DEPARTMENT OF AGRICULTURE, SOUTH AUSTRALIA

Agronomy Branch Report

THREE STUDIES OF BARLEY STORED IN BULK

1965 - 1967

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FOREWORD

This report describes tests carried out in 1965 on barley stored in two cells in the vertical concrete silo at Bute and similar test carried out in 1966 and 1967 at Ardrossan.

The difference in the barley in the two cells at the time of intake was the moisture content. So, in fact, the three experiments measured the effectiveness of storage methods on barley at two levels of grain moisture.

The report describes the storage, the aeration system and the application of insecticide to the grain at intake.

The experimental procedures for taking samples and for measuring temperature, moisture and germination percentages are described.

The data obtained are summarised and discussed.

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PART I

STUDY OF BARLEY STORED IN BULK AT BUTE IN 1965

I. INTRODUCTION

Prior to the harvest of 1964 comparatively little barley had been stored in bulk in South Australia. Seven country silos were established to receive barley in bulk from the 1964 harvest and in addition barley was received and stored in bulk at four terminal installations.

An arbitrary grain moisture content limit of 12% (using a Marconi meter) was imposed. The imposition of this limit meant that some farmers would not be able to deliver barley in bulk.

The relative humidity of air in equilibrium with grain at 12% moisture content is approximately 55% and for some areas in South Australia there are insufficient hours during harvest time when the relative humidity is low enough to ensure grain of less than 12% moisture. It would therefore be desirable to have a limit of moisture above 12%.

When considering safe storage of grain it should be realised that there is an interaction between temperature, moisture and time. Grain temperature in fact is probably a more important consideration than moisture and for every combination of temperature and moisture there is an appropriate time limit. However in practice moisture limits can be imposed whereas temperature limits cannot, but nevertheless these three factors need to be considered together, along with the conditions under which the grain is to be stored.

This investigation was conducted by the South Australian Department of Agriculture and the South Australian Co-operative Bulk Handling Limited in co-operation and at the request of the Australian Barley Board.

The experiment comprised one treatment in which approximately 38,000 bushels of No 3 grade barley of moisture content (Marconi) in therange 12.5% to 13.5% was received for storage. A similar quantity of No 3 grade barley received at moisture contents up to and including 12% was placed in an adjoining cell and held as a control.

The barley received at less than 12% moisture was compared with the barley received between 12.5% and 13.5% during the latter part of the storage period.

The barley was held for a period of 11 months.

II. DESCRIPTION OF THE STORAGE:

Bute is 90 miles north, north west of Adelaide. The mean rainfall is 15.5 inches. Bute has sea 20 miles to the west (Spencer Gulf) and 20 miles to the south (St. Vincents Gulf).

The storage comprises 8 main cells and 3 interspace cells. The concrete main cells are 93'6" high and 30' in diameter and have a capacity of approx 52,000 bushels. They have flat floors, a feature which influences the pattern of outflow of the grain.

III. AERATION:

With the high air temperatures at harvest time barley which is delivered directly from the paddock has a high temperature. This would allow insects to multiply rapidly if they were present, not only damaging grain but increasing temperature still further.

Moisture migration results from the temperature gradients, moisture is deposited at cold surfaces and mould damage can occur. Grain quality, and in the case of barley germination capacity, can be reduced as a consequence of temperature also.

For practical purposes a safe upper limit might be 65°F. and perhaps the aim of aeration is to attain this as soon as possible with further reductions to 60°F or even less to ensure safe storage.

(a) Description of Aeration System

The cells are fitted with a half round perforated duct of 16 gauge mild corrugated steel 14 feet long and 3 feet in diameter. The outer end of the duct is fitted to a fan and air is drawn through the grain.

The air flow rate in the cells is designed to be 1/20 c.f.m. per bushel of barley.

(b) Control of Aeration System

To achieve cooling of the grain then aeration can only be used when the ingoing air is cooler than the grain. The operation is carried out by progressively lowering the upper temperature limit of the ingoing air.

In fact two upper limits of the ingoing air are imposed, viz. - dry bulb temperature and relative humidity. The electronic controls consist of hi-limit and lo-limit thermostats and a humidistat. Normally the hi-limit control on the temperature of the ingoing air is set 10°F below grain temperature and the lo-limit setting 20° below the hi-limit setting.

The humidistat control has a range from 0–80% and in the experiment was set at a maximum of 75%.

IV. TEMPERATURE RECORDING EQUIPMENT:

Each cell in the installation is fitted with a central thermocouple cable with 14 junctions located 6' apart. The cables are wired back to a control panel. Temperatures can then be taken within the cell from 6' to 84' levels.

The cable and the junction can be selected by two switches at the reading station and the temperature of the selected point is then shown on a temperature indicator.

V. APPLICATION OF INSECTICIDE:

All barley was treated with premium grade malathion at 8 p.p.m. at intake. The protectant was sprayed on to the grain stream on the inloading conveyor.

Malathion residues were determined as 3.6 p.p.m. at the end of February.

VI. EXPERIMENTAL PROCEDURE:

(1) Sampling Procedure

Turning of the grain is a regular procedure and so samples were taken from the grain stream during turning when it was usual to discharge approximately 2,000 bushels of grain and return it to the cell.

Samples were collected in clear acrylic plastic capsules which held approximately 2 ounces of grain. Early tests showed that these containers were airtight at normal pressures.

(2) Measurement of Moisture Content

The moisture content of a composite sample from each load was determined by the local silo agent in following his normal procedure. The moisture content was determined using a Marconi Moisture Meter TF 933A and the ground grain method.

Moisture of samples of the grain from both cells was measured at intervals throughout storage and upon discharge. Moisture was determined using the standard air-oven method by drying at 130°C ± 3° for 1 hour. All values were determined on a wet weight basis and the determinations were carried out by the Department of Chemistry.

Moisture was determined using the Marconi Moisture Meter on similar samples on each occasion.

(3) Measurement of Germination Percentage

Germination percentage was used as an index of the quality of the grain. The tests were performed by the Seed Testing Section of the Department of Agriculture using International Seed Testing Association methods.

In this method samples of 100 grains were germinated at 20°C on moistened blotting paper in a metal tray.

Two tests were performed on each sample submitted. In addition tests were carried out on prechilled samples (5°C for 7 days) until it was established that dormancy had been broken.

(4) Measurement of Temperature

Records of temperature from the permanent installation were kept.

(5) Examination for Insects

Samples of approximately 1 lb. were taken from each load at intake and stored in plastic bags. These were kept at room temperature for 6 weeks and then screened for insects.

During storage samples were regularly screened for insects.

VII. RESULTS:

1. Moisture Content

Grain moisture percentage data are tabulated below.

Date	Test Cell		Control Cell	
	Oven Method	Marconi	Oven Method	Marconi
At intake	-	13.3%	-	12%
1/12/64	12.6		11.0	
9/12/64	12.8		11.5	
16/12/64	12.7			
23/12/64	12.7			
30/12/64	12.5			
6/1/65	12.6			
19/1/65	12.7			
26/1/65	12.4			

contd.

Date	Test Cell		Control Cell	
	Oven Method	Marconi	Oven Method	Marconi
19/2/65	12.6			
3/3/65	12.2			
9/4/65	12.4			
28/4/65	12.3		11.0	
11/6/65	12.4		11.2	
*27/10/65	11.8		10.7	

* Taken during discharge which occupied several days.

The grain was accepted on the basis of a moisture determination made using a Marconi Moisture Meter and the mean was 13.3%. The first determinations made on the basis of the oven method showed a moisture content of 0.7% below. Subsequent investigations have shown that the oven method gives results 0.2 - 0.3% below the Marconi method. This may account for part of the drop in moisture content following intake.

From then on the moisture content fell only slightly during storage.

2. Grain Temperature

The following grain temperatures in the test cell have been selected from those recorded to illustrate the reduction of temperature brought about by aeration.

Date	Approx. time from intake	Temp. Range in ^{o}F	Mean Temp. in ^{o}F
23/12/64	1 month	82^{o} - 69^{o}	78.5^{o}
26/1/64	2 months	70^{o} - 61^{o}	69^{o}
24/3/64	4 "	73^{o} - 63^{o}	69^{o}
1/6/65	6 "	65^{o} - 51^{o}	65.6^{o}
9/8/65	8 "	60^{o} - 54^{o}	57^{o}
14/10/65	10 "	58^{o} - 56^{o}	57^{o}

The barley in this cell was subjected to 937.5 hours of aeration. It is significant that approximately 550 fan hours were required to reduce the mean temperature to 65°F and an additional 160 hours to reduce to a mean of 60°F.

3. Germination Percentage

The data tabulated below are mean germination percentages from samples collected.

Date	Test Cell	Control Cell
19/2/65*	95% (93% for samples not prechilled)	
3/3/65	97.5	
9/4/65	97	
28/4/65	97	97
11/6/65	97	96.5
27/10/65	96.5	97.5

* Dormancy was almost completely broken by this date.

The germination percentage can be regarded as being constant throughout the storage period.

4. Insects

No live insects were found in the samples taken at intake or in samples taken throughout the experiment.

VIII. CONCLUSION

From a practical point of view the barley received at a moisture content in the range 12.5 - 13.5% using a Marconi Moisture Meter was stored in as good a condition as that received at moisture contents of less than 12%. Barley in both the test and control cells appeared to be in good condition at outturn after 11 months storage and as far as could be established by the measurements made had in no way deteriorated. On its arrival at the terminal the barley was reported to be in good condition and better in appearance than "cut bag" barley arriving at the same time.

The data also illustrated that grain temperature can be reduced by aeration thus making the combination of malathion - aeration a powerful aid to safe storage of barley which is received into silo storage direct from farms at harvest time and which has moisture contents in the range $12\frac{1}{2}\%$ - $13\frac{1}{2}\%$.

PART II

STUDY OF BARLEY STORED IN BULK AT ARDROSSAN IN 1966

I. INTRODUCTION

When considering safe storage of grain in bulk it is important to consider the interaction between grain temperature, grain moisture and time. In fact, grain temperature is probably a more important consideration than moisture and for every combination of grain temperature and grain moisture, there is a practical time limit for safe storage.

In practice, moisture limits for receival can be imposed whereas temperature limits cannot. However, they need to be considered together along with the conditions under which the grain is stored and attempts to manipulate these factors by the use of storage facilities may be desirable.

For the 1964 harvest when there were eleven receival points for barley, an arbitrary grain moisture limit of 12% (Marconi Meter) was imposed. This limit obviously restricted some farmers in some districts and it became important to test the hypothesis that grain could be safely stored when received at higher levels of moisture.

A series of experiments to be conducted by the South Australian Department of Agriculture and the South Australian Co-operative Bulk Handling Limited in co-operation with the Australian Barley Board, were initiated.

The first study at Bute has been reported previously. It showed that barley received at a moisture content in the range 12.5-13.5% could be stored satisfactorily. The Australian Barley Board approved of the receival of barley in bulk from the 1965-6 season with a moisture content not exceeding 13%.

The second experiment was conducted at Ardrossan with barley from the 1965-66 season crop. Approximately 74,500 bushels of no 3 grade barley of moisture content (Marconi) in the range 13.1% to 14.5% was received for storage and placed in one main cell. A similar quantity of No 3 grade barley was received at moisture contents up to and including 13.0% was placed in an adjoining cell and held as a control.

II. DESCRIPTION OF THE STORAGE

Ardrossan is situated on the east coast of Yorke Peninsula, some 35 miles north of an east-west line through Adelaide. It is the largest receival centre of wheat and barley direct from growers in Australia and is also a Terminal port.

The shore Terminal facilities comprise -

BLOCK 1 - 1 million bushel Horizontal Bulk Grain Bin.

BLOCK 2 - a 22 cell (16 main, 6 interspace) conventional concrete vertical Silo.

BLOCK 3 - a 23 cell (15 main, 8 interspace) conventional concrete vertical Silo.

INTRANSIT BARLEY SILO of 5 cells (4 main, 1 interspace) and are all operated and controlled by South Australian Co-operative Bulk Handling Ltd.

Barley is received almost exclusively from Yorke Peninsula, an area with the climate influenced by the nearness to the sea.

The experiment was conducted in Block 3.

The cells in Block 3 are concrete and are 93 ft. high, 35 ft. in diameter and have a capacity of approximately 74,600 bushels. The floors are conical (hopper bottom) and hence are self emptying.

III. AERATION

Although the mean air temperatures on Yorke Peninsula are lower than some other cereal growing districts, they are sufficiently high at harvest time to ensure that the majority of grain delivered is above the safe storage temperature.

Aeration becomes important as it is the only practical device available to reduce grain temperature to levels where insect activity is unimportant and to limit moisture migration by convection.

The aeration facilities are used to reduce grain temperatures to at least 65°F as quickly as possible.

(a) Description of Aeration System

The cells are fitted with perforated ducts of 16 gauge steel approximately 13 ft. long and 3 ft. in diameter. Air is drawn down through the grain at a theoretical rate of 1/20 c.f.m. per bushel of barley.

(b) Control of Aeration System

The aeration can be controlled automatically or manually with temperature and dewpoint elements so that only air between certain temperature limits and below a certain relative humidity is used. In the experiment the hi-limit control was initially set at 72°F and lowered as grain temperatures were reduced.

The dewpoint control was arranged so that air of 80% relative humidity or less was used.

IV. TEMPERATURE RECORDING EQUIPMENT

Each cell in the installation is fitted with a central thermocouple cable with 18 junctions located 5 ft. apart. The cables are wired back to a control panel. Temperatures can then be taken within the cell from 10ft. to 95 ft. levels.

The cable and the junction can be selected by two switches at the reading station and the temperature of the selected point is then shown on a temperature indicator.

V. APPLICATION OF INSECTICIDE

Barley was treated with premium grade malathion at 8 p.p.m. at intake. The protectant was sprayed on to the grain stream on the unloading conveyor.

Malathion residues were determined on six occasions during the experiment.

VI. EXPERIMENTAL PROCEDURE

(1) Sampling Procedure

Turning of the grain is a regular procedure and so samples were taken from the grain stream during turning when it was usual to discharge approximately 2,000 bushels of grain and return it to the cell.

Samples were collected in clear acrylic plastic capsules which held approximately 2 ounces of grain. Early tests showed that these containers were airtight at normal pressures.

(2) Measurement of Moisture Content

The moisture content of a composite sample from each load was determined by a member of the Silo Staff in following his normal procedure. The moisture content was determined using a Marconi Moisture Meter TF 933A and the ground grain method.

Moisture of samples of the grain from both cells was measured at intervals throughout storage and upon discharge. Moisture was determined using the standard air-oven method by drying at $130^{\circ}C \pm 3^{\circ}$ for 1 hour. All values were determined on a wet basis and the determinations were carried out by the Department of Chemistry.

Moisture was determined using the Marconi Moisture Meter on similar samples on each occasion.

(3) Measurement of Germination Percentage

Germination percentage was used as an index of the quality of the grain. The tests were performed by the Seed Testing Section of the Department of Agriculture using International Seed Testing Association methods. In this method samples of 100 grains were germinated at 20°C on moistened blotting paper in a metal tray. Two tests were performed on each sample submitted.

(4) Measurement of Temperature

Records of temperature from the permanent installation have been recorded.

(5) Examination for Insects

During storage samples were regularly screened for insects.

(6) Aeration

The number of fan hours per month and the settings were recorded.

VII. RESULTS

1. Moisture Content

(1) At Intake

The intake moistures were determined using a Marconi Meter. The quantities delivered at various moisture levels are as follows:

Test Cell		Control Cell	
13.1 to 13.3	10,074 bushels	8.7 to 9.1	1,316 bushels
13.4 to 13.6	25,048 bushels	9.2 to 9.9	4,556 bushels
13.7 to 13.9	16,549 bushels	10.0 to 10.8	12,360 bushels
14.0 to 14.2	13,775 bushels	11.0 to 11.9	28,768 bushels
14.3 to 14.5	9,041 bushels	12.0 to 12.9	25,168 bushels
		13.0	2,354 bushels
Average Moisture Content 13.7%		Average Moisture Content 11.6%	

(2) During Storage

The following moistures were determined using the standard oven method.

Date	Test Cell	Control Cell
20/12/65	12.5%	10.9%
21/1/66	12.2	10.8
8/2/66	12.1	10.7
22/2/66	12.3	10.9
14/3/66	12.4	11.4
31/3/66	12.7	11.0
19/4/66	12.5	11.2
10/5/66	12.5	11.2
1/6/66	12.7	11.2
24/6/66	13.0	11.8
20/7/66	12.6	11.4
4/8/66	12.6	11.3
16/8/66	12.6	11.2
7/9/66	12.7	11.3
20/9/66	12.6	11.4

In all cases the figure is the mean of four samples except the last which is the mean of 20 samples. The moistures determined by the standard oven method appear to be approximately 0.5% below the measurement obtained by the Marconi Meter. This accounts for some of the apparent drop from intake to the first sampling.

2. Grain Temperature

The grain temperature records indicate that approximately four months were necessary to reduce the whole of the cell to a safe storage level.

Date	Test Cell		Control Cell	
	Temp. range in °F	Mean Temp. in °F	Temp. Range in °F	Mean Temp. in °F
December, 1965	76 - 65	75.0	78 - 75	77.0
January, 1966	74 - 64	70.7	75 - 71	73.0
February	71 - 66	68.4	74 - 70	71.0
March	68 - 59	62.5	70 - 62	66.5
April	64 - 55	59.0	66 - 59	61.8
May	58 - 51	54.7	60 - 54	57.5
June	57 - 50	54.5	60 - 54	57.5
July	50 - 47	48.0	55 - 46	51.0
August	48 - 42	46.0	52 - 46	50.0
September	49 - 42	46.4	52 - 48	50.0

The amount of aeration used to achieve these temperatures is set out below.

	Aeration Fan Hrs.	Air Temp. Settings	Dew Point Settings	Relative Humidity
December, 1965	62.5	72°F	67°	80%
January, 1966	130.3	70	65	80
February	274.2	70	65	80
March	196.0	65	60	80
April	161.9	60	55	80
May	102.9	53	48	80
June	30.0	50	45	80
July	112.7	50	45	80
August	86.4	45	40	80
September	8.4	45	40	80
Total	1,147.3			

Although both cells were subject to 1,147 hours aeration that to the end of April, viz. 825 hours, was sufficient to reduce the temperature to a safe level.

3. Germination Percentage

The data tabulated below are mean germination percentages from samples collected.

Date	Test Cell	Control Cell
16/12/65	97.1%	97.1%
30/12/65	98.6	99.1
21/1/66	97.4	98.4
22/2/66	99.1	99.5
31/3/66	98.9	99.4
19/4/66	99.6	98.4
10/5/66	99.0	97.9
1/6/66	99.5	98.9
24/6/66	98.9	98.9
20/7/66	98.5	98.6
4/8/66	98.9	98.8
16/8/66	99.4	98.7
7/9/66	99.0	98.9
20/9/66	98.9	98.9

The data indicate a slight initial increase in germination and from late December until the end of storage, the percentage remained constant and at a high level.

Germination percentage can be regarded as a measure of deterioration and from the data presented, no biochemical deterioration occurred.

4. Insects

No insects were detected in any samples. There were no signs of insect damage.

The protectant, Malathion, was applied at the rate of 8 p.p.m. The following residues were detected.

Date	Malathion Residue in p.p.m.	
	Test Cell	Control Cell
January	3.0	3.0
May	1.1	1.2
June	1.6	1.6
July	2.0	1.7
August	1.0	1.3
September	1.4	1.8

CONCLUSIONS

1. The intake moisture content of the barley in the test cell was in the range 13.1-14.5% with a mean content of 13.7%. This was 2.1% above the mean of the control cell but the higher moisture content undoubtedly had no effect on the barley during the 9 month period it was in storage. At outturn there was no visual or measurable difference between the barley in the two cells.

2. It is apparent from this experiment that barley can be received at these higher moisture content levels and stored safely in similar bulk grain storage facilities in South Australia.

3. The application of Malathion Grain Protectant provides a measure of protection to the grain in cell storage in the period before the full benefits of aeration can be gained.

4. The aeration system at Ardrossan in Block 3 (where the experiment was conducted), has been a prime factor in the relatively quick reduction in grain temperatures to a safe storage level.

5. A more economic aeration schedule may be developed as the grain temperature after the first five months was reduced below 65°. The further reduction in grain temperatures in the period May to September of grain temperatures to below 50° involved to the order of 400 aeration fan hours and may not have been entirely necessary as it is recognized that bulk grain in cell storage below 65° can be stored safely for extended periods.

6. It is recommended that in any future experiment full scale aeration be discontinued when grain temperature is reduced to below 55°, it being considered that normal inspection procedures and limited aeration would ensure stocks being maintained in good order and condition.

PART III

STUDY OF BARLEY STORED IN BULK AT ARDROSSAN IN 1967

I. INTRODUCTION

The safe storage of grain in bulk is largely dependent on the three factors - grain temperature, grain moisture and storage time. Because of its important role in regulating the activity of spoilage organisms, grain temperature may be a more important factor in safe storage than is grain moisture. At the storage however, a grain moisture limit rather than a grain temperature limit is imposed at receival because of practical considerations.

In the 1964 season, an arbitrary limit on grain moisture at receival for bulk storage was imposed. The limit was 12% moisture for ground grain (Marconi Meter) which severely restricted farmers with their delivery of grain in some areas. The South Australian Department of Agriculture and South Australian Co-operative Bulk Handling Limited with the co-operation of the Australian Barley Board initiated a series of experiments to study the problem.

The first study was made at the vertical silos at Bute in 1964-65. It showed that with the aid of aeration and Malathion grain protectant, grain received in the moisture range 12.5-13.5 could be safely stored. Consequently, it was agreed by the Australian Barley Board and South Australian Co-operative Bulk Handling Limited to receive barley with a moisture limit at receival up to 13%.

A second study at Ardrossan in 1965-66 tested the storage of No 3 grade barley received in the 13.1-14.5% moisture range against that of grain received under the normal 13% limit. Again with the use of Malathion and aeration, there was no visible difference in the two grain samples at shipping 9 months later. The final temperatures were however in the order of 50°F while it is generally considered that 60°F is a low enough temperature for safe storage.

The third study was again carried out at Ardrossan with the 1966-67 season crop, using the same treatments as the second study. The control cell was filled with No 3 grade barley received under the 13% moisture limit, and the experimental cell was filled with No 3 grade barley received in the range 13.1-14.5%. In an attempt to reduce costs, it was decided to reduce the number of aeration hours when the grain temperature dropped below 60°F.

II. DESCRIPTION OF THE STORAGE:

Ardrossan is a terminal port on the east coast of Yorke Peninsula about 50 miles North West of Adelaide. It is one of the largest receival centres for wheat and barley direct from the growers, in Australia. The storage facilities are controlled and operated by South Australian Co-operative Bulk Handling Limited.

The cells where the experiment was conducted are each 93 feet high, 35 feet in diameter and hold about 75,000 bushels. Most of the barley received at the storage, and used in the trial, is from Yorke Peninsula where the proximity of the sea influences the climate.

III. AERATION:

The grain received during harvest is generally above the safe storage temperature and aeration is used to reduce this to safe levels - generally considered to be around 65°F or lower.

(1) Description

Air is drawn down through the grain into 13 foot long by 3 foot diameter perforated steel ducts at the base of each cell. Air flow is theoretically 0.2 c.f.m. per bushel of barley.

(2) Control

Operation may be either manual or automatic. Air between set temperature limits and below a set humidity limit(by the use of a dew-point control) is used. In the experiment the upper temperature limit was set at 75°F and progressively dropped to 50°F by the end of the experiment. The dew point was set to give an 80% limit to the Relative Humidity.

IV. TEMPERATURE RECORDING EQUIPMENT:

Each cell in the installation has a central thermocouple cable with 18 junctions located 5' apart. Temperature for each cell can be read for the 10 ft. to the 95 ft. levels at a central control panel.

V. APPLICATION OF INSECTICIDE:

Barley was sprayed with premium grade malathion at 8 p.p.m. as it travelled along the receival conveyor. Residue levels were determined 3 times during the trial.

VI EXPERIMENTAL PROCEDURE:

1. Sampling:

The normal silo procedure involves turning the grain at intervals. At these times, when approximately 2,000 bushels were turned, samples were taken during the trial period and were placed in air-tight acrylic plastic capsules holding about 2 ozs. of grain.

2. Moisture Content:

The moisture content of a composite sample from each turning period was determined with a Marconi Moisture Meter TF 933A using the ground berry method. The moisture content of the samples taken through the storage period and at discharge was measured by the standard air-oven drying method (130°C ± 3° for 1 hour). All values were determined on a wet basis by the Department of Chemistry.

3. Measurement of Germination Percentage:

Germination percentage was used as an index of quality of the grain. The seed testing section of the Department of Agriculture, using the International Seed Testing Association methods carried out the tests. The method involved germinating 100 grains on moistened blotting paper in a metal tray.

4. Measurement of Temperature:

Temperature records were taken from the central control panel twice weekly.

5. Examination for Insects:

Samples were screened for insects at each sampling period.

6. Aeration:

The number of fan hours per month and the settings were recorded.

VII. RESULTS:

1. Moisture Contents:

The following are figures for the grain moisture taken from samples through the test period. They were read by the ground berry method with the Marconi meter. Oven dry measurements were taken at wider intervals and are included in brackets.

Date	Test Cell	Control Cell
December 1966	13.8	10.9
January 1967	12.9	11.9
February	13.0	10.8
March	12.7 (12.5)	10.4 (9.6)
April	12.8	10.4
May	12.9 (12.5)	10.5 (9.6)
June	12.9 (12.6)	10.5 (9.7)

As in the previous trials, the oven dry readings tend to be below the Marconi meter readings. The oven dry readings are means of 5 samples, and the Marconi meter readings, the average of about 10 readings.

2. Grain Temperature:

The intake temperature of grain for the experimental cell was 10°F lower than that of the control cell and this discrepancy was maintained over the period of the experiment. While the test cell had reached a safe storage temperature in two months, it was 6-7 months until the control cell reached a safe temperature level.

Date	Test Cell		Control Cell	
	Range (°F)	Mean Temp. (°F)	Range (°F)	Mean Temp.(°F)
December 1966	78-64	70	86-75	80
January 1967	66-59	63	71-68	70
February	64-61	62.9	71-66	70
March	63-59	60.5	71-61	68
April	63-57	60	72-64	68
May	50-48	50	64-55	60
June	50-47	50	63-55	60

The amount of aeration involved in reducing the temperatures to this level is set out below:

	Aeration fan hours	Air Temp. Settings	Dew Point Settings	Relative Humidity
November	43.3	75	65	80%
December	321.3	65	55	80%
January	63.0	65	55	80%
February	27.0	65	55	80%
March	100.0	60	52	80%
April	5.7	60	54	80%
May	172.5	50	44	80%
June	17.6	50	44	80%
	750.4			

In the previous trial, the cells were given 1,147 hours of aeration of which 825 hours were sufficient to bring the temperature down to a safe storage level. With a total of only 750 hours of aeration, costs in this trial would be much lower with no loss of safe storage. Only 563 hours were necessary to bring the temperature of the barley in the experimental cell down to a safe storage level.

3. Germination Percentage:

The data tabulated below are mean germination percentages from samples collected.

	Experimental Cell	Control Cell
	%	%
March	98.1	99.0
May	99.2	98.9
June	98.8	97.6

Germination percentage was virtually unchanged over the period of the experiment. This indicates that dormancy had been broken by the time the first measurement was made. The grain did not suffer any biological deterioration during storage or the germination figures would have dropped.

4. Insects:

No insects or signs of damage caused by then were seen in any sample.

Malathion grain protectant was applied at the rate of 8 p.p.m. The following residues were detected:

Date	Malathion residue in p.p.m. Experimental Cell	Control Cell
March	2.0	2.1
April	2.6	2.3
May	1.6	1.5

CONCLUSIONS:

1. The intake moisture content of the barley in the test cell averaged 13.8% which was 2.1% above that of the control cell.

   The higher moisture did not appear to have any effect on the barley during its 7 month storage period.

2. There was a marked difference in intake temperatures with the experimental cell receiving barley 10°F cooler than the control cell. This trend for the higher moisture barley to be cooler has appeared in the previous experiments. (It has possibly contributed towards the success of the experiments).

3. The safe storage of grain at these higher moisture content levels appears possible in similar storage facilities in South Australia with the combination of Malathion Grain Protectant and aeration.

4. It was recommended after the previous experiment that full scale aeration be discontinued when the grain temperature had been reduced to 55°F. This was done but the grain was not stored long enough to observe the effects.

5. It would therefore appear that another trial with similar conditions should be carried out having in mind that another successful result could result in a recommendation of 13.5% as the upper limit for receival for the safe cell storage of barley.