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R2285(S)

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

Report No. 9: EC DGXII Research  
Project Workshop, Accra, Ghana,  
30 October - 3 November 1995

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Project Nos. A0227/C0326

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## Acknowledgement

We are very grateful to Professor George Odamtten and the University of Ghana for hosting the second workshop of this project. Funding for the workshop was provided from within the framework of the European Community Research Programme with a financial contribution by the European Commission and the Natural Resources Research Department of the UK Overseas Development Administration. In addition to this technical report, a set of workshop proceedings will be compiled and edited by Professor G Odamtten as a project-funded output from the Ghanaian collaborators.

## STACKBURN OF MAIZE IN COMMERCIAL STORAGE

(STD3 Project ERBTS3\*CT920097)

### THE PROBLEM

Maize stackburn has emerged as a significant threat to food security in sub-Saharan Africa in the last decade. Stackburn can affect both local and imported varieties of white and yellow maize and is characterised by a brown discolouration of the grain pericarp and germ resulting from heat build-up in the interior of stacks held in commercial storage. Affected maize may be downgraded in commercial markets or have to be diverted for animal-feed use. Where discolouration is severe, food aid agencies attempting to distribute stackburned maize may meet beneficiary resistance or rejection and be forced to dispose of large quantities of deteriorated maize at considerable cost. The underlying factors responsible for the onset of maize stackburn are not well understood and the nutritional and/or toxicological implications for consumers are similarly unclear.

### THE PROJECT

#### *Objectives*

- To identify the causes of stackburn in stocks of stored maize in sub-Saharan Africa.
- To determine the causal relationship, if any, between stackburn and the introduction of grain bags made from polypropylene tape.
- To examine potentially effective methods of minimising the incidence of stackburn.
- To develop efficient, effective and appropriate maize management strategies.
- To communicate the strategies to managers of national food stocks, government agencies and traders.

#### **Time-frame**

1993-96

#### **Collaborators**

Natural Resources Institute, UK (NRI)

Instituto de Investigacao Cientifica Tropical, Portugal (IICT)

University of Ghana (UG)/Ghana Food Distribution Corporation (GFDC)

University of Zimbabwe (UZ)/Grain Marketing Board (GMB)

## **OBJECTIVES OF THE WORKSHOP**

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", workshops are scheduled to disseminate research results. The second workshop was held in Accra from 31 October to 3 November 1995 after the completion of year two activities. A full account of project outputs from all collaborators is given in the 1994/95 project annual report. The objectives of the workshop were to:

review project progress, exchange information and appraise research methodologies;

define priority research areas for year three and refine work plans based on outputs to date and observed operational constraints;

review budget estimates and finalise funding requirements to project termination.

2. The programme workshop was based on a framework drawn up by the Ghanaian collaborators and developed in collaboration with all co-workers. Workshop sessions were held in the Department of Zoology on the University of Ghana campus at Legon and field trips included a day of visits to the Botany Department, University of Ghana, and several of Ghana Food Distribution Corporation's warehouses and procurement/drying/storage sites (Annex 1).

## **PARTICIPANTS**

3. Representatives from the four collaborating institutions (each with a different role and area of work within the project) and two sub-contractors involved in the field work attended the workshop.

4. The EU representative in Ghana, Mr Van Helder, attended the opening ceremony and was supplied with a selection of project documentation bringing him up to date with activities and outputs.

5. A number of research students and academic personnel from the University of Ghana sat in on various workshop sessions and contributed to technical discussions.

#### **MAIN POINTS ARISING FROM WORKSHOP DISCUSSIONS**

6. Each collaborator presented an overview of activities and outputs in the form of a country statement, following which presentations were given grouped under broad subject themes (see Workshop programme at Annex 1).

#### **Theme - Mycology (Ghana, Zimbabwe, UK contributions)**

7. A major point of discussion was the possible application of the volatile extraction procedure for monitoring commercial stacks. The work to be done within the project will not lead to a fully worked-out method, but should define its content. A sampling system would be needed, perhaps a spear system. Cost of the analysis would be a major difficulty. Identification of the commencement of stackburn would be a desirable output from the method, and relating measurement of volatiles to the stack temperature would be important. The possibility of using the method to distinguish between metabolic activity of grain, insects and microorganisms was raised; while each gives a different volatile profile, these overlap and identification of components of a mixed system would not be possible.

**Theme - Entomology (Zimbabwe, Portugal, Ghana contributions)**

8. Much of the discussion centred around the two Zimbabwean studies on a comparison of insect development on normal and stackburnt maize. In the University of Zimbabwe (UZ) study, there was no significant difference in numbers of adults emerging between normal and stackburnt maize; insect development, however, was slower on stackburnt compared with normal maize. In the GMB study, the rate of development was also faster on normal compared with stackburnt maize. The longer timescale of GMB compared with UZ experiments probably contributed to the higher populations on normal, as compared to stackburnt maize, in contrast to UZ data. It was suggested that the brittleness of stackburnt maize may be a factor in depressing insect growth, or that heating of maize produced an anti-feeding effect, slowing development.

9. The question of why stack heating peaked at 42°C was raised. It was noted that most insect species do not multiply above 35°C, but that both adults and larvae are actually killed at around 42°C. Other discussions centred around the proposed experiments at IICT to measure heat and CO<sub>2</sub> production by insects in a grain mass, and the difficulties of determining these in a small-scale laboratory experiment. In particular, it was felt that a significant temperature rise would be difficult to induce.

**Theme - Packaging (UK, Portugal contributions)**

10. Jute was the most permeable material in both NRI and University of Ghana (UG) studies on gas permeability of bags, followed by Zimbabwean woven polypropylene (WPP). The NRI study suggested that of the Ghanaian fabrics, the 8x6 weave was the next most permeable, followed by 7x7



and 8x8. The UG experiments gave 8x8 as the most permeable of the Ghanaian fabrics, followed by 8x6 and 7x7. The difference between the two lab's results may be due to the variability of the weave in Ghanaian fabrics. It was noted that the Zimbabwean material was much more permeable than any of the Ghanaian fabrics, although much less permeable itself than jute.

11. It was suggested that the stack cooling model should now incorporate the use of ventilation channels. Other factors already incorporated include the effects of the height of the stack on temperature differences. It was confirmed that the model also included the optional bag fabrics and that it could be used to determine the proportion of heat lost due to convection, as well as conduction.

**Theme - stack trials (Ghana, Zimbabwe, UK contributions)**

12. Delegates agreed that the trials described in the session were particularly important contributions to the project and recognised the large amount of work involved.

13. Additional data from the Ghana trials showed that no grain discolouration had been observed in the samples from the Tema warehouse and that stacks were fumigated several times during the observation period.

14. A suggestion was made that it would be useful to consult store records to try to determine whether there was a critical size of stack influencing the incidence of stackburn.

15. The success of the channelled stack in limiting temperature rise had led the GMB to move towards adopting this system throughout the country. However, the cost-benefit analysis which was to be conducted would also

evaluate the possibility of reverting to jute sacks as an alternative.

16. The evidence for involvement of insects in inducing stackburn has not been strengthened by the data from these trials. Although, in Zimbabwe, heating was more pronounced in "communal" than "commercial" maize, the data on hidden infestation on intake does not indicate higher levels of insects in communal than commercial grain. The level of insect damage recorded was similar for maize of both origins. Early, circumstantial evidence pointing to insects as the primary cause of stackburn included high infestation levels found in samples taken for grain colour determination, but these levels were not necessarily representative of the grain bulk.

#### **Theme - Processing (UK contribution)**

17. Nutritional analyses supplemented by poultry feeding trials had clearly shown that rations incorporating stackburnt maize suffered a reduction in nutritive value for both poultry and ruminants with a clear indication that the results would hold for all classes of livestock.

18. More detailed studies are needed to develop utilisation strategies and blending formulae which will maximise income from the use of stackburnt maize and to develop firm recommendations on the incorporation of stackburnt maize in livestock rations.

#### **WORKPLANS AND TIMEFRAMES FOR YEAR 3**

19. Workplans for 1995/96 were developed by each collaborating organisation and presented at the workshop to resolve any areas of duplication and to ensure all the major areas of research were covered. Summaries of these

**Table 1: Workplans of collaborating organisations 1995/1996**

NRI, UK	ICT, PORTUGAL	UG/GFDC, GHANA	UZ/GMB, ZIMBABWE
<p><u>TRAINING</u></p> <p>Data logger instrumentation - data handling, analysis and reporting for UZ and GMB staff.</p> <p><b>September 1995</b></p>	<p><u>OPTIMUM SPACING OF VOIDS FOR COOLING STACKS</u></p> <p>Predictive modelling studies to determine the effects of varying channel spaces in stacks.</p> <p><b>March 1996</b></p>	<p><u>SAMPLING OF TRIAL STACKS AT KANESHE WAREHOUSE</u></p> <p>Collection of a full range of samples for comparison with baseline trial samples.</p> <p><b>January 1996</b></p>	<p><u>SAMPLING OF TRIAL STACKS AT MVURWI AND CONCESSION DEPOTS</u></p> <p>Collection of a full range of samples for comparison with baseline trial samples).</p> <p><b>November 1995</b></p>
<p><u>MAIZE VOLATILES</u></p> <p>Completion of field sampling, reporting of results with recommendations for future use as an indicator of stackburn initiation in maize stocks.</p> <p><b>February 1996</b></p>	<p><u>INSECT DEVELOPMENT</u></p> <p>Determination of the role of insects in causing heating in maize through laboratory trials.</p> <p><b>February 1996</b></p>	<p><u>STACK DATA ANALYSES</u></p> <p>To include insects, moulds, temperature, moisture and colour changes, comparing ventilated and non-ventilated warehouses.</p> <p><b>January 1996</b></p>	<p><u>STACK DATA ANALYSES</u></p> <p>Statistical analyses of insects, temperature, moisture and colour changes, comparing communal and commercial maize, and poly/jute sack material.</p> <p><b>February 1996</b></p>
<p><u>COST/BENEFIT ANALYSIS</u></p> <p>The use of ventilated stacks as a management procedure for reducing stackburn (in collaboration with GMB)</p> <p><b>January 1996</b></p>	<p><u>GRAIN/FUNGAL INTERACTIONS</u></p> <p>Role of enzymes in causing changes which may induce stackburn.</p> <p><b>March 1996</b></p>	<p><u>JOINT MYCOLOGICAL STUDIES</u></p> <p>Paecilomyces spp. and Aspergillus spp.</p> <p><b>January 1996</b></p>	<p><u>HISTORY OF STACKBURN IN ZIMBABWE</u></p> <p>Historical incidence of stackburn in at least three selected depots.</p> <p><b>February 1996</b></p>

NRI, UK	ICT, PORTUGAL	UG/GFDC, GHANA	UZ/GMB, ZIMBABWE
<p><u>PROJECT CO-ORDINATION</u></p> <p>Stackburn newsletters.  <b>September 1995 and March 1996</b></p> <p>Short activity reports.  <b>September 1995</b>  Accra Workshop - Coordinator's report  <b>November 1995</b>  Final technical report and costs statement.  <b>March 1996</b></p>	<p><u>FINAL COLLABORATORS WORKSHOP</u></p> <p>To complete reporting, co-ordinate research results and finalise cost statements</p> <p><b>March 1996</b></p>	<p><u>HISTORICAL DATA OF STACKBURN</u></p> <p>In warehouses where it has been detected viz-a-viz fumigation and environmental data</p> <p><b>February 1996</b></p>	
		<p><u>COLOUR CHART</u></p> <p>For stackburn grains in Ghana</p> <p><b>March 1996</b></p>	
<p><u>PUBLICATIONS</u></p> <p>Final technical reporting  <b>March 1996</b></p>	<p><u>PUBLICATIONS</u></p> <p>Final technical reporting  <b>March 1996</b></p>	<p><u>PUBLICATIONS</u></p> <p>Accra Workshop proceedings  <b>December 1995</b>  Final technical reporting  <b>March 1996</b></p>	<p><u>PUBLICATIONS</u></p> <p>Final technical reporting  <b>March 1996</b></p>

workplans, together with planned timeframes for the year September 1995 to April 1996 are given in Table 1.

## PROJECT MILESTONES/DEADLINES

### Milestones

20. Revised project milestones were discussed and agreed.
21. These milestones should be read in conjunction with the technical annex of the contract document.

### Deadlines

22. Each country project co-ordinator is responsible for submitting annual technical reports and cost statements to the overall project co-ordinator (J A Conway, NRI) for transmission to the EC by certain deadlines. To allow time for overall co-ordination of reports, the following deadlines should be adhered to:

- Final technical progress report (long report covering all scientific results for the period 1 April 1995 to 31 March 1996) to be approved and finalised at terminal Lisbon workshop in March 1996.
- Final cost statement<sup>1</sup> to be agreed and submitted to NRI at Lisbon workshop in March 1996.

## FUNDING ISSUES

23. As discussed with all collaborators, considerable financial adjustments will be necessary in the final period in order to fully meet both output and expenditure

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<sup>1</sup> The final, consolidated technical report and the final cost statements have to be sent together to the EC. It is important to keep to deadlines as production of these documents on time is vital to obtain the final instalment of funds as set out in the contract.

targets. The possibilities of diverting 1995/96 funding allocations from underspending collaborators to others with excess capacity and opportunities to contract in expertise from one collaborator to another were discussed at some length.

24. It was agreed that tentative adjustments to work plans could go ahead pending clarification on the extent of funding flexibility permissible by DGXII and a more clear explanation on the mechanisms used for both reconciling the initial funding advance and payment of the final 10% of funds to collaborators.

#### **PUBLICATIONS AND DISSEMINATION OF INFORMATION**

25. A list of reports and papers published by the project is given in Annex 2

26. As stated in Annex II of the stackburn project contract (Articles 6, 7), participants in the project should be aware that all reports should be regarded as confidential. Any communication or publication of the progress of work under the contract (including at seminars and conferences) must include the following statement:

"Research was carried out by (name of organisation/s) in the framework of the European Community Research Programme with a financial contribution by the European Commission."

## ANNEX 1

### PROGRAMME FOR COLLABORATORS' WORKSHOP TO BE HELD AT THE DEPARTMENT OF ZOOLOGY, UNIVERSITY OF GHANA AT LEGON, ACCRA

MONDAY, 30 OCTOBER, 1995

Time	
	Arrival
	Individual meetings between Project Co-ordinator and Country Co-ordinators to discuss project administration, finances and tentative workplans for final project phase:
10.00	IICT, Portugal
17.00	UOG, Ghana
18.00	UOZ, Zimbabwe
15.00 - 17.00	Visit to Kaneshie Warehouse/Field trial site

TUESDAY, 31 OCTOBER

Time	Objective
09.00 - 11.00	<b>OPENING CEREMONY<sup>1</sup></b> Professor Nukunya, Pro-Vice Chancellor, University of Ghana Professor S Odoom, Acting Dean, Faculty of Science, University of Ghana  <b>Overview of project objectives</b> Mr J A Conway, Project Coordinator, Food Security Department, NRI, U.K.
11.00 - 11.30	Tea Break
11.30 - 12.00	<b>Post-harvest policy on maize and other cereal grains in Ghana</b> Mr K Nicol, Director, Post-Harvest Development Unit, Ministry of Food and Agriculture
12.00 - 12.30	<b>Storage and distribution of maize in Ghana; Past, Present and Future role of GFDC</b> Mr J Edwards, General Manager, Ghana Food Distribution Corporation
12.30 - 13.30	Lunch
14.00 - 14.30	<b>Country report, Ghana</b> Professor G Odamtten, Department of Botany, University of Ghana
14.30 - 15.00	<b>Country Report, U.K.</b> Mr T Donaldson, Food Security Department, NRI, U.K.
15.00 - 15.30	Tea Break
15.30 - 16.00	<b>Country report, Portugal</b> Eng. A Maia, IICT, Portugal
16.00 - 16.30	<b>Country report, Zimbabwe</b> Dr D Cole, Crop Sciences Department, University of Zimbabwe

<sup>1</sup>The Opening Ceremony will be held at the School of Administration (Graduate Wing)

WEDNESDAY, 1 NOVEMBER

Time	Objective
09.00 - 09.30	<i>Theme - Mycology</i> <b>Survival of fungal spores and insect-fungal relationships in stored maize</b> Professor G C Clerk, Department of Botany, University of Ghana
09.30 - 09.45	<b>Mycological studies, Zimbabwe</b> Dr D Cole, Plant Pathology, Kutsaga Research Station
09.45 - 10.00	<b>Possible biocontrol of fungi in maize samples</b> Professor G Odamtten, Department of Botany, University of Ghana
10.00 - 10.15	<b>Detection of maize volatiles</b> Dr P Wareing, Food Safety Department, NRI, UK.
10.15 - 10.45	<b>DISCUSSION</b> Chair: Professor G C Clerk/Professor G Odamtten/Rapporteur: J New
10.45 - 11.00	Tea Break
11.00 - 11.15	<i>Theme - Entomology</i> <b>Entomological studies, field and laboratory based</b> Professor D Giga, Crop Science Department, University of Zimbabwe
11.15 - 11.30	<b>Development of insects in stackburnt maize</b> Eng A Barbosa, IICT, Portugal
11.30 - 11.45	<b>Entomological studies</b> Professor G Odamtten, Department of Botany, University of Ghana
11.45 - 12.15	<b>DISCUSSION</b> Chair: Professor D Giga/Rapporteur: P Wareing
12.15 - 13.15	Lunch
13.15 - 13.30	<i>Theme - Packaging</i> <b>Sack material properties</b> Dr J New, Food Security Dept., NRI
13.30 - 13.45	<b>Stack cooling</b> Eng A Maia, IICT
13.45 - 14.15	<b>DISCUSSION</b> Chair: Dr D Cole/Rapporteur: P Wareing
14.15 - 14.30	<i>Theme - Experimental stack data</i> <b>Field trial in Zimbabwe</b> Professor D Giga, Crop Sciences Dept., University of Zimbabwe
14.30 - 14.45	<b>Ventilated stack trial in Zimbabwe</b> Ms R Tanyongana, Grain Marketing Board, Zimbabwe Mr T Mudzonga, GMB, Zimbabwe Mr T Donaldson, Food Security Dept., NRI
14.45 - 15.00	Tea Break
15.00 - 15.15	<b>Field trial in Ghana</b> Professor G Odamtten, Dept. of Botany, University of Ghana



15.15 - 15.45	<b>DISCUSSION</b> Chair: Mr J Conway/Rapporteur: J New
	<i>Theme - Processing</i>
15.45 - 16.00	<b>Chemical, physical and processing characteristics of stackburnt maize</b> Professor S Sefah-Dedeh, Institute of Food Studies, University of Ghana
16.00 - 16.15	<b>Use of stackburnt maize as a poultry feed</b> Mr J Conway, Food Security Department, NRI
16.15 - 16.45	<b>DISCUSSION</b> Chair: Eng. A Maia/Rapporteur: J New

#### THURSDAY, 2 NOVEMBER

Time	Objective
07.30 - 17.00	Visit to:  Field trial sites, Tema/Kaneshie warehouses University of Cape Coast campus Department of Botany, University of Ghana

#### FRIDAY, 3 NOVEMBER

Time	
09.00 - 10.00	<b>Presentation of workplans 1995/96</b> IICT, Portugal NRI, UK UoG, Ghana UoZ, Zimbabwe
10.00 - 10.30	<b>DISCUSSION</b> Chair: Mr J A Conway
10.30 - 11.00	Tea Break
11.00 - 12.00	<b>Publications</b> Chair: Professor Odamtten, Dept. of Botany, University of Ghana
12.30	<b>CLOSING CEREMONY</b>
13.00 - 14.00	Lunch
14.00 - 16.00	Individual meetings between Project Co-ordinator and Country Co-ordinators to finalise financial/administration plans for terminal project phase as required

## ANNEX 2

### REPORTS PRODUCED TO DATE

Devereau, A.D. (1995). *Report No.7: Ventilated bagstack trial, Zimbabwe, September 1994 to January 1995*. NRI Report R2255(S). Chatham, UK: Natural Resources Institute.

Donaldson, T.J. (1993). *Report No.2: Assessment of spoilage and loss within stackburned maize*. NRI Report R2073(S). Chatham, UK: Natural Resources Institute.

Donaldson, T.J. (ed.) (1994). *Stackburn Newsletter No.1*. September 1994.

Donaldson, T.J. (ed.) (1995). *Stackburn Newsletter No.2*. March 1995.

Donaldson, T.J. (ed.) (1995). *Stackburn Newsletter No.3*. September 1995.

Donaldson, T.J. and Conway, J.A. (1995). *Report No.9: EC DGXII Research Project Workshop, Accra, Ghana, 31 October - 3 November 1995*. NRI Report R2285(S). Chatham, UK: Natural Resources Institute.

Donaldson, T.J., Nosenga, S., Kutukwa, N., Tanyongana, R. and Maia, A. (1995). *Does your maize turn brown?* News item for Spore newsletter (August 1995 edition).

Gough, M.C. (1994). *Report No.6: Visit to Zimbabwe and Ghana to participate in the implementation of trials on stackburn in stored maize*. NRI Report R2186(S). Chatham, UK: Natural Resources Institute.

Kennedy, L. and Devereau, A.D. (1994). *Observations on large scale outdoor maize storage in jute and polypropylene sacks in Zimbabwe*. Paper presented at the XI International Working Conference on Stored Products Protection, Canberra, Australia.

Locke, M.T., Donaldson, T.J. and Gough, M.C. (1993). *Report No.1: Quality changes in an outdoor stack of bagged maize*. NRI Report R2085(S). Chatham, UK: Natural Resources Institute.

Maia, A., Gough, M.C. and Kennedy, L. (1994). *Report No.4: A study of the effect of bag material on the development of stackburn in sacks of maize*. NRI Report R2255(S). Chatham, UK: Natural Resources Institute.

New, J.H. (1995). *Report No.8: Tests on sack fabrics: air and water vapour transmission through woven polypropylene and jute*. NRI Report R2236(S). Chatham, UK: Natural Resources Institute.

Odamtten, G.T., Minamore, A.A. and Clerk, G.C. (1995). *Influence of the metabolites of three Paecilomyces species on the germination and radicle developments of two Ghanaian maize varieties*. Proceedings 3rd International Mycological Association African Regional Mycological Congress. Harare, Zimbabwe, 7-10 March 1995

Panigrahi, S., Bestwick, L.A., Davies, R., Wood, C.D. and Conway, J.A. (1995). *The nutritive value of stackburned yellow maize for broiler chickens and ruminant livestock*. NRI Interim Technical Report, Project No. A0122. Chatham, U.K.

Phillips, S.I. (ed.) (1994). *First Annual Report on ECDGXII project (contract TS3\*-CT92-0097)*.

Phillips, S.I. (ed.) (1995). *Second Annual Report on ECDGXII project (contract TS3\*-CT92-0097)*.

Phillips, S.I. and Donaldson, T.J. (1994). *Report No.5: EC DGXII Research Project Workshop, Harare, Zimbabwe, 6 - 10 June 1994*. NRI Report R2140(S). Chatham, UK: Natural Resources Institute.

Tyler, P.S. (1992). *Heat and discoloration of bagged maize*. World Grain, September 1992, pp. 14-16.

Tyler, P.S. and Kutukwa, N. (1993). *Report No.3: Technical note on a coordination visit to Ghana*. NRI Report R2042(C). Chatham, UK: Natural Resources Institute.

Tyler, P.S. and New, J.H. (in press). *Using woven polypropylene sacks for agricultural produce*.

## ANNEX 3

### CONTACT ADDRESSES OF COLLABORATING SCIENTISTS

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