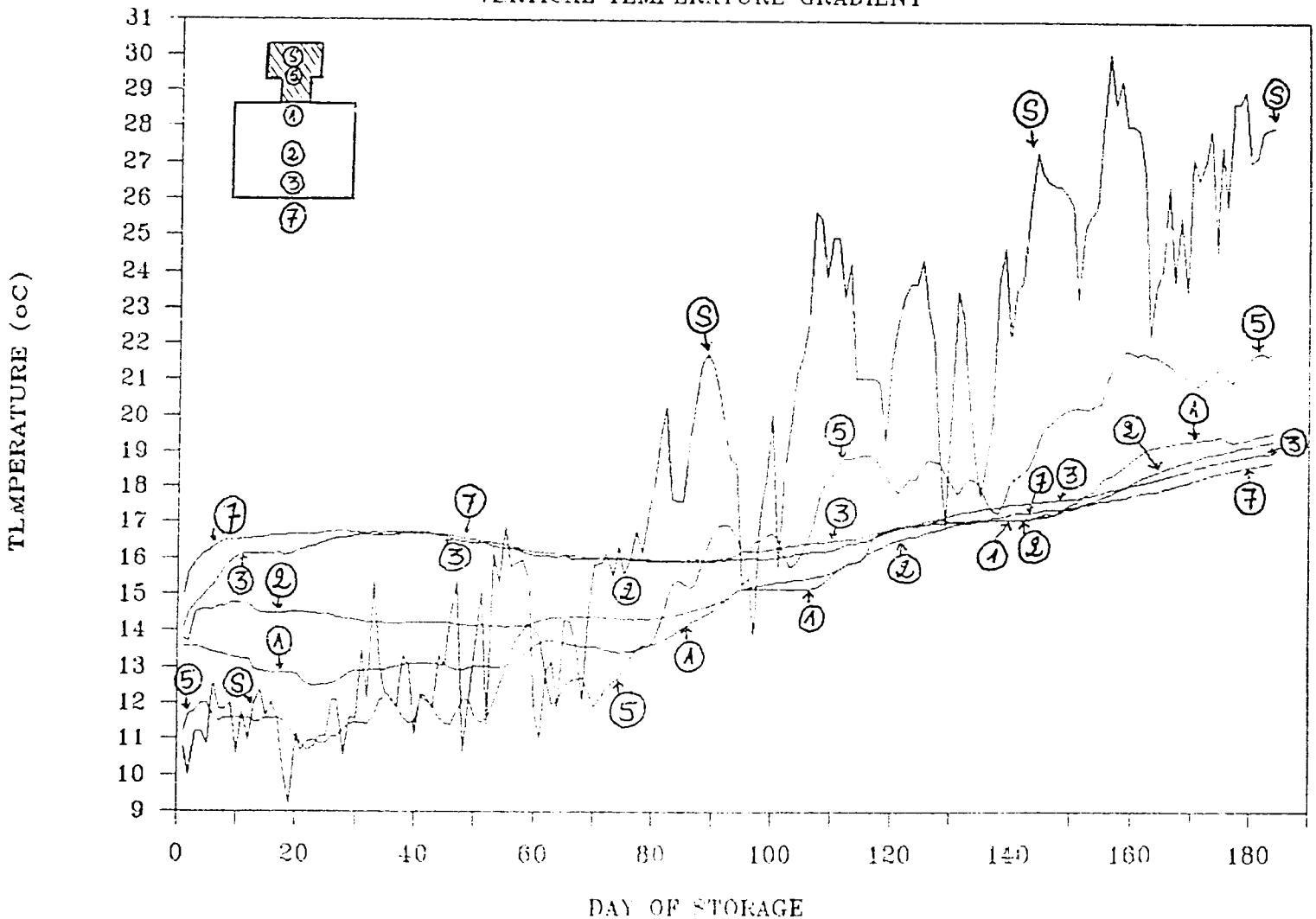


Fig 10.

STRAW LINED PIT

HORIZONTAL TEMPERATURE GRADIENT

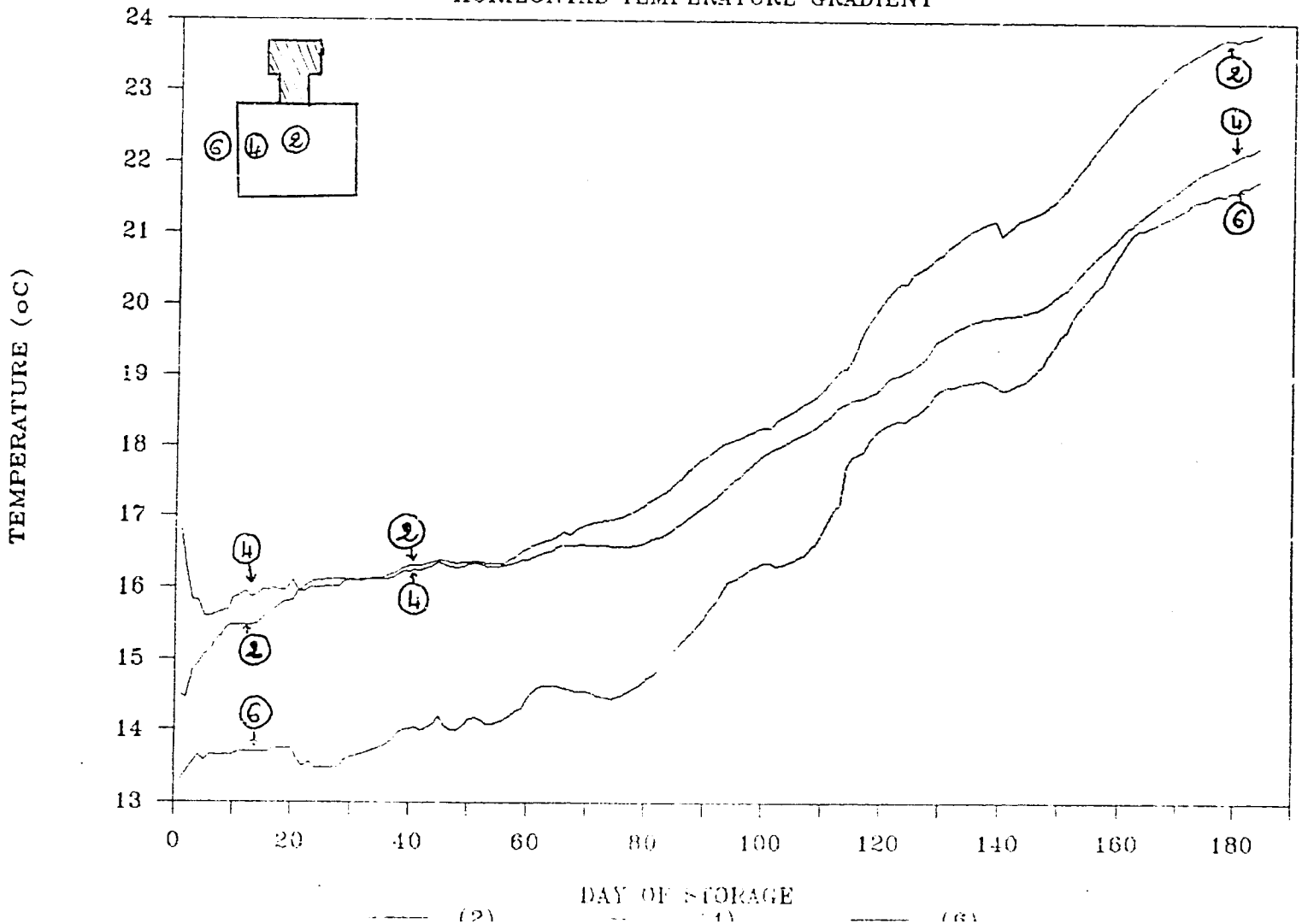


Fig 11. *PLASTIC LINED PIT*

HORIZONTAL TEMPERATURE GRADIENT

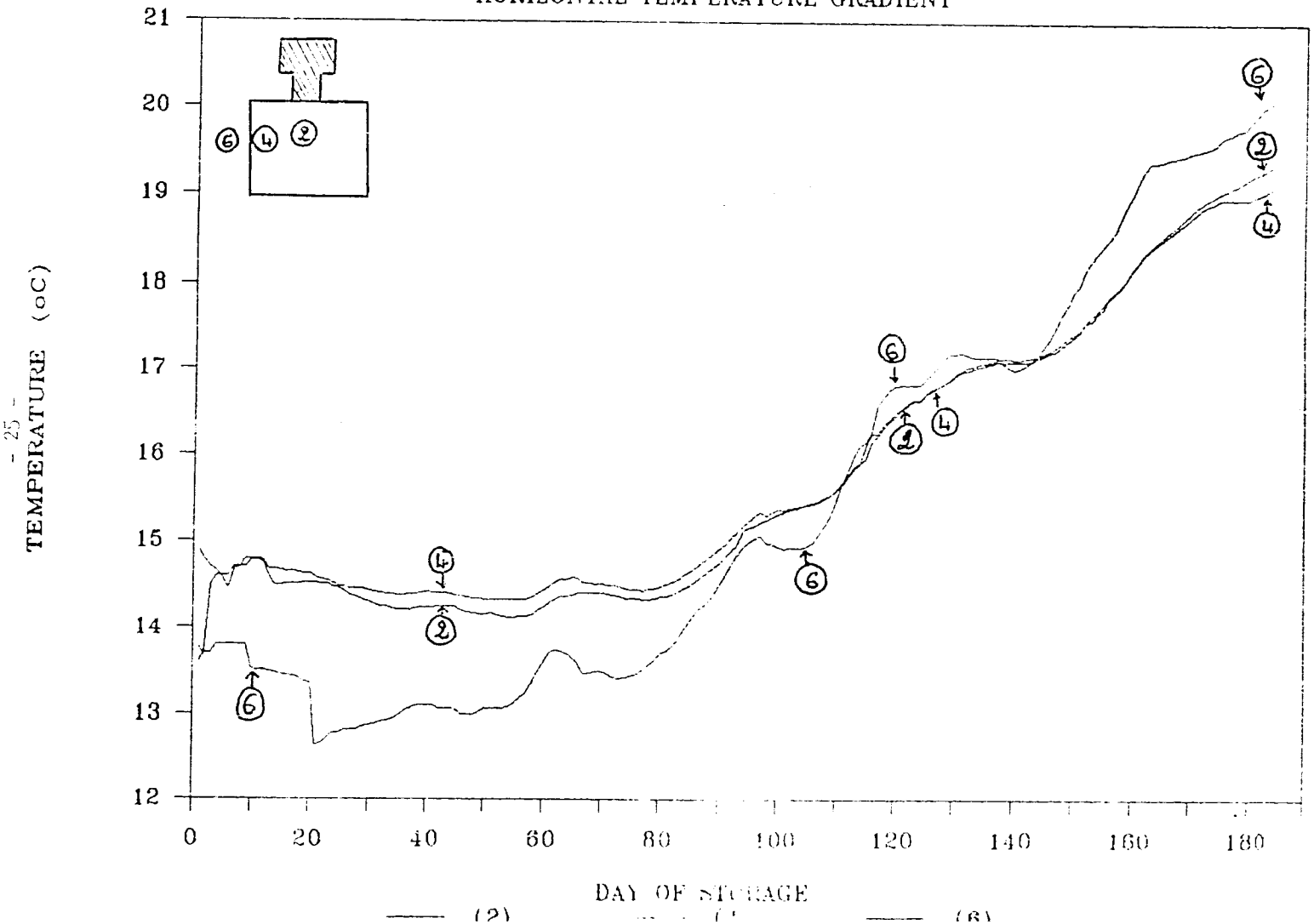


Figure 5 shows sharp variations of relative humidity until a stabilisation is reached around the second month of storage. The sensor utilised is very sensitive to presence of water at its vicinity. At the center of straw pit, relative humidity reaches 76 %.

A.3. Carbone dioxide

Measurement of carbone dioxide levels were regularly taken from both plastic and straw pits. The results are indicated in figures 12 and 13. The figures show that the concentration of CO_2 is higher in straw pit compared to plastic pits. CO_2 concentrations in straw pits reached about 10 % at center. The corresponding values in plastic pits are only 7 %. This confirms the presence of a higher metabolic activity in straw pits.

B. Unit weight and moisture content of grain

Initial values of moisture content and unit weight of grain were compared to the values obtained after 3 months of storage. The results are summarised in tables 2 and 3. The details of the calculations for both straw and plastic pits are respectively shown in tables 4 and 5. For plastic pits, the unit weight of grain has slightly decreased and the moisture content slightly increased. In the straw pits, the moisture content has increased significantly in the first

Fig 12.

STRAW LINED PIT

VARIATION OF CO2 LEVELS

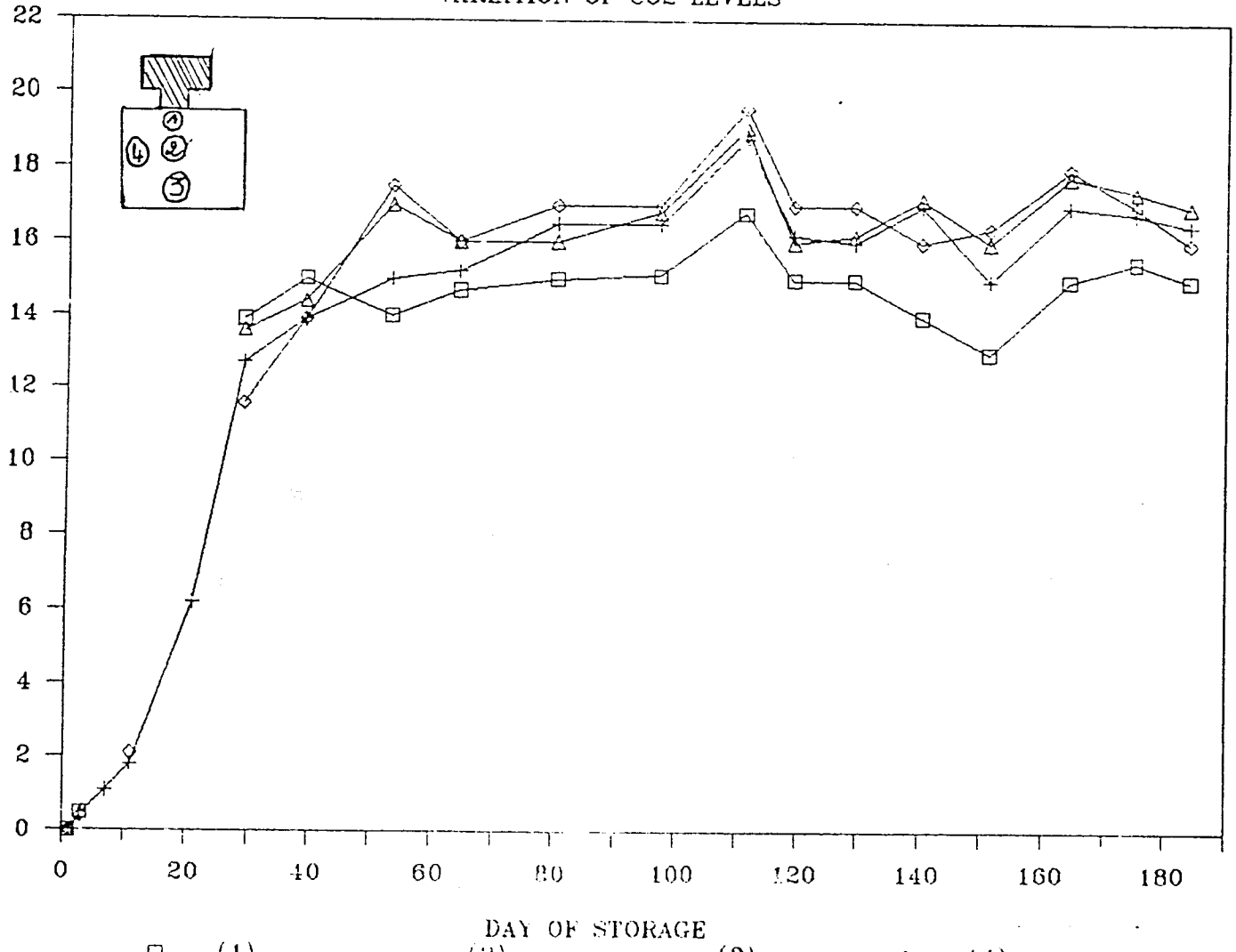


Fig 13. *PLASTIC LINED PIT*

VARIATION OF CO2 LEVELS

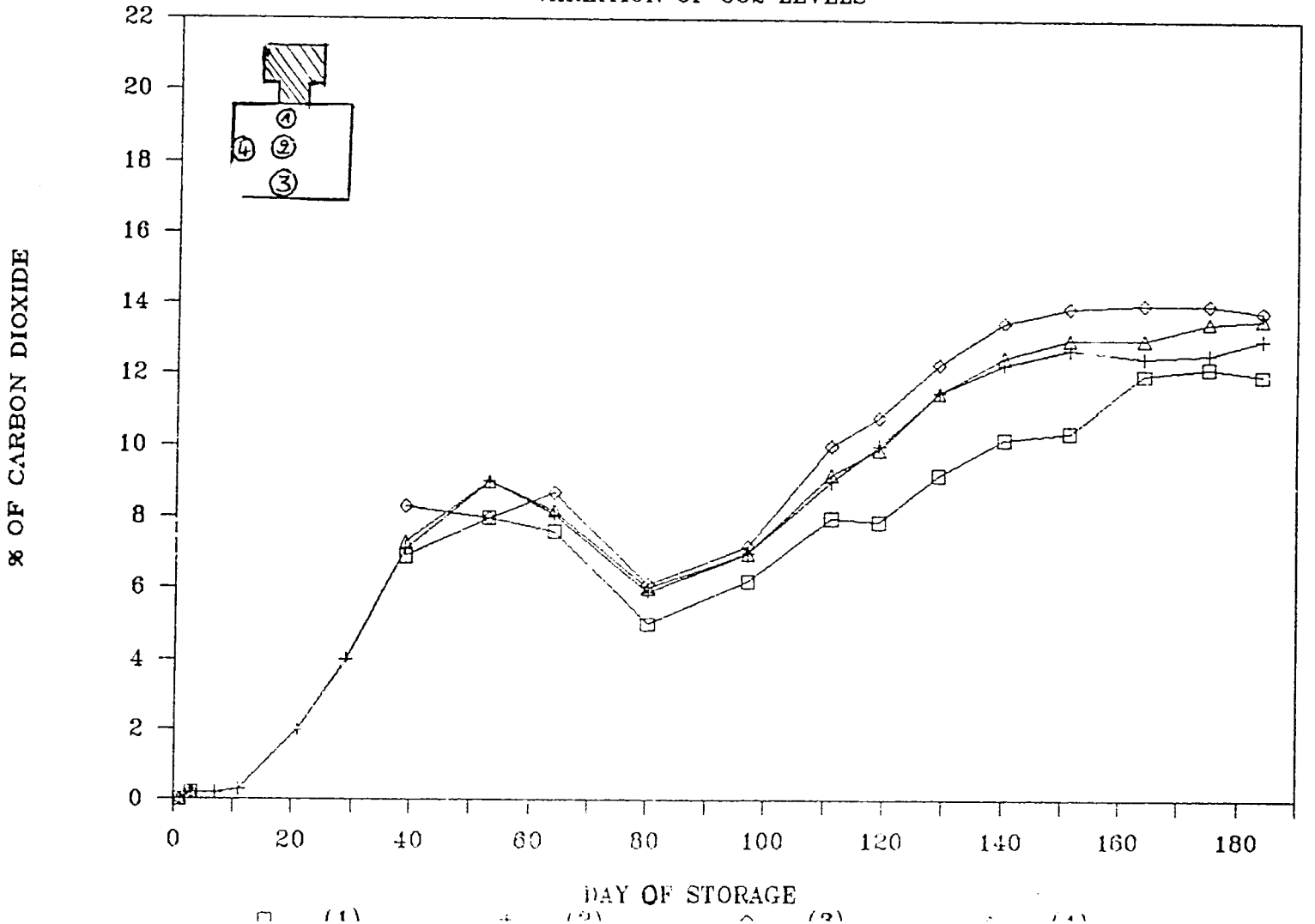


Table 2. Unit weight evaluation

Type of lining	Initial unit weight (g/l)	Average unit weight after 3 months (g/l)
Plastic	775.52	770.5
Straw	775.52	683.33

Table 3. Moisture content evaluation

Type of lining	Initial moisture content %	Average moisture content after 3 months of storage
Plastic	11.76	12.045
Straw	11.76	18.26

Table 4. Unit Weight and Moisture Content of Grain

Straw Pit, 3 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 (%)
PS	PS (DZ 1)	620	19,07	672	8,5	678,81	18,30
	PS 1	700	16,40	732	7,8		
	PS 2	708	16,10	751	13,2		
	PS 3	681	18,30	745	43,3		
	PS 4	695	17,19	736	20,9		
	PS (DZ 2)	602	27,91	654	6,3		
	Mean	667,66	19.16	715,00			
	St.Dev.	45,12	4.43	41,22			
OS	OS (DZ 1)	417	31,51	584	8,5	687,85	18,22
	OS 1	718	15,92	744	7,8		
	OS 2	692	15,48	749	13,2		
	OS 3	743	15,63	761	43,3		
	OS 4	700	15,81	753	20,9		
	OS (DZ 2)	588	34,69	666	6,3		
	Mean	643,00	21,51	709,50			
	St.Dev.	122,7	9,04	70,62			
					Mean	683,33	18,26
					St.Dev.	6,39	0,056

Table 5. Unit Weight and Moisture Content of Grain

Plastic Pit, 3 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
EP	EP (Top)	755	12,38	786	0,94	770	12,13
	EP 1	766	12,30	783	10,88		
	EP 2	770	12,17	788	12,09		
	EP 3	772	12,07	785	53,2		
	EP 4	768	12,16	786	22,89		
	Mean	766,20	12,216	785,60			
	St.Dev.	6,65	0,123	1,82			
KP	KP (Top)	764	12,30	788	0,94	771	11,96
	KP 1	766	12,27	779	10,88		
	KP 2	770	12,16	782	12,09		
	KP 3	772	11,78	784	53,20		
	KP 4	772	12,12	786	22,89		
	Mean	768,80	12,126	783,8			
	St.Dev.	3,63	0,2073	3,493			
					Mean	770,5	12,045
					St.Dev.	0,707	0,12

three months of storage. This has probably been caused by infiltration of water into the pits. During this period figure 4 shows that a relatively high amount of rain has fallen in Settat.

C. Waste and damage evaluation

At the opening of pits, it was noticed that wheat stored in plasic pits showed almost no traces of visible damage, except for the plastic pit KP where rain water has leaked along the plastic pipes protecting the wires used for data measurement. This leakage was accidental and was avoided since. On the contrary, on wheat coming from straw lined pits, there existed two zones of damage. One zone comprises the top layer of the grain mass in the matmora, 8 cm thick and a strip along the edges of the pit. This strip presents an average width of 3 cm at the upper level and 1 cm at the bottom level. Wheat belonging to this zone presented a yellow-grey color and a rot smelling. Cakes of wheat were noticed. The other zone of damaged grain is located at the bottom of the pit and has an average thickness of 4 cm. Wheat from this zone is yellow-grey, very wet and roted.

For the laboratory analysis, samples of 5 kg each were taken at different levels of the opened pits. These levels correspond to the positions of temperature sensors 1 to 4 and to the upper level of pit. In addition, samples were taken from the very bottom of grain in straw lined pits. Figures

Table 6. Percentage waste evaluation

Type of lining	Initial percentage of waste	percentage of waste after 3 months
plastic	3.514	3.296
straw	3.514	2.974

Table 7. Percentage damage evaluation

Type of lining	Initial percentage of damage	Percentage of damage after 3 months
Plastic	7.758	7.130
straw	7.758	20.61

Table 8. Damage Evaluation (%)
Straw Pit, 3 months of Storage

Pit	Sample	Degenerated kernels %	Insect attacked kernels %	Shrunken kernels %	Broken kernels %	Germinated kernels %	Kernels with visible mold	Other damage on kernels	Total of damaged kernels %	Volume of Zone in %	% Damage
[illegible]	PS [illegible] DI 1	–	–	–	–	–	100	–	100	8,5	20,10
	PS 1	3,5	0,5	0,9	0,2	0	1,9	2,1	8,6	7,8	
	[illegible] 2	3,6	0,4	0,7	0,3	0	0,2	2,4	7,6	13,2	
	[illegible] 3	2,0	0,5	0,8	0,6	0	0,3	0,6	4,8	43,3	
	[illegible] 4	1,7	0,3	2,5	0,1	0	0,6	2,5	7,4	20,9	
	[illegible] DI 2	–	–	–	–	–	100	–	100	6,3	
	Mean	2,7	0,425	1,225	0,3	0	33,83	1,9	38,06		
	St.Dev.	0,99	0,096	0,8	0,216	0	51,25	0,883	47,99		
[illegible]	PS [illegible] DI 1	–	–	–	–	–	100	–	100	8,5	21,12
	PS 1	3,3	0,6	0,9	0,2	0	0,5	2,2	7,9	7,8	
	[illegible] 2	2,9	0,7	0,6	0,2	0	0,4	1,7	6,5	13,2	
	[illegible] 3	3,5	0,3	1,3	0,6	0	0,3	1,9	7,9	43,3	
	[illegible] 4	3,1	1,1	0,9	0,6	0	1,2	1,0	6,8	20,9	
	[illegible] DI 2	–	–	–	–	–	100	–	100	6,3	
	Mean	3,2	0,725	0,925	0,4	0	35,73	1,7	38,18		
	St.Dev.	0,258	0,33	0,287	0,231	0	51,33	0,51	47,88		
										Mean	20,61
										St.Dev.	0,72

Table 9. Damage Evaluation (%)
Plastic Pit, 3 months of Storage

Pit	Sample	decolorated kernels %	Insect attacked kernels %	Shrunken kernels %	broken kernels %	germinated kernels %	kernels with visible mold %	other damage on kernels %	Total of damaged kernels %	Volume of Zone in %	% Damag
EP	EP(Top)	3,7	1,5	0,8	0,2	0	0	1,4	7,6	0,94	7,38
	EP 1	3,00	0,5	1,5	0,3	0	0	0,5	5,3	10,88	
	EP 2	3,4	0,7	1,6	0,4	0	0	1,3	7,4	12,09	
	EP 3	4,1	0,75	0,6	0,45	0	0	1,5	7,4	53,20	
	EP 4	2,7	0,9	2,6	0,5	0	0	1,6	8,3	22,89	
	Mean	3,38	0,87	1,42	0,37	0	0	1,26	7,2		
	St.Dev.	0,554	0,38	0,79	0,12	0	0	0,44	1,125		
EI	EI (Top)	2,4	0,5	1,0	0,4	0	0,3	1,4	6,0	0,94	6,88
	EI 1	2,9	0,9	1,3	0,3	0	0	1,1	6,5	10,88	
	EI 2	2,8	0,8	0,8	0,3	0	0	1,2	5,9	12,09	
	EI 3	3,0	0,4	2,2	0,6	0	0	1,6	7,4	53,20	
	EI 4	1,8	0,4	2,4	0,1	0	0	1,7	6,4	22,89	
	Mean	2,58	0,6	1,54	0,34	0	0,06	1,4	6,44		
	St.Dev.	0,49	0,234	0,719	0,18	0	0,134	0,255	0,594		
										Mean	7,13
										St.Dev.	0,35

19 an 20 indicate the different regions of sampling. A comparison of initial percentages of waste and damage on wheat before storage and after 3 months of storage was made and is presented in tables 6 and 7. The details of evaluation of damage, waste material, odor and color changes are indicated in tables 8 to 11.

D. Second Opening of pits

After a period of six months of storage, 4 pits: BS, CP, HP and NS were opened on June 30. A large number of farmers, reseachers, extension specialists and representatives from the Ministry of Agriculture as well as Dr R. Sterling, Director of the Underground Space Center at the University of Minnesota and coinvestigator in the project attended this succesfull opening.
Activities related to the second opening of pits will be included in the third progress report.

2.1.3.2. Plant Pathology

Dr. B. EZZAHIRI

A- Preliminary tests of barley for storage fungi

In the preliminary experiment on underground grain storge on I.A.V campus, barley stored in two types of pits

Table 10. Percentage of waste, odor and Color Evaluation.

Straw Pit, 3 months of Storage

Pit	Sample	Percentage of waste	Volume of Zone in %	Percentage of Waste in Pit %	Odor	Color
PS	PS (DZ 1)	2,25	8,5	2,834	Odor of mold	Yellow with grey spot
	PS 1	3,12	7,8		Slight mold odor	darker than normal
	PS 2	2,82	13,2		〃	〃
	PS 3	2,92	43,3		〃	〃
	PS 4	2,87	20,9		〃	〃
	PS (DZ 2)	2,59	6,3		Strong mold odor	Yellow
	Mean	2,762				
	St. Dev.	0,303				
OS	OS (DZ 1)	4,03	8,5	3,113	Odor of mold	Yellow with grey spots
	OS 1	3,25	7,8		Slight mold odor	darker than normal
	OS 2	3,28	13,2		〃	〃
	OS 3	3,02	43,3		〃	〃
	OS 4	2,75	20,9		〃	〃
	OS (DZ 2)	3,2	6,3		Strong mold odor	Yellow
	Mean	3,255				
	St. Dev.	0,427				
			[illegible]	2,974		
			[illegible]	0,197		

〃 Same

Table 11. Percentage of waste, odor and color Evaluation.

Plastic Pit, 3 months of Storage

Pit	Sample	Percentage of waste	Volume of Zone in %	Percentage of Waste in Pit %	Odor	Color
EP.	EP(Top) EP 1 EP 2 EP 3 EP 4	2,81 2.64 2.53 3,5 3.08	0,94 10,80 12,09 53,2 22,89	3,186	// // normal // //	// // normal // //
	Mean St. Dev.	2.912 0.388				
KP	KP(Top) KP 1 KP 2 KP 3 KP 4	3,41 4.35 4.24 3.16 3.09	0,94 10,88 12,09 53,2 22.89	3,406	// // normal // //	// // normal // //
	Mean St. Dev.	3.65 0.602				
			Mean St. Dev.	3,296 0.155		

// Same

with straw and plastic lining for 6 months was evaluated for storage fungi.

Table 12 Average % of surface desinfected barley kernels from which storage fungi grow on Malt-salt-agar

FUNGI	AVERAGE % (*)	
	Plastic lined pit	Straw lined pit
Aspergillus candidus	10,75	35.50
A. clavatus	06.25	19.50
A. flavus	03.87	23.00
A. glaucus	03.50	19.25
A. versicolor	13.25	31.25
A. niger	01.25	00.00
A. ochraceus	01.62	00.00
A. terreus	02.00	28.00
Penicillium sp.	00.12	01.00

* Average of 4 samples, 50 kernels per sample

After 6 months of storage, most species of Aspergillus were more frequent on barley kernels from straw lined than plastic lined pits, while qualitatively very small difference was detected between the two types of pits. The low frequency of occurence suggests the improved conditions of storage in plastic lined pits as reported in the previous progress report.

B- Tests for fungi in durum wheat kernels before and after 3 months of storage in two types of pits.

Wheat samples from straw and plastic lined pits were tested first for germination before and after 3 months of storage. The germination test was conducted on filter paper in petri dishes at 23 C.

Table 13 Percentage germination of durum wheat kernels after 3 months of storage in two types of pits

Sampling location	% Germination *	
	Plastic lined pit	Straw lined pit
Top of pit or DZ1	87	20
15 cm from top (1)	81	42
Center (2)	79	52
Bottom (3)	81	49
Near the edge (4)	76	48

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

97 % of kernels germinated before storage. Significant reduction in germination was obtained for kernels from straw lined pits, while a relatively high germination capacity was maintained for the wheat stored in plastic lined pits.

C- Tests for fungi

Three subsamples of 50 kernels each were taken from each sample. Kernels were shaken for 90 sec in 10 % NaClO and placed in petri dishes containing malt agar containing 8%

NaCl and 200 ppm Tergitol NPX. After incubation at 27 C for 8 to 10 days, fungi growing from the kernels were identified and counted with the aid of a dissecting microscope.

Table 14 Average % of surface desinfected durum wheat kernels from which various fungi grow, before and after 3 months of storage in plastic lined pits (PLP) and straw lined pits (SLP)

Fungi	% infection		
	Before storage	3 months of storage	
		PLP	SLP
Field fungi :			
Alternaria tenuissima	83.87	11.18	01.52
Fusarium sp.	01.50	06.46	01.46
Fusarium roseum	00.00	03.12	00.58
Helminthosporium sp.	00.00	00.06	00.00
Intermidiate fungi :			
Cladosporium sp.	03.50	04.18	01.44
Stemphylium botryosum	02.18	00.06	00.00
Scopulariopsis sp.	00.00	01.32	00.52
Syncephalastrum sp.	00.00	00.00	00.20
Trichothecium roseum	00.00	00.00	00.20
Rhizopus sp.	00.06	00.26	00.00
Storage fungi :			
Aspergillus glaucus	01.25	01.06	31.44
A. candidus	00.37	00.64	27.18
A. flavus	00.31	00.86	23.78
A. versicolor	00.06	01.58	20.98
A. ustus	00.00	00.00	15.12
A. fumigatus	00.18	01.26	11.32
A. terreus	00.00	00.00	10.84
A. clavatus	00.50	02.40	09.78
A. cremeus	00.00	00.00	09.38
A. restrictus	00.00	00.00	03.26
A. ochraceus	00.37	00.38	03.12
A. nlger	00.50	01.92	00.84
A. sp	00.00	00.00	12 58
Penicillium chrysogeneum	00.00	01.72	18.32
P. cyclopium	00.00	00.00	16.72
P. frequentens	00.00	02.38	07.12
P. sp	01.25	01.78	10.24

After 3 months of storage, the two types of pits differ significantly in the kind and the amount of storage fungi. The species Penicillium cyclopium, Aspergillus ustus, A. terreus, A. cremeus, and A. restrictus were only found on kernels stored in straw lined pits. A relatively high frequency of occurence of storage fungi was also found in kernels from the straw pits. The species A. glaucus, A. candidus, A. flavus, A. versicolor, and Penicillium chrysogenum occured at a frequency ranging from 18 to 31 %. Storage fungi occured at low frequencies in plastic lined pits, less than 3 %. Therefore, this represents a significant improvement in storage conditions.

Data on non-desinfected kernels and incubated in the same manner as previously described will be presented in the next progress report. Also, we are in the process of analyzing the effect of sampling position from the pit on the frequency of occurence of storage fungi. This will be presented in the next report in relation to temperature and moisture.

2.1.3.3. Plant Breeding

Mr Z. EL FATEMI

A- Germination test

The germination test was run again in the laboratory of the D.P.V.C.T.R.F. (Direction de la Production des Végétaux, Controle Technique et Repression des Fraudes). Thanks are expressed to Mr. TOURKMANI for his help. This test was run as it was described in the first progress report.

The result are summurised in table 15 :

Table 15 Summary of the germination results

Sample location	Mean	Standard Deviation
	Straw pit	
1	51.68	24.32
2	79.62	4.87
3	39,96	33.28
4	41.88	17.55
DZ1	0	0
DZ2	0	0
	Plastic pit	
1	92.62	4.55
2	95.62	1.80
3	95.75	2.54
4	84.62	14.55

In order to asses if there is any effect of lining or site on germination and to detect if there is an interaction

of lining and site, an analysis of variance was run. The model used is a split-plot with lining as the whole plots treatment and site as the sub-plots treatment. The analysis of variance is summurised in table 16.

Table 16 Analysis of variance table for germination

Source	DF	SS	MS	F
Lining	1	24175	24175	63.598
Replication	7	7505.1	1072.2	
Error 1	7	2660.8	380.12	
Site	3	5373	1791	10.514
Lining*site	3	3314.2	1104.7	6.485
Error 2	40	6813.8	170.35	
Total	61	49842		
Grand average	1	338450		

The analysis of variance shows that the effects of lining and of site are highly significant and so is the interaction of both factors.

Table 15 shows that germination of seeds from straw lining matmoras is lesser than those from plastic lining matmoras. The germination of seed from real top (DZ1) and real bottom (DZ2) of straw lining matmoras was nul. The seeds from the outer parts of the straw lining matmoras (top, bottom and sides) have the lowest germination (less than 52 %). Those from the center of the straw lining matmoras have about equal germination than those from the side of the plastic lining matmoras (79.6 % and 84.6 % respectively). The germination of the seed from the top of the plastic lining matmoras is just a little lesser than the germination of the

original seed (92.6 % and 95.7 % respectively). While the two remaining locations (center and bottom) didn't show any decrease of germination.

B- Early vigor test :

The early vigor was assessed by measuring seedling dry weight in a growth chamber (at 24 to 25 C) at 21 days after planting. Seedlings were cut, dried at 80 C for 30 hours, and weighed. For this test, it is considered that better quality seed is supposed to produce heavier seedlings. The seedling dry weight, from seeds before storage, is summurised in table 17. Each sample was run into two replications. These results show that the seed used for the underground storage is uniform concerning early vigor. The results for the seed at the first openning are summurised in table 18.

Table 17 : Seedling dry weight from seed before storage

Sample number	Seedling dry weight
	(mg)
1	500
2	480
3	450
4	550
5	580
6	550
7	600
8	490
9	500
10	480
11	570
12	590
13	590
14	570
15	580
16	600
	X = 542.5

Table 18 : Seedling dry weight after 3 moths of storage

Lining	Site	Mean (mg)	Standard deviation
1	1	20	4,08
1	2	150	18,26
1	3	78.75	8,54
1	4	71.25	8,54
1	real top	0	0
	real bottom	0	0
2	1	460	82.06
2	2	520	62.72
2	3	327.5	34.03
2	4	392.5	43.49

The analysis of variance for seedling dry weight (table 19) shows that the effects of lining and site are highly

significiant. The interaction of both factors is also highly significant.

Table 19 : Analysis of variance table for seedling dry weight

Source	DF	SS	MS	F
Lining	1	952200	952200	574.90
Replication	3	5593.8	1864.6	
Error 1	3	4968.8	1656.3	
Site	3	78606	26202	14.70
Lining*site	3	38956	12985	7.29
Error 2	18	32075	1781.9	
Total	31	1112400		
Grand Average	1	2040200		

Table 18 shows that the seed from the straw lining matmoras was less vigorous than the one from the other matmoras.

The seed from the plastic lining matmoras have different seed vigor according to the different sites. That is to say the ones from the bottom and the sides of the matmora were less vigorous than the ones from the center and in a lesser degree, from the topo-the vigor of the seed from the center of the plastic lining matmora wasn't affected by the storage since it is about equal to the original seeds'vigor.

C- Conclusion :

The plastic lining seems, so far to protect, the best, the seed germination quality and also the seed vigor.

2.1.3.4. Entomology

Mrs. K. BOURARACH

Before the grain was stored, samples were taken to assess insect damage on wheat kernels (refer to first report). After incubation at 27 C we noticed that many insect pests were present (table 20).

When matmoras were opened for the first tim : five samples of different locations were taken from each matmora. The seiving of the samples was carried at the Departement of Ag. Engineering. With the exception of some dead insects, all four matmoras were insect free (table 20). The same table shows that matmoras lined with straw were more damaged by insect pest than matmoras lined with plastic. There was also more visible decay. All these sifted samples were then incubated at 27 C for 5 weeks. Table 21 presents the sanitary state of these samples after incubation.

1. All samples were heavily infested by acarians

2. The number of acarians were in some cases extremely high, the abundance of acarians was presented by: (+) very few, (++) few, (+++) many and (++++) very high number of acarians. re these acarians pests or not ? We are identifying them.

3. It was noticed that all variables were higher for

matmoras lined with straw than matmoras lined with plastic. These diferences found after only three months of storage can already favor the plastic method of lining over the straw mehtod.

In conclusion, unlike before storage, insects were absent after storage, this may be due to environmental conditions inside the matmoras.

Table 20 : Samples of wheat before storage examined after one month and a week of incubation

Sample number	Presence of insects			Number of kernels presenting holes and black spots
	Coleopteras	Lepidopteras	Others	
1	Rhizopertha dominica (1)	-	-	40
4	Sitophilus granarius(1)	-	-	49
13	Rhizopertha dominica(1)	Indeterminés (2)	- -	36
5	Rhizopetha. dominica(1)	-	-	127
16	Rhizopertha dominica(2)	-	-	31
			m =	56.6
			SD=	35.69

( ) : number of insects

Table 21 : Damages and depredators at the first control before incubation

Samples	DAMMAGE IN %						INSECTS		
	Kernels with hole	Decolorated black spots	Shrunken	Broken	Visible mold	Other damage	Species	Live	Dead
EP/TOP	1,5	3,7	0.8	0.2	-	1.4	-	-	-
EP1	0.5	3.0	1.5	0.3	-	0.5	-	-	-
EP2	0.7	3.4	1.6	0.4	-	1.3	-	-	-
EP3	0.75	4.1	0.6	0.45	-	1.5	-	-	-
EP4	0.9	2.7	2.6	0.50	-	1.6	-	-	-
KP/TOP	0.5	2.4	1.0	0.4	0.3	1.4			
KP1	0.9	2.9	1.3	0.3	-	1.1			
KP2	0.8	2.8	0.8	0.3	-	1.2			
KP3	0.4	3.0	2.2	0.6	-	1.6			
KP4	0.4	1.8	2.4	0.1	-	1.7	Larva buterfly	-	1
m	0.78	2.98	1.48	0.35	0.03	1.33			
SD	0.15	0.62	0.68	0.14	0.09	0.33			
PS/DZ1	-	-	-	-	100	-	Ant	-	1
PS1	0.5	3.5	0.9	0.2	1.9	2.1			
PS2	0.4	3.6	0.7	0.3	0.2	2.4			
PS3	0.5	2.0	0.8	0.6	0.3	0.6			
PS4	0.3	1.7	2.5	0.1	0.6	2.5			
PS/DZ2	-	-	-	-	100	-			
OS/DZ1	-	-	-	-	100	-			
OS1	0.8	3.3	0.9	0.2	0.5	2.2			
OS2	0.7	2.9	0.6	0.2	0.4	1.7			
OS3	0.3	3.5	1.3	0.6	0.3	1.9			
OS4	1.1	3.1	0.9	0.6	1.2	1.0			
OS/DZ2	-	-	-	-	100	-			
m	0.57	1.92	0.72	0.23	33.78	1.2			
SD	0.27	1.46	0.69	0.23	48.91	0.99			

Table 22 : Results after incubation

Samples	Kernels with holes	Decol.	Shrunken	Broken	Visible mold	Other damages	lack cot	Species	Dead	Acariens
KP1	44	242	29	30	-	70	-	-	-	450 ++
KP2	15	210	77	41	-	16	-	-	-	500 ++
KP3	8	534	188	39	-	8	-	-	-	153 ++
KP4	56	171	31	55	-	144	-	-	-	600 ++
EP1	Sample non examined									
EP2	-	113	22	18	-	27	-	-	-	1000+++
EP3	30	272	141	31	-	64	-	-	-	1000+++
EP4	39	156	68	48	23	84	-	-	-	88 +
m	27.43	242 57	79.43	37.43	3.28	59	-	-	-	541.57
SD	18.96	128.88	58.43	11.40	8.05	43.87	-	-	-	336.1
OS/DZ1	169	338	67	26	-	46	142	-	-	2000++++
OS1	61	283	147	48	46	166	-	-	-	2000++++
OS2	44	304	98	37	112	81	-	-	-	1000+++
OS3	15	301	152	41	17	161	-	-	-	2000++++
OS4	27	299	46	20	163	26	-	-	-	2000++++
OS/DZ2	48	41	84	19	367	-	-	-	-	2000++++
PS/DZ1	Sample very infested with molds non examined									
PS1	104	181	98	40	86	47 Psocoptere (Psoque)			1	500++
PS2	112	180	125	51	8	34	-	-	-	300++
PS3	20	49	87	35	65	64	-	-	-	200++
PS4	47	163	79	35	65	64	-	-	-	190++
PS/DZ2	Sample very infested with molds non examined									
m	64.7	213.9	98.3	35.2	92.9	68.9	14.2	-	-	1219
SD	46.45	102.48	32.23	10.25	102.86	51.88	42.6	-	-	809.72

Note: no live insects were found.

m: mean; SD: Standard Deviation

2.1.3.5 Food Chemistry and Biochemistry

Dr B. BEN JILALI

A- Precisions on the methodology

1. Humidity : The humidity is expressed in % of dryed materiel. It was determined by dessication of grain at 103 C during 72 H (AACC 44-15A).

2 - Relative humidity : The relative humidity was determined on the whole grain by a ROTRONIC HYGROSKOP.

3 - Fat acidity: The free fat acidity was determined on the whole flour using the AACC method No 02-02A.

4 - Peroxyde value of lipidic fraction: The lipids were extracted on a soxhlet apparatus with pet. ether 40-60 C. The peroxyde value was determined following the AOCS official method CD 8-53 (1960 reapproved 1973).

B- Determinations not done

1 - Vitamin B1 evaluation

We suggested to follow the thianine evolution during storage. We have tryed to use the fluoremetric method as described by the AOAC (thiochronic method). This method

supposes excitation at λ_{ex} =360nm and emission at 435 nm.

At the IAV Hassan II we have a fluorimeter in a neighboring department: Turner model 112 with fixed wavelength bands (filters system). The best available filters for us are :

- for excitation : 110-811 (λ = 320-390 nm)
- for emission : (110-81[illegible], 2 A (λ > 415nm)

So, the bands given by these filters are too large and interferences of other substances during thianine quantification of samples are too important. After several trials we were obliged to conclude to the poor validity of results.

To solve this problem, 2 solutions are to be considered:

- The best one is to have one spectrofluorimeter with a monochromator.
- Or, if not, to have filters with fixed wavelengths: one at 360 nm and the other at 435 nm. for the available spectrophotometer.

2 - Aminoacid evolution with a special reference to lysine

This determination can be done with the aminoacid autoanalyse available in our department. Unfortunately we are short of one chemical: the thiodiglycol. We coundn't find this product in local market. Waiting for this product, the samples were in the meantime hydrolysed and stored for later analyses.

C. Some comments on the results

The results given in table 23 are worth some comments :

1. Moistures

The samples provided from plastic matmora have moistures ranging from 12.30 to 19.78 % with an average of 12.09 %. The samples provided from straw/matmora showed moistures comprised between 15.48 % and 18.3 % with an average of 16.27%. We conclud from these result that plastic protects the cereals in storage from an exces moisture.
On the other hand, the moisture in cereals from straw matmora increases at sides and surface of matmora. In the former matmora type, the moisture was roughly constant. It can be infered that excess of moisture in the straw matmora is due to water infiltration and plastic apparently is a good

protector against water infiltration.

2. Relative humidities

The relativ humidities of samples from plastic matmora were about 66 %. This level of relative humidity would not permit bacterial, yeast and mold proliferation, and, slows considerably the extent of enzymatic reactions.
On the opposite, in the samples from straw matmora, the relative humidity values were between 76 and 83 %. In these conditions all deterioration phenomena are possible, especially fungi development and enzymatic activity. This was indeed confirmed by visual observation. Organoleptic evaluation of samples showed that wheat from straw matmora had relatively strong aroma.

3. Free fat acidity

Regarding free fat acidity, wheat samples from straw matmora rather developed, in the average, high free acidity values than corresponding samples from plastic matmora, i.e. 114 mg KOH/100 g flour (PS1 sample),120 (PS4), 91 (PS3), 66 (PS2 and OS4) and 61 (OS1).The EP2 was the only sample from plastic/matmora that gave a comparable acidity : 77 mg KOH/100 flour.

It can be concluded that hydratation of stored wheat in the straw matmora induces an increased lipid hydrolysis. This might be attributed to 2 different causes :

- hydratation can help the activity of endogenous enzymes.
- hydratation facilitates fungi development especially lipolytic species.

Whatever the cause of this phenomena is, the increased flour free acidity, a such lipolisis will have great impact on thechnological and organoleptic properties of the final product: the flour.

4 - Peroxidevalues

With the increase of free fat acidity we could expect a speeding up of the oxidation phenomena. The free fatty acids are more oxidable than the triglycerides. However, the results of the peroxidevalues do not show significant differences. This may be due to moisture content of samples. The auto-oxidation is higher at low level of relative humidity (table 23).

5 - Wheat aroma

The samples from straw matmora showed a stronger aroma than

Table 23 Fat acidity and lipid peroxyde index.

Sample No	Moisture contenent	Relative humidity %	Fat Acidity mgKOH/100 flour	Lipid peroxyde index
EP1	12.30	67.2	31.8	11.9
EP2	12.17	66.9	76.8	10.8
EP3	12.07	66.1	38.2	9.5
EP4	12.16	66.9	29.4	5.2
KP1	12.27	68.4	40.9	2.9
KP2	12.16	66.6	45.2	3.6
KP3.1	11.78	66.7	39.9	8
KP3.2	11.78	65.6	40.8	8
KP4	12.12	66.9	40.7	6
PS1	16.40	83.1	114.2	3.1
PS2	16.10	81.5	66.3	8.5
PS3	18.30	87.8	91.1	9.3
PS4	17.19	85.6	119.8	6.4
OS1	15.92	80.4	60.7	6.5
OS2	15.48	79.1	46.9	9.2
OS3.1	15.63	76.0	41.7	3.4
OS3.2	15.63	74.8	43.6	3.4
OS4	15.81	83.7	66.5	9.8

those from plastic matmora. This may be due to :

- lipid oxidation, but we have seen that there were non significant differences between the 2 types of samples :
- lipid hydrolysis: it can explain, at least, part of the aroma increase in the straw matmora.
- non enzymatic-browning reaction: the optimum of this reaction is between 60 and 80% of relative humidity. This is the case of all samples, Therefore the cause of differences between straw matmoras and plastic matmora samples could be the amounts of reducing sugar and free aminoacids available in samples. We can assume that in the straw matmora we do not have lipid hydrolysis only (free fat acidity), but starch and protein hydrolysis also. So, we are planing for the next sampling to determine reducing sugar.

2.1.3.6. Food microbiology

Mr GOURAMA & Dr TANTAOUI

In this report, partial results relative to the study of samples taken on April 6 th 1988 will be presented.

A- Mycological Analysis :

On each sample, the following determinations have been made :

a - The percentage of seeds contaminated with molds. Direct technic was used, the grains were placed on Malt Agar medium in Petri dishes after disinfection with 50 % NaHCLO solution for 1 min and washing with sterile distilled water.

b - The number of mold spores per gram of wheat. Serial dilution in 0.9 % Nacl Solution containing 0.01 % Tween 80, and cultivation on Potato Dextrose Agar at 25 C for 4-5 days were utilised. The number of thalli were counted and reported to 1 gr of sample. Furthermore, from each sample, 5 to 10 thalli have been isolated, purified and stored on Czapeck Dox-Agar for further identificatication . The total number of molds isolated is 115. Table 24 summarizes the results observed.

B- Mycotoxin analysis

A multidetection method was chosen to detect three mycotoxins: Aflatoxin B1, Ochratoxin A and Zearalenone (see reference), chloroform extraction was made and the extracts frozen and stored for futher steps. These, i.e. thin layer chromatographic partitioning of the toxins and their confirmation, will be done as soon as the delivery of all the chemicals needed will be accomplished.

Table 24: Results of the mycological analysis of the samples after 3 months of storage

Désignation of sample	% of grain contaminated	Number of fungal spores/g	Number of molds isolated and stored
PS1	94	1.5.106	8
PS2	97	6.0.105	10
PS3	100	2.2.105	5
PS4	100	7.0.105	5
OS1	P	5.0.105	P
OS2	P	2.0.105	P
OS3a	88	3.5.104	7
OS3b	89	4.7.104	10
OS3c	86	3.1.104	7
OS4	P	3.0.104	P
EP1	88	n,d.	5
EP2	90	2.8.102	7
EP3	83	2.7.102	6
EP4	86	3.0.102	7
KP1	96	4.0.104	8
KP2	92	5.0.104	8
KP3a	94	1.2.102	
KP3b	88	2.0.102	17
KP3c	91	1.0.102	
KP4	96	5.0.104	5
		TOTAL	115

P : still in progress
n.d. non determined

C- Analysis of wheat kernels before storage

The results of this analysis are shown below:

Percentage of kernels contaminated by molds:	100%
Number of molds spores per gram of sample:	940 sp/gr
Number of stump (souches) isolated and conserved:	16

D- Reference

LE TUTOUR B., TANTAOUI-ELARAKI A. and BELHELBA A. 1983 Recherche de l'aflatoxine B1, de l'ochratoxine A et de la zearalenone dans les farines de blé - Actes - Inst. Agro. Vet. - 3, 65-69.

2.1.3.7 Food Science

DR. M. BAKHELLA

A- Introduction

1. Mixograph test

The mixograph is used to measure possible rheological changes in flours issued from stored wheat grains. This apparatus is widely used to measure the mixing properties of flours. It is a rapid test and requires small sample sizes. It registers a definite peak at the optimum mixing time and is sensitive to changes in mixing time. The important indices obtained from a mixogram are:

1- Peak time (mixing time)
2- Peak height
3- Mixing tolerance angle
4- Weakening angle
5- Widht of mixogram at the peak.

Contrarily to the data of the farinograph, the mixograph curves are good indicators of optimum mixing time, rate of dough breakdown and an approximate protein content. The peak time can be used to predict the loaf volume and oxidation requirements. Mixing time decreases as protein content increases to about 12%, then remains fairly constant. Peak height decreases with decreasing protein and increasing absorption. The larger the angle of mixing tolerance the less the rate of dough breakdown is. Doughs that have a large weakening angle tend to overmix easily. Finally, the width

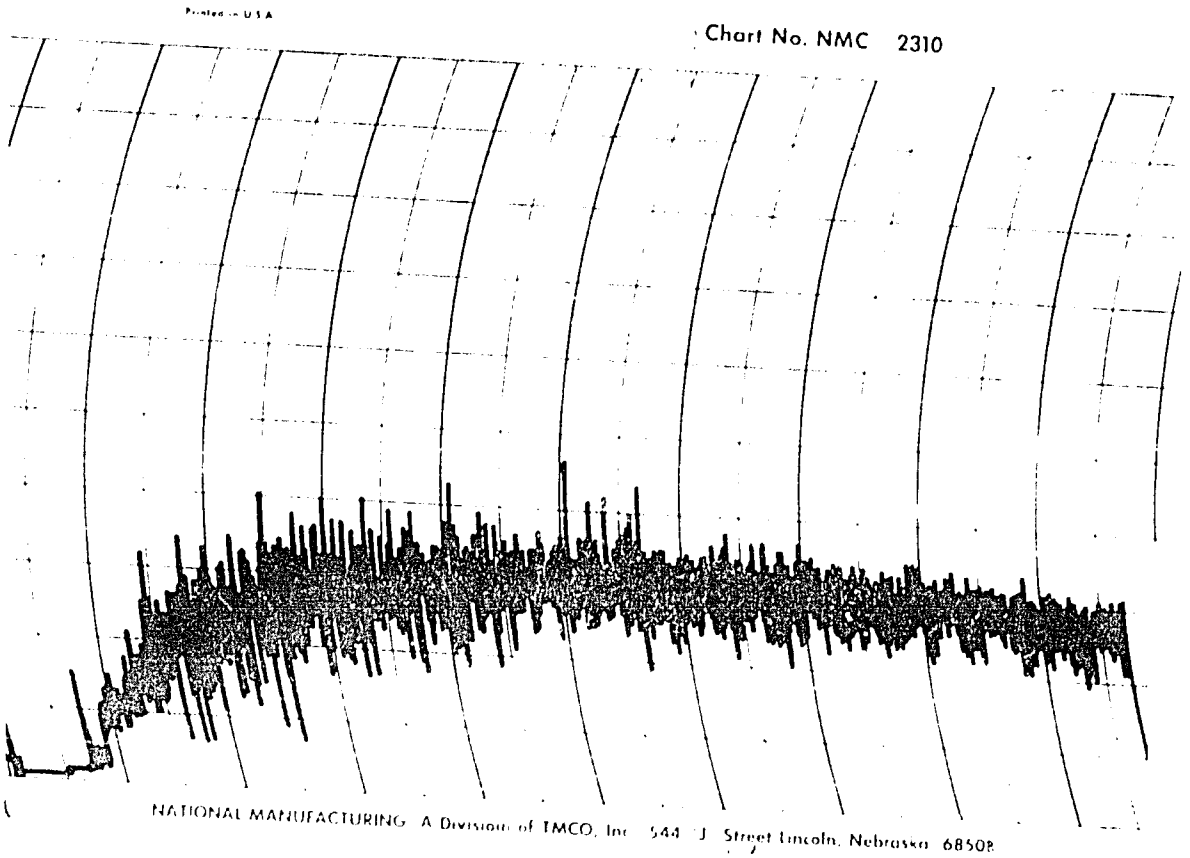


Fig.14. Typical mixograms obtained for non- stored wheat

of the mixogram at the peak increases with larger amounts of proteins.

2 - Falling number test

This test has been introduced in the previous report.

B- Procedures used

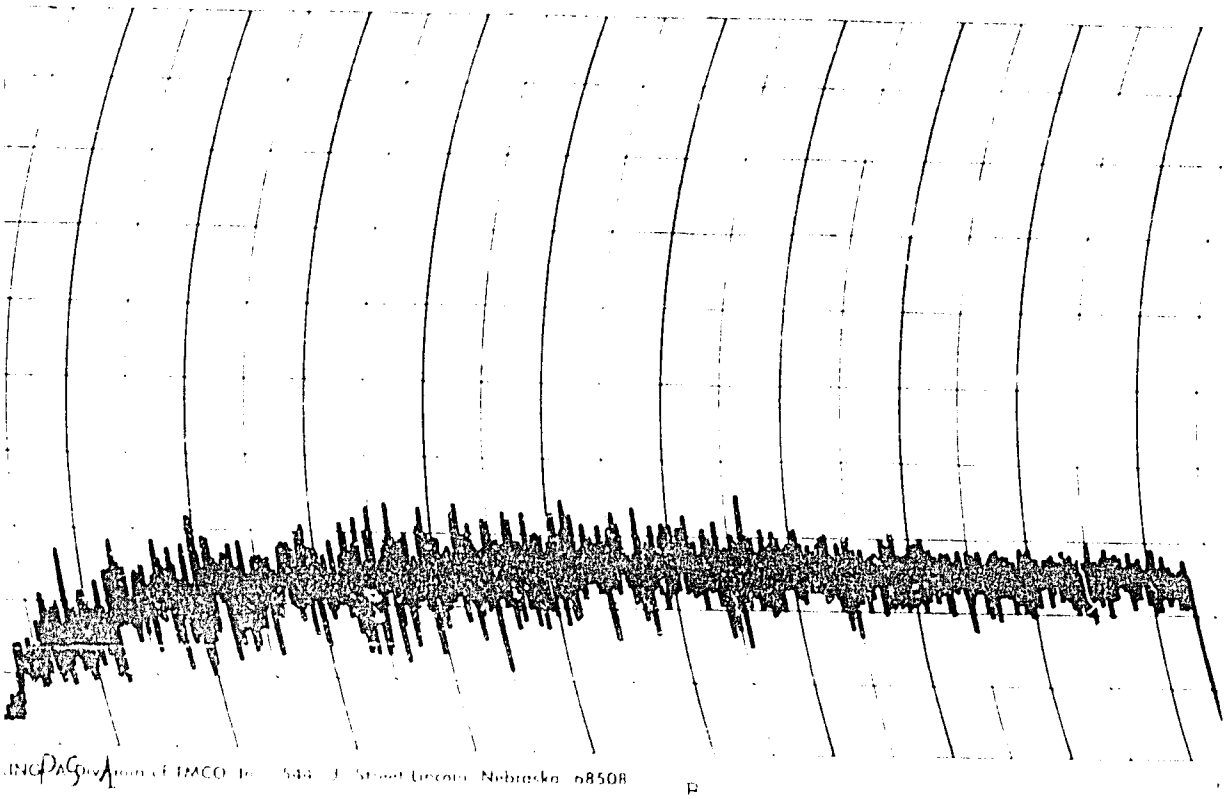
1 - Falling number test

Refer to first report.

2 - Mixograph test

The swanson - working mixograph (National Mfg - Co., Lincoln, Nebr.) was used. 30 grams of flour were used in every test since we have a 30 gram version and not a 10 grams (Finney and Shogrein, 1972, and Hoseney, 1988: Personnal communication).

The wheat samples analysed are 16 sub-samples of the durum wheat cultivar 2909: Oued Zenati before storage, and 16 other samples of the same cultivar stored in underground pits under different storage conditions. These latter 16 samples were taken from different positions of the pits (fig. 1) and milled the same way. The flours are supposed to have almost identical moisture contents which was manitained fairely constant by putting flour samples in sealed plastic bags and



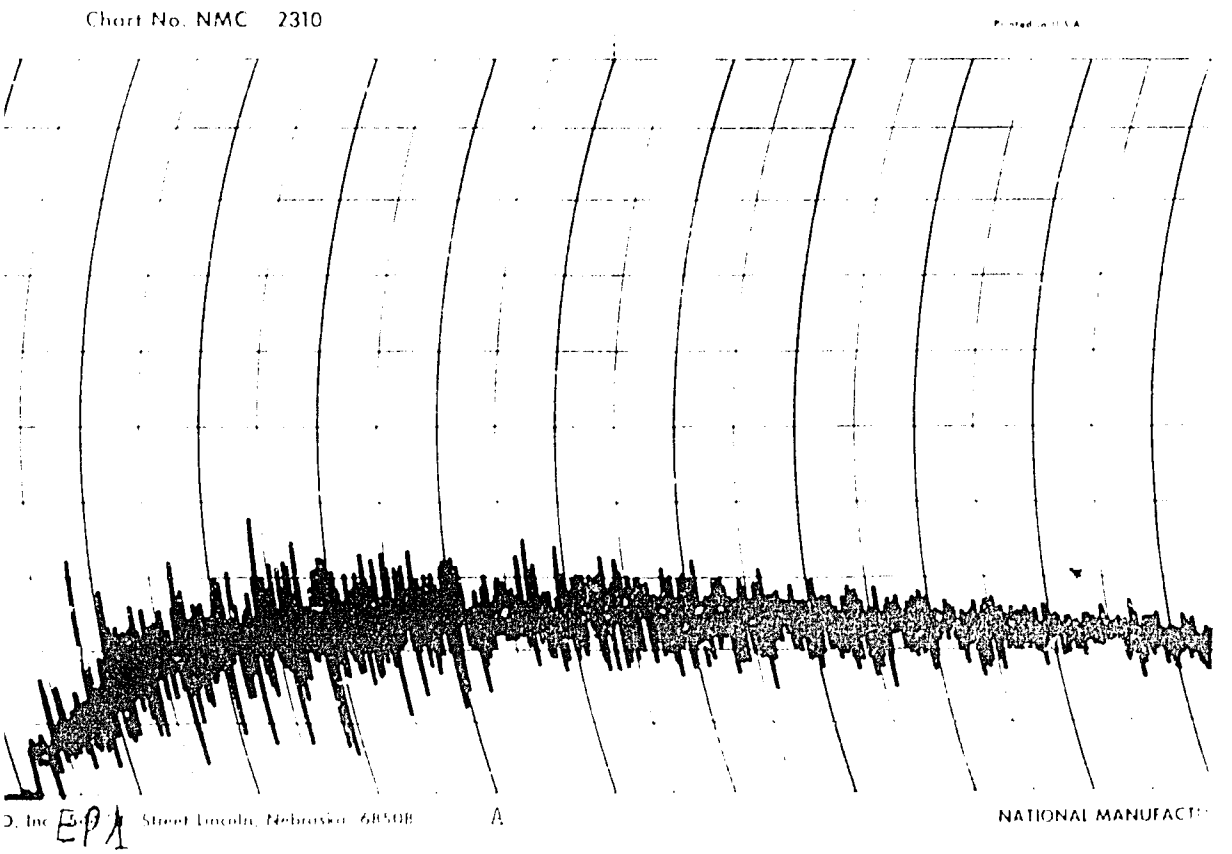
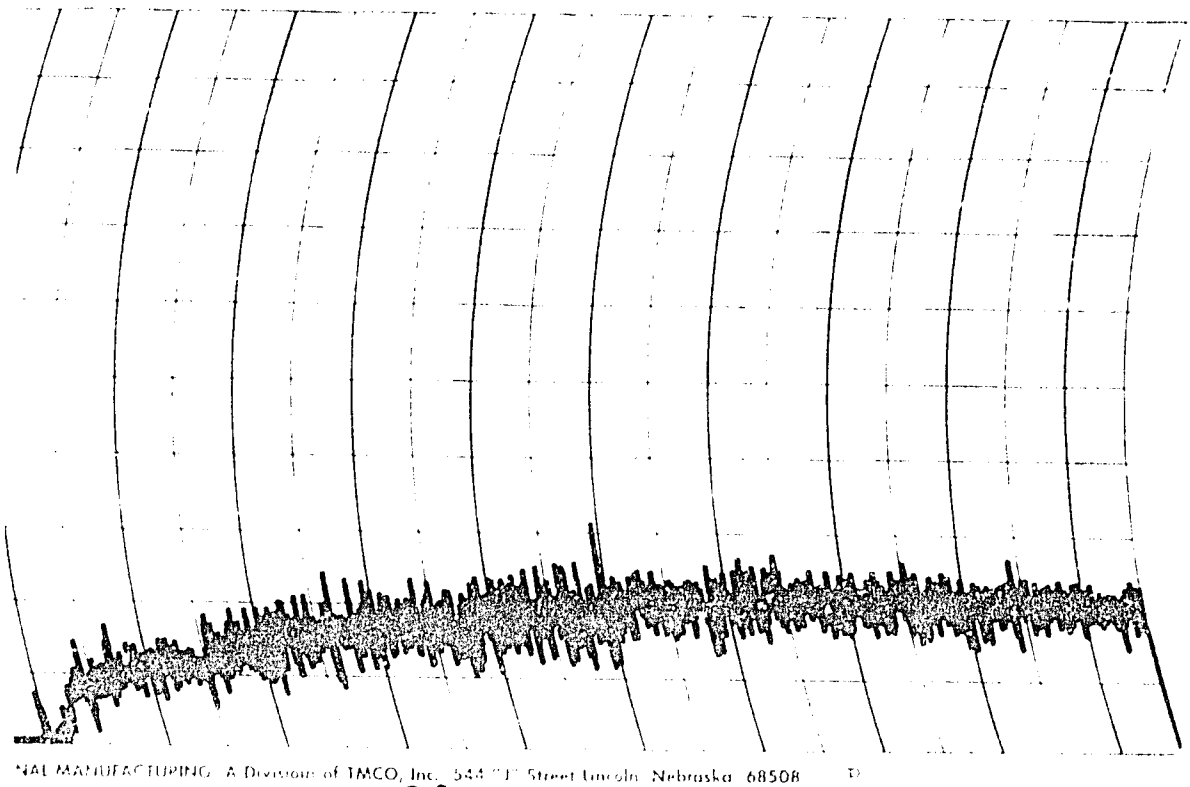


Fig. 18. Typical mixograms obtained for (position 1).

A: Plastic - lined pit
B: Straw - lined pit

stored at 4C before use. This allowed us not to correct flour weights accordingly (after determining the optimum water absorption level). In fact, as will be discussed in the results later, the 16 non-stored wheat sub-samples gave very similar curves by adding the same volumes of water to the same weights of flour. Flour samples (stored at 4 C) are still available in case we want to register new curves and run moisture measurements to see whether some small changes in curve shape are due to the moisture problem or not. This discussion might be reported in the neet report but fully discussed in the final report.

To determine the optimum water absorption, several absorption levels were used as described by Finney and Shobren (1972). The alternative of using protein content to determine the absorption level (as described by the AACC Method 54-40) was not followed and is known to be less accurate than the first method. Several samples were analyzed and all of them gave similar curves at different moisture levels and exhibited the same optimum water absorption indicating that the original flours have practically the same moisture contents. To register our curves, we then used the following procedure : 30 grams of flow were mixed with 20 ml. of H20 (about 67 % absorption level : % flour weight for 7 minutes. This time was enough to obtain an easy-to-read curve. The slothook was in the outer-most position (Slot 12) of spring-tension-index bar as recommended by Finney and



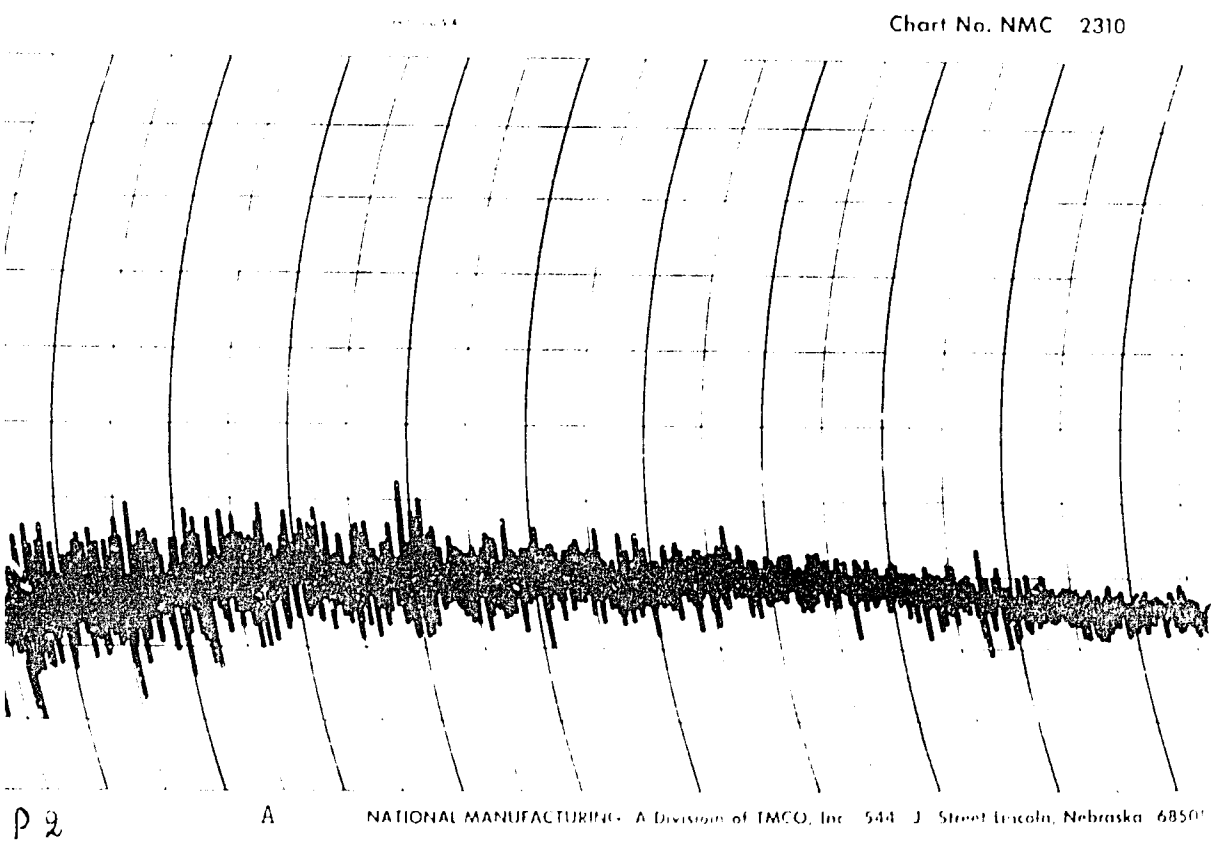


Fig 16. Typical mixograms obtained (position 2) for

A: Plastic - lined pit

B: Straw - lined pit

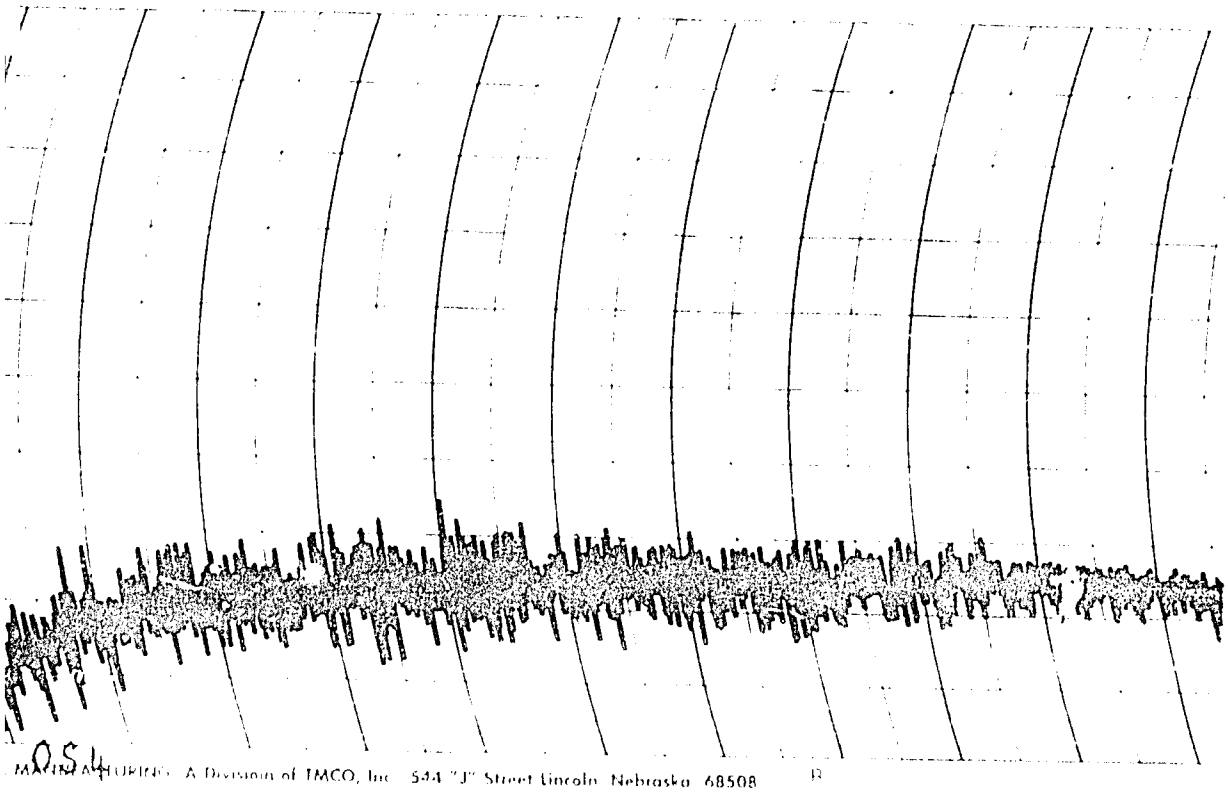
Barmore (1972). We observed that lower positions gave higher peak hights and very easy-to-read curves, but the oscillations have slightly smaller amplitudes that can be adjusted by slightly changing the absorption level. However we kept using the former procedure as repcited in the litterature.

C- Results and discussions

1. Falling number test :

Falling numbers of non-stored and stored wheats (the numbers were corrected to 14% m.b.) are shown in table 25.

In general all these numbers are very high indicating that non-stored and stored wheats are very hypodiastasic. Wheats from plastic lined pits have in general higher values than wheats from straw-lined pits. When several storage periods will be covered, a variance analysis will be carried out as to better visualize differences among samples of different pits.



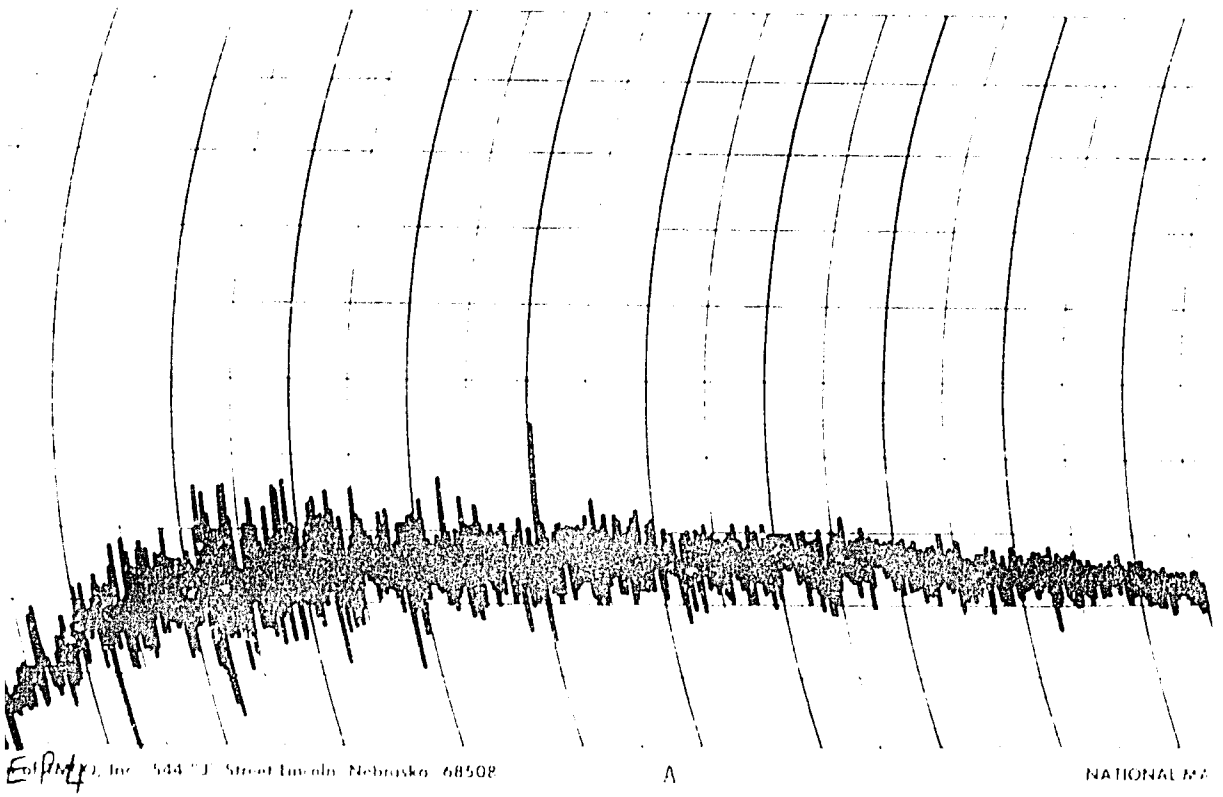


Fig.17. Typical mixograms obtained for (position 4).

A: Plastic - lined pit

B: Straw - lined pit

Table 25 Falling numbers of wheat before storage and after 3 months of storage

NON STORED WHEAT				UNDERGROUND STORED WHEAT			
				With plastic lining		With straw lining	
Sub-sample no	Falling number (sec)	Sub-sample no	Falling number (sec)	Sub-sample no no	Falling number (sec)	Sub-sample no	Falling number (sec)
1	608	9	628	KP1	574	OS1	566
2	701	10	678	KP2	720	OS2	625
3	685	11	593	KP3*	689	OS3*	707
4	708	12	634	KP4	654	OS4	619
5	733	13	677	EP1	642	PS1	607
6	726	14	602	EP2	700	PS2	578
7	629	15	654	EP3	556	PS3	457
8	642	16	710	EP4	735	PS4	604

(*) Two other determinations were run on KP3 and OS3 as was decided by the project team :
KP3 = 686, 692
OS3 = 725, 713

2 - Mixograph results (figures 14 to 18)

In this report, only mixogram types (general appearance) are discussed. Numerical values for some parameters will be reported and discussed later when several points (several covered periods) will be available which may also allow for some statistical analyses. Through the mixograms registered, it appears that wheat stored in plastic-lined pits did not undergo any significant change except that the mixogram peack height decreased for both positions 4- and 1 compared to the non-stored wheat and to the other positions of the pit. For

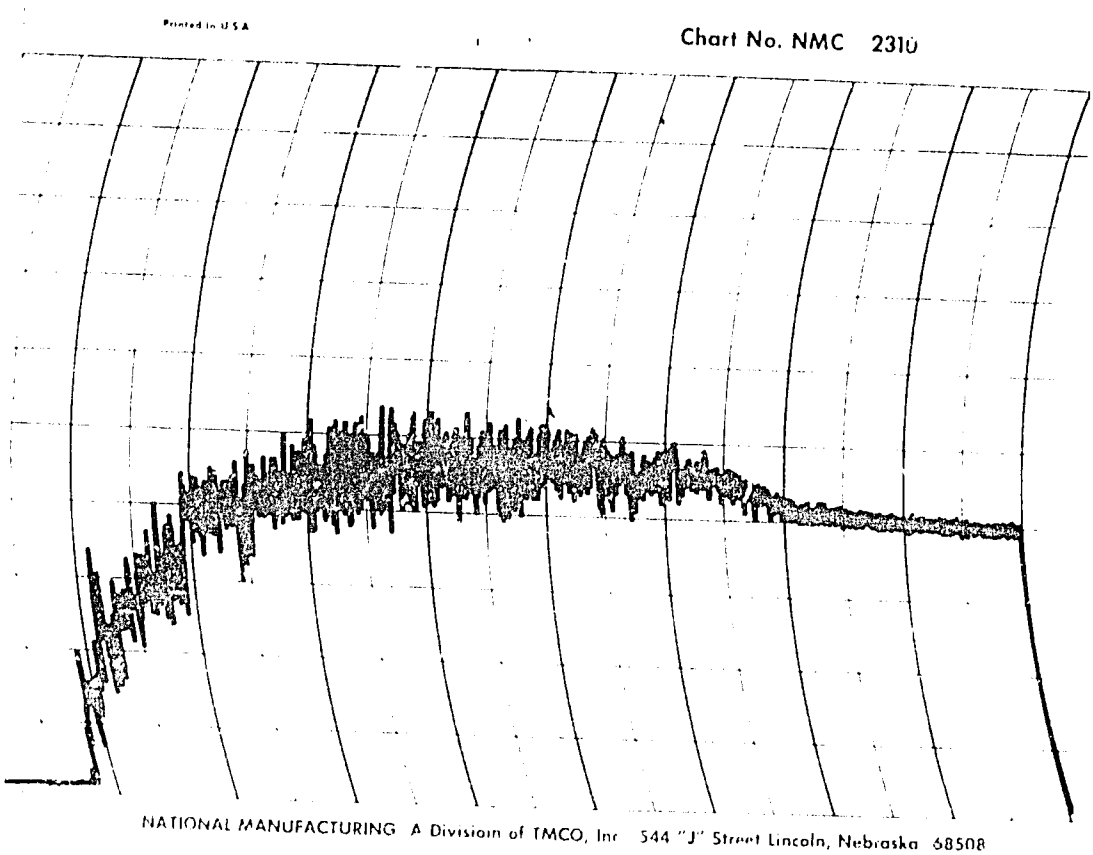


Fig. 18. Registered mixogram with Slot hook on position 7.

straw-lined pits, a definite change in mixogram type was observed. These mixograms have lowerpeak height, longer mixing time (about 4 minutes) and a slightly smaller weakning angle. For straw-lined pits we may suspect the existence of an already significant rheological change. However, one has to look at results of several periods before confirming the prevalence of such a change.

D- Reference

FINNEY,K.F. and SHOGREN, M.D. (1972) - A Ten-Gram Mixograph for Determining and Predicting Functional Properties of Wheat Flours. Bakers Digest - Vol. 46 , No 2. pp. 32-35, 38-42, 77.

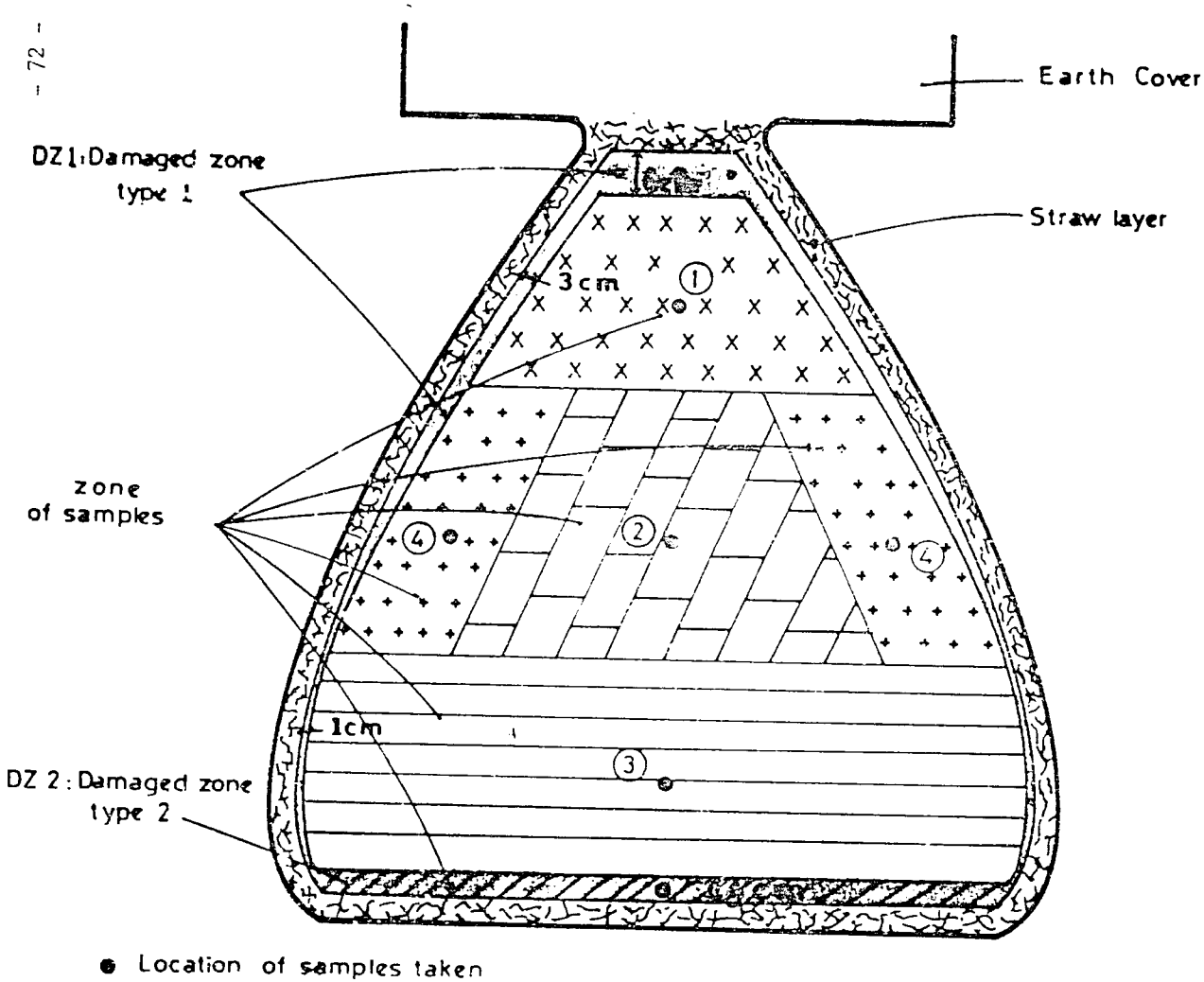
D- Acknowledgments

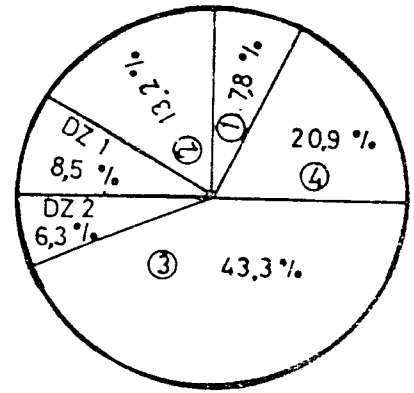
I would like to thank the Research Institute Scientists for carrying out the falling numbr tests and for milling samples used for mixogram studies. I thank also Mr. Majid (technicien at Ag Eng. Department. IAV Hassan II) for helping in the analysis.

2.1.4. Estimate of loss during the first 3 months of storage

2.1.4.1. Procedure used

The concept as well as the method of loss determination for a





Volume of each zone
(in percent of total volume)

Fig 10: Sampling zones in a straw pit.

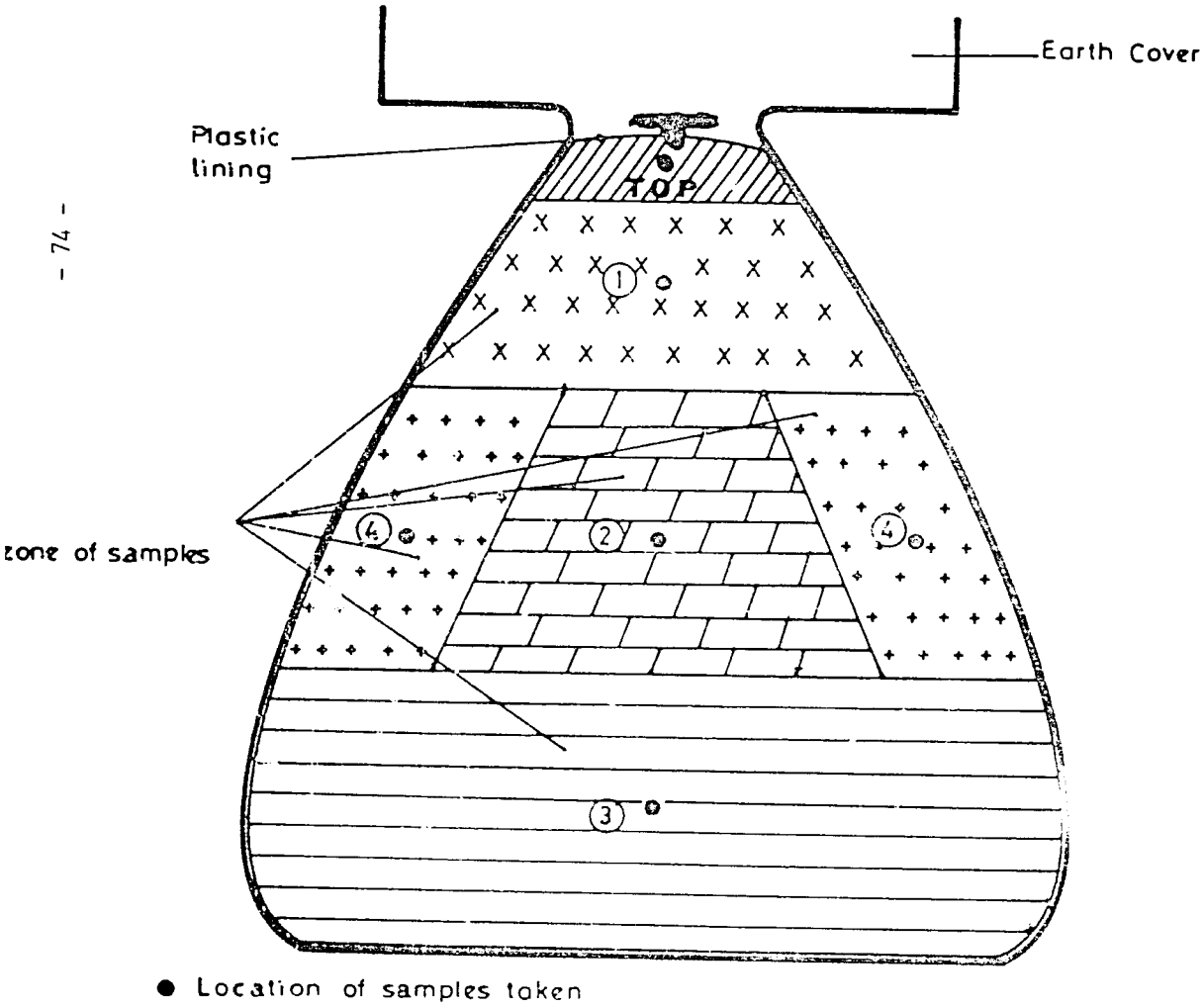
stored grain is variable with authors. The group of researchers involved in this project examined in a meeting held on April 11, 1988 the loss evaluation techniques. Dr F. Dunkel, principal coinvestigator introduced the subject by giving a conference on post harvest loss. Dr E. Persoons, Head of the Agricultural Engineering Department at the University of Louvain la Neuve in Belgium also attended the conference and the dsicussion. Two types of losses are considered in this study: quantitative and qualitative losses. Two methods were used to evaluate the quantitative losses: the dry weight loss method and the thousand grain method (Ref. FAO). The summary of results obtained by these two methods is shown in table 26. The details of calculation of the loss rate are respectively indicated in tables 27 and 28 for the dry weight method and 29 and 30 for the thousand grain method for both straw and palstic pits.

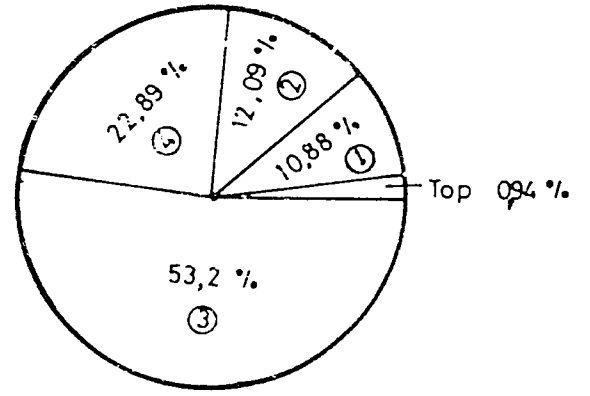
2.1.4.2. Regional evaluation

In order to determine the total rate of loss in a pit, each sample that is taken from this pit, is considered to represent a certain volume (or zone) of the pit. These zones are shown in figures 19 and 20. The determination of these volumes is based on the following considerations:

-Observations made on grain at opening of pits.

In the case of straw lined pits for instance, two zones of





Volume of each zone (in percent of total volume)

Fig 20: Sampling zones in a plastic pit.

very damaged grain were distinguished, DZ1 and DZ2 respectively at the upper and the lower level of pit (figures 19 and 20). The volumes of these two zones were respectively evaluated and affected to the samples of grain that were taken from them.

-For both straw lined and plastic lined pits and for the sampling locations numbered 1 to 4 as shown in figure 1, the thickness of each zone affected to a sample is taken as twice the distance between the sampling location to the nearest wall, the bottom or the top of the pit. This method is applied to the sampling points 1, 3 and 4. The volume corresponding to the sampling point 2 is then determined by deduction from the preceeding ones. For each zone, the sample is taken from the center. The ratio of the volume of a given zone to the total volume of the matmora is a coefficient used in the computation of total rate of loss in the pit.

2.1.4.3. Dry weight loss

The detail of calculations are shown in tables 27 and 28. A dry weight loss is evaluated in each region of the pit and an average loss is calculated. The values of loss obtained after 3 months of storage are .967 % for plastic and 18.045 % for straw.

Table 26. Loss evaluation

Method of evaluation	Type of lining	Dry weight loss after 3 months of storage
Dry weight loss	Plastic	0.967
	Straw	18.045
Thousand grain method	Plastic	1.255
	Straw	8.305

2.1.4.4. Thousand grain method

Tables 29 and 30 indicate the detail of calculation.
One difficulty met with this method is that the sample of thousand grain taken from the zones DZ1 and DZ2 contain zero undamaged kernels. To overcome this difficulty, the estimation of loss for these zones was made by the dry weight method. The values of loss after 3 months of storage obtained by the thousand grain method are 1.255 % for plastic and 8.305 for straw. The disadvantage of the thousand grain method is the error that comes from the fact that this method does not take into account the difference between the moisture contents of the kernels. This difference is particularly high in straw lined pits. This method tends to underestimate loss.

2.1.4.5. Sensory evaluation

A tentative was made to evaluate one aspect of qualitative loss generated by storage of grain in pits by trying a consumer evaluation on June 6 th, 1988. Two dishes of couscous were prepared by the farmer using wheat stored in plastic and wheat stored in straw lined pits. The evaluation of organoleptic changes was made by a panel of six persons including members from the farmer's family and the research team of IAV. The test revealed that wheat stored in straw pit gave an acid taste to couscous and made the grains of

Table 27. Loss by dry weight method

Straw Pit, 3 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 %			
OS	OS (DZ 1)	775,52	417	11,76	31,51	58,265	8,5	17,23
	OS 1	"	718	"	15,92	11,78	7,8	
	OS 2	"	692	"	15,48	14,53	13,2	
	OS 3	"	743	"	15,63	8,396	43,3	
	OS 4	"	700	"	15,81	13,88	20,9	
	OS (DZ 2)	"	588	"	34,69	43,88	6,3	
PS	PS(DZ 1)	775,52	620	11,76	19,07	26,67	8,5	18,86
	PS 1	"	700	"	16,40	14,487	7,8	
	PS 2	"	708	"	16,10	13,197	13,2	
	PS 3	"	681	"	18,30	18,69	43,3	
	PS 4	"	695	"	17,19	15,90	20,9	
	PS(DZ 2	"	602	"	27,91	36,58	6,3	
							Mean	18,045
							Standard deviation	1,153

" Same

Table 28. Loss by dry weight method

Plastic Pit, 3 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 %			
EP	EP (Top)	775,52	755	11,76	12,38	3,33	0,94	1,126
	EP 1	"	766	"	12,30	1,833	10,88	
	EP 2	"	770	"	12,17	1,17	12,09	
	EP 3	"	772	"	12,07	0,804	53,2	
	EP 4	"	768	"	12,16	1,42	22,89	
KP	KP (Top)	775,52	764	"	12,30	2,09	0,94	0,808
	KP 1	"	766	"	12,27	1,8	10,88	
	KP 2	"	770	"	12,16	1,163	12,09	
	KP 3	"	772	"	11,78	0,477	53,2	
	KP 4	"	772	"	12,12	0,86	22,89	
							Mean	0,967
							Standard deviation	0,225

" Same

couscous stick to each other during the preparation of the dish. This later observation was made by the person who prepared the two dishes.

2.2. Completion of preliminary experiment with barley on campus

The experiment on underground barley storage on I.A.V campus in plastic and straw pits for six months ended with positive results obtained with plastic. The values of loss obtained are respectively 6.27% with straw and .97% with plastic.
Mr Said Afif, a graduate student in Agricultural Engineering Department who's research topic was related to this experiment defended his thesis in April 1988. His evaluating committee was chaired by Mr Steeve Clark, Director of the I.A.V - University of Minnesota Project and a research leader in the A.I.D project on storage of beans in Rwanda.
A paper titled "Stockage des Cereales dans les Entrepots Souterrains" and related to this research will be included in the proceedings of the International Colloquim of Technology on "Cereales en Regions Chaudes: Conservation et Transformation" held from February 22 to 27, 1988 in N'gauoundere, Cameroun.

Table 29. Loss Evaluation: Thousand Grain Method.

Straw Pit, 3 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 (%)
OS	OS (DZ 1	0,	47,1	47,1	1000	58,26	8,5	9,77
	OS 1	42,45	3,65	46,1	89	1,067	7,8	
	OS 2	43,9	3,00	46,9	78	1,5	13,2	
	OS 3	43.82	3,78	47,6	110	3,323	43,3	
	OS 4	42,62	3,18	45,8	85	1,673	20,9	
	OS (DZ 2)	0,	56,5	56,5	1000	43,88	6,3	
PS	PS (DZ 1)	0	48,3	48,3	1000	26,67	8,5	6,84
	PS 1	42,39	4,11	46,5	99	1,164	7,8	
	PS 2	42,3	3,50	45,8	92	1,684	13,2	
	PS 3	43,23	4,27	47,5	120	3,308	43,3	
	PS 4	43.3	3,5	46,8	98	2,51	20,9	
	PS (DZ 2)	0	53,8	53,8	1000	36,58	6,3	
							Mean	8,305
							St.Dev.	2,072

Table 30 Loss Evaluation: Thousand Grain Method.
Plastic Pit, 3 months of Storage

Pit	Sample	Weight of undamaged kernels (g)	Weight of damaged kernels (g)	Total Weight (g)	Number of gamaged kernels	loss of dry weight	Volume of Zone in %	Loss of dry weight in the Pit (%)
EP	EP(Top)	42,36	3,60	45,96	85	0,073	0,94	1,287
	EP 1	43,10	2,53	45,63	73	1,858	10,88	
	EP 2	41,61	3,51	45,12	87	1,0	12,09	
	EP 3	44,00	3,60	47,60	84	0,905	53,20	
	EP 4	42,65	4,00	46,65	105	2,107	22,89	
KP	KP(Top)	43,60	2,75	46,35	66	0,993	0,94	1,224
	KP 1	42,31	3,20	45,51	73	0,289	10,88	
	KP 2	44,83	2,80	47,63	67	0,87	12,09	
	KP 3	42,34	3,68	46,02	92	1,31	53,20	
	KP 4	42,50	3,12	45,62	80	1,246	12,89	
							Mean	1,255
							St.Dev.	0,045

2.3. New experiments initiated

2.3.1. Reuse of plastic lined pit by farmer

The farmer recovered the four pits after the first opening on April 6, and requested the two plastic bags that have served as lining to the plastic pits EP and KP. His intends, given the performance of plastic lining to reuse them for underground grain storage on his farm.

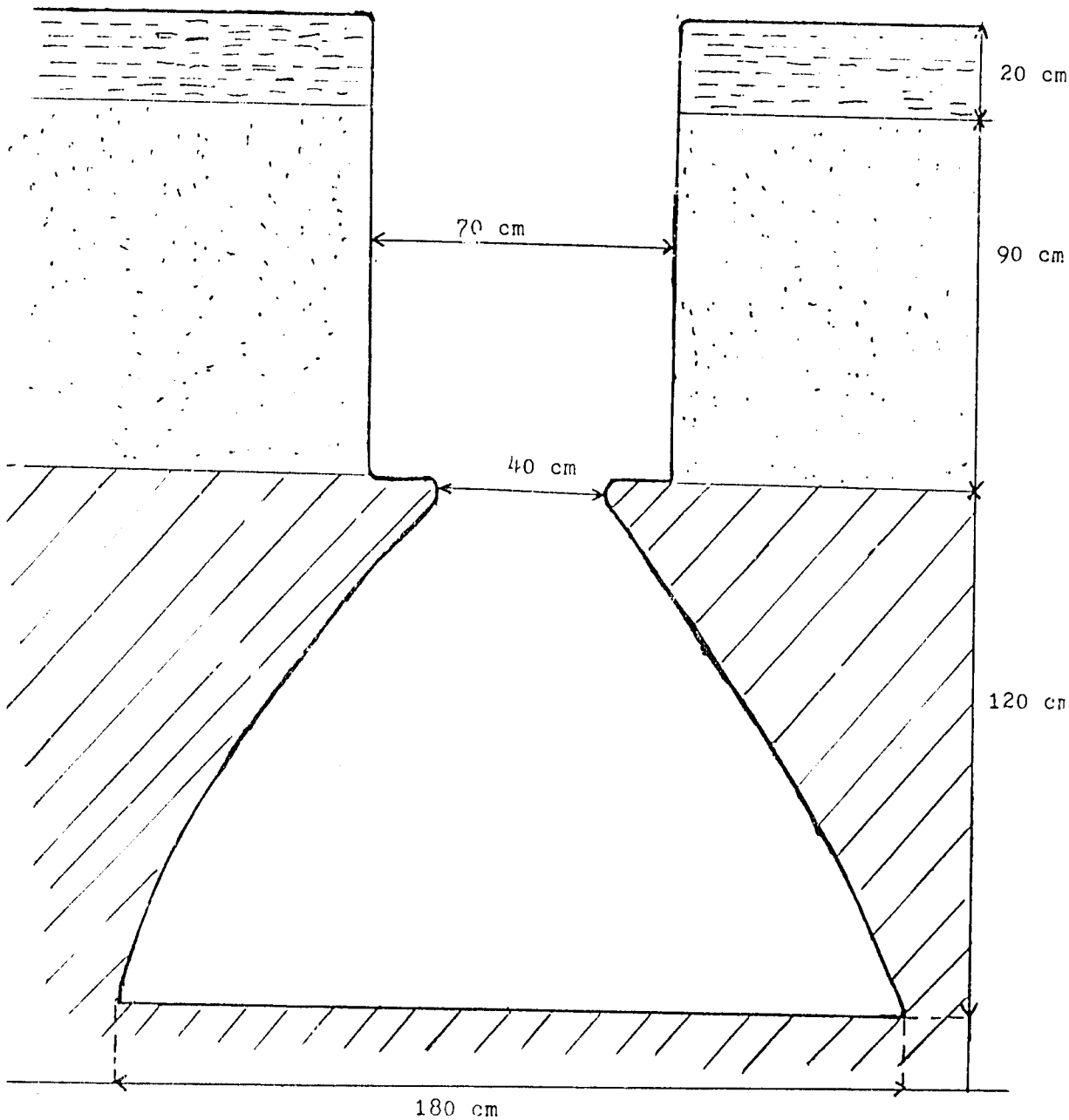
2.3.2. On campus installation of experimental wheat for long term storage

2.3.2.1. Experiment facility

On the 27 th of April, two underground pits were filled with wheat that was recovered from two plastic pits from the experiment site on farm. These two pits were the same size as those used on farm, about 1.2 metric ton. The dimensions of the pits and the soil profile on campus are shown on figure 21. The initial characteristics for the wheat stored on campus are tho found for wheat after three months of storage in plastic pits in Settat.

2.3.2.2. Lining

Two types of lining are tested: plastic and plastic and straw combined as shown on figures 22 and 23. The use of plastic



Sand and organic matter

Sand

layer of clay

Fig 21. Section of a Storage p
and soil profile
IAV Campus

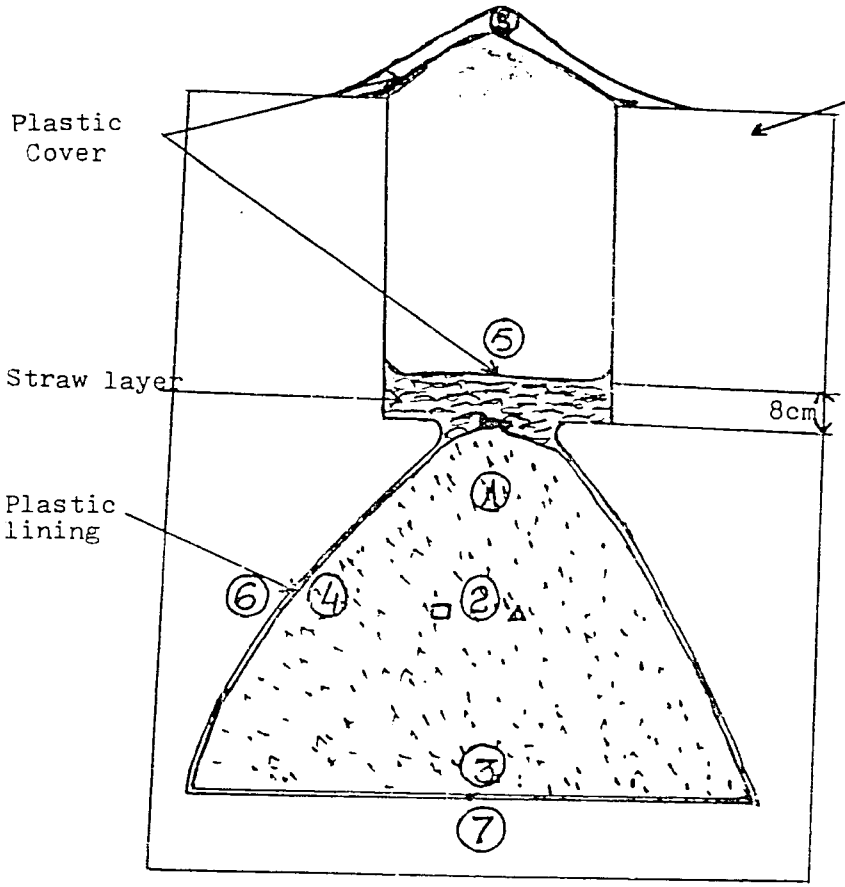
and straw together as a lining will permit to investigate the effect of combining the waterproofing property of paistic and the thermal insulation property of straw. The objective is to study long term storage of wheat underground. Grain will be stored for a period of 5 years. Farmers are laid in some occasions to store their grain for long periods of time. The installation of these pits on campus allows to conduct the research with no constraints with respect to the use of the farmer's land.

2.3.2.3. Monitored data

The data that monitored are temperature, carbone dioxide in both pits. Relative humidity of internal air is monitored in the plastic lined pit alone. The relative humidity sensor that is used replaces the sensor that was not working properly in Settat. The location of these equipments is shown in figures 22 and 23 .

2.4. Introduction to Project for INRA Laboratories

Dr Florence Dunkel, principal coinvestigator visited the National Institute of Agricultural Research in Nantes, France from 12 to 15 of April, 1988. Dr Florence introduced the Morocco Underground Storage Project to Drs D. Richard Mollard and B. Cahagnier respectively Director and staff member. This



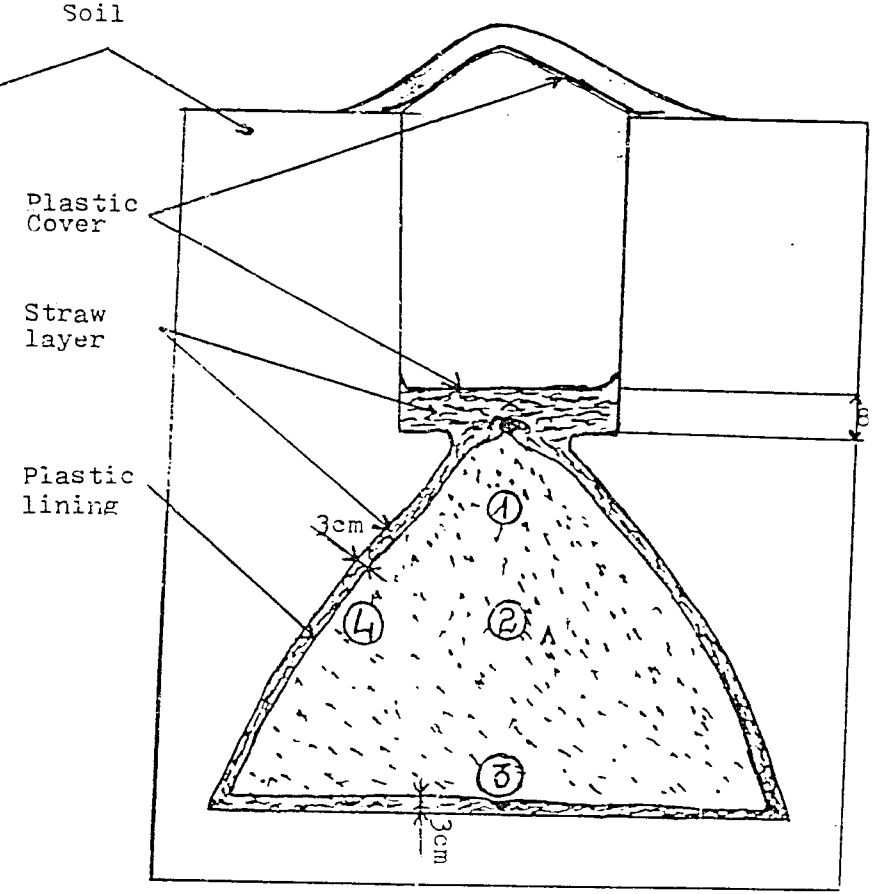


Fig 22. Section of a plastic lined grain pit
IAV Campus

S, 1 through 7: Temperature measurement points

□ : Relative humidity measurement

Δ : Carbone dioxyde measurement

Fig 23. Section of plastic/straw lined grain pit

IAV Campus

Institute carries out an impressive research work on micro-aerotolerant fungi. Dr Dunkel suggests in her report to include yeast identification in wheat used in pits based on this Institute's techniques and to also do ergosterol as a measure of important fungal growth leading to dry weight loss.

3.0. Visitors to Project

3.1. Visitors to on farm research site

April 6 th, 1988

-Dr F. Dunkel,
Principal coinvestigator in the project, Undrground Space Center, University of Minnesota

-Representatives from SCAM of Casablanca and DPA (Provincial Directorate of Agriculture of Settat) extension office, namely Mr El Klalech, Chef du Service de Mise en Valeur Agricole.

April, 26 th

-Mr Ghioot and Pr E. Persoons,
Respectively, Head of Division of Cooperation at Belgium

Embassy, Morocco and Head of Agricultural Engineering Department University of Louvain la Neuve, Belgium

June 27, 1988

-Dr R. Sterling, coinvestigator, Director of Underground Space Center, Civil and Mineral Engineering Department, University of Minnesota. In addition to this visit, Dr Sterling who's stay at I.A.V was from June 24 to July 5 th, gave a conference on undegrround space uses which was attended by research team members and grad students. During his stay, Dr Sterling's activities also included: attending second opening of pits, visiting modern port facilities for grain storage and handling in Casbalanca and contributing to the outlining of a research proposal on the investigation of large underground grain storage rooms and heat transfer modeling.

-Members of A.I.D Evaluation team for the Agronomic and Veterinary institute-University of Minnesota project:
Dr Alice Horton, Vice-President Ronco Consulting Corporation
Dr Sherwood O. Berg, President Emeritus South Dacota State University.

-Mr Robert Helleyer, Project Officer, A.I.D mission in Rabat
-Dr D. Johnson. team leader, A.I.D sponsored I.A.V-

University of Minnesota Project

June 30, 1988

On this day, the second opening of pits which will be covered in the next report took place. Several visitors attended this opening particlularly from Minsitry of Agriculture Directorate of Extension, Grain Storage Cooperative in Casablanca, Research Center on Aridocultura in Settat and School of Agricultural Engineering of France.

3.2. Visitors to on Campus research site on grain storage

-Pr J.C Verbruggen, Department of Agricultural Engineering, University of Gembloux, Belgium, Visiting Professor to I.A.V in Soil Mechanics

-Pr Lints, Dean, College of Agriculture, University of Louvain la Neuve, Belgium, Head of I.A.V Belgium coopperation project.

-Mr F. Kern, Professor of Structural and Geotechnical Engineering, Conservatoire National des Arts et Metiers, Paris

4.0 Plans for next six months

4.1 Visit of Dr. H. Bartali to International Conference on Tunneling and Underground Space in China to present paper on project

Dr H. Bartali, principal investigator will present a paper on "Temperature Variations in Underground Grain Storage Structures" at this conference that will be held at the Tongji University in Shangai, China in September 1988. This paper is related to the analysis of temperature changes in barley and soil of experimental pits installed on campus over a six months storage period. The results will also be compared to those obtained for a similar period of storage for a different crop (wheat) and a ditferent environment (Settat).

4.2. Meeting of Drs Sterling, Dunkel and Bartali with chineese counterparts regarding project

This meeting will allow the discussion of the research progress and results contained in the second progress report as well as the workplan for the second year of the project. In addition, it will also allow to investigate the use of heat transfer models in underground grain storage and to explore future directions in underground food storage research.

4.3. Defense of M.S theses based on project

Mr Khalid Tlemcani and Mr Ibrahim Abellah respectively grad student in Ag. Engeering and Plant Pathology Departments will defend their theses in September 1988. These two defenses will give opprtunities to examine the research findings and to invite persons concerned by grain storage subject from the Ministry of Agriculture and other private or public institutions.

4.4. Third opening of pits at Settat

By end of September 1988 will take place the third opening of grain pits. This will allow the study of changes that occured in wheat after a storage period of nine months in plastic and straw. Invitations to grain storage and extension boards as well as announcements to farmers will be made by I.A.V on this occasion.

4.5. Planning for conferences and seminars on Grain Storage

4.5.1. World Food Day 1988

On the occasion of World Food Day, the Moroccan Association of Nutrition will organise the First National Conference on Food and Nutrition the 13 and 14 th of October 1988. A presentation of the content and progress research on grain

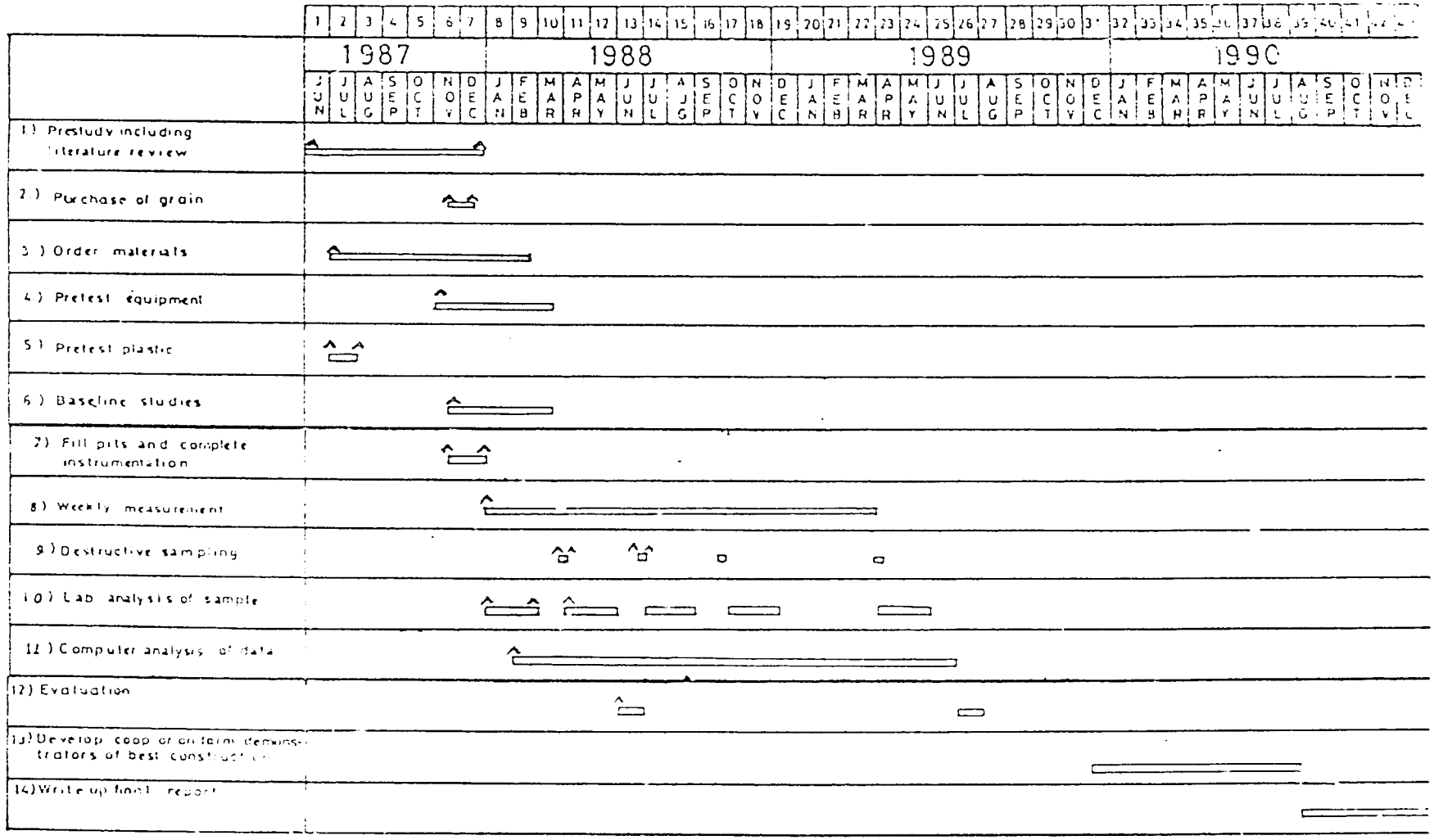
storage is scheduled.

4.5.2 International Seminar on Grain Storage Facilities

The International Commission of Agricultural Engineering is planning to organise an international seminar on grain storage in 1990 in Morocco. This seminar can include a section on underground and controlled atmosphere storage.

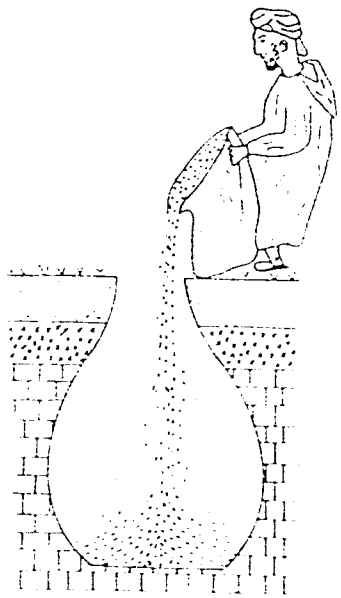
4.6. Completion of publication regarding barley pits

A publication on barley matmora experiment is being prepared for submission to the Journal of Agricultural Engineering Research. The draft will be discussed by Drs Bartali and Dunkel during the China Conference in September.



Gantt chart

completed



Group for the Study of Grain Storage

Founder:
Dr. M'Hamed Sedrati
Director
Institute of Agriculture and
Veterinary Science Hassan II

Team Members

Agricultural/Hydraulic Engineering
El Houssine Bartali (Project Director)
Abdelhafid Debbarh
Mohamed Ben Moussa
Zoology (Entomology)
Khadija Bourarach
Amin Farjane
Food Technology
Mohamed Bakella
Food Chemistry and Biochemsitry
Bachir Ben Jilali
Amar Kaaniane
Microbiology
Hassan Gourama
Laraqui Tantaoui
Agronomy and Plant Breeding
Zine El Abidine Fatemi
Plant Pathology
Brahim Ezzahiri

For more information contact:

Dr. El Houssine Bartali
Project Director
Storage Studies
Department of Agricultural Engineering
Hassan II Institute of Agricultural and
Veterinary Medicine
B.P. 6202 Rabat Institute
Rabat - Morocco
Telephone: 7 717 59 ext.240
Telex: 3187 AGROVET

American Collaborators:
Dr. Florence Dunkel
Coordinator
Underground Food Storage Studies

Dr. Raymond Sterling
Director
Underground Space Center

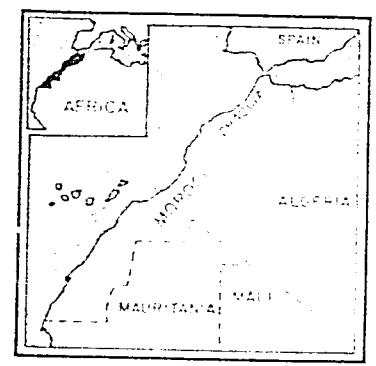
Department of Civil and
Mineral Engineering
University of Minnesota
Minneapolis, Minnesota 55455 USA

Telephone: 612-624-6366, 626-1784
Telex: 910-260-4902
Telefax: 612-624-0293

Hassan II Institute of Agricultural and Veterinary Medicine
Department of
Agricultural Science Engineering

STORAGE SYSTEMS

Research on the Improvement of Matmoras for Underground Storage



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THE SITUATION

Morocco is undertaking a continuing effort to support self sufficiency in cereals. The area cultivated in soft wheat attained 1.5 x million hectares in 1987.

The storage of cereals in inadequate conditions continue to hinder this effort because of the large losses.

On-farm storage utilizes mainly traditional techniques including the "Matmora".

A mastery of the conditions of storage in the matmora will contribute to a reduction in postharvest loss and a better utilization of this low cost technique in storage design.

THE APPROACH

A multidisciplinary team of faculty of the Hassan II Institute of Agriculture and Veterinary Medicine and two American collaborators has been assembled to scientifically evaluate the limits and advantages of the storage of cereal in the matmora by:

1) Conducting a regional survey of storage practices using underground silos.
2) Evaluating the causes of loss which are related to underground storage.
3) Establishing the correlations between various factors which influence the environment in the matmoras.
4) Evaluating appropriate improvements in the plastic sheeting used to line the matmora.
5) Conducting an experiment with these storage practices on a farm where the understanding of the technique already exists.
6) Developing a guide for good management of underground storage.
7) Ensuring that the supporting organization charged with agricultural information dissemination takes advantage of these findings.

Faculty charged with these tasks are from the following departments of Hassan II Institute of Agriculture and Veterinary Medicine:

- Agriculture Engineering
- Zoology
- Food Technology
- Food Chemistry and Biochemistry
- Microbiology
- Agronomy and Plant Breeding
- Plant Pathology

THE OBJECTIVE

To reestablish techniques of storage for the small producer

Provide more storage capacity by developing on farm storage

Promote the national effort in self-sufficiency by the reduction of loss in cereal grains