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Washington D.C. 20523

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 first progress report regarding the AID Grant indicated in reference.

Sincerely,

El Houssine Bartali

Dr. El Houssine BARTALI

Principal Investigator
DEH
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RABAT - MAROCCO

Attachment:
Financial status

PN-AA2-834

AID - SCIENCE ADVISOR COUNCIL GRANT

UNDERGROUND GRAIN STORAGE PROJECT

GRANT No DPE-5542-G-SS-7030-00

PROJECT NUMBER 7.336

SIX MONTH PROGRESS REPORT

PERIOD COVERED

JULY 1 TO DECEMBER 1987

HASSAN II AGRONOMIC AND VETERINARY INSTITUTE RABAT- MOROCCO

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1.0. INTRODUCTION

1.1. Preliminary experiment on campus

In December 1986, under the supervision of Agricultural Engineering Department, the installation of three experimental underground pits was started on the Hassan II Agronomic and Veterinary Institute of Rabat. Two of them are 4 metric ton capacity each and are used for barley storage which is provided by a nearby horse barn. The third pit is 6 metric ton capacity and is left for visits and demonstration. The purpose of this experiment site on campus is to provide an opportunity for the faculty involved in AID sponsored project to initiate collaborative research and to serve as an academic facility for teaching, and continuing education in the field of grain storage. The barley pits were filled and equipped with remote temperature instruments in end April 1987. Barley storage was carried over a period of six months and two types of interior lining of pits were considered : plastic and straw.

1.2. Contract negotiating

The contract negotiating process between AID Science Advisor Council and the Hassan II Agronomic and Veterinary Institute was enhanced by a meeting held on June 29, 1987 in Washington. This meeting was attented by AID/W staff and Dr. El Houssine BARTALI and Dr. Florence DUNKEL respectively principal investigator and principal coinvestigator. It was an opportunity to submit to AID the remaining information regarding the Hassan II Agronomic and Veterinary Institute accounting system in particular.

AID Mission in Rabat that was kept informed of the progress of contract negotiating proposed this meeting which coincided with Dr. BARTALI's visit to the University of Illinois at Urbana Champaign. Approval of the grant was acertained by AID during this meeting which hilighited the standard provisions associated with the grant.

1.3. Signing of the contract

The contract document was signed in Washington on October 31st 1987. Uncontrolled delays took place before the signing of the contract by the Agronomic and Veterinary Institute on October 6th, 1987 and during the shipment of the signed document back to Washington.

1.4. Commencement of work in Chaouia - Province of Settat

On October 5th, 1987, Dr. El Houssine BARTALI (principal investigator) Mr. Mohamed BEN MOUSSA and Mr. Khalid TLEMCANI, respectively faculty member and graduate student at the Agricultural Engineering Department, visited the Regional Agricultural Authority in Settat (La Direction Provinciale d'Agriculture or DPA de Settat) and met with the Director, Dr. EL HIMER. This visit aimed at :

- Informing the DPA of Settat of the AID sponsored research on underground grain storage and the desire of the Agronomic and Veterinary Institute to benefit from the DPA collaboration and involvment particulary in the extension aspects of the research.

- Selecting an experiment site that the DPA would recommand.

For the former point, the "Service de la Mise en Valeur Agricole de la DPA" (Land reclamation Service) was selected by the DPA to follow the IAV project research on underground grain storage. For the second an individual farm was recommended by the "Centre de Travaux Agricoles de la DPA" (Agricultural Works Center, in charge of extension). The farm belongs to Mr. MAMDOUH Bouchaib and his brother MAMDOUH Lhaj Ahmed. An oral approval was obtained from Mr. MAMDOUH Bouchaib on October 5th, to host and to look after the experiment site on their farm, located about 11 kilometers away from the city of Settat. The two farmers are very active and cooperative. They practice underground grain storage on their farm. Selecting an on-farm experiment instead of a land plot in a "Centre de Travaux" owned by the local extension service was also recommented by Dr. M'Hamed SEDRATI, Director of the Agronomic and Veterinary Institute. The project team has approved this recommendation in order to help demonstrate the research objectives to farmers.

2.0. RESEARCH ACCOMPLISHMENTS

2.1. Preliminary experiment with barley on campus

A graduate student, Mr. Said AFIF from the Departement of Agricultural Engineering with Dr. BARTALI H. as major advisor was assigned to work on the barley pits on campus and also to investigate the use of underground pits in Chaouia, where the project is planned. Following is a brief presentation of this experiment.

The scope of this study was limited by the storage period (6 months, to fit in the graduate student training program and by the available equipment).

2.1.1. Materials and methods of construction and analysis

2.1.1.1. Site

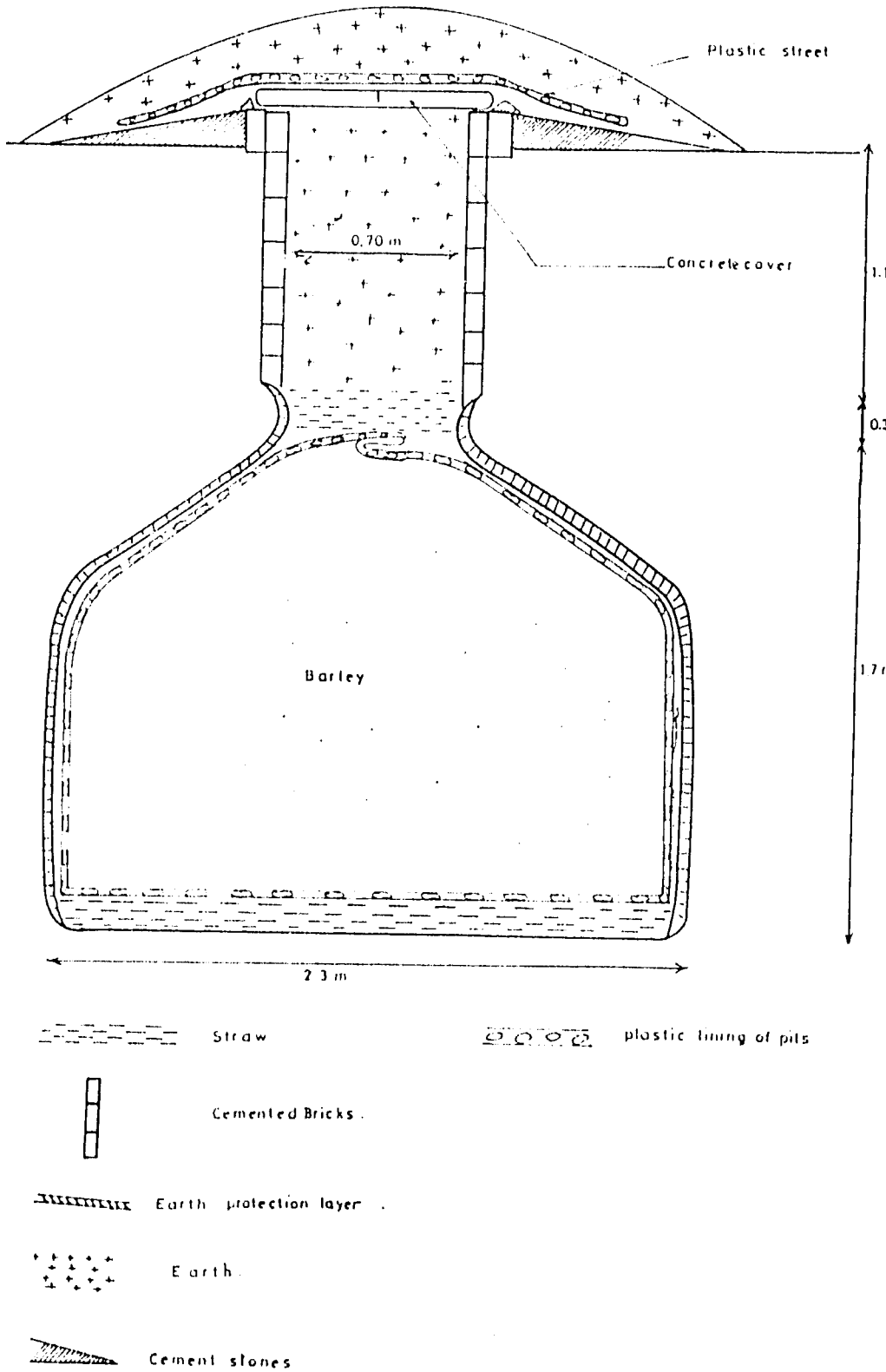
The site is located on the campus of the Hassan II Agronomic and Veterinary Institute, of Rabat on a flat land . The soil presents a superficial layer of sand, 1.1 m deep underlined by a clayey layer of 1.6 m . sandstone -limestone thick layer exists at 2.7 m depth. Permeabilities to water are respectively 22.7 cm per hour for the sand and 5.8 cm per hour for the clay layers. Water table is at 20 m depth.

2.1.1.2. Pits construction

The digging of the pits was carried out manually by two workers in January 1987. Two underground pits out of three were used to store barley. Each pit has 4 metric ton capacity, a conical shape, 3.2 m depth and 2.2 m width at the bottom. The entrance of each pit has 1 m diameter and 1.1 m height and crosses the sandy layer(Fig.1). The walls of this entrance were stabilised by a lining (15 cm thick) made of bricks and cement. The interior walls of both pits were covered by a 5 cm thick lining made of clay and straw. The purpose of this lining is to protect the plastic from being punctured by sharp edges of the limestone - sandstone layer. The pits were later burnt in the interior in order to reduce the humidity and kill insects. This practice is commonly used by some farmers. Two conditions for barley storage were compared over 6 months : using straw lining in one pit, and plastic (polyethylene) in the other.

2.1.1.3. Lining material

Fig 1 : Vertical section of plastic Barley pit



Straw and plastic sheets (polyethylene) are loally available materials. A 10 cm thick layer of straw was put on the bottom and over the wall of one pit. This technique , is well mastered and continues to be used by farmers. The lining of the wall is performed as the filling of the pit progresses. A plastic sheet, 0.18 mm thick was taped in order to make a plastic bag approximately similar in size to the second pit.This plastic bag was introducted in the pit prior to filling it . Tests of permeability to water and oxygen were undertaken on samples of this plastic at the School of Packaging at Michigan State University. Results showed permeability to water insignificant, permeability to oxygen 68 cc per cm2 per 24 hours.

2.1.1.4. Barley

Barley used for experiment was purchased through the Horse Club on the Institute campus who accepted to contribute to the research. The filling of the pits along with installation of temperature equipment took place on April 27 and 28, 1987. Just before the filling operation, water content of barley was 9.6 % and temperature 26 C. Reading of water content and temperature of grain were made by inserting a field hygrometer and a thermometer into barley bags prior to emptying them into the pits. Relative humidity of air inside the pit was measured by a psychrometer and found to be 76 % and temperature of air 24 degrees C. Unit weight was 0.64 metric ton per cubic meter. Entomological analysis of samples taken from different bags before filling showed a fairly high insect infestation of barley. Number of insects varied from 748 to 1069 per kg, with a death ratio varying between 30.8 and 33.7 % . The dominant specie was Rhizoperth Dominica.

The barley was kept stored underground in the two pits between April 27 and November 20 th, 1987. This storage period has been characterized by a hot and dry summer followed by the start of a relatively rainy and cold season in Morocco.

2.1.1.5. Remote temperature measurement

Temperature sensors were installed in each pit. As the filling process started these sensors were located at specific locations in order to measure temperature of barley, soil and air. Each set of 14 sensors were hooked to a portable data acquisition unit (UPAD), of belgian make. Such a unit is battery operated and provided with a microprocessor and 16k memory. It can automatically make temperature measurements and store them at specified intervalls of time, after it has been itialised. Communication can be performed with an UPAD using a software "DIALOGUE" run on tape ,on a portable EPSON microcomputer . Measured temperatures were retreived on site on tape to the EPSON and then to the hard disk of an XT IBM microcomputer, in the Agricultural Engineering Department where a graduate student undertook the processing.

2.1.2. Results and discussion

The study has addressed several aspects related to the evolution of storage conditions over the six months period. These include determination of the barley initial and final characteristics, interpretation of temperature data. Some of the main results are presented here .

2.1.2.1. Moisture content

Comparison of water content of barley in the two pits showed that in the straw pit the moisture content increased at the end of the storage period with respect to its initial value (9.55 %). Final values were 12.7 % in the center of the pit and 21.4 % at the top. In the plastic pit the moisture content of barley at the end of the storage period was uniform over the pit and remained close to the initial value. The values reached at the center and top were respectively 9.8 % and 11.7 % . There was a humidity migration from soil to barley in the straw pit .This in turn allowed development of fungi and insects.

2.1.2.2. CO_2 concentration

Equipment to measure CO_2 concentration purchased with AID project fund was brought by Dr. DUNKEL whose visit in November 87 coincided with the 2 pits opening on campus. This equipment (pump and CO_2 detector tubes) were used to evaluate the CO_2 levels. The values obtained in the straw pit and plastic pit were respectively 16% and 5%. This confirmed that biological activity was higher in the straw pit (respiration of insects and fungi existing on kernels and straw).

2.1.2.3. Temperature

The temperatures obtained at various points in the straw pit were higher than the corresponding temperatures in the plastic pit. This is caused by a more intense activity of insects and fungi in the straw pit.No condenstation material was noticed on the plastic

liner.

2.1.3. Conclusion

This preliminary experiment showed that plastic constitutes an obstacle to biological activity, water penetration, and this represents a potential improvement to storage conditions.

The experiment that dealt with barley storage was limited by time and material conditions. However it was meant to serve as a preparation to investigate on farm wheat storage. Results of this preliminary investigatin will serve for a paper to be presented in a future meeting.

2.2. Experiment of wheat on farm

2.2.1. Design and construction of experiment site

2.2.1.1. Pits

On October 16th, the digging of the 16 experimental pits started. Local labor was hired. The objective was to make the storage pits in the same manner as those owned by farmers in Chaouia. The pits were finished in two weeks. All the pits had the same volume : 1.7 m3. Pit dimensions and are shown in Figures 2 and 3 .

The site is located on a hill, next to the farmer's house. An access path for village residents separates the site from the farmer's house. This makes it convenient for the farmers to watch the experiment site daily. The diameter of the opening of each pit is 0.40m. This size is just enough to let a person get in and out of the pit and helps reduce admission of air into the pit.

2.2.1.2. Geology of the site

Being installed on [illegible]ll, the site is in very good drainage conditions. The water table is at 60 m depth. At 0.5m below the soil surface exists a calcareous crust. This crust is underlined by a soft accumulation of carbonate, where the body of the pit is located, (Fig.2 and 3).

2.2.1.3. Disposition of the pits

The 16 pits are installed within a squared plot 15m x 15m. This is to adjust with the shape of the area allowed by the farmer on his land and with the proximity of a rural path for villagers. A shelter was built in the middle of the site in order to keep the scientific equipment inside. This shelter is a single room 2m wide 3m long and 2m high. This allowed to reduce, the length of the wires of temperature and humidity sensors, CO_2 tubes, necessary between the different pits and the shelter. Figures 4 and 5 show details of installations. The wires are inserted in plastic pipes that are burried between the shelter and the pits.

The construction of a suitable shelter for the equipment was found necessary as well as the installation of a fence around the site.

2.2.1.4. Lining material

Plastic sheets (polyethylene) 0.18 mm thick and similar to those used for barley experiment were bought. Eight plastic bags were made in the Agricultural Engineering Department to match the interior lateral surface of the pits. A graduate student and a technician

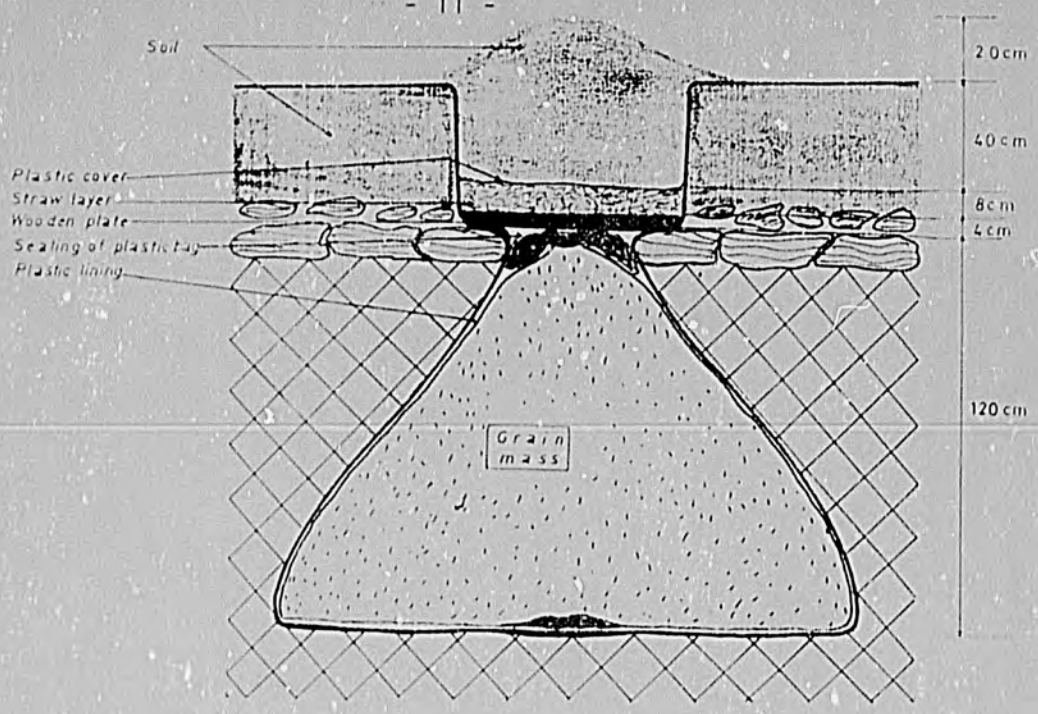


Fig 2 Detail of plastic pit sealing

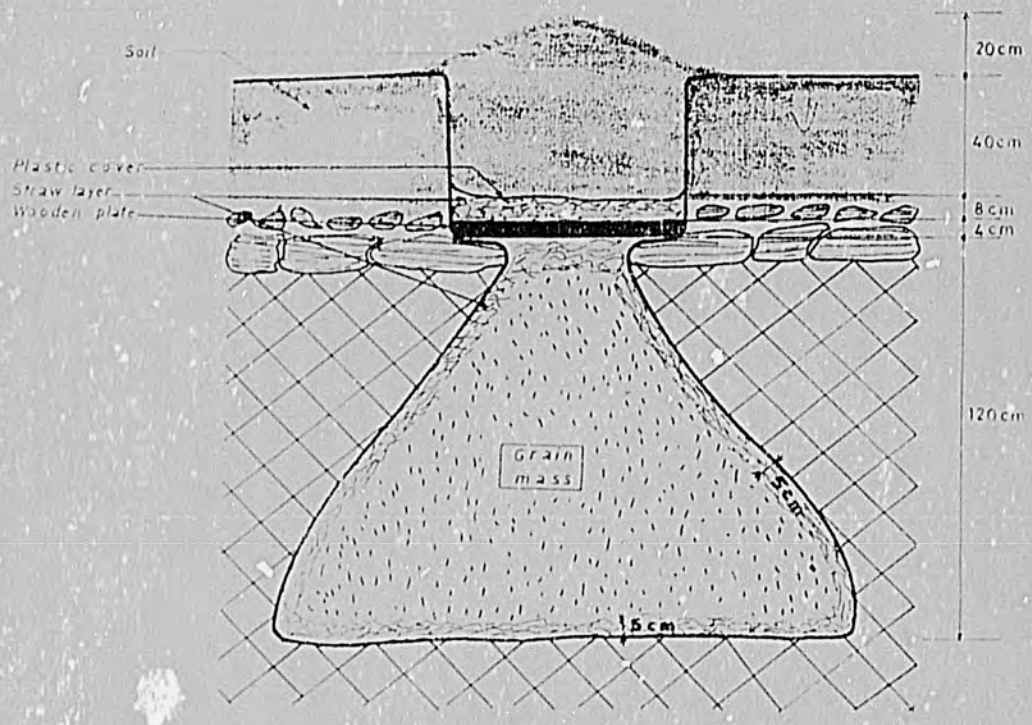
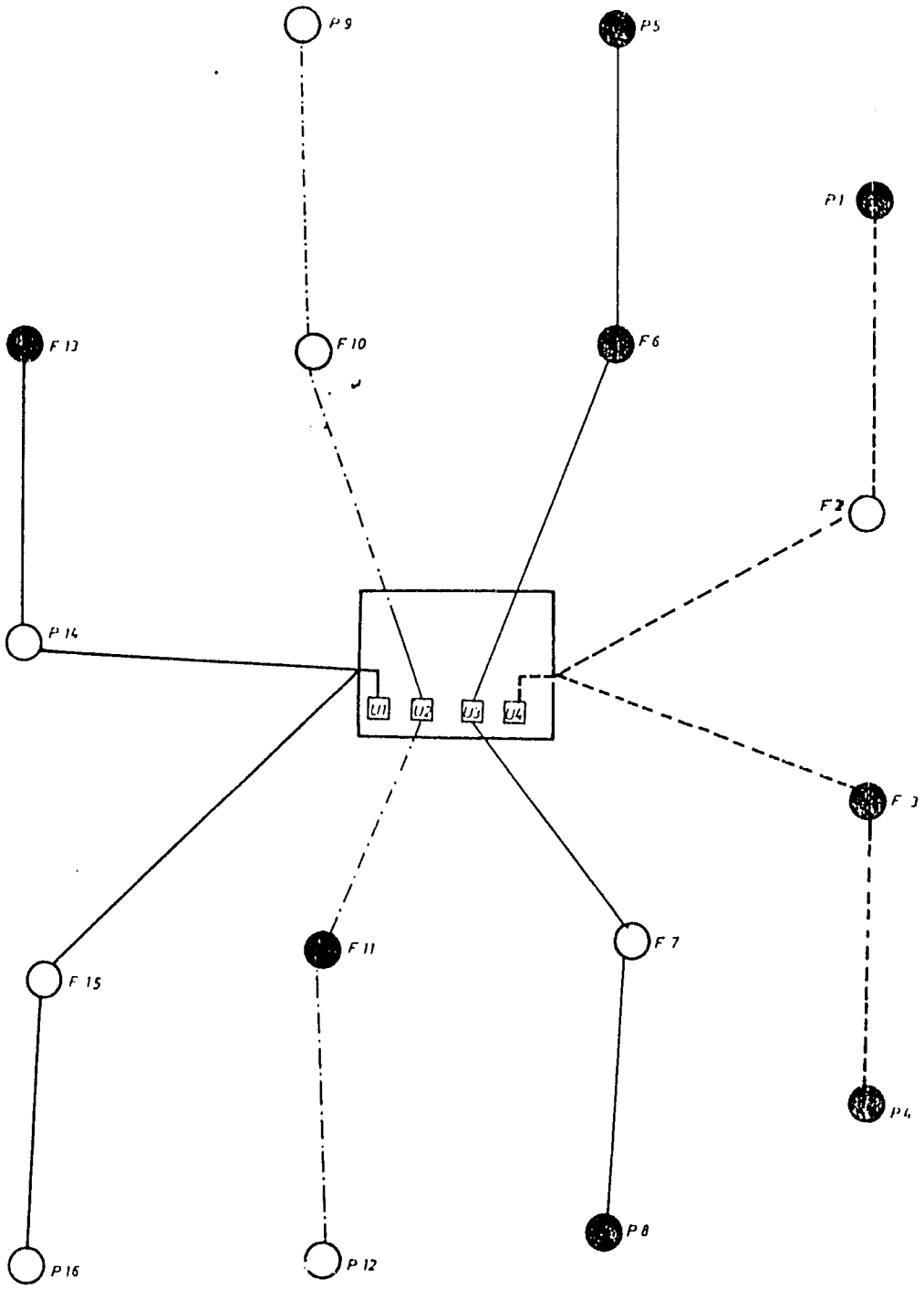


Fig. 3 Detail of straw pit sealing

Xerochept (Rendzinasoil)

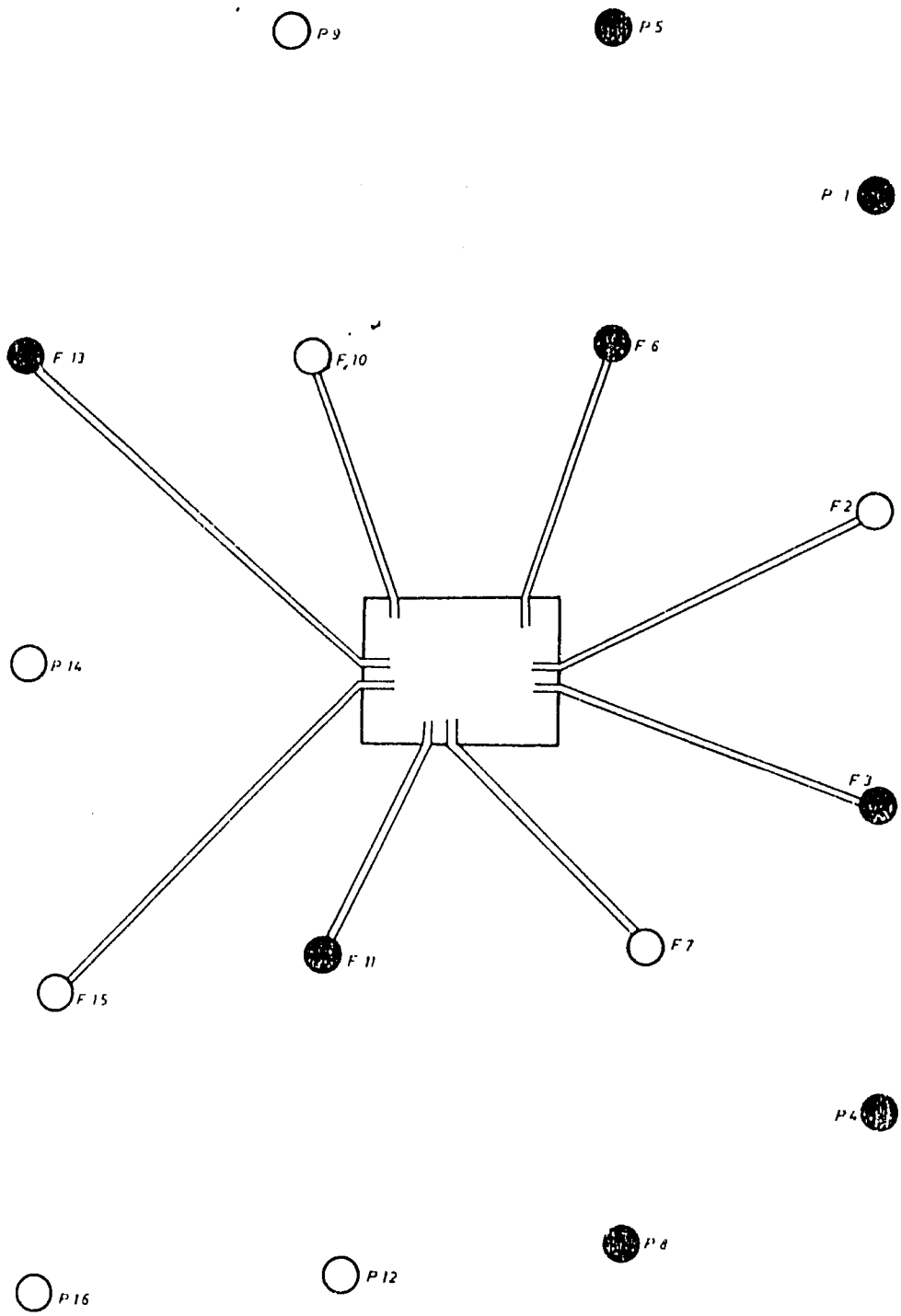
Caliche (Calcareous crust)

Soft accumulation of carbonate



F Fully instrumented Pit
P Partially instrumented Pit
Plastic-Lined Pit
Straw-Lined Pit
U UPAD

Figure 4 :Diagram of temperature and moisture cables.



F : Fully instrumented Pit
P : Partially instrument Pit
Plastic - Lined Pit
Straw - Lined Pit

Figure 5 Diagram of CO_2 tubes

confectioned the bags using tape. The bags were ready by the end of November. Wheat straw was used to line the interior of the eight straw pits on the one hand and to close all of the 16 pits, on the other.

2.2.2. Procurement of wheat

2.2.2.1. Wheat variety

The quantity of wheat needed, i.e. 20 metric tons was bought from SOGETA. This stands for "Societe de Gestion des Terres Agricoles". It is a Government owned Company that manages some agricultural land in the country. The variety of wheat bought is known as "Blé Dur 2909" and can be used for seeds or consumption. A major advantage of this grain mass is its homogeneity. It comes from one same plot in the Gharb area (40 miles North of Rabat). This quantity was harvested in July 1987 and stored in bags in good conditions inside a warehouse. SOGETA has made available recorded data regarding the identification of this wheat (Table 4).
Autorisation to purchase this quantity of wheat was requested to AID mission in Rabat and the approval was obtained.

2.2.2.2. Homogeneisation of the grain mass

Given that the wheat quantity was stored for about 6 months in bags, it was necessary to mixt it in order to obtain a more homogeneous mass prior to storing it in the pits. This operation was achieved in one day thanks to the facilities and the skilled labor of SOGETA. Dr. DUNKEL (principal coinvestigator), Mrs. BOURARACH

TABLE 4 - Characteristics of purchased grain

Producer : SOGETA

Speci : durum wheat

Variety : 2909

Category : R1

Year of production : 1986-1987

Termination of analysis : 8/26/87

Caracteristics :	Results
- Germination capability %	98.00
- Specific purity %	98.42
- Unit weight (kg/hl)	80.10
- Kernels of other species	205
- Weeds kernels	44
- Kernels of other grain species	161
- Moisture content	12.40
- Weight of 1000 kernels	43.29
- Ratio of inert matter	0.36

Source : Analysis carried out for SOGETA by Service du Controle des Semences et des Plants. DPVCTRF - RABAT.

(entomologist), Mr. ZAHAR (Food Chemistry - Biochemistry), Mr. Khalid TLEMÇANI (Grad. student) and Dr. El Houssine BARTALI (principal investigator) participated in this operation.

The 200 piled bags (100 kilos per bag) were first divided in equal groups of 50 bags each. These groups were taken from : 1) the above surface of the pile ; 2) The 2 lateral faces of the pile exposed to the air ; 3) The 2 lateral faces that were unexposed to air (one was next to a warehouse wall, and one next to a sunflower pile) and 4) from the central part of the pile. The four groups were set near a hopper and bags (one from each group) were simultaneously poured into the hopper. From there, the grain was sent up to an elevator and down to the bags where the wheat was poured and weighed.

This opportunity was taken to perform the first sampling of wheat. 16 samples were taken as the wheat was poured back into the bags. Each sample weighed 5 kg approximately and was taken every time 12 bags were filled.

The 200 bags once filled were piled up in the warehouse until the filling of the pits took place on December 30th.

2.2.3. Procurement of equipment

Procurement of equipment has been initiated thanks to both the Agronomic and Veterinary Institute and the University of Minnesota. First contacts to order equipment from the US started in Summer 87 under the care of Dr. Florence DUNKEL (principal coinvestigator) and the accounting Office, International Programs of

University of Minnesota. Dr. El Houssine BARTALI (principal investigator) who visited Belgium from October 15 to 25th, investigated the possibility to purchase temperature and humidity measurement and recording equipment from Belgium.. This type of equipment was selected because it has been tested on the barley storage experiment on campus and proved to be satisfactory .

A manufacturing company of equipment for remote temperature and humidity measurement L.G.R. (Laboratoires Generaux de Recherche) was visited by Dr. H. BARTALI. The visit was organised by Dr. Etienne PERSOONS. The latter is Professor and Head of Agricultural Engineering Department at the University of Louvain la Neuve .He is also a visiting Professor at the Agricultural Engineering Department of the Agronomic and Veterinary Institute. Two waivers were requested and obtained from AID Washington to purchase 3 portable data acquisition units (UPAD), for temperature and humidity recording and 4 humidity sensors (VAISSALA) from L.G.R.

The humidity sensors VAISSALA are being tested for the first time to measure relative humidity of intergranular air in a stored grain. Two of them were ordered.

2.2.3.1. Tesing of equipment

The department of Agricultural Engineering undertook the connection and testing of the temperature and relative humidity equipment that arrived from Belgium. The principal connection of sensors on a data logger (UPAD) are shown in Figures, 6, 7 and 8.

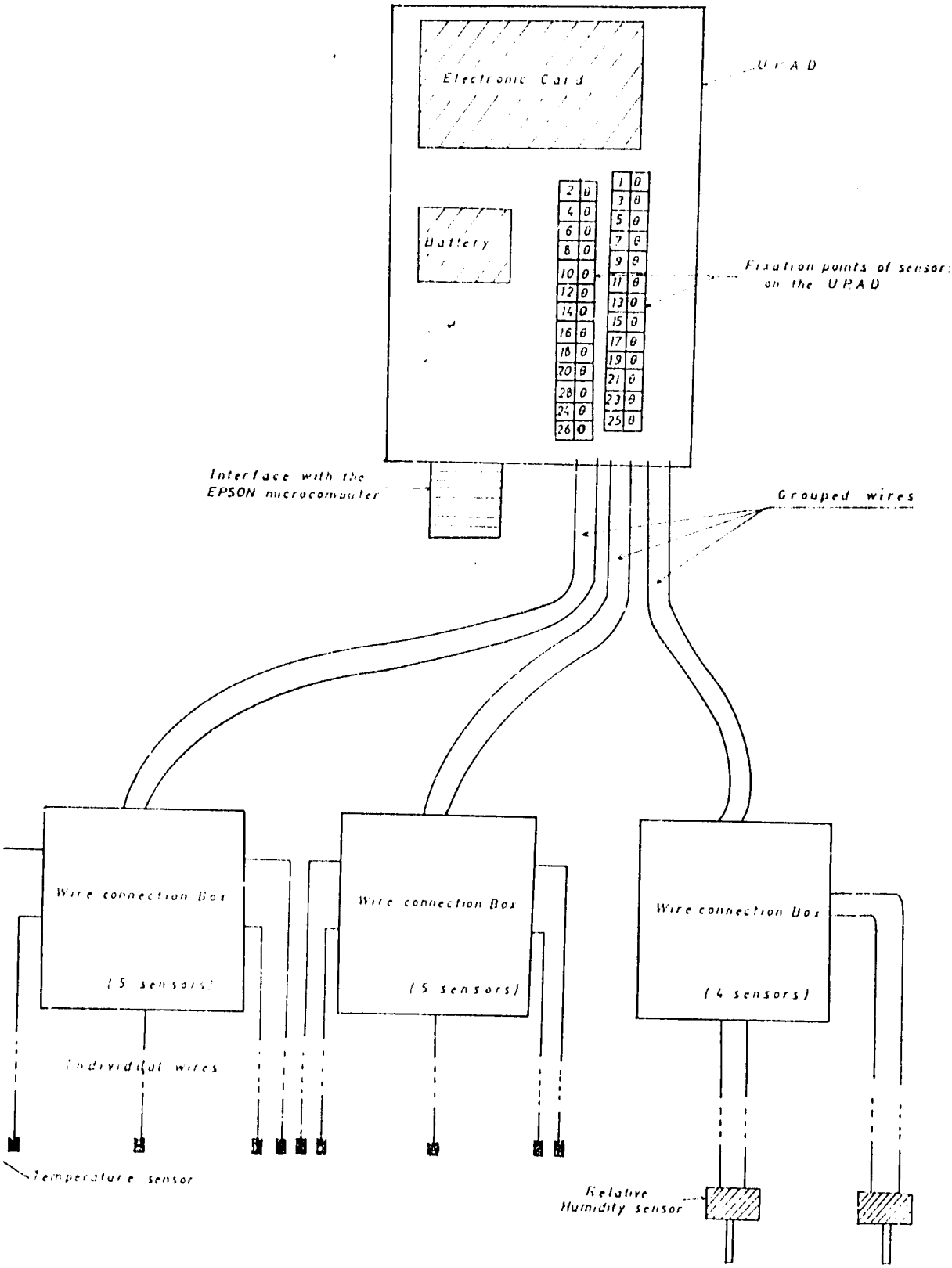


Fig . : Connection of sensors to Portable Data Acquisition Unit (U.P.A.D)

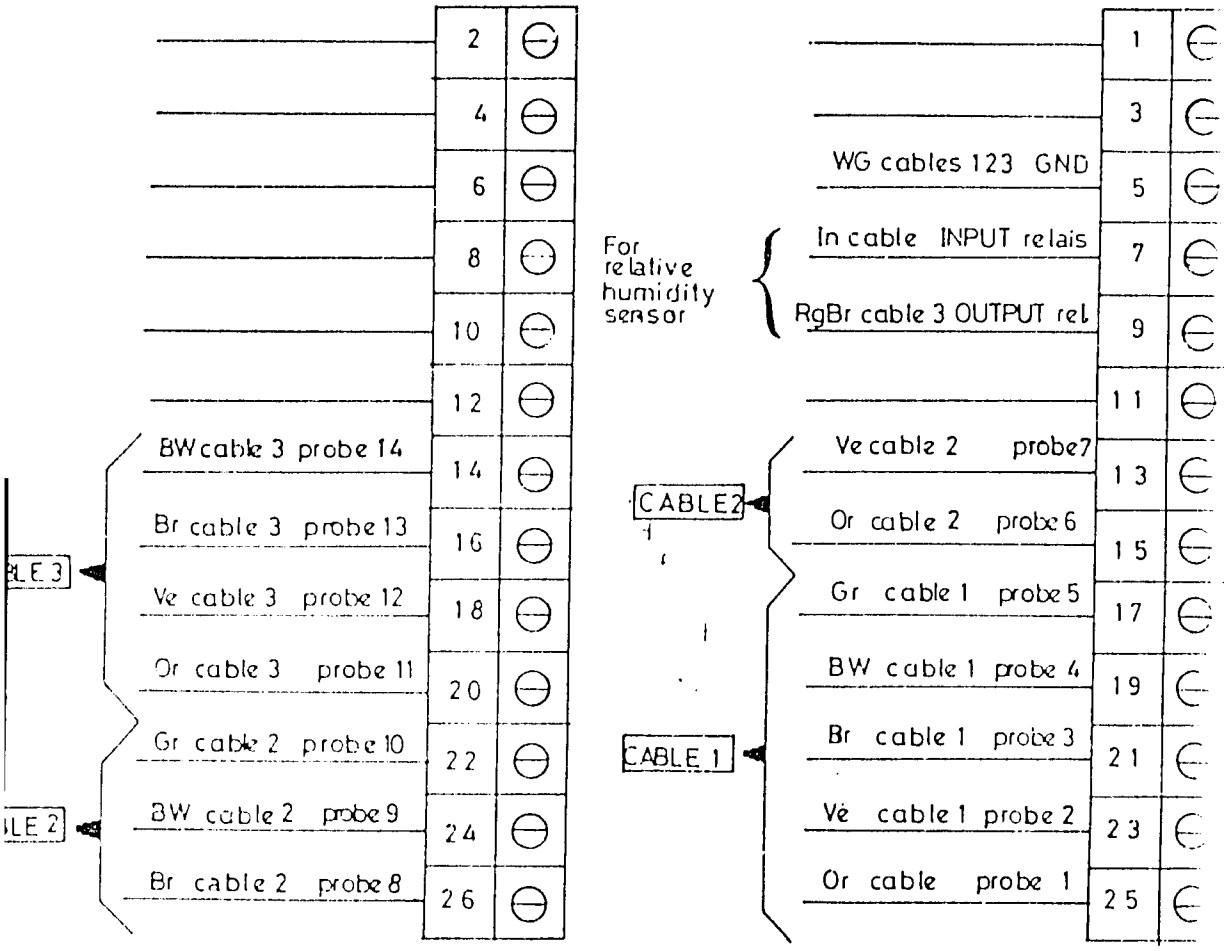


Fig 7 Diagram of connections box in UPAD

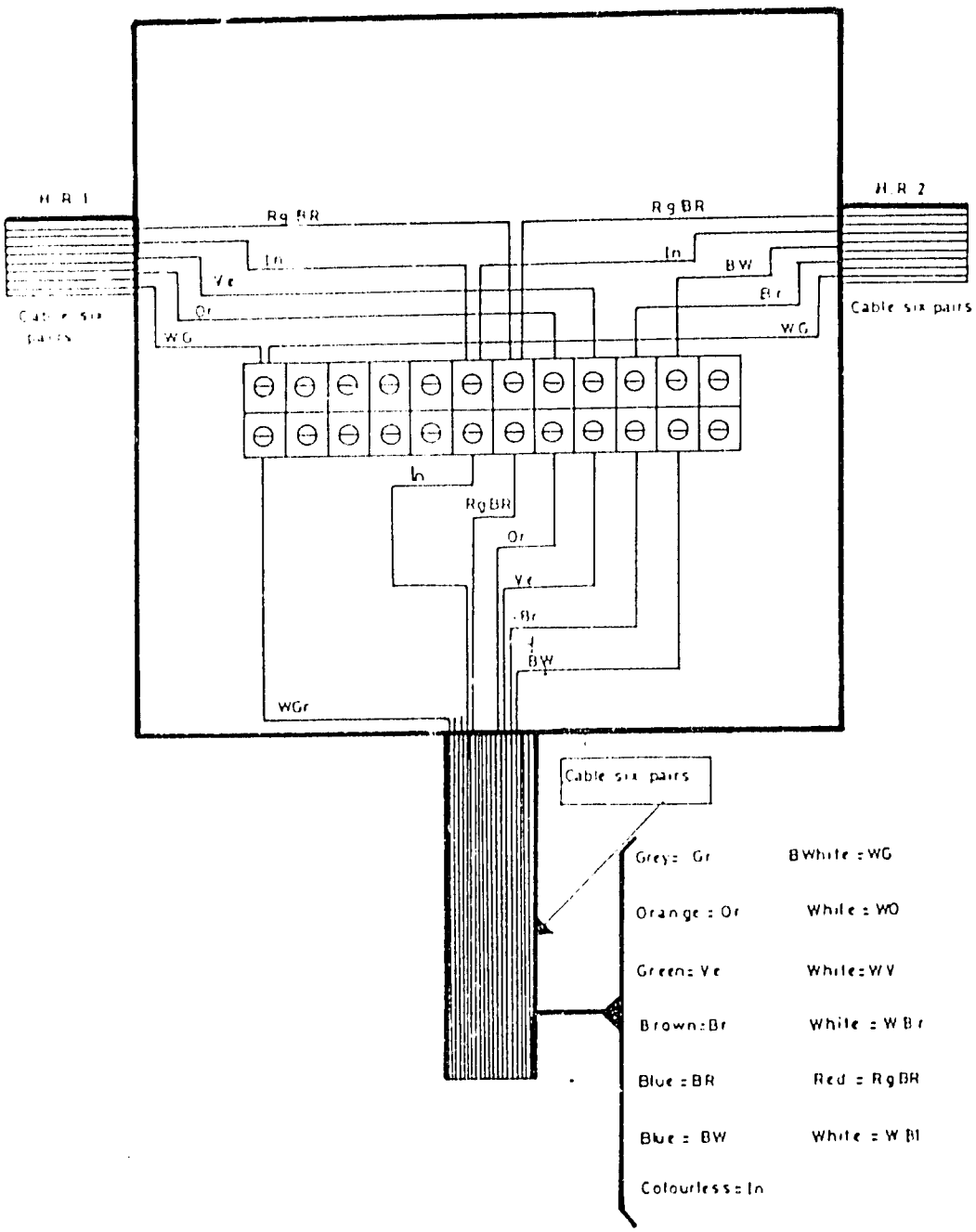


Fig 8 :Diagram of connections box for relative humidity sensor

2.2.3.2. Installation of equipment in the pits

The position of temperature and relative humidity sensors in the pits are shown in Fig.9 and Table 9. Equipment was placed in the pits two days prior to the filling operation. Some pits are intensively equipped (fully instrumented pits) as shown in Fig.10 and others are less equipped (partially instrumented pits) as shown in Fig.11

2.2.4. Baseline sampling and development of analysis procedure

Wheat samples were divided among the participating Departments for analysis according to the flow diagram shown in Figure 12.

2.2.4.1. Agricultural Engineering

The Department of Agricultural Engineering carried out the general grading operation with the contribut'on of the Entomology Department. Results are shown in Tables 1, 2 and 3.

Some characteristics of the purchased grain are shown in Table 4. SOGETA kindly accepted to make them available for this research. These characteristics were determined at "Direction de la Protection des Vegetaux" (DFVCTRF) in Rabat.

Moisture content of whole grain samples was determined in an oven. The results are shown in Table 7.

On the day of filling data loggers (UPAD) were initialised and programmed to record temperature and relative humidity every hour. Values measured on the day of filling are shown in Table 10.

Every week, recorded values of temperature and relative humidity

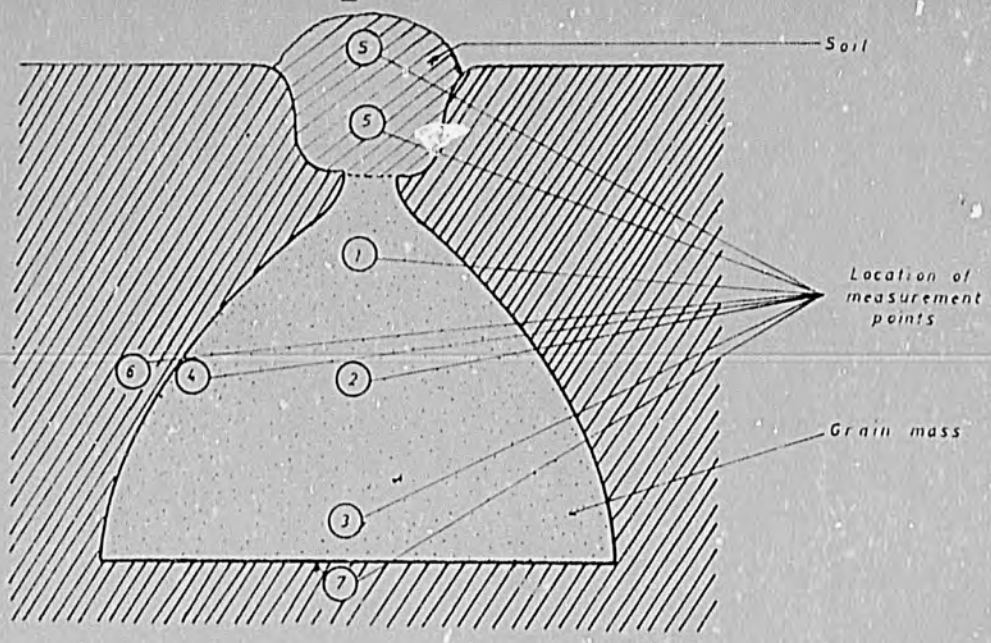


Fig. 9 POSITION OF SENSORS IN A PIT

Table 9: Detail of instrumentation in the 16 pits

Pit N°	Location of thermocouples	Location of relative humidity sensor	Location of CO_2 extraction tubes
1	2		
2	1 2 3 4		1 2 3 4
3	1 2 3 4		1 2 3 4
4	2		
5	2		
6	1 2 3 4 6 7		1 2 3 4
7	1 2 3 4 6 7		1 2 3 4
8	2		
9	2 5		
10	1 2 3 4 5 6 7	2	1 2 3 4
11	1 2 3 4 5 6 7	2	1 2 3 4
12	2 5		
13	1 2 3 4		1 2 3 4
14	2		
15	1 2 3 4		1 2 3 4
16	2		

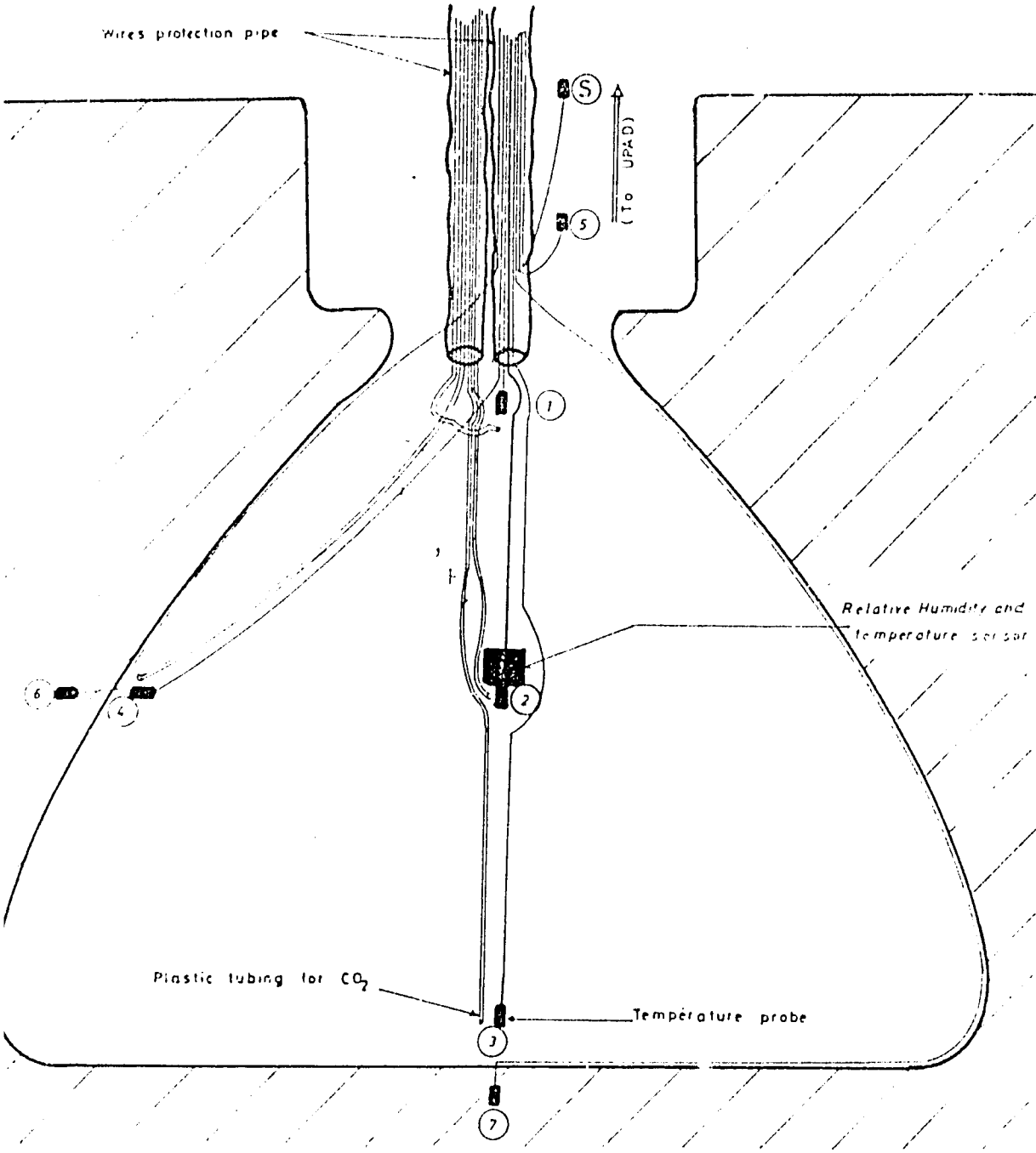


Fig 10 : Diagram of a Fully-instrumented pit

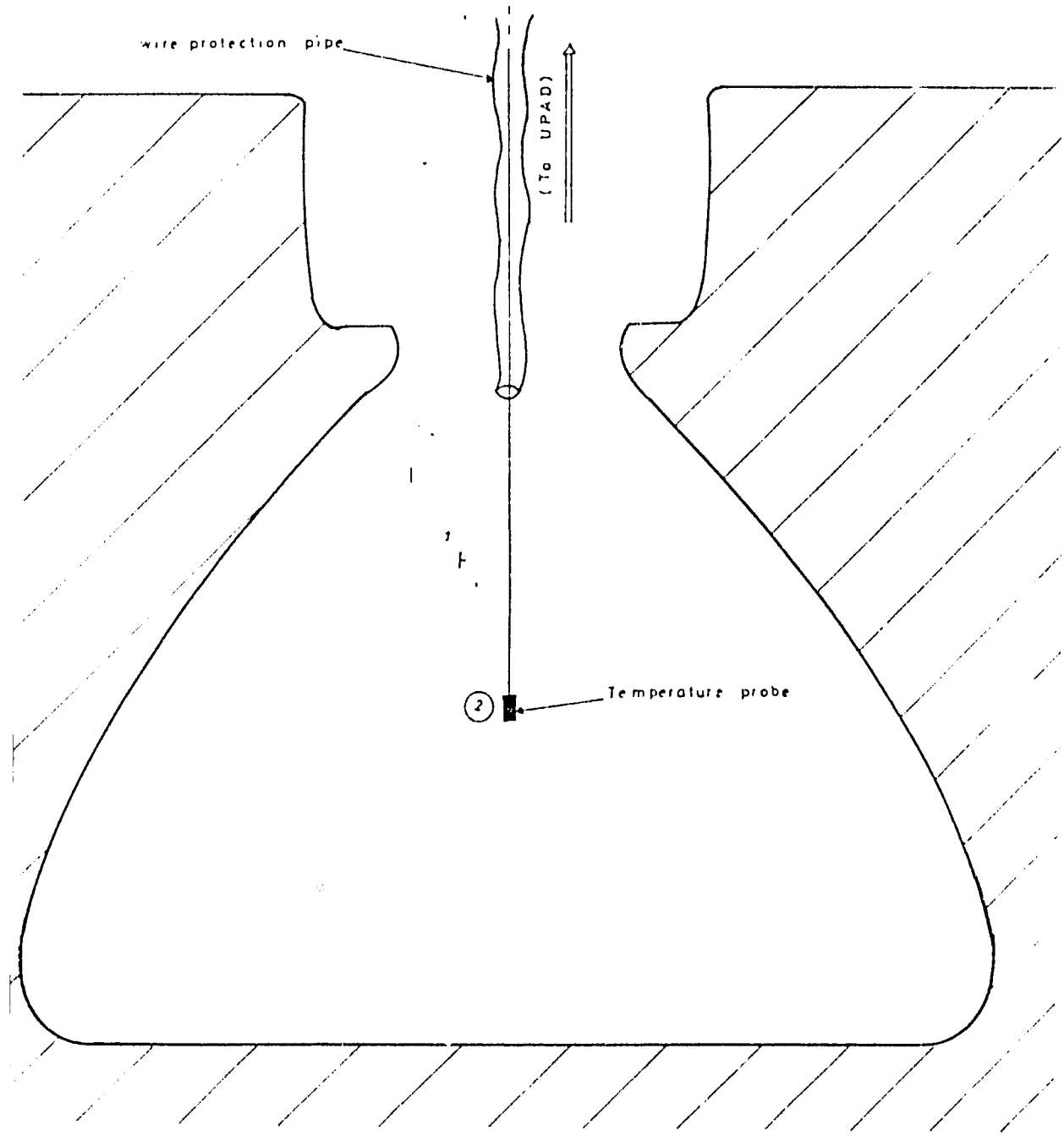
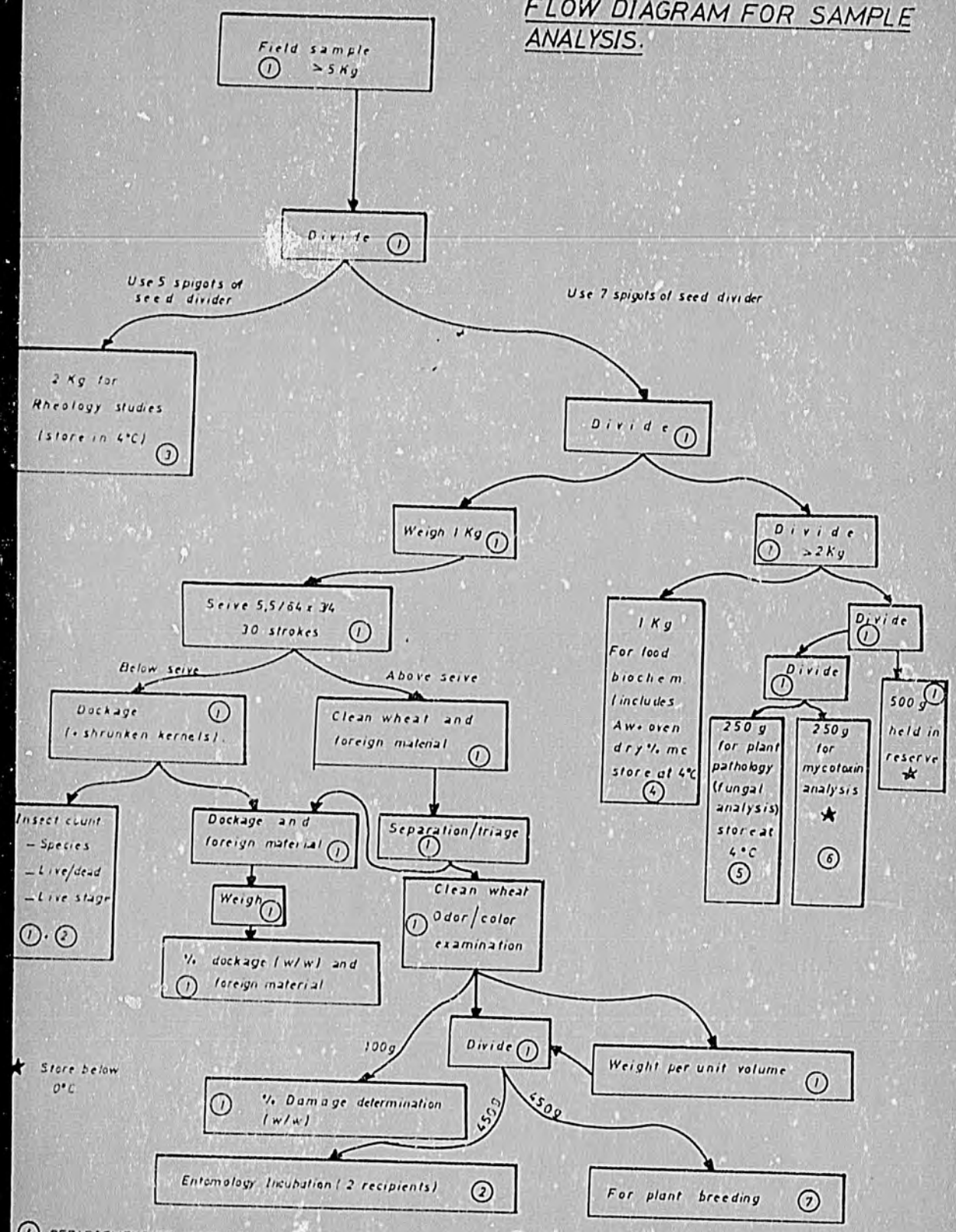


Fig 11: Diagram of a partially-instrumented pit

FLOW DIAGRAM FOR SAMPLE ANALYSIS.



(1) DEPARTEMENT OF AGRICULTURAL ENGINEERING
(2) DEPARTEMENT OF ZOOLOGY
(3) DEPARTEMENT OF CHEMISTRY AND FOOD TECHNOLOGY
(4) DEPARTEMENT OF CHEMISTRY AND FOOD BIOCHEMISTRY
(5) DEPARTEMENT OF PLANT PATHOLOGY
(6) FOOD MICROBIOLOGY AND BIOTECHNOLOGY DEPARTEMENT
(7) DEPARTEMENT OF AGRONOMY AND PLANT BREEDING

FIG. 12

TABLE N° 1 - Percentage of dockage and unit weight

Sub-sample N°	Total weight (g)	Weight of dockage (g)				Remaining weight (g)	% of dockage	Unit weight (g/l)
		Stones	Barley	Small wheat seeds	Other dockage			
1	1000	5.5	7	23.6	0.3	963.6	3.64	777.2
2	1000	6.5	9.5	15.9	0.5	967.6	3.22	777.6
3	1000	5.8	6.9	17.8	0.2	969.3	3.07	779.8
4	1000	5.4	8.6	31.7	00	951.3	4.57	780.4
5	1000	5.4	7.8	14.7	0.3	971.8	2.82	776.4
6	1000	7.1	25.5	18.2	0.2	949.0	5.10	759.8
7	1000	6.2	13.5	22.8	0.3	957.2	4.28	776
8	1000	9.59	6.1	17.5	0.2	966.6	3.34	785.2
9	1000	7.05	13.7	32.2	0.5	946.5	5.35	763.6
10	1000	9.5	8.1	15.85	0.6	965.9	3.41	777.2
11	1000	1.7	12.5	22	0.2	960.6	3.94	766
12	1000	6.05	5.7	13.9	0.2	974.1	2.59	783.2
13	1000	8.4	7.9	12.8	00	970.9	2.91	774.8
14	1000	7.0	7.0	9.8	00	976.2	2.38	781.2
15	1000	8.7	6.4	11.7	0.3	972.9	2.71	780.8
16	1000	7.0	9.55	12.2	0.3	971.1	2.89	777.2
Mean	1000	6.808	9.733	18.291	0.244	964.863	3.514	775.525
Standard deviation	0	1.493	4.905	6.648	0.163	8.993	0.899	7.808
Standard error	0	0.1393	1.504	2.762	0.0017	5.0546	0.0505	3.81

TABLE N° 2 - Cleanliness of grain - insects

Sub-sample N°	Total weight (kg)	Clean grain		Insects			
		Odor	Color	Species	Live	Live stage	Dead
1	1	Normale	Normale	Sitophilus oryzae	-	-	1
2	1	"	"	//	-	-	2
3	1	"	"	-	-	-	-
4	1	"	"	-	-	-	-
5	1	"	"	-	-	-	-
6	1	"	"	-	-	-	-
7	1	"	"	-	-	-	-
8	1	"	"	-	-	-	-
9	1	"	"	-	-	-	-
10	1	"	"	-	-	-	
11	1	"	"	Sitophilis oryzae	-	-	1
12	1	"	"		-	-	1
13	1	"	"	-	-	-	-
14	1	"	"	-	-	-	-
15	1	"	"	-	-	-	-
16	1	"	"	"	-	-	1

TABLE N° 3 - Percentage of damaged grain

-sam- n°	Total weight (g)	Discoloured grain (g)	Insect damaged grains (g)	Shrunken grain (g)	Broken grain (g)	Germinated grain (g)	Other damage (g)
1	100	1.86	0.35	1	0.2	-	0.4
2	100	2.75	0.5	0.9	0.15	-	2
3	100	2.8	0.3	0.6	0.1	-	0.9
4	100	2.5	0.4	1.3	0.25	-	1.3
5	100	3.7	0.3	0.9	0.1	-	1.9
6	100	3.7	0.35	3.3	0.6	-	1.7
7	100	5.1	0.15	1.4	0.1	-	2.7
8	100	6.6	0.1	1.6	0.35	-	4.0
9	100	2.6	0.2	3.1	0.42	-	3.2
10	100	4.3	0.3	1.4	0.2	-	2.3
11	100	3.0	0.2	1.5	0.2	-	2.9
12	100	4.1	0.3	1.1	0.25	-	3.2
13	100	3.1	0.45	2.2	0.2	-	2.1
14	100	4.3	0.2	1.3	0.2	-	2.3
15	100	2.5	0.3	2.8	0.2	-	1.1
16	100	3.5	0.3	1.5	0.1	-	1.5
						-	
an	100	3.525	0.294	1.619	0.226	-	2.094
ndard iation	0	1.178	0.106	0.808	0.134	-	0.954
ndard ror	0	0.0867	0.0007	0.0408	0.0011	-	0.0569

TABLE(") - Moisture content (wb) (1)
of whole grain

Sample n°	Moisture content (%)
1	11.77
2	11.66
3	11.64
4	11.74
5	11.68
6	11.44
7	11.53
8	11.86
9	12.08
10	11.89
11	11.88
12	11.80
13	11.79
14	11.63
15	11.84
16	11.96

(1) Whole grain at 100°C during 72 h.
Ref. FAO.

TABLE 10 - Temperatures of grain and soil, relative humidity measured by UPAD on the day of filling.

	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_S	H.R %
Plastic lined pit	13.5	13.7	13.9	14.8	11.0	13.6	14.8	9.2	52.2 %
Straw lined pit	13.6	14.5	15.5	16.4	11.0	13.2	15.0	8.7	52.5 %

See Fig. 9 - For location of measurement points

are collected. CO_2 levels are measured using colorimetric tubes. Figure 13 shows the variation of CO_2 levels at the center of pit for the first month of storage.

2.2.4.2. Plant Pathology

Dr EZZAHIRI B.

The Plant Pathology Departement has undertaken analysis for both the barley experiment on campus and the wheat experiment underway in Chaoula. The analysis concerning wheat is presented here.

The objectives of the analysis are:

- To test a culture medium for storage fungi
- To identify the kinds of fungi associated with stored seeds.

The pre-storage test for fungi associated with durum wheat seeds are as follow :

For each seed lot, 5 categori..s of grains were caracterized :

1. Whole, apparently healthy grains
2. Grains without embryo
3. Grains with black points
4. Shrivled grains
5. Broken grains

The whole, apparently healthy grains were subdivided into two groups, surface desinfected and non-desinfected.

The other categories were surface desinfected

10 seeds per petri dish with T6 were incubated at 27C.

100 grains per lot were utilized (16 lots).

A detailed report of the results will be prepared where the

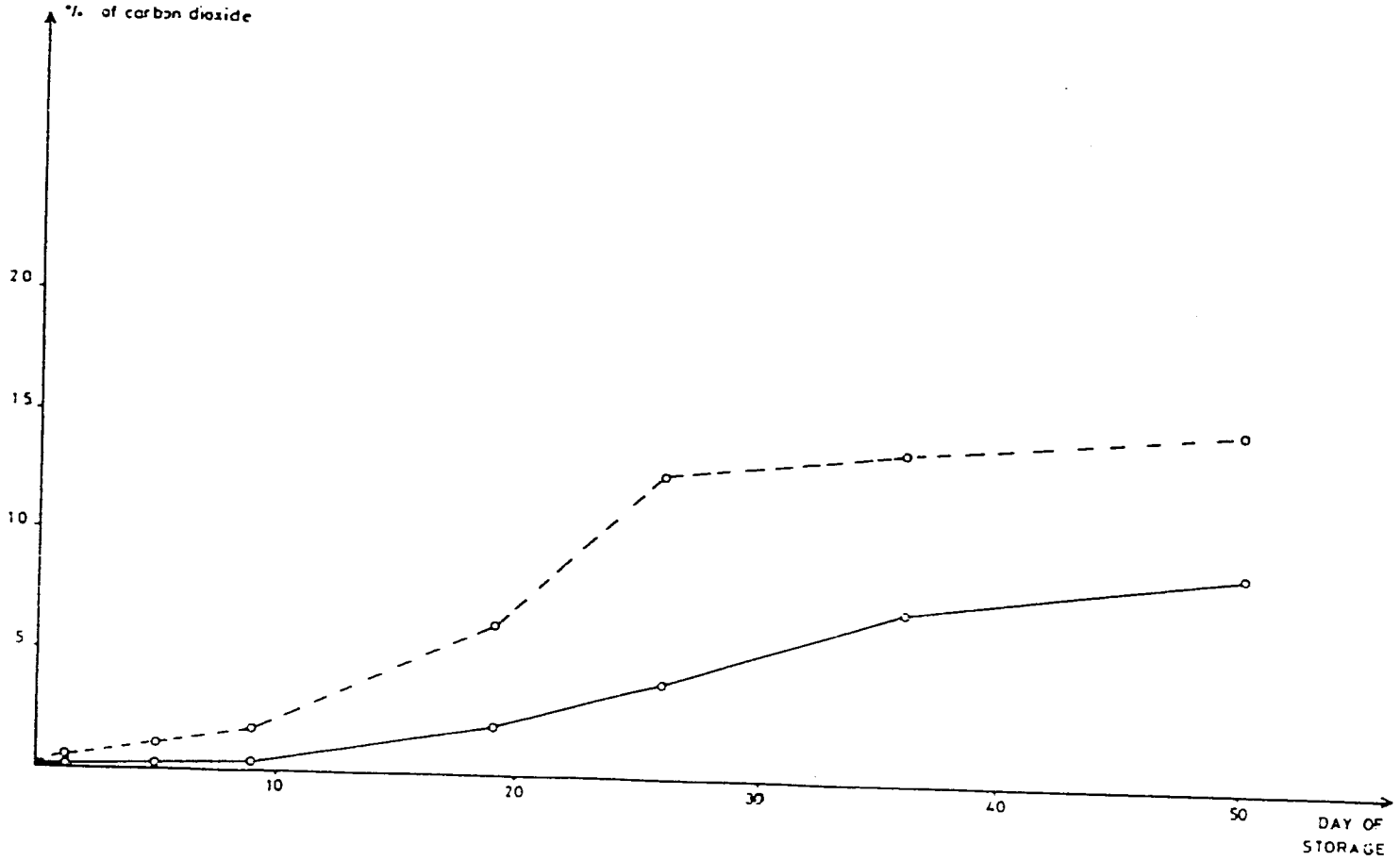


Fig.13 . VARIATION OF CO_2 LEVELS AT THE CENTER OF PITS.

PLASTIC LINED PIT

STRAW LINED PIT

proportion of different kinds of fungi will be presented.

2.2.4.3. Plant breeding

Mr Z.FATEMI

Germination tests were conducted for both barley stored on campus and for wheat used in AID funded research. The results concerning wheat are presented here.

Germination test and planting in the field were accomplished. The samples were planted at the Institute farm at Tadla. The experimental design is a randomnized complete block design with three repetitions. The area of the experimental plots is 4m2.

The germination test was run in the laboratory of the DPVCTRF (Direction de la Protection des Végétaux, Controle Technique et Répression des Fraudes). Thanks are expressed by the author to Mr. TOURKMANI for his help.

From each sample, 400 seeds were counted at random into 4 replicates of 100 seeds. The seed were spaced uniformly between two layers of moistered germinating paper for seven days at a temperature of 20°C exposed to white fluorescent light for 12 hours in every 24 hours and at the relative humidity of 75%. The first count was done after 4 days. During this count, the normal seedlings, and also the rotten seeds and the decayed seedlings were removed and counted. The number of hard and fresh ungerminated seeds were counted at the final count,(Table 5).

Table 5 : Results of the wheat germination tests.

Sample number	Normal seedlings	Abnormal seedlings	Hard seed seeds	Fresh un-germinated	Dead seeds
1	96	2	0	0	2
2	97	0	0	0	3
3	96	2	0	0	2
4	97	1	0	0	2
5	91	4	0	0	5
6	93	2	0	0	5
7	97	1	0	0	2
8	97	0	0	0	3
9	94	3	0	0	3
10	98	1	0	0	1
11	96	1	0	0	3
12	96	2	0	0	2
13	97	0	0	0	3
14	96	1	0	0	3
15	94	3	0	0	3
16	97	1	0	0	2

The germination test shows that there is no difference between the samples. So the seed used for underground storage is uniform concerning the germination

2.2.4.4.Entomology :

Mrs. K.BOURARACH

The Entomology Departement carried out analysis of insects population for both barley storage on campus and wheat storage at Chaoula

The samples were then incubated at 27°C under binocular microscope, two species of Coleoptera were identified:

1. Rhizopertha Dominica F. (the lesser grain borer).
2. Sitophilus Oryzae L. (Rice weewil)

Regarding wheat storage, an examination of wheat kernels was conducted before storage. The kernels are now under incubation (27°C). The results will be presented in the next report.

Examination of wheat samples showed the presence of lepidopter : a white caterpillar. Complete identification will be given.
First control of 16 samples under binocular was made before incubation. Healthy kernels were separated from broken or abnormal kernels. (kernels with black spots, or colored). All the samples are incubated in a controlled atmosphere room at 25-30°C.
The next control is scheduled for February 10 th.

2.2.4.5. Food Chemistry and Biochemistry

Dr.BEN JILALI

Wheat samples were ground and placed in an isothermal oven at air pressure. A temperature level of 105°C was applied in the oven during a period of 4 hours and a half until a constant weight was reached (French standard NF V03-903, April 1966). The percent humidities are shown in Table 6 .Analysis regarding humidity, water activity, lipid content, lysine, thiamine will be performed as ordered chemicals arrive.

2.2.4 6 Molds and Mycotoxins study

Mr GOURAMA .Dr TANTAOUI

Preliminary determination of the first sample mycoflora was investigated. The following technics were used : serial dilution technic and direct plating technique. In the direct plating technic, the grains were placed on the agar with and without surface desinfection. The grains were desinfected using 50% NaHClO solution (bleach) for 1 min and washed with distilled sterile water, they were then evenly space on agar on a Petri dish and lightly pressed into the

TABLE 6 : Moisture content of grain samples

Sample N°	% Humidity (wt percent)
1	10.9
2	11.0
3	10.9
4	10.7
5	11.0
6	10.8
7	10.6
8	11.0
9	11.1
10	11.0
11	11.1
12	11.3
13	11.4
14	11.0
15	11.1
16	11.5

agar. Different media were used : Potato Dextrose agar, Malt extract agar, Czapeck-Dox agar and malt extract agar + chlortetracycline (40 mg/l) + NaCl (7.5 %).

The occurrence of mold is recorded in percentages in the direct plating technic while in the dilution technic, the plates are counted.

There are two major problems encountered during this first preliminary study with direct plating technique. First the growth of the fast growing species such as the mucorales and second the seed germination. However, the use of malt extract supplemented with salt and chlortetracycline retards the growth of the mucorales and prevents the seed germination. The desinfection of the grains surface inhibited only the growth of the mucorales.

Concerning the mycoflora encountered it is too early to give final results but it seems that there is a dominance of Aspergilli and Penicillia plus other unidentified genera.

For the mycotoxin analysis, a multidetection method was chosen to search for three mycotoxins : Ochratoxin. A, Zearalenone and aflatoxin B_1. Due to the delay in the delivery of some chemicals and equipment, the analysis is not done yet. However, the preliminary study of the analysis is under investigation.

2.2.4.7.Food Science

Mr. BAKHELLA Mohamed

I - Introduction

Within the Moroccan rural community, it is a common knowledge that wheat stored in underground pits yields, very often, end-products of improved quality. Whether this comes from rheological and/or

fermentative changes is unknown.

Through the proposed studies two objective were sought :

1. First, it is of interest to see whether or not a relatively long-time storage in a confined atmosphere affects somehow the rheological properties of dough such that its bread-making characteristics will be significantly affected.

2. Second, and from the analysis of Alpha-amylase activity, possible changes in fermentative quality will be roughly assessed (in terms of the total carbon dioxide produced during fermentation).

Wheat grown in Morocco is predominantly durum wheat used for couscous and pasta production, and commom wheat (called "soft" wheat) used for bread or pastry. An interesting reality in Morocco is that durum wheat is also used for bread making, and in some regions, people prefer bread made out of durum wheat to common wheat. Wheat that has been stored is a durum wheat (tetraploid cereal specie) cultivar called 2909 or Oued Zenati. Conventional rheological tests were normally designed to test flours issued from common wheats (hexaploid specie). This is why the number of tests to be performed has been limited to one, that is the mixograph test. Furtheremore, in case of a rheological change (if any), one test is sufficient to detect it since the ultimate result of one or several tests is essentially the same.

This first research report deals with the knowledge of wheat characteristics before getting stored. The "Hagberg test" for alpha-amylase activity has been performed on 16 samples of the same wheat lot. This was done using the apparatus of another research institution, because the order we made was canceled due to some budget restrictions. The mixograph test will be delayed till reception of the equipment. Concerning the sensory evaluation, the author was not supposed to undertake it. A tentative method for this evaluation based

on the opinion of the farmer, is considered by the research team.

II - MATERIALS AND METHODS

II.1. Introduction to the falling number test (Hagberg test)

The type and quantity of amylases in flour are important in baking. Amylases provide fermentable sugars for yeast during the fermentation process. This is realized by amylolytic action at 25-45°C because yeast activity ceases at 45-50°C (1). Commonly bakers and millers use the falling number test to evaluate alpha-amylase activity in ground grains. The measurements obtained permit them to adjust alpha-amylase activity to the desired level, either by addition of malt or by blending flours of different alpha-amylase activities. This appears beneficial where wheat sprounting is not a big problem and where flour blending is possible. This method is based upon rapid gelatinization of a flour suspension and subsequent measurement of degradation of the starch paste by alpha-amylase, under conditions similar to those encountered in baking (2) : this test has been found to give reliable results over a wide range of alpha-amylase activity (3). In contrast, it has been reported that the falling number measurements suffer from several sources of errors (4). Some falling number ranges were recommended by the U.S. Department of Agriculture :175-350 seconds : flour all purposes : 200-300 seconds : bread flours.

II.2. Procedure (AACC Method : 56-81 B)

7.00 grams of ground meal meeting granularity specifications were weighed and put into a dry falling number tube tipped to 45 angle. Then 25 ml of water were added. The rubber stopper was inserted

and the tube was shaked in upright position (up and down) 10 times, making sure that all flour particles were suspended by upending. The upper part of the tube was scraped with the viscomete-stirrer. The stopper was removed from bath well, and simultaneously the timer was started and the tube placed in the bath (100 °C) and locked into position (taking no more than 5 seconds). Thereafter, the sample was stirred with the viscometer-stirrer at a rate of 2 strokes per second until the clock reached 60 seconds. This was stopped with the stirrer in up-position. When the stirrer has gone thru the suspension, the timer was automatically stopped and the time (in seconds) was recorded as a falling number. To calculate the falling number on 14 % moisture basis, the following formula was used :

$$\text{F.N (as-is)} \times \frac{100 - 14}{100 - \text{moisture (\%) of sample}} = \text{F.N. (14 \% m.b.)}$$

III - RESULTS AND DISCUSSIONS*

TABLE 8 - Falling number results

Replications	Falling number as - is	Falling number reported to 14% m.b.
1	624	608
2	720	701
3	704	685
4	727	708
5	753	733
6	748	726
7	647	629
8	658	642
9	642	628
10	695	678
11	608	593
12	650	634
13	694	677
14	619	602
15	670	654
16	727	710
Mean	680.38 ; Ú=46.92 V.C= 6.90%	Mean : 663.00 ; Ú=45.34 V.C. =6.84 %

* These tests were carried out by the techniciens of the National Institute of Agronomic Research. Their technical assistance is acknowleged.

Discussions : Values of Table 8 were evaluated using moisture content of grain sample shown in Table 7 . These results show that the wheat analysed is very hypodiastasic. This will be taken as a blank test for possible changes that may occur during storage.
It seems that the numbers are abnormally high. The reasons for this are not clear. The nature of wheat (durum wheat) may account for that.

LITTERATURE INDEX

1 - PERTEN, H. (1984). A modified falling-number method suitable for measuring both cereal and fungal alpha-amylase activity. Cereal Chem. 61 (2) : 108-111.

2 - PERTEN, H. (1984). Application of the falling number method for evaluating alpha-amylase activity. Cereal Chem. 41 : 127-140.

3 - HAGBERG, S. (1960). A rapid method for determining alpha-amylase activity. Cereal Chem.. 37 :218-222.

4 - HAGBERG, S. (1978). Factors affecting the reading of falling number measurement. Milling feed and fertilizers CLXI (3) : 16-18.

3.0. VISITORS TO PROJECT

3.1. Prof. Etienne PERSOONS and Mr. GHIOOT

In April 1987 the Director of the institut visited the experiment site on campus . He was accompanied by the chief of Cooperation Division in Belgian Embassy Mr Ghioot,Dr. E.Persoons, head of Agricultural Engineering Department at the University of Louvain La Neuve Belgium . Dr Persoons who was visiting the Department of Agricultural Engineering of the Institut attented the intallation of temperature equipment and the filling of pits.

3.2. Minister of Agriculture

His Excellence the Minister of Agriculture of Morocco, Mr.Othmane DEMNATI visited the experiment site on grain storage on campus on Friday July 31st, 1987. It was an opportunity to inform the Minister of the research carried out on grain storage by the Agronomic and Veterinary Institute and of the AID Washington Grant in particular. Several faculty members representing the Department participating in grain storage research were introduced to the Minister who expre ssed his encouragements to the research team.

3.3. AID Mission

Mr. HANAFI from AID Mission in Rabat made a visit to the experiment site.He was accompanied by,during this visit by two grain storage experts. Dr Bartali presented the objectives and approach of the research undertaken on grain storage at IAV.

3.4. Visitors on World Food day

Friday October 16 th, 1987 was World Food Day. A group of the eminent persons visited the experiment site on IAV campus. Mr.ALAOUI, General Secretary of Ministry of Agriculture , FAO Mission Director in Rabat Mr. KORTAS, Director of COMAPRA (Morrocan Company at Agricultural Products), Head of Extension Directorate Mr. BEN SOUDA, Head of Division of cooperation in Ministry of Agriculture Mr. CHELOUATI, Dr. SEDRATI, and Mr. FIRDAWCY respectively Director and General Secretary of The Agronomic and Veterinary Institute. The experiment objectives and the approach of the investigation on grain storage at IAV,were commented to the visitors.

3.5. Dr. Florence DUNKEL

During November 1987, Dr. Florence DUNKEL, principal coinvestigator, attented the opening of the two barley pits on campus. Her visit was an opportunity to check the ordering of equipment with Morrocan coinvestigators from the following Departments : Dr. EZZAHIRI B. (Plant pathology), Mr. FATEMI Z. (Plant Breeding), Dr. BENJILALI (Food Chemistry and Biochemistry), Mrs. BOURARACH.K (Entomology), Mr. BAKHELLA (Food Tlence), Mr.GOURAMA.H (Microbiology). Dr. DUNKEL F. along with the principal investigator also met with Dr. SEDRATI M. (Director of IAV) Mr. FIRDAWCY L. (General Secretary of IAV), Dr JOHNSON D. (Team Leader, Minnesota Project at IAV), Mr. HELLEYER R. (Project Officer AID Mission Rabat).Dr. DUNKEL met Dr. AIT KAI M. Chairman and DEBBARH HAFID, coinvestigator from the Agricultural Enginneering Departement, during her stay. Dr. DUNKEL was also able to visit the experiment site in Chaouia and meet wihth the

farmer.

3.6. Dr. GUSTAFFSON R.

The chairman of the Agricultural Engineering Department at Ohio State University Columbus, Dr. GUSTAFFSON R. visited the experiment site in Chaoula on January 21 st 1988. Dr. GUSTAFFSON is a major advisor for a doctoral research on applying numerical models to predict heat and moisture transfer in a stored grain mass. This research is being carried out by an IAV Faculty member, Mr. Driss Massahou from Food Engineering Department. The theoretical numerical model once completed well become a useful tool to process the temperature and moisture data collected from the experiment carried out at I.A.V.

3.7. Farmers

On Monday January 25 th, Mr. MAMDOUH Bouchaïb and MAMDOUH Haj Ahmed, the brother farmers who host the experiment in Chaoula were invited for a one day visit to IAV by the Director Dr. SEDRATI IAV. Research activities on grain storage were presented to the farmers who were received by the Director and the General Secretary of IAV. The farmers were able to tour some Departments such as Agricultural Engineering, Plant Pathology, Zoology, Plant Breeding, Microbiology. The farmers were encouraged by IAV Director and General Secretary to extend invitation to farmers from around the experiment site in Chaoula to visit IAV and know more about its research activities in general and grain storage research in particular.

3.8. Moroccan Television

On Tuesday January 26 th, Morrocan Television prepared a first report on the ongoing research on grain storage at IAV. Dr. BARTALI H. the principal investigator commented the research plan including the IAV and Chaouia experiment sites. A presentation of this research was made on the Moroccan TV on Wednesday 27th. Emphasis was put on IAV contribution to promote appropriate storage technologies and reduce grain losses.

4.0. PLANS FOR THE NEXT SIX MONTHS

4.1. First opening of pits

On March 30th, 3 months after the filling , 4 pits will be opened (2 straw lined and 2 plastic lined). Sampling and analysis will be carried out by the research team. About 50 metric tons of grain will be taken out of the experiment site, bagged and transported to Rabat, sampling will take place on site.

4.2. Visit of Dr F.Dunkel

A second visit one week long is scheduded for Dr F.Dunkel (principal coinvestigator) at the time of the first opennig of pits and analysis of grain simples(End of March 1988).This visit is important because it will strengthen the efforts of the research team to coordinate its work regarding adeguate analysis of grain samples.

4.3. Reuse of grain for a long term storage

It is planned to use part of the wheat taken out of the 4 opened pits on March 30, to fill 2 underground pits similar to those on the farm site in Chaouia which will be installed on the Institute Campus in February 1988. The wheat will be kept stored in these pits for a much longer period (5 years). This experiment will permit to investigate the evolution of quality of grain when the latter remains underground for longer periods. This long term storage used to be practiced by some farmers and may still take place when the farmer's situation permits. This long term storage goes beyond the time limit of the AID sponsored project, but its results will be beneficial to the research on underground storage. The choice of Institute Campus to extend this experiment is made in order to reduce costs and avoid any disturbance to the farmer who is hosting the present experiment.

4.4. Second pits opening

The second pits opening is scheduled for the end of June 1988, i.e six months after the filling . 4 pits will then be opened (2 straw lined and 2 plastic lined). Sampling of grain from pits will be carried out on site in the same way as for the first opening. This second opening will coincide with the visit of Dr. Raymond sterling (Principal coinvestigator) to Morocco.

4.5. Completion of procurement and installation of part of equipement

The equipment ordered from abroad will still be arriving during the next months. Its testing and installation will then take place.

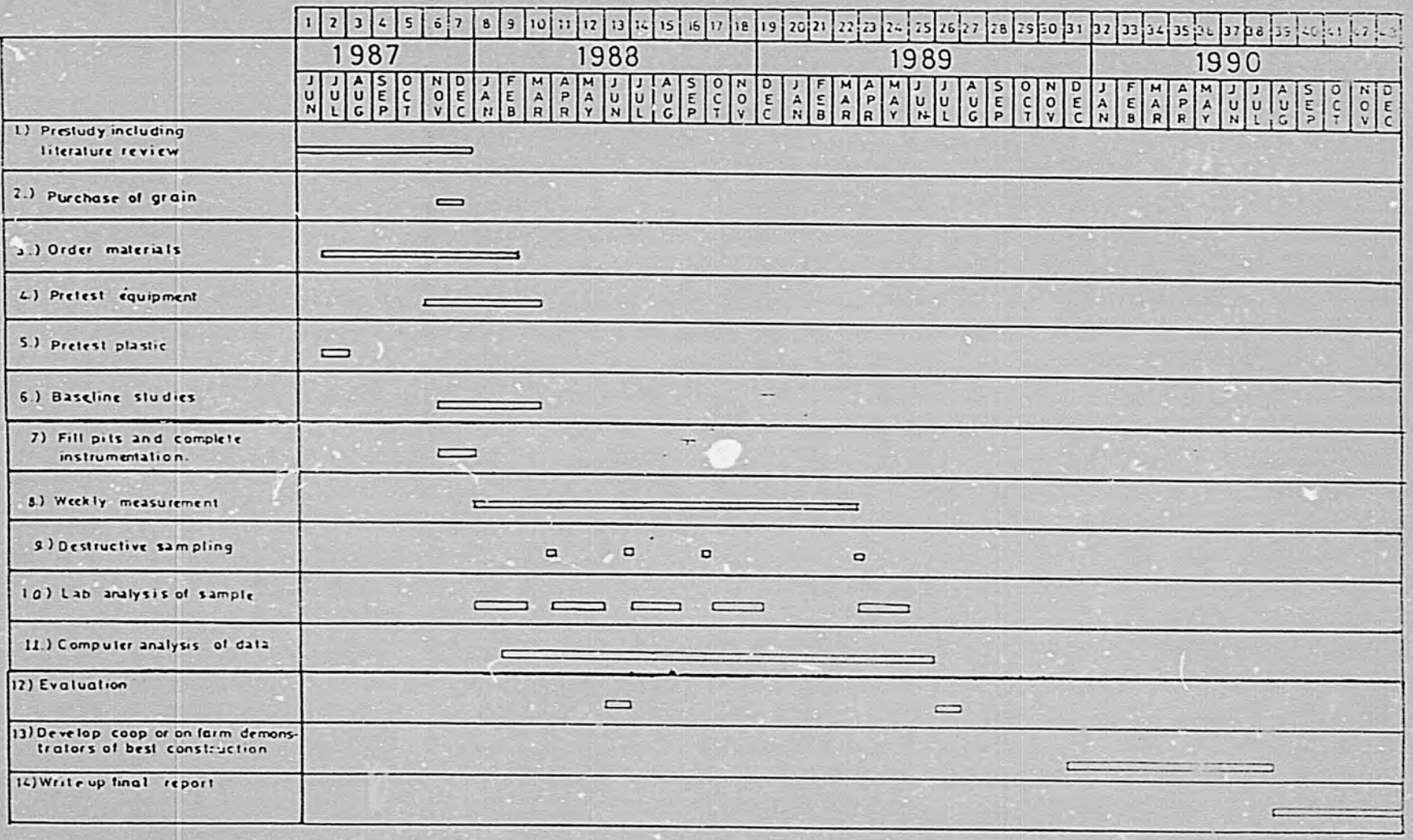
4.6. Possible visitors

Several visits are planned to both the experiment site in Chaouia and to the one campus. These visits will enable researchers, maroccan farmers, extension peopole know about the ongoing experiment. The next progress report will summarize and comment these visits.

5.0. Revised Gnatt chart for project

A revision of the Gnatt chart is shown in Table 11. This revision was necessary to cope with new planing condition .

TABLE 11 : Revised Gnatt Chart



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FINANCIAL STATUS REPORT

(Follow instructions on the back)

1. FEDERAL AGENCY AND ORGANIZATIONAL ELEMENT TO WHICH REPORT IS SUBMITTED: Agency for International Developement Office of Science Advisor

2. FEDERAL GRANT OR OTHER IDENTIFYING NUMBER:

OMB Approved No. 80-R0180

PAGE 1 OF 1 PAGES

3. RECIPIENT ORGANIZATION (Name and complete address, including ZIP code)
Agronomic and Veterinary Institute B.P.6202
Rabat-Instituts Rabat - Morocco
Tél.7 717-58 Telex AGROVET 31873 M

4. EMPLOYER IDENTIFICATION NUMBER:

5. RECIPIENT ACCOUNT NUMBER OR IDENTIFYING NUMBER: DPE -5542 - G -SS-7030-00

6. FINAL REPORT: ☐ YES ☒ NO

7. BASIS: ☒ CASH ☐ ACCRUAL

8. PROJECT/GRANT PERIOD (See instructions)
FROM (Month, day, year): August 31/1987
TO (Month, day, year): December 31/1990

9. PERIOD COVERED BY THIS REPORT
FROM (Month, day, year): August 31/1987
TO (Month, day, year): December 31/1987

10. STATUS OF FUNDS

PROGRAMS/FUNCTIONS/ACTIVITIES ►	(a) Salaries	(b) Equipment supplies	(c) Travel Transport	(d) Other Direct Costs	(e) Indirect costs	(f)	TOTAL (g)
a. Net outlays previously reported	$ 0	$ 0	$ 0	$ 0	$ 0	$	$ 0
b. Total outlays this report period	4,928	18,227	3,264	79	1,000		27,498
c. *Less:* Program income credits	0	0	0	0	0		0
d. Net outlays this report period (*Line b minus line c*)	4,928	18,227	3,264	79	1,000		27,498
e. Net outlays to date (*Line a plus line d*)	4,928	18,227	3,264	79	1,000		27,498
f. *Less:* Non-Federal share of outlays	0	0	0	0	0		0
g. Total Federal share of outlays (*Line e minus line f*)	4,928	18,227	3,264	79	1,000		27,498
h. Total unliquidated obligations	0	0	0	0	0		0
i. *Less:* Non-Federal share of unliquidated obligations shown on line h	0	0	0	0	0		0
j. Federal share of unliquidated obligations	0	0	0	0	0		0
k. Total Federal share of outlays and unliquidated obligations	4,928	18,227	3,264	79	1,000		27,498
l. Total cumulative amount of Federal funds authorized	21,000	59,566	30,820	11,340	12,274		135,000
m. Unobligated balance of Federal funds	16,072	41,339	27,556	11,261	11,274		107,502

11. INDIRECT EXPENSE
a. TYPE OF RATE (*Place "X" in appropriate box*) ☐ PROVISIONAL ☐ PREDETERMINED ☐ FINAL ☐ FIXED
b. RATE: 10 %
c. BASE:
d. TOTAL AMOUNT: 12,274
e. FEDERAL SHARE:

12. REMARKS: *Attach any explanations deemed necessary or information required by Federal sponsoring agency in compliance with governing legislation.*

13. CERTIFICATION
I certify to the best of my knowledge and belief that this report is correct and complete and that all outlays and unliquidated obligations are for the purposes set forth in the award documents.

SIGNATURE OF AUTHORIZED CERTIFYING OFFICIAL: Le Directeur de l'Institut Agronomique et Vétérinaire Hassan II

TYPED OR PRINTED NAME AND TITLE: Director of Institute
Dr. Mohamed SEDRATI
Signature

DATE REPORT SUBMITTED: February 22nd 1988

TELEPHONE (Area code, number and extension): 212 7 717 58

269-102

STANDARD FORM 269 (7-76)
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- Expenditures are made in dollars and local currency in Morocco (dirhams).

- Expenditures in dollars are based on information obtained from University of Minnesota up to December 31.

- Rate used in preparing financial status (between dollar and dirham) is 1 $ = 7.82 DH.

- Chèque from USAID arrived to Institute on January 7th 1988.