AUSTRALIAN NUFFIELD FARMING SCHOLARS ASSOCIATION

REPORT OF VISIT TO THE UNITED KINGDOM

By D. P. Donavan
(Northern Territory 1984 Scholar)

A study of the handling and storage of Grain at high moisture levels in the United Kingdom.

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ACKNOWLEDGEMENTS

I would like to thank all those who assisted me and made my Nuffield Farming Scholarship possible. My trip was very rewarding and enlightening. I have gained a great deal out of it personally and made some very good friends I plan to remain in touch with. I had a lot of trouble coming to terms with the short distances; I travel 250km. to my nearest town, so it is a shock to find a town or village every few kilometres overseas.

To thank all individually would be impossible but, some must be singled out and I make particular reference to:-

- *The Australian Nuffield Farming Scholars Association.*
- *The Northern Territory Government and Qantas Airways Ltd., who sponsored my trip.*
- *Captain J.S. Stewart O.B.E., Director of Nuffield Farming Scholarship Trust and Mrs. Stewart.*
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INTRODUCTION

For the past three (3) years I have been involved in developing a project farm in conjunction with the Northern Territory Government.

This has included clearing country from the virgin state and developing it so that we can sow a cash crop e.g. maize, sorghum, soy beans etc. during the "wet" season.

Location:- 250kms. south west of Darwin. Average rainfall 750 - 1,500mm. October to March inclusive.

Area:- Approximately 8,000 Ha. of which only 1,000 Ha. is sown to crop. The balance is natural tropical woodland.

The Nuffield Farming Scholarship gave me the opportunity to gain knowledge in the handling and storing of grain at high moisture levels. This is of great importance to me as the humidity plays havoc with the drying and storing of grain in our area.

This report consists of:-

1. Acid Preservation of moist grain.
2. Sealed Storage.
3. Storage Losses.
4. Grain Cooling.
5. Handling of High Moisture Grain.
6. Artificial Grain Drying.
7. Hay and Silage Practices.
8. Reduced Tillage.
9. Farmer Marketing.

The average European harvest sees a major portion of grain being harvested with a moisture content (M.C.) higher than the safe storage level. This grain is handled in one of two ways:-

No. 1 Consumed on farm

No. 2 Sold

For grain to be consumed on farm it can be treated in the following ways:-

a) Cool
b) Chemical
c) Sealed
d) Dried

Any grain which is sold is treated in one of the following ways:-

a) Dried on Farm
b) Sold direct
c) Placed in Central Store or Co-op Store

If grain is to be used on the farm, the need for artificial drying depends on the method used for processing. Hammermills work best on dry grain (i.e. below 14% M.C.) while grain between 18 - 22% is very suitable for rolling. If the farmer is able to use grain with a high M.C. the storage of this grain is an attractive proposition. It may extend the capacity of existing drying facilities or allow the preservation of feed grains at optimum moisture content.

The main methods employed are:-

Cooling the grain
Sealed storage
Use of preservative agents (generally acids)

The last two methods can only be used when the grain is to be used for feed as the treatment kills the seed. Cooling may be used for long or short term storage, grain quality should not be affected adversely and maybe it could be improved in some instances.

When cooling is employed the grain must be held at around 2°C. and the M.C. should be about 20%. Sealed storage is effective up to 26% M.C. while the use of preservative agents is effective up to 40% with maize. It should be noted the higher the moisture the more expensive storage becomes and the greater the risk if machinery fails or errors are made.

Stored grain, associated insects and microflora respire, using atmospheric oxygen to convert the carbohydrates in grain into carbon dioxide and water. This respiration process results in the generation of heat. In poorly ventilated bulk storage systems this heat is not readily dissipated, consequently the temperature rises, the respiration rate increases and the rate of deterioration is accelerated. Safe storage is achieved by keeping the grain under conditions in which the spoilage organisms are not able to develop significantly. The main areas which can be controlled are temperature, relative humidity and hence moisture content, and the composition of the storage atmosphere. A guide to safe storage atmosphere:- it must be remembered this is only a guide as varieties, species, end use of product, storage hygiene etc. all vary the figure.

Insects require a grain temperature of 15°C. plus to survive and multiply.

All in germination and baking quality will occur at 20% M.C. at 0°C. and at 10% M.C. at 30°C.

Visible fungal growth will appear at 20% M.C. and 0°C and also 13% M.C. at 20°C.

While the ambient temperature in most of Europe is in Fall (Autumn) and Winter i.e. immediately post harvest, is generally in the safe grain storage range as mentioned earlier, the grain respires and creates heat which then allows spoilage to occur.

The most common method of storing high moisture grain - as distinct from artificial drying was the chemical option.

ACID PRESERVATION OF MOIST GRAIN

This option is carried out in a number of areas on feed grain to be consumed on farm. The feed value of the grain is preserved by the application of Propionic Acid (there are also other products used e.g. Alkalies and Urea). The aim is to treat the crop with acid (or other) immediately after harvest so every grain is covered. This is usually done as the grain is loaded into the store. Propionic acid is commonly used on feed barley but is also effective on beans, wheat, maize and oats.

Grain treated with acid etc. will not germinate and being tainted will be unfit for human consumption.

Any machinery or structure, which comes into contact with treated grain is subject to corrosion, so concrete silos or storage sheds are used and other machinery e.g. Augers, are washed and have untreated grain put through them to clean them out as soon as possible.

The application rates are important, as with all chemicals, this is for safety as well as economics. Grain at 16% M.C. required approximately 6 litres of acid per ton, while grain with M.C. of 30% will require 15 litres per ton. The higher the M.C. the less attractive this option is economically. At 20% M.C. feed barley costs approximately A$ 12 - 14 per ton to treat.

If grain is treated correctly, this includes knowing the M.C. of the grain so the correct quantity of acid may be added and the acid is applied in such a way as each grain comes in contact with the acid, then this system appears quite attractive as a long term storage means i.e. twelve (12) months or more. The protection will extend to processed grain and the presence of the Propionic Acid may improve the pallatability of the ration. One big problem with the used of Propionic acid is that it is a dangerous, inflammable chemical which is very corrosive.

There are other products on the market which include Caustic Soda Solution and various alkalies.

I saw a number of farmers in Scotland who were using a mixture of Urea - 46% Nitrogen Fertilizer - with high moisture grain and the grain became preserved as with Propionic Acid - with very good results. The advantages with this system is the cost saving and the less dangerous nature of Urea.

SEALED STORAGE

If feed grain of high moisture content (15 - 26%) is sealed in a container so that gaseous exchange with the atmosphere is prevented, it can be preserved for long periods with only minimal changes to its feeding value. When the silo or store is filled and sealed there is a slight fermentation. Initially the grain ferments until most of the oxygen between the grain is used up, and this gives the grain its characteristic sweet smell and flavour - not dissimilar to good silage - which makes it attractive feed for all stock. The risk of dust from dry grain (which can cause respiratory problems in Europe, as some grain samples I saw contained possibly 20% dust) is much reduced by moist grain storage.

The success of sealed storage depends on the air - tightness of the silo. The principal causes of air leakage are variations in pressure within the silo caused by temperature changes. During the European winter months ambient air temperature fluctuations do not usually pose serious problems. Leakage may, however, become more acute during the spring and summer when the range of temperature variations is greater and the silo is partially empty.

Diurnal temperature fluctuations within the silo can result in moisture migration, condensation and the development of wet spots. Grain in these areas is more susceptible to mould, particularly when oxygen leaks into the store. These problems can be minimised by sighting the silo in sheltered shady locations, so they are not exposed to climatic extremes. The small amounts of air that enter the silo when grain is removed do not cause serious deterioration when the silo is full, but they do tend to become a problem as the silo empties. From the experiences I noted, it appears inadvisable to leave small quantities of grain in sealed storage beyond Spring. This grain should be used or artificially dried.

STORAGE LOSSES

Losses in sealed storage systems are directly related to the rate of air leakage into the store. For example, if a bin containing 100 Tonnes and a loss of one (1) per cent of dry matter is considered unavoidable during a storage period of eight (8) months, then the leakage rate must be limited to an exchange of about 15 M^3 of air per day. This volume of air could enter the silo through a hole one (1) cm. square. Effective sealing is therefore vitally important.

One common observation is when home made rigid silos, or home air-proofed rigid silos are used; cracks often appear in the frame of the structure and cause grain spoilage.

The only really successful stores of this type I came across were, for example, Boythorpe Vertical Bins which come in sizes from 30T. to over 1,000 T. capacity. These stores look similar to the vertical silage storage systems which appeared in Australia in the "60's". This system of moist grain storage is more common out of the main grain producing areas and tend to be found around Yorkshire and the like. A disadvantage of this system can be unloading the silo. If the grain has a M.C. of 25 plus, it tends to bridge and if air has entered the silo it may become very difficult to empty. Because the atmosphere in the store is lethal to humans, it is a major problem when the grain breaches.

It would appear the best course of action when that happens is to open the store and remove all grain and dry it.

GRAIN COOLING

There are two (2) basic systems for cooling grain and holding it at high M.C. - some drying occurs in both.

The first I will discuss is a West German Patented System known as GRANIFRIGOR (registered trade mark). The Grainifrigor System was first put into commercial use in 1963 and now extends throughout Western Europe and as far afield as Sudan, Argentina and Brazil, as well as some Easter European countries.

This system is suitable for both feed grain and baking quality or sowing seed grain and every type of grain may be stored in this way. The Company which manufactures these units in West Germany claim that - in 1984, 84,000,000 tons of grain around the world would be treated in their units both before and after processing.

Very simply the unit is a fan and refrigeration unit, with a battery of safety equipment all self contained on a small trailer. The unit is placed beside the grain store or silo and when activated, it blows artificially chilled air into the grain. The temperature of this air depends on M.C. of the grain, with cereal M.C. up to 18% a temperature of plus 9°C. to plus 12°C. is considered sufficient. If the M.C. is higher then air temperature of down to plus 3°C. may be used.
Because grain is a very poor conductor of heat, once the required temperature is reached, it is only a matter of running the cooling unit for perhaps a few hours per week to maintain the temperature. There are too many variables here to give examples of "top-up" times as maize requires more than small seeds and the relative humidity and ambient temperature play an important part. This method is useful for unlimited storage

time and with some planting seed it reduces dormancy and abnormal seedlings, this is the case with Soy Beans in tropical climates where they must be stored in a cool room anyway.

Another big advantage for having chilled grain is the less damage caused to planting seed, peanuts etc. when the grain is being conveyed from point to point or when it is being run over a cleaning table or grader.

The cost of this method is relatively cheap compared to some. While it is hard to compare electricity and fuel prices from country to country and example of grain chilling with the Granifrigor System costs approximately 50% of the cost incurred by artificially drying grain. Some drying does occur with this system, maybe as much as 3% M.C. could be extracted from some grain over a period of six (6) months.

The second grain cooling system I came across is a new development from an old principle which has been evaluated in Ireland and is coming into production. This system chills grain and a heat pump dries the grain. It works by having an engine driven heat pump unit and chilled air from an evaporator is used to prolong the storage life of undried grain, while air heated by the engine and heat pump is used to dry the grain (open cycle mode). When the unit is not being used to chill stored grain, heat is recovered from the air exhaust by the drier and most of this dehumidified air is recycled to the inlet of the heating section thus allowing higher drying temperatures for a given airflow and consequently improve drying efficiency (closed cycle mode). This system is slow with an output of only a few tonnes per day of dry grain, however it has a lot of potential for grain grown and consumed on the same farm where small quantities are required daily. The cost of drying grain in this manner would appear to be 30% less than high temperature dryers.

In summarising the storage of high moisture grain, there are ways and means of doing so but none of them are without problems. The chilled grain would seem to be the better option but in some circumstances the other methods have their merits too.

HANDLING OF HIGH MOISTURE GRAIN

Grain with a high M.C. is generally easier to handle - i.e. convey from bin to bin etc. - than grain which is at a safe storage M.C.

The usual methods employed in handling grain are augers, belt elevators, bucket elevators, pneumatic systems, grain throwers, gravitating and mechanical i.e. front end loaders.

Grain augers are the most common means of handling grain on farms. They are low priced, of simple construction, negligible maintenance and have a long life. They are also prone to damaging grain. When peas or wheat are passed through an average large auger which is in very good condition and set with the correct clearance between flight and casing for the grain being used, the damage will be 0.8% to 1.1%. The other handling systems are less harsh than augers, depending on the grain and the application of the handling systems, there could be zero damage.

ARTIFICIAL GRAIN DRYING

I visited a Roman Villa in Oxfordshire which was built about 160 A.D. which had a grain drying room incorporated in the structure. This room consisted of a floor with perforated clay tiles and a basement directly below in which a fire was lit. All driers - or kilns as they were known, built in Europe up to the beginning of the 20th Century were of the same principle. Some are still in use today in Scotland where malt Barley is dried for the distilling industry where special flavours are gained from the special peat which is burnt to dry the grain before it is added to the special Scottish water to produce the special NECTAR of Scotland - or so the locals would have you believe.

The kiln works by having grain spread 100 to 150 mm. thick over the floor and a fire lit and maintained under the floor. Fuel for the fire was often straw and chaff from the field the grain came from or oat husks. Later Coke, Wood, Peat, etc. became the standard fuels. A kiln operator kept the fire going and turned the grain to avoid over-drying and burning. In the roof of the kiln there was an opening - or open roof - to allow fumes and smoke to get away from the grain and the operator.

Most grain which is dried in U.K. even today is placed on the floor at various depths up to four (4) metres and has tunnels under the floor where hot air is blown with large fans. This system is very effective and since the U.K. has no centralised marketing authority, the grain is held on farm until the farmer is able to sell for the price he requires. With the recent surplus of grain in the E.E.C. there are a number of Intervention Stores being built which receive grain of a high standard - by European standards - and make up shiploads for export.

Some farms - usually away from the grain bowl of East Anglia - have high temperature driers. These are used to bring the M.C. down to usually below 18% as the grain is going into storage and the floor driers are used from there to reduce the M.C. to usually around 15%.

I came across one farm in Scotland owned by Barcley Forrest who has 30,000 ton grain storage and besides producing his own grain, he buys in to the tune of 115,000 tonnes per year. The bought in grain is cleaned, dried - usually 5% M.C. removed, stored, tested for nitrogen, sampled etc. and loaded out of the silo for a cost of A$12 per tonne. If no drying is involved the cost is A$7 per tonne. This unit has high temperature driers as well as air ventilation under the floor of the silos.

On the Continent I found the grain handling facilities closer to the Australian System than the U.K. In the major grain producing areas such as - The Paris Grain Basin and the Polders in Holland, there are large central Co-op storages not unlike the State Wheat Handling facilities in Australia. These Silos take grain in from Co-op members during harvest and clean and dry the grain as required, then sell to the end user during the year.

During my tour I found very little high quality grain produced in the E.E.C. countries I visited. Wheat with a protein level of 12% is considered good milling grain in Europe whereas, in Australia, it is only a base standard. The European farmers have sacrificed quality for quantity over recent years and this may be very commendable too as yields of 10 plus T/Ha. are very common. The price they receive on farm for feed wheat is approximately A$200 per tonne at 15% M.C. a very few, if any, other standards of excellence are required. While I managed to find some information of value to myself on Economics, Entymology and Micro Biology of grain quality, particularly protein levels, germination rates, oil contents etc., it is generally of a scientific nature and unsuitable for inclusion in a brief report of the nature of this one.

HAY AND SILAGE PRACTICES

Hay is not as common a product as I had imagined it to be in Europe. The principle reason being whenever they mow a paddock for hay it invariably rains and the crop is spoilt or lost. Some farmers do persist with hay and when it is stacked in the shed, fans are placed at strategic points and air is blown through the stack to keep the moisture down and stop the hay from heating. The majority of hay produced is in conventional bales, however, straw is often baled in round bales or 500 KG. rectangular bales.

Every farm with livestock has a silage programme of some sort. The silage is generally made of improved grass species containing very little, if any, legume species. All farms seem to have three (3) silage cuts per season and a lot get as many as five (5) cuts - this is a commendable feat considering the short growing season enjoyed in Europe. Without exception, the silage is of a very high standard, usually it is wilted in the field before being carted to a clamp: alot of farmers place additives with the material as it is put down. In England there are silage competitions run on similar lines to crop competitions in Australia. They have various bodies e.g. Agricultural Development and Advisory Service (Dept. of Ag.) and commercial companies who analyse the silage for quality and formulate rations for farmers. Silage is fed on almost every Dairy and Beef farm as well as a lot of sheep properties. I also came across a number of pig farmers who were experimenting with some silage in pig rations. Common complementary feeds to silage are brewers grain and beet pulp, both of which are stored in a clamp similar to silage. On the whole, U.K. silage practices are not greatly different from those in Australia but the end product is considerably superior.

REDUCED TILLAGE

In a farming situation where the more you plough, rotary hoe, chisel plough and combine cultivate - not to mention rolling, power harrows etc. the higher yield you achieve, it becomes difficult to justify REDUCED TILLAGE. The average English farmers response to the Reduced Tillage question is "Yes - I tried that, the following year I bought three (3) large tractors, large mouldboard ploughs, power harrows etc. and now work the soil twice as much and gain higher yields and returns". I.C.I. had a major push with research work and advertising campaigns trying to replace conventional land preparation with chemical applications in U.K., the whole programme was such a failure it was abandoned in 1982.

There are, however, some farmers persevering with Reduced and No Till farming. One is Will Cumber of Culham, Oxfordshire, who is very successful and is actually gaining higher yields without conventional tillage. Will's operation is very impressive and in fields where reduced tillage has been practiced for a number of years, the soil structure is perfect with no plough pan or change in structure to impede root development. He appears to have no more, if as much, disease as conventional tillage farmers. His variable costs on cereal crops are lower than other farmers and his Gross Margins are considerably higher. The soil type Will has in his reduced till programme is not dissimilar to what is known as Black Soil Plains in N.W. New South Wales. It is a difficult soil as, in wet seasons, it builds up on tyres and implement tines only cut groves and weed kill is very hard and, in dry seasons, it cracks open and becomes impossible to work.

Apart from Will Cumber, the only people I came across who were advocates of Reduced Tillage were research officers on Experimental Farms who have been persisting with small trials but are not able to gain farmer support on interest.

An important part of Reduced Tillage farming is being able to burn the stubble from the previous crop. There is a very active anti-burning lobby in U.K. now and I think a lot of farmers are not keen to develop a new farming technique only to have it modified by immanent anti stubble burning laws in the foreseeable future.

Some European farmers are moving into what they call reduced tillage by performing multiple operations in one pass. One fairly common multiple operation machine combines:- rotary hoe; power harrow and a levelling device. These units have very large power requirements and pulverise the soil leaving it far too fine for Australian conditions as erosion could not help but take over.

It would appear Europe does not have the need for minimal tillage farming as their rainfall is low and usually very gentle; their incidence of water erosions is very minimal. Most wheat growers have a return of A$2,000 per HA. for feed quality grain, so they are not in a position of cutting costs as Australian farmers are.

FARMER MARKETING

Because the U.K. has a lack of Commodity Marketing Boards compared with Australia, there are some e.g. Milk and Potatoes, I saw fit, as part of my study, to include Farmer Marketing on my list.

The average British grain farmer markets all his grain privately. There is a complex network of independent grain merchants as well as end users in the market place. There is also effectively a floor price supported by the E.E.C. so in the event of a farmer not being able to place his grain in the market place, he can sell to the Intervention Stores, providing the grain meets a low standard of excellence set by the E.E.C.

Since vertually all farms have on farm storage for almost 100% of their crop and considering grain prices rise after harvest e.g. 1983 Irish Harvest Price I£ 125 per tonne and January 1984 price for the same grain was I£ 160 per tonne; it is not such a difficult task to market produce there since they have a flow price set by the E.E.C., very minimal standards of excellence and very short distances to move produce.

The E.E.C. could be analysed in this section, however the ideals of the Treaty of Rome and the actual operation of the E.E.C. are not exactly the same thing and I feel it is a subject best left alone.

In America and Canada the marketing system is a little less complex and I would suggest more economical. Where there is a choice of Wheat Board and Private Traders e.g. Canada, grain is traded at world price without subsidies to the tune of the European system.

The U.K. changed to metric weights and measures shortly after Australia, about 1976. Most farmers and Departmental personnel etc. could not identify a hectare or kilometre if they tried. Their transfer to metric is being drawn out and is becoming very painful. Some examples include milk. This is produced on the farm in gallons or litres - usually litres, it is sold to the Milk Marketing Board in kilogrammes from where it goes to a factory and is processed in litres and then sold in pints. Grain yields are usually given in metric tonnes per acre, sometimes tonnes per hectare and occasionally bags per HA. or acre or stones per acre.

Fish is sold by the stone while petrol is by the litre whilst road signs and speed limits are in miles.

I appreciate Australia has been through this stage but, I suggest, we did not let it drag on the way the U.K. has. It becomes dangerous when they spray kilogrammes of chemical per acre or pints per hectare - both of which are done.

It is often difficult to obtain exact information from farmers and Departmental personnel as they are not sure if they calibrate machinery in metric or imperial units.