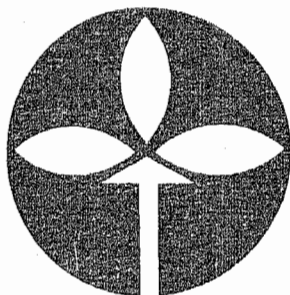


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Chief Extension Officer*



DEPARTMENT OF AGRICULTURE, SOUTH AUSTRALIA

## Agronomy Branch Report

FROST DAMAGE IN CEREALS, 1970

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## FOREWORD

Because severe frost damage occurred to cereals in 1970, the Agronomy Branch Conference, March, 1971, contained a session devoted to this topic. Three papers were presented during this session, one by each of the following officers:-

P.D. Fairbrother,  
District Agricultural Adviser, Keith

K.G. Bicknell,  
District Agricultural Adviser, Murray Bridge

F.C. Gross,  
Agricultural Adviser, Adelaide.

These three papers, together with a summary by K.G. Bicknell, constitute this report.

## FROST DAMAGE IN CEREALS, 1970

### Summary:

Heavy frosts occurred during late September and October causing heavy losses in yield throughout the State. The most severe frost was on the night of 14th October and this was followed by a number of frosts during the following week. The areas of heaviest loss were the Murray Mallee, the Upper South East and Murray Plains.

Losses ranged from slight to 95% on individual properties with some paddocks being a complete write off. Reduction in yield for the State was assessed at 5,000,000 bushels of barley and 3,000,000 bushels of wheat.

Wheat and barley suffered most damage whilst oats did not appear to be greatly affected. Yields from pea crops were reduced. Clover pastures were burnt which reduced hay yields.

An unusual feature of the frosts was that crops on the rises were as severely damaged as those on the flats.

All varieties of wheat and barley were affected.

It is generally accepted that cereals are most susceptible at the flowering stage although damage can occur to the flag, early tillers and to the stems. In this case crops in all stages of maturity, from early flowering to dough stage, were damaged.

On many farms frost damage was not suspected until the header was put into the crop. This was especially so with wheat, because there was little or no change in appearance. It was found very difficult to assess damage to wheat immediately after the frost. Barley changed colour drastically within a day, changing to brown through to white.

Recognition of frost damage is outlined by F.C. Gross (see later). This information will be valuable in assessing damage in future.

Large areas were cut for hay; this applied to barley more so than wheat. In most instances crops were too far advanced to make good quality hay (see analysis figures by K.G. Bicknell). Hay made from crops in the dough stage went mouldy, had an offensive smell and was most unpalatable.

Where damage was not evident, crops were left standing, the approach being to wait and see. Many of these were used for autumn grazing.

At harvest time the quality of grain was spoilt by shrivelled grain harvested from frost affected areas. Re-growth also made harvesting difficult. Down-grading resulted for these reasons.

### FROST DAMAGE - UPPER SOUTH EAST

By P.D. Fairbrother, Agricultural Adviser, Keith

The heavy frosts which occurred during October caused considerable losses, particularly in wheat and barley crops. Yields from pea crops were low and clover pastures were burnt and this reduced hay yields. Oat crops were not badly affected by the frosts.

The frosts alone cannot be blamed for the losses as they followed two months of below average rainfall.

#### Rainfall, 1970:

	<u>Tintinara</u>	<u>Keith</u>	<u>Bordertown</u>	<u>Wolseley</u>
January	128	110	108	95
February	2	5	1	3
March	58	76	91	103
April	185	200	206	249
May	166	146	193	187
June	183	277	195	236
July	190	197	223	180
August	233	326	309	289
September	189	186	94	99
October	65	91	73	73
November	261	298	479	420
December	184	164	129	134
<u>Total</u>	1844	2098	2123	2070
<u>Average</u>	(1893)	(1841)	(1942)	(1908)

Rainfall to the end of August was well above average, however, it was below average for the months of September and October. Warm weather occurred during these months and many crops showed symptoms of moisture stress.

Heavy falls (up to 5½") fell during November but this only benefited the late wheat and oat crops.

### Crops:

Up to the end of winter crops were growing well and farmers were anticipating above average yields. It was an excellent year for winter growth (both crops and pastures), and many said that it was the best they could remember.

Dry weather and frosts in September checked the growth of crops on light soils. Crops turned yellow and the leaf tips were withered. In many cases this was confused with manganese deficiency. Following ½" or so of rain in late September they recovered to some extent.

A series of frosts then occurred in mid-October and severely damaged cereals in the district. Some farmers said that there were as many as 9 frosts in 14 days.

### Losses:

It would be difficult to assess the losses from the frosts because the outlook before September was for an above average harvest. This was followed by a period of uncertainty because of the lack of rain and finally drastically reduced estimates because of the frosts.

100% losses occurred in many crops. Pooginagoric had some 100% losses in wheat. 100% losses in wheat and barley occurred at Pine Hill (north Wolseley), Cannawigara, Senior and Tintinara.

A rough guide to the losses can be obtained from the cereal estimates and the silo receiptal figures.

### Cereal Estimate (Cardwell & Buckingham)

	<u>Wheat</u>	<u>Barley</u>
1st estimate (13/10/70)	1,482,000	995,000
Revised estimate (28/10/70)	1,120,000	768,000

<u>Receivals</u>	<u>Wheat</u>	<u>Barley</u>
Tintinara	53,170	117,350
Keith	116,000	63,000
Wirrega	113,000	-
Bordertown	265,000	79,150
Wolseley	275,000	43,000
	<u>822,170</u>	<u>302,500</u>

(The above figures can only be taken as a guide to losses because grain grown in the district could be delivered to silos outside the district, over quota wheat sold over the border and errors in estimating).

The bulk handling agent advised that deliveries were about half of his first estimate.

Barley losses were greatest in the northern part of the district (Tintinara and Culburra).

Overall estimates of losses have been 30% for barley and between 30 and 50% for wheat.

(Bordertown area           30%)  
(Other areas up to       50%)

Soil Types:

Heaviest losses occurred in the light soils. This was possibly because:-

- (1) Crops were suffering from moisture stress.
- (2) Soil temperatures were lower.

Crops were affected both on the flats and rises (particularly in lucerne paddocks).

On the sandy soils wheat yields ranged from complete losses to 6-8 bags; barley yields from complete losses to 10-11 bags.

On the heavier soils in the Hundreds of Wirrega, Tatiara, Stirling and Coombe, yields were often half that estimated (6-8 bags instead of 15-17). However, late crops (Pinnacle and Summit) in Tatiara were not greatly affected and yields ranged from 12-16 bags. These crops also benefited from the heavy November rain.

Varieties:

Greatest losses occurred with Heron, however other varieties were affected (Raven, Sabre, Halberd, Insignia). One complete loss of a Summit crop at south Mundalla was reported.

All barley varieties were affected.

Generally oats were not affected. There were some losses in the early district but yields in the later districts were as high as 33 bags.

Stage of the Crops:

Normally crops are affected at the flowering stage but last year the frost affected crops at all stages. The September frosts checked crops at the tillering stage. The October frosts affected crops which had heads still in the boot through to crops at the flowering stage. One farmer said that he lost a crop which was at the soft dough stage (the grain turned black).

Symptoms:

Damage to barley crops could be noticed a day after the frosts as the tips of the heads turned white. The heads then turned white, did not fill and remained upright.

It was difficult to diagnose frost damage in wheat crops. Many crops (particularly Heron), turned yellow, however other crops looked quite healthy right up to the time they were reapt. The heads of some frosted crops turned either white, yellow or black.

The only way damage could be accurately assessed was to watch grain development in the heads.

Uses for Affected Crops:

Many barley crops were cut for hay as soon as it was obvious that damage was severe.

The situation in regard to wheat was different. There was considerable confusion and debate as to what to do with crops. Some were cut for hay or grazed off, but most were left standing. It was difficult to assess damage to wheat crops.

It was obvious soon after the frosts that many Heron crops were badly damaged. However, with other varieties it was usually too late to cut them for hay by the time it was possible to assess severe damage.

Many crops were left standing to see how they would yield. Regrowth from badly frosted crops of Heron delayed harvesting but enabled some grain to be taken off the paddocks. One farmer reapt as low as 4 bushels from a 20 acre paddock. Badly affected crops were usually grazed by stock (not reapt).

Many farmers were disappointed with yields after they reapt crops which they thought had escaped damage.

Conclusion:

- (1) Losses were due to a combination of a period of moisture stress followed by heavy frosts.
- (2) Losses were due to a series of frosts.
- (3) Generally, crops affected were:-
  - (a) sown early (before mid-July)
  - (b) from early districts
  - (c) early varieties.
- (4) Diagnosis of frost damage was difficult in wheat crops.
- (5) Losses were heavy in both wheat and barley crops.
- (6) Accurate assessment of damage is difficult.
- (7) The district is subject to losses from frosts but the frosts which occurred last year were particularly severe.

Some farmers may have been a little hasty in cutting crops. One farmer was going to cut barley but was not able to - it reapt 5 bags. He thought that it was going to be a complete loss.



FROST DAMAGE

By K.G. Bicknell, Agricultural Adviser, Murray Bridge

Time:

Late September - affected mainly wheat in the Palmer district.

15th October. Wheat, barley and oats. Damage severe over a very large area. Most severe damage and largest area affected in County Buccleuch followed by County Russell and least damage in County Sturt.

In some districts, sand rises were as severely affected as flats. An indication of damage - one farmer east of Karoonda harvested 85 bags off 350 acres of barley, his anticipated yield before frost was 6 bags per acre.

Damage was done to crops from flowering to the mid-dough to late dough stage.

- (a) Grain did not form.
- (b) Empty husks were shed from head.
- (c) Grain shrivelled - had appearance of being cooked.
- (d) Grain formed on part of head.

Appearance:

Barley turned brown through to white. Affected heads tended to stand upright. Wheat was very difficult to pick because there was little or no change in colour.

In the early stages, the first week after the frost it was very difficult to assess damage, especially in wheat.

Of the frost itself, reports varied from very little to heavy. Damage was very severe where farmers reported very little frost. Apparently lowest temperature was at head height.

What Was Done with Frosted Crops:

Large areas of the worst affected were patched out and cut for hay. Where possible, grain was harvested, a lot for feed on farms. Large areas were left standing to be grazed.

Information Required:

Value of frosted grain for stock feed.

Value of frosted crops for hay.

Grain (barley) sample analysed. It was hand sorted into good and poor grains.

	<u>Protein</u>	<u>Fibre</u>
Sample as supplied	10.4	4.7
Poor	10.5	5.08
Good	10.5	4.46

Barley and oaten hay samples analysed from Murray Bridge district and wheat from Palmer were listed as follows:-

From a property in Hundred Mobilong

Oaten hay and lucerne not affected by frost:-

% D.M.	78.3
% Dig.	60.1
% C.P.	11.11

Barley which was frosted during mid-October and baled on 26/10/70:-

% D.M.	82.4
% Dig.	54.2
% C.P.	4.92

Noyep barley which was frosted in September and cut 7 days after frost and baled:-

% D.M.	86.8
% Dig.	62.2
% C.P.	10.80

From a property in Hundred Tungkillo

Wheat frosted during 22nd-23rd September and cut 16 days after and stoked:-

% D.M.	86.2
% Dig.	52.9
% C.P.	6.45

From another property in Hundred Mobilong

Frosted Prior barley which was baled north of the railway line:-

% D.M.	76.6
% Dig.	64.6
% C.P.	6.85

Frosted Clipper barley from a standing crop:-

% D.M.	73.0
% Dig.	57.2
% C.P.	6.37

Frosted Prior barley:-

% D.M.	70.9
% Dig.	61.5
% C.P.	5.24

FROST DAMAGE IN CEREALS

By F.C. Gross, Agricultural Adviser

A record loss caused by frost damage in cereal crops occurred in the 1970-71 season. Barley and wheat were the principal crops affected.

The reduction in the State's crop yield due to generally dry weather from mid-September to mid-November and late frosts in mid-October, is indicated by the wheat and barley yield estimates prepared by the district agricultural advisers.

Date	Wheat		Barley	
	Total Yield Bush.	Average Yield/ Acre Bush.	Total Yield Bush.	Average Yield/ Acre Bush.
mid-October	37,000,000	17	43,000,000	22
end October	33,000,000	15.5	37,500,000	20
Yield (Government Statistician)	29,000,000	14.5	33,000,000	19

Wind loss in barley was the lowest ever last season, virtually negligible. Possibly half of the reduction in yield of the barley crop of 5,000,000 bushels can be attributed to frost damage, and one third of the wheat loss, or 3,000,000 bushels also due to frost.

The more severe damage occurred as the result of a heavy late frost on the night of Wednesday, 14th October. Recording centres where the minimum air temperature was 32°F. or less were Yongala, higher parts of the Mt. Lofty Ranges, Loxton, Wanbi, Murray Bridge, Nildottie, Lameroo, Keith, Bordertown and Naracoorte. In these areas barley and wheat crops, which were in head, from flowering to early dough stage, suffered up to 95% damage.

#### How Does Frost Damage Occur?:

Growing plants are composed of from 80% to 90% water. The space in between plant cells may be considered to be occupied by some water which may be pure or almost so and therefore liable to freeze at or near 32°F. or 0°C.

If freezing occurs inside the protoplasm which contains all the living matter of the plant cell, then the cell is invariably killed. When freezing occurs outside the cells injury may or may not result, depending on whether the protoplasm suffers mechanical injury of another sort.

As vapour pressure over ice is less than over water, water will be deposited on the extra-cellular ice which will gradually increase in size as water diffuses through the cell membrane. The equilibrium which was established between cell sap and extra cellular water becomes upset and frost dehydration occurs. As a result

of this process the concentration of the cell sap within the vacuole increase steadily and freezing of the vacuolar solution is avoided. Following the removal of water from within the cell by diffusion, the protoplasm is subjected to tensions. The contraction of the cell can be so great that opposite sides of the cell wall touch. Extra cellular ice crystals can grow much larger than cell size. On thawing the ice crystals reconvert to water and leave the plant or part of the plant water soaked and limp. Uninjured cells rapidly re-absorb water, but injured cells which have become brittle as a result of dehydration are unable to do so.

Forms of Frosting:

1. Flag frosting. Leaves of cereal plants curl, assume a bluish colour and die back from the tips.
2. Early tiller frosting. Young plants can be frosted in the early jointing stages, resulting in the death of the forward tillers.
3. Stem frosting. Can occur at any stage after the formation of nodes. Early damage in lower part of the stem, as indicated by pinching, usually just above the node, swelling and browning of the nodes and splitting and twisting of internodes. The final result is a tendency for the crop to lodge.

Stem frosting at or after heading usually affects the upper part of the stem; the susceptible sappy portion of the base of the final internode. This cuts off the supply of sap to the head. If the tissue on the inside of the stem only is affected the stem bends in a typical "gooseneck" effect.

4. Head frosting. All or part of the head can be damaged, before or after emergence. The young head can be killed at any stage after differentiation and fail to emerge.

At or slightly before flowering, the reproductive organs are most susceptible. A few degrees of frost can cause sterility with no damage to the glumes. The glumes gape, and there is a translucence caused by water soaking of tissue.

Frost at a later stage can cause shrivelling of the developing grain. A common symptom of head frosting is the shrivelling and dwarfing of spikelets. Sometimes all the spikelets are blighted, but more often only a few are affected, at the tip, central or basal part of the ear. These malformed spikelets often fall off, leaving the rachis bare in the frosted portion of the head.

On other occasions the heads are found to be completely bleached and empty (white heads) without any shrivelling of the spikelets. Partial and complete head blighting may also be caused by hot dry winds. However, wind injury always involves the terminal spikelets and so may be distinguished from frosting which can injure the central and basal spikelets without affecting those at the top.

Developing grain may be affected in various ways, depending on its moisture content at the time of frosting. Grain frosted in the milk stage tends to become shrivelled. Cracking of the seed coat is a common feature of grain frosted in a more advanced state.

Frost injured plants are more susceptible to root rots.

Head or stem frosting are the most serious forms.

#### Pre-disposing Factors:

1. Seasonal conditions. Plants growing actively are very susceptible to frost. In a mild winter, and particularly with high soil fertility, succulent growth occurs. Cereal plants are most resistant to the stage of the formation of ears near the base of each tiller. Susceptibility increases as the stems elongate and the benefit of warmer temperatures very close to the ground is lost. In normal winters, temperatures gradually fall, frosts recur without prolonged periods of mild weather. Plants become hardened.

Mild winters with only occasional frosts favour the development of soft growth, susceptible to spring frosts.

2. Degree and duration of frosts is important. Wheat can stand severe frosts in the early tillering stage but a light frost can cause sterility in the flowering stage.

3. Varietal resistance. There is no varietal resistance. Late varieties with good stooling habits are less liable to frost damage than the early varieties which run up to head quickly. In New South Wales, for example, two varieties, Wingleen and Winter Minflor have been developed which remain in the resistant "rosette" stage during the winter or most of the growing period and elongate at the same time each spring, regardless of the sowing time.

4. Soil type could have some influence on frosting. Light soils are more frost prone than heavy soils.

5. Soil moisture. Crops growing under relatively dry conditions seem to be more sensitive to frost injury.

6. Condition of seedbed. Severe losses have occurred in crops sown on poorly consolidated seedbeds. This may be partly due to poor moisture holding capacity of poorly prepared soils.

7. Situation. Crops in low lying situations are more severely frosted than adjoining rising land.

8. Copper deficiency. There is some evidence to suggest that crops grown on soils with some degree of copper deficiency are more susceptible to frost injury.

9. The effect of trees. Areas of crop adjacent to shelter belts or scrub appear to be more severely affected by frost than the adjoining crop.

#### Recognition of Frosting:

1. Strip leaf sheaths. Damage to nodes and internodes can be seen.

2. Brush over crop plants, back and forth with hands. Damaged plants bend at point of injury and fall.

3. If ears have not emerged, expose by splitting stem with a pen knife. If the developing ear is water soaked or flabby, it is frosted.

4. After ear has emerged the damage is less striking. The reproductive organs could be killed or damaged. The glumes although uninjured, gape.

Treatment of Frosted Crop:

1. Cut for hay or silage or graze off. Hay (and silage) quality will vary according to the stage of maturity the crop had reached when it became frosted and how soon after frosting the crop was cut.

Percentage of Protein in Barley Hay  
from Frosted Crops, 1970

	<u>Crude Protein</u> %
Badly frosted	5
Noyep barley	11
Prior	6.5
Prior	5.2
Clipper	6.4

2. Leave alone.

3. Frosted crops can recover - produce new tillers which head and form grain. Good grain in damaged heads can increase in size resulting in a reasonable yielding crop. The net value of a crop as hay has to be considered against the net value of the crop for grain, after obtaining some estimate of likely yield before deciding whether to cut for hay or leave for grain or grazing.

Minimise Frost Damage & Loss by:

1. Sow at the correct time the varieties of cereals recommended for the district.

2. Feed off crops which are too forward because of sowing too early or as a result of mild weather conditions. This applies to wheat crops and only considered if practicable.

3. Good soil preparation.

4. In frost prone areas, avoid sowing wheat in low lying situations.

5. Keep up copper dressings on soils where copper deficiency is proven.



Research:

Research into low temperature resistance in wheat has been conducted in New South Wales for a number of years. Material from Afghanistan has been used in recent cross breeding. 2% to 4% frost losses occur in New South Wales each year.

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