R2186(S)

Investigations into the causes and prevention of heating and discoloration ('Stackburn') in bag stored maize

Report No.6: Visit to Zimbabwe and Ghana to participate in the implementation of trials on stackburn in stored maize.

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TERMS OF REFERENCE - ZIMBABWE

1. To advise the University of Zimbabwe (UZ) and Grain Marketing Board (GMB) staff on the suitable location and installation of monitoring equipment in two 1,500 tonne experimental stacks of maize stored outdoors at Mvurwi GMB depot.

2. Confirm methodology used for sampling instrumented sacks.

3. Give instruction on the use of Delta-T dataloggers for collecting and downloading data.

4. Develop a protocol for measuring carbon dioxide inside the experimental stacks.

5. Obtain samples of maize used for the stacks and organise their air freight back to NRI.

TERMS OF REFERENCE - GHANA

1. Provide advice on stack instrumentation and data handling for proposed experimental stack trials in Ghana.

2. Discuss detailed questionnaire results concerning maize storage and stackburn in Ghana; implications of storage conditions to potential development of stackburn (Prof. Odamtten, Dr J Allotey, Mr J Edwards).

3. Purchase different types of polypropylene bags (Poly Sacks) for Dr New's experimental studies.

CONCLUSIONS

In both Ghana and Zimbabwe the training and other tasks were completed. This was helped by the fact that the trials were started during the visits and became part of the training activities.

ACKNOWLEDGEMENTS

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INTRODUCTION

1. As part of the EC DGXII project (TS3*-CT92-0097) "Investigation of maize stackburn in national stocks of stored maize in sub-Saharan Africa", experimental trials are planned in Zimbabwe and Ghana. In Zimbabwe the trials will evaluate differences in stackburn potential between commercial and communal maize stored in woven polypropylene (wpp) and jute sacks. In Ghana the trials will monitor maize stored in ventilated and non-ventilated warehouses for temperature, quality criteria and incidence of insects and fungi.

2. The author visited both countries to provide advice, training and assistance to the project collaborators, University of Zimbabwe (UZ) and University of Ghana (UG), for the implementation of trials.

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3. Training and advice on the experimental techniques to be used in the trial were given to Professor Giga of UZ. This included familiarisation with the sensors and methods used for measuring temperature, moisture content and carbon dioxide changes; and training in the use of Delta-T dataloggers for recording temperature data. The temperature and moisture sensors to be used were thermistors and Reethorpes respectively, which were taken from a used batch at the Grain Marketing Board (GMB) Aspindale Depot. Carbon dioxide is to be measured by placing tubes in the stacks and drawing out samples via detector tubes using a bellows. Advice was given on the design of recording sheets for manual recording of moisture content data during the trial.

4. The experimental methodology for the planned trial, particularly the nature of the stored maize stacks and the position of sensors within them, was discussed and agreed

with Prof. Giga. The author recommended a change to the sensor position plan devised in June 1994. This was to place greater emphasis on monitoring conditions in the interior of the stacks, where stackburn is known to occur, rather than conditions at the outer regions of the stacks. It was also agreed to have a small number of extra sensor positions in each stack. Prof. Giga decided to increase the number of positions with moisture content sensors to include all temperature sensor positions as, in his view, moisture content changes may have a significant effect on stackburn development.

5. The procedure for sampling the maize for quality analysis during stack building was discussed and agreed. 250g samples were collected at each sensor position at the time of sensor installation. These samples were placed in labelled cloth bags and the analysis was later undertaken at UZ. Specific advice was given on the method of sampling for accurate moisture content analysis by oven drying using the International Standards method (ISO 6540). 50g samples of grain taken from alongside each Reethorpe during stack building and placed in labelled metal tins and sealed. The oven moisture content determinations were later undertaken at GMB.

6. The facilities for measuring moisture content to international standard at the Aspindale GMB Depot were inspected. They appeared adequate except for a lack of oven gloves, grease for desiccators and spatulas for handling milled samples. This deficiency has since been rectified by NRI.

7. Plans of the experimental stacks and the sensor positions to be used are shown in Appendix A. Two stacks are planned: one of jute sacks, one of wpp sacks. Each stack will consist of two halves: one of commercial maize and one of communal maize. Identical planes of sensors are to be positioned across the width of the stacks in the

centre of each of the four halves, with positions concentrated in the interior of the stack. The layout of sensors corresponds to that in Annex 3 of report R2140(S) (Phillips and Donaldson, 1994) except that sensor positions were added at the top and bottom centre of each plane to confirm that the response of the stack to the changing climate is normal. Sensors were also placed at the surface of the stacks, in the outside air and at the interfaces of the communal and commercial maize in each stack.

8. The site for the trials is the GMB Mvurwi depot which is approximately 100km north-west of Harare. Both stacks will be built on pole dunnage using normal stacking techniques and will be covered with tarpaulins. Maize for the trials will be fresh intake, re-bagged in jute sacks as appropriate. The stacks will be fumigated and aired according to normal practise.

9. Detailed training in the preparation and installation of the sensors was given to Mr Lazarus Chigwere of UZ and Mr Titichonga Mudzonga, Mr Tendai Chasauka, Mr Levius Nyakudya and Mr Richard Nyanhanga of GMB. Construction of the jute stack began during the training period so the author was able to participate in preparation and installation of the monitoring equipment. This training enabled the counterparts to duplicate installation in the wpp stack after the author's departure.

10. Four sacks of maize (50 kg each) and ten empty wpp sacks were purchased from GMB Mvurwi Depot and taken to the Research Department at the GMB Aspindale Depot. It was fumigated by GMB staff using phosphine on Prof. Giga's recommendation, as in his view the normal fumigant (methyl bromide) can affect germination rates. The GMB Assistant Research Manager agreed to ship the maize and sacks to NRI and IICT, the Portuguese ECDGXII collaborators.

GHANA

11. Training and advice were again given on the experimental techniques to be used. The sensors and data collection methods employed are different to those in Zimbabwe. Thermocouples are to be used to measure temperature; these will be connected to a hand held meter and results recorded manually. Moisture content changes will be monitored using Reethorpe sensors as in Zimbabwe, with data recorded manually. Conditions in the warehouses will be monitored using thermohygrographs. These were inspected by the author and found to be of good quality and suitable for the trials provided they are calibrated frequently. Carbon dioxide will be measured by the same method used in Zimbabwe.

12. Advice was given on the method of sampling for moisture and quality analysis during stack building. This is to follow the same procedure used in Zimbabwe with a 250g sample for quality analysis at UG and a 25g sample for moisture content determination at UG.

13. The facilities for determining moisture content by a standard oven method were only briefly inspected. One potential problem with the milling operation for the determination was identified: the particle size distribution of the milled samples may be at variance with the standard.

14. Plans of the experimental stacks and the sensor positions are shown in Appendix B. Two stacks are planned: one in a warehouse at Tema and one in a warehouse at Kaneshie. Both warehouses were visited by the author. The Tema warehouse has a concrete wall and galvanised roof and has limited ventilation. Maize stored in it has developed stackburn. The warehouse at Kaneshie is well ventilated. A stack of 1300 sacks (50 kg each) is to be built in each warehouse, both on a dunnage of pallets. The size of the

experimental stacks is much smaller than those in Zimbabwe but they are realistic for Ghana. The stacks are also different in that they are indoors, so are not subject to wind chilling, radiation loss and strong convective cooling to the same extent as those in Zimbabwe. The sacks are also loosely filled. Because of this results from the two trials should not be directly compared.

15. Construction of the stack at Kaneshie took place during the training period so the author was able to participate in preparation and installation of the monitoring equipment and the gathering of data. Advice was given on the optimum position for the stacks at the Tema warehouse.

16. All the most recent written information on the farmer's questionnaire was passed on for forwarding to Miss Phillips. This work was discussed with Prof. Odamtten and Mr Edwards. Because of the outcome of the questionnaire the next step will be another survey to follow up the perceived initial good performance of jute sacks compared to wpp sacks in spite of the higher cost of jute. Jute sacks are even preferred to wpp if they are recycled and in a dirty condition.

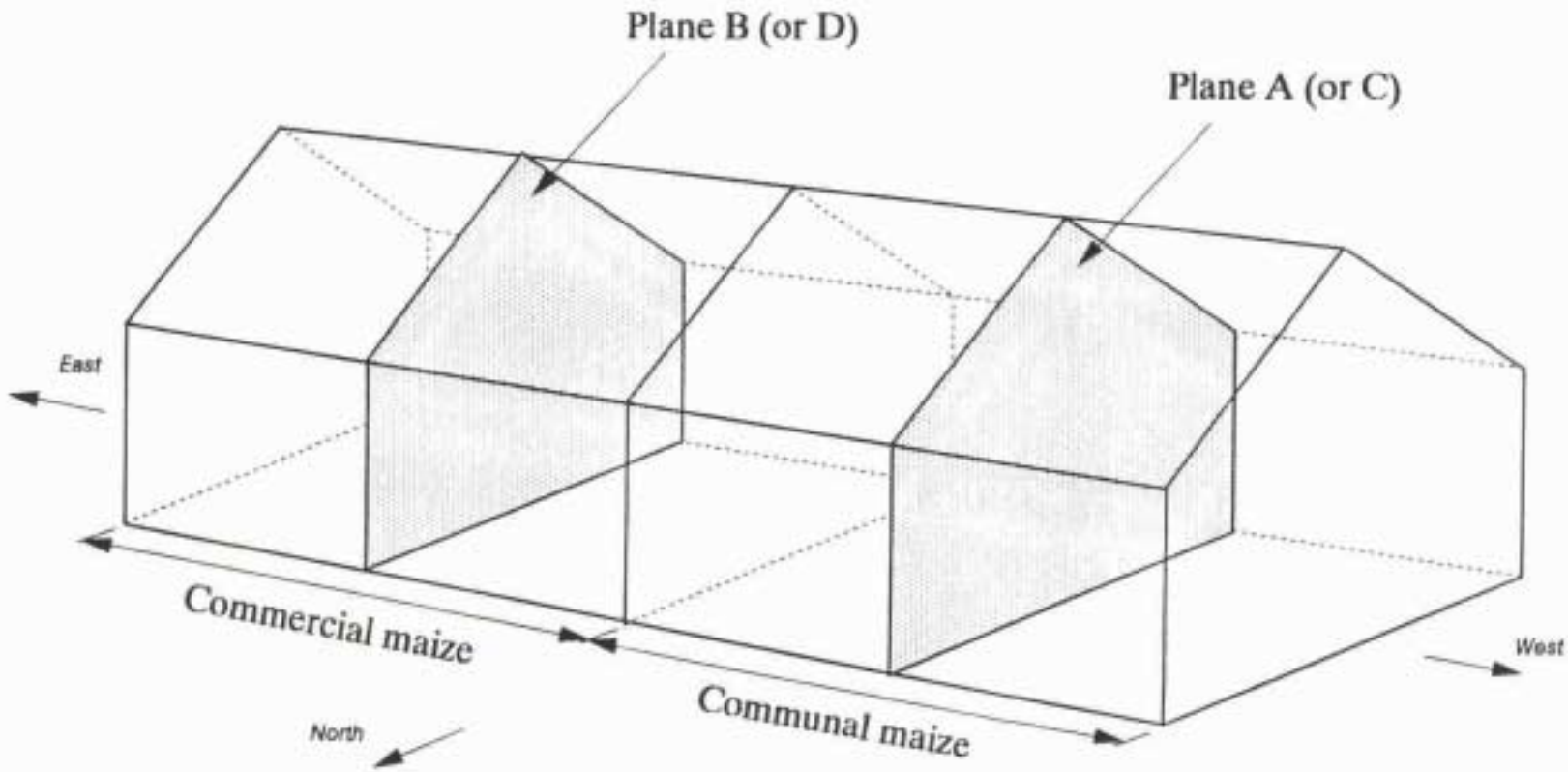
17. Wpp sacks were purchased and returned to NRI.

APPENDIX A

Five diagrams showing the monitoring sensor planes and the sensor arrays in the two experimental bagstacks at the Mvurwi Grain Marketing Board Depot, Zimbabwe.

Position of instrumented planes within stacks of polypropylene or jute bags

Planes A and B in the stack of polypropylene bags
Planes C and D in the stack of jute bags

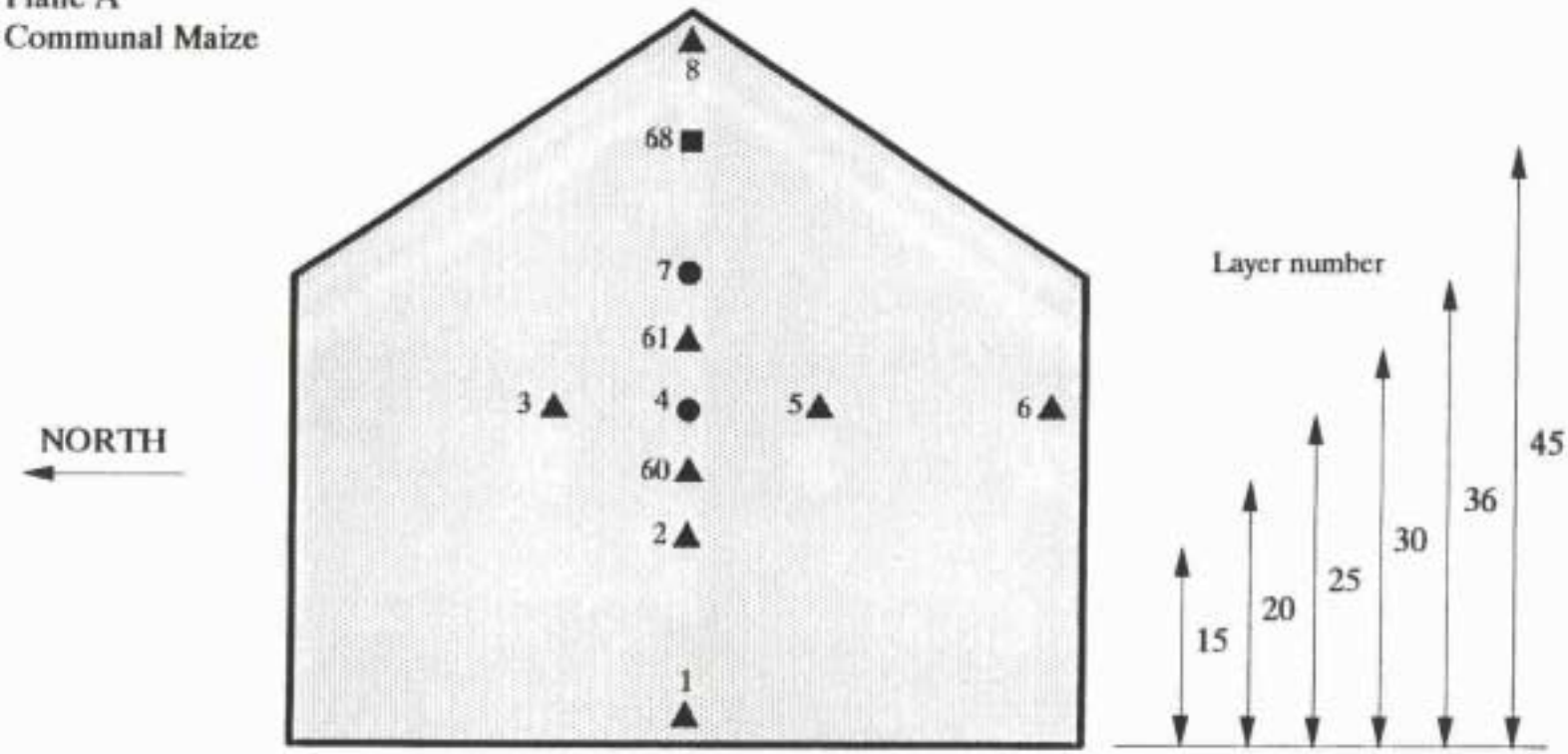


Key:

▲ Moisture and temperature sensor
● Moisture, temperature and carbon dioxide
■ Temperature only

Stack of Polypropylene bags

Plane A
Communal Maize

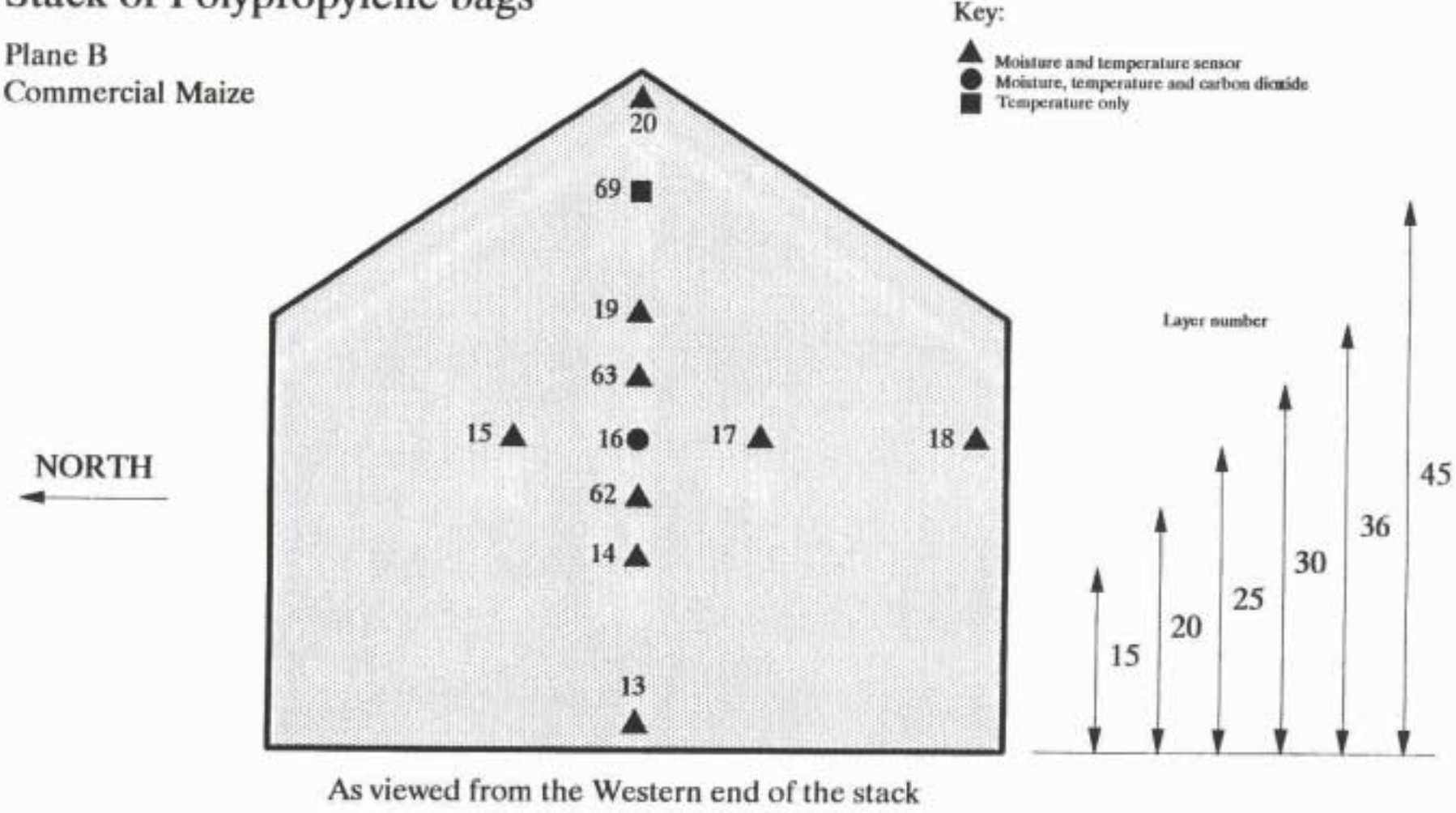


As viewed from the Western end of the stack

Positions 9 and 10 lie in front and behind of position 4 respectively
Positions 11 and 12 are not shown because they lie in the plane which divides the two types of maize
(position 11 is equivilant to position 3, and 12 is equivilant to position 5)

Stack of Polypropylene bags

Plane B
Commercial Maize



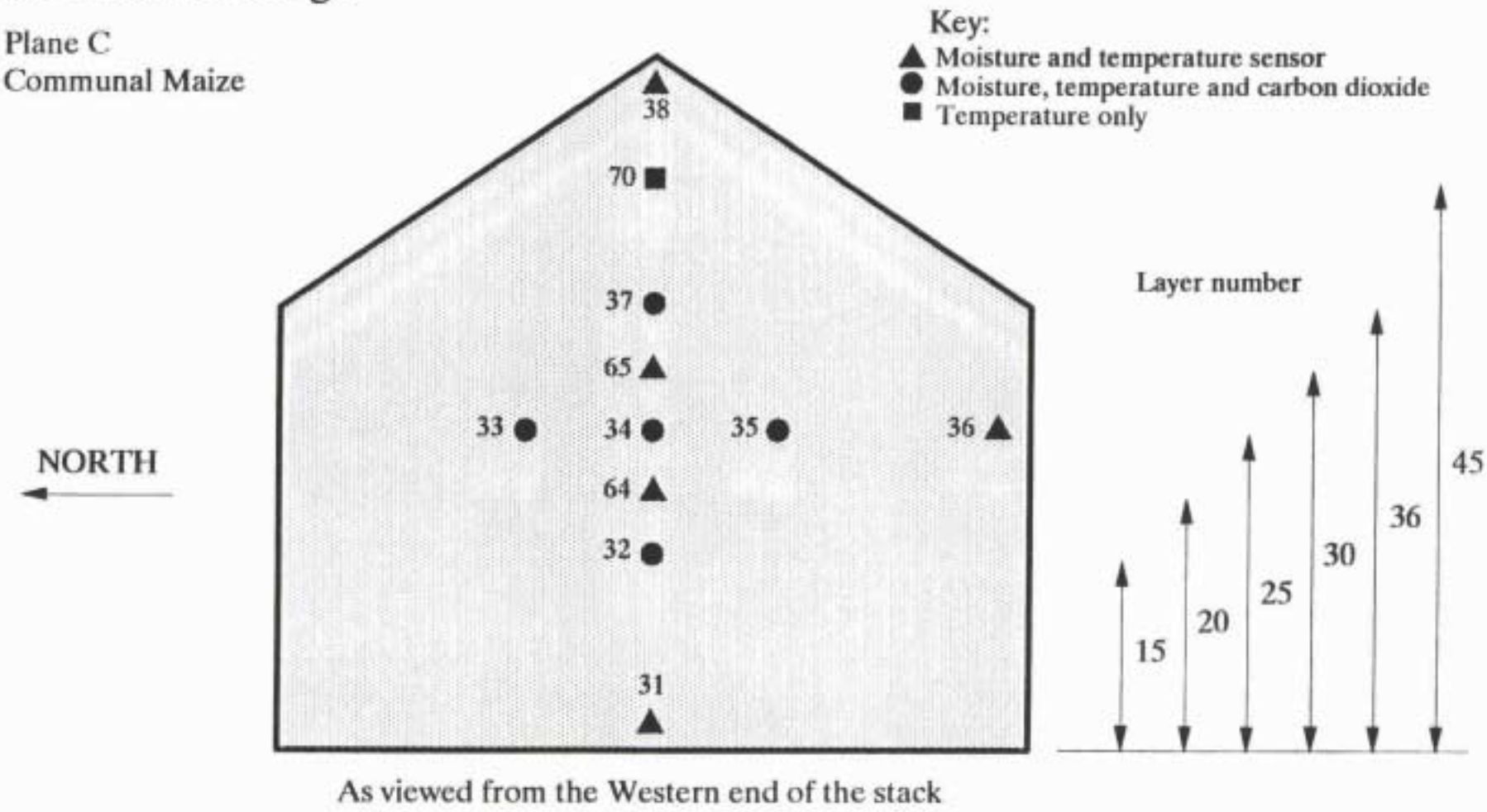
As viewed from the Western end of the stack

Positions 21 and 22 lie in front and behind of position 16 respectively

Positions 11 and 12 are not shown because they lie in the plane which divides the two types of maize (position 11 is equivilant to position 15, and 12 equivilant to position 17)

Stack of Jute bags

Plane C
Communal Maize



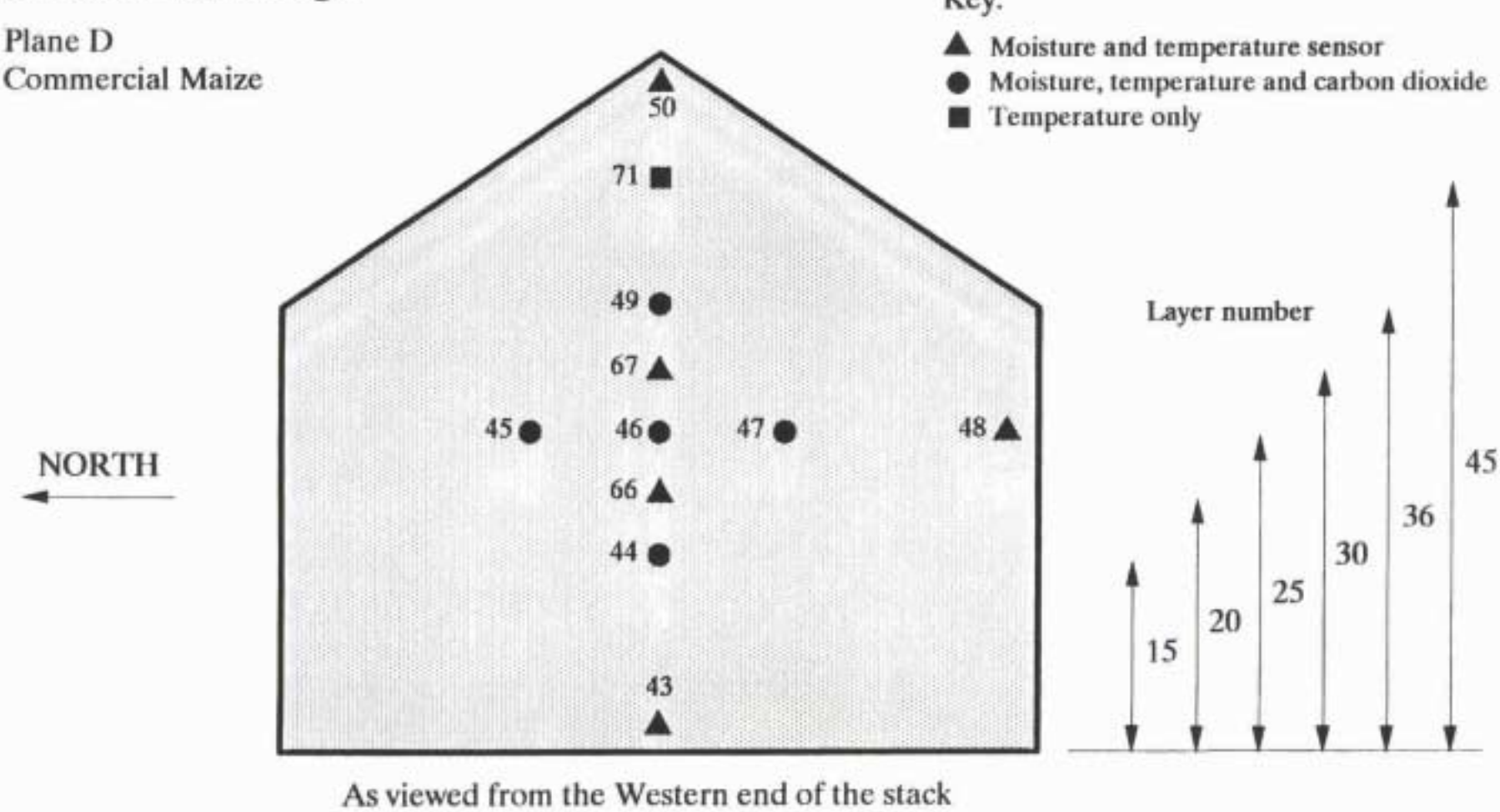
As viewed from the Western end of the stack

Positions 39 and 40 lie in front and behind of position 34 respectively

Positions 41 and 42 are not shown because they lie in the plane which divides the two types of maize (position 41 is equivilant to position 33, and 42 equivilant to position 35)

Stack of Jute bags

Plane D
Commercial Maize



As viewed from the Western end of the stack

Positions 51 and 52 lie in front and behind of position 46 respectively

Positions 41 and 42 are not shown because they lie in the plane which divides the two types of maize (position 41 is equivilant to position 45, and 42 equivilant to position 47)

APPENDIX B

Diagram showing the monitoring sensor plane and the sensor array in the experimental at the Kineshie warehouse, Ghana.

Cross section of the Kaneshie warehouse stack

through a plane four bags from the ENE wall