

DEPARTMENT OF
MARKETING AND EXPORTS
NIGERIA

WEST AFRICAN
STORED PRODUCTS
RESEARCH UNIT

ANNUAL REPORT
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I. INTRODUCTION

1. The functions, aims, constitution, financing and administration of the West African Stored Products Research Unit have remained unchanged and have been described in previous Annual Reports, of which this is now the fourth to be printed and covers the period from October 1958 until September 1959.

2. As a result of the increased attention being paid by W.A.S.P.R.U. to local foodstuffs such as grain, yams, and cowpeas there has been a corresponding increased liaison with the various agricultural research centres. In each region, field scale trials on local foods have been conducted by W.A.S.P.R.U. at various research centres or farms of the departments of agriculture.

3. W.A.S.P.R.U. was represented by an exhibit at the Onitsha Agricultural Show during November 1958, at the Oyo show and at the Festival of Kano in January 1959.

4. In the 1958 edition of this report special reference was made to recent researches on hermetic storage which indicated that the technique might have future possibilities. Further work reported on in the present report confirms that foodstuffs can be successfully stored for long periods with little deterioration.

5. One of the greatest difficulties in the tropics in preserving foodstuff quality is the prevention of cross infestation to commodities which are uninfested either naturally or by virtue of having been fumigated. Infestation pressure by stored products pests is naturally much higher in the tropics because the pests concerned are more active than in temperate climates. *Tribolium* spp., and various moths, for example, readily fly in the open and invade warehouses from without, whereas activity of this nature is greatly restricted in the United Kingdom. The protection of uninfested (particularly fumigated) produce is, thus, far more difficult to achieve under tropical conditions. Protection by spraying insecticides is costly, and insecticides in general have a much shorter life under tropical conditions; repeated applications are necessary and at best, surface spraying can never completely protect stored produce. In view of difficulties of this nature there has been a recent trend in the work of W.A.S.P.R.U. to adopt physical protective barriers wherever possible and dispense with spraying. Self-sterilisation by sealed storage as occurs in underground pits and hermetic storage in sealed containers, provide well-tried examples of this type of protection, while the construction of hermetically sealed buildings and use of polythene sheets have recently been considered.

6. There is a great need for a type of warehouse which can be hermetically sealed. The necessity for fumigation sheets would thus be eliminated and possibilities of reinfestation precluded. Ctesiphon storage so far seems the nearest approach to a solution of the problem but is not entirely suitable as is indicated in the text of this report. Several private companies have been approached regarding the production of a hermetically sealable warehouse and it is hoped to erect an experimental one during 1960.

7. Very recently, trials have been conducted using light polythene sheets for protecting produce after fumigation. It was found that the protection offered to bagged cocoa, where use of persistent insecticides is prohibited, was very satisfactory and details appear in this report. The technique has been independently developed by D. C. Price of the Produce Inspection Division of the Ministry of Agriculture, Northern Region, for protection of fumigated grain, constituting famine reserves, and is also referred to later in this report.

8. A new Section XI on Insecticides has been introduced in the present report. In previous reports, material under this heading was included with the section on the produce most likely to be affected.

9. A number of instances occur in this report where accounts have been given of work carried out by officers of organisations working in liaison with W.A.S.P.R.U. (e.g. Tropical Products Institute; Agricultural Research Station, Samaru, the pest control organisations of the Northern and Western Regions; and the Faculty of Agriculture, University College, Ibadan). In each case due acknowledgements have been given to the officers concerned. References to such work in the W.A.S.P.R.U. Annual Report enables a more complete picture of stored products research in Nigeria to be given, and the report thus provides a medium for recording data that in some cases would not otherwise become widely known.

II. ANNUAL REVIEWING COMMITTEE MEETINGS

10. The sixth W.A.S.P.R.U. Annual Reviewing Committee Meetings were held in Lagos in May 1959. The Chair at both the Technical and Administrative sessions was taken by Dr. W. F. Jepson, O.B.E., who represented the Stored Products Sub-Committee of the Colonial Office.

11. The 1958 W.A.S.P.R.U. Annual Report and the work programme for the coming year were discussed at the Technical Session. At the Administrative Session the committee decided to recommend that W.A.S.P.R.U. should become a separate Division of the Ministry of Commerce and Industry with effect from April 1960. Subsequent action has been taken on this matter and it has now been officially sanctioned that the recommended change should take place.

12. The Committee agreed that the constitution of the Annual Technical and Administrative Meetings should be formally defined, and in addition it was agreed to recommend that Regional Technical Meetings (also to be formally constituted) should precede the Annual Meetings in May to discuss and agree on items for the respective regional work programmes. Such an arrangement will ensure that the various regional interests are fully considered and will reduce the business of the Annual Reviewing Meeting.

III. STAFF

13. At the beginning of the present reporting period nine of the ten established senior posts in the Unit were occupied. In April 1959 a new post of Senior Scientific Officer was created for W.A.S.P.R.U. at Port Harcourt,

making in all three Senior Scientific Officer posts in the Unit; one in respect of each Regional Laboratory. Port Harcourt now has the same amenities and personnel for research as the other W.A.S.P.R.U. Regional centres at Ibadan and Kano.

14. During 1959 there has been a most unfortunate exodus of qualified staff, four expatriate officers having resigned against only one recruited. The only senior Nigerian officer in the Unit has recently announced his intention of leaving and it has been quite impossible to obtain any suitable qualified Nigerians from the University College, Ibadan (U.C.I.) or elsewhere to fill the vacant posts. At the present time six indents have been sent to the United Kingdom but only two are in sight of leading to recruitment. The staff of the Research Unit thus remains much depleted and the output of technical work during 1959 has been very much restricted in consequence.

15. The following senior service officers have resigned: G. W. Ozburn on 22/5/59, P. Ward on 2/6/59, and J. R. Cutler on 31/7/59.

16. M. J. Glover gave notice of his intended retirement on 28/10/59 and U. I. Ukoha gave notice in August 1959 of his resignation to take effect from 15/11/59.

17. K. C. Matheson (chemist) assumed duty at Ibadan on 28/5/59 and P. F. Prevett (entomologist) is expected to arrive in Nigeria on 15/10/59 and is to be posted to Kano.

18. In view of the difficulty of obtaining Nigerians with suitable post-graduate experience to fill vacancies in W.A.S.P.R.U. the Officer-in-Charge of W.A.S.P.R.U. has initiated a scheme which has met with the approval of the Federal Government and the authorities at U.C.I., whereby fresh graduates may be recruited to vacant posts or as supernumeraries. An honours degree and post-graduate experience have formerly been insisted on as essential requirements for prospective senior staff in W.A.S.P.R.U. The newly qualified graduates would remain at the University to undertake post-graduate research under the guidance of their professor, and the work would be pertinent to that of W.A.S.P.R.U. and mutually agreed upon by the professor concerned and the Officer-in-Charge, W.A.S.P.R.U. At the end of a suitable period of such post-graduate work it is hoped that the officer would be eligible for continuing research at one of the W.A.S.P.R.U. Laboratories.

19. Three new posts of Assistant Technical Officer (a grade just below senior service) were created on 1/4/59 and two have so far been filled by F. I. Nwankwo and S. A. Anja.

IV. LABORATORY AND OFFICE ACCOMMODATION

20. W.A.S.P.R.U. at Port Harcourt has been occupying temporary quarters, office accommodation and laboratory facilities having been kindly provided by the Director of Marketing and Exports and the Director of Produce Inspection Eastern Region, respectively. The former chemistry laboratory of the Tropical Testing Establishment has also been made available. Construction of the new W.A.S.P.R.U. laboratory is nearing completion and the premises referred to above have been vacated.

21. The W.A.S.P.R.U. laboratory at Lagos has been condemned as

structurally unsafe. Alternative premises comprising chemistry and entomological laboratories, a workshop and a store are in the process of being fitted out.

22. The new laboratory and office premises at Ibadan and Kano are now in use and at Ibadan the controlled temperature/humidity unit has recently been installed.

V. VISITORS

23. T. A. Phillips, the Director of Agriculture, Eastern Region, visited W.A.S.P.R.U., Port Harcourt in October 1958 and again in March 1959 in connection with the storage of yams and rice.

24. P. H. Giles and R. Booker, of the Agriculture Department at Samaru, visited W.A.S.P.R.U., Kano, in December 1958 to discuss future planning of research on grain storage.

25. C. C. Spilsbury, Agricultural Economist, Fat and Oils Division, U.S.D.A., visited W.A.S.P.R.U., Kano, in January 1959.

26. C. Smedley of Cadbury Brothers toured Nigeria in April and May 1959 and saw something of the work of W.A.S.P.R. U. at Lagos, Ibadan and Kano.

27. Dr. Jepson and Dr. Hall from the United Kingdom visited various W.A.S.P.R.U. stations prior to participating in the Annual Reviewing Committee Meetings in May 1959, and J. Rawnsley of the Ghana Cocoa Marketing Board also visited W.A.S.P.R.U., Lagos, in connection with these meetings.

28. W.A.S.P.R.U., Kano, was visited by a party of Produce Inspectors in June 1959 and in September 1959 by a number of final-year agricultural students from University College, Ibadan, accompanied by Dr. Fayemi and Dr. Oyenuga.

29. H. Davelaar and H. Brandsma of U.N.I.C.E.F., Vom, visited W.A.S.P.R.U., Lagos, in September 1959 for the purpose of discussing infestation control in a high-protein foodstuff (groundnut flour-milk powder mix) being distributed by U.N.I.C.E.F.

VI. COCOA

Routine Pest Control Measures in the Western Region and Lagos

30. Close collaboration has continued with the Pest Control Section of the Produce Inspection Division of the Ministry of Trade and Industry, Western Region, who carry out all pest control measures on stored cocoa in the Western Region and Lagos.

31. On the advice of W.A.S.P.R.U. pest control measures are now confined to a limited amount of misting with pyrethrins in conjunction with fumigation measures. Spraying of warehouse walls with D.D.T. during the moratorium period between seasons is an annual routing measure. Cocoa is shipped as soon as possible after fumigation to avoid the need for measures to prevent reinfestation. Early shipment is not always possible, however, and

this has led W.A.S.P.R.U. to continue investigations on methods of protecting fumigated cocoa.

32. P. O'Donoghue of the Pest Control Section of the Western Region Produce Inspection Division, in collaboration with W.A.S.P.R.U., has investigated variations in the standard fumigation techniques and the next paragraph describing this work is based on a report by him.

A Proposed Modified Fumigation Technique.

33. At the suggestion of J. Rawnsley, entomologist of the Ghana Cocoa Marketing Board, a six-hour fumigation was tried using a new method of arranging the gas pipes in the top of a stack of cocoa bags. A central ridge was built and the gas delivery lines were laid on each side. The stack was covered with a polythene sheet 0.01 in. thick, and methyl bromide was led in at a dose of 32 oz. per 1,000 cu. ft. After six hours the stack was uncovered; a further two days were needed for airing to clear the gas. Although examination of bags suggested that the fumigation was successful, there were several features which delayed further consideration of this method. The arrangement of the top of the stack gave obvious advantages in better distribution of the gas to the corners, but difficulty was found in rolling the sheets on the ridge and drawing them over.

34. The reduced fumigation time did not confer any economic benefit as it led to a long working day, and because of the closure of the warehouse at night no time was saved on airing. Also a higher dosage was used on the six-hour fumigation (32 lb. for 181 tons).

35. Tests for living insects showed that by the time the cocoa was aired, bags on the outside of the stack contained living adult *Tribolium castaneum* (Herbst) but no larvae or other insects. Bags from inner layers contained no living insects and it was deduced that reinfestation by *T. castaneum* had taken place during airing.

36. It was concluded that though the modified fumigation technique might have advantages in Ghana, there appeared to be no advantages when applied to the fumigation of cocoa in Nigeria.

Cocoa in the Eastern Region

37. Production of cocoa in the Eastern Region has continued to show an upward trend and tours of inspection have been made to keep under observation the degree of infestation in the stored crop.

38. The Pest Control Section of the Produce Inspection Division which was inaugurated in August 1958, following a recommendation by W.A.S.P.R.U., has continued its work of routine spraying of empty cocoa warehouses with D.D.T. The annual report of the Produce Inspection Division for 1958/59 indicates that improved evacuation combined with the institution of pest control measures has resulted in a marked reduction in deterioration of graded cocoa, as is shown in Table I which is reproduced from the aforementioned report.

TABLE 1

<i>Year</i>	<i>Total Tons Graded</i>	<i>Total Tons Deteriorated</i>	<i>Percentage Deteriorated</i>
1954-55	964	16	1.7
1955-56	1,175	153	13.0
1956-57	1,590	176	11.0
1957-58	1,519	515	33.8
1958-59	2,380	39	1.7

Protection of Fumigated Cocoa against Reinfestation

39. Stacks of bagged cocoa beans are usually exposed to cross infestation either from other cocoa in a trading store or from endemic infestation in the area of the cocoa warehouse. It has been found that fumigated cocoa rapidly becomes reinfested if unprotected and three experiments have been carried out to study the problem of protection.

Cocoa Stacks Covered with Treated Baft

40. A parcel of cocoa was fumigated and immediately after airing was built into five one-ton stacks. The stacks were treated as follows:

1. Untreated.
2. Covered with untreated baft sheet.
3. Sheeted—Sheet treated with D.D.T. 25%, at the rate of 160 mg./sq. ft.
4. Sheeted—Sheet treated with Dieldrin at the rate of 130 mg./sq. ft.
5. Sheeted—Sheet treated with synergised pyrethrin at the rate of 160 mg./sq. ft. of mixture containing 2.5/25% pyrethrin/piperonyl butoxide.

41. The insecticides were applied in water and the sheets dried before placing over the stacks of cocoa. The store in which the experimental stacks were situated was a normal trading store in Ibadan and for most of the period of the experiment contained infested cocoa.

42. After 18 weeks' storage the cocoa was examined by sieving all the bags in each stack and the results of insect counts are shown in Table 2, where means and standard errors were obtained after logarithmic transformation and final reversion to normal data.

43. The results show that the baft covering impregnated with D.D.T., and with Dieldrin, resulted in considerably less infestation than the other treatments. The insect most affected was *Lasioderma serricorne* (F.), the tobacco beetle. *T. castaneum* seemed less affected by the treatments than the other insects.

44. A feature of the results is the low level of *Ephestia cautella* (Wlk.) infestation in the unsheeted stack. There is thus no evidence that the treatments prevent the entry of this moth. No treatments, however, resulted in a heavy *E. cautella* infestation.

45. At present the use of D.D.T. or Dieldrin is not allowed in proximity to cocoa, so that although the two treatments involving these insecticides led

to considerable reduction of insects, their use cannot at the present time be recommended. (G. W. Ozburn, J. Riley, P. Ward, M. R. George, E. A. Effiong.)

TABLE 2

MEAN NUMBERS OF INSECTS PER BAG FOUND IN BAGS OF COCOA FROM STACKS TREATED IN VARIOUS WAYS AND STORED FOR 18 WEEKS

	<i>Unsheeted</i>	<i>Sheeted</i>			
		<i>Untreated</i>	<i>D.D.T.</i>	<i>Dieldrin</i>	<i>Pybuthrin</i>
<i>L. serricorne</i> ..	56.4 ± 1.3	32.4 ± 1.1	2.3 ± 1.3	3.8 ± 1.6	25.8 ± 1.3
<i>T. castaneum</i> ..	47.3 ± 1.3	41.1 ± 1.1	13.1 ± 1.5	27.4 ± 1.3	29.6 ± 1.1
Parasites	24.6 ± 1.4	3.3 ± 1.2	—	1.1 ± 1.0	1.3 ± 1.1
<i>Cryptolestes</i> sp. ..	2.3	1.8	7.4	2.7	2.9
<i>E. cautella</i>	1.2	1.7	1.1	—	2.6
<i>Oryzaephilus mercator</i> (Fauv.)	1.1	—	—	—	2.6
<i>Carpophilus dimidiatus</i> (F.) ..	1.1	1.0	—	—	—
<i>Tenebroides mauritanicus</i> (L.)	1.5	—	—	—	1.6
TOTAL (Original Data)	137.1	89.5	37.1	43.4	78.0

Data obtained after Log. Transformation and Reversion (16 bags in each treatment); S.E. omitted for less important insects.

The Use of Polythene Sheets

46. Two experiments have been carried out on the use of polythene sheets for protecting fumigated cocoa, one in Ibadan in a typical licensed store and one at Apapa in the port area of Lagos.

47. For the Ibadan experiment, a stack of 40 tons of bagged cocoa beans was fumigated with methyl bromide by the Pest Control Section of the Western Region Produce Inspection Division. After airing, the stack was rebuilt into two equal stacks, one being covered by a polythene sheet 0.005 in. thick. The base of the sheet was held to the floor by long sandbags, and pressed on to an area previously sprayed with D.D.T.

48. Nine weeks after fumigation, the two stacks were compared for infestation by sieving 30 bags from each stack; for quality by examining spear samples taken from outer bags, and for moisture content of cocoa in outer bags by testing with a probe-type moisture meter.

The results of sieving are shown in Table 3.

TABLE 3
NUMBERS OF INSECTS IN BAGS OF COCOA FROM COVERED AND
UNCOVERED STACKS NINE WEEKS AFTER FUMIGATION

Insect Species	Total Insects from 15 Bags in Each Category			
	Polythene Covered		Uncovered	
	Outer Bags	Inner Bags	Outer Bags	Inner Bags
<i>L. serricorne</i>	0	0	89	43
<i>T. castaneum</i>	0	0	93	45
<i>E. cautella</i>	0	0	27	11
<i>Ahasverus advena</i> (Waltl.)	63	7	3,322	585
Parasites	5	0	46	16
Others	2	2	40	47
TOTAL	70	9	3,627	747
Mean per bag	4.7	0.6	241.8	49.8
Mean based on Log. trans- formation and reversion from normal data ..	3.3	0.42	186.1	26.9

49. The results show that the stack covered with the polythene sheet had suffered little reinfestation, none being by the major pests *L. serricorne*, *T. castaneum*, and *E. cautella*. Infestation by all these species was present in the uncovered stack.

50. Tests for quality based on a sample of 300 beans showed no difference in insect damage between the two stacks, but mouldy beans were less in the sample from the covered stack than in that from the uncovered stack. Moisture meter readings showed no difference between the two stacks.

51. The Lagos experiment was of short duration. It was carried out in an area of high endemic *T. castaneum* infestation and results could be obtained rapidly as reinfestation of fumigated cocoa usually began on the evening of the day when the cocoa was aired after fumigation.

52. Two adjacent 20-ton stacks of bagged cocoa beans were fumigated under a 0.01 in. thick polythene sheet, by the Pest Control Section of the Western Region Produce Inspection Division. Immediately after desheeting for airing, four bags were examined from the corners of the stacks. No living insects were found. In the hopes of preventing cross infestation by dusk-flying insects the stack chosen for sheeting was covered for three consecutive nights using the same sheet, by which time the gas had cleared and the sheet could be left on permanently.

53. After three days it was found that the unsheeted stack had become lightly infested with *T. castaneum*, *A. advena*, and parasitic Hymenoptera. The only species seen in the covered stack was *Cryptolestes pusillus* (Schön.)

which was absent in the uncovered stack and did not appear in the examination described below.

54. The final examination took place three weeks after fumigation, when, of 12 bags examined from each stack, only one contained infestation in the case of the covered stack, while all 12 bags from the uncovered stack were infested. The results are shown in Table 4.

TABLE 4
NUMBERS OF INSECTS IN BAGS OF COCOA FROM COVERED AND UNCOVERED STACKS THREE WEEKS AFTER FUMIGATION

Insect Infestation	Total Insects from 6 Bags in Each Category			
	Polythene Covered		Uncovered	
	Outer Bags	Inner Bags	Outer Bags	Inner Bags
<i>T. castaneum</i>	0	1	18	9
<i>A. advena</i>	0	0	117	19
<i>L. serricorne</i>	0	0	0	1
Parasites	0	0	2	2
<i>E. cautella</i>	0	0	0	1
Other species	0	0	4	1
TOTAL	0	1	141	33
Mean number of living insects per bag ..	0	0.2	23.5	5.5

55. No detectable difference between the quality of cocoa beans in each stack was found by the Western Region Produce Inspection Division.

56. The two experiments described above show that polythene sheeting of from 0.005 in. to 0.01 in. thick is effective in preventing reinfestation when used to cover stacks of cocoa immediately after fumigation. In trading stores away from the port there is little danger of cross infestation during the airing process following fumigation, but at port endemic infestation necessitates the covering of the stack before dusk each day until airing is completed. This cumbersome process could be overcome if the rate of airing was increased and could be completed in the daylight hours of one day.

57. Acknowledgement is made to P. O'Donoghue of the Pest Control Section for his co-operation and advice during the second experiment described above. (J. Riley, K. U. Ndukwe, E. A. Effiong.)

Bulk Storage of Cocoa in Silos

58. Bulk storage and handling of cocoa beans could offer several advantages over bag storage; in particular, automatic handling, ease of quality and control, and elimination of the cost of bags. However, the capital cost of changing to bulk storage would prevent serious consideration at present.

Nevertheless, it was felt that a preliminary trial on handling and bulk storage of cocoa might be carried out using the silo project at University College, Ibadan.

59. Accordingly, 16 tons of fumigated cocoa were divided between a steel and a concrete block silo. The silo system is equipped with ducting and a fan blower but it was found that cocoa could be fed only very slowly into the ducting system otherwise a blockage would result. With a more powerful fan the air ducting system would be quite suitable for cocoa as beans were not damaged by being blown into the silo.

60. An augur conveyor was also tested for lifting the cocoa but 40% of the beans were cut by the blades. Because of the failure of mechanical systems the greater part of the filling took place by hand.

61. After one month's storage a series of measurements of temperatures was carried out and a report on this will be issued in due course.

62. After $2\frac{1}{2}$ months' storage, cocoa in the concrete bin was removed to another concrete bin in order to examine the different layers. The result of cutting beans showed little difference between the quality of cocoa in each layer.

63. A slight reduction in quality seemed to have been caused mainly by an increase in the numbers of mouldy beans.

64. Final emptying of both silos was carried out by hand in mid-August, after four months' storage. Dampness on the floor of the concrete silo led to caking of a very small quantity of cocoa, and neglecting results for the bottom layer, Table 5 shows the average quality in each silo based on nine samples of 300 beans for the steel silo. The examination of beans was carried out by a Produce Inspector of the Western Region Produce Inspection Division.

TABLE 5
THE CHANGE IN QUALITY OF COCOA FROM STEEL AND CONCRETE SILOS
DURING FOUR MONTHS' STORAGE

	<i>Defective</i> %	<i>Mouldy</i> %	<i>Insect Damage</i> %
Initial	$3\frac{1}{2}$	1	$\frac{2}{3}$
Final: Steel Silo	5	2	$1\frac{1}{3}$
Concrete Silo	$3\frac{2}{3}$	$1\frac{2}{3}$	$\frac{2}{3}$

65. The higher damage in the steel silo could be accounted for by the greater ease of penetration of damp air and insects through various gaps in the structure, especially under the eaves.

66. When the cocoa was finally rebagged for grading it was classed as Grade II (above 5% defective), but it is evident that only slight deterioration had in fact taken place, and this could not directly be attributed to storage in silos. The whole of the storage period was during the wet season and the cocoa used had already been in store for several weeks. If the cocoa had been new stock at the time of filling and fumigated *in situ* in the silo, little

deterioration would be expected. Handling could be carried out by a blower system using ducting providing a fan of sufficient power were used.

67. Thanks are due to G. H. Caswell and R. Myhill of Faculty of Agriculture, U.C.I., for assistance with this experiment. (J. Riley, M. R. George, K. U. Ndukwe, E. A. Effiong.)

VII GROUNDNUTS

General Storage Position

68. The 1958/59 crop, although not achieving the size of that of 1957/58 has been large. Comparison of the size of the crop with those of previous years may be made by reference to Table 6. Railment has been rapid but a considerable quantity of nuts will remain at Kano well into next season for use by the local oil millers.

Special Grade Groundnuts

69. It is interesting to note the continued improvement in the quality of groundnuts as a result of the introduction of the Special Grade specifications. Table 6 includes data for groundnuts purchased in the Kano area only.

TABLE 6

<i>Season</i>	<i>Crop (Tons)</i>	<i>Special Grade (Tons)</i>	<i>Special Grade %</i>
1954-55	348,232	Nil	Nil
1955-56	508,966	11,233	2.2
1956-57	347,110	140,513	40.5
1957-58	691,497	677,600	97.9
1958-59	510,954	509,408	99.9

Fumigation of Groundnuts and other Food Products

70. The information given in Table 7 illustrated very well the efficacy of fumigation by methyl bromide in reducing populations of *Trogoderma granarium* (Everts.) in groundnuts during the last seven years. The fumigation work has been carried out by the Pest Control Unit of the Produce Inspection Division of the Ministry of Agriculture, Northern Region.

TABLE 7

<i>Season</i>	<i>Crop in Kano Area</i>	<i>Groundnuts Infested with T. granarium and Fumigated</i>	
	<i>Tons</i>	<i>Tons</i>	<i>% of Crop</i>
1952-53	401,161	111,452	27.8
1953-54	402,488	41,445	10.3
1954-55	348,232	53,251	10.1
1955-56	508,966	22,124	4.3
1956-57	347,110	9,403	2.7
1957-58	691,497	42,989	6.2
1958-59	510,954	942	0.2
Up to Oct. 1959)			

71. Mention was made in the 1958 W.A.S.P.R.U. Annual Report (paragraphs 80-86) of the problem of *T. granarium* found to infest groundnut cake in oil mills in Kano. The situation with regard to the Kano oil mills has considerably improved however, as the figures for the tonnage of groundnut cake, which it was found necessary to fumigate, show (see Table 8). This has been made possible by the co-operation of the oil millers with the Produce Inspection Division. In an effort to trace the sources of infestation of *T. granarium* in groundnut cake in Kano, oil mills at Matameye and Maradi in French Niger were visited on different occasions by W.A.S.P.R.U. officers during January 1959. Evidence of previous infestation by *T. granarium* was found and advice for the improvement of storage premises at both stations was given.

TABLE 8

Year	Tonnage of Groundnut Cake Fumigated	Tonnage of Local Foodstuffs Fumigated
1955	147	1,095
1956	1,870	1,958
1957	3,976	4,339
1958	2,553	526
Up to October 1959	886	5,155

72. Two cargoes only of groundnut cake from Nigeria have so far been reported in 1959 (up to October) as being infested with *T. granarium* upon arrival in the United Kingdom. This insect thus seems to have been less common than in any previous year. Whether this is due to a natural fluctuation in the population density or to the control measures carried out, is difficult to assess.

73. The Pest Control Unit is also rendering invaluable service by the fumigation of increased tonnages of local foodstuffs (infested with *T. granarium*), as can be seen in Table 8. This aspect of their work is most important as not only does it help the various authorities to maintain good stocks of corn, but the danger of cross infestation to groundnuts from these sources is very much reduced.

Control of T. castaneum

74. The Pest Control Unit of the Produce Inspection Division of the Ministry of Agriculture, Northern Region, have continued routine control measures against *T. castaneum*, i.e. the regular spraying of the external surfaces of groundnut stacks with a suspension of malathion wettable powder, and the treatment of the underside of sisalkraft dunnage with a 4% malathion dust as described in the 1958 W.A.S.P.R.U. Annual Report (paragraphs 94-6).

75. Attempts have been made by the Pest Control Unit of the Produce Inspection Division to destroy the large numbers of adult *Tribolium* spp. at the time of their dusk flight by the production of a fog containing malathion,

using portable pulse jet applicators in the areas around pyramids. A successful method of assessing the usefulness of these operations has not yet been evolved and it is proposed to continue the work at the time of heavy population next season.

76. The assessment of the density of population of *T. castaneum* remains a difficult problem. Experienced observers believe that the dusk flights of *Tribolium* spp. were much less dense during this past season. This evidence does add some weight to the fact that light trap figures for 1959 indicate decreasing population densities of the insect compared with previous years. Table 9 shows the total number of *Tribolium* spp. for each month caught at the light trap during the past few years. The figures for 1959 are exceedingly low. Many factors influence the size of the insect populations, and it may be significant that the proportions of Special Grade nuts have increased enormously during the two past seasons. Possibly more important is the fact that the Pest Control Unit changed from B.H.C. to malathion for their routine control measures at the beginning of this period.

Infestation of Groundnuts by Moth

77. Many complaints have been received this year about a moth, the larvae of which produces large masses of webbing both inside and outside bags of groundnuts. The moth has been identified as *Corcyra cephalonica* (Staint.) and has become firmly established in many stores in Kano. The reason for the sudden prominence of this insect is not known. It was recorded as a pest of significance in groundnuts in 1958 W.A.S.P.R.U. Annual Report (paragraph 91) but this was in areas outside Kano. Many groundnuts in stores have been fumigated to kill off the infestations, but this method of control does not, of course, affect previously-formed webbing. Trials are being planned to discover a suitable method of early control of the moth.

Storage Outside Kano

78. In January 1959 groundnut storage sites were visited at Yola following complaints of badly infested and damaged nuts. Groundnut storage was also inspected at Maiduguri and recommendations were made concerning pest control measures and for improving storage hygiene in both these areas.

Contamination of Groundnuts with Malathion

79. In the absence of any legislation in the United Kingdom W.A.S.P.R.U. decided to adopt as a guide the Canadian limits for malathion in stored food products, viz. eight parts per million. Every effort is made to prevent exceeding this figure with the cumulative amounts of malathion deposited on pyramids during the periodical (three-weekly) routine spraying procedure. To this end, samples of nuts are being taken at four-monthly intervals from random pyramids in Kano for the purpose of checking the amount of malathion present. Malathion analyses are carried out on the samples by both the Tropical Products Institute in the U.K. and by W.A.S.P.R.U., Kano.

80. The few checktests which have been carried out so far, indicate that contamination in the outermost 6 inches or so of a pyramid (i.e. the average

TABLE 9

TOTAL *TRIBOLIUM* SPP. CAUGHT AT LIGHT TRAP OVER THE PERIOD FEBRUARY 1956-SEPTEMBER 1959

Year	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1956	No records	555	1,898	5,655	1,075	986	2,497	3,644	1,141	247	86	7	17,791
1957	7	11	705	1,788	374	1,553	3,872	1,921	244	102	105	3	10,685
1958	18	210	1,504	445	113	91	650	1,909	298	94	23	0	5,355
1959	2	6	19	24	72	339	236	75	12	—	—	—	785

depth up to which the sampling spear penetrates) may just exceed the figure of 8 p.p.m. after four or five successive applications of insecticide. Calculated on the basis of total weight of the pyramid, assuming that malathion affects the outer surfaces only (or very roughly 2% of the total volume of the pyramid) contamination may be said to be negligible. Results obtained indirectly during experimental treatment of pyramids, support this view. Routine checktests will continue to be made in future.

Hermetic Storage of Groundnuts.

81. A small-scale experiment was commenced in March 1959, in which insect-free whole nuts were stored in airtight Kilner jars. Similar samples were stored in Kilner jars covered with fine gauze only. Three jars from each set have been opened after three and six months, and their contents examined for f.f.a. and moisture contents.

82. There has, as yet, been no significant alteration in the f.f.a. content in any of the nuts. The moisture content of the hermetically stored nuts has remained unchanged, while that of control nuts has increased as a result of changing humidity during the "wet" season; these results, of course, are to be expected.

83. Further samples will be tested after nine, and twelve months, when a full report will be made on the trial. (M. J. Glover, M. R. George, G. Udo, I. Kazaure.)

*Effect of Hermetic Storage of the Eggs of *T. castaneum**

84. Recently the firm of Glaxo Ltd., at Apapa, has started preparing a high protein native foodstuff from groundnut flour and milk powder. A similar preparation is also being manufactured at the milk processing plant at Vom for distribution by U.N.I.C.E.F.

85. Officers of U.N.I.C.E.F. and the management of Glaxo have approached W.A.S.P.R.U. independently for advice regarding the infestation of their products by *T. castaneum* which originates from the groundnut flour. It was suggested that all the groundnut flour should be packed in hermetically sealed drums before leaving the mills at Zaria and Kano and should be kept for two months before use to ensure self-sterilisation. It was also suggested that the finished mix should be passed through an entoleter immediately before packing.

86. The question arose as to whether eggs of insects would survive periods of hermetic storage owing to their low rate of respiration. This problem had not previously arisen and in view of its general importance it was decided to carry out a few simple tests.

87. Kilner jars containing thriving cultures of *T. castaneum* on wholemeal flour have been hermetically sealed and are being kept in the Kano laboratory. Three such cultures subject to airtight conditions for 35 days have been unsealed and an attempt made to breed out any viable eggs present; after three weeks no signs of life have yet been noted. Further work will be carried out to determine the effect of hermetic storage on populations of very low

density in which, of course, the oxygen requirements will be very much lower. (M. R. George, L. A. W. Hayward, S. C. Morah.)

Mechanism of Free Fatty Formation in Groundnuts

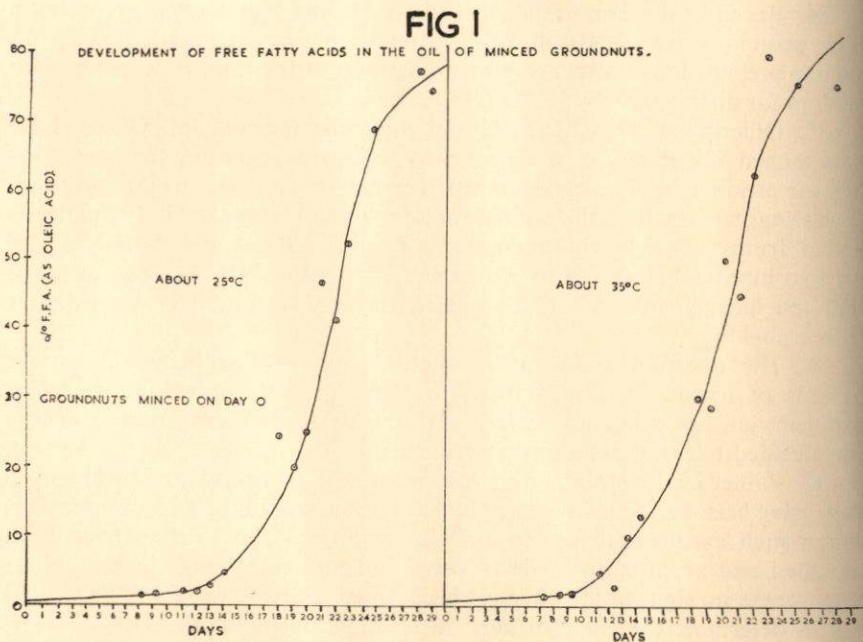
88. Following discussion with Professor Collard at U.C.I. on the subject of the mechanism of f.f.a. formation in groundnuts it was decided that further insight into the factors involved should be in the first instance attempted through a study of the f.f.a. formation rate curves. (The same approach was decided on in the case of palm oil—see paragraph 114.)

89. Undamaged groundnuts were exposed to atmospheres of 100% relative humidity (in desiccators containing water) one lot at 20° C. and a second lot at 35° C. until their moisture contents had reached a steady high level. Both lots of groundnuts were then passed through a domestic mincer and returned to their respective desiccators. Samples from each batch of nuts were examined at intervals for moisture contents and f.f.a. in the extracted oil.

90. Curves showing the f.f.a. formation appear in Figure 1 and are of sigmoid shape. Moisture contents rose from 6–10% in the conditioned unminced nuts to a final value of 17–20% after keeping the minced samples for a month at 100% R.H.

91. It is to be noted that lipolysis proceeded to a greater extent at the higher temperature and the mould growth was more profuse on the minced nuts at 20° C. than those held at 35° C.

92. Further work will be planned when the significance of the curves shown in Figure 1 has been fully considered. (M. J. Glover.)



Experimental Groundnut Stack

93. The difficulties associated with the building and use of the "pyramid" shape of stack were outlined in the 1957 W.A.S.P.R.U. Annual Report (paragraphs 131-2). A short progress report on an experimental stack of different shape was included in the 1958 W.A.S.P.R.U. Annual Report (paragraph 134). A full report has since been written on the subject.

94. The experimental stack, which was built in February 1958, and evacuated during October 1958, was erected upon a rectangular plinth formed by joining together two adjacent conventional plinths, the laterite floor being sloped to form a ridge along the long axis of the plinth which was two feet higher than the edge of the plinth. The dimensions of this base were 124 ft. long, and 54 ft. wide.

95. The stack itself was built with vertical walls to the tenth layer. Above this layer, it was sloped to give a curved surface. A transverse vertical section of the stack would have roughly the appearance of a rectangle surmounted by a hemisphere. The total height of the stack was 31 bags, and a trench was made along the apex to take fumigation pipes and nozzles. The stack contained 2,280 tons of groundnuts.

96. The cost of covering the stack with 17 tarpaulins was approximately £1,100. This compares quite favourably with the cost of about £500 for the tarpaulins needed to cover a normal pyramid of 850 tons. Some economy was also made in the sisalkraft paper dunnage required for the stack.

97. Monthly samples of nuts were taken for the determination of f.f.a. and moisture contents. During evacuation samples of nuts were taken along a cross-section, and also from similar positions in a pyramid stack. The analyses showed that there is little difference in the build-up of f.f.a. content between the experimental and a normal type of stack. Moisture contents were also quite normal.

98. Despite the economies which might be made if this type of stack were generally adopted, a number of disadvantages have been put forward by the Produce Inspection Division of the Ministry of Agriculture, Northern Region, which are as follows:

- (a) It was felt that many licensed buying agents might have difficulty in purchasing the required amount of groundnuts, especially at stations outside Kano, to complete such a large stack.
- (b) If such stacks could be built, railment of groundnuts may not be sufficiently rapid to prevent the stacks remaining in a semi-dismantled condition for quite a long period.
- (c) The cost of fumigation of the large stack would be almost treble the cost for a pyramid stack. The cost of methyl bromide alone would be approximately £120-£130 for the large stack compared with £44 for a standard size pyramid.
- (d) It is also now realised that the experimental stack was more difficult to build than was originally anticipated owing to the continually changing angle of the sides above the tenth layer. In any case it would take a considerable time for labourers to become used to building the unfamiliar shape.

99. Thus, for the above reasons, it is unlikely that this type of stack will be adopted in the immediate future, despite the economies which might result. One thousand tons is generally thought to be the maximum easily manageable size for a stack. (J. R. Cutler.)

Dunnage for Groundnuts

100. The experimental use of roofing-felt as a dunnage for groundnuts, has been commented on in the 1957 and 1958 W.A.S.P.R.U. Annual Reports (paragraphs 139-40 and 131-133, respectively).

101. Roofing felt tested on one of the experimental plinths during the 1957/58 storage season, has been used for a second season after patching a few perforations and tears. The surface of the felt was blinded with a layer of sand before placing bags on it.

102. Evacuation of the groundnuts from this plinth was completed in September 1959. The efficiency of the felt is illustrated by the fact that no bags of groundnuts in direct contact with the felt were found to have deteriorated. The roofing-felt was found to be in excellent condition although some damage was apparent, mainly due to misuse. The felt is now extremely well bedded down and forms a most compact, semi-permanent, damp-proof surface. After suitable patching the surface will be used for at least a third season.

103. The cost per unit area of roofing-felt is slightly less than for sisalkraft paper, while roofing-felt can also be used for two or three seasons instead of for one season only as is the case with sisalkraft. Thus, providing that a little more care is taken in the use of roofing-felt than is necessary with sisalkraft paper, considerable economies could be effected by the general adoption of roofing-felt dunnage and recommendations to the Produce Inspection Division have now been made for the substitution of roofing-felt for sisalkraft paper as dunnage for groundnuts.

Ctesiphon Buildings

104. These buildings, on which short reports appear in the 1957 and 1958 W.A.S.P.R.U. Annual Reports (paragraphs 143-55 and 141-6, respectively) were handed over to the Ministry of Agriculture, Northern Region for the storage of famine reserves of corn, at the end of the third season they had been used for groundnut storage.

105. Although these buildings are no longer the subject of W.A.S.P.R.U. experiments, observations are still made on their behaviour by both W.A.S.P.R.U. and the Produce Inspection Division. It has been obvious that the buildings are by no means impervious to the entry of either insects or water. When opened up in September 1959 for the first time for some months after fumigation, the guinea corn in both stores was found to be highly infested with *Tribolium* spp. It seems probable that the insects enter the buildings either through the air-conditioning ducts in Store No. 1, or through the expansion joints in both stores, the plastic filler in these gaps having contracted. Much water was found within the inspection doorway of Store No. 1 and the loading doorway of Store No. 2, being rainwater driven in through cracks above the porches.

106. The aluminium paint on Store No. 1 remains in a reasonably satisfactory condition. The white plastic emulsion paint surface on Store No. 2, however, is superior. A full report on the three years of groundnut storage in the two Ctesiphon buildings has been produced.

Experimental Dutch Barn

107. In the near future, work will be commenced by W.A.S.P.R.U. and the Produce Inspection Division of the Ministry of Agriculture, Northern Region, on the erection of a Dutch barn for the storage of groundnuts. The barn, specially designed to the specifications of Produce Inspection, will have galvanised steel roof and wall cladding, and will be equipped with sliding doors. Having a capacity of 500-600 tons, this type of structure is extremely cheap compared with other metal structures and the economic possibilities of replacing outdoor storage of groundnuts with its inevitable heavy recurrent expenditure on tarpaulins and plinth surfaces, by this cheap weather-proof building will be investigated.

VIII. PALM PRODUCE

108. Collaboration has continued between the Produce Inspection Division of the Eastern Regional Ministry of Agriculture and W.A.S.P.R.U. on both routine and special testing methods for palm oil, palm kernels and copra. A considerable amount of time has been spent, as in previous years, on analytical work and provision of evidence in connection with legal cases initiated by the Produce Inspection Division.

109. Liaison has also been maintained with the West African Institute for Oil Palm Research at Benin, and with the Supervising Manager, Bulk Oil Plants (B.O.P.s) of Nigeria. Visits have been paid to the four B.O.P.s in Eastern Nigeria, to a large proportion of produce buying stations, and to the Calabar Oil Palm Estate.

Mechanism of Lipolysis in Palm Oil

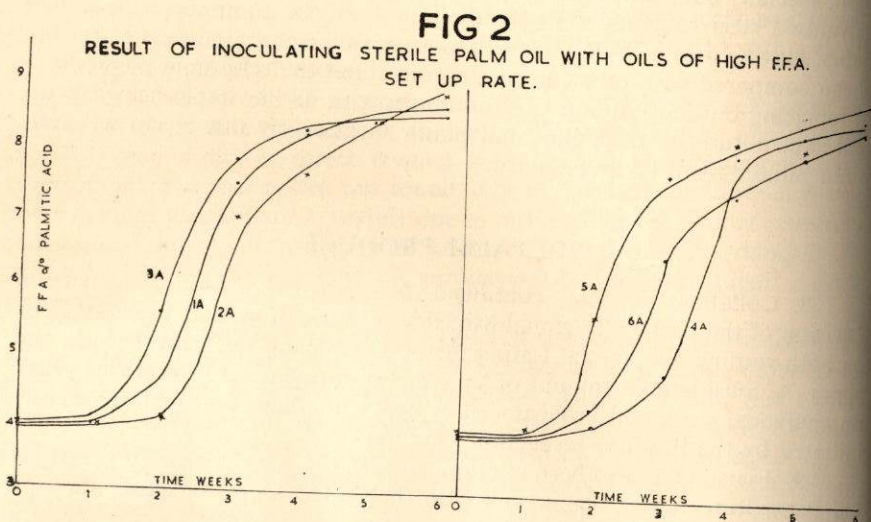
110. Current views on this topic were given in paragraph 163 of the 1958 W.A.S.P.R.U. Annual Report. Further progress in this field has been hampered by the lack of improved laboratory facilities at Port Harcourt, but some further experiments on the effects of chemical sterilants, and of inoculation of pure oil with small quantities of crude oil have been carried out.

111. Studies were made on the effects of phenol, terramycin and "topanol" (a butylated hydroxytoluene) on the rate of f.f.a. set-up of samples of palm oil, to which 5% of sterile water had been added.

112. The results, although somewhat inconclusive, suggested that terramycin and "topanol" do not have any inhibitory effect at the dosage rate used in this experiment. Phenol, however, contrary to previous results, appeared to show a marked inhibitory effect. (U. I. Ukoha, T. I. Ekemezie.)

113. Further inoculation experiments similar to those described in the 1958 W.A.S.P.R.U. Annual Report (paragraphs 171-2) were carried out, at the suggestion of Professor Collard of U.C.I. Six samples of Special Palm Oil

(S.P.O.) were taken from drums arriving at Port Harcourt from various stations. Tests for f.f.a. were carried out on these samples (Samples 1 to 6) at weekly intervals. A sample of pure S.P.O. from the bulk oil plant, which was of low moisture content, and which, having been recently processed, could be expected to be sterile, was divided into seven portions (Control, plus samples 1A to 6A): to each of these was added 5% of sterile water, while sample 1A was inoculated with 1% of oil 1, 2A with 1% of oil 2, etc. F.f.a. tests were also carried out weekly on these samples. The results are shown in Figure 2, and it will be seen that the curves approximate to the sigmoid form.



(D. G. Coursey and L. U. Enyenih.)

114. Professor P. Collard of U.C.I. has given advice in planning further work on investigations into the mechanisms involved in the formation of f.f.a. in both palm oil and groundnuts, and work is to be conducted in which it is hoped to elucidate the significance of the results obtained to date.

Oxidative Stability of Palm Oil

115. In view of the apparent importance of oxidation in connection with the problems of the bleachability of palm oil, experiments have been initiated on the effects of atmospheric conditions of palm oil, and also on the natural iron contents of Nigerian palm oil—iron being a well-known pro-oxidant for lipids including palm oil. (See, for example, Deschreider, van Collie and Meaux, in *Fette Seifen Anstrichmittel*, **59**, 12 (1959).)

116. Samples of palm oil were treated with two anti-oxidants, butylated hydroxytoluene (B.H.T.) and hydroquinone—and the peroxide values determined at intervals during storage. The results, expressed as millilitres of 0.002N thiosulphate per gram of oil, are given in Table 10. Both the substances investigated thus appear to exert some antioxidative effect.

TABLE 10
EFFECTS OF ANTIOXIDANTS ON THE STABILITY OF PALM OIL

Date	Peroxide Values		
	B.H.T.	Hydroquinone	Control
11/8/59	Nil	Nil	Nil
19/8/59	0.03	0.02	0.05
28/8/59	1.14	0.8	1.6
4/9/59	1.4	0.8	1.6
11/9/59	1.5	1.2	2.4

117. Determinations of the iron contents of a number of samples of palm oil, specially prepared so as to be as free as possible from metallic contamination, have been made, the palm fruit having been collected from various parts of the country. The methods of British Standard B.S. 684: 1950 was used for the iron analysis: the results are as given in Table 11.

TABLE 11
NATURAL IRON CONTENTS OF SAMPLES OF NIGERIAN PALM OIL

Source of Palm Fruit	Iron Content in P.P.M.
Nwaniba	5
Calabar	4
Itu	4
Ikom	0
Ezillo (near Abakaliki)	0
Nsukka	0
Bori	0
Isoba (a) (near Port Harcourt)	2
Isoba (b)	10
Isoba (c)	8
Isoba (d)	4
Ohafia (near Bende)	0
Ozuabam (near Bende)	8
Ovom (near Aba)	7
Isiokpo (near Port Harcourt)	1
Sapele	4

(U. I. Ukoha, U. E. Enyenihi, I. Davies.)

Bleachability of Palm Oil

118. Further work on the bleachability of palm oil was conducted by Dr. Raymond and his staff of the Tropical Products Institute (T.P.I.) in liaison with W.A.S.P.R.U., who carried out the fieldwork in connection with this investigation and prepared under controlled conditions samples of palm oil and fruits for despatch to T.P.I.

119. A series of reports has been issued by Dr. Raymond on these samples, and the factors concerned with bleachability of palm oil are now far more

clearly understood and a brief resumé of the results is given in the following paragraphs, in which reasons for the poor bleachability of Nigerian palm oil are outlined.

120. It has been established that the bleachability of Nigerian palm oil is not inherently bad, when prepared in such a way that damage to fruit, and delays in sterilising and processing the fruit, are minimised.

121. Mixing of oils of good and poor bleachabilities produced blended oils of poorer bleachabilities than the arithmetic mean of the two original values. It was also shown that oils of poor bleachability had a residual colour beyond which it was virtually impossible to bleach them, even when very large quantities of bleaching earth were used.

122. In an experiment designed by W.A.S.P.R.U. the effect of delay in processing of the fruit on the bleachability of the resultant oil was examined. Samples prepared in this connection by W.A.S.P.R.U. were examined at T.P.I. and gave the results shown in Table 12.

TABLE 12
EFFECT OF PROCESSING DELAY ON THE BLEACHABILITY OF PALM OIL

Delay in Processing	Carotene Content (Initial, Mgs./Kig.)	Residual Colour after Bleaching		
		Earth Bleaching	Heat Bleaching	Heat/Earth Bleaching
0	1,677	45	61	39
6 hours ..	2,935	185*	60	60
12 hours ..	1,085	32	40	28
1 day	1,208	27	30	28
2 days	1,842	105	71	38
4 days	1,877	90	70	38
8 days	2,163	190	102	76
16 days	1,283	153	144	135

* This result is aberrant, owing to the abnormally high carotene content of the oil.

123. Following upon the previous experiment, further work by T.P.I. revealed the presence of lipoxidase activity in fresh palm fruit. Experiments were then conducted on the effect of lipoxidase preparations on palm oil. It was found that when palm oil was treated with a preparation of dried haricot beans (known to contain lipoxidases) there was an appreciable decrease in the ease with which it could be bleached. The treatment of palm oil with an extract of fresh palm fruit also resulted in a deterioration in its bleachability. It has been established that although a high carotene content in palm oil does not necessarily imply poor bleachability, the bleachability of such oil is adversely affected by aerial or enzymic oxidation to a greater extent than that of oils of low carotene content.

124. Coupled oxidation between unsaturated glycerides and the carotene present in the oils occurs, mainly in the fruit before processing, under the catalytic influence of lipoxidases naturally present in the fruit, but also, to a lesser extent, as a result of atmospheric oxidation during the handling of the

oil after processing, especially where contamination from heavy metals (e.g. iron) has occurred. The coloured products of these processes are less strongly absorbed by the bleaching agent than the original carotenes, whilst other fatty acid oxidation products may, on account of their polar nature, tend to block the absorption of the remaining carotene on the bleaching agent.

125. Although much detailed investigation remains to be done in this field, the increase in residual colour after bleaching brought about by the delays in processing is clearly demonstrated. An improvement in trade practice in this direction is most desirable, and would also have an advantageous effect on the free fatty acid content of the oil. (D. G. Coursey.)

Calibration of an Electrical Moisture Meter for Use with Palm Kernels

126. At the request of the Tropical Liaison Officer of the United Kingdom attempts have been made to calibrate a multiprobe electrical resistance meter. The work was carried out at Ibadan according to suggestions sent by the Tropical Liaison Officer, and is described in outline below:

127. Six test bins each containing 40 lb. of mixed palm kernels at different levels of moisture content were employed for the calibration. Three of the bins held kernels dried down appropriately; two were wetted artificially and the remaining bin was used for kernels in an "as received" condition.

128. When equilibrium was established, meter readings (five replicates) and oven losses in $2\frac{1}{2}$ hours at $100-105^{\circ}$ F. (three replicates) were obtained for the contents of each bin at 80° F. The bins were then stored at 70° F. and the operation repeated.

129. For both temperatures the results showed considerable scatter.

130. The probes of the instrument are arranged in a circular pattern, and this arrangement is not altogether suitable for use with palm kernels. Piercing of the kernels and distortion of the probe alignment by jamming of the large kernels in the free spaces between the probes occurs easily. A more robust instrument with two or more probes in line and wider spacing of these probes is suggested as being more suitable for palm kernels. (K. C. Matheson, L. S. O. Ene, K. U. Ndukwe.)

Weight Changes in Palm Kernels during Storage

131. Further experiments have been conducted at Port Harcourt in order to investigate the losses in weight occurring during storage of palm kernels of normal commercial quality at different times of year.

132. Six bags were selected at random from produce arriving at the Marketing Board stores (Arcon Sheds) at Port Harcourt at the beginning of each month, and weighed periodically over a three-month storage period. A total of twelve such experiments, covering a whole year, were carried out (August 1958–July 1959).

133. Very great differences between the behaviour of individual bags, even during a particular storage period, were observed, probably owing to differences in the initial moisture content of the produce. Average losses for different times of the year are given in Table 13. It will be observed that, as would be expected, losses are high on storage periods lasting from a wet to a

dryer part of the year, and low on storage periods lasting from a dry to a wet season.

TABLE 13
AVERAGE WEIGHT LOSSES IN BAGGED PALM KERNELS DURING THREE-
MONTHS STORAGE PERIODS (KERNELS STORED AT PORT HARCOURT
WEIGHT LOSSES IN LB./BAG)

Storage Period Started	Average Weight Loss After:					
	1 Week	2 Weeks	3 Weeks	1 month	2 months	3 months
August 1958 .. (week 31)	- 0.2	0.2	0.8	1.3	2.2	2.9
September 1958 .. (week 35)	1.8	2.3	2.2	3.8	4.8	6.2
October 1958 .. (week 39)	0.8	2.3	2.7	2.8	5.8	7.7
November 1958 .. (week 44)	2.0	2.5	3.3	3.7	5.3	6.7
December 1958 .. (week 48)	1.2	2.1	3.2	4.0	5.8	6.3
January 1959 .. (week 2)	0.9	3.3	3.9	4.2	5.0	6.6
February 1959 .. (week 6)	1.3	2.2	2.6	3.9	5.1	6.2
March 1959 .. (week 10)	- 0.5	- 0.3	0.2	0.0	1.2	2.3
April 1959 .. (week 14)	1.3	2.6	2.9	3.7	5.4	6.3
May 1959 .. (week 18)	2.1	2.3	3.4	3.5	4.2	4.2
June 1959 .. (week 22)	1.0	2.3	3.1	3.8	5.5	6.1
July 1959 .. (week 28)	1.9	2.1	3.5	3.5	4.3	4.7

134. A number of determinations of moisture content of the palm kernels were carried out, but it was not found possible to establish any rational correlation between changes in moisture content and changes in weight. This is probably due to variation in initial moisture contents of different batches of kernels that have been combined in one bag. (D. G. Coursey, L. U. Enyenihi and I. Davies.)

Discoloration of Palm Kernels

135. Preliminary investigations have begun on the problem of discoloration of palm kernels. A small but increasing number of complaints have been received by the Nigerian Produce Marketing Company in London of kernels which, although apparently sound, are discoloured to a dark chocolate colour. This discoloration appears to be caused by overheating of the kernels, possibly during artificial drying, or as a result of excessive spontaneous heating in large stacks of in-shell kernels. The latter may occur at "Pioneer" Mills, during the peak of the palm oil season, when large stocks of palm nuts tend to accumulate. Only one sample of such discoloured

kernels has been subjected to detailed examination to date. In this case, the f.f.a. content of the oil extracted was not excessively high nor was the oil abnormally coloured. (D. G. Coursey.)

COPRA

136. Copra has recently become a Marketing Board crop in the Eastern Region so that methods for testing the quality of this commodity have assumed importance.

137. At the request of the Eastern Region Marketing Board tests were carried out with a Marconi moisture meter to ascertain to what extent this instrument could be applied to determine the moisture content of copra.

138. It was found that when suitably grated before placing in the Marconi cell consistent readings were obtained which gave reasonable agreement with results obtained by oven drying at 100–105° C. for six hours. (K. C. Matheson.)

Weight Losses in Copra

139. At the further request of the Eastern Region Marketing Board test were conducted to ascertain the weight losses likely to be sustained by copra during storage.

140. Sixteen bags of copra (i.e. one ton), eight bags of which contained sun-dried, and eight bags (native) kiln-dried copra, were loaned to W.A.S.P.R.U. for this experiment. They were stacked in a store in Port Harcourt and weighed individually at weekly intervals over a six-week period.

141. It was found that a very rapid loss in weight, of the order of 10 lb./bag, occurs in the first week or two, followed by a comparatively slight further loss. The losses are somewhat greater in the case of sun-dried than in kiln-dried copra, though in both there were large variations between the behaviour of individual bags. Average weight losses for the two types of copra are shown in Figure 3.

Quality of Copra

142. Determinations of the f.f.a. of oil extracted from samples of copra have been made as an index quality. Samples of fresh copra gave values of about 1% f.f.a. (as lauric acid), while samples from the same store, which had been stored for about a month gave figures of about 4% f.f.a. Oil from good-quality Ghanian copra contained about 1% f.f.a. when examined. (D. G. Coursey, I. Davies.)

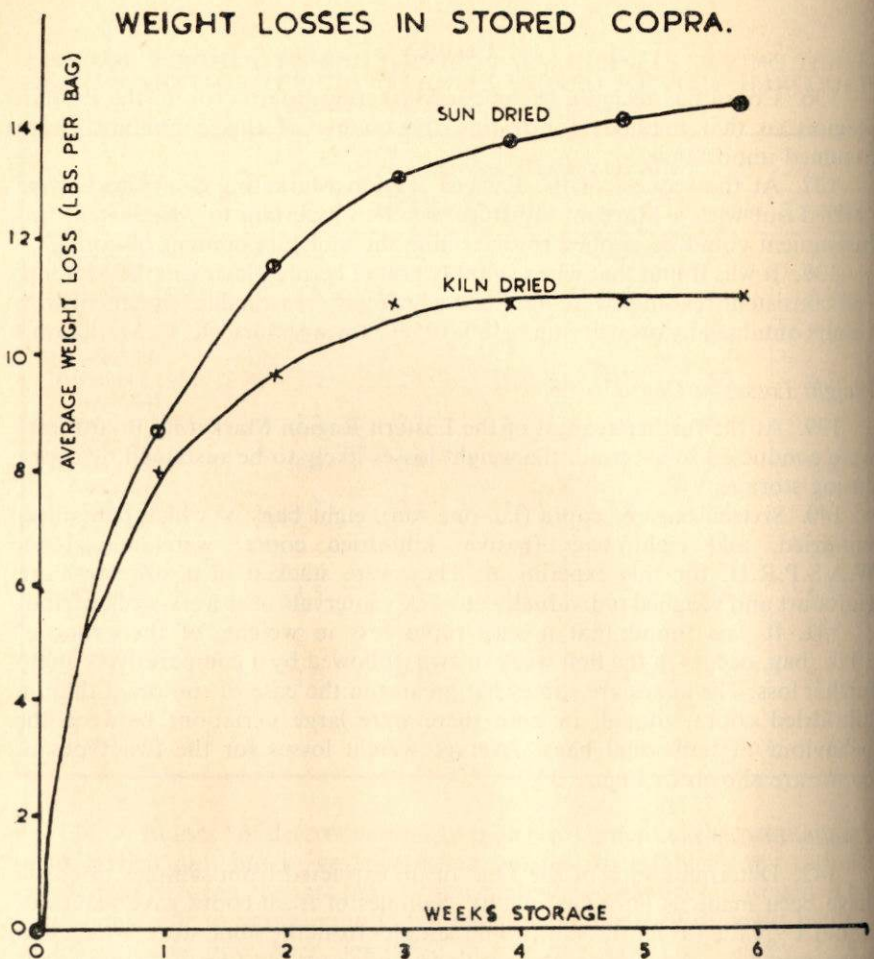
IX. GRAIN STORAGE

NORTHERN REGION

Famine Reserves

143. It has been decided by the Ministry of Agriculture, Northern Region to utilise existing storage space for the storage of corn famine reserves for the time being. Stocks will be gradually built up at a number of centres, the Produce Inspection Division of the Ministry of Agriculture being responsible

FIG 3



for their maintenance. At present a total of about 3,100 tons of corn has been acquired. At Kano, 1,900 tons of corn are held in the two Ctesiphon structures; in a conventional store with stone walls, pan roof and concrete floor; and in a similar store which had once been modified to serve as a fumigation chamber. 400 and 800 tons of corn are in stores at Funtua and Gusau, respectively;

144. The Pest Control Unit of the Produce Inspection Division have covered a number of the stacks with plastic sheeting, the corn then being fumigated by means of previously laid fumigation lines. The sheets have been left in position after fumigation and will remain thus until the corn is

required for consumption, additional fumigations being carried out whenever it is considered necessary. In this way it is hoped to store corn for several years.

145. The stack in the conventional store in Kano was laid on sisalkraft paper, the floor close to the stack being treated with a 4% malathion dust before PVC sheets of 0.01-in. thickness were laid over the stack. The sheets were weighed down at the edges with sandbags.

146. Owing to suitable plastic sheeting being unavailable at the time of building the stacks, the corn at Funtua and Gusau has been temporarily covered with fumigation sheets. These will be replaced by PVC and polythene sheeting. In all the stores it is possible to extend the stack by building on to one end, more gas-proof sheeting being added subsequently as necessary.

147. Any changes of palatability or nutritional value of the corn stored under these relatively dry, but non-airtight conditions, will be of considerable interest. Both the Pest Control Unit and W.A.S.P.R.U., Kano, will make observations on the stacks protected in this fashion. The technical aspects of storage in connection with these famine reserves have been developed by D. C. Price of the Produce Inspection Division of the Ministry of Agriculture, Northern Region.

Experiments with Native Rumbus

148. The commonest method by which farmers store corn in the Northern Region of Nigeria is by the use of rumbus. These are containers with capacities which vary from a hundredweight to two tons or more of corn (generally on the head), and are usually constructed of a mud compound or of woven zana grass. Rumbus may be flask-shaped with a relatively small aperture, or roughly cylindrical; the containers are invariably raised from the ground on short legs or on a crude base of logs, while the apertures are closed with a thatched cover. The building material, shape, and size, depend on local soil conditions and on local tradition. In the more extreme north of the region, zana rumbus are more commonly made than mud rumbus. They have the advantage of being cheap and easily portable although obviously more permeable to insects.

149. Acting on requests from the Ministry of Agriculture, Northern Region, for information regarding the protection of farmer's corn and on small-scale storage in general, W.A.S.P.R.U., Kano, and the Agricultural Research Station, Samaru, have commenced trials in which the effectiveness of a 0.5% B.H.C. formulation is being investigated.

150. The trials referred to in the W.A.S.P.R.U. Annual Report 1958 (paragraph 192) unfortunately could not be completed owing to the premature emptying of the rumbus by the farmers concerned.

151. Trials involving the dusting of unthreshed guinea corn in rumbus with B.H.C. at the rate of approximately 2 p.p.m. have been carried out in conjunction with entomologists of the Agricultural Research Station, Samaru. In Kano, the corn has been stored in three mud-built rumbus and in six zana rumbus. Corn in three of the zana rumbus was untreated. Corn in the other containers was treated by dusting alternate layers of heads with

measured amounts of 0.5% B.H.C., during the filling operations. One rumbu from each group of three was to be opened up after periods of one, six and twelve months from the initial treatment which took place in March 1959. Samples were to be taken from the top, middle, and bottom layers as the rumbus were emptied, and were to be subjected to a number of analyses to measure the B.H.C. contamination, damage due to insects, and moisture content.

152. The results from the first two samplings are detailed in Table 14.

TABLE 14

Date of Sampling	Type of Rumbu	Key Number	Mean Moisture	Insect Damage				Initial B.H.C. Treatment on 6/3/59 P.P.M. (by analysis)	B.H.C. Found in Sample after Storage P.P.M.
				Top	Middle	Bottom	Mean		
16/4/59	Zana	4	8.3	1.3	5.8	2.4	3.2	0.0	0.0
16/4/59	Zana	1	8.7	2.2	3.5	2.0	2.6	2.3	0.1
16/4/59	Mud	7	8.1	2.5	3.0	4.5	3.3	1.4	0.5
17/9/59	Zana	5	13.3	16.4	10.4	21.6	16.1	0.0	0.0
17/9/59	Zana	2	12.5	14.4	5.6	19.6	13.2	1.6	0.0
17/9/59	Mud	9	12.9	7.0	2.0	3.0	4.0	1.6	0.0

153. The date of filling and treatment was 6/3/59, when the moisture content of the corn was found to be 7.9%, and the insect infestation was too small to be detected by the method employed. The insect species subsequently causing infestation were *Sitotroga cerealella* (Oliv.), and occasional specimens of *O. mercator* and *T. castaneum*.

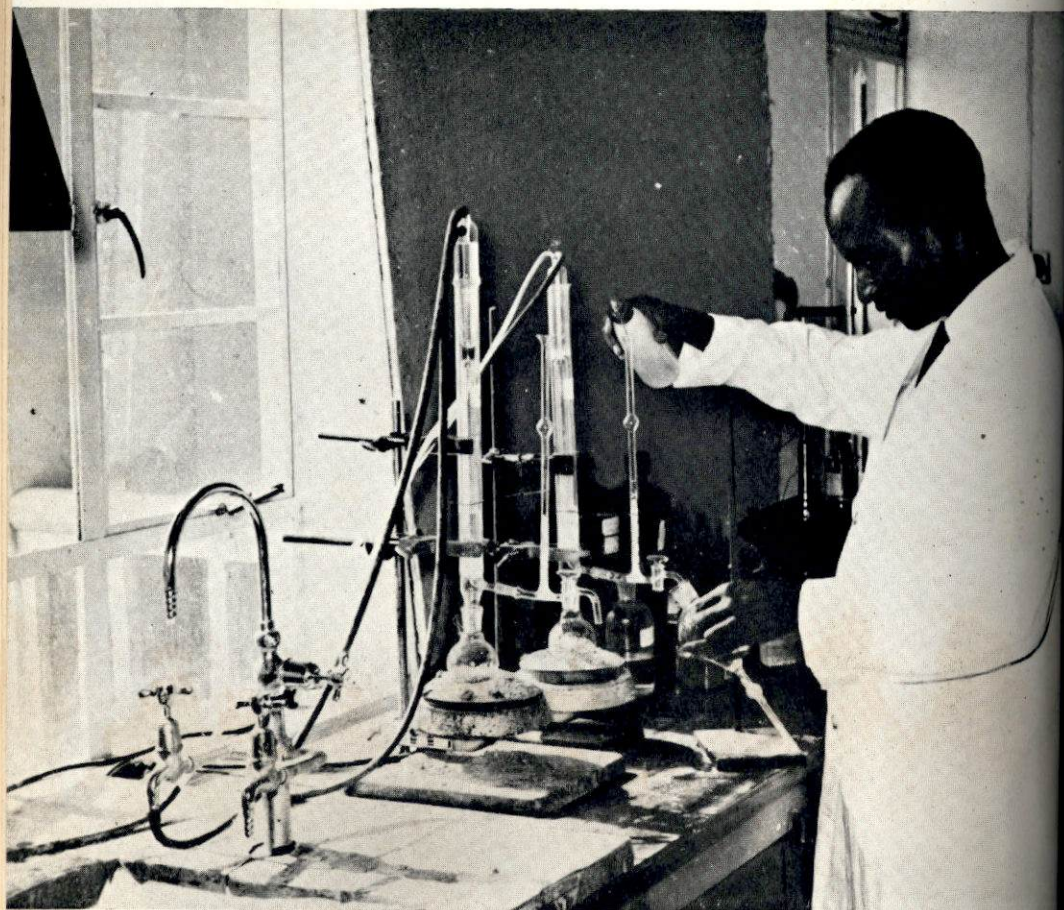
154. It is probable that there is little need for insecticidal protection during the dry season, i.e. from time of harvest to May-June, owing to the low rate of insect development. At the beginning of the wet season, however, the B.H.C. content of the corn is so low that it gives little protection in the case of zana rumbu. Unfortunately no untreated and mud rumbu were set up, but it does appear that the more impervious wall structure retards the influx of fresh insects. (J. R. Cutler, M. J. Glover, M. R. George, S. C. Morah, G. M. Udo, I. Kazaure, M. Iwugoh, M. Okeke.)

155. Trials at Samaru have been carried out using mud rumbu only, each containing 350 lb. of untreated guinea corn. A great deal of damage was caused by *S. cerealella* and *Rhyzopertha dominica* (Fabr.). (P. H. Giles, and R. H. Booker of the Ministry of Agriculture, Northern Region.)

156. From the foregoing observations it would appear to be a better procedure if corn were dusted at the beginning of the wet season rather than when first loaded into rumbu. However, this would entail double handling of corn stocks (emptying, treating, and refilling rumbu) and would be unlikely to meet with favour by the farmer.



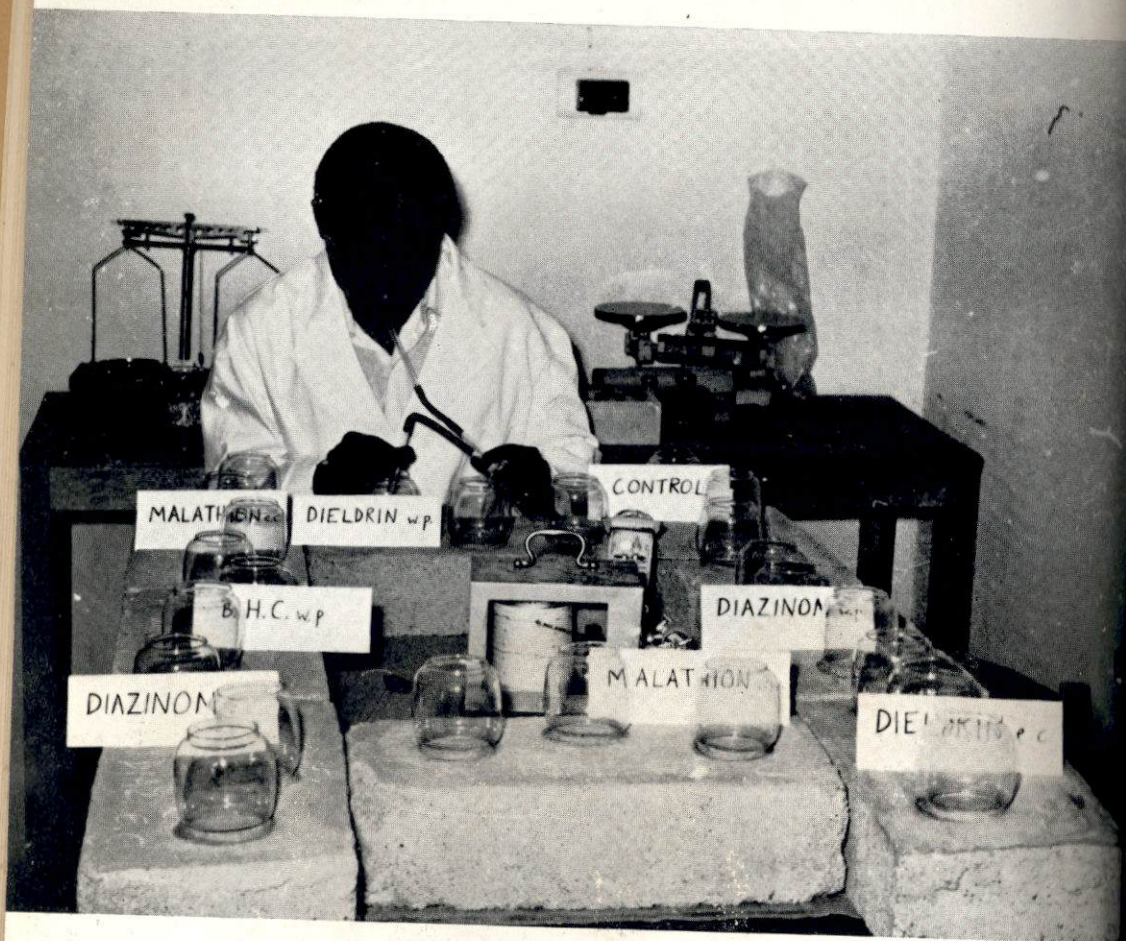
Palm Kernel Storage Trial (Port Harcourt)



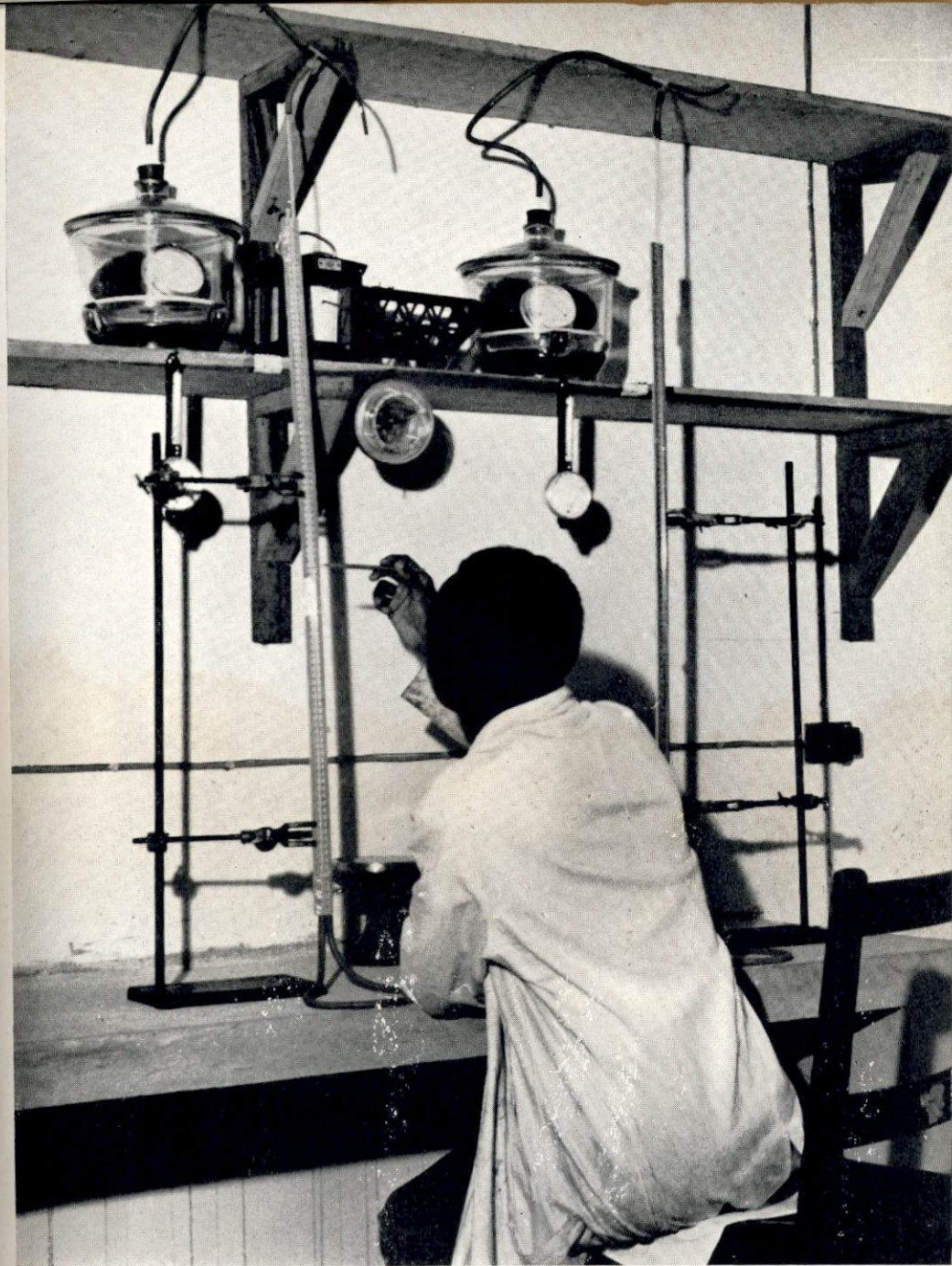
Schechter-Hornstein apparatus for micro-determination of B.H.C. (at Kano.)

The Insectary at the Ibadan Laboratory

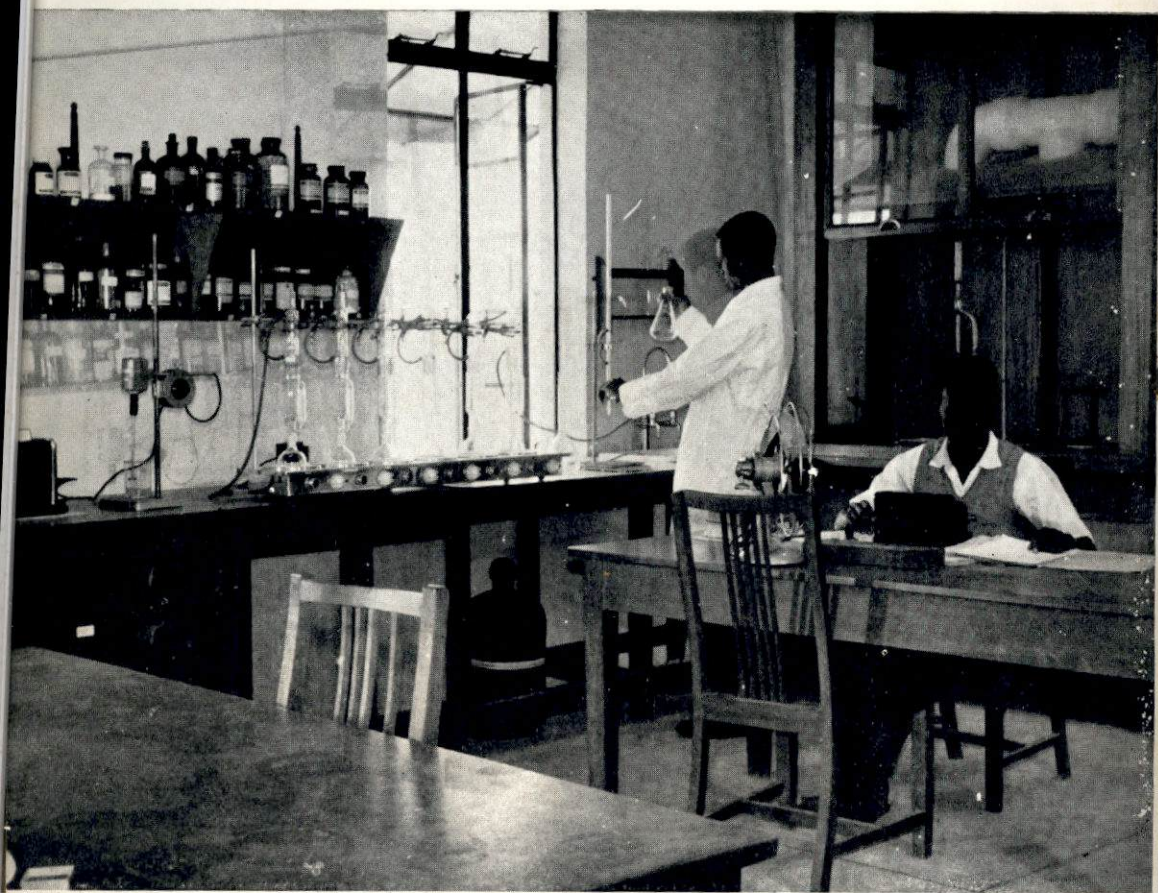




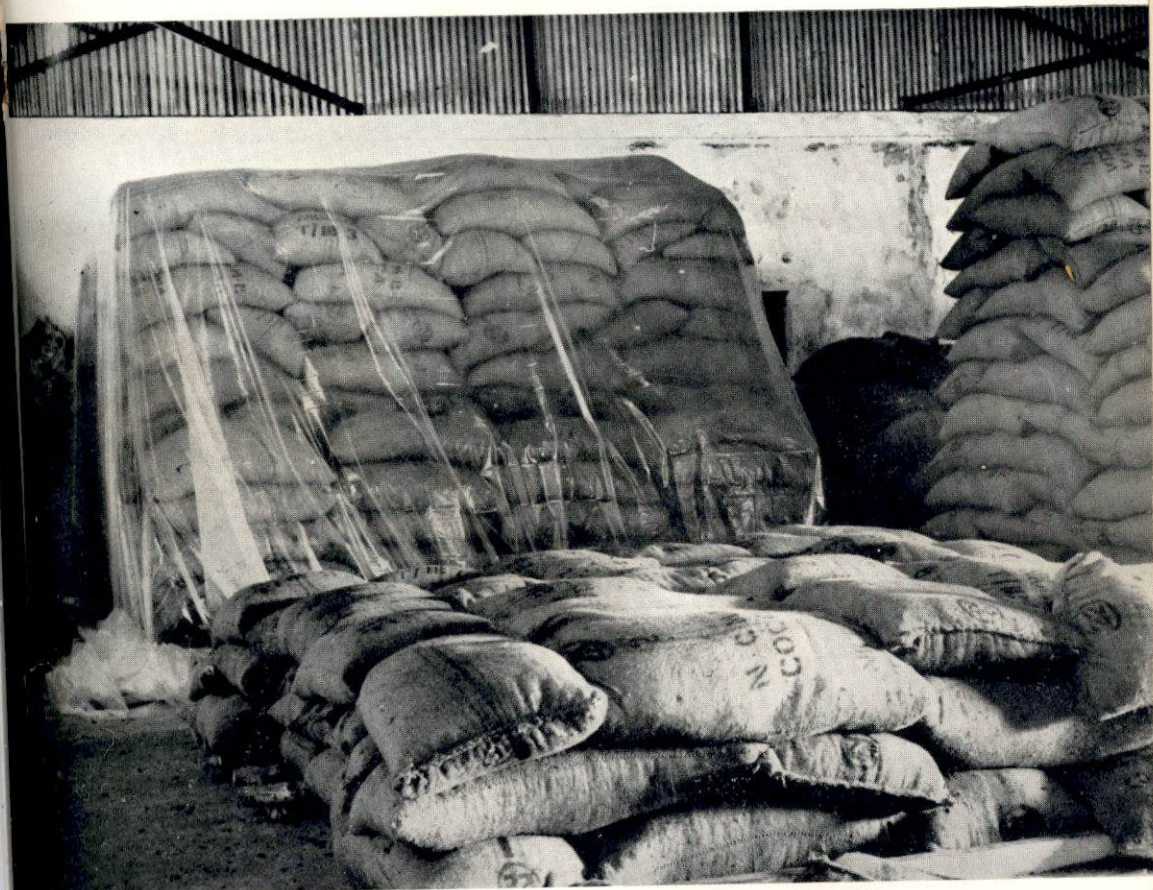
*Comparison of the persistence of various Insecticides on Concrete Surfaces
(at Kano) see paragraphs 254-260.*



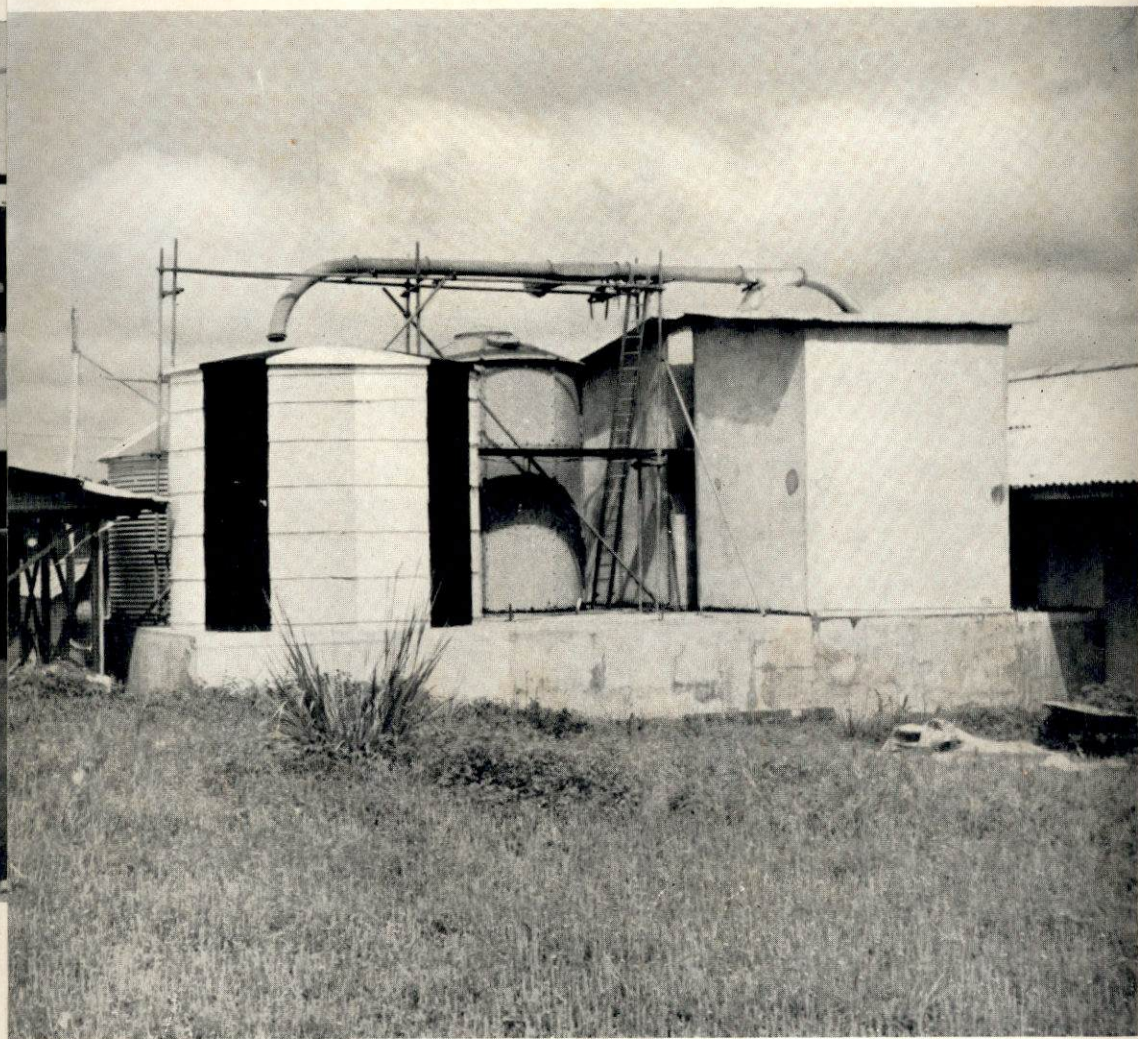
Respirometric Studies on Yams (at Lagos) see paragraph 229.



The Chemistry Laboratory at W.A.S.P.R.U., Ibadan



*Protection of Fumigated Cocoa with Polythene Sheetting (at Ibadan)
see paragraph 46 et seq.*



Silo Project at University College, Ibadan. See paragraph 182 et seq.

157. Further trials have been planned for the next storage season in which a malathion dust, an inert dust, and also heavier initial admixture of B.H.C. dust, will be applied to corn at the normal time of loading into rumbus.

Underground Grain Storage Pit

158. The construction of the experimental grain storage pit at Kano was described in the 1957 W.A.S.P.R.U. Annual Report (paragraphs 197-200) and a progress report on the storage of guinea corn in the pit was given in the 1958 W.A.S.P.R.U. Annual Report (paragraphs 189-91). Gas samples for the measurement of the oxygen content of the atmosphere within the pit have since been taken at intervals of about a month. Temperature measurements have been made mainly by the use of three long-distance continuous temperature recorders. Grain samples were taken with a spear from three places in the top, middle, and bottom layers, in July and December 1958 and June and September 1959.

159. Table 15 shows the results obtained from an examination of these grain samples. The total weight of all samples when bulked was roughly 2½ lb. on each occasion of sampling. Disturbingly high numbers of insects were found in the grain samples taken in December 1958 and it was concluded that the pit was not adequately airtight. Some improvements were made to potential points of weakness, particularly the manhole covers. These had been treated with a thin layer of a bitumen emulsion. In March 1959 tar was applied thickly to the covers by the Pest Control Unit of the Produce Inspection Division, and subsequently painted with an aluminium compound. Grain and gas samples have since shown that the repair was quite effective. Further measures will be carried out to eliminate other points of possible leakage.

TABLE 15
RESULTS OF EXAMINING GRAIN SAMPLES FROM PIT LOADED IN
JUNE 1958

	July 1958	December 1958	June 1959	September 1959
Germination ..	58*	83	74	72
Moisture content (%)	9.7	10.7	10.3	10.0
Damaged grain (%)	9.2	—	5.3	14.0
Total live insects in 2½-lb. sample ..	†	21	2	6

* Samples for germination were taken from the stores which were the original source of the grain in the pit.

† Insects found were *T. castaneum*, *O. mercator* (both in large numbers) and *R. dominica* (few).

160. The numbers of live insects found in grain samples after the repairs had been made indicate that the pit is now more airtight. It is interesting to note that although *O. mercator*, *R. dominica*, and *Tribolium* spp. were found in varying numbers at the commencement of the storage period, *Tribolium*

spp. alone have since been found alive in grain samples. This suggests that the other two species are more susceptible to oxygen deficiency than *Tribolium* spp. Despite the continued presence of live insects, the insect damage remains low. In this respect, a more precise method of the determination of insect damage will be used to deal with further grain samples, the present method of comparing the volume of 1,000 grains with the volume of the damaged grains extracted from that sample, yielding very variable results.

161. The initial germination figure was obtained from samples taken from the original source of the grain in the pit, but not from the grain in the pit itself. The period of storage for one month in bags may account for the low result. It is worth noting the similar effect obtained in the experiment carried out on the hermetic storage of cowpeas at Ibadan (1958 W.A.S.P.R.U. Annual Report, paragraphs 213-6). The percentage germination of corn in the pit will be seen to have dropped a little but still remains high.

162. The moisture content of the corn within the pit varied very little. The data obtained suggested that there was a long time-lag between periods of high ambient relative humidity, and high moisture content of corn from the top and from the bottom of the pit.

163. Gas samples were taken from seven points within the pit. Oxygen content was measured with an Oxley-Howe apparatus using chromous chloride solution for absorbing the oxygen. Results are shown in Figure 4. The application of tar to the manhole covers resulted in an immediate fall in the concentration of oxygen. Although insects still survive within the pit it is obvious from the graph that the oxygen rise-and-fall cycle has been shortened, indicating that the insects' oxygen supply has been diminished.

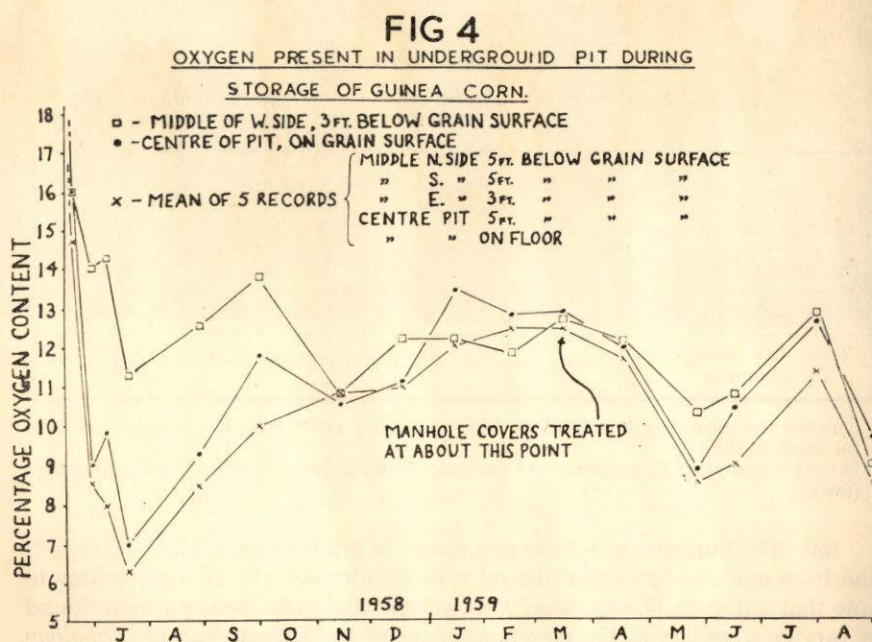
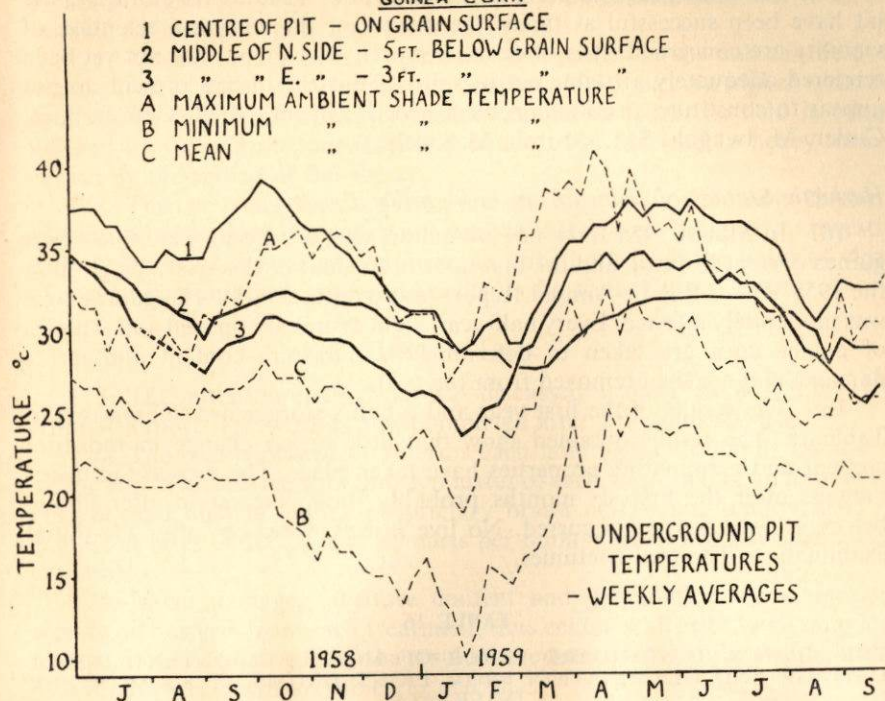


FIG 5
TEMPERATURES IN UNDERGROUND PIT DURING STORAGE OF
GUINEA CORN



164. Figure 5 compares temperature conditions within the pit with ambient shade temperature conditions extracted from meteorological data from the nearby Kano Airport. The pit records are shown as weekly averages for three points within the pit; No. 1 recorder is located in the centre of the pit on the surface of the grain; No. 2 is close to the vertical axis of the north wall, about 5 feet below the grain surface; No. 3 is about 3 feet below the grain surface close to the vertical axis of the east wall. A fourth recorder, located at the bottom of the grain mass has, unfortunately, been out of action for most of the period covered by Figure 5. The average weekly temperatures are plotted for both maximum and minimum temperatures.

165. It will be seen that the major peaks and valleys for No. 2 recorder lag about three to four weeks behind those for No. 1 recorder. A time-lag is not obvious with No. 3. Recorders Nos. 1 and 3 show considerably greater seasonal variation than No. 2, which is to be expected. The peaks and valleys for No. 1 recorder correspond very closely with those of the minimum and mean ambient temperatures, but lag about a week behind those for maximum ambient temperatures. Solar temperatures have not been considered, although the pit roof is not shaded. Inclusion of solar effects would elevate the mean ambient temperature graph, possibly extend the seasonal extremes, but would

not alter the general pattern a great deal. The diurnal variation within the pit has been, at the most, of the order of 1-1.5° C.

166. From the practical point of view, the first 15 months of storage in the pit have been successful as far as the quality of the corn and retention of viability are concerned. It is obvious, however, that the pit has not yet been rendered adequately airtight, but in spite of this the insects present do not appear to constitute a serious problem. (M. J. Glover, M. R. George, J. R. Cutler, M. Iwugoh, S. C. Morah, M. Okeke.)

Hermetic Storage of Guinea Corn in 44-gallon Drums

167. In March 1958 forty new 44-gallon steel oil drums were filled with guinea corn at Mokwa, and the first interim account of this trial was given in the 1958 W.A.S.P.R.U. Annual Report (paragraphs 196-8). The guinea corn was moderately infested. Every half-year, eight drums are opened and samples of guinea corn are taken to determine the moisture content and insect damage, and are then removed from the trial.

168. The results of the first year and a half's storage are summarised in Table 16. The results obtained show that little or no change in moisture content and germinating properties have taken place. The increase in insect damage after the first six months probably took place soon after filling, before self-sterilisation occurred. No live insects were seen after the initial examination. The trial continues.

TABLE 16
THE MEAN AND STANDARD ERROR OF MOISTURE CONTENT, INSECT DAMAGE AND GERMINATION FROM EIGHT DRUMS AT SIX-MONTHLY INTERVALS

Storage Period	No. of Drums	Mean Moisture Weight		Mean Insect Damage		Mean Germination	
		Initial	Final	Initial	Final	Initial	Final
		%	%	%	%	%	%
Six months	8	9.1 ± 0.1	9.5 ± 0.1	22.6 ± 0.7	27.2 ± 1.4	74.3	75.3
One year	8	9.6 ± 0.2	9.3 ± 0.2	24.6 ± 1.1	31.0 ± 2.3	76.3 ± 2.8	74.4 ± 1.5
Eighteen months	8	9.4 ± 0.1	9.0 ± 0.2	21.6 ± 1.1	27.3 ± 1.0	71.1 ± 1.7	76.6 ± 1.9

(J. Riley, K. U. Udukwe, O. Aderibigbe.)

WESTERN REGION

Crib Storage of Maize

169. Maize can be stored on the cob in cribs, or after shelling, in bags or silos.

170. The control of insect pests is more readily accomplished in the latter method of storage but the maize must be dry with a moisture content as low

as 13% before it is safe to store it in bulk. This degree of dryness is difficult to accomplish by sun drying of the wet season crop harvested in August in the Western Region of Nigeria, and artificial drying is necessary but is more suitable for central depots than for local farmers.

171. The advantage of crib storage is that maize on the cob can be put into well-ventilated cribs at a moisture content of 20% or even higher without spoilage by dampness. However, maize coming in from the field is often infested by *Calandra oryzae* (L.), and crib storage can lead to heavy losses caused by the spread of this insect.

172. The two trials discussed here, one of which was conducted at Ibadan, and the other at Ilora (the latter not yet complete), were designed to investigate the effect of insecticides on maize in cribs both from the point of view of contamination of the grain, and control of insects.

IBADAN TRIAL

173. The initiation of this trial was discussed in the 1958 W.A.S.P.R.U. Annual Report. The work is now completed after one year's storage.

174. The trial consisted of 16 cribs each holding about 700 lb. of maize on the cob. Treatments, with four replicates of each, consisted of an untreated control, and dusting with a proprietary brand of Lindane quality, 0.45% B.H.C. at rates of 10, 20, and 40 parts per million parts of maize (including the cob).

175. Insect damage, moisture content and germination were assessed weekly on one crib from each treatment, thus enabling all cribs to be sampled once a month. For simplicity the results have been averaged for each month. The results are shown in Tables 17 and 18.

176. The results presented by the tables show that the rapid increase in damage which took place in the untreated cribs did not occur in the treated ones.

177. The initial rise in infestation in the 10 and 20 p.p.m treated cribs was expected, as the maize in these cribs was moderately infested before loading and the insecticide would probably not prevent the emergence of adults from eggs and larvae already inside the grain.

178. It was unfortunate that the maize treated with 40 p.p.m. was initially less damaged than the remainder of the maize, so that conditions for the insecticide were more favourable.

179. Because of the doubt over the contamination caused to grain, a further trial was initiated in order to investigate this aspect more fully at lower dosages of insecticide. (J. Riley, G. W. Ozburn, P. Ward, M. R. George, L. S. O. Ene, E. A. Effiong, O. A. Fayinka, J. B. Ojo, O. Aderibigbe.)

ILORA TRIAL

180. The trial set up at Ilora in the southern part of the savannah zone is based on the same cribs and the same variety of maize as the trial referred to in the previous section. The grain was obtained in August, from the wet season harvest, and thanks should be expressed here to E. Baker of the Ministry of Agriculture, Western Region, who organised the provision of

TABLE 17
MEAN PERCENTAGE OF GRAIN DAMAGED BY *C. ORYZAE* AS MEASURED BY PROPORTION OF GRAIN SHOWING DAMAGE
AND MEAN NUMBER OF EXIT HOLES PER 100 GRAINS IN MAIZE STORED IN VARIOUSLY TREATED CRIBS FOR 11½ MONTHS
Each mean based on 8 replicates of 300 grains

Months	Control		10 P.P.M. B.H.C.		20 P.P.M. B.H.C.		40 P.P.M. B.H.C.	
	Damage %	Holes per 100 Grains	Damage %	Holes per 100 Grains	Damage %	Holes per 100 Grains	Damage %	Holes per 100 Grains
0	3.8	4.0	3.8	4.0	2.9	3.0	0.0	0.0
1	15.2	24.4	12.7	14.8	14.6	18.2	2.2	2.2
2	17.5	22.5	21.5	26.9	13.3	15.3	0.4	2.2
3	18.3	31.3	19.4	31.8	9.4	12.6	2.7	0.4
4	26.5	64.1	16.2	21.5	14.6	21.1	2.7	1.9
5	28.1	66.2	23.9	34.2	14.9	19.4	9.8	3.3
6	37.8	105.7	19.6	30.1	13.3	19.1	1.8	16.1
7	50.1*	159.9*	23.6	50.5	14.3	21.8	6.7	2.6
8			25.7	48.1	22.9	43.8	1.7	11.6
9			30.0	56.0	25.8	43.8	4.5	2.2
10			29.1	61.8	11.6	17.5	2.6	7.1
11			23.2	56.4	11.5	18.4	2.0	3.7
11½			23.7	55.1	14.3	28.4	4.7	7.5

* Terminated to save grain from total spoilage.

TABLE 18

MEAN PERCENTAGE MOISTURE CONTENT AND GERMINATION IN MAIZE STORED ON THE COB IN CRIBS

Mean moisture content based on eight tests per month and mean germination from four samples of 200 grains

Months	Control		Dosage Rates of Gamma B.H.C.			
	Moisture Content	Germination	10 P.P.M.	20 P.P.M.	40 P.P.M.	Germination
August	17.9	78	17.9	19.0	22.2	94
September	15.4	66	16.0	16.2	16.7	94
September - October	15.3	76	15.6	15.6	16.1	94
October - November	13.8	58	14.6	14.7	14.9	91
November	13.2	26	13.7	13.5	14.0	43
December	12.1	21	12.7	13.5	12.7	36
January	12.1	23	12.2	11.9	11.8	54
February	12.1*	26*	11.4	11.5	11.6	77
March	..	..	11.9	11.9	11.4	88
April	..	..	12.4	12.4	11.9	83
May	..	..	13.0	13.0	13.0	74
June	..	..	13.4	13.1	13.0	64
July	..	..	13.6	13.0	13.2	35

* Terminated to save grain from total spoilage.

both grain and site. Dosage rates of 8 p.p.m. Malathion and 5 and 10 p.p.m. Lindane quality B.H.C. were used. Each treatment was replicated four times, as was the control. Samples are to be taken monthly for moisture content, germination, and insect damage, and every two months for contamination.

181. The maize was placed in the cribs within a week of harvest, after sun-drying to about 18% moisture content. Moderate infestation by *C. oryzae* and *Cathartus cassiae* (Kohe.) was present from the field, and about 12% of grains were damaged. Initial analysis for contamination by B.H.C. after shelling and winnowing the grain to remove dust, was carried out using the Schechter-Hornstein method and no measurable amount of insecticide was found. The experiment is planned to last six months. (J. Riley, K. C. Matheson, K. U. Ndukwe, E. A. Effiong, J. B. Ojo, O. Aderibigbe.)

Silo Storage Project at Ibadan

182. The joint grain storage project between the Faculty of Agriculture, University College, Ibadan, and W.A.S.P.R.U. was described in the 1958 W.A.S.P.R.U. Annual Report, paragraphs 205-208. At the beginning of the present year the installation was complete except for fans and heating equipment for the In-Sack and Ventilated silo dryers. Two of the six silos in the installation showed obvious defects which are referred to hereunder.

183. The plywood silo, after being in position for two years, showed a patch of decay at the base and it was feared that further filling with grain might cause structural collapse. It was accordingly demolished. An improved plywood silo is available and it may be possible to erect this on the site.

184. The present concrete silo was filled with dry maize but on emptying during the wet season, patches of caking caused by dampness were found on the wall. Caking was not severe but a method of waterproofing the silo was needed for future security, and three treatments were applied (see paragraph 208).

185. During the period under review cocoa was held in the steel bin and one of the locally made block bins details of which have been given already in paragraphs 58-67. Experimental work on grain was mainly concerned with drying maize prior to storage in the aluminium and concrete bins, where it was subsequently kept in good condition for eight months.

186. A report on the drying prepared by R. T. Lewis of the Faculty of Agriculture, University College, Ibadan, now follows. He was assisted in the work by G. W. Ozburn and P. Ward of W.A.S.P.R.U. Much of the work on the silos was under the guidance of G. H. Caswell of the Faculty of Agriculture.

Grain Drying: September-October 1958

187. Maize stored in bulk in silos under tropical conditions must be at a moisture content of 13% or less to prevent heating, and the development of moulds which may partially or completely destroy its value as a foodstuff.

188. Two crops of maize are grown during the year in the Western Region of Nigeria. The main crop is harvested in August, and usually has a high moisture content after shelling, e.g. 20% or more. A lighter second crop

which is harvested in December after the dry season has started, has a shelled moisture content of about 16%. To carry out the drying necessary before storing in bulk, a Woolley "In-Tray" dryer (Model 1T/25/0/3, No. 16440) with oil-fired furnace, electrically-powered fan, and a capacity of 20-25 cwt. of loose grain, has been in use since 1957. Early in 1958 the dryer was installed in its permanent position in an open-sided shed from which it was possible to convey dried grain pneumatically to and from any point in the storage system, using the dryer fan to provide the necessary air flow.

189. During September and October 1958, 26 tons of maize were dried, then conveyed into the silos for experimental purposes. Records were kept of the drying procedure for each batch of grain to obtain some preliminary information about the cost of drying with an "In-Tray"-type dryer. The 26 tons were dried in 23 separate batches, summarised records being given in Table 19.

TABLE 19

<i>Items Recorded</i>	<i>Range of Batch Readings</i>	<i>Mean Batch Readings</i>
1. Batch size	16.7-25 cwt.	22.6 cwt.
2. Drying temperature	100-180° F.	140° F.
3. Initial moisture content	15-19%	17.92%
4. Final moisture content	11-13.5%	12.13%
5. Moisture removed	3-8%	5.79%
6. Time to fill tray:		
(a) By pneumatic conveyor ..	0.75-4.5* hrs.	1.89 hrs.
(b) By hand (3 men)	0.5 hrs.	0.5 hrs.
7. Drying time	3.5-6 hrs.	4.66 hrs.
8. Cooling time	0.75-2 hrs.	1.23 hrs.
9. Emptying time	0.5-1 hr.	0.59 hrs.
10. Fan operating time	5.5-11* hrs.	7.04 hrs.
11. Fuel consumption	Total: 108 gals.	4.7 gals.

* High readings resulting from a blockage in the conveyor ducting.

190. With reference to item No. 2, it was found difficult to control the drying temperature accurately. The temperatures recorded are those indicated by the standard instrument on the dryer, which was not calibrated. In items Nos. 3 and 4, moisture contents were recorded with a Marconi moisture meter which may have given variable results. Regarding item No. 6, it was possible to fill the dryer tray via the pneumatic conveyor for less than half the batches, as the conveyor did not handle wet maize satisfactorily. Hand loading from sacks proved much more efficient. In items Nos. 7 and 8, the times could probably have been reduced appreciably, had more continuous supervision been possible. Any reduction in drying time per batch would reduce the averages recorded under heads 10 and 11, cutting down the consumption of electricity and kerosene.

191. Dryer performance is usually expressed as the number of B.Th.U.s consumed per pound of water evaporated, or the weight of water evaporated per gallon of fuel. Figures obtained for the Wooley dryer used in this work were 4,220 B.Th.U./lb. water evaporated, or 35.5 lb. water evaporated per gallon of kerosene.

192. Little comparative data is available, but a more complex "In-Tray" dryer with recirculation of partly-saturated air may be expected to show evaporation figures of 90–100 lb. water/gallon of oil. Although the dryer used here is not of this type and cannot be expected to give the same performance, the recorded figure of 35.5 lb./gallon could probably be improved upon, with a resulting drop in the cost of drying. The manufacturers claim that drying rates of $2\frac{1}{2}\%$ moisture removal per hour from one ton at a drying air temperature of 60° F. above ambient, can be achieved, equivalent to an evaporation rate of 45 to 67 lb./gallon, depending on fuel consumption (not stated), i.e. an appreciable increase over 35.5 lb./gallon. Two factors should, however, be borne in mind, which will result in a lower drying efficiency at Ibadan than in the United Kingdom using the same equipment; ambient relative humidity levels are higher in Ibadan than in the United Kingdom, and maize grains are larger than cereal grains grown in temperate regions.

The Cost of Drying and Handling

193. It is difficult to calculate the actual cost of drying and handling per ton during the experimental work, as most of the labour was provided by senior staff, in the absence of others with the necessary experience. As the main object of this account is to make an accurate estimate of the cost of these operations using specified equipment in the most economical manner, the subsequent paragraphs will attempt to show what could be achieved in addition to the actual cost found in each category.

194. Since two maize crops are grown annually it is possible to use the dryer for two seasons, here considered to be of four weeks each; the first in September, and the second in January. Because of the difference in moisture content after shelling of the main and late crops, it is possible to dry only one batch per day in September, while two can be done each day in January. Assuming 26 working days per month it is thus possible to dry 26 tons of maize in September and 52 tons in January, a total of 78 tons. The cost items will now be considered separately.

195. Fixed Costs. (a) *Depreciation*. The dryer and its shed, with the pneumatic conveying system and scaffolding support, cost £1,220: assuming a life of 20 years for the whole plant, £61 must be charged against the tonnage dried per annum. In 1958/59, 26 tons were dried, i.e. a charge per ton of £2 6s. 11d. If 78 tons were dried per annum as suggested above, the charge would be reduced to 15s. 8d. per ton.

(b) *Interest on Capital*. Where depreciation is calculated by the "straight line" method, the accepted way of charging interest on capital over the life of the equipment is at the current bank rate per annum on half the initial capital cost. In this case, charging interest at 5% p.a. on the appropriate sum of £610, £30 10s. must be added to the cost of drying the annual tonnage, an item of £1 3s. 6d. per ton for 26 tons, but 7s. 10d. per ton for 78 tons.

(c) *Housing and Insurance*. The cost of housing is included in the total capital investment and no special insurance cover is involved.

196. Variable Costs. (a) *Labour*. After some instruction an officer of C(T) 1 grade should be able to take full responsibility for drying, aided by

two labourers at 4s. 1d. per day for general plant operation and maintenance. The cost of labour for one month (26 days) would be £44 12s. 4d. or 34s. 4d. per ton dried in 1958/59. With the proposed 78 tons dried annually, this figure is reduced to 22s. 11d.

(b) *Kerosene*. 108 gallons of kerosene were used in the experimental work at a cost of £17 9s., i.e. 13s. 6d. per ton dried in January, drying 52 tons of maize from 16% to 13% moisture content would require approximately 170 gallons of kerosene at the evaporation rate of 35.5 lb./gallon mentioned earlier. At 3s. per gallon this costs £25 10s. or 9s. 10d. per ton: the average annual cost of kerosene is thus 11s. per ton of maize dried.

(c) *Electricity*. The 3-phase, 3-h.p. induction motor uses approximately 2.5 units per hour, at a price of 4d. per unit, the 162 hours fan operation for drying 26 tons in September cost £6 15s., i.e. 5s. 2d. per ton. Calculating drying time from the summarised records above, and filling the dryer tray by hand it should be possible to process 52 tons in January using the motor for only 195 hours, at a cost of 3s. 2d. per ton. The average cost of electricity per ton on an annual basis is 3s. 10d.

197. No repairs have been necessary up to the present time, so no charge is included under this heading.

198. In summarising these charges, it is clearly possible to arrive at two figures for the overall cost per ton of drying and handling: main crop maize involving a higher cost because it has a higher initial moisture content. From a contracting viewpoint it would be desirable to make separate charges for main and late crop work, but an average figure would be adequate where both crops are dried by the same enterprise, and probably stored and used together.

199. Accordingly, the two levels of drying and handling costs are summarised in Table 20, and the average figure given in the third column. Some of the following items have not been specified in the test, but may be calculated without difficulty.

200. It is hoped that some simple instrumentation of the dryer, closer supervision when the next drying programme is carried out will give information as to the most efficient drying method and lead to a reduction in drying costs.

201. Eventually the "In-Tray" dryer will be compared with the two alternative methods planned, the "In Sack" and "Ventilated Bin dryer", on the widest basis of cost and efficiency.

Silo Storage of Dried Maize

202. The experimentally dried maize referred to in the previous paragraphs was stored in both the precast concrete silo and the aluminium silo.

203. The following notes concerning the storage of this maize were prepared by G. H. Caswell of University College, Ibadan.

204. The initial moisture content of the maize in September 1958 was about 18% and about 8.2% of the grain showed insect damage. The grain was dried to about 12% moisture content and stored until July 1959 by which time the moisture content of most of the grain was unchanged although at

TABLE 20
APPROXIMATE COSTS PER TON OF REDUCING MOISTURE CONTENT OF
MAIZE 5-6% AT IBADAN

Cost Item	Main Crop ¹		Late Crop ²		Average ³	
	s.	d.	s.	d.	s.	d.
Depreciation	46	11	11	9 ⁴	15	8
Interest on Capital	23	6	5	10 ⁵	7	10
Labour	35	4 ⁶	17	2 ⁶	22	11
Kerosene	13	6	9	10	11	0
Electricity	5	2	3	2	3	10
TOTALS	123	5	47	9	61	3

NOTES: ¹ Costs calculated on the basis of 26 tons dried per annum.

² Costs calculated on the basis of 52 tons dried out of an annual total of 78 tons.

³ Total annual costs divided by total annual tonnage dried.

⁴ & ⁵ Half the annual charge spread over 52 tons.

⁶ The labour charge for one month spread over the tonnage dried in that month.

the surface, moisture contents of 16.6% and 14.1% were recorded in the two bins.

205. By December 1958 insects were noticed in increasing numbers and one bin was fumigated with a 1:1 mixture of carbon tetrachloride and ethylene dichloride and one using "Phostoxin". In each case the treatment was satisfactory. It did not eradicate the insects, but they were adequately controlled so that by July the percentage of grains showing insect damage had risen only to 10.2%.

206. Collections of insects were made when the bins were emptied. These did not give much indication of the degree of infestation but they did suggest the relative numbers of the different species present. Altogether just over 1,000 insects were collected; 60% of these were *C. oryzae*, 20% were *T. castaneum*, about 15% were an unidentified species of *Collembola*, and the remaining 5% consisted of a few specimens each of *L. Serricorne*, *O. mercator*, *T. mauritanicus*, *Carpophilus dimidiatus* and *Piezostethus ater* together with a few unidentified species.

207 Temperatures were taken at monthly intervals at various points and samples were taken for moisture content and damage determinations in both the aluminium and the pre-cast concrete silo. Maximum and minimum air temperatures during the period were 95° F. and 60° F. Above the grain in the aluminium bin, maximum and minimum temperatures were 110° F. and 71° F. and in the pre-cast concrete bin they were 110° F. and 70° F. In the grain in the aluminium bin, maximum and minimum temperatures were 92° F. and 70° F., and in the pre-cast concrete bin, 94° F. and 70° F.

208. Control of moisture is better in the aluminium bin, very little seepage of water occurs along joints, resulting in a negligible amount of caking. In the pre-cast concrete bin, some of the staves proved to be porous, and in a

few places there was serious caking. This may have been due to inadequate vibration of staves during manufacture; this, and the possibility of using a waterproof concrete are being discussed with the manufacturers. In addition, three different compounds have been applied to the outside of the bin, and these are being compared for waterproofing properties and cost. The roof of the silo was divided into 12 segments. In every quadrant each of the three treatments occupied one segment, so replicating each treatment. The roof divisions were carried down the side of the silo and painted as for the roof. A white plastic emulsion, a cream cement paint and black bitumen were used.

209. Both bins suffer from moisture which rises from the floor, either because it has passed between walls and plinth or through the plinth. In the case of the aluminium bin the joint between wall and floor was sealed with electricians' pitch. This involved melting the pitch and treating the plinth, ensuring that the pitch sticks firmly. The floor was then covered with roofing-felt.

210. In the case of the pre-cast concrete bin an attempt was made to stop both sources of water by covering the floor with roofing-felt which was continued up the wall for about two inches and then pouring two inches of concrete on the roofing-felt. This was not successful and when the grain was removed severe caking was found round the bottom of the bin. When the concrete raft was removed, the roofing-felt was found to be very wet both above and below, and this was clearly the source of water in the grain. The joint between wall and plinth has not been sealed with "Seelastic" which is much simpler to apply than pitch, particularly if a "caulking gun" is used. The floors of both bins are now covered with roofing-felt.

211. Control of insect pests is simpler in the pre-cast concrete bin because it can be sealed very easily, making fumigation more efficient; the continuous construction between wall and roof prevents the entry of crawling and flying insects.

212. In the coming year further comparisons will be made between the pre-cast concrete and aluminium bins, and the remaining bins will be used by the University farm and their usefulness studied. At the same time any grain stored in them will be examined at frequent intervals.

RICE

213. Experiments were carried out to investigate the viability of seed rice, which was supplied by the Eastern Regional Ministry of Agriculture, Agricultural Division, at Abobiri.

214. Six tins with tightly-fitting lids were filled with this rice which was visually free from insect infestation, and were sealed by covering the pressed-in lids with paint. The remaining sample, which served as control, was kept in a bag. The viability of the seed rice was examined at monthly intervals by opening one tin, and taking a sample from the bag. In viability tests a hundred seeds were placed on a wet filter paper contained in a covered petri dish; the number of seeds sprouting was counted daily over two weeks.

215. The percentage germination of the rice in both the tins and sacks

did not fall below 80% after a storage period of six months. In both instances no infestation was observed at the end of the test period. Had the control become infested a drop in its germination would have been expected. (D. G. Coursey, T. I. Ekemezie.)

X. YAMS

216. Following a request from the Director of Agriculture, Eastern Region, it was decided to include yam storage in the W.A.S.P.R.U. work programme for the Eastern Region in view of heavy suspected weight losses.

217. Experiments to investigate weight losses were carried out at Bori (Ogoni), Umudike (Umuahia) and Abakaliki—representative of the major yam producing areas of the Eastern Region. At Abakaliki and Bori, 50 white yams (*Dioscorea rotundata*), and at Umudike, 25 each of white and yellow yams (*D. cayenensis*) were supported on racks in the conventional manner. Additional yams were included at Umudike and Bori for the determination of moisture content. The yams were weighed individually at fortnightly intervals at Bori and Abakaliki, and at monthly intervals at Umudike. At Bori, and Umudike, one yam was removed at the time of each weighing for the determination of moisture content. The site facilities of the local Agriculture Farms were used, and Department of Agriculture staff collaborated by arranging for the supply of material, and at Abakaliki assisted with some of the routine weighings.

218. A full report on these experiments "Storage of Yams. Part I: Investigation of Weight Changes" has been published and a summary of the results is given below in Tables 21-24.

219. In the analysis of the results the yams have been divided into four groups:

- (1) Yams which show no visible rotting, and have not sprouted. ("Sound Yams.")
- (2) Yams which show visible rotting, but have not sprouted. ("Yams showing rotting.")
- (3) Yams which show no visible rotting, but have sprouted. ("Sprouting Yams.")
- (4) Yams which show visible rotting, and have sprouted. ("Sprouting Yams showing rotting.")

220. From these experiments it was found that very substantial losses in weight occurred during the storage of sound yams of the order of 10% after three months, and 20% or more after five months. The losses increased when rotting occurred and were slightly greater in sprouting than in non-sprouting yams.

221. Yellow yams stored at Umudike showed greater losses than white yams at the same station probably because of a higher incidence of rotting.

222. There was also an appreciable loss of moisture content though this only accounted for about half the loss of weight. It was also noted that the average weight loss was less in Abakaliki than at the other stations. (D. G. Coursey, U. I. Ukoah, F. I. Nwankwo.)

TABLE 21
WHITE YAMS STORED AT BORI
(1) Incidence of Rotting and Sprouting after Various Storage Periods

	Number of Weeks										
	2	4	6	8	10	12	14	16	18	20	22
Sound Yams ..	100	100	96	76	64	44	38	14	4	2	2
Yams showing rotting ..	—	—	4	20	22	22	20	18	18	12	12
Sprouting Yams ..	—	—	—	4	12	30	42	50	56	50	42
Sprouting Yams showing rotting	—	—	—	—	2	4	10	18	22	36	44

(2) Average Weight Losses of Yams in the Different Groups

	Number of Weeks										
	2	4	6	8	10	12	14	16	18	20	22
Sound Yams ..	3	5	5	5	9	10	16	20	20	20	21
Yams showing rotting ..	—	—	13	12	15	18	26	33	38	40	42
Sprouting Yams ..	—	—	—	4	6	10	14	15	19	21	23
Sprouting Yams showing rotting	—	—	—	—	17	15	17	20	30	35	36
Overall Av'ge (%)	3	5	5	7	10	12	17	20	25	29	31

TABLE 22
WHITE YAMS STORED AT ABAKALIKI
(1) Incidence of Rotting and Sprouting after Various Storage Periods

	Number of Weeks										
	2	4	6	8	10	12	14	16	18	20	22
Sound Yams ..	100	100	100	96	84	70	64	48	28	24	24
Yams showing rotting ..	—	—	—	—	4	4	2	2	2	2	2
Sprouting Yams ..	—	—	—	4	12	26	32	48	68	72	72
Sprouting Yams showing rotting	—	—	—	—	—	—	2	2	2	2	2

(2) Average Weight Losses of Yams in the Different Groups

	Number of Weeks										
	2	4	6	8	10	12	14	16	18	20	22
Sound Yams ..	3	4	5	6	7	8	10	11	13	17	18
Yams showing rotting ..	—	—	—	—	11	18	15	17	18	23	22
Sprouting Yams ..	—	—	—	6	7	12	13	15	17	21	23
Sprouting Yams showing rotting	—	—	—	—	—	—	31	39	39	52	50
Overall Av'ge (%)	3	4	5	6	7	10	11	14	16	21	22

TABLE 23

WHITE YAMS STORED AT UMUDIKE

(1) Incidence of Rotting and Sprouting after Various Storage Periods

	1 Month	2 Months	3 Months	4 Months	5 Months
	%	%	%	%	%
Sound Yams	100	76	16	0	0*
Yams showing rotting ..	—	—	—	—	—
Sprouting Yams ..	—	24	84	100	76
Sprouting Yams showing rotting	—	—	—	—	4

* Remaining 20% of the Yams missing at the final inspection.

(2) Average Weight Losses of Yams in the Different Groups

	1 Month	2 Months	3 Months	4 Months	5 Months
	%	%	%	%	%
Sound Yams	3	6	8	—	—
Yams showing rotting ..	—	—	—	—	—
Sprouting Yams ..	—	6	15	23	30
Sprouting Yams showing rotting	—	—	—	—	33
Overall Average (%) ..	3	6	14	23	30

TABLE 24

YELLOW YAMS STORED AT UMUDIKE

(1) Incidence of Rotting and Sprouting after Various Storage Periods

	1 Month	2 Months	3 Months	4 Months	5 Months
	%	%	%	%	%
Sound Yams	80	40	4	0	0*
Yams showing rotting ..	4	8	20	24	20
Sprouting Yams ..	16	48	64	52	36
Sprouting Yams showing rotting	—	4	12	24	36

* Remaining 8% of the Yams missing at the final inspection.

(2) Average Weight Losses of Yams in the Different Groups

	1 Month	2 Months	3 Months	4 Months	5 Months
	%	%	%	%	%
Sound Yams	6	16	20	—	—
Yams showing rotting ..	4	26	40	50	62
Sprouting Yams ..	9	18	27	37	38
Sprouting Yams showing rotting	—	11	26	33	49
Overall Average (%) ..	6	17	29	39	48

The Importance of Weight Losses in Yams

223. The results referred to in the preceding paragraphs confirm the view of the Director of Agriculture, Eastern Region, that losses in weight of yams stored in conventional yam barns are in fact very considerable.

224. The losses associated with clamp, and "in ground" storage such as is practised in parts of the Western Region, are not known; neither are the average periods associated with the different types of storage.

225. In the circumstances it is not yet possible to give any reliable indications of the economic losses being sustained throughout the country as a whole.

226. Losses of sound yams in barns have been shown to be about 10% during a storage period of three months and are greater for rotting and for sprouting yams (see paragraph 220). Much of the crop of estimated value £95,400,000 per annum ("Economic Survey of Nigeria 1959", published by the Economic Council) is stored in barns and overall losses in Nigeria are probably appreciably in excess of £10,000,000 and it is clear that further detailed investigations of the subject are warranted. (L. A. W. Hayward.)

Weight Losses in Yams due to Respiration

227. In paragraph 222 it was indicated that weight losses of yams during storage were only in part accounted for by loss in moisture content, and that there appeared to be an appreciable and unaccountable loss of dry matter.

228. The most likely explanation is that such dry matter losses are due to respiration. Preliminary respirometric studies were therefore conducted. The usual technique of using tissue slices was rejected in favour of a system utilising whole tubers as the results obtained would have a closer relation to changes occurring under field storage conditions.

229. Several types of respirometer were specially constructed for the work. A constant volume system was eventually found to be the most sensitive and satisfactory, and a respirometer based on pressure measurement at constant volume was perfected. Expired carbon dioxide was absorbed by a 38% w/w solution of potassium hydroxide, and the pressure reductions caused by inspiration of oxygen were measured manometrically at constant temperature (a photograph of the apparatus appears elsewhere in this report). Readings could be conveniently taken at any desired intervals, facilitating a close study of respiratory rate changes. At no time was the oxygen concentration allowed to fall appreciably below 20%, in order that the respiration measurements should exclusively represent aerobic activity. It is intended in due course to compare the results obtained by this method with a flow method in which expired carbon dioxide is estimated chemically.

230. Preliminary trials showed that apparently similar yams of the same species and variety, which were harvested on the same day, and which had the same storage history, may have widely varying respiration rates.

231. The results obtained also show that respiratory losses (which are due to the difference between weights of the equal volumes of carbon dioxide and oxygen which are respectively expired and inspired, plus respiratory water) may vary between zero and a loss rate of about 2.7% of the wet weight of

yam per month. A respiratory quotient of unity is thus assumed for the purposes of this calculation. This weight loss figure was calculated from an oxygen absorption rate figure of 65.2 c.c. of oxygen at N.T.P. per 24 hours per 100 grms. wet weight of yam.

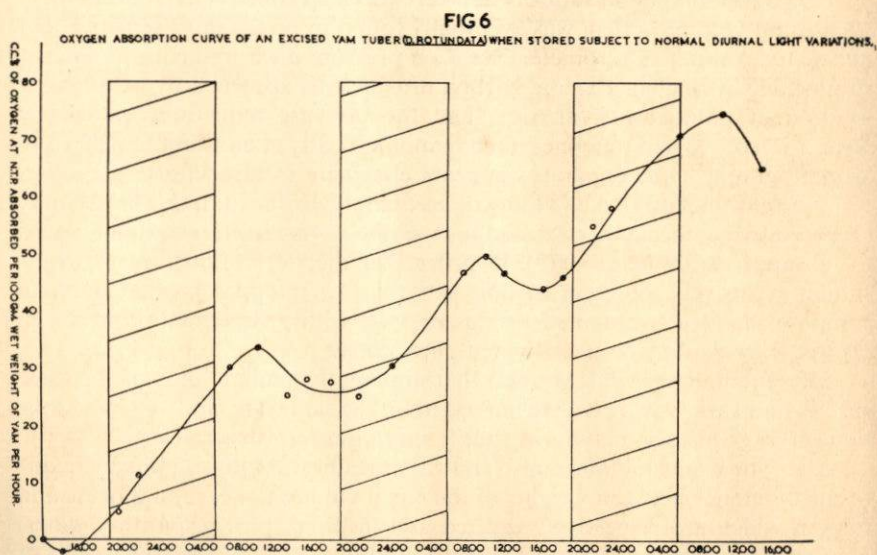
232. Sufficient information was collected to show that the products of aerobic respiration constitute an important source of weight loss in stored yams. Consequently a storage trial has been started in which freshly-harvested yams of known variety and species are to be kept for several months on well-ventilated racks in the laboratory. The respiratory behaviour of each yam is being followed at 10-day intervals through the storage period and it is hoped to obtain figures showing the average magnitude of respiratory losses and possibly to relate them to rotting and sprouting.

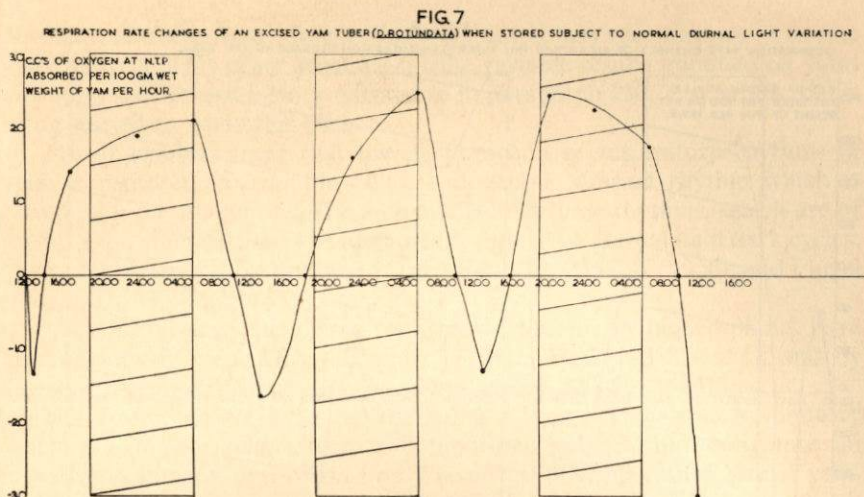
Respiratory Rhythms in Yams

233. Every actively respiring yam tuber examined (comprising various varieties of *D. rotundata*, *D. cayenensis*, and *D. alata*) has exhibited a characteristic diurnal respiratory rhythm. Respiration rate (measured as rate of oxygen absorption) rises rapidly at dusk (7 p.m. local time) from almost nil to its maximum value, which is maintained throughout the hours of darkness and falls away in the morning at about 8–10 a.m., and generally diminishes to almost nil by noon.

234. Between about noon and 4 p.m. a very small but characteristic evolution of oxygen appears to occur which is shown by depressions in the total oxygen absorption curve in Figure 6. This effect gradually ceases and changes to a characteristic and abrupt high oxygen absorption rate at 6.30–7 p.m., which lasts throughout the hours of darkness.

235. Figure 6 shows the total oxygen absorption curve for an actively





respiring yam, and is typical and representative of all such curves obtained. By plotting the gradients of this curve an oxygen rate absorption curve was constructed (see Figure 7).

236. The apparent evolution of oxygen was an unexpected result, and the effect has been the subject of a closer study in which possible errors due to slight temperature changes were eliminated. This work is continuing and the evidence so far indicates that the effect is, in fact, a small but real one. It is possible that this effect is associated with incipient sprouting at which time green pigments develop and photosynthesis occurs.

237. Blacking out the yam during the hours of daylight appeared to have no immediate effect on its respiratory rhythm and the diurnal respiratory variation thus appears to be independent of the amount of illumination received by the yam, over the period of the test (see Figure 8).

238. Artificial illumination during the time of natural darkness, over a period of three days (using mercury fluorescent strip lighting) appeared to cause a small initial but temporary disturbance to the normal diurnal respiratory rhythm, but the usual rhythm was resumed on the second and third days. After stopping artificial illumination, enhanced oxygen absorption occurred at the advent of natural darkness (see Figure 9).

239. A determination of respiratory quotient (R.Q.) was made by enclosing a yam known to be actively respiring, in the respirometer described, with no absorbent material. No pressure changes were observed at constant temperature (87° F.) during a period of 24 hours, which indicated an R.Q. of unity if oxygen absorption and carbon dioxide evolution were the only changes occurring. No overall volume changes were detected during the hours of daylight when the very small respiratory inversion appears to occur.

240. In addition to the daily respiratory rhythm described above, it was observed that the daily rates are in themselves subject to changes. An actively respiring yam may gradually decrease in respiratory activity and become

FIG. 8

RESPIRATION RATE CHANGES OF AN EXCISED YAM TUBER (*D. CAYENENSIS*) ON STORAGE IN THE DARK.

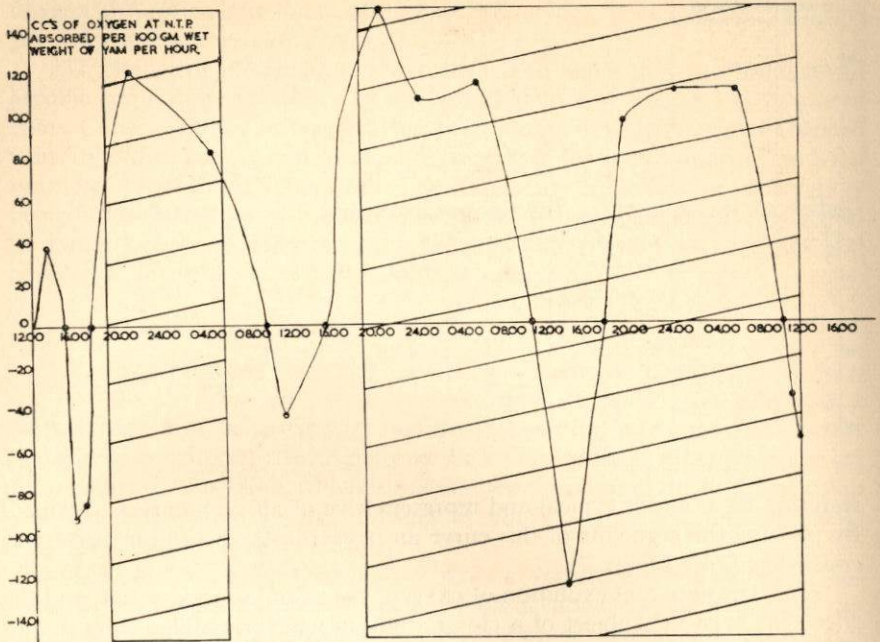
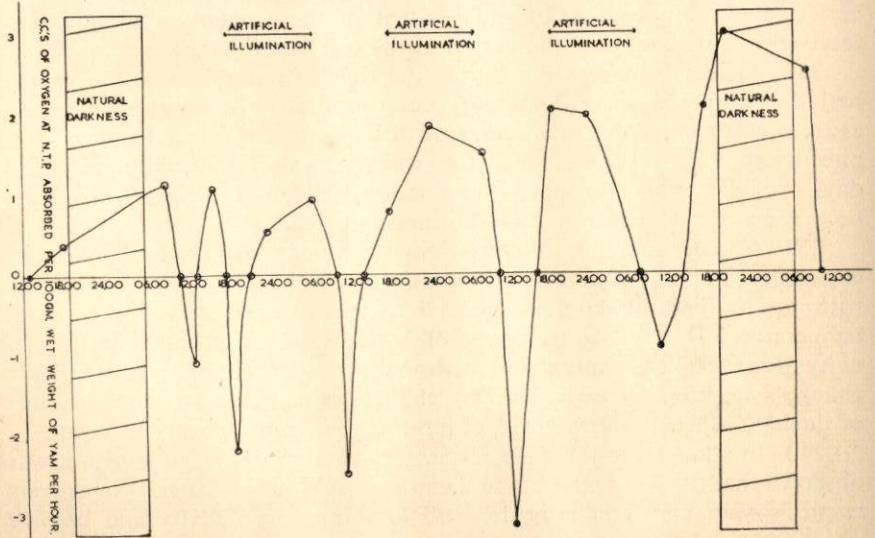


FIG. 9

RESPIRATION RATE CHANGES OF AN EXCISED YAM TUBER (*D. CAYENENSIS*) SUBJECT TO CONTINUOUS ILLUMINATION.



dormant, and after some days in this condition it may recommence to respire more actively. This effect accounts for the variable results obtained on yams of similar species and history referred to in paragraph 230. A separate trial is being started to study this effect.

241. It would appear that the phenomenon of respiratory rhythms in yams constitutes an example of an endogenous diurnal rhythm which is common in plant material. The factors affecting these rhythms, which are of many types, and which may be temporarily related to diurnal light dark cycles, have been described by Bunning (*Ergeb Biol.*, **23**, 235-247, 1936), and Flugel (*Planta* **37**, 337-75, 1949).

242. Instances of analogous respiratory rhythms in higher plants have been previously recorded by Schmitz (*Planta*, **39**, 271-308, 1951), and by Gregory, Spear and Thinman (*Plant Physiol.*, **29**, 220-29, 1959).

243. From the work so far carried out it is evident that respiratory exchanges in yam tubers form a complicated subject, but constitute an important source of dry weight loss. The effects of temperature, size of yam, and sprouting inhibitors, will also be studied in due course.

244. Anaerobic and partially anaerobic storage will also be of interest in connection with underground and clamp storage.

245. All respiratory studies on yams are being conducted at Lagos. (L. A. W. Hayward, S. A. Anja, V. A. Oloyede.)

XI. INSECTICIDES

New Testing Technique for Insecticidal Suspensions

246. The application of standard and uniform deposits of insecticides to test surfaces, has always presented difficulties in insecticide persistence tests conducted by this Unit. In the absence of a standard spraying tower, a hand atomiser has been used, but the degree of scatter of the results has always been wide and far from satisfactory. After the work referred to in paragraphs 261-166 had been carried out, an attempt was made to find a better procedure for obtaining standard deposits.

247. A new method of applying suspensions of wettable powder to absorbent surfaces, such as mud, and concrete, has been developed, and consists basically of introducing, by pipette, a known quantity of the suspension to the surface to be treated, the liquid being restricted to a fixed area by means of a cylindrical lamp-glass, and leakage being prevented by "Plasticine" or putty applied around the base of the cylinder. As the liquid soaks into the absorbent surface a uniform deposit is left as a result of the filtering process. The strength of the insecticidal suspension is so arranged that when a convenient quantity is pipetted into the cylinder, the required deposit will be obtained.

248. No chemical tests have yet been made to test the reliability of this method but satisfactory results have been obtained in bioassays in which the method has been used. (L. A. W. Hayward.)

249. Insecticides such as malathion (which breaks down quickly when applied to an alkaline surface) have usually been tested on filter papers which are not readily adaptable to the method described in the previous paragraphs

owing to the distortion produced on wetting the papers. As a solution to this problem, neutral surfaces have been made by pouring small quantities of plaster of paris into the cylindrical lamp-glasses placed on a horizontal glass sheet. The porous disc formed when the plaster sets, is very suitable for treatment with insecticides in manner described above. (M. R. George.)

The Persistence of Diazinon and Malathion on Concrete Surfaces

250. Trials reported in the 1958 W.A.S.P.R.U. Annual Report (paragraphs 112-8) showed that diazinon had a slightly better insecticidal effect than malathion when test insects were exposed on filter papers treated with diluted emulsion concentrates of the two insecticides. The current tests were commenced in Kano in March 1959 with the intention of observing if diazinon was more effective than malathion when applied to alkaline surfaces.

251. Concrete blocks were treated at various rates with malathion and diazinon emulsion concentrate formulations. Continuous exposures of *T. castaneum* adults, always resulted in very low mortalities, the diazinon treatments giving only slightly better results than malathion. Both insecticides lost any insecticidal effect on the concrete surfaces within a few days.

252. Pre-treatment of concrete surfaces with calcium sulphate (used as a neutral whitewash) increased the initial toxicity of both insecticides but this effect disappeared within a week.

253. It was concluded that diazinon was only slightly better than malathion and that neither insecticide was suitable for giving a residual effect on alkaline surfaces such as concrete walls. (M. J. Glover, S. C. Morah.)

Comparison of the Persistence of Several Insecticides on Concrete Surfaces

254. Concrete blocks were treated with various insecticides at an application rate of 100 mgs./sq. ft. (50 mgs./sq. ft. in the case of the diazinon emulsion concentrate) using the method described in paragraphs 246-248. Emulsion concentrates of the insecticides were included, although the technique of application used was primarily designed for wettable powders. The control block was treated with distilled water, while the following insecticides were applied to the test blocks:

Malathion 50% wettable powder (w.p.)
and 40% emulsion concentrate (e.c.)
Diazinon 20% w.p., and 10% e.c.
Dieldrin 50% w.p., and 20% e.c.
 γ B.H.C. 50% w.p.

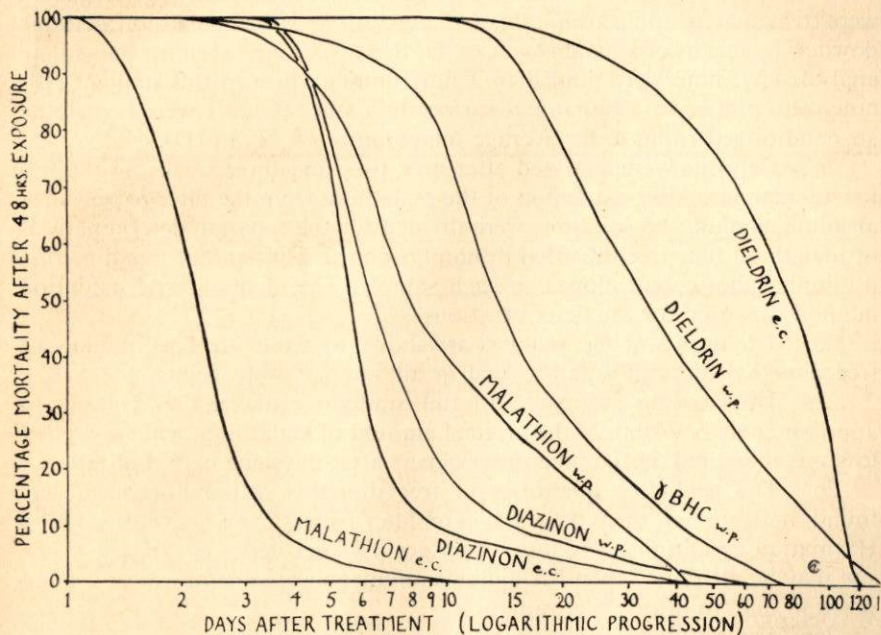
255. Batches of ten adults of *T. castaneum* were subjected to 48-hour exposures on the treated surfaces. The numbers of dead, moribund, and active insects were counted 24 hours after removal from the surfaces. The tests were repeated at frequent intervals during a period of about 3½ months during which time the concrete blocks were exposed to normal laboratory conditions of temperature and humidity at Kano.

256. The average mortality curves obtained are given in Figure 10. The γ B.H.C. gave results very similar to those found by earlier W.A.S.P.R.U.

workers (J. C. Duerden, L. A. W. Hayward and B. Somade., "The persistence and toxicity of insecticides under tropical conditions. I—The persistence of the γ B.H.C. and its toxicity to *Tribolium castaneum* (Hbst.)", *Bull. Ent. Res.*, 47 (4): 797–801). The longer persistence of the γ B.H.C. in the present work may be ascribed to the higher rate of application used, and possibly to the prevailing climatic conditions ("wet" season, compared with "dry" season conditions of the earlier trial).

FIG.10

TOXICITY TO *T.CASTANEUM* OF CONCRETE SURFACES TREATED WITH VARIOUS INSECTICIDES DURING WET SEASON CONDITIONS AT KANO.



257. Little difference was found between the persistence of the malathion and diazinon formulations.

258. Both dieldrin treatments yielded promising results. This insecticide was obviously little affected by the alkaline conditions on concrete, and its insecticidal persistence was long. Mortalities in excess of 90% were produced after 15 and 30 days, and in excess of 50 per cent after 30 and 75 days, by the wettable powder and emulsion concentrate, respectively. When the experiment was terminated after about 3½ months, a high proportion of test insects were still being rendered inactive by the emulsion concentrate treatment, although the lethal effect was negligible.

259. Dieldrin has a much higher mammalian toxicity than the other insecticides tested and would not be suitable for direct application to bagged food products. However, it may well prove useful for the treatment of the

fabric of stores and warehouses providing that safety precautions are strictly observed by pest control operators.

260. Further trials will be necessary to find which of the two formulations are most suitable. Pilot-scale tests will be necessary to determine whether the persistence of dieldrin under practical conditions is similar to that found by laboratory tests. (M. R. George.)

The Persistence of Malathion

(a) Chemical Breakdown

261. A trial has been carried out to estimate the chemical persistence of malathion during the Harmattan (dry) season in Kano. Thirty filter papers were treated at an application rate of 95 mgs./sq. ft. with a malathion wettable powder, by means of a hand atomiser. Of these, six were taken for immediate analysis (A); nine were pinned to a horizontal surface in full sunlight (B); nine were pinned to a horizontal surface in a store (C); six were kept in an air-conditioned room at an average temperature of 72° F. (D).

262. Deposits were analysed after one, two, and three weeks, in the following manner. After extraction of the malathion from the filter papers with absolute alcohol, the solutions were divided for the separate determinations of malathion plus free dimethyl dithiophosphoric acid, and of free dimethyl dithiophosphoric acid alone, on each sample. The alcohol-ferric oxidation method was used for the determinations.

263. The results of the analyses are shown in Table 25. The amounts of free dimethyl dithiophosphoric acid in all samples were negligible.

264. Three weeks' exposure to full sunlight reduced the deposits to approximately one-sixth of the original amount of malathion, while a smaller loss was measured on the other filter papers after the same period of time.

265. The negligible quantities of free dimethyl dithiophosphoric acid found, indicate that there is little loss on filter papers from hydrolysis during Harmattan conditions. The loss which occurs from deposits exposed to the sun may be attributed to either high maximum solar temperatures or decomposition due to ultra-violet radiation.

266. The results in Table 25 show a high degree of scatter and it was for this reason that a more satisfactory technique of application was devised as described in paragraphs 246-249. The latter technique was employed in further studies on the persistence of malathion as described in the following section. (M. J. Glover.)

(b) Biological Persistence and Chemical Breakdown

267. In an attempt to gain information about the behaviour of malathion under various conditions of relative humidity, a trial was started in September 1959 in which plaster surfaces at the bases of glass cylinders, treated with malathion wettable powder at an application rate of 200 mgs./sq. ft., are being stored in atmospheres of differing relative humidity produced by suitable saturated salt solutions at a constant temperature. Five salts have been used to produce conditions ranging from 10-100% R.H. The cylinders

TABLE 25
CHEMICAL PERSISTENCE OF MALATHION

Week After Treatment	Sample	Malathion Deposit on Each Replicate mgs./sq. ft.			Mean Deposit mgs./sq. ft.
0	A	153 110	117 171	109 110	130
1	B	93	78		86
2	B	64	54		59
3	B	9	32	25	22
1	C	64	98	73	78
2	C	96	93	96	95
3	C	88	157	49	98
1	D	168	47		108
2	D	102	98		100
3	D	61	107		84

A — Initial application.
 B — Exposed to full sunlight.
 C — Exposed horizontally inside a warehouse.
 D — Inside a darkened air-conditioned room at 72° F.

are being removed from the containers once every two weeks, when the treated surfaces are being examined using *T. castaneum* as the test insect.

268. A number of similarly-treated cylinders also stored at various humidities are being examined for malathion content at intervals. In this way it is hoped to complement the bioassay results with a measure of the chemical deterioration of the malathion. This experiment will not be completed for several months. (M. R. George.)

Toxicity to T. castaneum of Sacking Sprayed with Pyrethrins/Piperonyl Butoxide Wettable Powder

269. The following trial was carried out in the Ibadan laboratory at the end of the wet season under normal atmospheric conditions which varied between 70° F. and 80° F. and 70% and 80% R.H.

270. The wettable powder used was stated by the manufacturers to contain 2.5/25% wt. Pyrethrins/Piperonyl Butoxide and the recommended treatment is 10/100 mgm. per sq. ft. It was decided to run two treatments: (a) as recommended, and (b) employing half the recommended concentration, i.e. 5/50 mgm. per sq. ft.

271. For each experiment, five circles of hessian sacking, backed by absorbent paper resting on porous concrete blocks and enclosed by open

glass cylinders of similar internal basal area were treated by the technique described in paragraphs 246-248.

272. Ten *T. castaneum* adults were placed on the sacking in every cylinder and counts of knock-down made after 1 and 24 hours. Mortalities were recorded after 48 hours. The operation was repeated daily for three days and then weekly until the toxicity became reduced. The results of the investigation are summarised in Table 26.

TABLE 26
TOXICITY OF SYNERGISED PYRETHRINS WETTABLE POWDER TO ADULT
T. CASTANEUM ON HESSIAN SACKING

(50 *T. castaneum* for each experiment)

A. Concentration of 10/100 mgm. Pyr./Pip. Butoxide per sq. ft.

Period from Start of Experiment	Knock-down after 1 hr. Exposure	Knock-down after 24 hrs. Exposure	Dead in Subsequent 24 hrs.
	%	%	%
1 day	100	100	98
2 days	96	100	100
3 days	100	100	100
1 week	94	100	100
2 weeks	68	100	100
3 weeks	32	78	74
4 weeks	28	76	66
5 weeks	26	52	52
6 weeks	20	24	20

B. Concentration of 5/50 mgm. Pyr./Pip. Butoxide per sq. ft.

Period from Start of Experiment	Knock-down after 1 hr. Exposure	Knock-down after 24 hrs. Exposure	Dead in Subsequent 24 hrs
	%	%	%
1 day	88	100	100
2 days	62	74	74
3 days	52	100	100
1 week	52	92	92
2 weeks	36	56	56
3 weeks	0	44	24

273. It is seen that the 10/110 mgm. deposit on hessian sacking gives a satisfactory kill of *T. castaneum* for up to three weeks. The 5/50 mgm. dose also is effective but the duration of persistence is reduced in rough proportion to the concentration. There was no knock-down in the control. (K. C. Matheson, K. U. Ndukwe.)

XII. PORT STORAGE

APAPA

Cocoa

274. There are now two very large warehouses for housing cocoa in the port area at Apapa which are suitable for the *in situ* fumigation of cocoa. However, in view of the size of these warehouses and the continual movement of cocoa and personnel it is only in exceptional circumstances that fumigation may be undertaken. It has been agreed, however, that fumigation, when necessary, will be conducted in the smaller Board Stores nearby where less dislocation would occur. Small quantities of cocoa continue to be treated in the fumigation installation.

275. The fabric of all cocoa stores in the Port Area is sprayed with D.D.T. emulsion each year when they are empty and this is part of the "Disinfestation of Stores Programme" carried out by the Western Region Produce Inspection Service, Pest Control Section.

276. Large scale misting of stored cocoa with pyrethrins has now ceased, the only exception being when fumigations are carried out. Immediately prior to a fumigation the store is misted and after the fumigation, misting is carried out each night for seven nights, and thereafter alternate nights until the cocoa is shipped.

277. The main storage pest of cocoa at Port is now *T. castaneum*, the origin of which is the groundnuts stored in four large transit sheds. Efforts are now being concentrated on controlling the cross infestation at source as is described in the next section.

Groundnuts

278. The programme for treating groundnuts stored in transit sheds at Apapa has been considerably modified during the year under review. The treatment is now being carried out by the Pest Control Section of the Western Region Produce Inspection Service and is being paid for by the Northern Region Marketing Board. Two schemes were drawn up by W.A.S.P.R.U. in February 1959, one to take effect at once and one to await the arrival of new equipment. The initial scheme was to treat groundnuts in one transit shed per night with an oil-based mist containing lindane and synergised pyrethrins. The second scheme involved misting and fogging all groundnut stacks nightly with a formulation containing malathion in diesoline. In each shed a routine treatment has been adopted based on physical conditions. On the ground floor, pulse-jet fog applicators apply fog through the partly open doors on the windward side, while rotating disc applicators put up a mist on the lee side. In addition, one motorised knapsack sprayer deals with the corners under the stairways. This ensures complete coverage of the space round the groundnut stacks. On the first floor there is no verandah on the windward side and a mist is applied with two motorised knapsack machines.

279. It is hoped that this routine misting of groundnuts will greatly reduce the regular evening spread of *T. castaneum* and *E. cautella* in the Port

of Apapa. It should also help to reduce the possibility of cross infestation to ships at the quay, and check damage being caused to the groundnuts.

280. Assessments of the effectiveness of the initial scheme showed that large numbers of flying insects were being destroyed. A more detailed survey will be undertaken when the second scheme is operating fully.

PORT HARCOURT

281. A survey of the storage hygiene of the transit sheds in Port Harcourt was carried out. The inclusion of copra, which is very liable to infestation, as a Marketing Board crop, and the rising trend in the output of cocoa in the Eastern Region may necessitate the initiation of a disinfection programme in the near future.

282. Advice and assistance have been given to the Marketing Board storekeepers for the control of rodents, which were becoming a serious menace in palm kernel stores adjacent to Port Harcourt wharf.

APPENDIX I
PUBLICATIONS OF THE RESEARCH UNIT IN 1959

<i>Title</i>	<i>Author</i>	<i>Publication</i>
Storage of Yams. Part I: Investigations on Weight Changes.	D. G. Coursey	Federal Government Printer, Lagos, 1959

APPENDIX II

SENIOR SERVICE STAFF LIST, SEPTEMBER 1959

		Station
Officer-in-Charge and Principal Scientific Officer		Lagos
Senior Scientific Officer		Ibadan
Scientific Officers		Port Harcourt Port Harcourt
		Kano
		Ibadan
		Due to arrive Kano October 1959

Published by the West African Stored Products
Research Unit, Department of Marketing and Exports, Lagos, Nigeria
and printed by the Tonbridge Printers Limited, Great Britain