Queensland
AGRICULTURAL JOURNAL
January-February, 1979, Vol. 105, No. 1

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COVER. Centennial, the new orange-fleshed sweet potato, is gaining popularity in Queensland. See 'Sweet potato recipes' in this issue. Photograph—B. Rogers.

QUEENSLAND AGRICULTURAL JOURNAL

Vol. 105 No. 1 January–February 1979

Editor, P. R. Lee

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The *Queensland Agricultural Journal* is published every second month by the Department of Primary Industries, William Street, Brisbane, Queensland, 4000. Telephone 224 0414.

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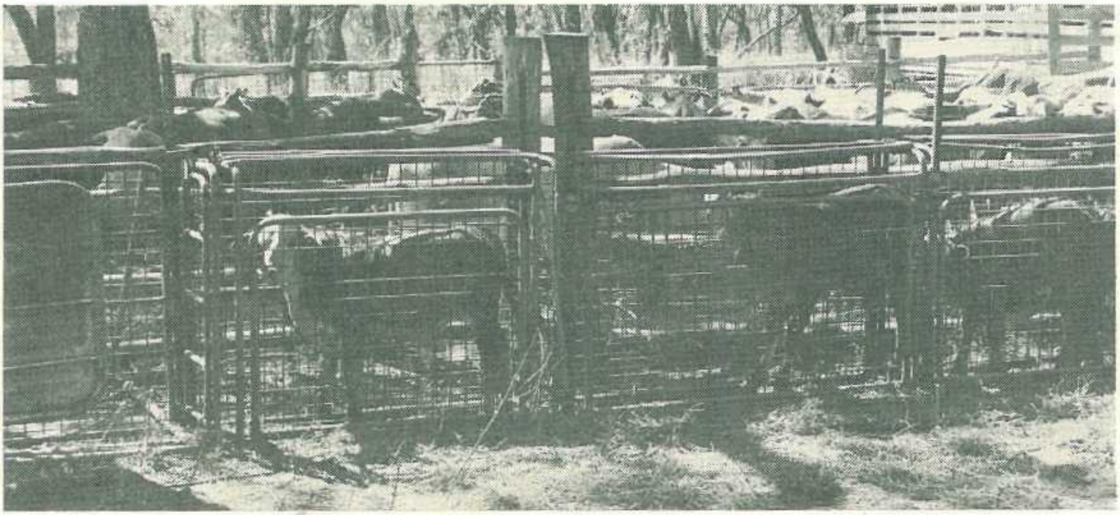


Plate 1. Peter Marriott's portable calf crush and cradle set up in the shade in the Ruth Creek yards on 'Crocodile Station'.

Portable calf crush and cradle

SOON after Crocodile Holdings purchased Crocodile Station in 1970, the manager, Peter Marriott, decided he needed to improve the station's calf branding facilities.

There were three sets of drafting yards on the property but no calf crushes or branding cradles. Previously, all calves had been branded by roping.

Crocodile is 34 km south of Laura and has an area of 940 000 hectares. It is currently running 3 000 head of cattle and Peter expects to brand 800 No. 7 calves.

Peter decided he could do better than build a calf crush at each yard and then buy a branding cradle to put on the end of each.

Instead, he bought one branding cradle and built three portable panels of crush (see plates 1, 2). The branding cradle was set up on a frame and is also portable. In addition, the unit only requires two gates behind the crush and it can be set up in the gateway of any yard.

Specifications

The inside measurements of the crush panels are: 42 cm wide at the top, 39 cm wide at the bottom and 1·15 m high. Two panels are 1·9 m long and the other which goes immediately behind the branding cradle is 1·6 m long. The short panel has gates front and rear which are included in its length.

The frame of the crush panels is made from 25 mm galvanized water pipe. The sides are filled with 100 mm x 100 mm weldmesh.

The crush panels are locked together and to the branding cradle by steel fence posts dropped through rings of 50 mm pipe welded to the frame (see plate 3). With the benefit of hindsight, Peter says that the pipe rings are too small as the steel posts only just fit through. This makes it difficult to line them up when the crush is set up on uneven ground.

by A. J. Boorman, Beef Cattle Husbandry Branch.

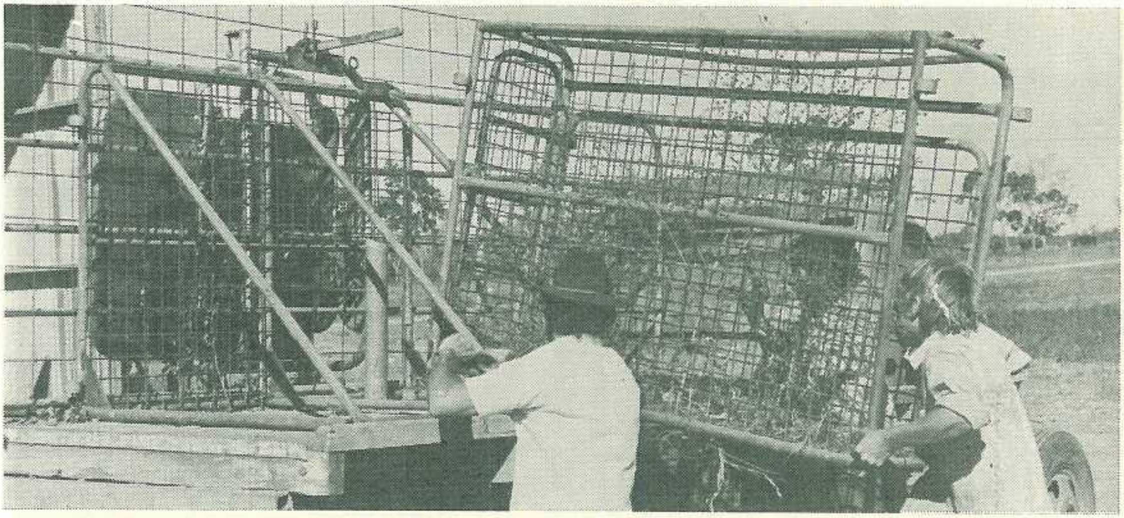
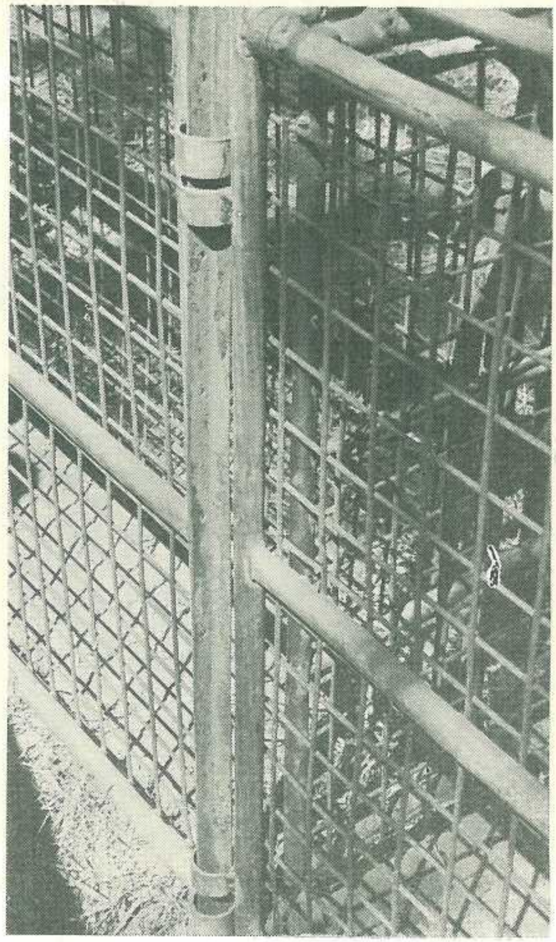


Plate 2. Three men loading a section of the portable calf crush. Two men can load the section simply by lifting one end at a time.

cut costs



Originally, the posts used to lock the panels together were driven into the ground but one of the special features of the panels has made this unnecessary. Now, only the branding cradle and the back of the crush are fixed into position.

The branding cradle is mounted on a base made of 32 mm water pipe which measures 1·75 m x 1·63 m. The cradle bedding legs are welded to grader blade cutting edges which in turn are welded to the pipe frame of the base (see plate 4).

When in the upright position, the cradle rests against a backstop which is a frame made of 25 mm waterpipe filled with 100 mm x 100 mm weldmesh. The backstop is supported at the top by three braces made of 25 mm waterpipe (see plate 5).

RIGHT. Plate 3. The sections of crush are joined by dropping steel fence posts through rings of water pipe welded to the frame.

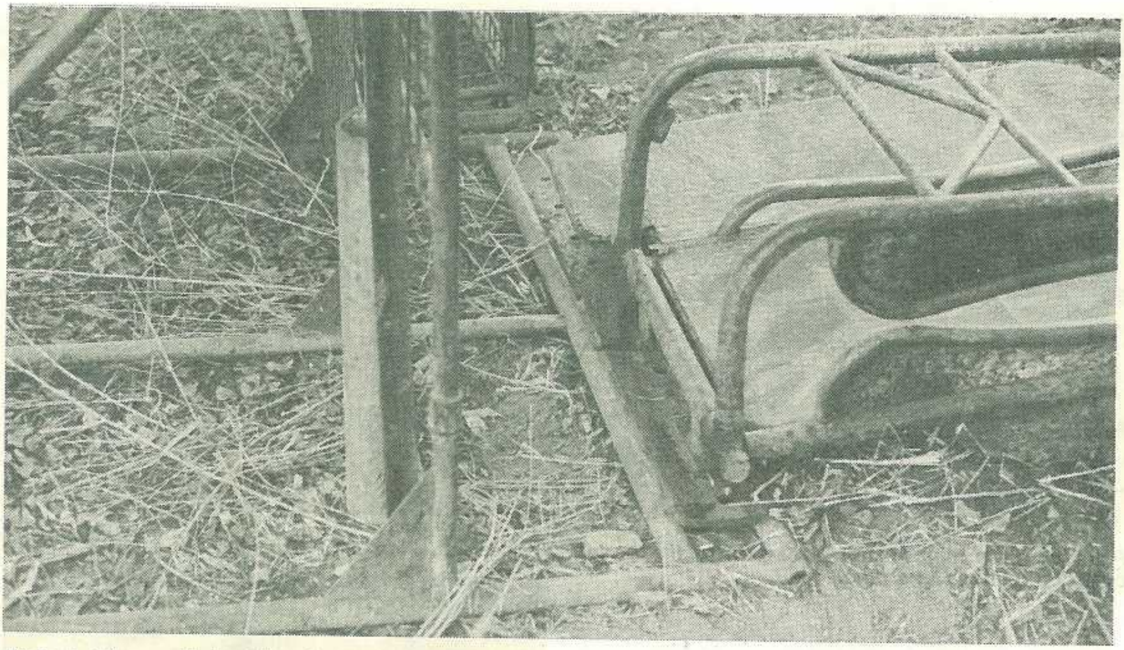


Plate 4. The cradle bedding legs are welded to grader blade cutting edges which in turn are welded to a pipe frame.

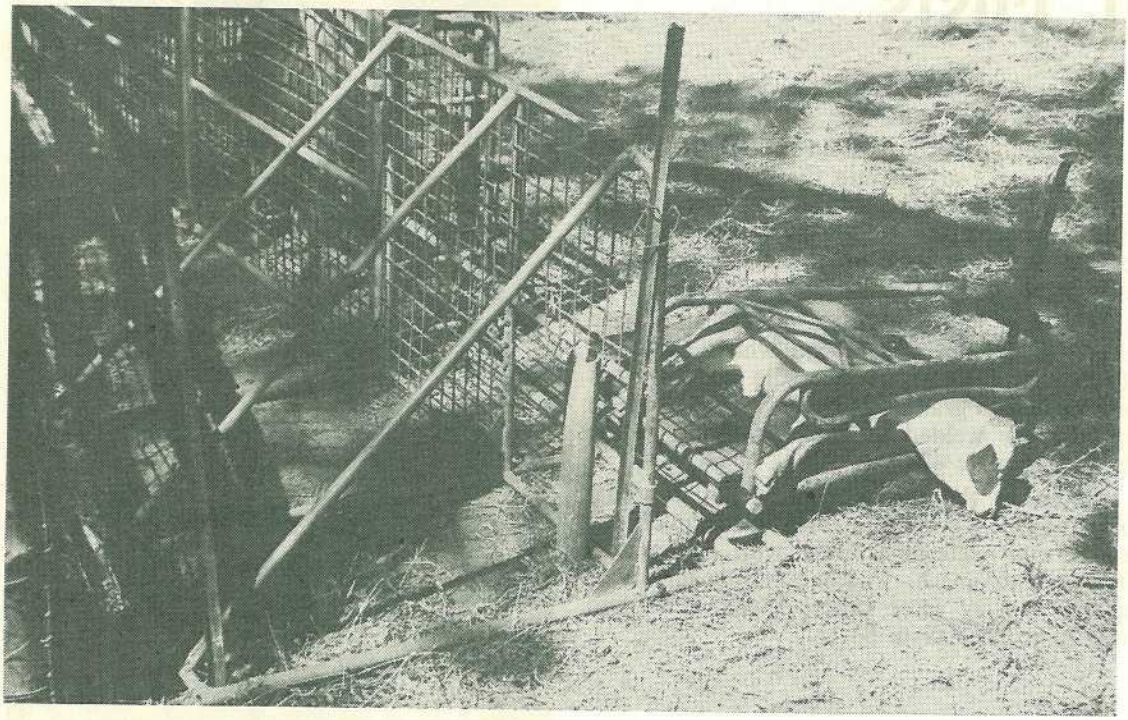


Plate 5. When in the upright position, the cradle rests against a pipe frame backstop which is filled with weldmesh. The backstop is supported at the top by three braces. The base is held in position with steel fence posts driven through pipe rings and into the ground.

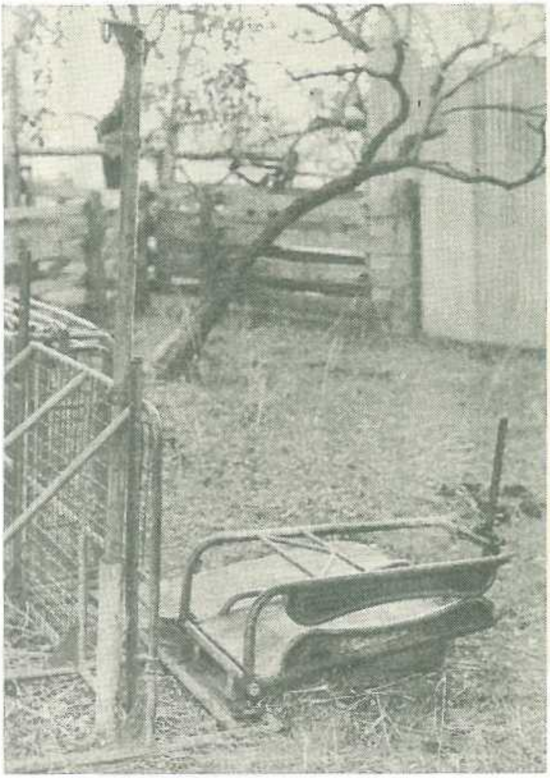


Plate 6. A 2·4 m length of 50 mm pipe which drops into a 60 cm length of 75 mm pipe welded to the cradle base and backstop supports the pulley which the rope for the cradle counterbalance passes over. In practice, the counterbalance is seldom used.

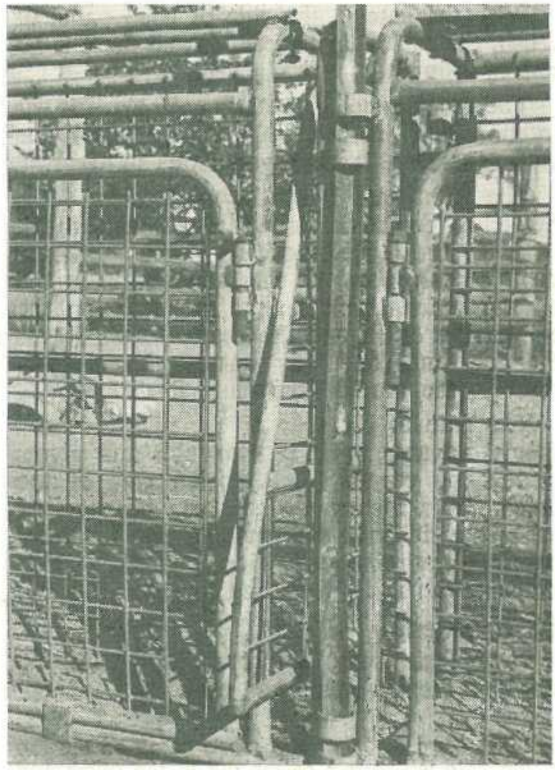


Plate 7. The catches and one of the hinges of the gates in one side of the crush panels can be seen in this photograph. The gates open out and down from the top to let calves which go down get back on their feet. The triangular gate at the rear of the front panel of crush can also be seen.

The pole which supports the pulley over which the wire for the branding cradle counterbalance runs is 50 mm waterpipe (see plate 6). It is 2·4 m long and drops into a 60 cm length of 75 mm waterpipe welded behind the back stop. In practice, however, the counterbalance is seldom used.

Special features

Peter considers the special features of the system to be the floor in the crush panels, the opening sides of the crush panels and the triangular gate at the rear of the front panel of crush.

The floor in the crush panels stops the calves from lifting the panels out of position. Each panel also has three bars of 25 mm waterpipe along the top to stop the calves jumping out.

Without the floor, it would be difficult to anchor the crush panels. As it is, the panels are held firmly in place by steel fence posts dropped through the pipe rings welded to the frame.

One side of each crush panel is hinged at the bottom so that it can be opened from the top out and down (see plate 7). This is for calves which get down in the crush. When the top of the gate is opened, the calf can get up easily. Peter's memories of crushes which almost had to be dismantled to get calves up lead to this innovation.

With the gate in the side of each panel of crush, the calf is up in seconds and there is no risk of losing it.

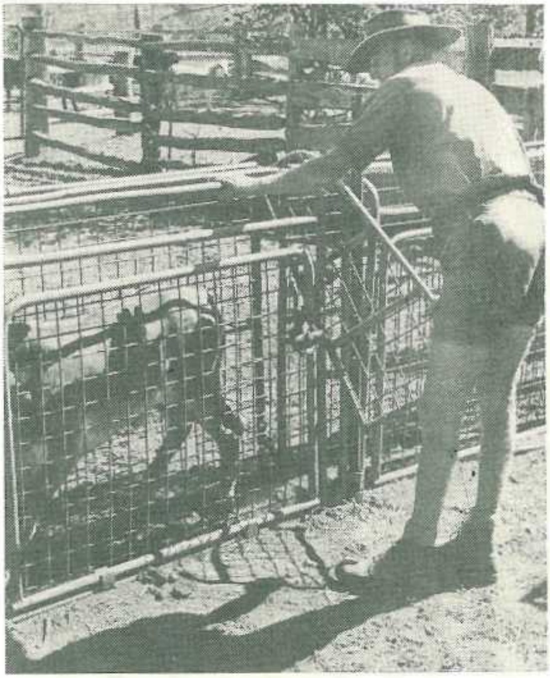
The front panel in Peter's calf crush is, as in most calf crushes, built to hold only one calf. Therefore it has a gate front and rear.

The front gate is of the usual type. It is hinged inside the crush so that it turns through 90°. In the locked position it blocks movement of calves out of the crush while in the open position it blocks the gap between the end of the crush and the cradle. This leaves the calf only one way out of the crush—through the cradle (see plate 8).

The gate at the rear of the panel gives a special advantage. It is triangular and pivots at the top corner from the off side of the crush. This means the gate can be dropped on to the side of a calf moving into the front panel and automatically close behind it. This prevents others from getting in (see plate 9).

Improvements

Peter feels some improvements could be made to the set-up he has now.



ABOVE. Plate 9. The triangular gate at the rear of the front panel of crush is hinged at the top on the off-side of the crush. It can be dropped on to the side of a calf walking past and will close automatically behind it.

BELOW. Plate 8. The home-made catch on the top of the gate which lets calves out of the crush and into the cradle.

Firstly, he would make the crush panels lighter by using 12 mm square tube instead of 25 mm galvanized waterpipe. He would also replace the timber in the floor with weldmesh. This mesh would have to be small enough so that the calves could not get their feet through to get leverage against the top or sides of the crush from the ground.

Secondly, he would make the two rear crush panels 3 m long. This would mean that more calves could be put in the crush each time and less time would be wasted filling it.

A longer panel would mean two or three gates would be needed in the side of each panel to stop other calves getting out when the gate was opened to let a calf get up.

Peter's third improvement would be to construct the crush panels so that one side could be moved in or out according to the size of calves being branded. This could be done by drilling three holes in the top and bottom bars of the frame at each end of the panel on the side opposite the gates. The ends of the mesh in the side would be welded to a bar with a hole top and bottom. This bar could then be shifted by undoing two bolts, repositioning the side and replacing the bolts.

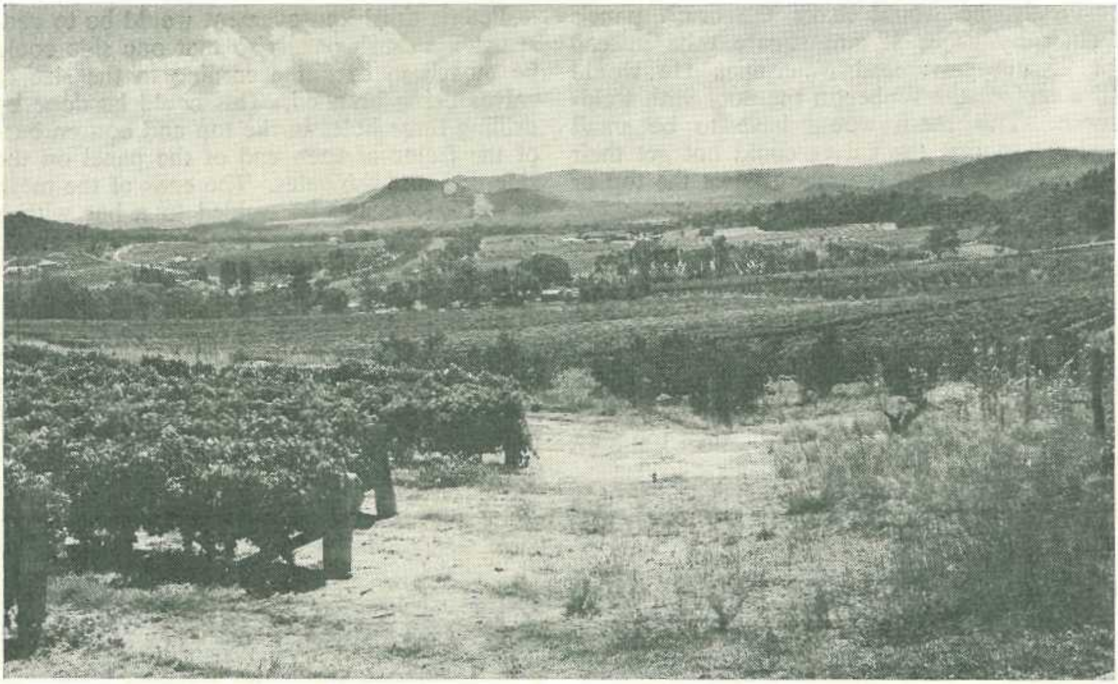
The final improvement would be two gates at the back of the crush. These should be 3 m long. These gates would allow the crush and cradle to be set up anywhere there is a round yard in a holding paddock as well as at any drafting yard.

Bovine tuberculosis free herds as at 4-12-78

C. P. Adams, Warwick Park, Pratten.	MG
J. H. Anderson and Sons, 'Inverary', Yandilla.	PH
Australian Estates, Eurella, Mitchell.	SG
Australian Estates, Wainui Station, Bowenville.	SG
A. J. and M. A. Bell, Karingal, Millmerran.	PH
W. H. Bowden, Brendale Braford Stud.	BF
Central Estates, 'Comet Downs', Comet.	SG
Cherokee Group, Tanby, via Yeppoon.	BM
B. L. and M. O. Christensen, 'Elavesor', Rosevale, via Rosewood.	PH
J. P. and M. M. Erbacher, Leafmore, Hodgsonvale.	GS
P. J. Evans, M.S. 28, Dragon Street, Warwick.	FS
B. Goddard, 'Inverell', Mt. Tyson.	AS
N. J. and H. M. Guppy, River Dell Friesian Stud, M.S. 852, Hodgsonvale.	FS
W. G. Henschell, 'Yarranvale', Yarrawlea.	PH, AIS
H. M. State Farm, Capricornia Stud, Etna Creek, via Rockhampton.	JS
H. M. State Farm, Palen Creek, via Rathdowney.	JS
G. T. and H. W. Hopper, Ellendean Guernsey Stud, Maleny.	GS
Klein Bros., Kapleton A.I.S. Stud, Ma Ma Ck., Grantham.	AIS
W. Leonard and Sons, Welltown, Goondiwindi.	PS
N. E. Lobley, Neloby, Mt. Pleasant, via Dayboro.	FS
R. G. McDonald, 'Buffelvale', M.S. 807, Mundubbera.	JS
K. J. D. McPerrett, Creek Street, Bundamba.	MG
C. R. and J. L. Marquardt, Cedar Valley A.I.S. Stud, Wondai.	AIS
W. H. C. Mayne and Sons, 'Gibraltar', Texas.	AG
H. J. and D. J. Morris, 'Gaiview' Stud, Clifton.	PH
E. I. and S. Pacholke, 'Sunnylawn', Braford Stud, M.S. 74, Clifton.	BF
R. S. and G. C. Postle, 'Yarallaside', Pittsworth.	JS
Q.A.C., Lawes.	AIS
Q.A.C., Lawes.	JS
Q.A.C., Lawes.	FS
Q.A.C., Lawes.	BM
D. G. Raff, Forres Angus Stud, Karara.	AG
H. N. Schelback and Co., Allanview A.I.S. Stud, Warwick.	AIS
J. N. Scott and Son, 'Auchen Eden', Ayrshire Stud, Camp Mountain.	AS
J. and S. C. Siebenhausen, 'Merriton', M.S. 195, Pittsworth.	AIS
E. J. Smith, 'Hillcrest', Borallon.	AS
Stanbroke Past. Co., Waverley Brahman Stud, St. Lawrence.	BM
N. L. Stiller, 'Vineveil', Guluguba.	PH, CN
University of Queensland, Veterinary School, St. Lucia.	DM
A. R. and D. G. Vonhoff, M.S. 918, Toowoomba.	FS
Westbrook Training Centre, Westbrook.	JS

KEY

Angus—AG
Ayrshire—AS
AIS—AIS
Braford—BF
Brahman—BM
Chianina—CN
Droughtmaster—DM
Friesian—FS
Guernsey—GS
Hereford—HF
Jersey—JS
Murray Grey—MG
Poll Hereford—PH
Poll Shorthorn—PS
Santa Gertrudis—SG



A vineyard in the Granite Belt district.

Grape growing in Queensland

GRAPES are grown over a wide area of Queensland with about 80% of the crop established in the Granite Belt district.

In 1977, approximately 1 600 hectares were planted to grapes throughout the State and about 5 300 tonnes of fresh fruit were produced.

In the Granite Belt, approximately 1 200 hectares are under this crop and annual production is close to 4 500 tonnes.

Other centres where grapes are produced include the Brisbane metropolitan area, the Western Downs, Roma, the Atherton Tableland, Inglewood, Rockhampton, the Lockyer Valley and Charters Towers.

Compiled by D. E. Taylor and C. W. Winks, Horticulture Branch.

In recent years, wine production has increased steadily and this promises to become an increasingly important section of the grape industry in Queensland.

Climatic requirements

As the grape vine is a deciduous plant, it grows most satisfactorily when the winter climate is sufficiently cold to ensure a period of complete dormancy each year. The plant is capable of withstanding severe frosts when completely dormant. However, vines have been successfully grown in coastal Queensland in many areas where the winter is not cold enough to ensure complete dormancy.

For most satisfactory development, the grape requires warm to hot summers with dry weather when the fruit is ripening. Wet and humid weather allows the development of fungus diseases, and periods of rain when the fruit is mature will cause berry splitting and allows rot to develop within the bunch.

All grape areas in Queensland have a summer rainfall distribution and encounter wet weather problems in some seasons. Successful viticulture in these regions therefore depends on the routine application of fungicide sprays to protect vines from severe disease problems.

Growers on the Granite Belt and in other inland areas are better situated in this regard as these districts have a lower average rainfall and less humid conditions.

Prolonged easterly weather with frequent periods of light rain can cause harvesting problems in some years on the Granite Belt.

Two other climatic hazards, frost and hail, can cause severe damage in some situations.

Selection and preparation of land

Soils

The soils planted to grapes range from sands to clay loams. Each type produces quite satisfactory crops where the subsoil is well-drained and there is no risk of waterlogging after periods of rain. No single characteristic of good vineyard land is more important than good drainage.

Low productivity can be expected on any soil that shows a tendency towards poor drainage. There should be no impediment by way of impervious layers of clay or hard pans in the subsoil that will restrict or prevent root or water penetration.

Vines on sandy soil overlying a very porous sandy subsoil frequently show symptoms of moisture stress such as reduced cane growth and berry shrivelling. This occurs if deficiencies in soil moisture cannot be corrected by irrigation during hot, dry weather.

Aspect

In the selection of land for vines, one must consider aspect with particular emphasis on freedom from spring frosts. These are a major hazard in some areas of the Granite Belt. A northerly or north-easterly slope, sheltered from westerly winds and with all obstacles and timber cleared off at the lowest point, are reasonable sureties against frost damage in the established vineyard.

Low-lying flats are extremely vulnerable to frost damage. In the warmer parts of the State, a southern, south-eastern or south-western aspect may be used.

Clearing

The preparation of land for planting follows a standard practice. Clearing the timber and 'running' the tree roots is done by contractors with bulldozers and associated heavy equipment. Deep ripping with a dozer ripper attachment is essential to bring to the surface as many native tree roots as possible so they can be gathered and burnt. Ripping also loosens the subsoil and allows better moisture and root penetration.

A skilled dozer operator can push the stands of native timber into rows with a minimum loss of topsoil. When planning vineyard expansion it is worthwhile to 'ring-bark' the native trees in the proposed area a few years before clearing. During this interval, the roots decay and lessen the risk of Armillaria fungus infecting the established vineyard.

After clearing and ripping, the land should be levelled and ploughed, then cross-ploughed, disc harrowed and brought to a good tilth. The depth of cultivation is adjusted so that little subsoil is brought to the surface. During soil preparation, root fragments and other debris should be removed at every opportunity.

Drainage

Poor drainage can adversely affect vineyard production by:

- Reducing the vigour of vines making them more liable to other disorders.
- Causing poor drought resistance due to previous death of deeper roots.
- Shortening the vine life where vines are subjected to varying periods of poor drainage.
- Killing vines in very badly-drained areas.

Although Granite Belt soils have a sandy topsoil, the subsoil can be badly drained because of shallow impervious clay layers, compaction layers, and cement and rock bars.

Where vines are stunted and yield poorly, poor drainage is often the cause. To obtain good drainage, the following points must be considered:

- Careful selection of site before planting.
- Prevention of external water moving on to the vineyard.
- Removal of wet spots in the vineyard.

In recent years, PVC perforated pipes have been used for underground drainage.

These are available in sizes ranging from 4 cm to 10 cm in diameter in single length coils up to 300 m long, and are much simpler to lay than agricultural tile pipes.

The drainage system used will depend on the topography of the land and the direction of flow of the water to be removed. The most general system consists of an exit or main drain with lateral drains feeding into it. The lateral drains can be placed at right angles to the main drain allowing the necessary fall, or in a herringbone pattern. The distance at which lateral drains should be placed depends on soil type; the heavier the soil, the closer the drains. In most soils in the Granite Belt, drains are placed at 12 m apart; in heavier soils they are set about 6 m apart.

The depth at which the drain pipes are placed is governed mainly by the depth the clay layer starts. The pipes should be bedded in this hard layer half in and half out. The usual depth of placement in Granite Belt soils is 60 to 90 cm.

A plan showing the exact position and lay-out of the drainage system is essential. This is very helpful in locating blockages should they occur.

Soil conservation

On land where the slope exceeds 3%, consideration should be given to contour planting. Vineyards must be relatively clean cultivated during most of the summer, and are therefore subject to soil erosion. Contour planting, with provision for grassed waterways and banks where necessary, is an effective preventive measure.

Contour planting has proved successful in vineyards provided the design is simple and rows do not bend too sharply. If the rows are too sharp, intermediate posts will be pulled over. When contour planting, posts on bends should be placed more deeply in the ground and the bilateral cordon system of pruning used.

Replanting

Vines propagated on a resistant stock are a useful rotation crop following a stone fruit tree or vine planting that has become aged and unprofitable. After the removal of the stone fruit trees or vines, the land can be cover cropped to advantage for a few years before replanting to vines. Fumigation for the control of nematodes may be necessary before planting. The use of nematode-resistant rootstocks is recommended in problem situations.

Varieties

The major grape varieties are:

- Muscat Hamburg. This is an early-maturing grape. The vine is of moderate vigour producing large-shouldered, tapering bunches. The berries are large, oval, black in colour and have a thin skin. The flesh is sweet with a fine muscat flavour. This variety is harvested from February onwards on the Granite Belt.

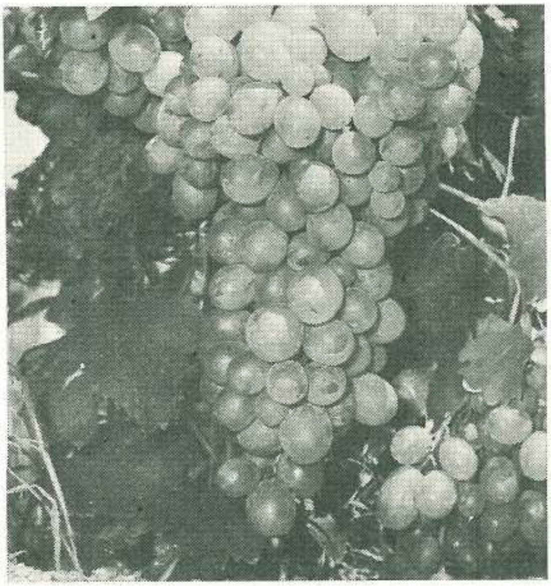
In other areas in the State, the fruit is harvested earlier and growers benefit from the high early season prices.

In virgin soils, Muscat Hamburg is normally grown on its own roots but, on soils of low fertility, rootstocks should be used to confer vigour. Berry colour of Muscat Hamburg on Phylloxera-resistant stocks is usually inferior to that of fruit grown on vines on their own roots. However, berry size is larger but there is usually more berry splitting after rain.

- Waltham Cross. This is a mid to late season maturing grape, that produces large, tapering bunches, with very long stalks. Berries are large, oval, greenish-yellow in colour and moderately thick-skinned. The flesh is sweet but not particularly rich in flavour.

Harvesting begins on the Granite Belt during March.

Vines of this variety tend to produce weak canes, and are shy bearing on their own roots.



ABOVE AND BELOW. Waltham Cross grapes.

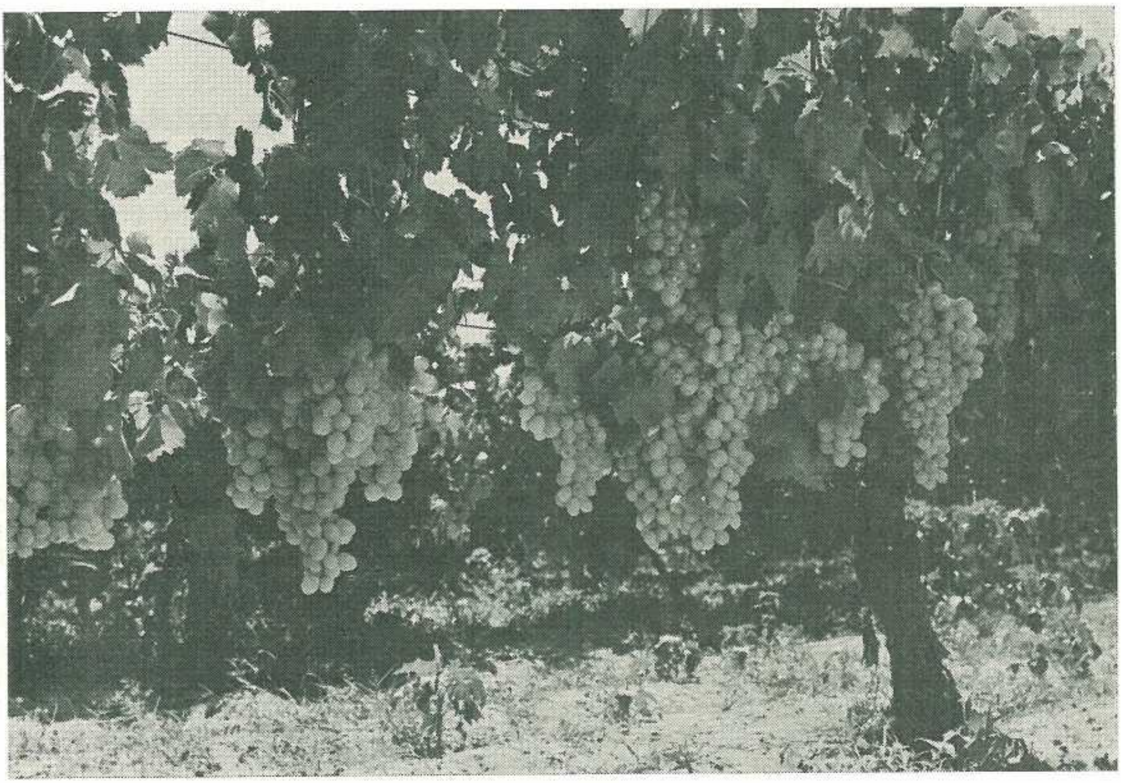
This fault is corrected by grafting the variety on to Phylloxera-resistant stocks such as Rupestris du Lot and 3306, and also by long pruning. This variety is very subject to erratic setting, producing the disorder known as 'hen and chicken'.

Waltham Cross is not well suited to warmer areas as it does not crop well in these situations.

- Purple Cornichon. This is a late-maturing grape that tends to produce weak canes. Bunches are of medium size and hang well when ripe. The berries are large, elongate oval, purplish-black in colour and have thick skins. The flesh is moderately sweet but without a distinctive flavour.

The fruit is harvested in March and April on the Granite Belt.

The variety lacks vigour and is apt to be shy bearing on its own roots. It should be grafted on to Rupestris du Lot or 3306 stock.



Severe leafroll virus is very widespread in Purple Cornichon.

- Chaouch. This variety is an early-maturing grape. Vines are vigorous and the canes have long internodes, but are generally weak at the base. The bunches are of moderate size with greenish-skinned berries having fair flavour.

Harvesting occurs in mid to late January.

The vine is normally propagated on its own roots. This variety is very subject to poor berry setting and has lost favour.

- Black Hamburg. This variety is grown in some coastal districts as an early-maturing grape. The vine exhibits moderate vigour. The berries are black, medium in size, oval in shape and bunches are of medium size. Flavour is not as attractive as Muscat Hamburg.

Muscat Hamburg, Waltham Cross and Purple Cornichon make up the bulk of the plantings in Queensland. There are small plantings of Chaouch and Black Hamburg in localities where berries mature early.

New regulations permitting the introduction of grape plant cuttings, subject to strict conditions, were introduced in 1973. Since then, a number of new varieties of both table and wine grapes have been introduced into Queensland from approved sources.

These new varieties have been established at the Granite Belt Horticultural Research Station at Applethorpe, and cuttings have been made available to growers wishing to try them on their own properties.

- Cardinal. This variety is showing promise and already some growers have planted small areas. Earliness is its value, the fruit being harvested just before the Muscat. Cardinal is an early, black table grape with a large, roundish berry. It has good flavour with a slight Muscat tang when ripe. From its performance to date on the Granite Belt, the main faults in this variety are shown as some lack of colour and ring cracking of fruit if subjected to rain periods when nearing maturity.
- Italia. This variety is a midseason, white table variety. It may replace Waltham Cross if its fruit quality, cropping habit and reliability in setting are superior. Berries are very large, long, oval, and have a mild muscat flavour. The bunches are medium to large. Ring cracking may be a problem if rain periods occur when the fruit is nearing maturity.
- Ribier. This variety is an early to midseason, black table grape with a very large, roundish berry. It is a good cropper, and has good flavour and appearance. It appears that competition with the popular Muscat Hamburg would make the total success of this variety doubtful. Ring cracking occurs if the fruit is subjected to rainy periods nearing maturity.
- Nyora. This is a new table grape bred by the New South Wales Department of Agriculture. It is a black, late-maturing variety reputed to be superior to Purple Cornichon. Nyora is a cross between Purple Cornichon and Ohanez, and is virus-free. If it performs well in Queensland, it could replace Purple Cornichon in future plantings.
- Barlinka. This is a midseason to late Black table grape with a very large bunch of good appearance. Barlinka is a successful variety overseas.

Wine grape varieties

The Department of Primary Industries has introduced a range of wine grape varieties. At present, a few small areas have been planted by growers, and research is being carried out on the new varieties and in wine making.

The table wine industry in Queensland is expanding.

Rootstocks

Grape vines may be established on their own roots or grafted on to selected rootstocks.

In virgin soils of good fertility and drainage, most varieties can be grown successfully on their own roots. However, on poor or replant ground it is recommended to graft on to stocks according to the soil type or expected problems.

Rupestris du Lot (syn. Rupestris St. George) is one of the Phylloxera-resistant rootstocks that produce very vigorous growth in the scion variety. It is recommended for deep soils but will not tolerate poor drainage. This stock is inclined to sucker profusely.

3306 is another Phylloxera-resistant rootstock. It is recommended for shallow soils as well as for deep, sandy soils. This stock will tolerate poorer drainage on heavier soils than Rupestris du Lot.

Isabella stock can be used in damp situations where other stocks fail.

Phylloxera-resistant rootstocks were originally tested in Queensland to guard against the consequences of the possible introduction of this serious grape pest. Their widespread adoption has been due to their enhanced vigour and cropping ability.

In some situations where nematodes are present in large numbers, it will be necessary to use nematode-resistant stocks.

Nematode-resistant rootstock varieties available in Queensland include Dog Ridge, Salt Creek, Teleki, 1613, SO4 and Harmony. Dog Ridge gave good results in the early years of field trials. Salt Creek is a difficult stock to strike and to graft, and causes incompatibility problems with some varieties. It is recommended that growers include some of these stocks in future plantings to allow for comparisons to be made with the stocks used at present.

Propagation

Grape vines are propagated from cuttings taken from mature wood of the previous season's growth. These are collected during the winter pruning from selected, vigorous vines with a good cropping record. Where practicable, short-jointed wood should be used for cuttings.

Considerable benefit can be obtained by selecting the better vines in the vineyard as a source of cuttings for future plantings. This type of selection can considerably improve the varieties which have been grown for many years in a district. The basic steps in making the selection are:

- Examine vines when they are growing rapidly in spring and mark those with the most vigour which show no abnormal growth.
- Just before harvest, mark vines which have heavy crops of good quality grapes. This can most easily be done by tying strips of coloured plastic on the selected plants.
- In autumn, examine the vines for symptoms of leafroll virus. Any showing symptoms should be avoided.

When the vines are dormant, cuttings should be taken only from those which have been marked in the selection programme.

As a guide, by marking initially about twice the number of vines required, sufficient cuttings should still be obtainable after rejecting vines infected with leafroll.

Grape vine leafroll virus disease can substantially reduce the profitability of a vineyard, and it is known only to be spread by man. The main sources of spread are cuttings, buds or grafting wood taken from infected vines, or from grafting infected rootstocks or infected unwanted varieties with clean wood. Grape vine leafroll virus disease in not spread by insects, nematodes or by pruning tools.

The desirable features of improved planting material are:

- Consistently high yields.
- Good vigour.
- Freedom from virus diseases and pests, particularly vine blister mite.
- Good quality fruit with high sugar, good colour, and which ripens evenly.

Preparing cuttings

Cuttings are trimmed with sharp secateurs to about 30 cm long with the bottom cut just below a node and the upper cut just above a node. The cuttings are then loosely tied in bundles of 50 and buried horizontally under about 15 cm of soil until required. Alternatively, they may be heeled in at an angle, with about 5 cm showing above the surface. Cuttings keep best under shade. The soil should be kept damp, but not too wet.

Cuttings from resistant stocks are usually cut to a length of about five buds. They are shorter and thinner than European varieties.

Rooting the cuttings

The cuttings are normally propagated in beds about 1·2 metres wide or set out in rows that can be cultivated with implements. They should be located in close proximity to where water is available for irrigation.

The pH of the nursery soil should be around 6.0.

The nursery bed should be fumigated in late autumn with DD or EDB 15 or other EDB formulations used at equivalent rates to control nematodes.

A few weeks before September, when the cuttings are planted, the soil should be again thoroughly prepared and fertilized with a 12:14:10 NPK or similar mixture at the rate of a small handful to the square metre and then levelled off.

Rows in the beds are spaced at convenient widths for inter-row weed control, and the cuttings are spaced about 15 cm apart. The soil in the row lines may be opened with a spade but, when large quantities are to be planted, it is usual to make a furrow with a mouldboard plough. Each cutting is inserted in the soil at an angle of about 45 degrees with two buds protruding above ground level. The soil should have a good moisture content and it is advisable to water the cuttings in the furrow before levelling the soil.

It is an advantage to stand the bundles of cuttings upright in a few millimetres of water for 2 days before setting them out in the nursery bed.

Top growth which develops during the summer is allowed to spread and no training is necessary.

Transplanting

Rooted cuttings are transplanted in the winter following their establishment in the nursery bed. Before transplanting, the beds are watered and the plants dug up carefully by hand or by machine. They should be covered with wet sacks to prevent the roots from dying out and then planted out as soon as possible. When preparing the rooted cuttings for planting, long roots at the base are shortened and all other roots removed. In addition, the most upright cane is reduced to two buds and all other canes are completely removed.

The young vine is set at the same depth as it was in the nursery, and with the roots well spread out. The soil should be firmed around the roots and water added to the planting hole when returning the soil. The holes to accommodate the young vines can be opened with a shovel or a tractor-mounted post hole digger. A jet of water from the spraying lance of a spraying machine, using a pressure of around 2 000 kPa can be used to open the planting hole.

Rooted cuttings of rootstocks are planted out in the same way as own-rooted cuttings.

Grafting

In the Granite Belt, resistant stocks are grafted in early spring when the sap is rising. A good indication is when sap oozes from the young stock when it is cut off in preparation for grafting. This could be towards the end of August, depending upon seasonal conditions.

A method quite successfully used for a number of years in the Granite Belt is to take grafting wood directly from unpruned vines. At this stage, the unpruned vines are dormant.

The cleft graft is normally used and is made at, or just below, ground level. The degree of success achieved in grafting depends largely on the skill of the operator.

After tying the graft with soft twine, soil must be mounted over the graft and scion to exclude air, and to minimize the risk of damage. Sucker growth from the stock, and roots developing from the scion, are carefully cut away with a knife or secateurs as they appear. When removing soil to examine the graft and to remove suckers or scion roots, care should be taken not to displace the scion.

Bench grafting

In bench grafting, single bud scions are budded on to either unrooted canes or 1-year-old rootlings of the desired rootstock variety.

The whip tongue graft is normally used when grafting is done by hand. Several machines are now available for this type of work.

It is essential in grafting to select scion wood and rootstock cuttings of approximately the same thickness to give a greater area of contact of the cambium layer. After grafting, the union is usually tied with a plastic strip to secure the graft.

Bench grafts are then allowed to callus by burying in moist soil or, preferably, by placing in a moisture-retaining medium such as sawdust, and placing in a room at 28°C. Under these conditions, callusing should be completed in about 4 weeks. Warmth, moisture and aeration are essential for rapid callusing.

Once the callus is completed, the grafts can be lined out in the nursery. Great care should be taken not to dislodge the scion piece.

Budding

Resistant stocks may be worked by ring budding during midsummer when the bark strips freely on the stock and scion material and the scion buds are well developed.

The bud is placed on the stock a short distance above ground level where it remains dormant until the following spring.

At pruning, the stock is cut off about 15 cm above the bud and a tie taken to the bottom wire. A light stake is placed in the soil beside the stock and tied to the bottom wire. The short stock stem piece and the stake are used to tie the bud growth as a support in its early stages of growth.

Re-working

The cleft graft is normally used for re-working one grape variety to another that is better suited to the district, or is in greater demand on existing markets.

The graft is made at a height of about 0·6 metres, just below the bottom wire, and scions are inserted in the stock at each side of the cleft. The union is protected by grafting mastic, then covered with soil in a conical paper wrap that is tied to the trunk below the graft.

Vertical knife cuts should be made on the stock to prevent the union from being flooded with sap. When the scion has made about 35 cm of growth, all suckers developing on the stock should be removed. It is also necessary to make regular inspections of newly-grafted vines so that excessive quantities of congealed sap about the union can be removed.

The old paper cone round the graft is replaced by a new cone that is filled with fresh soil. Where the sap flow is excessive, additional knife cuts should be opened in the stock.

Trellising

The standard trellis used in Queensland is constructed of durable hardwood posts. The straining posts should be at least 20 cm in diameter, approximately 2·1 m long and sunk 75 cm into the ground. Intermediate posts are 12 x 10 cm in cross section, approximately 1·8 m long and sunk 60 cm or more into the ground. Strainer posts will be needed at every 140 cm of trellis, and each should be stayed to prevent displacement when the trellis carries a full load of canes and fruit.

Steel intermediate posts in the trellis row are being used by some growers.

A three-wire trellis, constructed from 2·5 mm (12 gauge) high tensile wire is quite serviceable. These wires run through the posts at heights of either 75 cm or 90 cm from ground level to the first wire, and then 30 cm above to the second wire, and 30 cm above the second wire to the third wire.

A useful variation to the single second wire is to run two wires parallel to each other through holes bored near each side edge of the post. Summer canes will tend to grow up through these two wires which assists trellising operations. The bottom wire supports the frame of the vine and must be kept tight with an adjustable barrel strainer at one end. The middle and upper wires support the canes carrying fruit, and also are fitted with strainer attachments.

A three-wire vertical trellis.

When trellises are constructed to follow contour lines, posts should be set more deeply than conventional trellising. A post setting of 75 cm or more into the ground near and on the curve of the line is desirable. The bilateral cordon (double-armed vine) method of training can be used to advantage on contour lines.

The trellis rows are 3 m apart. This spacing is sufficient to give access to equipment used for cultivation and spraying. A 1·8 m spacing between vines is satisfactory. Trellis rows on the contour will vary in width according to the slope of the land.

'T' trellis designs

There has been an increasing acceptance of 'T' trellising systems over the past few years and variations have been adopted by Granite Belt growers.

The two suggested 'T' trellis systems are the narrow fixed and the wide trellis.

The narrow trellis consists of a fixed 25 cm wide 'T' supporting two cordon wires 1·4 m above ground level. At present, a single foliage support wire is suggested 330 mm to 380 mm above the cane 'T'. However, it may be necessary to replace this with a 'T' foliage support with two wires.

To train vines to the 'T', a temporary wire is used 15 cm below the first 'T'. This serves for initial training and is subsequently removed.

The wide 'T' trellis system consists of two 40 cm wide Ts. The cordon 'T' is 0·95 m above ground and the foliage 'T' is at a height of 1·35 m. A single training wire is run through the posts at a height of 0·8 m above the ground. When the cordons are developed, the training wire is removed.

Wide trellis designs are suggested for the more vigorous vines, and the narrow trellis systems for medium vigour vines. There is no advantage to be gained from growing low vigour vines on 'T' trellis.

The main advantages of the 'T' trellis can be summarized as:

- Increased yield potential.
- Better display of foliage to sunlight, giving more open foliage, and thus more fruitful buds.
- Better spray penetration and faster drying of leaves and bunches after rain.
- Better bunch colouring and less sunburn.
- More convenience in harvesting and pruning and less tucking in.
- Suitable for mechnical harvesting of wine grapes.

The disadvantages of the 'T' trellis are:

- Increased costs.
- More attention to training in early years.
- The need for longer trellis posts.

There is a distinct cost disadvantage when low vigour vines are grown on 'T' trellis.

A minimum row spacing of 3·5 m is suggested for the wide 'T' trellis and 3 m for the narrow. Plant spacing can be 1·8 m and, if higher plant densities per hectare are favoured, the spacing can be reduced to 1·5 m.

Steel intermediate posts are being used by some growers for the narrow 'T' trellis system.

Soil management

Cultivation

The standard soil management practice during the growing season is clean cultivation using such implements as tines or discs. Cultivation is designed to maintain maximum soil moisture by destroying weed growth and leaving the soil surface more receptive to infiltration by rain.

Excessive weed growth, if permitted to compete with the vines at any time during the growing season, can markedly reduce yields and place severe stress on the vines.

Cultivation should be shallow, otherwise root damage can result.

The frequency of cultivation should also be kept to a minimum. Frequent cultivation speeds up loss of soil organic matter and general fertility, and also tends to destroy soil structure. This results in the soil becoming less permeable to water and more susceptible to erosion. Therefore, a vineyard that is slightly weedy is preferred to one kept either very clean or very weedy. Later in the season, near harvest time, a light grass cover is desirable.

Control of weed growth under vine rows is achieved by using herbicides and under vine mechanical weeders. The mechanical weeders are attached to a tractor and operator by the tractor driver. Skill is needed to avoid cutting the roots by operating too deeply. Care must be taken not to damage vine trunks.

Herbicides

Herbicides are widely used for weed control. Current recommendations are Domatol 44 (R) or simazine. Domatol is a mixture of simazine, 2,2-DPA and amitrole. Amitrole and 2,2-DPA are knockdown herbicides while simazine has residual activity. Because of its knockdown effect, this herbicide mixture is usually applied in late spring after some weed growth has commenced. Simazine by itself is only pre-emergent in nature so must be applied to clean ground early in the spring.

Both herbicides should only be used on vines 3 years or older. They will not give complete control for the whole season, so when weeds again become a problem, a knockdown herbicide such as paraquat should be used. Some growers use paraquat only for weed control and in this case three to four applications per year will be required.

Nutrition

The grape has an unusual ability to adapt to a wide range of soil types which may call for very different fertilizer programmes. Organic manures are widely used and green manure crops are commonly grown to build up the organic matter content of the soil. On low fertility soils, productivity depends to a large extent on the success of green manuring and fertilizing programmes.

A newly-established green manure crop.

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Green manures

Recent investigations on the Granite Belt using a range of green manure crops have shown that New Zealand Blue Lupins and Black Winter Rye will increase nematode populations in the soil. In addition, lupins are subject to some soil-borne fungus diseases such as base rots which have been known to cause heavy losses in vineyards.

Oats were found not to have these disadvantages and is now the recommended cover crop. Suitable varieties for the Granite Belt include Saia, Rodney and Minhafer. Locally-grown varieties may prove more suitable in other grape-growing areas.

A rough seedbed is prepared in February and 200 kg per ha of superphosphate and 100 kg per ha of urea are then applied and lightly worked into the soil. These fertilizers should not be mixed together but spread separately. About a week later, the seed is broadcast at 30 to 45 kg per ha and covered using spring tines or discs.

Planting may take place from February to April and the soil should be sufficiently moist to ensure good germination.

The cover crop is turned in early in August using disc harrows set for a shallow cut. The aim is to incorporate most of the crop with the surface layer of soil leaving some of the green matter on the surface. Discing in at this time of year will ensure that the green crop does not compete with the vines for moisture following budburst that occurs about mid September.

A contoured vineyard.

Fertilizers

Each winter it is desirable to check the soil for acidity by having a pH estimation carried out. If necessary, dolomite or lime could be applied following the turning in of the cover crop and before adding a complete fertilizer to the soil.

In addition to the fertilizer applied for the green manure crop, about 150 kg per ha of an approximately 8:8:27 NPK mixture should be applied in late winter to nourish the vines. This is the usual rate of application for mature vines. Lesser amounts may be used for younger vines or in particular instances where excessive growth occurs. Where soils are of very low fertility, heavier applications may be required.

The fertilizer may be broadcast or applied in 0·6 to 0·9 m bands in the case of younger vines, keeping 30 cm away from the vine trunk. The fertilizer may be applied when turning in the cover crop or it could be applied later and worked in with light cultivation implements.

If desired, instead of using a complete fertilizer mixture, nitrogen, phosphorus and potassium may be applied at the following rates per hectare:

N—35 kg ammonium nitrate or 25 kg urea.

P—130 kg superphosphate.

K—80 kg muriate of potash or 100 kg sulphate of potash.

Superphosphate and urea should not be applied together.

Vines have a low requirement for nitrogen, and nitrogenous fertilizers should be used with discretion, as over-supply of this element can lead to excessive vegetative growth and poor fruit production. Phosphate deficiency also is rare and direct addition of phosphatic fertilizers often has a greater benefit on cover cropping than on the vines.

However, bearing vines require high levels of potassium and a deficiency of this element especially in sandy soils such as those of the Granite Belt can lead to marginal burning and curling of leaves and premature leaf fall. Potash-deficient vines often carry small, tight clusters of small, unevenly-ripened berries.

Magnesium usage

Magnesium deficiency is also common on the Granite Belt where it is often confused with the symptoms of leaf roll virus. Leaves show a yellowing between the veins and with black varieties of grapes these areas become reddish in colour. If symptoms have appeared by mid-summer, the deficiency is likely to be serious, leading to greatly reduced yields.

Magnesium deficiency may be reduced by applying dolomite, the rate of application depending on the pH of the soil. Foliar sprays containing 2 kg of magnesium sulphate in 100 litres of water are also useful. It may take several years of treatment to correct a severe magnesium deficiency.

A lack of vigour in vines should not always be attributed to deficiencies of major plant nutrients. Poor drainage, diseases or trace element deficiencies are other likely causes.

Trace elements

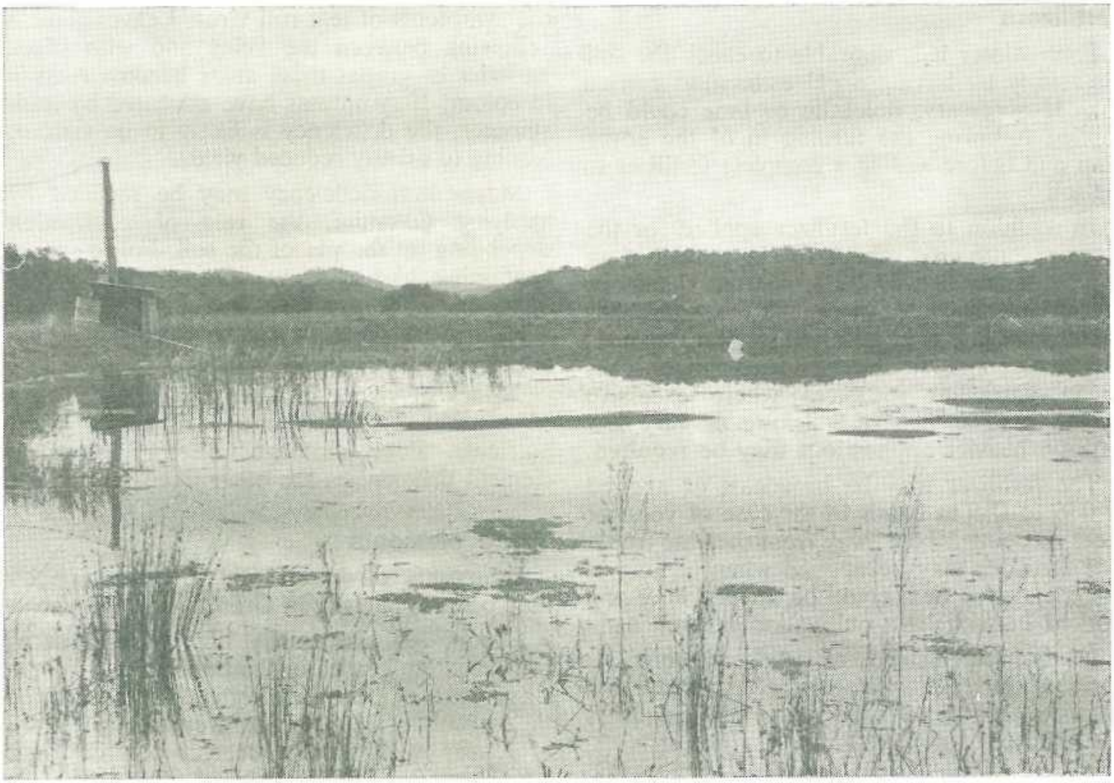
Symptoms of boron and zinc deficiencies may occur especially in Granite Belt vineyards.

- Boron. An abnormally high proportion of seedless berries in the bunch could be the result of boron deficiency. Borax applied evenly at 30 g per mature vine every third year will usually correct the disorder. Amounts in excess of this may be injurious. Borax can be applied mixed with the fertilizer. Where a quick response is needed, the vines can be sprayed 3 weeks before flowering with a solution containing 275 g of soluable polyborate in 100 litres of water. This treatment can be applied each year.

Unfavourable weather at flowering time especially involving low temperatures and rain can also upset pollination and result in the production of many seedless, small berries.

- Zinc. Symptoms of zinc deficiency are stunting, short internodes, a reduction in crop and small harsh leaves with chlorotic areas between the veins.

To control this deficiency, pruning cuts should be swabbed with a solution containing 200 g of zinc sulphate (23% Zn) heptahydrate in 1 litre of water. If monohydrate (36% Zn) is used, the rate is 125 g in 1 litre of water. For successful results, vines must not be bleeding at the time of swabbing. An alternative treatment is to apply foliar sprays during the growing season.



A farm dam.

Irrigation

Most grape areas in Queensland have sufficient rainfall to satisfy the requirements of grape vines in normal seasons. However, uneven distribution during the growing season can cause stress periods where irrigation can be used to advantage. This is of particular importance during the first few years of vine development.

At budburst, growth of vines is rapid and moisture requirements are high. If moisture is deficient at setting time, cropping can be reduced. Moisture is also required to increase berry size, but as the fruit approaches maturity, care should be taken in the amount of water applied as excessive irrigation late in the season can harm fruit quality.

Where irrigation is practised, the following programme should be followed:

Ensure that soil moisture is sufficient from 1 month before flowering up to 3 weeks after flowering. This is a critical period for the uptake of nutrients for satisfactory growth, good fruit set and early fruit development. After this period, for approximately 3 weeks, fruit development is slow and water deficiencies are not so important.

After this stage, active fruit development takes place and soil moisture should again be maintained at a favourable level.

When the berries begin to ripen, little advantage will be gained from irrigation, as at this stage the berries are able to compete with the plant for water, and are independent of soil moisture. Severe drought can, however, delay maturity. It is advisable to withhold water from the vines once the berries reach the stage where ripening processes begin. This enables the sugar content to rise to the required level.

As with other fruits, it is of course desirable to have good soil moisture available for maximum plant growth and fruit production.

When consideration is being given to buying an irrigation plant, it is important first of all to ensure that the vineyard will be well drained. The quality of the water to be used should also be checked. The Queensland Department of Primary Industries provides a water analysis service, and also advises on the suitability of the sample for irrigating grapes.

The most suitable irrigation system to meet requirements should be selected and designed by an irrigation expert who is also prepared to guarantee its installation and maintenance.

Trickle irrigation is gaining favour and growers who have already installed this system are quite pleased with the results. A trickle system is less expensive than some others, and is less wasteful of water. If possible, this system should be installed at planting time, so that the water needs of the young vines can be met.

Pruning

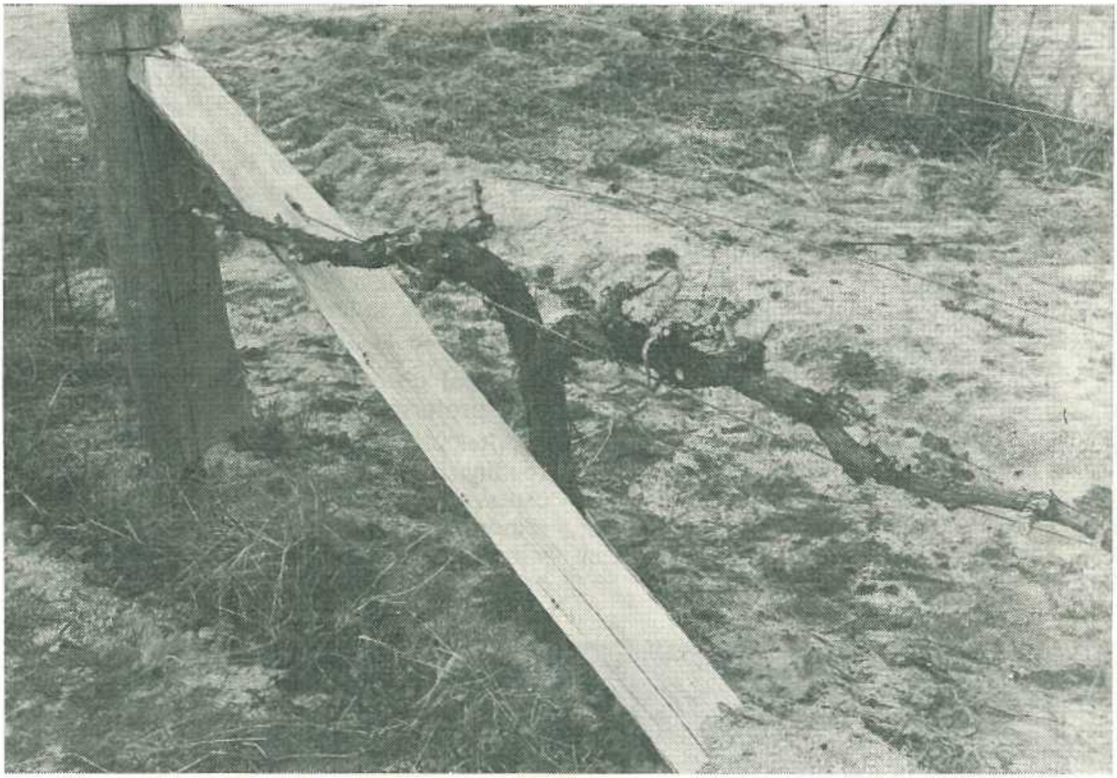
Vines are normally pruned during winter when they are dormant and the canes have matured. However, in districts where spring frosts can be injurious, it is best to prune as late as possible before budburst. Pruning in late August and September is therefore generally preferred where vineyards are in frost susceptible areas.

Grape vines are trained either as a bilateral cordon or a unilateral cordon. Both training systems can be short or long-pruned.

Bilateral cordon. (A two-armed vine—the preferred system).

After planting, the most upright cane of the rootling is reduced to two buds and all other canes are removed. During the first growing season, a single cane is trained to the first wire as near to the perpendicular as practicable and allowed to run up to succeeding wires.

Two bud spur.



Bilateral vine spur-pruned to two buds.

When pruning in the first winter, this cane is cut through a node just above the first wire and tied to the wire. During the second growing season, canes should be allowed to arise from two buds about 10 to 20 cm below the wire. These canes are trained upwards to succeeding wires.

At pruning in the second and subsequent winters, these canes are cut to appropriate lengths according to their vigour through the node just beyond a bud on the underside of the cane. This extra node is used to aid tying and the bud on this node should not be allowed to grow.

Crossing the canes before tying down in the second winter produces a structurally stronger and neater head. The first spurs can then be established close to the head of the vines.

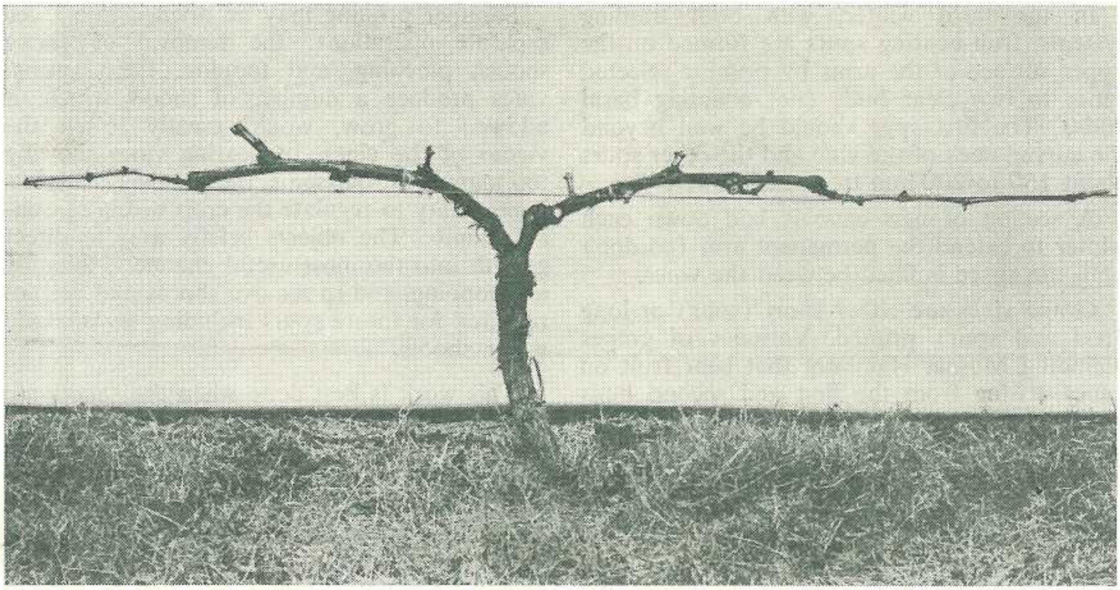
If vines make strong growth during the first season, the operation listed for pruning in the first winter may be carried out to advantage in midsummer. Thus a year is gained in training.

If vines make poor growth during the first season it will be necessary to cut back to two buds on the most upright cane and repeat the first growing season.

Unilateral cordon. (A single-armed vine).

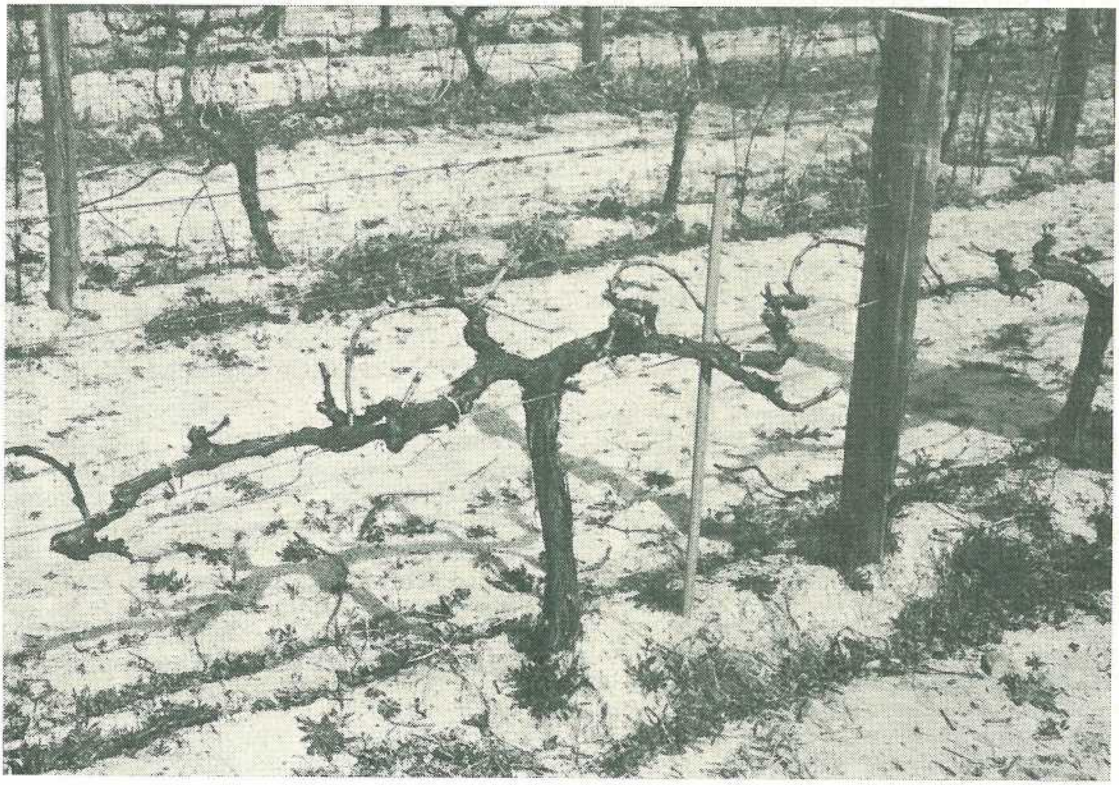
When pruning in the first winter, the most upright cane is shortened back to three buds. All other canes are cut away.

In the next winter, the strongest cane is trained on to the bottom wire in a graceful curve and shortened back to a bud on the undersurface of the cane as described in the bilateral cordon section. During the third growing season all growth below the bottom wire is suppressed.



ABOVE. Bilateral vine.

BELOW. Rod and spur-pruned vine.



In the third winter, with both training systems, fruit-bearing spurs are formed on the upper surface of the arms by pruning selected canes to two clear buds (not counting basal buds). The first spur should be well beyond the curved neck of the vine and the other spurs about 150 to 200 mm from each other.

A section of new cane is laid down each winter to extend the permanent arm (cordon) until the space is filled between the vines.

Grape vines are either short (spur) or long (rod and spur) pruned. Varieties of grapes including Muscat Hamburg that bear fruit on canes arising from the first and second buds are short-pruned to spurs with two buds. While varieties which develop their best fruit canes from the fourth or later buds are long-pruned to rods. Waltham Cross and Purple Cornichon are long-pruned.

For short-pruning in the fourth and subsequent winters, the cane growing from the bottom bud on each spur is cut back to two buds. All other canes are removed.

For long-pruning in the fourth and subsequent winters, the uppermost cane in each spur is shortened to five or six buds. This rod is tied in the form of a bow to the bottom wire. The lower cane of each spur is cut back to two buds to provide renewal wood for the following season. All other growth is removed. The number of rods a vine can carry is determined by its vigour. Usually four or five rods are sufficient for a mature vine.

Pruning is essentially the art of controlling fruit production without reducing the vigour of the vines. An over-estimate of vigour at pruning is invariably followed by erratic spur development which is difficult to correct.

Grafted vines show more early vigour than those on their own roots and are pruned accordingly.

Summer pruning

Irrespective of the system of training adopted, winter pruning should be supplemented by the removal of surplus shoots in spring as soon as it is practicable to distinguish between fruiting and non-fruiting wood. Opening up the vine in this way promotes better cane development and it also makes spraying for disease control more effective.

Summer pruning may be divided into three separate operations: the removal of young shoots, pinching, and topping. Each spring, vines produce a number of shoots which, if allowed to grow, would greatly lessen the vigour of the vines. In bearing vines showing too many fruit blossoms, the removal of shoots is necessary to regulate the crop within reasonable limits. The objects briefly are: to direct growth into the most useful channels, thinning and topping, and to remove shoots that are not required for future spurs including suckers and water shoots.

This work is best done when the shoots are about 20 to 25 cm long, and can be easily removed under pressure of the thumb and index finger. At this stage of growth, it will be readily seen which shoots are carrying fruit. All water shoots coming from dormant buds in the old wood, on both arms and trunk, should be removed unless they can be used in reforming a vine, such as the replacement of fruit spurs that have become elongated and knotty, and filling up gaps in the spurs.

In spur-pruned vines, two or more shoots often arise from each bud. Few vines can support such growth, more especially if it is fruitful. Where more than one shoot occurs, the weakest should be removed leaving only one at each node. On vines that are long-pruned, the treatment consists of removing the surplus shoots on the rods and keeping the strongest on the spurs so that strong renewal wood is available for the following pruning. Pinching back the shoots developing from the end buds of fruit-bearing rods helps to break the buds further back and promote normal growth. This practice is very useful on vigorous vines.

Topping should be practised on vines only when the strong cane growth interferes with cultivation, harvesting or spraying operations. If foliage is too dense around the bunches, some of the lower and side leaves may be removed. This should be done with discretion as the removal of too many leaves at one time will result in the bunches being too exposed and berries becoming sunburnt.

In recent years, tractor-mounted topping machines have been developed. These can be used to shorten back strong cane growth that interferes with cultivation and spraying. Canes that rest on the soil are very subject to fungus diseases.

Repruning after frost injury

Spring frosts occasionally cause considerable damage to grape vines. By repruning, it is possible to produce about a half-crop or more provided the damage occurs before the vines have made too much growth. The repruned crop will ripen satisfactorily under normal conditions.

A few days after frost injury, the damage is clearly defined and repruning should be carried out as soon as possible. The damaged shoots should be removed from the vine at a point just below the first buds but not too close to the spur, thus preventing any damage to dormant buds at the base of the shoots.

Repruning depends on the extent of damage and stage of vine growth. If shoots are frosted when they are around 5 to 10 cm long, they may be killed outright, but there will be no need to prune the vines as the dormant bud will automatically develop.

If the young canes are only partly damaged by frost and sufficiently soft to snap off under pressure of the thumb, the work can be done by hand.

Should damage occur to older canes which have become pithy, secateurs or a sharp knife should be used to avoid damaging the basal buds. Shoots bearing fruit that may have escaped injury while the rest of the vine is badly damaged must be pinched back so that the dormant eyes on the frosted spurs may develop.

When repruned vines bring their second growth, they invariably shoot from unexpected places. Water shoots will appear along the main arms and the base of spurs. This surplus growth must be suppressed and only the main shoots required on the spurs retained. If this work is neglected, the vine will develop into a dense mass of slender, weak canes producing little fruiting wood for the following pruning.

Some varieties when repruned crop more freely than others. Repruning aims at producing a crop of fruit and developing cane growth that is capable of producing a normal crop in the following year.

Grape pests

The production of quality grapes both for table use or wine requires efficient crop protection against insect pests. Pest activity is sufficient to warrant the application of insecticides when certain pests threaten to reduce yield and/or quality of grapes.

Insects attack all parts of the growing vine at various times throughout the season. Microscopic mites such as the blister, bud, and rust mite as well as leaf-eating moths, such as the grape vine moth, and the grape vine hawk moth, feed on the leaves. Mealybugs, light brown apple moth and occasionally fruit fly damage the developing bunches, while grape vine scale, termites, and nematodes attack the vine itself.

Leaf insects

The grape leaf blister mite causes blister-like malformations on the leaves. On the under leaf surfaces, the blisters are lined with a felt-like mass of abnormal hairs. Damage most commonly occurs on the variety Muscat Hamburg.

The bud mite feeds on the embryonic leaves within the buds. Damaged buds produce thick, stubby canes with short internodes. Damage most commonly occurs on Waltham Cross.

Rust mite damage appears at first as a pale discolouration along the main veins. Later, this becomes brown and spreads over the whole leaf surface. Severe infestations can occur in hot, dry seasons and premature leaf fall can result.

These mites and bunch mites can be controlled with lime sulphur sprays just before bud movement followed by miticides during the growing season.

The larvae of the grape vine moth and hawk moths can rapidly defoliate vines and ruin young bunches. The larvae of the vine moth are initially black but later develop yellow, green and red markings and grow to about 5 cm in length. Adult moths have bright black and yellow markings on the wings and body and have a wingspan of 5 cm.

Hawk moths are large, brown and swift-flying. The grey-green larvae grow to about 7·5 cm and are easily recognized by a curved spike. Two or three of these drab-coloured larvae can defoliate a vine in a short time.

If required, spray applications of carbaryl before flowering, and carbaryl or azinphos-methyl after flowering, are normally sufficient to control both of these pests.

Bunch insects

The bunch mite feeds on the berry stalks, causing them to become black. This is not a pest in the Granite Belt.

Mealybugs although not a widespread problem in the Granite Belt are more common in the wetter and warmer coastal areas. The adult females are covered by a fine, white, mealy powder and grow to about 5 mm long. Various stages of development can be found on leaves, stems, bunches and under loose bark where the insects overwinter. Mealybugs are usually attended by black ants which feed on their honey-dew excretions. A parathion-oil spray in winter, and parathion sprays in the growing season have given the best control.

Larvae of the light brown apple moth web leaves together and build silken galleries inside the bunches. Damaged bunches are made more susceptible to bunch rots. If this pest is known to occur, azinphos-methyl or carbaryl sprays should be used just before and again 3 to 4 weeks after flowering.

Fruit fly is seldom a problem on grapes in the Granite Belt but it is more of a problem in the humid coastal and subcoastal regions of the State. Dimethoate or fenthion sprays may be used if required.

Vine insects

The grape vine scale has caused problems in the past. The use of efficient insecticides such as superior dormant oil plus azinphos-methyl has reduced the insect population below economic proportions. The scale is oval and dark brown. It feeds by sucking the sap thereby weakening the vine and in severe cases it causes death.

Termites, commonly referred to as 'white ants', may cause damage to the vines as well as reducing the life of wooden trellis posts. The worker termites eat only the heart wood of the vine and leave the living sapwood. In old vines, the heartwood is eaten out to give a honeycomb appearance.

New trellis posts should be soaked in protective chemicals before being used.

The grape phylloxera, a serious pest in some Australian vineyards and overseas, does not occur in the main viticultural areas of Queensland. Stringent quarantine regulations are enforced to prevent its introduction.

The use of resistant rootstocks against nematodes and phylloxera has been a great asset in combating these soil-inhabiting pests. Although the choice of rootstocks is influenced by horticultural considerations, the value of resistant rootstocks cannot be over-emphasized.

Application of insecticides will in the main be determined by the extent of pest activity and from past experience. Routine spraying may not be necessary unless it has been in the past. Frequent inspection of the vines will give an indication of which pests are present, and insecticides should be applied accordingly.

Diseases

In Queensland, successful grape growing requires an expensive and regular programme of disease control each year. The major diseases of the crop are downy mildew, anthracnose, leafroll, powdery mildew, grey mould and nematodes.

Downy mildew

This disease mainly attacks the leaves but shoots, tendrils and fruit are also affected. Leaves first show yellow, oily spots which, in moist conditions, produce a white mildew on the under-surfaces. Affected bunches show large, purplish blotches on fruit stalks and berries.

Cool, moist weather favours the disease which can be controlled only by spraying thoroughly at regular intervals throughout the season with copper or dithiocarbamate fungicides. If copper fungicides are used, spraying must be suspended firstly during flowering, otherwise berry set is reduced, and secondly when the berries are maturing to avoid residue problems.

Removing and burning all prunings and other debris will help to reduce the sources of infection.

Anthracnose

Anthracnose disease attacks all parts of the vine particularly new shoots and fruit. Shoot symptoms are most conspicuous with small spots coalescing into dark, purplish, elliptical, sunken cankers which cause stunted and deformed growth. Fruit spots have grey centres and black edges often tinged with red. Leaf spots are small and dark-brown but, as they age, the centres lighten and may drop out. Leaf distortion is common.

Anthracnose is controlled by spraying with fungicides such as thiram, ziram or mancozeb according to the spray schedule.

Removing old prunings is also helpful in controlling this disease.

Leafroll

Leafroll is the most widespread and serious virus disease of grape vines in Queensland. Yields from infected vines may be reduced by up to 80%. Common symptoms include downward rolling of the leaf margins and, in green-leafed cultivars, darkening of the veins. In those cultivars that show red leaf pigmentation, the red colouration develops earlier and more intensely in infected vines and the veins remain green.

The disease does not spread in the field and infected vines cannot be cured. Prevention is possible only by planting vines propagated from cuttings or rootstocks that are derived from material certified free from leafroll virus.

Powdery mildew

Powdery mildew affects all parts of the vine but is usually seen on the top surfaces of leaves as a grey, dusty film. Affected fruits are russetted, mis-shapen and cracked but mildew is not always present.

Powdery mildew is not controlled by the sprays used for downy mildew or anthracnose. Instead, sulphur as a spray or dust is used. Applications should be made according to the spray schedule.

Cases of Muscat grapes.

Nematodes

Most vineyards are infested with several types of plant-parasitic nematodes. The problem is most severe with cultivars grown on their own roots.

Control will eventually be achieved in large measure by the use of Dogridge and other stocks resistant to root-knot nematodes.

Nematodes in the soil can be controlled by replant fumigation with DD or EDB and post-plant fumigation with DBCP (Nemagon, Fumazone). As fumigants are less effective in cold soils, it is important that these treatments are applied before the end of April.

Dead arm

Dead arm occurs only occasionally and then mostly in coastal districts. Infections occur through injuries or large pruning cuts beyond which the vine becomes unthrifty and finally dies.

When pruning, affected parts should be cut back well below the visible infection and preferably large cuts should be swabbed with a solution or paste of a copper fungicide.

Fruit rots

Several diseases attack grape berries during ripening, the main ones being bitter rot and grey mould. These often follow damage by other diseases and insects and are favoured by wet weather.

Bitter rot appears as large, watersoaked areas studded with small, black dots which are the fruiting bodies of the fungus.

The symptoms of grey mould are well described by its name. During prolonged wet weather, every bunch in a particular area may be affected.

Control is obtained by spraying with benomyl or thiophanate methyl twice during flowering and twice before harvest.

Spray schedule

As disease control is only one part of the crop protection programme, specific details of fungicide concentrations and when to apply sprays are not included here. It is recommended that the spray schedule contained in the current edition of the 'Deciduous Fruit Handbook' Part 2 be followed.

Harvesting and packing

It is necessary to harvest the fruit at the correct stage of maturity to satisfy consumer requirements and also to meet marketing grade standards. It is important therefore that only mature grapes should reach the consumer, helping to keep demand and prices at a desirable level. Immature fruit has a depressing effect on the whole grape market.

Higher prices are obtained for the early-matured fruit of each variety and, to take advantage of this, it would be necessary to make two or more pickings. Market prices for table grapes depend heavily on quality, and every effort should be made to ensure that fruit reaches the market in prime palatable condition. The presence of faulty berries lacking colour or otherwise immature can prejudice the whole consignment.

When harvesting the fruit, it should be handled as little as possible to preserve the natural bloom and attractiveness of the berries. Fruit should be harvested only when the bunches are dry.

The bunches are removed from the vine with grape trimming secateurs. Damaged and sub-standard berries are trimmed off and the stalks cut short to produce an attractive bunch.

The fruit is marketed in wooden or fibreboard containers which can be packed at the vine as the bunches are harvested. Wooden containers are lined with clean, white paper. All containers used for marketing grapes are referred to as the 'Half Standard Package' with internal dimensions of 450 mm long, 290 mm wide, and 135 mm deep.

These half standard packages are volume-filled and are known as the volume fill case or carton. The containers are 'loose-packed' with the stalks of the bunches on the top layer facing downwards to present an attractive face of fruit.

Light metal frames, or the more recent two-wheeled mobile carrier, are suitable for carrying containers when packing the fruit at the vines.

After the containers have been loose-filled at the vines, they are placed in the shade under the vine rows. After allowing time for slight wilting, the container is shaken lightly to settle the fruit into position then lidded in the vineyard.

Tractor-drawn trailers, light trucks and utilities with some form of roofing cover over the tray can be used very satisfactorily as mobile packing sheds for harvesting in the vineyard.

Marketing

Grapes from the major producing areas of Queensland are sent to markets in Brisbane, Toowoomba, the larger cities of Queensland, and the interstate markets of Newcastle and Sydney.

Queensland regulations

Standards relating to marketing grapes are prescribed under the Queensland Fruit and Vegetable Grading and Packing Regulations. These standards may be summarized as follows;

- The definition 'Mature' means that the titre (acidity) shall not exceed that shown in Table 2A of the Regulations for each level of Total Soluble Solids (T.S.S.).
- The initials (or the Christian name), full surname and address or in the case of a corporation or unincorporated association the name and address of the packer or in every case the packer's registered brand or, if the packer is a firm registered as such under 'The Registration of Firms Act of 1942', the name or registered brand of such firm, should be legibly and durably marked on the outside of such package.

The markings should be in letters not less than 19 mm in height.

- The word 'grapes' or the abbreviated form 'GPS' and the name of the variety of grape should also be marked on the package.

TABLE 2A

Total Soluble Solids (T.S.S.) per cent.	Titre (ml $\frac{N}{10}$ NaOH per 10 ml juice). Not to be exceeded	Total Soluble Solids (T.S.S.) per cent.	Titre (ml $\frac{X}{10}$ NaOH per 10 ml juice). Not to be exceeded
13·0	9·2	16·0	16·0
13·1	9·4	16·1	16·2
13·2	9·6	16·2	16·4
13·3	9·9	16·3	16·6
13·4	10·1	16·4	16·9
13·5	10·3	16·5	17·1
13·6	10·6	16·6	17·3
13·7	10·8	16·7	17·5
13·8	11·0	16·8	17·8
13·9	11·2	16·9	18·0
14·0	11·5	17·0	18·2
14·1	11·7	17·1	18·4
14·2	11·9	17·2	18·6
14·3	12·1	17·3	18·9
14·4	12·4	17·4	19·1
14·5	12·6	17·5	19·3
14·6	12·8	17·6	19·6
14·7	13·0	17·7	19·8
14·8	13·3	17·8	20·0
14·9	13·5	17·9	20·2
15·0	13·7	18·0	20·5
15·1	13·9	18·1	20·7
15·2	14·1	18·2	20·9
15·3	14·4	18·3	21·1
15·4	14·6	18·4	21·4
15·5	14·8	18·5	21·6
15·6	15·1	18·6	21·8
15·7	15·3	18·7	22·0
15·8	15·5	18·8	22·3
15·9	15·7	18·9	22·5

The minimum T.S.S. shall be thirteen percentum (13%).

New South Wales regulations

When grapes are forwarded to New South Wales for sale, the following marketing regulations apply in that State:

No person shall pack for sale or sell any grapes that are immature.

In this regulation, 'Immature' means that the filtered juice of not less than 1 lb (454 g) weight of grapes taken at random from any package gives a reading on a Brix hydrometer, standardized at 20°C or 68°F.

16.3 when the temperature of the juice is from 12.0°C up to 15.9°C.

16.1 when the temperature of the juice is from 16.0°C up to 19.9°C.

15.9 when the temperature of the juice is from 20.0°C up to 22.9°C.

15.7 when the temperature of the juice is from 23.0°C up to 25.9°C.

15.5 when the temperature of the juice is from 26.0°C up to 29.0°C.

It is permissible to market the Chaouch and Cardinal varieties when the Brix is 14.5 at 20°C.

'Grapes' means any grapes for sale in their fresh state excepting grapes consigned direct from the grower to a factory for processing.

Maturity sampling

As a guide to the stage of maturity of grapes intended to be harvested for market, a sample can be taken for testing the sugar and acid content. Clipping a few berries from as many bunches as possible from the section of the vineyard to be harvested will ensure that the sample truly represents the maturity of the grapes to be marketed.

Should the sample indicate an acceptable maturity standard, it will be essential for pickers to harvest fruit of a similar standard.

The accuracy of the maturity test is only as accurate as the sample taken.

Footnote

Regulations govern the movement of grape vine material (excluding fruit) into and within Queensland.

The introduction of cuttings into Queensland from other States is only permitted under several conditions designed to prevent the entry of Phylloxera.

Only unrooted cuttings from annual growth can be imported. They can come only from approved Government Research Stations and must be accompanied by a certificate verifying that the cuttings were produced on that Research Station where Phylloxera has not been known to occur. They must be received by the Queensland Department of Primary Industries in Brisbane for fumigation and inspection before proceeding to their final destination.

Within Queensland, the removal of any grapevine material grown within the boundary of the City of Brisbane is prohibited.

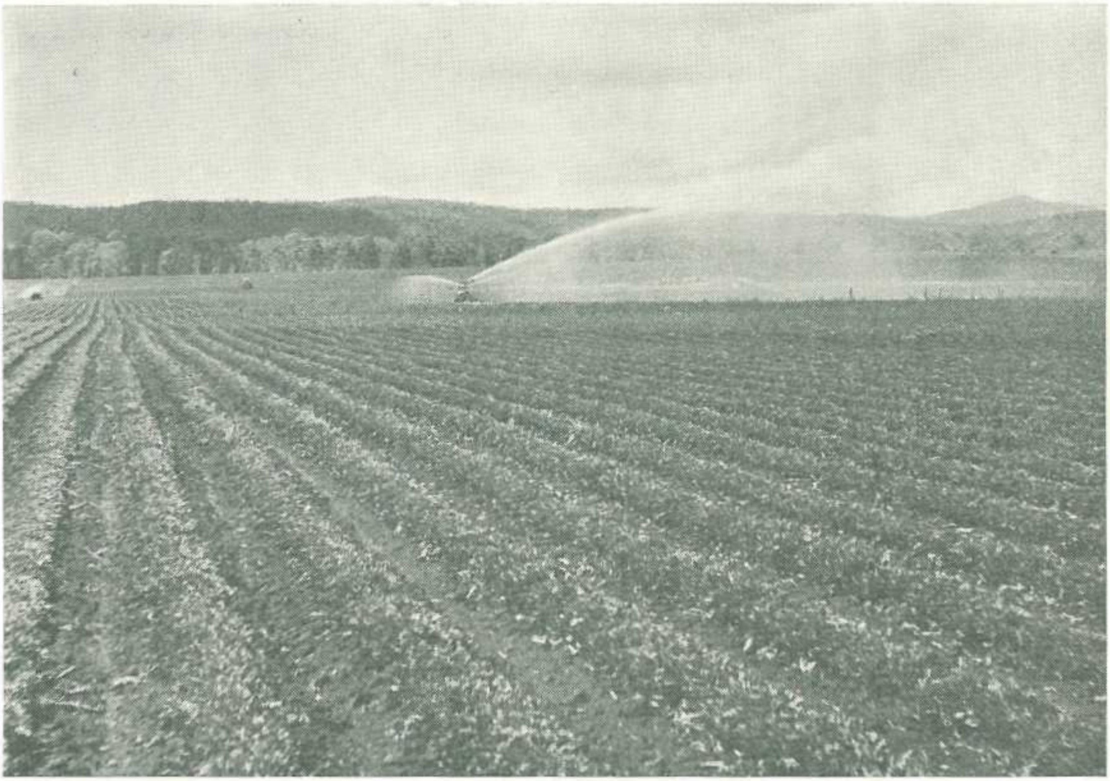
There is no restriction on the movement of grapevine material elsewhere within the State.

Growers intending to import cuttings should seek advice at the nearest office of the Queensland Department of Primary Industries.

Landsat 79— The First Australasian Landsat Conference

A conference on the applications and technology of Landsat in the Australasian context will be held in Sydney from 21 to 25 May 1979. For information, contact Mr J. Davies, Conference Secretary, Landsat 79, P.O. Box 136, North Ryde, N.S.W., 2113, Australia.

Irrigation pays off



in North Queensland peanut crops

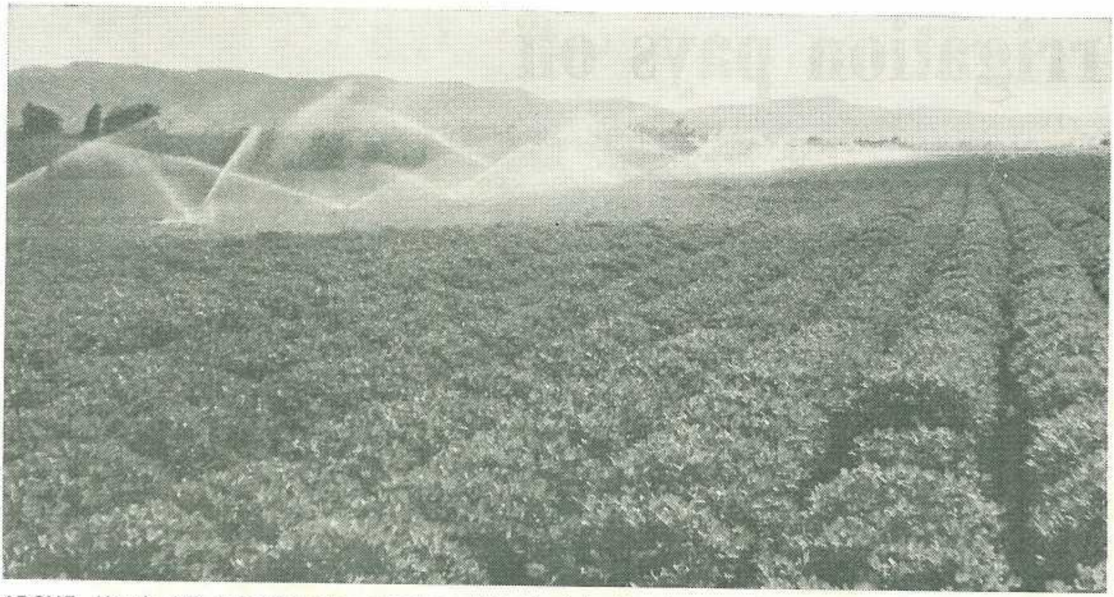
OVER the last few years, many improved cultural practices have been adopted by North Queensland peanut growers which have considerably reduced the risk of crop failure.

Weed control methods, disease control programmes and better harvesting machinery combined with good artificial drying technology have all contributed to the consolidation and rapid expansion of the industry.

by J. Kilpatrick, Agriculture Branch.

One factor which had not been considered a potential problem to the North Queensland peanut crop was lack of soil moisture. On the contrary, too much rain is usually the most troublesome, uncontrollable influence during the growing season.

Photograph above. At Kaban in the south-west corner of the Atherton Tableland, this travelling irrigator saved a 35 ha crop of Virginia Bunch. Adjacent rain-grown plantings yielded less than 1·25 t per ha of poor quality peanuts, while the crop illustrated was watered twice and yielded just over 2·25 t per ha of fair to good quality nuts.



ABOVE. Hand shift irrigation was used on this Virginia Bunch peanut crop grown north of Tolga on the forest soil of Northey Road.

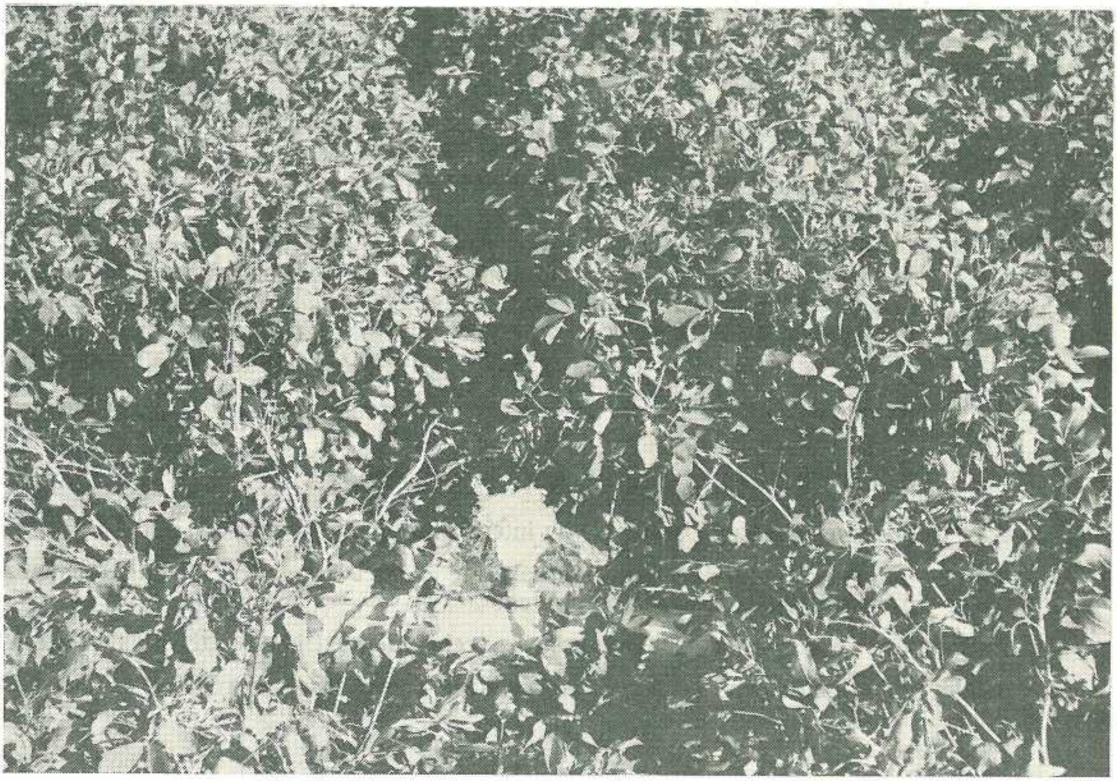
Yields of nearly 3·5 t per ha were harvested from the irrigated plantings. Quality payments provided an average upgrading of about $40 per tonne.

On the same farm, a 4 ha paddock which could not be irrigated yielded less than 2 t per ha and was downgraded $20 per tonne.

BELOW. A crop of Red Spanish peanuts showing severe moisture stress. They should have been irrigated about 3 weeks earlier. The crop is about 12-weeks-old and was grown at Innot Hot Springs near Mount Garnet.

The spectacular response to irrigation is clearly illustrated in the above photograph. The erect, darker-coloured irrigated plants on the right contrast strongly with the pale and wilted peanuts on the left.

The crop was flood irrigated using gated aluminium pipes as shown below. It was grown at Crocodile on the Laura River in the Cape York Peninsula.



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Following the record wet season of 1976-77, the summer of 1977-78 was unexpectedly and exceptionally dry. Only 550 mm of rain fell at Atherton between January and April 1978. 1 000 mm is normally received in these 4 months. As a result, irrigation played a significant part in producing the record district production of over 10 000 tonnes of nuts in shell. This was in a district where supplementary irrigation of summer-grown peanuts had never been practised before.

Many waited too long

Following a good start to the wet season during late December 1977 and early January 1978, most of the peanut plantings were completed during a 3 week period in January.

The usual follow-up rains, however, did not eventuate. Promising cloud formations built up a number of times, but all failed to produce rain to ease the severe moisture stress being experienced by the peanut crop.

As early as 5 or 6 weeks after planting, a few peanut farmers indicated their intention to irrigate.

However, the belief that satisfactory rains would bring relief 'in a few days' postponed the initial waterings until 10 or 11 weeks after planting.

Experience in other peanut-growing areas of the world indicated that this was later than desirable but North Queensland farmers who did irrigate peanut crops were very pleased indeed with the final result.

Once the first farmers to apply irrigation had illustrated the rapid and spectacular response by their peanut crops, others followed quickly.

Fortunately, many peanut producers have irrigation equipment on their farms and so there was no large capital outlay involved.

In every case, irrigation paid for itself many times, though water was applied a little late in the development of most peanut crops. Most growers applied water twice, with the second irrigation about 2½ to 3 weeks after the first.

Equipment used

All types of irrigation systems were used including flood irrigation where possible. Elsewhere, travelling irrigators were winched into motion. Hand shift pipes were laid out and some small, solid set systems were adapted when nothing else was available.

Future irrigation use

Where irrigation was applied to peanut crops in North Queensland during the 1977-78 season, improved quality and higher yields produced excellent economic returns.

Now that the responses to strategic irrigation have been demonstrated, more frequent use of this practice can be expected. The critical growth period for a peanut crop is early flowering and peg set. If there is a soil moisture shortage at this time, supplementary irrigation will boost both quality and yield. It is too late to wait until the plants are showing moisture stress symptoms.

The existing 'five point plan for better peanut yields' (see 'Growing peanuts in North Queensland' in the November-December 1978 issue of the *Queensland Agricultural Journal*) now becomes the 'six point plan' where suitable water and irrigation equipment are available.

CHANGING YOUR ADDRESS?

Please let us know as soon as possible if you intend changing your address.

Because the addressed wrappers and journals are printed separately, changes cannot take effect until the next batch of wrappers is printed.

This means that, in some cases, subscribers will receive the next issue at their old address.

If possible, two months' notice should be given to ensure your journal is sent to the correct address.

Pizzle dropping on wethers at Canaway Downs

DON and Gordon Duff have been doing the pizzle drop operation on their wethers for 5 years. They have found that it prevents pizzle strike and stained bellies and, if combined with radical mulesing and jowling, eliminates the need to handle wethers between shearings.

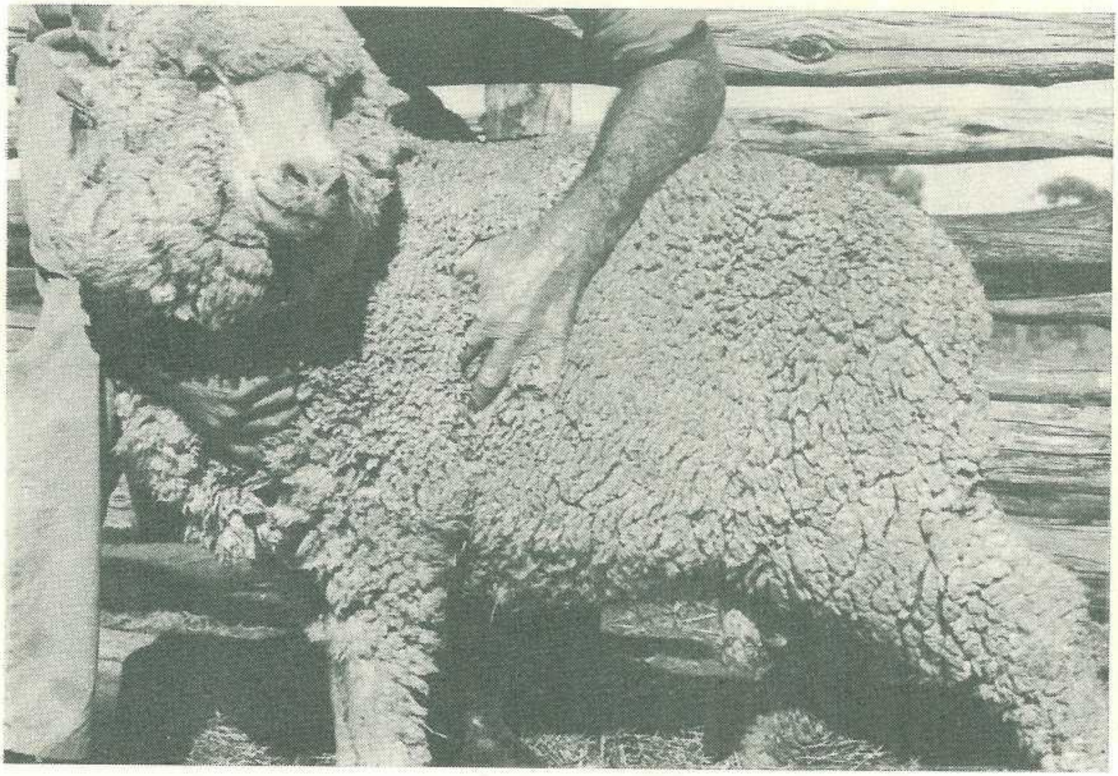
Don Duff says that their adult Merino wethers average 6·3 kg per head. With the long staple that they grow, the need to avoid pizzle strike and smelly bellies is obvious. Ringing is unsatisfactory even when done well as the wool closes around the pizzle and the edges of the wool are again stained.

Wethers at 'Canaway Downs' are pizzle dropped to a length of 10 cm (4 in.) so the pizzle comes well below the staple tip when the sheep is in full wool.

The Duffs' property is 112 km N.N.W. of Quilpie in south-western Queensland. It is 'Boree' Mitchell grass downs surrounded by hilly mulga country. The district is prone to heavy blowfly waves.

by L. B. Dunlop, Sheep and Wool Branch and D. and G. Duff, Canaway Downs.

BELOW. A wether in 9 months' wool. The pizzle comes well below the tip of the belly wool.



The operation

Pizzle dropping involves surgically dropping the pizzle of wethers with mulesing shears. The end of the pizzle is held in the fingers and the shears placed against the belly with the points facing the breech. A cut is made flat along the belly between it and the pizzle for about 10 cm (4 in.). This severs a ligament and allows the pizzle to drop down. When the woolly skin heals, the pizzle should come well below the staple tip of a sheep in full wool. This eliminates urine-stained wool on the belly.

Don and Gordon Duff do the combined operation when the wethers are 1 week off shears at 11 months of age.

Results

To show the operation's effectiveness against pizzle strike, Gordon said that in 1976 there was no pizzle strike in 2 248 dropped wethers at Canaway Downs, but there was 30% strike in 250 undropped 6-year-old wethers at crutching in March and 30% also in 1 500 undropped weaners at shearing in July. The Duff brothers have to crutch, wig, and ring all undropped wethers every year.

In the summer of 1976, some wether flocks recorded losses as high as 30%.

Of 2 248 mixed age wethers shorn in July 1976, only 142 were missing 12 months later. They had not been jetted, crutched, dipped or handled in any way in that time. Don and Gordon Duff only rode through them to check on fly. They have never seen a blown pizzle in the dropped wethers.

BELOW. The sheep are held in a 'Cranmore' cradle for jowling, mulesing and pizzle dropping.

Savings

There are worthwhile savings in time and money as there is no need to wig, ring or crutch.

The following costs are saved annually when wethers are jowled, mulesed and pizzle dropped.

Crutching, wigging and ringing	\$17 per 1 000 sheep
Jetting, 2 man days @ \$30 per day ..	\$60 per 1 000 sheep
Extra 2% death rate for undropped wethers at \$8 per head ..	\$160 per 1 000 sheep
One muster of 11 000 acres @ 6 man days at \$30 per day ..	\$180
Total	\$417

This represents an annual saving of 41 cents per head. Because the wethers are not crutched, it is likely that less skirtings will be removed from the breech area. Belly wool may command a higher price as stains are eliminated. Without including this benefit, a flock of 1 000 pizzle dropped wethers kept for 6 years would save the owner a net \$2 500.

Grass seed

Grass seed infestation is apparently no problem. On Canaway Downs, the wethers have also been run in a hard, stony mulga paddock. It is hilly country covered with low mulga and low bushes and is heavily infested with grass seed and all the burrs that go with hard mulga country. Pizzles did not become infested with grass seed.

Shearing

Shearers do make unfavourable comments. However, once shearers are told about dropped sheep, the rate of cut pizzles is no worse than in undropped sheep. When the pizzle is held by the prepuce and shorn like a tail, all cuts are avoided.

Shearers are slower on the belly at first but adapt very quickly. Some shearers have told the Duff brothers that they appreciate the elimination of smelly, maggoty bellies.

Advantages

Pizzle dropping saves on labour and chemical costs and reduces deaths in wethers.

The practice is ideally suited to the pastoral areas of Queensland where labour is scarce and mustering costs are high. The greatest benefit would be seen during serious blowfly waves.

Be careful when restraining horses

THE Department of Primary Industries' Veterinary Services Branch has urged horse owners to be careful when restraining their animals.

The aim of restraining a horse was to give man an advantage over the animal. Physical restraint worked by distraction, usually pain, or by actual physical restriction of movement.

A Branch veterinarian warned that severe forms of restraint caused the animal unnecessary pain, and could injure it.

Points to watch when using the common forms of restraint were:

- A nose twitch should not be applied too tightly or for too long a period. The animal's sensitive upper lip could be damaged, causing disfiguration and hindering grass gathering.
- Ear twitches should not be used as they damaged the cartilage and caused the ear to 'lop'. (fall forward).
- Hobbles could cause damage such as ring bone. Felt padding on the inside of the hobbles could remedy this. Leather dressing should also be used on hobbles.
- Rope side lines used around the bone pastern caused rope burn. It was best to thread rope side lines through a hobble strap.
- A suitable crush for horses was one which could be opened at any point, so that if an animal went down, it could be quickly and easily extracted. A gate could also be used as a crush.

Bovine Brucellosis Accredited-free Herd Scheme as at 30-11-78

J. L. and S. E. Abraham, 'Kaho' Stud Farms, M.S. 892, Meringandan.	AIS, JS, SM
Agar Pastoral Co., P.M.B. 3, Murgon.	SG
Alcheringa Pastoral Co., 10 Coomber St., Bundaberg.	CH
R. N. Alexander, 'Trefoil Pk', Warra.	HF
J. H. and B. J. Amor, 'Carinya', Dulacca.	BF
F. Anderson, 'Castle Mitchell', Clifton.	MA
Anderson Past. Co., 'Inverary', Yandilla.	PH
E. R. Andrew, Woodford Road, Peachester.	FS
Animal Husbandry Research Farm, D.P.I., Rocklea.	MIXED
F. R. B. Anning, 'Cardross Charolais Stud', Cardross, Grandchester.	CL
P. Atkinson, P.O. Box 1, 'Coorumburra', Marlborough.	SG
S. J. Atkinson, 'Wairuna Brahman Stud', 'Bundarra', Nebo.	BM
Australian Estates, Eurella, Mitchell.	SG
Australian Estates, 'Wainui', Bowenville.	SG
N. D. Bahnisch, 'Brafield' Stud, 'Orchard Vale', Guluguba.	BF
H. A. Balke, 'Balhaven', Westbrook.	JS
R. Barr, Eukey Murray Grey Stud, P.O. Box 194, Stanthorpe.	MG
E. Bassingthwaighte, 'Woodlands Stud', Greenmount.	PH
A. Bassingthwaighte, Yabba Past. Co., Yabba, Junica, via Kilcoy.	SG
A. V. Bauer, 'Warralea' Droughtmaster Stud, M.S. 825, Ipswich.	DM
D. J. and E. M. Beal, 'Tara Park', Gowrie Junction.	MG
G. W. Beck, 'Banbeck', Blenham Road, Laidley.	DM
C. H. Beckingham, 'Cosme Jersey and Hereford' Stud, Bridgeman Downs, Darien Street, Aspley.	JS, HF
R. J. Begg, 'Misty Downs', M.S. 848, Rosehill, via Warwick.	MG
E. C. Behrendorff, 'Inavale' Stud, M.S. 488, Boonah.	FS
A. J. and M. A. Bell, 'Belheath' Stud, Karingal, M.S. 1231, Millmerran.	PH
M. G. Bell, 'Heatherlea' Stud, Dulacca.	BF
W. H. Bell, 'Bilandra', Jambin.	BM
J. Bennett and S. A. Wells, Box 3202, Townhall, Toowoomba.	FS, HF
H. G. and C. M. Benstead, 'Analwon', Wonglepong, via Tamborine.	AIS
E. J. and P. A. Bentley, 'Jedda Park', No. 1 Pope Road, Mother Mountain, Gympie.	AG
Berajondo Past. Co., (R. J. Stephenson), 'Glenmore', Berajondo.	BM
B. and E. Bergstrom, 'Chrisaelgy' Brahman Stud, 'East End', Mt. Larcom.	BM
J. W. and J. W. Best, 'Idlewild' Stud, Idlewild, Warwick.	CL
Binda Brae Pastoral Co., 'Binda Brae', P.O. Box 2, Jimbour.	BF, HF
P. R. Bishop, Garglen, Southside, Gympie.	BM
T. G. and M. K. Black, 'Hazeldean' Stud, M.S. 692, Nanango.	SG
C. J. H. and M. E. Blackley, 'Alcheringa', M.S. 851, Wandoan.	BF
N. J. and E. B. Blumel, 'Willow Glen Farm' Stud, Farm Road, Bunya.	DM
A. R. and V. H. Bondfield, 'Palgrove', Dalveen.	CL
Boreview Past. Co., 'Boreview', Wallumbilla.	PH
Estate of W. Bourke, 'College Green', M.S. 422, Clifton.	AIS
R. R. and I. A. Bowen, 'Pine Tree Farm', Roma.	HF
K. and L. Bredhauer, 'Carana', Charleville.	PH
L. J. Breen, 'Tarrawatta', Eukey, via Stanthorpe.	AG
J. J. and S. L. Brider, 'Kenmar' Stud, Cryna, M.S. 1916, Beaudesert.	FS
Broadlea Partnership, 'Broadlea', Box 35, Theodore.	BM
I. and D. J. Brimblecombe, 'Wyalong', Jimbour.	BF
H. D. and P. R. Brown, 'Westerngales' Stud, Wight's Mountain Road, Samford.	SG
W. L. and J. M. Brown, 'Acedale' Stud, P.O. Box 18, Southbrook.	AIS
T. J. Brownlie, 'Thornton', Columboola.	SG
C. E. Buchholz, 'Baron Downs', P.O. Box 175, Maryborough.	SG
Bundaberg Sugar Co., 'Avondale' Brahman Stud, Marlborough Station, Marlborough.	BM
Burnett Downs Pastoral Co., 'Burnett Downs', P.O. Box 11, Brigalow.	MG
H. E. Burnham, 'Boolgalgopal', Abercorn.	BM
J. A. and A. W. Butler, 'Coochin', Old Gympie Road, Beerwah.	BF
F. and E. L. Cameron, Evelor A.I.S. Stud, M.S. 767, Yarraman.	AIS
R. B. and J. P. Cameron, 'Belconnen', McDougall Street, Warwick.	MG
J. D. and H. Campbell, 'Hilden', Burpengary Road, Narangba.	MG, LM
M. P. Campbell Tiaro Park, Tiaro.	BM
J. Cardillo, 'Oena', Springs Road, Mareeba.	DM
D. I. and J. C. Carlyle, 'Wonga Hills' Stud, M.S. 355, Chinchilla.	PH
C. J. Chambers, 'Marbett Park', Goombi.	BF
L. A. and C. M. Chesworth, 'Willette', Cryna Road, Beaudesert.	FS, SW
B. L. and M. O. Christensen, 'Elavesor', Poll Hereford Stud, Rosevale, via Rosewood.	PH
G. E. Christensen, 'Double E', Moorang, via Rosewood.	SG
T. and W. Christensen, 'Omaha', Tarome, via Kalbar.	PH
E. M., C. and G. W. Ciesiolka, 'Valley View', M.S. 212, Oakey.	AIS, SG
J. R. and H. M. Ciesiolka, 'Trebon', A.I.S. Stud, Taylor St., Toowoomba.	AIS
R. B. Clarke, 'Allawah', c/- P.O. Box 476, Theodore.	BM
P. J. Clarkson, 'Baroona', Bowenville.	BF
D. B. Coates, 'Narayen', Mundubbera.	BR
B. K. Coleman, 'Greenstock, P.O. Box 37, Goombungee.	JS
C.S.I.R.O., Belmont Research Station, P.O. Box 542, Rockhampton.	BR
I. S. Conochie, 'Brookland', M.S. 461, Kalbar.	JS
B. M. Conroy, 'Logan View', via Coominya.	CL
Coombe Bros., 'Roxborough', Greenlake Road, Rockhampton.	BM

Mrs E. B. Corden, 'Currajong Angus Stud', 'Netherby', Warwick.	AG
W. D. Cormack, 'Fourex Braford Stud', 'Oakwood', Wallumbilla.	BF
R. T. and P. A. Craig, 'Dulong' Stud, M.S. 1096, Nambour.	MG
D. B. and E. Crane, 'Keglsugl', P.O. Box 7, Dayboro.	PH
Mrs M. Crombie, Old Hidden Vale No. 49, Old Hidden Vale, Grandchester.	SG
V. R. and T. W. Crank, 'Gracelyn', Mt. Tyson.	AIS
C. N. and P. J. Crisp, 'Destiny Stud Farms', P.O. Box 40, Stanthorpe.	HF
D. Dance, 'Double D' Murray Grey Stud, M.S. 720, Millmerran.	MG
Dandilla Pastoral Co., 'Dandilla', M.S. 514, Kingaroy.	BF
S. H. and V. I. Davidson, 'Cedar Grove' Poll Hereford Stud, Cedar Creek Road, Wolfdene, via Beenleigh.	PH
J. J. E. Davies, 'Glenwyn Park Stud', Charker Street, Toowoomba.	HF
K. W. Davis, 'Walkah', Carpendale, via Helidon.	JS
W. D. Davis, Wambo A.I.S. Stud, M.S. 918, Toowoomba.	AIS
G. F. and A. M. Dean, 'Gadfield' Stud, Home Creek, Wooroolin.	CH, SM
L. De Landelles, 'Cherokee', Tanby, via Yeppoon.	BM
N. J. and E. J. Dingle, 'Dingleville Braford Stud', 'Dingleville', M.S. 221, Maryborough.	BF
W. A. Dodd, Glengannon Stud, M.S. 435, Rosewood.	PH
C. M. and B. E. Dolding, 'Dilston', Gayndah.	DM
F. M. and G. Donovan, 'Ashby' Braford Stud, Jimbour.	BF
Doondi Pastoral Co., 'Doondi Poll Hereford Stud', St. George.	PH
Doro Park Friesians, 'Doro Park', M.S. 918, Toowoomba.	FS
E. O. and L. A. Dorries and Son, 'Panorama', M.S. 212, Oakey.	AIS
F. R. and G. A. Dowe, 'Wahroonga', Tara.	PH
L. J. Drew, "Bluevale' Stud, M.S. 1116, Haden.	AY
V. L. Duhs, Murray Grey Stud, Image Flat Road, Nambour.	MG
D. P. H. and C. G. Earl, 'Boolaroo', Boyland, via Tamborine Village.	MG
Eidsvold Station Holdings Pty. Ltd., 'Belvedere', Eidsvold.	SG
R. W., A. J. and D. G. Elder, 'Katupna Park', Goombi, via Chinchilla.	PH
T. V. and P. M. A. Erbacher, 'Everush', M.S. 465, Cambooya.	JS
G. D. Evans, 'Arababy Stud', 'Arababy', Moore.	AG
P. J. Evans, Dragon Street, Warwick.	FS
R. C. Fahl, 'Sandalwood', Meandarra.	PH
G. T. C. Farrawell, Landershute Road, Palmwoods.	DM
Dr E. S. P. Ferguson, 'Coonoona', Wellcamp.	PH
J. A. and D. P. Ferguson, 'Dorallah' Jersey Stud, Veresdale, via Beaudesert.	JS
M. J. and J. Ferguson, 'Antrim', The Gums.	HF
G. C. Fischer, 'Karalee', Murray Grey Stud, 68 Hume Street, Pittsworth.	MG
M. J. and M. Fitzgerald, 'M-Jay' Stud, 'Tarooma', Texas.	HF
D. J. Fogg, 'Den-Dia' A.I.S. Stud, M.S. 336, Toogoolawah.	AIS
Ford Holdings, Maraja Stud, P.O. Box 238, Caloundra.	BM
S. R. Ford and Sons, 'Wattlebrae', M.S. 514, Kingaroy.	CL
F. and D. Fordyce, 'Waterhole', Bloomsbury.	BM
M. R. and J. E. Fowler, 'Donna-Lynn', M.S. 195, Pittsworth.	CH
F. and I. C. Fraser, 'Dundee' Brahman Stud, Richmond.	BM
W. A. Freeman, Trevlac Stud, Walloon Road, Rosewood.	CL
A. J. and Y. L. French, 'Wilston Park', M.S. 181, Pittsworth.	FS
J. Friedland and Son, 'Glen-Opal', Obi Obi, via Nambour.	JS
A. W., E. M. and D. W. Frohloff, 'Trinity', M.S. 191, Cambooya.	FS
Garryowen Past. Co., 'Corolla' Stud, M.S. 29, Clifton.	HF
C. Gaul, 'Moongana', Brooweena.	SG
Gayway Past. Co., 'Gayway', Anduramba.	BM
M. and G. M. Geddes, 'Rhodavale', Hodgson Vale, via Toowoomba.	FS
J. S. and E. J. Genge, 'Carinya', P.O. Box 78, Miles.	SG
H. C., K. C. and I. E. Genrich, P.O. Box 10, East Cooyar.	CL
W. W. Gibson, 'Glencrest', Mooloo, via Gympie.	GS
D. H. and G. M. Glasser, 'Yagaburne', Goondiwindi.	PH
Glenrae Pastoral Co. Pty. Ltd., 'Bowenfels', P.O. Box 54, Kingaroy.	PH
B. Goddard, 'Inverell', Mt. Tyson, via Pittsworth.	AY
Golden Grove Past. Co., 'Golden Grove', Glenmorgan.	SM, HF
Goondicum Past. Co., 'Goondicum', Gin Gin.	HF
H. A. Gordon, 46 Mellifont Street, Banyo.	MG
K. J. and J. L. Gordon, 'Merriwa', M.S. 499, Toowoomba.	BF
B. B. Gotke, Reynold Valley Jersey Stud, M.S. 461, Kalbar.	JS
G. B. Gould, "Guluguba' Stud, 'Waitangi', Guluguba.	PS
L. M. Graham, 'Glenmore' and 'Glenlea' Studs, P.S. 1494, Nanango.	BF, HF
R. N. and L. M. Graham, 'The Homestead' Stud, Couper's Road, Westbrook.	FS
L. R. Granzien, 'Caboonbah' Jersey Stud, Kalbar.	JS
W. J. Grayson, 'Lindavale', Killarney.	DV
G. W. and A. L. A. Green, 'Woodridge', M.S. 371, Greenmount.	GS
G. A. Greenup & Co., 'Benroy', Kingaroy.	SG
J. R. and R. Grieve, 'Invernaion', Yandilla.	PH
J. C. Grigg, 'Bethonga' Braford Stud, P.O. Box 4, Wamuran.	BF
D. H. and P. O. Guilford, 'Mooloolah' Stud, 'Richmond', Allora.	HF
N. J. and H. M. Guppy, 'River Dell', M.C. 852, Hodgson Vale, via Toowoomba.	FS
S. K. Guppy, 'Lyndstarr', M.S. 1096, Nambour.	FS
N. D. and A. V. Hams, 'Shandah', P.O. Box 89, Nanango.	SG
B. and M. Hannant, 'Croalah', Stud, M.S. 243, Kingaroy.	PS

D. and P. E. Hardgrave, 'Arrawatta Stud', Sharon, via Bundaberg.	FS
C. R. Hardwick, 'Charlyn', Marlborough.	BM
B. M. and J. R. Hare, 'Wahpunga', Kin Kin.	BF
H. R. Harris, 'Temora Park' Stud, M.S. 33, Cedar Creek, via Samford.	PH
N. and F. M. Harrison, 'Oakridge Stud', Bartholomew Rd., Elimbah.	BS
A. E. Harvey, 'Ronel', Kingsthorpe.	FS
E. and R. F. Harvey, 'Dunboy', M.S. 918, Toowoomba.	FS
T. R. Hay & Co., Pindi Pindi.	BM
B. E. Hayward, 'Denville' Stud, M.S. 465, Cambooya.	HF
G. H. and L. F. Hayward, 'Nashville', M.S. 1840, Greenmount.	PH
M. F. Hemmings, 'Bileena', Canningvale Road, Warwick.	AIS
V. A. Henderson, Barkala Stud, Greenmount Road, Cambooya.	HF
J. and J. L. Henry, 'Rocky Ponds', Massie, via Warwick.	HF
K. Henry & Sons, 'Tara' Stud, M.S. 465, Cambooya.	AIS
W. G. Henschell, 'Yarranvale'', M.S. 1444, Brookstead.	PH
Lester Brothers, 'St. Andrews' Stud, M.S. 623, Warwick.	AIS
H.M. Prisons, Etna Ck., via Rockhampton.	MIXED
H.M. State Farm, Numinbah Valley, Numinbah, via Nerang.	FS
H.M. State Farm, Palen Creek, Rathdowney.	JS
H.M. Prisons, 'Wolston' Stud, Station Road, Wacol.	FS
Superintendent, Her Majesty's Prison, Neurum Road, Woodford.	JS
C. J. Hewitt, 'Judel' Friesian Stud, Delaney's Creek, via D'Aguilar.	FS
H. L. Higgs, 'Bangalla', River Road, Tinana.	BR
Hindmarsh and Son, 'Wingfield', Monto.	HF
G. and J. F. Hodgens, Bunyeris, Peachester, via Beerwah.	JS
G. F. and N. E. Hoey, 'Coolalinga Jersey Stud', M.S. 74, Clifton.	JS
J. L., Z. P. and L. M. Hoey, 'Emoh-Ruo' and 'East Lynne', M.S. 74, Clifton.	SG
N. T. and M. A. Hoey, 'Merrawah' Stud, M.S. 371, Greenmount.	JS
A. T. Holt & Son, 'Karowara Santa Gertrudis Stud', Hartley Rd., Tamborine Mt.	SG
L. R. and E. E. Hoopert, 'Happy Valley', M.S. 212, Oakey.	SG
H. W. Hooper, 'Ellendean' Guernsey Stud, P.O. Box 4, Maleny.	GS
I. C. and S. D. Huey, 'Ashview', M.S. 918, Toowoomba.	JS
M. E. and V. E. Hughes, 'Mi-von', Hopelands, via Chinchilla.	HF
Sir A. Hulme, care of R. Ledger, 'Alcheringa Stud', Highlands Road, Eudlo.	DM
S. E. Hunt and D. J. and M. Doyle, 'Kudo' Stud, 'Komirra Pastures', Glasshouse Mountains.	PH
R. B. and S. R. Huth, 'Crestview', Roadvale.	FS
C. J. and M. E. Jackson, 'Jaffra', Gogango.	BM
E. P. J. and M. Jackson, 'Rotherham' Stud, 'Ennismore', Nobby.	PH
M. D. and B. E. R. Jannusch, 'Albion Park', c/- P.O. Box 25, Pittsworth.	FS
G. D. and B. M. Jensen, 'Kuyura', Jimbour.	BF
L. G. Jensen, 'Towertown' Stud, Glenwood, Gunalda.	FS
F. M. and K. W. Jobling, 'Karalee' and 'Karanga' Studs, M.S. 979, Monto.	AIS, PS
F. S. Johnston, 'Jon-Dene', Obi Obi, via Mapleton.	AIS
R. W. Johnston, 'Wallum Hills', Santa Gertrudis Stud, Franks Lane, Wamuran.	SG
R. L. and S. S. Jones, 'Valley View' Stud, Samford Road, Samford.	AY
B. C. Juers, Mimosa B.J. Stud, 'Mimosa', Gayndah.	DM
C. and D. I. Kajewski, 'Glenroy', Glencoe, M.S. 1049, Gowrie.	AIS
L. K. Kath, 'Kathleigh', M.S. 1049, Gowrie Junction.	JS
F. A. and M. Kehl, 'Hillview', Wallumbilla.	BF
J. T. and F. Kelman, 'Mt. Tabor' Station, Warwick.	SH X CH
J. E. Kemph, 'Bunya Vale', M.S. 222, Oakey.	CL
Kengoon Pastoral Co., 'Kengoon' Studs, Kengoon, Kalbar.	BM, CL, DM, AF, PH
R. and M. Kerr, 'Maryview', Miva.	BF
R. R. Kerr, 'Sunnyside', M.S. 117, Monto.	GS
Kerwee Past. Co., 'Argyle', Kingsthorpe.	SG
F. W. and E. M. Kiepe, M.S. 223, Nobby.	FS
R. J. and J. J. Kiepe, 'Charlton View Ayrshire Stud', Charlton, via Ayrshire.	AY
D. H. Killer, 'Kilbunda' Brahman Stud, M.S. 108, Bundaberg.	BM
A. J. Kinbacher, 'Garthowen', P.S. 1216, Biggenden.	DM
L. B. and M. Kirby, 'Kalanga' Stud, Wesley Road, Kallangur.	CL
K. R. and M. S. Knight, Mt. Mee, via Dayboro.	FS, SW
S. G. Knight and Co., 'Baalgammon', Manumbar Road, Nanango.	AIS
S. S. Knitter, 'Charnu' Stud, M.S. 546, Forest Hill.	FS, JS
A. F. Krinke, 'Plain View', c/- Box 92, Pittsworth.	HF
B. R. and J. H. Kummerfield, 'Lonley', Goovigen.	GS
L. H. Kunst, 'Sunnyside', Miva.	BS
B. G. and R. M. Lamb, North Kilan, M.S. 311, Avondale.	BM
P. A. and J. L. Lange, 'Cerana', M.S. 222, Oakey.	AIS
K. J. and M. Lau, 'Rosallen', Goombungee.	JS
K. R. and E. A. B. Lawler, 'Coolibah' Stud, M.S. 292, Marburg.	AIS
D. C. Lawrie, 'Croxley', M.S. 918, Toowoomba.	DM
F. Lax and Sons, 'Wyroona', M.S. 212, Oakey.	FS
C. F. Leacy, Coominga Droughtmaster Stud, 93 Summit Road, Pomona.	DM
Leacy and Pavan, 'Calmrancho', 93 Summit Road, Pomona.	DM
R. S. and R. I. Learmont, 'Scotlea', P.O. Box 102, Monto.	SG
K. J. Lee, 'Brigalow Park', Kurrumbul.	HF
Lenorco Past. Co., Pierce Avenue, P.O. Box 143, Caloundra.	CL
W. M. Leonard and Sons, 'Welltown', Goondiwindi.	SH
C. J. and W. T. Lewis, 'Medland', Toowoomba Road, Crows Nest.	HF
P. M. Lewis, 'Spring Glen', Kingsthorpe.	FS

C. P. and E. G. Liebke, 227B West Street, Toowoomba. MG

O. H. and W. L. Lind, 'El-Jaycee', Gordon Brook South, M.S. 780, Kingaroy. BF

K. D. and J. K. Little, 'Woodleigh' Stud, Beaudesert. JS

R. and M. Little, Lauroy Past. Co., 'Lauroy', P.O. Box 72, Miles. CL, SM

H V. and N. A. Littleton, 'Lanacoora', Bowenville. LM

W. J. and A. Lloyd, 'Wriembilla', Chinchilla. SG

Lobegeier & Co., Wallaville. BF

G. L. and A. E. Lobegeiger, 'Sunny Grove' Jersey Stud, Moorang, via Rosewood. JS

N. E. Lobley, 'Neloby', Mt. Pleasant, via Dayboro. FS

L. K. Lostroch, 'Shamrock Vale', M.S. 212, Oakey. AIS

J. R. and M. D. Louittit, 'Lagoona', M.S. 979, Monto. BM

C. R. Loweke, 'Willowside', Kenilworth. JS

S. H. and R. L. Ludwig, 'Glenvale', Boyland, via Tamborine. GS

Lynn-Eden Braford Stud, 'Warrigal', Columboola. BF

J. A. and A. McCamley, 'Lancefield' Brahman Stud, Dululu. BM

W. J. McClelland Pty. Ltd., 'Oakland', Jandowae. HF

D. J. and W. E. Macdonald, 'Rosneth' Jersey Stud, Goombungee. JS

W. D. and M. M. McErlean, 29 Rowbotham St., Toowoomba. PH

F. W. McFadzen, 'Glenvale Friesian Stud', M.S. 1598, Sarina. FS

D. D. and J. L. McGuckin and I. D. and B. J. Francis, 5 Mile Rd., Tinana. HF

M. M. and G. E. McGuire, 13 Burton St., North Booval. CL

L. M., M. B. and I. D. McIntosh, 'Widgee Homestead', Widgee, via Gympie. AG

W. R. McIntosh, 'Roadvale' A.I.S. Stud, 1 Tipman Rd., Gympie. AIS

J. Mac'ntyre, Dulong Rd., Dulong, via Nambour. JS

P. D. Macintyre, Ti Tree Springs, P.S. 1096, Dulong, via Nambour. JS

G. N. and V. M. McNamara, 'Strath-Vale', M.S. 360, Bell. BF

J. and T. McNamara, 'Athol Pines', Athol, via Westbrook. PS

R. M. and E. C. McNaught, 'Kenjame Park', Abels Road, Woolooga. FS

F. A. Mallison, 'Ganbeer' A.I.S. Stud, M.S. 438, Boonah. AIS

C. R. and J. L. Marquardt, 'Cedar Valley' Stud, Box 69, Wondai. AIS

R. J. P. Martin, 'Jacaranda' Friesian Stud, M.S. 546, Forest Hill. FS

V. and D. Mason, "Deejay", M.S. 150, Pittsworth. AIS

R. G. and M. Matheson, 'Inabui', Eatonvale Road, Tinana. DM

R. G. and M. Matheson, 'Mioko', Owanyilla, M.S. 221, Maryborough. DM

J. B. and J. M. Matthews, 'Mt. Moriah', P.O. Box 15, Jondaryan. SM

R. F. and R. M. Maynard, 'Greenfields', Jambin. BM, CL

W. H. C. Mayne & Sons, 'Gibraltar', Texas. AG

F. D. and P. A. Mayo, 'Logan Park' Simmental Stud, Pacific Highway, Longanholme. SM

B. J. and B. F. Melrose, 'Glen Eildon' Braford Stud, 'Glen Eildon', Highfields. BF

G. H. Miller, Greenlake Rd., Rockhampton. BM

S. J. and H. L. Hiller, 'Nardoo', Miller St., Warwick. SM

Mimosa Stud & Cattle Co., 'Mimosa', Gayndah. DM

Mindaribba Pastoral Co., care of W. H. Perkins, P.S. 1608, Nanango. SG

R. C. Mogg, 'Raymount' Friesian Stud, Dulong, via Nambour. FS

P. A. Moore, 'Bell Tower', South Isis, Childers. BF

A. E. Morris, 'Hillsdale', Gowrie Junction. JS

P. Mort, 'Franklyn Vale', Braford Stud, Franklyn Vale, Grandchester. BF

G. W. Mowat, 'Town View', Jane Street, Yarraman. AIS

J. Mulholland, 'Widgee Crossing Santa Gertrudis Stud', 'Widgee Crossing', Gympie. SG

A. C. and G. A. Muller, 'Quamby', P.S. 1767, Maleny. FS

K. B. and K. T. Muller, 'Lyndon', P.O. Box 69, Clifton. CL

J. T. Mundell, 'Redmarley Stud', 'Redmarley', Condamine. SH

M. Newton, Imalland, Kaimkillenbun. PH

M. R. and D. E. Newton, 'Royelle', Kaimkillenbun. PH

A. and K. Niethe, Lockrose, M.S. 546, Forest Hill. DM

D. M. and M. T. Nolan, 'Maydan', M.S. 848, Warwick. BF

J. D. and K. F. Noonan, M.S. 182, Laidley. GS

M. J. and B. F. Norgaard, 'Yarrabine', Box 61, Post Office, Yarraman. FS

Norolle Past. Co., 'Norolle', P.O. Box 138, Roma. PH

R. J. and B. M. Nothdurft, 'Glen Heath', Yalangur, M.S. 918, Toowoomba. AY

N. F. Nutt, Fernyvale, Canungra. FS

A. O'Dwyer, 'Mt. Manning Past. Co., M.S. 422, Clifton. SG

L. & N. M. Ogden, 'Red Hill Brangus Stud', M.S. 1017, Biloela. BS

G. and K. G. Orphant, 'Westbank', Paterson. HF

J. D. O'Sullivan, Navilloween, M.S. 371, Greenmount. PH

P. W. O'Sullivan, 'Navleigh' A.I.S. Stud, M.S. 371, Greenmount. AIS

R. J. O'Sullivan, 'Beenbah Stud', Killarney. HF

E. I. and S. Pacholke, 'Sunnylawn', M.S. 74, Clifton. BF

Pagel and Hayes, 'Trafalga' Stud, Tarampa, via Lowood. AIS

L. R. Pain, 'Cabandah', Jandowae. BF

Palahra Farming Pty. Ltd., P.O. Box 19, Grantham. BF

L. S. Park & Co., 'Parklands', Maclagan. MG

C. W. W. Pask, 'Beacon Pastures Brahman Stud', 33 Perry Street, Mackay. BM

P. A. and J. T. Paterson, 'Wheel Park', M.S. 852, Hodgsonvale, via Toowoomba. FS

A. F. Paton, 'Warragah' Stud, M.S. 30, Millmerran. SG

C. F. Paton, 'Glenroy' Stud, M.S. 30, Millmerran. SG

E. A. Paton, 'Sherdale', M.S. 30, Millmerran. SG

K. H. Paton, Wallanba Past. Co., 'Sherglen Stud', 'Wallanba', Meandarra. SG

K. S. R. Patrick, Boyland, via Tamborine. GS

S. and S. M. Paulger, 'Adadale', Kenilworth. JS
M. C., R. C. W. and I. M. Pearce, M.S. 582, Toowoomba. JS
Pearson Bros., M.S. 1184, Murgon. COM.
J. N. Penglis, 'Pendale' Poll Hereford Stud, Westbrook Road, Wellcamp. PH
M. J. and E. M. Perkins, Byce Jersey Stud, M.S. 692, Nanango. JS
Perrett Grazing Partnership, P.O. Box 181, Kingaroy. PH
A. J. and M. T. Peters, 'Ashwell', M.S. 366, Rosewood. AY
A. V. Peters, Gladwyn Angus Cattle Co., M.S. 892, Meringandan. AG
L. W., M. J. and G. F. Peters, 'Wilmington' A.I.S. Stud, M.S. 212, Oakey. AIS
P. J. and V. R. Peters, Ripple Vale Angus Stud, M.S. 582, Toowoomba. AG
R. G. Pharoah, 'Merroo' Encourage Stud, P.O. Box 34 Chinchilla. HF, SM
C. W. Phillips, 'Sunnyview Park', M.S. 623, Warwick. AIS
J. Phillips and Sons, 'Sunny View' Stud, M.S. 90, Kingaroy. DM
Dr S. M. Piaggio, Natural Arch Farm, Natural Bridge, Numinbah Valley, via Nerang. FS
Pickering Brothers, 'Granite Vale' Stud, Sellins Road, Mt. Mee, via Dayboro. FS
R. J. Pontifex, Roburn Friesian Stud, M.S. 212, Oakey. FS
J. F. Porter, Westwood Jersey Stud, M.S. 16, Maleny. JS
N. R. Potter and Sons, 'Acton Vale' Stud, Wellcamp. PH, AIS
W. T. and E. A. Potter, 'Derrymore', Texas. CL
D. A. Price and Co., 'Deloraine', P.O. Box 7, Jimbour. CL
C. and E. L. Prosser, 'Thuruna' Stud, Tara. HF
H. D. N. and C. K. Quast, 'Lincolnfield', P.O. Box 150, Beaudesert. SM
E. R. and H. G. Quilty, 'The Grange', Nanango, care of P.O. Box 7, Nanango. SG
R. D. and G. R. Radunz, 'Cool Hill', Woorolin. SG
D. G. Raff, 'Forres', Karara. AG
O. A. Raine, 'Raine Drops Poll Hereford Stud', 43 Dunbeath Drive, Burpengary. PH
A. A. and M. I. Ranger, 'Glenoyra', M.S. 222, Oakey. AIS
A. W. Rasmussen Pty. Ltd., 'Praguelands', Alligator Ck., via Mackay. DM
E. J. Rassmussen, 'Euluma Stud', Mossman. DM
P. Rawson, 'Beenbah', Killarney. SG
K. R. and G. A. Reid, Goomeran, Thane, via Warwick. HF
Reid and Sons, 'Bundarra Hereford Stud', 'Gregmore', Malakoff Road, Dalby. HF
K. G. Reinhardt, 'Kenway' Red Poll Stud, M.S. 906, Mapleton. RP
B. W. and R. A. Reisenleiter, 'Viscount', M.S. 149, Gatton. HF
Research Station, Biloela. FS
S. B. and L. W. Reynolds, 'Moorlands', M.S. 918, Toowoomba. HF
K. O. Roberts, Purga Pastoral Co., School Rd., Purga. CL
J. and E. Robinson, 'Pinora Hereford Stud', Railway St., Jackson. HF
W. E. and R. M. Rose, 'Rosevale' Friesian Stud, M.S. 1184, Murgon. FS
A. J. T. and I. M. Ross, 'Rosdale' Stud, Dayboro Road, Samford. FS
W. Ross and Co., 'Starview' Stud, M.S. 23, Rosewood. AIS
P. D. and B. M. Rowley, 'Lac-Mel', Mt. Pleasant, via Dayboro. FS
L. D. Russell, 'Courtleigh' Brahman Stud, Woodford Rd., Peachester. BM
H. L. Rutledge and Co., 'Darrian', Jondaryan. PS
G. G. Savage, 'Ven Vale', Ramsey, via Cambooya. AIS
Estate of W. T. Savage, 'White Park', M.S. 852, Toowoomba. AIS
Sawley Family, c/- R. M. Sawley, 'Nakara Poll Hereford Stud', M.S. 394, Warwick. PH
T. D. and I. F. Sawley, 'Glengallan Poll Hereford Stud', M.S. 394, Warwick. PH
N. N. Schelbach, 'Allanview', M.S. 848, Warwick. AIS
Mrs K. W. W. and V. J. Schlodfeldt, 'Wyandah', P.O. Box 212, Beaudesert. SM
K. G. and M. A. Schloss, 'Tarlatin Hereford Stud', M.S. 648, Yarraman. HF
B. and T. Schmidt, 'Bando', Wyandra. BM
W. L. W. and D. J. Schossow, 'Teviot Brooke', M.S. 488, Boonah. FS
E. A. and R. E. Schroeder, 'Elverum Jersey Stud', Farm 21, Dagun, via Gympie. JS
C. N. Scott, M.S. 1471, Manumbar Road, via Nanango. FS
E. I. Scott and J. S. Edwards, 'Auchenflower', Glenore Grove, via Forest Hill. AY, FS
W. J. T. and D. V. Scrymgeour, 'Aberfoyle', 'Arran', Warwick. AG
G. C. Seibel, 'Mountvale', M.S. 848, Warwick. HF
L. Shaw, 'Padue' Stud, Karellpa, via Nambour. SM
L. J. Sheahan, 'Kyilla Park Stud', 'Kyilla' Condamine. HF
N. K. and S. B. Shelton, 'Vuegon', Hivesville. BF
J. and S. C. Siebenhausen, 'Merriton', M.S. 195, Pittsworth. AIS
J. S. and E. A. Sichter, 'The Loch Brahman Stud', Alligator Ck. BM
D. J. and S. R. Simpson, 'Kildirk', Commissioners Flat Road, Woodford. AIS
R. E. Simpson, 'Tangarine Springs', 25 Waraba Crescent, Caboolture. MG
F. Sippel, 'Callemondah', Ballandean. JS
A. W. and M. J. Skerman, 'Ar-Dee' Braford Stud, 'Rossman Downs', M.S. 590, Wandoan. BF
B. S. Skerman, 'West View' and 'The Highlands', Booroobin, via Maleny. AIS
W. R. Slatter and Sons, Berryglen Murray Grey Stud, M.S. 1605, Killarney. MG
E. J. Smith, 'Hillcrest' Ayrshire Stud, Borallon, via Ipswich. AY
F. H. and E. Smith, Sommerville Brahman Stud, 'Brahmeadows', M.S. 1883, Rockhampton. BM
F. J. and H. R. Smith and Sons, 'Rubyvale' Angus Stud, 'Bralea', Burnside Road, M.S. 1096, Nambour. AG
J. Z. Smith, Alum Rocks, Amiens. HF
L. D. and G. L. Smith, 140 Wecker Road, Mansfield. AIS
L. W. and K. J. Smith, 'Judi-Jindi' Braford Stud, M.S. 501, Dalby. BF
M. T. and B. R. Smith, 'Pamalyn' Friesians, Wellcamp. FS
N. S. Smith, 'White Gates Friesian Stud', M.S. 90, Kingaroy. FS
W. Spresser and Sons, 'Carnation', Mt. Walker Road, Rosewood. JS
A. H. and B. J. Springall, 'Beralan' Braford Stud, Imbil. BF
Stanbroke Past. Co., 'Waverley', St. Lawrence. BM
A. E. Stanton and Sons, Stanton's Dairy, South Pine Road, Strathpine. FS
P. Steel, 'Jerra Marumba', Witta, via Maleny. RP
Dr J. A. Stephenson, 'Sahwalid Sahiwal Stud', 'Belli Downs', Kenilworth Road, Belli, via Eumundi. SW
H. J. Stewart, 'Wycombe', St. George. BF
N. L. Stiller, 'Vine Veil', Guluguba. PH, HF, CH
M. D. Stokes, P.O. Box 56, Laidley. JS
E. A. Stubbs, 'Baroona Park', Canaga Road, Chinchilla. BF

R. L. and V. M. Stumer, 'Lavron Nook' Friesian Stud, M.S. 484, Boonah.	FS
L. R. and P. M. Summerville, 'Fairy Bower', Cryna, via Beaudesert.	FS
K. Sutton, 'Startwell', Basin Road, Wamuran.	BM
Tarata Pty. Ltd., 'Tarata', M.S. 212, Oakey.	CL
Tennant and Geddes, 'Doonside', Rossmoya, via Rockhampton.	BF, BS
H. R. and D. M. Thomas and Son, 'Euranga-tuck', Jandowae.	HF
C. Thompson, 'Kingston', Dulacca.	BF
W. H. and D. M. Thompson, P.O. Box 20, Nanango.	AIS
H. G. M. and B. V. Thorne, 'Dewhurst Stud', Hatton Vale, via Laidley.	JS
T. L. and U. J. Tidcombe, 'Wallumlands A.I.S. Stud', M.S. 493, Bells Bridge, Gympie.	AIS
A. J. and E. A. Tigell, 'Avondale', Googa Creek, Blackbutt.	MG
J. R. Todd, 'Aberfoyle', Laravale, via Beaudesert.	JS
Tomkins Pastoral Co., 'Stuart's Creek', Roma.	HF
Mrs B. Tout, 'Berrima', Elbow Valley, Warwick.	AG
R. N. and C. M. Towner, Par Deux Droughtmaster Stud, Thornton, M.S. 182, Laidley.	DM
R. R. and E. D. Treasure, 'Iona Park', Brigalow.	MG
J. P. and V. Trier, 'Tamrookum Valley' Braford Stud, Rathdowney.	BF
D. C. Tunstall, 'Hi Valley', M.S. 692, Nanango.	SH
M. Vandoren, 'Glen-Aero' Stud, P.O. Box 46, Applethorpe.	MG
P. and B. H. Van Popering, 'Brunetta' Jersey Stud, Coominya Road, Lowood.	JS
S. I. Vellnagel, 'Rosedale', Brigalow.	HF
A. R. Vohland, M.S. 150, Pittsworth.	JS
E. M. Voight, 'Chelmadale' Stud, M.S. 825, Ipswich.	BF, AIS
W. T. and L. Voss, Mt. Vista Stud, M.S. 292, Glamorgan Vale, Ipswich.	AIS
D. V. Wagner & Co., 'Aranbanga Braford Stud', 'Barncleuth', Gayndah.	BF
Wal-Anne Pastoral Co., 'Wal-Anne' Stud, P.O. Box 2, Haden.	PH
Walloon Pastoral Co., 'Walloon', Banana.	AF, BR
L. N. and S. A. Walker, 'Strathmore No. 65', 'Strathmore', Longreach.	SG
R. and M. Walther, 'Roseborough', P.S. 1790, Lowood.	BM
I. L. and M. R. Walker, Menlo Park Stud, M.S. 1573, Southbrook.	DM
Sir James Walker, 'Cumberland', Longreach.	SG
Sir James Walker, 'Camden Park', Longreach.	SG
M. L. and R. A. Walker, M.S. 366, Rosewood.	SM
G. I. Warfield, 'Dernan Court', M.S. 223, Nobby.	PH
P. R. and H. D. Watters, 'Lynford' Stud, Callemondah, Ballandean.	JS, HF
G. C. and C. A. Webster, Gympie.	BF
B. G. and B. Wells, Burdilla Murray Grey Stud, Thorton, M.S. 182, Laidley.	MG
M. G. and G. E. Weir, 10 Wickham Street, Laidley.	PH
E. E. W. West, 'Belmadochie', 19 Oatlands Court, Samford.	FS
A. C. and V. J. Westphal, 'Alun Jersey Stud', M.S. 342, Roadvale.	JS
Wharton Creek Past. Co., Wharton Creek, Springsure.	BF
K. Wheildon, 'Good Luck', Lower Cressbrook, Toogoolawah.	FS
Whitney Past. Co., Claverton Stud, Wyandra.	SH
F. A. Willey, 'Mar-sel Stud', M.S. 292, Lowood Road, Glamorgan Vale.	AIS
J. R. Williams, 'Forest Glen', Columboola.	BF
C. T. Williamson and Son, 'Colelgre Angus Stud', 'Eagle Farm', Nobby.	AG
L. W. and N. E. Wilmot, Koetong Hereford Stud, P.O. Box 7, Applethorpe.	HF
J. N. Wilson and Son, 'The Valley', Blackbutt.	DM, BM
R. S. Wilson, Calliope Station, Gladstone.	HF
W. G. Wilson, 'Tarko', M.S. 444, Jondaryan.	RP
S. J. and N. E. Wippell, 'Morocco', Roma.	HF
A. R. and G. G. Wockner, 'Durn' Stud, Maclagan.	AG
D. B. and V. M. Wolter, 'Cobba Poll Hereford' Stud, Beenleigh.	PH
O. J. and S. D. Woodcock, 'Kanara', Yelarbon.	BF
A. and A. Woodgate, 'Woodgate Park', Biddadabba, via Tamborine.	FS
G. T. and H. E. Woods, 'Hazelwood' Jersey Stud, M.S. 906, Mapleton.	JS
J. R. and A. Woods, 'Jarmal', M.S. 16, Maleny.	DM
K. V. Wright, 'Wattle Vale', M.S. 288, Boonah.	FS
M. G. Wright, 'Bethany' Stud, Mapleton Road, M.S.F. 956, Montville.	FS
Wyalla T.D.T., 'Wyalla', M.S. 886, Texas.	CL, LM, SM
J. A. Wyatt, 'Rokeby', Warwick.	HF
L. and J. Wyvill, P.O. Box 116, Warwick.	SM
Dr B. R. Yeates, 'Ugarapul', Boonah.	DM
G. S. Young and M. J. Cooper, 'Coograli', North Maleny Road, Maleny.	BF
R. and J. Ziesemer, Belbar Stud, Bell.	HF
L. W. and H. M. Zirbel, 'Lacewood', Derrymore, via Helidon.	PH
E. F. and I. M. Zischke, 'Lynview' Jersey Stud, M.S. 231, Laidley.	JS

KEY

Afrikaander—AF
Angus—AG
Australian Illawarra Shorthorn—AIS
Ayrshire—AY
Belmont Red—BR
Braford—BF
Brahman—BM
Brangus—BS
Charolais—CL
Chianina—CH
Devon—DV
Droughtmaster—DM
Friesian—FS
Guernsey—GS
Hereford—HF
Jersey—JS
Limousin—LM
Marchigina—MA
Murray Grey—MG
Poll Devon—PD
Poll Hereford—PH
Poll Shorthorn—PS
Red Poll—RP
Sahiwal—SW
Santa Gertrudis—SG
Shorthorn—SH
Simmental—SM
Commercial—COM

CROSSBREEDS

Hereford X Chianina—HF X CH
Shorthorn X Chianina—SH X CH
Afrikaander X Belmont Red—AF X BR
Mixed—MIXED

The following herds have been withdrawn from the Bovine Brucellosis Accredited-Free Herd Scheme.

L. T. and T. O. Christensen, Coolaroo Jersey Stud, Moorang, via Rosewood.	JS
H. J. Murray, Greydale Murray Grey Stud, Upper John Street, Rosewood.	MG
Dr and Mrs R. H. Parker, Little Sussex Charolais Stud, Charleville.	CL

Brucellosis tested swine herds as at 31-5-78

Aboriginal and Island Affairs Department, Cherbourg.	LW
P. and N. Batterham, Raby Park, Inglewood.	L, LW
R. A. and B. E. Bool, Rossvale Stud, M.S. 223, Nobby.	LW, L
D. J. Brosnan, Bettafield, Mt. Murchison, via Biloela.	LW, L
F. D. and E. C. W. Corney, Pagel, Tara.	LW
N. J. Cotter, Olarey, Goomeri.	LW
R. H. Crawley, Rockthorpe, Linthorpe.	B
G. F. and A. M. Dean, Home Creek, Wooroolin.	LW, LB
E. Diete, 'Ettrock', Ingoldsby.	X
Mrs W. S. Douglas and Son, Greylight, Goombungee.	W
R. and L. M. Duckett, Fairview, Capella.	L, LW
C. P. and B. J. Duncan, Colley, Flagstone Creek, Helidon.	LW
J. A. and B. L. Duncan, Ma Ma Creek.	LW
Dunlop Meats Pty. Ltd., Coondulla Stud, 8 Malkara Street, Townsville.	L, LW
L. Fletcher, 'Par-en-eri', P.O. Box 143, Mundubbera.	LW, L
K. J. and B. D. Fowler, Kenstan, M.S. 195, Pittsworth.	L, LW
K. P. Fowler, Northlea Stud Farm, Hogg Street, P.S. 1436, Toowoomba.	L, LW
N. E. P. and M. P. Fowler, care of Kewpie Enterprises, Kingaroy.	L, LW, X
K. H. and B. Franke, Delvue, Cawdor.	LW
W. A. Freeman, Trevlac, Rosewood.	LW
W. E. and J. Geysing, Oakhurst, via Maryborough.	LW
S. C. Goodwin, Windera, M.S.F. 571, Murgon.	L
D. F. and R. F. Goschnick and W. M. and K. J. Pearce, 'Echoes', Bancroft, via Monto.	LW
T. G. and E. A. Gosdon, Naumia, Dalby.	L, LW
D. G. Grayson, Wodalla, Killarney.	L, LW
A. H. and R. N. Grundy, Markwell Piggeries, M.S. 499, Toowoomba.	L, LW
H. M. Prison, Etna Creek, via Rockhampton.	LW
H. M. State Farm, Numinbah.	B, LW
H. M. State Farm, Palen Creek.	LW
G. R. Handley, Locklyn Stud, Lockyer.	B
D. F. and R. K. Hinchliffe, Oakview, Milman, via Rockhampton.	L, LW
R. F. and V. D. Hudson, Rondel, Hogg Street, Wilsonton.	L, LW
K. B. and I. R. Jones, 'Cefn', M.S. 544, Clifton.	LW, L
C. and D. I. Kajewski, Glenroy, Glencoe, via Toowoomba.	LW, L
R. E. and M. D. Kajewski, 'Robmar' Stud, Acland.	L
A. R. Kanowski, Exton, Pechey, via Crows Nest.	LW
S. E. Kanowski, Miecho, Pinelands, via Crows Nest.	T
C. F. Kimber, M.S. 698, Biggenden.	L
E. R. Kimber, Tarella, M.S. 805, Mundubbera.	LW, B
I. E. and C. C. Kimber, 'Splenda View', Coalstoun Lakes, M.S. 698, Biggenden.	L
V. F. and B. L. Kruger, Greyhurst, Goombungee.	LW
V. and C. A. Kuhl, 'The Mounts', Boodue, M.S. 222, Oakey.	LW
R. R. and L. M. Law, 'Summerset', M.S. 757, Kingaroy.	LW, L
A. L. Ludwig, Beauview, Cryna, via Beaudesert.	B
Maranoa Stud Piggery, Mitchell.	L, LW
K. Mathieson, Iderway, Gayndah.	LW
W. Neuendorf, M.S. 794, Kalbar.	B
D. O'Connor, Rollingstone.	L, LW, X
T. O'Connor Enterprises 32 East Street, Toowoomba.	LW
G. R. and B. J. Patch, 'Kiara', Bell.	L, LW, X
L. A. Peters, Moonlight, Bongeen.	L
Queensland Agricultural College, Lawes.	B, LW
V. V. Radel, Braedella, Coalstoun Lakes.	LW
Research Station, Biloela.	LW
Research Station, Hermitage.	B
A. B. Robin, Blaxland Road, Dalby.	LW, L
G. Rosenblatt, Rosevilla, Biloela.	L, LW
A. F. and V. M. Ruge, 'Alvir' Stud, Biggenden.	LW
D. W. and L. J. Sharp, 'Arolla' Lavella, via Millmerran.	LW, L
G. A. Smith, 'Miandetta', M.S. 162, Warwick.	X
Smyth and Hewess, Woorilla, Goomeri.	L, LW
L. B. and L. J. Trout, 'Caminda', Crawford, via Kingaroy.	L, B
Wearmouth Piggeries, care of G. Varidel, Dalby.	X
Westbrook Training Centre, Westbrook.	B
L. J. Willett, Wongalea, Irvingdale, M.S. 232, Bowenville.	LW, L
K. Williamson, Cattermul Avenue, Kalkie, Bundaberg.	LW, L

KEY

Landrace—L	**Berkshire—B**	**Wessex—W**
Large White—LW	**Tamworth—T**	**Crossbreed—X**

Sulphur deficiency in pastures on the Darling Downs

by L. R. Loader and P. J. White, Agriculture Branch.

MANY farmers on the Darling Downs use fertilizers containing sulphur to boost production of pastures on their properties.

Sulphur applications have been directly responsible for increased quality and quantity of pastures, increased persistence of sown species in mixed pasture, and reduced infestation by weeds.

On a heavy clay at Gladfield, lucerne yields were doubled and protein contents increased by half with the addition of sulphur fertilizer.

A similar result occurred with naturalized medic on a shallow soil at Umbiram. On this site, the yield of native grasses was increased by half and the protein content increased by a quarter with sulphur application.

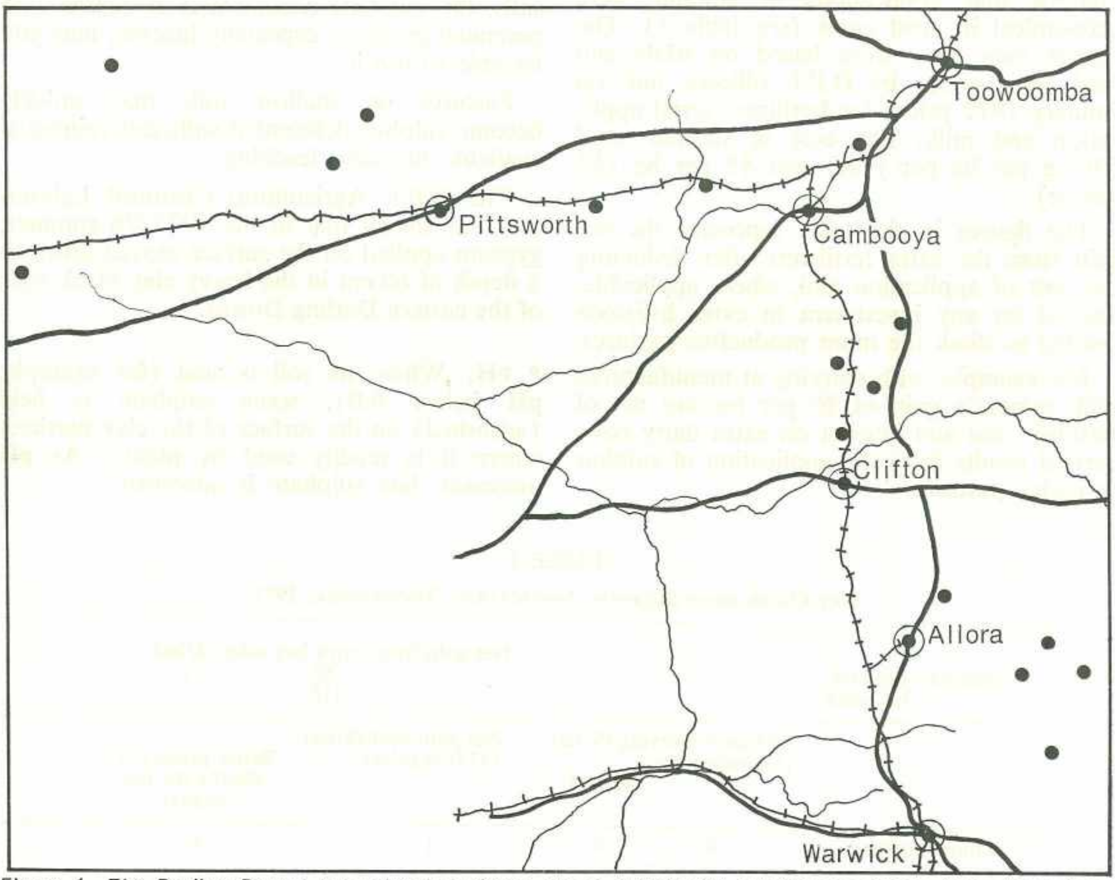


Figure 1. The Darling Downs area showing places where substantial sulphur responses have been found (indicated by black dots).

In mixed pasture at Nobby on a shallow soil, the yield increased by two and a half times with sulphur addition. The protein yield trebled.

Sulphur application can be a paying proposition.

How widespread is S deficiency?

Replicated trials have confirmed that responses of pastures to sulphur fertilization are widespread on the Darling Downs (see figure 1). Other observations have been made of responses of pasture to sulphur, particularly on the shallow soils of the upland ridge country.

Does S application pay?

J. S. Sloane (Economic Services Branch) and J. K. Cull (Agriculture Branch) of the Toowoomba D.P.I. Office, showed in a recent analysis that applications of sulphur were economical in most cases (see table 1). The figures they used were based on trials and field observations by D.P.I. officers, and on January 1977 prices for fertilizer, aerial application and milk. The cost of sulphur used (30 kg per ha per year) was $5 per ha ($2 per ac).

The figures in the table represent the net gain from the extra fertilizers after deducting the cost of application and, where applicable, interest on any investment in extra livestock needed to stock the more productive pastures.

For example, with dairying at manufactured milk prices, a gain of $6 per hectare net of fertilizer cost and interest on extra dairy cows carried results from the application of sulphur to native pastures.

When are pastures likely to respond to applied S?

Whether a pasture will respond to sulphur fertilizer is related to several factors.

• TIME OF YEAR. Deficiency symptoms of sulphur in pastures will most likely appear after a good growing season (that is, in autumn). This is due to soil reserves being used up.

• AGE OF PASTURE. The longer a pasture has been established, the more soil sulphur has been used up, and the pasture is likely to respond to applied sulphur.

• DEPTH OF SOIL AND SUBSOIL S. Sulphate may be leached out of the profile of a shallow soil over a period of time. In deeper alluvial soils, this sulphate accumulates at depths, and perennial pastures, especially lucerne, may still be able to use it.

Pastures on shallow soils may quickly become sulphur deficient if sufficient rainfall is available to cause leaching.

The D.P.I. Agricultural Chemical Laboratory has shown that in the 1975/76 summer, gypsum applied on the surface moved down to a depth of 60 cm in the heavy clay black soils of the eastern Darling Downs.

• pH. When the soil is acid (for example, pH below 6.0), some sulphate is held (adsorbed) on the surface of the clay particles where it is readily used by plants. As pH increases, less sulphate is adsorbed.

TABLE 1

NET GAINS FROM SULPHUR APPLICATION, TOOWOOMBA, 1977

		Net gain from extra hay sales ($/ha)
Lucerne—dryland		20
irrigated		115

	Net gain dairying ($/ha) Manufacture	Quota	Net gain beef ($/ha) 1975/76 prices	Better prices (i.e. 60c/kg dw for steers)
Natural pasture	6	9	1	4
Improved pasture	5	9	2	6

TABLE 2

THE AMOUNT OF FERTILIZERS TO APPLY TO 50 m^2 FOR TEST STRIPS

Element	Form of Fertilizer	% of element in fertilizer	Rate of Element (kg/ha)	Amount of Fertilizer (gm)
Sulphur	Elemental S	100	60	300
Nitrogen	Urea	46	80	860
Phosphorus	High analysis phosphate fertilizer	20	50	1250

On the alkaline soils of the Darling Downs (pH above 7.0), very little adsorption occurs and the sulphate can be more readily leached out of the root zone.

• IRRIGATION. Irrigation practices can cause increased leaching of sulphate. Greater pasture growth and subsequently greater removal of hay will also deplete soil reserves faster than under dryland conditions.

• TYPE OF PASTURE. Native pastures containing naturalized medics and grasses are generally grown on country not suitable for improved pastures and crops. This ridge country is often sulphur deficient. Research has shown that these pastures will respond to sulphur just as often as improved pastures and lucerne.

Symptoms and diagnosis of S deficiency

Diagonsis of sulphur deficiency can be difficult, but correction of the problem is a simple matter.

The symptoms are often not dramatic or distinctive. They are expressed first by a lack of vigour. This is not always detected by the farmer because it is difficult to assess. The pastures do not grow as well and appear to become more weedy. Loss of yield and reduced life of the pasture is the result.

In legumes, sulphur deficiency decreases nitrogen fixation efficiency. Some plants, notably medics, develop purple and brown tints in the stems and leaves.

Lucerne has short, thin stems and small leaves when sulphur is deficient. The plants also assume a hard, woody appearance. With more severe deficiency, the leaves become a pale green-yellow colour.

In grasses, sulphur deficiency symptoms appear as a general stunting with interveinal chlorosis (striping). The new leaves are more affected and these can be completely yellow under severe deficiency.

Positive early identification of sulphur deficiency can seldom be made by observing plants in the field. If the deficiency is visually obvious, there has already been a substantial reduction in yield.

Plant tissue tests are unreliable under field conditions, because climatic and nutritional conditions are generally not ideal. A soil analysis for sulphur determination is not presently available through the D.P.I. However, research is in progress to determine the best ways to test the heavy clays of the Darling Downs for sulphur.

To date, most sulphur deficiencies in the field have been identified by the application of sulphur fertilizer. This has resulted in visual responses in growth and/or colour of the plants treated. Plants responding to sulphur are taller and have a deeper green colour.

You may wish to know if deficiency of sulphur or other elements is restricting the growth of your pasture. Use hand broadcasting, a combine planter or a fertilizer spreader to apply overlapping strips of straight fertilizers of the nutrients you wish to check. In grasses, nitrogen and sulphur should be applied; for legumes—phosphorus and sulphur.

A proposed plan for putting out test strips is given in figure 1, 'Sulphur and plant nutrition' in this issue. The overlapping strips provide combinations of nutrient treatments which may detect multiple deficiencies.

If hand broadcasting, use plots of 10 m x 5 m dimensions. The rates of fertilizers to use per plot are shown in table 2.

These rates of fertilizer are higher than standard recommendations. In test strips, it must be ensured that the plants respond as much as they can to the applied fertilizers.

Correction of S deficiency

Sulphur is available as fertilizer in many forms. Three of the cheapest forms are:

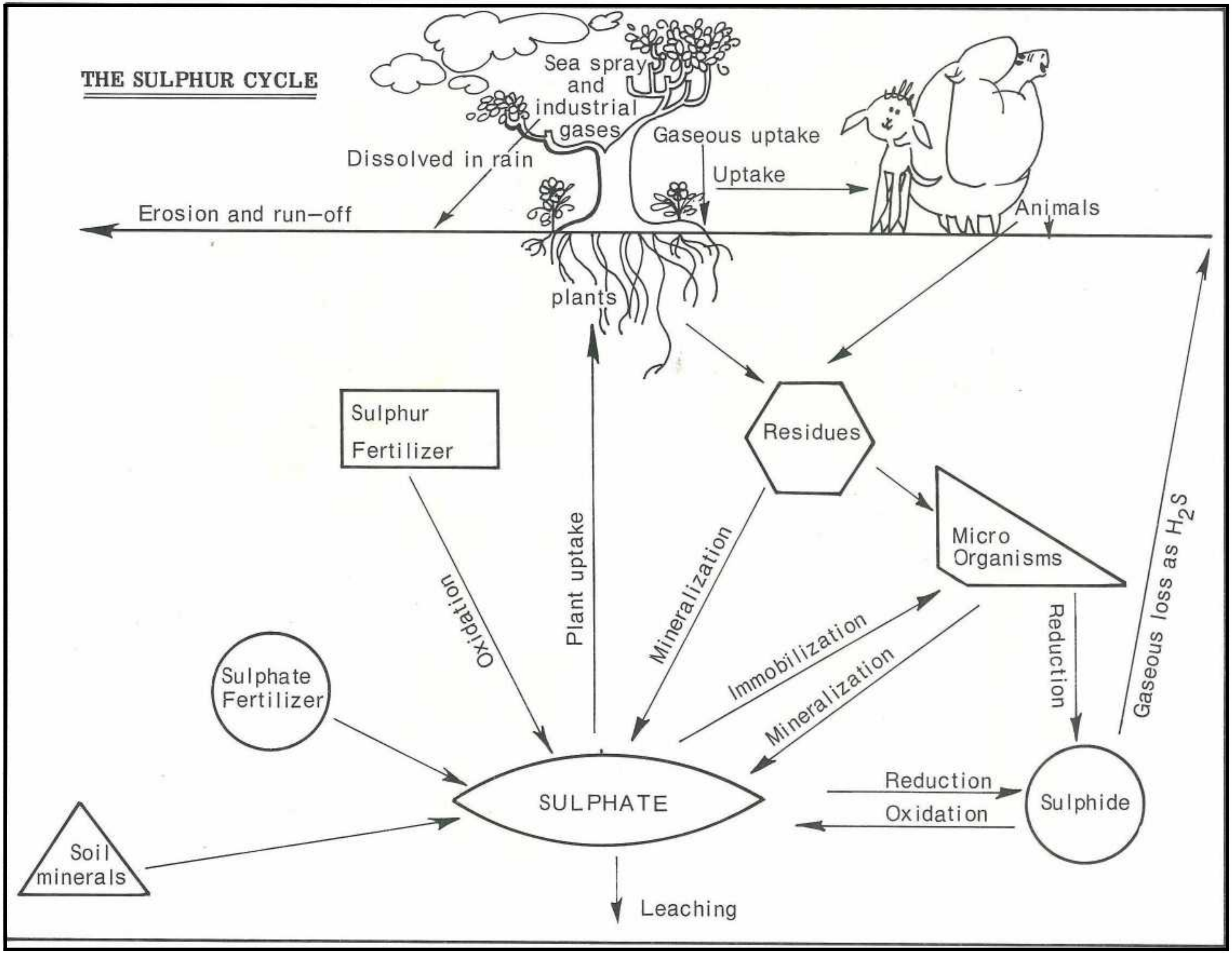
- Granulated sulphur. This costs $4.80 per ha for the recommended 30 kg per ha per year spread by air or $4.35 per ha spread by tractor and fertilizer spreader. Sulphur in this form in the elemental state has the advantage of not being very susceptible to leaching in the soil.

- Dump gypsum (14.5% sulphur). This is difficult to spread and because the sulphur content is lower, more of the product has to be spread to apply a certain amount of sulphur. Dump gypsum cannot be applied from the air. Cost of ground spreading is $7.94 per ha per year at the rate of 30 kg S per ha per year. This includes the cost of dump gypsum at Brisbane ($6.50 per tonne), freight to the Darling Downs ($12 per tonne) and spreading costs. The sulphur in gypsum is more readily leached than that in granulated sulphur because it is in the sulphate form, but it is also more readily available to plants.

- Super and sulphur (25.2% sulphur). This is recommended where phosphorus is also required. The cost is $9.79 per ha per year for ground application of the 120 kg super and sulphur needed to provide 30 kg per ha of sulphur.

Conclusion

Sulphur deficiency may be a problem in your pastures. Do not wait until you lose money through loss of yield. See your D.P.I. adviser now, or try a test strip for yourself.


THE SULPHUR CYCLE
Sea spray and industrial gases
Dissolved in rain
Gaseous uptake
Uptake
Erosion and run–off
Animals
plants
Sulphur Fertilizer
Residues
Micro Organisms
Oxidation
Plant uptake
Mineralization
Immobilization
Mineralization
Reduction
Gaseous loss as H_2S
Sulphate Fertilizer
SULPHATE
Reduction
Oxidation
Sulphide
Soil minerals
Leaching

Some sulphur

Plate 1.

Plate 3.

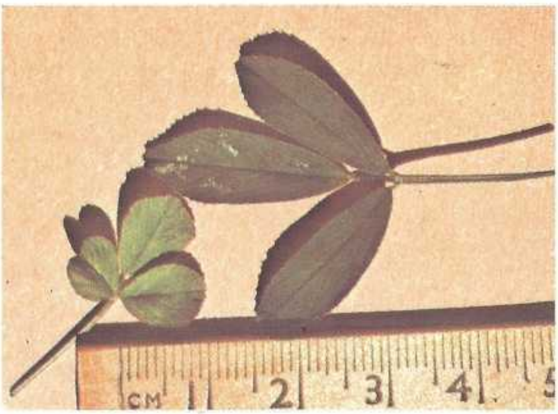


Plate 2.

Plate 4.

by P. J. White and L. R. Loader, Agriculture Branch

deficiencies

Plate 5.

Plate 7.

Plate 6.

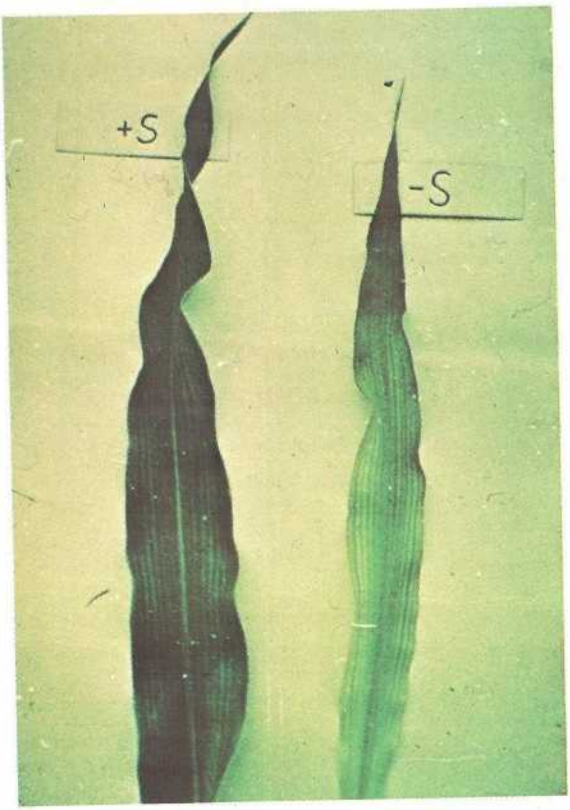


Plate 8.

Plate 1

AN unthrifty stand of lucerne (foreground) responded in growth and colour to sulphur fertilization (background).

This lucerne stand was stunted and yellowish when the owner, Mr Suhr, of Plainby near Toowoomba, top-dressed it with sulphur. There was a colour response in 2 weeks and an obvious growth response after 4 weeks. Mr Suhr top-dresses the lucerne with 30 kg S per ha early each spring. This stand is typical of many older lucerne stands on the shallow basaltic soils of the eastern Darling Downs.

Plate 2

SULPHUR deficiency results in decreased leaf size and poor colour in lucerne.

A trial was conducted on Mr Hart's property at Allora, on a black earth. With application of sulphur, the yield of lucerne was doubled. The leaf on the left was taken from an unfertilized plot. Compared to the non-deficient leaf (right), it shows general unthriftiness, decreased size and development, and a pale colour.

Plates 3 and 4

BURR medic and woolly burr medic respond to sulphur on upland basalt soil at Goomburra.

The medic growth in Mr Smith's native pasture at Goomburra was poor (plate 3) until he began using sulphur fertilizer.

He applied 30 kg per ha as super and sulphur in April, 1967 (plate 4). In April 1968, he applied another 30 kg per ha as super and sulphur to one-half of the paddock (back-ground, plate 4). This photograph was taken in September 1968.

The need for 30 kg S per ha per year is clearly demonstrated by the differences that are shown in plate 4.

Plate 5

PORTION of a native pasture trial at 'Banchory', Umbiram, showing the colour and growth response of woolly burr medic to sulphur application on plots.

Results from this trial on native pasture colonized with woolly burr medic on a shallow skeletal basaltic soil on the eastern Darling Downs show that:

- A single application of 67 kg S per ha gave a continuing but decreasing dry matter yield response in woolly burr medic over 3 years.
- Additional annual applications of 22 kg S per ha increased this response.
- Native grasses also responded in the sixth and seventh years of sulphur application.
- The nitrogen content of both medics and grasses was increased with sulphur fertilization.

Plate 6

AN improved mixed pasture containing green panic responded to sulphur (left) on a dark-brown basaltic clay.

Sulphur increased dry matter yield of green panic and naturally occurring burr medic. Dry matter yield response of green panic to nitrogen was dependent on the presence of sulphur.

Crude protein yield also reflected the response in dry matter.

The crude protein content of green panic was inversely related to dry matter yield.

Following five annual applications of sulphur, basal cover of the green panic was higher and that of native grasses lower compared with treatments receiving no sulphur.

Plate 7

OATS respond to sulphur and nitrogen fertilizer.

Mr Day of Ballandean, noticed that the leaves of oats growing on a deep sand at his property showed a striping condition. Test strips of nitrogen and sulphur were put down and the oats responded to both of these elements.

The plants received (from left to right), no fertilizer, nitrogen, nitrogen plus sulphur.

These plants show that, in most situations, grasses need basal dressings of nitrogen before they can respond to sulphur.

Plate 8

MAIZE leaves with and without sulphur. (Photograph courtesy of The Sulphur Institute).

This photograph shows the characteristic striping that occurs in maize with sulphur deficiency. It is similar to zinc deficiency, but there are important differences:

- Sulphur deficiency symptoms appear firstly on younger leaves:—zinc symptoms appear on older leaves.
- Sulphur deficiency symptoms appear firstly in the veins of leaves:—zinc deficiency appears between the veins.

Sulphur in plant nutrition

ALL plants require sulphur for growth.

They obtain this nutrient by a series of complex interactions in the environment commonly called the 'sulphur cycle'. This is similar to the nitrogen cycle, relying heavily on micro-organisms in the soil.

The system is complex, and involves plants, animals, atmosphere and soil.

Transformations in the soil

Plants take up sulphur in the sulphate form. Therefore, processes involving production of sulphates are important.

A wide range of micro-organisms is involved. Their populations vary with the type and amount of residues available. Population fluctuations are quite large and rapid. As microbiological action controls the sulphur available to plants, the conditions under which bacterial action is favourable are important to plant growth.

The main conditions are:

- Good soil aeration.
- High moisture content.
- Soil temperatures of approximately 30°C.
- High S and low C content of organic matter.

Four microbially-controlled processes influence the sulphate status of soils.

Mineralization

Many species of soil micro-organisms are responsible for mineralization. These break down organic matter (for example, plant and animal residues), and by a complex series of processes convert the large organic molecules to sulphates which plants can readily absorb.

Immobilization

Immobilization is the process in which simple compounds of sulphur are taken up by micro-organisms and immobilized in their body cells. This means that micro-organisms take up the sulphate molecules for their own biological processes. As a result, the sulphate is unavailable to plants.

Oxidation

Sulphur present in the soil as elemental sulphur (from fertilizer addition) or as sulphides (from previous waterlogging) must be converted to sulphate before plants can use it.

Thiobacillus thiooxidans is the principal micro-organism involved in this oxidation process. As the process is biological, it occurs most rapidly when finely divided fertilizer is in a warm, moist soil.

Reduction

Under prolonged conditions of poor soil aeration usually due to waterlogging, certain soil bacteria (*Desulfovibria* and *Desulfomaculum*) 'reduce' the sulphate to the sulphide form. This sulphide usually reacts with iron or manganese to form insoluble compounds. This results in temporary sulphur deficiency.

Where water remains ponded on soil, the 'rotten egg' gas, hydrogen sulphide (H_2S), is produced and is lost to the atmosphere.

by P. J. White and L. R. Loader,
Agriculture Branch.

Gains and losses to the system

GAINS

• Atmosphere. In industrial areas, the air contains sulphur dioxide (SO_2) gas as a pollutant from oil or coal burning. Along coastal strips, sulphate salt dust from evaporated sea spray is carried into the atmosphere by wind.

Atmospheric sulphur can be taken in directly by plant leaves or can enter the soil with rain water. The contribution of atmospheric sulphur to the soil system can vary.

New Zealand data indicates that annual sulphur addition in rainfall is about 5 kg per ha at the coast, and reduces to about 1 kg per ha at a distance of 100 km from the coast. The authors did not indicate the contribution of sulphur dioxide from secondary industry in the data.

• Plant material. Plants may produce a net gain of sulphur in the plant/soil system because they take up sulphates and so reduce leaching.

• Fertilizer. Sulphur fertilizer application contributes sulphur to the soil system.

LOSSES

• Erosion and run-off. Large quantities of topsoil are removed from some Queensland soils every year. In this way, organic matter and minerals containing sulphur are lost from agricultural soils. Small losses of sulphur occur in run-off in the absence of soil erosion.

• Leaching. Sulphate can be leached, especially from sandy and alkaline soils. In these soils, annual application of sulphur may be required; in heavier clay soils where leaching is minimal, less frequent applications of sulphur are usually necessary.

MINOR LOSSES AND GAINS

Minor losses from soil systems occur when hydrogen sulphide gas is given off from waterlogged soils, or when plants give off some gaseous sulphur compounds to the atmosphere.

Minor gains to the soil system can occur through rain leaching soluble sulphur compounds out of plants.

Sulphur in plants

Uptake and utilization

Plants take up sulphur as the sulphate ion (SO_4^{--}). Quantities taken up are reflected in their use of the element (see table 1). Plants use sulphur for the synthesis of proteins, via manufacture of the important amino acids—cysteine and methionine. These amino acids are important in animal nutrition, especially for non-ruminants.

Deficiency

Deficiency symptoms of sulphur appear first on younger leaves but may spread over the plant. This is because sulphur is slightly mobile in the plant and unless there is gross deficiency, some redistribution of the element occurs from the old to the new tissue.

Symptoms are generally characterized by a lack of vigour of the plant, thin stems, and a general yellowing (chlorosis) of plant tissue. These symptoms, as with those of other deficiencies, begin to appear only after the plant has already experienced retarded growth.

Diagnosis

Diagnosis of sulphur deficiency by plant analysis is unreliable and soil tests are costly and time consuming.

TABLE 1

SULPHUR USED IN PRODUCTION OF SELECTED CROPS

Crop	Yield T/ha	Sulphur Used kg/ha
Lucerne	15·0	33·0
Maize	4·8	14·5
Soybeans	2·0	15·0
Wheat	3·0	10·0
Cotton	3·75 bales	14·0
Onions	20·0	11·0

TABLE 2

SOME FERTILIZERS AVAILABLE FOR CORRECTION OF SULPHUR DEFICIENCY

Name of Product	S%	Other Elements	Equivalent Rates for 30 kg/ha S (kg/ha)
Superphosphate	10	P – 9·2%, Ca – 20%	300
Dump Gypsum*	14·5	Ca – 18·5%	207
Ammonium sulphate	24·0	N – 21%	125
Super + sulphur*	25·2	P – 7·5%, Ca – 16·5%	120
Elemental S	99	Nil	30
Sulphate of potash	17	K – 42%	177
Mo Super	10	Ca – 19·9%, Mo – 0·02%, P – 9·1%	300
Mixtures	(1–18·8)		

* Available only in bulk in Queensland.

FIGURE 1

Possible layout of test strips to ascertain S response. Sulphur is applied to the whole strip and combinations of N and P or any other element are then added in separate sections.

		P	P	
S	Sulphur + Nitrogen	Sulphur + Nitrogen + Phosphorus	Sulphur + Phosphorus	Sulphur
	Nitrogen	Nitrogen + Phosphorus	Phosphorus	Control
	N	N		

Research is currently being undertaken by officers of Agriculture Branch and the Agricultural Chemistry Laboratory to improve the accuracy of soil analysis techniques.

Sulphur deficiency may be diagnosed by the use of field test strips. These should be laid down in such a way that response to sulphur is not confused with responses to other elements. For this reason, sulphur or gypsum should be used in test strips and other elements added to part of the strip so that some sections also receive these nutrients. A layout for test strips is shown in figure 1.

Sulphur fertilizers

Several types of fertilizers, each with their own characteristics, are available on the market (see table 2).

Fertilizer type and quantity will have to be decided for individual situations. Soil type, crop grown and previous history of the site must be considered.

Departmental officers are available to assist primary producers to correct problems with sulphur nutrition.

Helicopter mustering

by A. J. Ernst, Beef Cattle Husbandry Branch

RECENTLY, the grazing industry has been hit hard by rapidly escalating costs.

One solution to this problem is to increase operating efficiency. Aerial mustering can do just this.

The use of fixed wing aircraft for aerial mustering is limited. Among the problems are their greater noise component and operational requirements, their unsuitability to handling cattle in anything but open country and their inability to keep stock together in groups. However, they do play an important role in spotting stock for mustering.

Benefits of helicopter mustering

They reduce mustering time. The speed of mustering varies with the type of country but broadly speaking a helicopter will do in a 6 or 7 hour day what six ringers will do in a week. Figures of 3 500 head mustered out of a 155 km^2 paddock in 2 days are not uncommon.

On one South-west Queensland property which has a heavy cover of mulga and brigalow scrub with dense undergrowth of wilga, lime and turkey bush, it takes four stockmen 6 weeks to do a complete muster. Using a helicopter, it took 3 days to do the mustering.

Photograph Above. A helicopter in action. Photograph courtesy of Canelands Helicopter Services Pty. Ltd.

Alan Ernst is a husbandry officer with Beef Cattle Husbandry Branch in Brisbane. Alan has prepared a series of aviation articles which will appear in future issues of this journal.

The cost of mustering on horseback with four men plus food for 6 weeks and transport was approximately \$3 000. Using a helicopter for 15 hours at \$115 per hour plus ferrying costs of \$200, \$236 worth of fuel and two men and food for 10 days was about \$2 700. It took 3 days to muster and handling was finished 7 days later; a total of 10 days. The real benefit is the reduced amount of time needed to carry out the muster.

Along with the fall in the rural population there has been a decline in the availability of good ringers. The use of helicopters has helped to overcome this problem. However, even the best pilot needs good ringers to help out on the ground.

Method of operation

The success of the operation depends largely on the helicopter pilot. It is preferable that the pilot should understand the art of handling cattle. He needs to be aware that the correct use of helicopter noise for a few seconds is all that is required to move and alter the direction of the cattle.

It is interesting to note that when cattle are turned with a helicopter, the whole mob turns not just the wing. Also the pilot has a far better view than the ringer on horseback.

Where possible, mustering should be considered in relation to the wind direction to avoid down-wind turns of the helicopter. This will make most use of the wind speed and direction of sound from the helicopter.

Cattle can be driven more easily if the best possible use is made of roads, fences, and short grassed areas for driving the cattle.

Activities like buzzing mobs and overflying at low heights (less than 65 metres) should be avoided. When driving, the helicopter should remain above and slightly behind the mob. In this way, cattle can be driven 13 to 16 km per day.

The present feeling among many users of aerial mustering is that cattle should not be driven by the helicopter right into the yards. Instead, they should be driven to within 1 to 3 kms of the yards where stockmen with or without the aid of coacher animals take over. Where coacher animals are used, the ringer should stay well out of sight until the mustered cattle have mixed with the coachers.

Where ringers and the helicopter are working together the pilot is the boss; he has a much better view. Also the beasts which break away from the mob should be left to the helicopter. Under these sorts of conditions, a small radio which allows the stockman to talk to the helicopter pilot is very useful.

Problems

There are many stories around the bush of cattle behaving badly when helicopters are used for mustering. Some people suggest that when cattle are handled a second time within a short space of time they respond better to this method of mustering. Cattle which manage to get away a couple of times are more difficult to handle but this is the same with cattle that get away on the ringer. Quiet, old bulls can be a problem.

It has been observed by several people that cows and calves rarely become separated when mustered by helicopter.

An experienced pilot can muster fat bullocks without knocking them about.

Care should be taken to keep landing and refuelling areas for the helicopter well away from yards and camps where cattle are being held.

One of the main problems to face the first-time users of helicopter mustering is the amount of holding yard space available. This could be overcome by combining with neighbours and using the helicopter day about. For those who decide to continue with aerial mustering, thought given to future fence positioning, the building of laneways and siting of yards will add to the efficiency of the system.

Remember, helicopter pilots perform a very demanding task and 4 to 5 hours of flying each day is probably sufficient. The employer should make sure he provides good conditions for the pilot and not expect him to help out in the yards or with other mustering camp activities.

All told, the big advantage is increased efficiency.

Acknowledgements

The author wishes to thank those people who provided their experiences for this article.

Manual measurement of beef fat

by V. ZIMMERLE, Slaughtering and Meat Inspection Branch

BEEF carcass classification is a system of objectively describing carcasses on the basis of sex, weight, number of teeth and level of fatness (as indicated by fat depth at a special point over the rib eye).

Classification's use is aimed primarily at providing a common trading language right across the meat and livestock industry. It will also provide standardization of the terms of trade for cattle sold for slaughter on a carcass weight basis by defining what will be weighed with the carcass, the amount of trimming allowed and ruling that weight will be hot weight (no deduction for shrink). Shrink is the term used for the deduction usually made from carcass weight for the anticipated weight loss due to the evaporation of water during chilling.

Since the Australian Meat and Livestock Corporation first considered classification in 1972, the measurement of fat has been the greatest hold up in the technical development of the classification system. After carcasses are chilled, the cold fat is easy to measure but because of abattoir practices the fat has to be measured hot—that is while the carcasses are

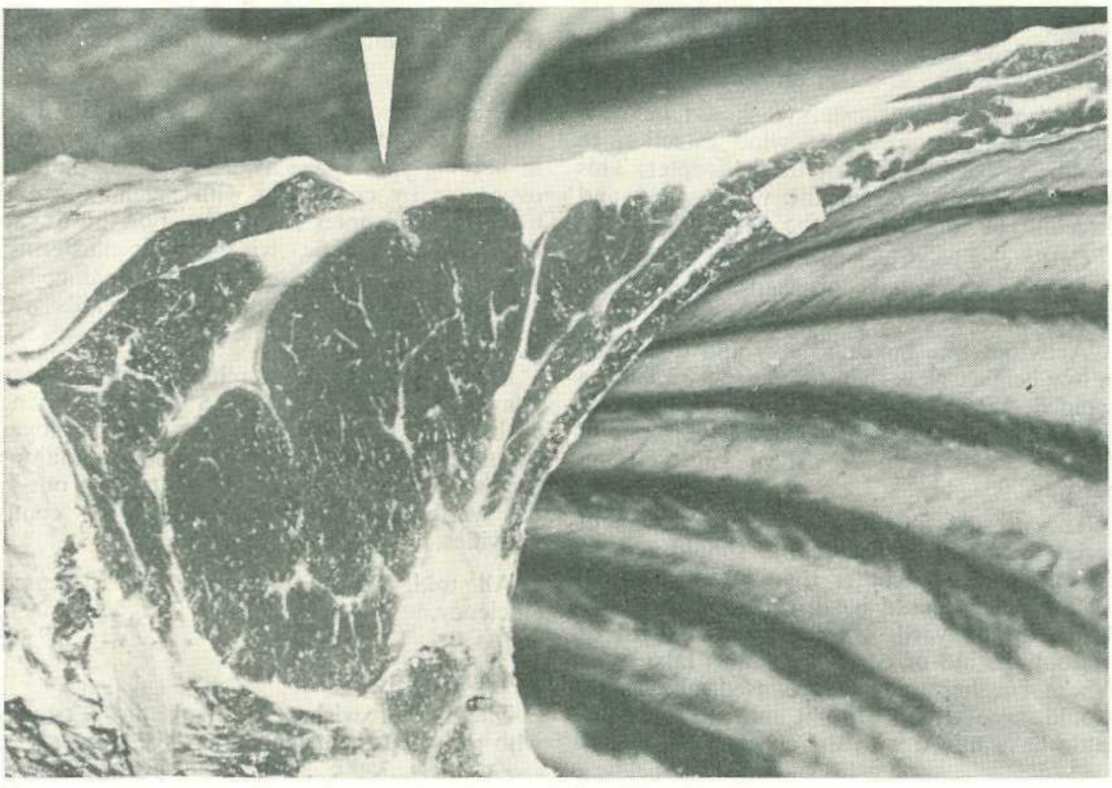


Plate 1. Fat is measured over the rib eye at the point indicated.

on the killing floor. This was a real problem until the manual methods described in this article were discovered. No significant problems were found in recording sex, teeth and weight manually.

The position for the vital measurement of fat is over the rib eye at the point shown in plate 1.

Many different attempts have been made to measure it, using sophisticated devices (including electrical conductivity probes and ultrasonic systems) of various makes and designs. There have been great difficulties with these, as they are very prone to breakdown and some may even give false readings. While a lot of progress has been made with these devices and research is continuing, none are completely satisfactory to date.

A breakthrough

In 1975, modifications were made to the Queensland blue ribbon beef grading system to bring it in line with classification ideas. There was a need to define acceptable limits of fat on gradable beef by measurements made in the same way as in the classification system.

The skill of a good knife man making a small incision in the fat and using a ruler to measure its depth had not been tested. A trial was conducted on 500 carcasses at the Metropolitan Public Abattoir, Brisbane.

The cut was 20 to 30 mm in length; the fatter the carcass—the longer the incision. Care was taken not to cut the underlying muscle.

In this trial, fat depths were measured in actual millimetres. Since cold fat is relatively easy to measure it was assumed that the fat depth measured cold in the same position as the hot measurement was the correct one. Comparing hot fat measurement with cold fat measurement results achieved in this trial were:

Correct	44 %
+1 mm—1 mm difference	43·2%
+2 mm—2 mm difference	11 %
+3 mm—3 mm difference	1·6%
+4 mm—4 mm difference	0·2%

Trials extended

When the need to devise an immediate, practical way of doing classification became urgent and it was realised that there were

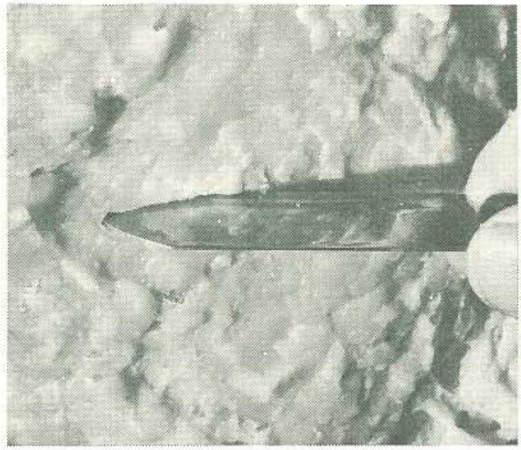


Plate 2. The knife.

Plate 3. The cut in the fat.

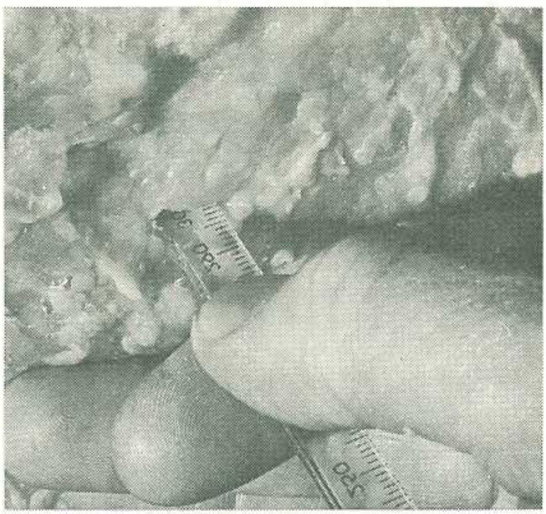


Plate 4. A ruler is used to measure the fat.

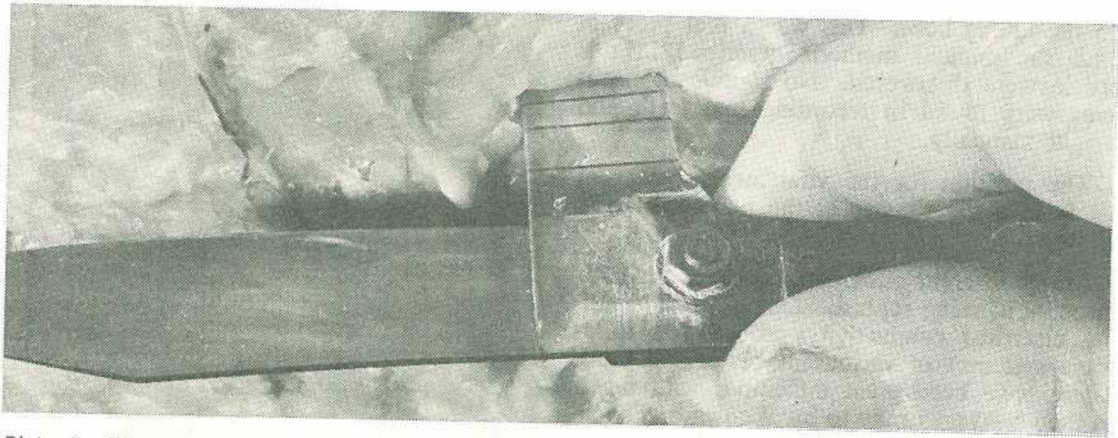


Plate 5. The ruler marked in 'blocks' is mounted on the knife.

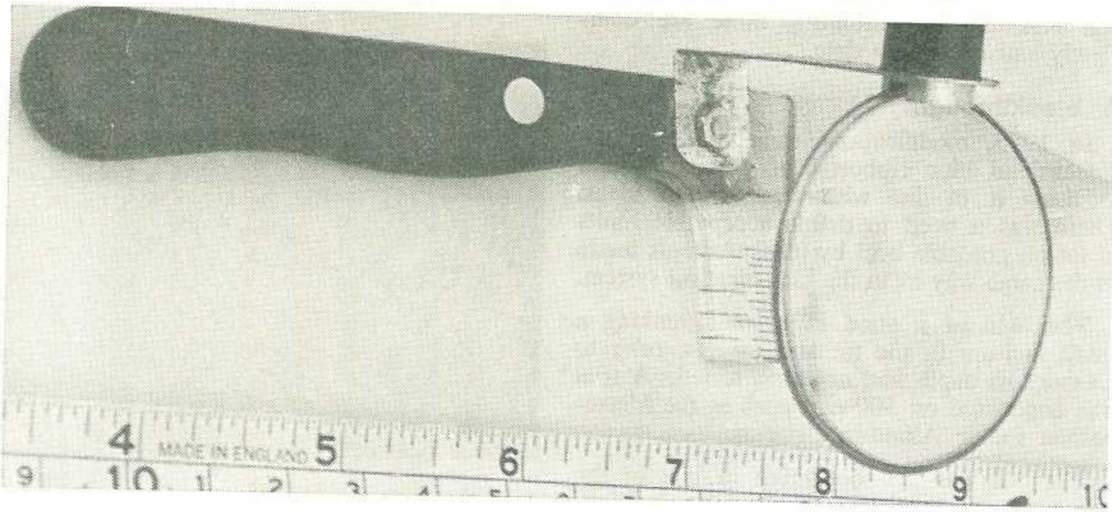


Plate 6. The knife, ruler and lens.

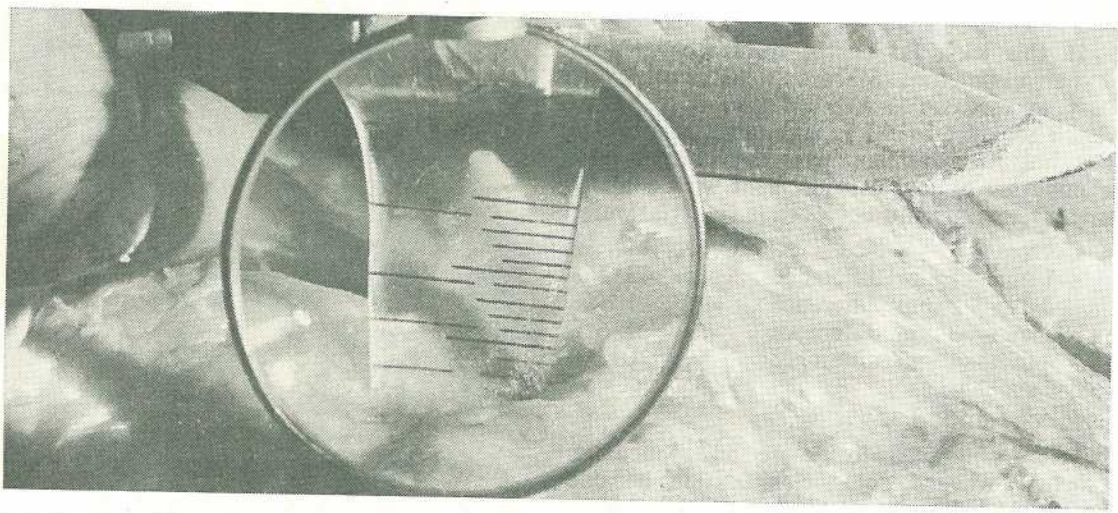


Plate 7. Magnifying the measurement makes the reading more accurate.

serious problems with the automated devices for measuring fat, a large commercial trial was carried out at the South Burnett Meatworks Co-operative at Murgon. Some thousands of carcasses were involved.

The carcass classification system being prepared will group fat depths into 'blocks' of millimetres (for example, 6 to 8 mm might be fat classification '4'). For this reason, in the trial at Murgon, fat was measured in 'blocks' of about 3 mm.

Since this trial was under commercial conditions, speed was important. To help the operator, the ruler marked in 'blocks' was mounted on the knife (see plate 5). Results of this trial were:

In Correct Block	88%
+1 mm—1 mm difference Cold-Hot	7%
+2 mm—2 mm difference Cold-Hot	4%
+3 mm—3 mm difference Cold-Hot	1%

Method accepted

The trials quoted showed that the manual method is a practical way of doing classification. The results quoted above on the degree of accuracy of the fat measurement were good enough for the Australian Agricultural Council to accept the manual method as a sound way of doing carcass classification. (The Australian Agricultural Council is the meeting of the ministers of Agriculture and Primary Industry of all the governments in Australia. It is the highest policy-making body in the primary industry area.)

In Western Australia, a small group of abattoirs have already adopted the manual method. There, a vertical cut is used in the same place using a surgical scalpel and a white plastic ruler with black markings.

The need for accuracy

Since carcass classification may be used as a basis for trading and official livestock market reports will be framed in the language of classification, accuracy is essential.

The results were good enough to start a system on. They compared favourably with those obtained by using the best available automated electronic probe. However, still greater accuracy was necessary.

A new device as an aid

Measuring fat is fine, close work. It was felt that magnifying the fat and ruler while the measurement was being done would help to make the reading more accurate.

A magnifying lens was mounted on a bracket on the knife over the ruler (see plates 6 and 7).

Another trial

Two hundred and thirty carcasses were studied and since measuring cold fat is simpler, only a ruler was used for this. The results are shown in table 1.

TABLE 1—DETAILED RESULTS

Fat Depth (mm)	No. of Carcases with this fat depth	No. of Errors at each fat depth	Extent of Error
1	37	2	
2	73	3	
3	61	4	
4	20	1	No
5	30	4	Error
6	4	2	Exceeded
7	3	..	1 mm
8	..	..	
9	1	..	
10	1	..	
Total	230	16	..

To put it another way, 93% of the measurements were correct, 7% were in error by 1 mm.

To sum up

A very high level of accuracy has been obtained by using this simple, reliable device.

Not only will it help get classification going until the electronic devices are improved but it will have a definite continuing place in smaller abattoirs where the cost of electronic equipment could be prohibitive.

Cassava . . .

a new look at an old crop

by G. H. Allen, Research Stations Section.

AS an agro-industrial crop, cassava (tapioca) offers some prospects for further development in Australia, especially in Queensland.

Established areas and land being planted total less than 250 hectares but if this crop is selected for alcohol production and its use for starch and animal feed expanded, cassava could become an important crop in this State.

Cassava products may be utilized as part replacement for high value grains in stock rations, as an industrial starch source, for paper or cardboard manufacture, as an export livestock feed in chip or pellet form, as a base for alcohol production and as a substrate for protein production systems.

It is possible that the starch may be used in mineral processing or other industrial processes.

Use and production overseas

Cassava is a staple food for people of many lands especially South America, Africa, Indonesia, India and some Pacific islands.

In addition, a number of European countries, the Netherlands, West Germany, Belgium and Italy are using increasing quantities of cassava for stock rations Inquiries indicate that additional markets are available in these countries and in the U.K., France and Poland.

Markets are available in the U.S.A. for cassava starch in competition with maize starch and thus keenly priced.

The Japanese markets are taking greater quantities of cassava for stock feed at favourable prices related to the high grain costs, but quotas apply.

The major producing countries such as Brazil, Nigeria, Thailand, Congo, Tanzania, India and Indonesia aim at increasing production but export capacity is limited by expanding home market demads. Malaysia has certainly increased cassava growing with the object of securing exports and the situation in Mexico is uncertain.

The author, Gordon Allen, is the Executive Officer of Research Stations Section.

Thailand is the largest exporting country with total sales valued at \$153 million for 2·69 million tonnes of cassava products in 1974 and a higher return in 1975 from a slightly higher export. The industry has been rapidly expanding for a decade to about 450 000 ha but new areas for cropping are now more difficult to obtain. The cropped area produces about 7·8 million tonnes of roots or approximately 17 tonnes per hectare. The markets in Europe take about 75% of the production of Thai chips and pellets.

Concurrently with the expansion of production in Thailand, there have been increasing demands in EEC countries for energy food sources competitive in price with maize and barley. The EEC countries have a high import levy on grains and a low levy on cassava.

Versatile crop

For food

For human nutrition, cassava is an inexpensive source of calories for high populations in tropical areas. It may be harvested as required. Despite the high labour input and often low yields, cassava requires less labour on a total yield or calorie basis than most other alternative crops grown in countries dependent on this staple food.

For starch

Commercial starch demands for cassava must depend on the costs of material produced from alternative sources: wheat, sorghum, and, to a lesser extent, potatoes or maize.

However, the use of starch bases for fructose or glucose sweeteners may well become significant if price differentials allow substitution against cane sugar or corn syrup.

Existing grain crops in Australia (maize, wheat, rice, sorghum) and potatoes provide material for some starch recovery but the cost is high due to competition for supply and higher prices as export grain and local feeds, especially for pig and poultry production. A small quantity of arrowroot is grown and processed for starch recovery in south-east Queensland and northern New South Wales.

Industrial developments and changes in economic conditions could create additional outlets for starch sources, especially in the mining industry.

For liquid fuels

In the mid-term, cassava offers prospects as one of many potential sources of liquid fuel. The plant is very efficient in converting solar energy. Methodology for ethanol production is available.

Cassava ethanol plants initiated in Brazil in 1930 subsequently closed due to the availability of cheap petrol and in 1950 a Government decision was made to concentrate on sugar-cane and its by-products for alcohol. These sources supplemented with cassava and palm nut alcohol now supply an increasing quantity of the alcohol needs for Brazil.

The projected shortages of liquid fuels in Australia may be offset by energy production from many plant sources. In Queensland, these would include sugar-cane, cassava and sucrose sorghums. The areas needed for this form of agro-industrial development are of considerable magnitude.

By rough calculation, the use of 5% ethanol as an additive to the Australian petroleum demand would need about 250 000 ha of cassava. This area of suitable land or double that area for a 10% blend would not readily be available for cassava. As this crop requires good rainfall and light-textured soils, the integrated use of sugar-cane and sweet sorghums in alcohol plants offers prospects for also using the heavier soils and the drier agricultural districts of northern Queensland. If the use of several plant sources can be technically employed in the fermentation processes, more regular supply of raw materials and a longer operating season could be achieved.

It is anticipated that detailed evaluation will be made by many organizations into alternative sources of alcohol to replace fossil fuels. The use of agricultural crops or their by-products appears worthy of investigation despite high energy requirements for production. The established use of molasses for alcohol produstion at the Sarina plant would require lower energy use than the enzymatic fermentation processes applicable to the treatment of cassava. However, the total cost in producing alcohol from cassava may be lower if this crop can be grown to produce a high yield at a reasonable price.

For alcohol recovery

In the evaluation of developments in Brazil it was estimated that 180 litres of alcohol may be obtained from a tonne of cassava roots and 70 litres from each tonne of sugar-cane. Estimates made in Queensland about 1925 when production of power alcohol was under investigation included production of 175 litres of alcohol from a tonne of cassava and 295 litres from a tonne of molasses.

Analyses of alcohol yields from sugar-cane, cassava and sorghums show production of approximately 4 000 litres per hectare as a reasonable average.

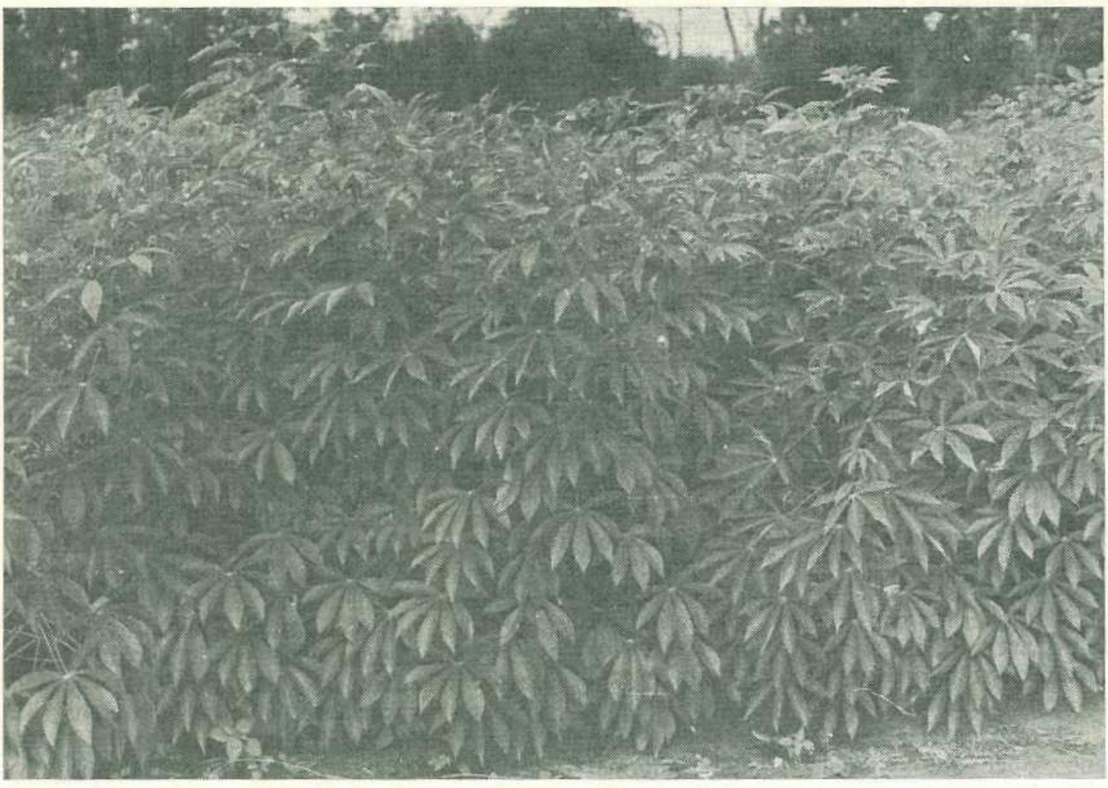
Ethanol from these plant sources can be blended with petrol (up to 10% by volume) without engine modification and vehicles will operate with 50% blends or straight alcohol with appropriate adjustments.

For stock feeds

Cassava in chip or pellet form is a recognized energy fodder. Its potential can only be assessed in terms of substitution and prices for alternative products, especially grains. Based on a feed value of $60 per t, cassava could be competitive in certain areas of production and with full mechanization and economic drying facilities.

Recovery of cassava leaf as a protein meal is worthy of special study as this may permit recovery of the cost of mechanization.

Cassava leaf, as dried meal, is of special significance having a high (20 to 26%) protein content. This is normally as high or higher than lucerne meal and with a favourable amino acid spectrum.



Cassava at Coolum Research Station (April 1977) after 5 months' growth.

A detailed study of cassava as a potential agro-industrial crop was reported by De Boer and Forno 1975[1] and other articles and reports have been presented on cassava by Asher, Evenson and others, also of the University of Queensland.

Review data on cassava have been adequately recorded by McCann and Saddler[2], University of Sydney. The Lockheed Information Retrieval Service produced 266 references to world literature on cassava and additional material is available in biological abstracts, chemical abstracts and food service and technology abstracts. A paper on 'Cassava Fuel Alcohol in Brazil' was included at the 12th. Intersociety Energy Conversion Engineering Conference, Washington D.C., U.S.A. in August-September 1977.

A conference of Alcohol Fuels was held in Sydney on 9 to 11 August 1978.

The conference was organized by the N.S.W. group of the Institution of Chemical Engineers and discussion included the production of alcohol from agro-industrial crops.

The local scene

With this brief review and study of available overseas and Queensland data it is appropriate to make an evalution of cassava as a potential agro-industrial crop in this State.

The author studied cassava production and utilization as part of an overseas tour in 1975.

Retrospect

Cassava (*Manihot esculenta,* Crantz, also known as *Manihot utilissima,* Pohl) is known in some places, as tapioca, manioc, mandioca, manihot or yuca. It has been reported in Queensland agriculture since 1902 and cultural practices were described in 1909[3] and in 1925 by Pollock. In 1926, Brooks[5] reviewed cassava as a stock food and in 1941, Brooks[6] published a general advisory article.

Eighteen varieties were introduced into Queensland in 1925 primarily for assessment as a power alcohol production source. However, a power alcohol plant at Sarina which came into production in 1926 utilized molasses as a base rather than cassava due to the ready availability of molasses and lack of markets or other means for disposal of this sugar industry waste product.

Cassava has been regularly grown in a few areas of Queensland for farm pig food, in several northern settlements as a preferred staple food and in many gardens and parks as an ornamental.

A total of 84 varieties were introduced (Annual Report, Department of Agriculture and Stock, 1928/29) during the preceding period for studies on yield, stock feed values and for alcohol production.

The origin and genetic characteristics of the many introductions were lost in time and thus the more recent collections of local varieties are distinguished by site names or sequence numbers.

A list of the Australian cultivar collection and the standard numbers adopted is given in appendix 1. A list of known imported cultivars is provided in appendix 2.

Research

The developments in Queensland by the University of Queensland and several officers of the Department were co-ordinated by meetings and consultation in 1974 and 1975 and liaison was established with commercial firms interested in this product.

In brief, it was agreed that the University group would continue variety collection, evaluation of climatic responses and some nutrition studies in glasshouse conditions. Areas of cassava established by the University at Redlands, Weipa and Mossman would be supplemented by the use of Departmental plots at Kairi, Walkamin, Southedge, South Johnstone, Burdekin, Coolum and Gatton for varietal assessments over a wide range of climatic conditions.

Within the Department, field agronomy studies (cultural and fertilizer treatments) are being conducted by Agriculture Branch and the Research Stations group is responsible for the development of production practices necessary to handle cassava as a commercial crop.

Several companies have undertaken surveys, feasibility reports and preliminary assessment of cassava as a crop and for starch extraction in Queensland and northern N.S.W. with a view to entering this industry. One company has established a starch mill and production areas of cassava at Yandaran near Bundaberg.

A company has also established cassava in study areas near Rockhampton and a large cassava area for pig feeding is planned in the Tiaro district.

Field production

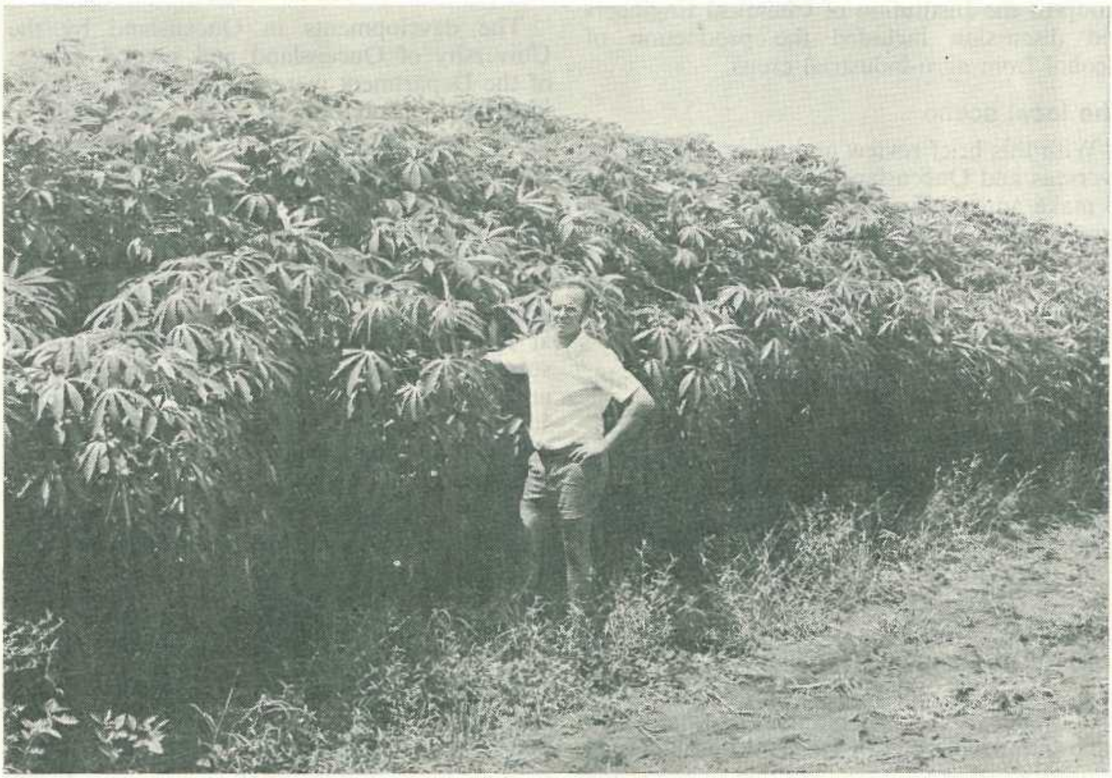
Cassava is planted with setts or pieces of mature stem 20 to 25 cm long. The stems can be stored upright for up to 2 months before cutting into setts. The setts may be placed horizontally, vertically or at an angle, in well-prepared and adequately-drained ground.

Experience indicates a preference for horizontal plantings at 5 to 8 cm depth depending on soil type in rows 1 m apart on prepared ridges and with setts spaced 0 to 100 cm apart (centre to centre) to provide plant populations of 10 000 to 12 000 per ha. These spacings and subsequent hilling-up during cultivation are geared to machine planting and mechanized harvesting techniques being developed by the Department.

Twin rows separated by tractor space for cultivation is being tried at one commercial cassava growing area to facilitate weed control.

Plantings in spring or early summer result in shoots emerging after 2 weeks under favourable moisture conditions and growth is rapid during the summer wet season. Weed control is essential until the leaf canopy limits grass or other weed growth.

Weed control by cultivation can be combined with hilling-up of the rows and can also provide better drainage.



Cassava at 'Fort Site' (30 km from Home Hill) after 9 months' growth. The tuber yield was 74 t per ha.

The development of tubers (the underground fleshy roots) will be evident 6 to 8 weeks after emergence and the rate of development will increase up to 8 months. However, in areas with a cool winter or variable rainfall, leaf fall will be evident in May to July with very little expansion in tuber size.

Cassava may be harvested generally after 8 months but the crop will continue to grow and total tuber yield increase through the second year.

Cassava will grow to a height of from 1 m to over 2 m depending on variety and there are considerable variations in the number, size and colour of the tubers.

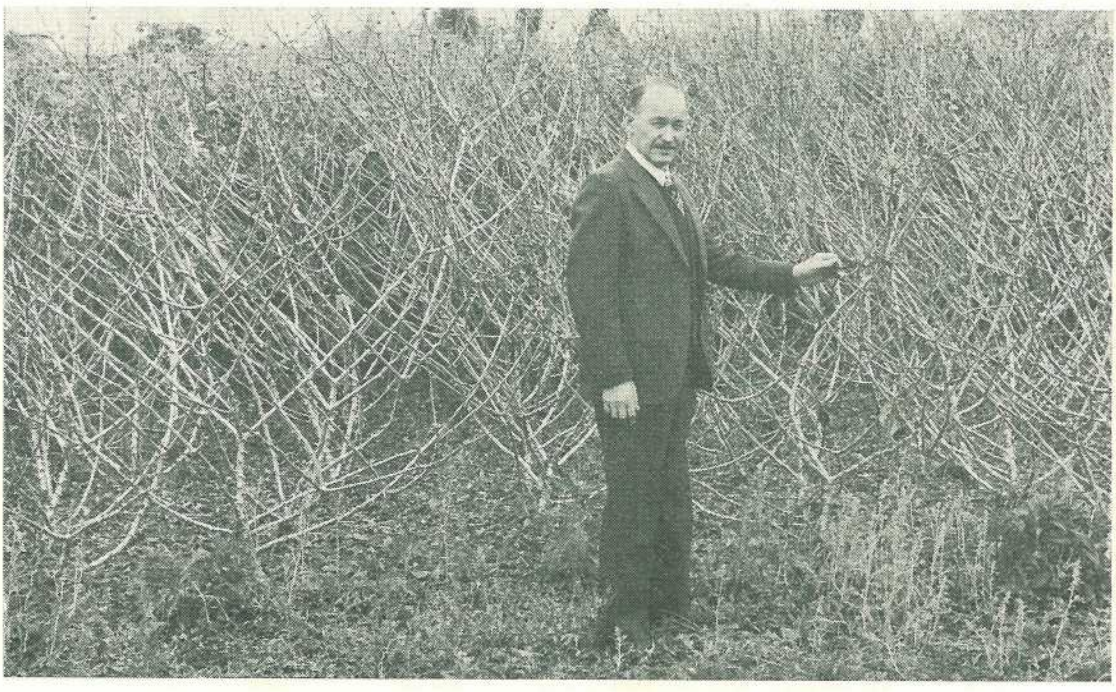
The high yields of cassava in leaf, stem and roots place heavy demands on soil nutrients. The regular use of fertilizers (especially potash) would be generally necessary for efficient production.

Tuber harvesting—yields

Very high yields have been recorded at the South Johnstone Research Station where tropical high rainfall conditions prevail. A 10 month growing term in 1973/74 yielded 58 t per ha of tubers giving 23 t per ha dry weight. Later trials including use of fertilizers have produced over 100 t per ha of fresh tubers.

On the coastal lowlands at the Coolum Research Station, yields of up to 58.2 t per ha of tubers giving 22.12 t per ha dry weight were obtained in 1975/76.

In early 1978 at Coolum, seven varieties were harvested mechanically after 14 months' growth which included winter and drought periods. The yield of the standard variety MAus 7 was highest at 39.5 t per ha of tubers (approximately 15 t per ha dry weight) from a plant population of 9 000 plants per ha.



Winter leaf shedding of cassava at the University Farm, Redland Bay.

Ten tonnes of chips were prepared from these tubers for a test run in a commercial starch plant and for use in rations fed to cattle at the Animal Research Institute.

In the dry, tropic Burdekin River region (30 km from Home Hill), a 10-month-old crop grown with irrigation and harvested in September 1977 produced 38.7 t per ha of fresh tubers despite incomplete recovery. Some varieties produced less than 20 t per ha of tubers but vegetative growth was excellent.

Small areas harvested in 1976 from plots on the Atherton Tableland at Kairi and Walkamin Research Stations yielded 40 t per ha of fresh tubers and 2 year crop MAus 4 'Black Twig' harvested in 1977 produced 100 t per ha at Walkamin.

Leaf harvesting and yields

Eight varieties were planted at Gatton Research Station in September 1975 for evaluation of leaf yield and to this end stem and leaf harvests were made in May 1976. Heavy foliage growth was evident under conditions of high fertility and supplementary irrigation.

Above ground material was harvested with an average green weight yield of 45 t per ha (highest 49 t per ha) giving an average dry weight of 11.2 t per ha (highest 13 t per ha).

The leaf section samples had 16·56% protein and the stems 4·81% on an air-dried basis.

The harvested material was later dried in a lucerne dehydration plant and hammer-milled. The leaf and stem meal had over 8% protein content. In the total yield of 11.2 t per ha, there was a leaf yield of 5 t per ha with a protein value of 17%.

In another observation at Coolum Research Station in 1975/76, the leading variety yielded stem and leaf of 12.84 t per ha or 4.07 t per ha dry matter. The leaf section, 1.6 t per ha dry matter, contained over 19% protein.

Future investigations will examine the prospects for a number of leaf harvests during the year and the effect of this treatment on final tuber production.

There are many areas where cassava would produce high leaf volume even though tuber yields would be below optimum.

Starch recovery

In conjunction with starch processing companies, information has been obtained on the acceptance of several varieties. The yield of starch has been satisfactory, ranging from 18% to 25% from wet tubers. A minimum starch standard of 62% applies overseas with respect to cassava pellets at maximum moisture of 14%. Overseas cassava chips normally contain over 70% starch.

Costing estimates

The yields of cassava recovered in Departmental trials in Queensland (30 to 100 t per ha) are high in comparison with commercial yields in many overseas countries (for example, 11 t per ha Uganda, 17 t per ha Thailand and 15 t per ha in Brazil). However, all of these overseas areas could increase yield by improved agricultural practices and the use of fertilizers.

Costs of production and yields are likely to vary widely in Queensland and an estimated cost per tonne has been calculated for different conditions.

Cost of production per ha	Cost per t of fresh tubers		
	at 30 t/ha	40 t/ha	80 t/ha
$	$	$	$
250	8·3	6·3	3·1
300	10·0	7·5	3·7
350	11·7	8·7	4·4

If these costs and a profit margin are used in arriving at a farm gate price for tubers, it is evident that efficient methods and high yields are necessary if cassava roots are to be obtained at a price which would allow for their economic conversion to stock feeds or alcohol.

Calculations based on very limited data indicate that an estimated farm price of $16 per t of tubers for stock feeds and $12 per t for alcohol production would appear necessary to maintain viability of producers and industrial processors. The returns may result from a 10 month crop or from harvests extended well into the second year and are not quoted on an annual term.

The price for tubers for alcohol production as an ethanol supplement in motor fuel has been based on petroleum costing 28c per litre in the future.

These figures are provided to indicate the potential value of crop plants such as cassava and sugar-cane in Queensland—and sugar beets in southern states—in providing energy for transport and industry.

New concepts in agriculture

In comparison with many potential crops, cassava offers attractive possibilities. There is a need for broad acreage cultivation to develop many tropical areas of the State and crops with industrial products promote secondary industry, employment opportunities and supporting services.

The growing need for liquid fuels to replace petroleum may be resolved by the use of cassava, preferably in conjunction with sugar-cane and sweet sorghums.

The following comments support the case for the further study of cassava.

- Cassava production can be initiated for starch production or as a small enterprise with all tubers being used in pig rations as a part grain substitute. The starch can be used for converted sweeteners such as fructose or glucose.

- Expanded levels of production could be more widely used in general livestock and poultry rations requiring only simple chipping and possibly drying equipment.

- Larger volumes, exceeding livestock food demands and still in chip form have export potential on existing overseas market prices. However, transport and freight charges may absorb all profits.

- Use of cassava in pellet form requiring modest capital investment, would allow access to wider markets in Australia and overseas.

- It is anticipated that existing starch industries would be used for processing cassava for this industrial purpose and, where justified, new plants would be established.

- Recovery of cassava leaf as a well-structured, high protein meal is of special significance as this would pay for the anticipated high costs in mechanization of field operations including harvesting and drying.

- It is stressed that the 'energy shortage' in future years is more significant than the 'protein shortage' which has dominated some press views of the future.

The starch and energy values of cassava are outstanding and this crop appears more attractive than others such as maize, rice, sorghum, potatoes, taro, yams or arrowroot as a source of starch and its subsequent industrial processes.

- Cassava is attractive as a base for power alcohol production. The shortfall in liquid fuels by the mid 1980s could be partly filled by the development of ethanol plants utilizing sugar-cane, cassava and possibly sweet sorghums.

- Overseas developments in juice protein extraction (for non-ruminant stock rations) could be applied to cassava leaf.

- Cassava starch has potential as a substrate for yeast or single cell protein production—thus filling an important dual role.

- Cassava does not require a fixed harvest date as for grain crops and it may be carried over to suit processing rates and as dictated by weather conditions. (Deferment of harvest should not be over-emphasised because under our conditions, economic success may require a crop within each year, whereas in many other countries harvest is made after 15 to 18 months' growth).

• Cassava is not severely attacked by insect pests. There are several insects which can cause damage to vegetation and tubers but no real trouble has been observed in Queensland plots. The cyanogenetic characters of cassava are apparently effective against insect attacks. In Thailand, red spider mites can reduce yield by 15%.

Diseases have been serious in some overseas countries and a leaf spot, probably *Cercospera cassavae,* causes leaf fall and reduced yields. A virus or mosaic disease has caused very severe crop losses in many countries and is evident in small plantations in the Philippines and Hawaii. It may be associated with the dichromatic plants used as ornamentals in Queensland.

• Cassava varieties contain a prussic acid yielding glucoside and are normally grouped as sweet (low levels) and bitter (higher levels). Cutting and drying processes render all varieties safe for feeding and some varieties are eaten in the raw state and assumed to be relatively free of cyanogenic glucoside. High intakes of cassava produce antithyroid action and the incidence of goitre has been studied in Columbia and Nigeria.

• Cassava once firmly established from setts will stand dry conditions. However, for efficient production with tuber development and high starch levels being obtained in 8 to 10 months, supplementary irrigation would be desirable in the dry tropic regions. Performance in our wet, tropical areas has been better than that reported from many overseas countries.

• Cassava can be planted, ridged and cultivated in the early stages with standard or slightly modified sugar-cane equipment. Use of weedicides, until the leaf canopy restricts weed growth, would eliminate one of the high labour inputs of cassava production overseas where weed control is primarily a hand operation.

• The current price for cassava overseas is attractive to those countries with export supply but all such production is secured with a high labour input and far lower wage structures than in Australia. However, preliminary production (yield) figures in Queensland are better than overseas and starch content and quality are competitive.

• Cassava will grow in a wide range of soil, climatic and topographic situations. Under our production requirements, high quality and yields involving use of fertilizer, weedicides and some irrigation would be desirable but not always essential. Areas of the coastal lowlands with drainage and reasonable rainfall and at present showing little return could be cropped in large areas for lower yields and with a longer growing season than the more favoured areas such as the wet, tropical lands at Innisfail, Ingham and Mossman.

Granitic and light-textured soils served by the Mareeba-Dimbulah Irrigation Scheme and the northern volcanic tablelands are also considered suitable. The coastal sands and red earths of the frost-free coastal belt between Nambour and Mackay and frost-free areas of the south Burnett are also likely areas for development.

The Burdekin Irrigation Area though providing excellent conditions has limited areas of lighter-textured soils that are not used for sugar-cane. Large areas would be available if the Burdekin Irrigation Scheme eventuated.

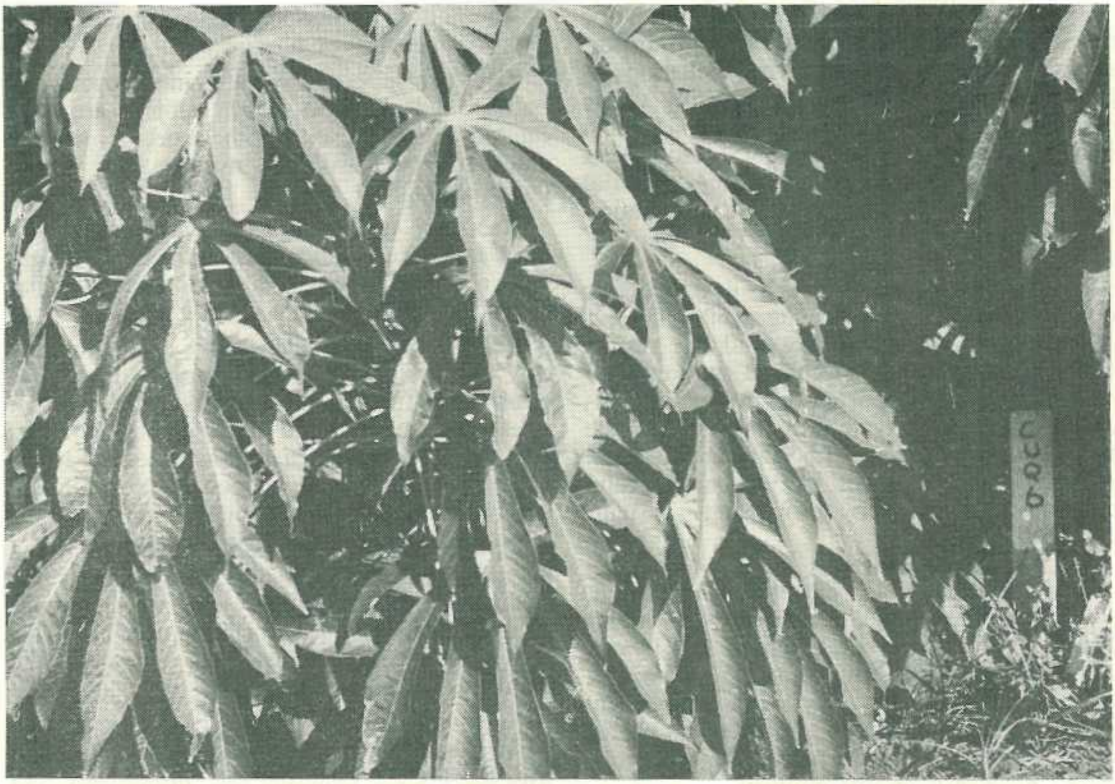
Assessment and production problems

There is a strong case to support the development of a cassava industry, but there are some problems to be overcome before attempting a sound economic assessment based on semi-commercial production and processing techniques. Some of the problems requiring resolution and comments on the current situation are as follows:

• Cassava draws heavily on soil nutrients and special attention to soil conservation measures would be essential. It is unlikely that cassava could be grown continually on the same land.

An assessment of rotation crops or cropping systems has not been made.

• Existing varieties and some recent introductions of Thailand origin require further study for assessment of growth, density, leaf and tuber yield, tuber formation and characteristics, response to nutrients and climatic or geographical variability.



Leaf of the accepted standard variety MAus 7.

Current varieties including MAus 3, MAus 10, MAus 7 and MAus 4 appear to be of a reasonable standard but it is not possible to measure against many past performances or a merit level of acceptance. The nominated international variety, Llanera, was not available for early comparative assessments of existing or new varieties, but researchers in Queensland agreed to adopt variety MAus 7 as the standard for current investigations.

There are 92 described varieties in the cassava genus and forward planning should include collection of a sufficiently wide range of cultivars to identify those most suitable for Queensland conditions for growth and mechanical handling.

Elimination of unsatisfactory varieties and verification of performance of two or three better lines should be expedited before material other than the standard variety is generally distributed.

These assessments using currently available varieties are in progress by the Queensland Department of Primary Industries, the University of Queensland and three companies. Other studies are being established in N.S.W. by the Grafton and Wollongbar Agricultural Research Stations of the Department of Agriculture.

• It will be necessary to define some specific areas for production of commercial material. As a high-yielding crop, the initial area would be comparatively small. Several properties with an aggregate crop area of 200 ha should produce about 2 000 t dry weight of tubers annually.

It is considered that such amounts from several production areas totalling up to 1 000 ha could be readily handled in stock feeds.

Expansion into chip export may not be practical even in close proximity to transport and shipping ports. However, pelleting at strategic centres could be economically viable provided a mill could receive at least 25 000 t of dry chips over a processing season of 4 months. A pellet mill should process material from 2 500 to 3 000 ha for efficient operation under our conditions.

• It is anticipated that major developments could be undertaken by commercial firms if the current feasibility studies and the results of the one established starch mill support such action. There are opportunities for plantation-type units and for private farmers to participate in cassava production with financial success, provided harvesting can be mechanized and economic drying or processing systems developed.

• Mechanization of cassava production, especially harvesting, is one of the major apparent limiting factors. Even in low labour cost countries, harvesting is a major expense. Overseas attempts to mechanize harvesting have been unsuccessful but the reported prototype units or systems are not of the type considered necessary in this country.

Mechanization in some countries simply means reduction in hand labour (for example, cutting of setts with a circular saw was a real innovation in one country).

Some attempts at harvesting methods other than hand pulling produce many broken tubers, early fermentation and lowered starch grades. For example, ploughing will facilitate tuber picking but in the absence of chipping and drying capacity for immediate treatment of the harvest, some deterioration must occur. It is suggested that with integrated equipment for harvesting and initial processing this problem could be overcome.

The field production problem is a major one and the approach adopted is to examine:

• The plant and tuber formation characteristics —to select varieties which develop suitably for machine harvesting and to study the best combinations of row and plant spacings, soil conditions, physical and nutrient treatments for mechanical recovery of tubers.

• To modify, devise and develop mechanical aids for recovery of tubers.

The two approaches are interwoven and background data on either subject are very limited. As a result, both aspects must be studied and some investigations have commenced.

Recovery of tubers from ridged rows has been fairly successful from red volcanic soils with a potato digger with spade front and bar elevators (Kairi Research Station).

Trial areas on light sandy soils overlying clay at Coolum Research Station have been established for harvesting tests with different tines and mouldboard lifters and this was followed by the use of specially-designed harvesting equipment developed in consultation with Richter Engineering at Boonah.

Queensland University staff have established an area of cassava on a private property for evaluation of an arrowroot harvester constructed also by Richter Engineering. This heavy duty unit incorporates some of the features of a potato harvester.

Cassava harvesters have also been developed by a Bundaberg firm working in conjunction with the Fielder Gillespie Ltd. production area at Yandaran.

The investigations now in progress will provide experience and information on harvesting requirements which will allow preparation of more detailed specifications on which to devise prototype equipment. Additional areas for harvest studies are now established.

In the long term, and if industry developments justify the expenditure, a multi-purpose harvesting machine should be the final objective. It is anticipated that such a unit should be a combine harvester to:

• Cut and chop top vegetative growth (that is, leafy canopy and associated young stem material) with delivery to side truck for dehydration (recovery of 60% of available leaf and stem should pay all harvesting costs).

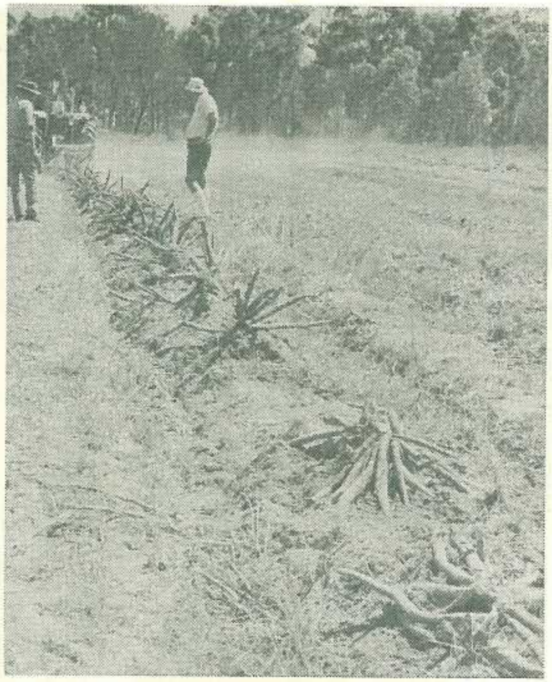
• Cut plants at or below ground level and shred coarse stems to be blown aside (to prevent regrowth and facilitate later cultivation). The stem sections are potentially useful as fuel and for the manufacture of cardboard-type materials.

• Loosen soil bed and ridges and take soil mass and tubers to elevators and separators freeing tubers of soil and delivering cassava roots or pieces to bin or side truck.

Processing and treatments equipment

Early treatment after harvest is essential if tubers are cut or broken, so prompt delivery for chipping must be arranged. For high quality starch production, pre-washing and cleaning of tubers is desirable. Chipping machine construction should not be a problem.

A small unit to D.P.I. design was built by a Queensland firm, Richter Engineering of Boonah, and it has worked effectively in providing chips for starch milling and for stock feeding investigations.



RIGHT. A machine digging cassava trials at Coolum Research Station. Tops have been removed with a forage harvester.

BELOW. One type of experimental cassava digger built by Richter Engineering, Boonah.

Chipping cassava tubers with a p.t.o.-driven chipper developed in conjunction with Richter Engineering, Boonah. Chip samples are used for starch and feed evaluations.

Drying as required for chip or pellet production of cassava is a major economic problem.

Drying of chips in the main producing countries is normally achieved on concrete slabs with periodic raking. Forced air and heat drying in an automated process would be desirable under our conditions to achieve a better product, to reduce wastage and lower handling costs.

Most reports indicate that a combination of air and mechanical drying will give the best economic results.

Equipment for pelleting cassava is readily available from manufacturers in the U.S.A., Germany, Sweden and Singapore.

Processing of cassava for starch is possible in most starch extract systems and practices for production of flour, flake or pearl forms are well known.

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Appendix 1

Australian Cassava Cultivar Collection

International Numbers	Old Numbers	Old Name and Site of Collection
MAus 1	CUQ 18	Oyster Creek Schiffkes, Bundaberg
MAus 2	CUQ 19	Cardwell
MAus 3	CUQ 2	S. Johnstone
MAus 4	—	Black Twig, Malaysia
MAus 5	CUQ 15	St. Lucia, Queensland
MAus 6	CUQ 16	New Guinea, Miallo, Queensland
MAus 7	CUQ 6	Fiji, Cairns
MAus 8	CUQ 17	Miallo, Queensland
MAus 9	—	Flying Fish Point, S. Johnstone
MAus 10	CUQ 1	Mourilyan Harbour, Innisfail
MAus 11	—	Daintree
MAus 12	CUQ 3	Innisfail
MAus 13	CUQ 4	Kamerunga
MAus 14	CUQ 5	Giant Red
MAus 15	CUQ 7	Babinda
MAus 16	CUQ 8	Mitchie, Cairns
MAus 17	CUQ 9	Kununurra, W.A.
MAus 18	CUQ 10	CCC, Cairns
MAus 19	CUQ 19	Cairns
MAus 20	CUQ 20	Cairns
MAus 21	CUQ 13	Weipa
MAus 22	CUQ 14	Variegated, St. Lucia

Appendix 2

Cassava Cultivars Introduced Into Australia

SM 1–50	from CIAT Columbia
MCol 1684	from CIAT Columbia
MCol 1463	from CIAT Columbia
MCol 638	from CIAT Columbia
MVen 218	from CIAT Columbia
MMex 59	from CIAT Columbia
COML MM	from Thailand
CMC 84	from Thailand
CMC 79	from Thailand
CMC 72	from Thailand
CMC 39	MCol 1467
Mameya	CUQ25 Puerto Rico
Pata De Paloma	CUQ24 Puerto Rico
Ceiba	CUQ23 Puerto Rico
Amarillo	CUQ22 Puerto Rico
Seda	CUQ21 Puerto Rico
Nina	CUQ20 Puerto Rico

Heatwave and maximum temperature probabilities

TEMPERATURE extremes are of major significance to agriculture in Queensland. Both frosts and heatwaves are a regular part of the Queensland climate.

To enable sound planning of production, it is necessary to be aware of the risk of occurrence of either of these climatic hazards. A previous article (*Queensland Agricultural Journal*, March–April 1978) discussed frost and minimum temperature probabilities.

Heatwaves and high maximum temperatures can also cause significant losses although in practice they frequently occur in association with moisture stress and low relative humidity and it can be difficult to isolate the effects of individual factors. Heatwave is taken here to mean a succession of days with the maximum temperature exceeding a specified critical level. The critical level employed will depend on the susceptibility of the plant or animal under consideration.

by K. M. Rosenthal, Development Planning Branch and G. L. Hammer, Agriculture Branch.

Effects of high temperatures

Temperature has a direct effect on the growth rates of plants and high temperatures above the optimum for growth result in reduced growth rates. However, perhaps more serious are the damaging effects of high temperatures and heatwaves when they occur at critical stages of development.

For example, in a sorghum crop, significant yield reduction can result if a heatwave (with a maximum temperature of 38°C or greater) occurs at the time of head emergence as the flowers enclosed in that section of the head not yet emerged are killed.

In sunflowers, the temperature during the seed-filling stage is important in the determination of oil quality; high temperatures being associated with reduced quality. In a number of crops, high temperatures immediately after flowering may interfere with pollination and this will decrease yields. However, low humidities generally associated with days of high temperature are also known to reduce pollen viability. The seasonal growth pattern and composition of pasture communities is also known to be influenced by the occurrence of heatwaves.

High temperatures also have direct effects on livestock. Cattle are known to suffer loss of appetite and decreased feed intake and bulls subjected to temperature stress incur seminal degradation. Prolonged heat stress can cause death and in some regions is a major factor in calf losses.

With sheep, heat-induced seminal degradation in rams is one factor causing high incidence of fertilization failure and heat stress on ewes during pregnancy is a factor causing embryo mortality and low birth weight with subsequent poor lamb survival. In the poultry industry, heat stress associated with temperatures above 35°C can cause death of birds and serious losses.

In most of these cases, the farmer must take preventative measures as little can be done when the heatwave occurs. With crops, it is necessary to adjust the time of planting and the variety used so that the risk of encountering a heatwave at the critical stage of development is kept at an acceptable level. With livestock, heat stress and its effects can be avoided by handling animals in the cool part of the day, providing shade, avoiding overcrowding, manipulating the mating period and breeding for better adapted animals.

With poultry in areas that experience heatwaves, the avoidance of losses due to heat stress is best achieved in the design and siting of the shed. Good ventilation and orientation to make best use of natural breezes and existing shade as well as an adequate supply of cool water are the most important factors.

Explanation of tables

This article presents tables of probabilities associated with occurrences of heatwaves and maximum temperatures. This provides a basis for planning for avoidance of heat stress.

Long term data (70 to 80 years) of daily maximum temperature measured in a standard screen at 1·25 m above the ground have been used to derive the probabilities of heatwaves and specified maximum temperatures occurring throughout the year. Computer programmes have been written to analyse these data and produce the tables presented in this article.

The locations for which these long term data are available to date are Charleville, Dalby, Emerald, Goondiwindi and Roma. The analyses relate to the official meteorological recording site at each of these locations. For any particular site within the region, a knowledge of local topographical effects on temperature will allow most accurate use of the information presented.

Three distinct types of tables have been produced for each station:

- First and last maximum temperature occurrence (tables in Appendix 1).

The body of each table gives the date of the first (or last) occurrence of a particular maximum screen temperature for a given risk. For convenience, the year has been divided at January 15 (approximately the hottest time of the year). A first occurrence is that date prior to January 15 when the maximum temperature first goes above the specified temperature. A last occurrence is that day after January 15 when the maximum temperature last goes above the specified temperature.

The dates of the earliest and latest recorded first (last) occurrences of a particular temperature are also given. The probability at the base of the table is the chance of receiving the particular maximum temperature at all before (after) January 15.

For example, consider the table for Goondiwindi (table 4). There is a 73% chance of receiving a maximum temperature of 40°C or greater before January 15 (that is, in 27% of years the maximum temperature does not go above 40°C before January 15) and there is a 10% chance that such a temperature will occur before November 10. The earliest first occurrence on record for this temperature is October 18 and the latest first occurrence recorded is January 15.

- Heatwave occurrence and duration probabilities (tables in Appendix 2).

These tables give the probabilities for the relevant weeks in the year which have at least 1 day, 2 consecutive days or 3 consecutive days with maximum temperature greater than or equal to that specified. Thus, they detail the chances related to the severity of heatwave throughout the season.

For example, at Dalby (table 7) there is a 13% chance of getting 2 consecutive days with maximum temperatures at or above 38°C in the week beginning January 8.

- Maximum temperature probabilities (tables in Appendix 3).

The tables give the weekly mean maximum temperature for a particular risk for each week of the year. The lowest and highest weekly mean maximum temperatures observed to date for each week are also given.

For example, at Roma (table 15) there is a 30% chance (or risk) that in the week beginning February 26 the weekly mean maximum temperature will be 34·0°C or higher. The highest and lowest weekly mean maximum temperatures observed to date for that week are 38·2° and 26·2°C respectively.

Use of tables

These tables present information that enables the risk, with respect to heat stress, associated with a particular management decision to be accurately specified.

For example, consider a sorghum crop on a property near Emerald that experiences maximum temperatures the same as those at the official recording site. It is desired to avoid the heatwave conditions of three consecutive days with temperatures above 38°C when the crop is at the head emergence stage. From table 8 it is seen that there is less than a 10% chance of such a heatwave occurring in any week after the end of January but there is still a 5% chance until the end of February. Thus, although the time of planting may be dictated by the occurrence of planting rain, the choice of variety remains a management option that can be used to manipulate the timing of crop development according to attitudes to risk.

Another example is with sheep where it is desired to avoid high temperatures at lambing. Consider a property near Charleville where rams are joined in autumn. Temperatures of 38°C at lambing can cause losses and from table 1 it can be seen that there is a 10% chance of the first occurrence of this temperature being before October 7. Hence, the timing of joining can be adjusted to take account of this particular factor depending on attitude to risk.

There are numerous situations where maximum temperature is a critical factor. Although there are usually many other factors that require consideration when making management decisions, the information presented here at least enables the specification of the risk with respect to maximum temperature associated with the decision. As a result, this information should prove a useful aid to farmers, advisers and researchers.

Appendix 1

Table 1—Charleville

Date of First Heatwave Temperature for Year							
Temperature °C ..		35	36	37	38	39	40
Earliest		Sep. 11	Sep. 18	Sep. 21	Sep. 24	Sep. 24	Oct. 10
% Risk	10	Sep. 21	Sep. 25	Oct. 3	Oct. 7	Oct. 14	Oct. 26
	30	Oct. 4	Oct. 10	Oct. 20	Oct. 27	Nov. 4	Nov. 17
	50	Oct. 13	Oct. 21	Oct. 31	Nov. 10	Nov. 19	Dec. 3
	70	Oct. 22	Oct. 31	Nov. 11	Nov. 24	Dec. 4	Dec. 21
	90	Nov. 3	Nov. 16	Nov. 27	Dec. 14	—	—
Latest		Nov. 23	Dec. 19	Dec. 24	Jan. 1	Jan. 11	Jan. 10
Probability (%) ..		100	100	100	99	94	88

Date of Last Heatwave Temperature for Year							
Temperature °C ..		40	39	38	37	36	35
Earliest		Jan. 16	Jan. 16	Jan. 20	Jan. 17	Jan. 20	Feb. 2
% Risk	90	—	—	—	Feb. 7	Feb. 18	Mar. 1
	70	—	Feb. 2	Feb. 13	Feb. 22	Mar. 4	Mar. 13
	50	Feb. 1	Feb. 15	Feb. 24	Mar. 3	Mar. 14	Mar. 21
	30	Feb. 16	Feb. 27	Mar. 6	Mar. 13	Mar. 23	Mar. 30
	10	Mar. 7	Mar. 16	Mar. 19	Mar. 27	Apr. 6	Apr. 11
Latest		Mar. 29	Apr. 1	Apr. 2	Apr. 17	Apr. 23	Apr. 29
Probability (%) ..		71	87	92	97	100	100

Table 2—Dalby

Date of First Heatwave Temperature for Year							
Temperature °C ..		35	36	37	38	39	40
Earliest		Sep. 22	Oct. 9	Oct. 9	Oct. 9	Oct. 20	Nov. 5
% Risk	10	Oct. 5	Oct. 11	Oct. 20	Nov. 4	Nov. 12	Nov. 27
	30	Oct. 25	Nov. 3	Nov. 16	Dec. 3	Dec. 12	Dec. 29
	50	Nov. 8	Nov. 20	Dec. 8	Dec. 30	—	—
	70	Nov. 23	Dec. 7	Jan. 5	—	—	—
	90	—	—	—	—	—	—
Latest		Jan. 9	Jan. 10	Jan. 16	Jan. 16	Jan. 16	Jan. 14
Probability (%) ..		94	89	77	62	52	42

Date of Last Heatwave Temperature for Year							
Temperature °C ..		40	39	38	37	36	35
Earliest		Jan. 16	Jan. 16	Jan. 17	Jan. 18	Jan. 19	Jan. 25
% Risk	90	*	—	—	—	—	—
	70	*	—	—	—	Feb. 2	Feb. 19
	50	*	—	—	Feb. 3	Feb. 17	Mar. 2
	30	*	Jan. 28	Feb. 6	Feb. 17	Mar. 2	Mar. 14
	10	*	Feb. 25	Mar. 1	Mar. 6	Mar. 18	Mar. 29
Latest		Mar. 14	Mar. 14	Mar. 19	Mar. 25	May 16	May 16
Probability (%) ..		25	42	48	67	82	92

* Insufficient occurrences for complete probability analysis

TABLE 3—EMERALD

Date of First Heatwave Temperature for Year							
Temperature °C ..		35	36	37	38	39	40
Earliest		Aug. 27	Sep. 14	Sep. 21	Sep. 22	Sep. 22	Oct. 3
% Risk	10	Sep. 5	Sep. 23	Sep. 25	Sep. 30	Oct. 9	Oct. 26
	30	Sep. 19	Oct. 8	Oct. 16	Oct. 25	Nov. 3	Nov. 19
	50	Oct. 9	Oct. 19	Oct. 30	Nov. 10	Nov. 21	Dec. 7
	70	Oct. 19	Oct. 30	Nov. 14	Nov. 27	Dec. 12	Jan. 2
	90	Nov. 3	Nov. 14	Dec. 5	Dec. 22	—	—
Latest		Jan. 2	Jan. 3	Jan. 4	Jan. 11	Jan. 11	Jan. 13
Probability (%) ..		100	100	99	97	89	77

Date of Last Heatwave Temperature for Year							
Temperature °C ..		40	39	38	37	36	35
Earliest		Jan. 16	Jan. 17	Jan. 18	Jan. 16	Jan. 19	Jan. 24
% Risk	90	—	—	—	—	Feb. 1	Feb. 16
	70	—	—	—	Feb. 9	Feb. 20	Mar. 6
	50	—	Feb. 2	Feb. 11	Feb. 22	Mar. 6	Mar. 18
	30	Feb. 1	Feb. 18	Feb. 25	Mar. 7	Mar. 20	Mar. 30
	10	Feb. 25	Mar. 9	Mar. 14	Mar. 25	Apr. 8	Apr. 17
Latest		Mar. 23	Mar. 31	Mar. 31	Apr. 22	Apr. 30	Apr. 30
Probability (%) ..		45	65	72	92	99	100

TABLE 4—GOONDIWINDI

Date of First Heatwave Temperature for Year							
Temperature °C ..		35	36	36	38	39	40
Earliest		Sep. 15	Sep. 15	Oct. 4	Oct. 8	Oct. 10	Oct. 18
% Risk	10	Oct. 3	Oct. 8	Oct. 12	Oct. 17	Oct. 24	Nov. 10
	30	Oct. 18	Oct. 25	Nov. 1	Nov. 8	Nov. 17	Dec. 4
	50	Oct. 28	Nov. 6	Nov. 15	Nov. 24	Dec. 5	Dec. 22
	70	Nov. 6	Nov. 19	Nov. 30	Dec. 11	Dec. 25	—
	90	Nov. 21	Dec. 7	Dec. 21	—	—	—
Latest		Dec. 20	Jan. 3	Jan. 6	Jan. 9	Jan. 15	Jan. 15
Probability (%) ..		100	99	99	92	86	73

Date of Last Heatwave Temperature for Year							
Temperature °C ..		40	39	38	37	36	35
Earliest		Jan. 16	Jan. 16	Jan. 17	Jan. 17	Jan. 19	Jan. 30
% Risk	90	—	—	—	—	Feb. 9	Feb. 18
	70	—	—	Jan. 31	Feb. 13	Feb. 22	Mar. 3
	50	—	Feb. 3	Feb. 13	Feb. 21	Mar. 2	Mar. 12
	30	Feb. 2	Feb. 15	Feb. 22	Mar. 2	Mar. 12	Mar. 20
	10	Feb. 21	Mar. 2	Mar. 6	Mar. 12	Apr. 2	Apr. 2
Latest		Mar. 19	Mar. 19	Apr. 1	Apr. 1	Apr. 19	Apr. 21
Probability (%) ..		51	72	78	90	97	99

TABLE 5—ROMA

Date of First Heatwave Temperature for Year							
Temperature °C ..		35	36	37	38	39	40
Earliest		Jul. 31	Aug. 11	Sep. 20	Oct. 4	Oct. 6	Oct. 9
% Risk	10	Sep. 20	Sep. 29	Oct. 4	Oct. 9	Oct. 17	Nov. 3
	30	Oct. 5	Oct. 14	Oct. 21	Oct. 31	Nov. 8	Nov. 22
	50	Oct. 15	Oct. 24	Nov. 2	Nov. 15	Nov. 24	Dec. 7
	70	Oct. 26	Nov. 3	Nov. 15	Nov. 30	Dec. 10	Dec. 26
	90	Nov. 10	Nov. 18	Dec. 2	Dec. 23	—	—
Latest		Nov. 25	Jan. 8	Jan. 8	Jan. 10	Jan. 14	Jan. 15
Probability (%) ..		100	100	99	96	95	82

Date of Last Heatwave Temperature for Year							
Temperature °C ..		40	39	38	37	36	35
Earliest		Jan. 16	Jan. 17	Jan. 17	Jan. 17	Jan. 17	Feb. 5
% Risk	90	—	—	—	—	Feb. 13	Feb. 25
	70	—	Jan. 25	Feb. 3	Feb. 13	Feb. 27	Mar. 10
	50	Jan. 29	Feb. 9	Feb. 15	Feb. 23	Mar. 9	Mar. 19
	30	Feb. 12	Feb. 21	Feb. 26	Mar. 8	Mar. 19	Mar. 28
	10	Mar. 1	Mar. 12	Mar. 13	Mar. 23	Apr. 2	Apr. 11
Latest		Mar. 19	Apr. 1	Apr. 1	Apr. 8	Apr. 14	Apr. 23
Probability (%) ..		65	80	86	92	100	100

Appendix 2

TABLE 6—CHARLEVILLE

Heatwave occurrence and duration probabilities (%)

Temperature °C	40			38			36		
Week Beginning	At least 1 Day	2 Consec. Days	3 Consec. Days	At least 1 Day	2 Consec. Days	3 Consec. Days	At least 1 Day	2 Consec. Days	3 Consec. Days
September 10	0	0	0	0	0	0	0	0	0
September 17	0	0	0	1	0	0	7	3	1
September 24	0	0	0	1	0	0	9	3	1
October 1	0	0	0	5	1	0	19	4	1
October 8	1	0	0	6	0	0	21	10	3
October 15	5	0	0	14	5	1	33	16	7
October 22	7	1	0	17	9	1	40	21	9
October 29	9	5	0	21	10	4	54	33	20
November 5	12	4	1	38	12	7	65	42	24
November 12	20	11	3	43	22	12	70	53	32
November 19	17	7	1	40	22	12	73	49	30
November 26	17	9	6	42	19	10	75	54	40
December 3	27	15	7	46	30	17	75	54	35
December 10	33	19	9	58	33	22	82	64	47
December 17	33	22	11	58	41	25	83	62	49
December 24	36	24	11	59	42	31	80	70	52
January 1	38	27	12	67	44	35	83	73	53
January 8	31	21	17	57	41	32	80	68	51
January 15	38	24	12	61	45	30	82	65	54
January 22	35	26	15	56	44	26	72	59	54
January 29	26	12	7	53	35	22	73	61	48
February 5	29	12	9	54	30	19	77	68	46
February 12	19	12	6	46	30	17	73	58	44
February 19	21	15	9	38	26	20	61	49	40
February 26	14	4	1	32	15	7	56	42	32
March 5	7	3	0	22	9	6	49	32	17
March 12	5	5	3	17	12	6	43	30	17
March 19	4	1	0	5	3	0	24	20	9
March 26	1	0	0	6	3	0	24	11	7

TABLE 6—CHARLEVILLE—*continued*
Heatwave occurrence and duration probabilities (%)

Temperature °C	40			38			36		
Week Beginning	At least 1 Day	2 Consec. Days	3 Consec. Days	At least 1 Day	2 Consec. Days	3 Consec. Days	At least 1 Day	2 Consec. Days	3 Consec. Days
April 2	0	0	0	1	0	0	11	5	3
April 9	0	0	0	0	0	0	4	3	1
April 16	0	0	0	0	0	0	1	0	0
April 23	0	0	0	0	0	0	1	0	0
April 30	0	0	0	0	0	0	0	0	0

TABLE 7—DALBY
Heatwave occurrence and duration probabilities (%)

Temperature °C	40			38			36		
Week Beginning	At least 1 Day	2 Consec. Days	3 Consec. Days	At least 1 Day	2 Consec. Days	3 Consec. Days	At least 1 Day	2 Consec. Days	3 Consec. Days
September 10	0	0	0	0	0	0	0	0	0
September 17	0	0	0	0	0	0	0	0	0
September 24	0	0	0	0	0	0	0	0	0
October 1	0	0	0	0	0	0	1	0	0
October 8	0	0	0	1	0	0	7	2	0
October 15	0	0	0	2	0	0	9	2	1
October 22	0	0	0	1	0	0	13	4	1
October 29	2	0	0	5	1	0	15	6	4
November 5	4	0	0	10	4	0	30	13	6
November 12	7	1	0	11	5	1	36	14	10
November 19	2	0	0	11	5	2	30	15	7
November 26	4	1	1	7	1	1	31	14	6
December 3	4	1	0	10	5	4	35	18	6
December 10	6	5	2	15	8	4	46	14	11
December 17	8	1	0	17	10	2	42	20	8
December 24	8	2	1	18	7	5	41	27	12
January 1	6	5	5	15	8	5	48	21	14
January 8	12	4	2	18	13	7	39	25	14
January 15	8	5	0	20	8	5	42	24	15
January 22	5	1	1	13	6	4	39	24	8

TABLE 7—DALBY—*continued*

Heatwave occurrence and duration probabilities (%)

Temperature °C	40			38			36		
Week Beginning	At least 1 Day	2 Consec. Days	3 Consec. Days	At least 1 Day	2 Consec. Days	3 Consec. Days	At least 1 Day	2 Consec. Days	3 Consec. Days
January 29	7	1	0	12	7	2	27	15	8
February 5	2	0	0	9	4	0	37	18	8
February 12	5	1	0	13	6	0	32	17	10
February 19	2	0	0	11	4	2	32	19	11
February 26	1	0	0	6	1	1	21	11	2
March 5	1	0	0	2	0	0	12	4	0
March 12	1	0	0	4	1	1	12	6	1
March 19	0	0	0	1	0	0	7	2	0
March 26	0	0	0	0	0	0	4	0	0
April 2	0	0	0	0	0	0	1	0	0
April 9	0	0	0	0	0	0	0	0	0
April 16	0	0	0	0	0	0	0	0	0
April 23	0	0	0	0	0	0	0	0	0
April 30	0	0	0	0	0	0	0	0	0

TABLE 8—EMERALD

Heatwave occurrence and duration probabilities (%)

Temperature °C	40			38			36		
Week Beginning	At least 1 Day	2 Consec. Days	3 Consec. Days	At least 1 Day	2 Consec. Days	3 Consec. Days	At least 1 Day	2 Consec. Days	3 Consec. Days
September 10	0	0	0	0	0	0	3	1	1
September 17	0	0	0	1	0	0	8	4	0
September 24	0	0	0	0	0	0	10	4	3
October 1	1	0	0	9	1	0	25	14	4
October 8	0	0	0	11	3	0	34	18	9
October 15	4	1	1	14	6	1	28	19	10
October 22	5	3	0	19	9	3	50	24	14
October 29	9	6	1	19	11	5	51	29	19
November 5	9	4	1	26	10	4	58	36	20
November 12	24	10	4	40	24	14	60	51	36
November 19	10	5	1	25	14	6	61	43	29

TABLE 8—EMERALD—*continued*
Heatwave occurrence and duration probabilities (%)

Temperature °C	40			38			36		
Week Beginning	At least 1 Day	2 Consec. Days	3 Consec. Days	At least 1 Day	2 Consec. Days	3 Consec. Days	At least 1 Day	2 Consec. Days	3 Consec. Days
November 26	15	4	3	25	15	9	56	39	21
December 3	23	11	6	40	26	15	71	54	36
December 10	29	13	8	50	31	14	73	59	45
December 17	23	9	5	45	21	13	71	51	35
December 24	20	5	3	41	24	14	77	61	41
January 1	26	14	6	48	33	19	73	54	43
January 8	20	11	8	35	21	13	65	46	33
January 15	18	5	3	33	20	11	70	54	38
January 22	16	9	4	29	14	10	55	36	24
January 29	16	5	1	33	18	9	55	35	28
February 5	8	4	3	19	6	3	50	31	23
February 12	13	6	4	30	14	9	50	35	23
February 19	11	4	1	25	16	5	54	38	21
February 26	8	4	3	11	6	5	43	20	16
March 5	5	1	0	13	8	4	30	20	13
March 12	3	1	0	8	5	1	25	13	9
March 19	1	0	0	4	1	0	24	14	5
March 26	0	0	0	1	0	0	15	6	3
April 2	0	0	0	0	0	0	15	3	1
April 9	0	0	0	0	0	0	4	3	1
April 16	0	0	0	0	0	0	4	0	0
April 23	0	0	0	0	0	0	1	0	0
April 30	0	0	0	0	0	0	1	0	0

TABLE 9—GOONDIWINDI
Heatwave occurrence and duration probabilities (%)

Temperature °C	40			38			36		
Week Beginning	At least 1 Day	2 Consec. Days	3 Consec. Days	At least 1 Day	2 Consec. Days	3 Consec. Days	At least 1 Day	2 Consec. Days	3 Consec. Days
September 10	0	0	0	0	0	0	1	0	0
September 17	0	0	0	0	0	0	1	0	0
September 24	0	0	0	0	0	0	1	1	0

TABLE 9—GOONDIWINDI—*continued*

Heatwave occurrence and duration probabilities (%)

Temperature °C	40			38			36		
Week Beginning	At least 1 Day	2 Consec. Days	3 Consec. Days	At least 1 Day	2 Consec. Days	3 Consec. Days	At least 1 Day	2 Consec. Days	3 Consec. Days
October 1	0	0	0	1	0	0	4	0	0
October 8	0	0	0	5	0	0	14	1	0
October 15	3	0	0	6	1	0	12	5	3
October 22	5	0	0	11	0	0	20	11	5
October 29	4	1	0	15	3	0	32	15	5
November 5	6	1	0	17	6	2	36	19	10
November 12	10	3	1	24	11	1	47	30	16
November 19	9	3	1	24	7	1	44	26	14
November 26	9	3	3	25	10	5	53	33	20
December 3	12	7	3	30	17	5	56	37	22
December 10	21	9	3	33	20	10	65	43	25
December 17	21	7	0	38	19	5	70	43	22
December 24	24	10	4	42	22	12	72	47	31
January 1	27	10	5	46	24	14	74	60	33
January 8	24	19	14	45	26	20	70	48	32
January 15	27	15	7	43	27	12	68	48	40
January 22	26	14	7	41	22	15	63	48	36
January 29	17	4	1	32	16	6	58	38	24
February 5	12	4	1	33	14	7	63	38	36
February 12	12	6	4	27	9	6	54	32	20
February 19	7	3	0	28	11	4	51	36	19
February 26	4	1	0	16	5	0	41	25	7
March 5	1	0	0	6	3	0	27	7	4
March 12	4	3	1	5	3	1	22	7	4
March 19	1	0	0	1	0	0	12	3	0
March 26	0	0	0	1	0	0	6	3	0
April 2	0	0	0	0	0	0	6	0	0
April 9	0	0	0	0	0	0	0	0	0
April 16	0	0	0	0	0	0	1	1	0
April 23	0	0	0	0	0	0	0	0	0
April 30	0	0	0	0	0	0	0	0	0

TABLE 10—ROMA

Heatwave occurrence and duration probabilities (%)

Temperature °C	40			38			36		
Week Beginning	At Least 1 Day	2 Consec. Days	3 Consec. Days	At Least 1 Day	2 Consec. Days	3 Consec. Days	At Least 1 Day	2 Consec. Days	3 Consec. Days
September 10	0	0	0	0	0	0	0	0	0
September 17	0	0	0	0	0	0	4	0	0
September 24	0	0	0	0	0	0	4	0	0
October 1	0	0	0	4	1	0	17	7	3
October 8	3	0	0	7	1	0	17	9	3
October 15	1	0	0	11	3	0	22	9	5
October 22	4	0	0	11	5	0	30	16	7
October 29	5	1	0	15	9	5	42	22	9
November 5	10	4	3	26	10	5	54	26	12
November 12	17	7	1	35	12	5	59	38	31
November 19	19	5	3	31	19	7	56	43	26
November 26	9	4	3	22	12	6	68	44	21
December 3	24	10	5	36	27	17	65	47	33
December 10	27	11	6	51	24	15	82	58	35
December 17	26	14	5	47	28	12	72	49	35
December 24	24	14	11	48	27	20	77	59	43
January 1	26	15	9	53	32	24	83	61	52
January 8	30	17	11	46	31	24	72	54	46
January 15	31	11	5	43	33	16	65	51	41
January 22	25	15	10	47	27	19	65	56	38
January 29	24	6	6	38	21	12	64	47	21
February 5	17	7	1	41	22	11	65	44	28
February 12	17	6	1	32	20	11	63	43	32
February 19	14	6	3	36	17	10	59	43	30
February 26	6	1	1	21	9	4	47	32	17
March 5	3	0	0	14	6	1	40	20	10
March 12	5	3	1	9	6	3	31	11	4
March 19	1	0	0	3	1	0	24	10	5
March 26	0	0	0	1	0	0	12	6	4
April 2	0	0	0	0	0	0	9	4	1

TABLE 10—ROMA—*continued*

Heatwave occurrence and duration probabilities (%)

Temperature °C	40			38			36		
Week Beginning	At Least 1 Day	2 Consec. Days	3 Consec. Days	At Least 1 Day	2 Consec. Days	3 Consec. Days	At Least 1 Day	2 Consec. Days	3 Consec. Days
April 9	0	0	0	0	0	0	3	1	1
April 16	0	0	0	0	0	0	0	0	0
April 23	0	0	0	0	0	0	0	0	0
April 30	0	0	0	0	0	0	0	0	0

Appendix 3

TABLE 11—CHARLEVILLE

Weekly mean maximum temperature (°C) for a given risk

Week Beginning	Lowest Observed	Percentage Risk					Highest Observed
		90	70	50	30	10	
January 1	26·5	31·2	33·7	35·4	37·1	39·5	41·4
January 8	27·7	31·2	33·7	35·4	37·1	39·6	42·5
January 15	28·2	31·0	33·6	35·3	37·1	39·6	42·3
January 22	25·6	30·6	33·3	35·1	36·9	39·6	42·6
January 29	23·5	30·6	33·2	34·9	36·7	39·2	43·0
February 5	27·7	30·6	33·1	34·8	36·5	38·9	41·0
February 12	26·7	30·3	32·8	34·5	36·3	38·8	41·8
February 19	26·0	29·8	32·4	34·2	35·9	38·5	41·5
February 26	26·1	29·1	31·7	33·4	35·2	37·7	40·8
March 5	24·2	28·4	30·9	32·6	34·3	36·8	39·9
March 12	24·6	28·2	30·5	32·1	33·7	36·0	40·4
March 19	25·1	27·8	30·0	31·5	33·1	35·3	38·3
March 26	23·0	26·9	29·1	30·7	32·2	34·4	36·0
April 2	21·7	26·3	28·4	29·9	31·4	33·5	34·9
April 9	22·3	25·6	27·7	29·1	30·5	32·5	34·8
April 16	22·0	24·3	26·3	27·6	29·0	31·0	30·2
April 23	19·4	22·9	24·8	26·1	27·3	29·2	33·4
April 30	19·9	22·2	24·0	25·3	26·5	28·3	30·0
May 7	18·9	21·1	23·0	24·3	25·6	27·5	29·3
May 14	17·1	19·8	21·7	23·1	24·4	26·4	29·3
May 21	16·1	18·7	20·7	22·0	23·4	25·4	27·0

TABLE 11—CHARLEVILLE—*continued*

Weekly mean maximum temperature (°C) for a given risk

Week Beginning	Lowest Observed	Percentage Risk					Highest Observed
		90	70	50	30	10	
May 28	15·6	18·1	20·0	21·3	22·5	24·4	27·6
June 4	13·4	17·5	19·4	20·6	21·9	23·7	26·9
June 11	14·8	17·1	18·9	20·1	21·4	23·2	27·1
June 18	13·6	16·5	18·4	19·7	21·0	22·9	25·3
June 25	15·1	16·4	18·2	19·4	20·7	22·5	24·5
July 2	14·0	16·3	18·1	19·3	20·5	22·3	26·6
July 9	13·2	16·2	18·0	19·3	20·6	22·4	24·8
July 16	14·4	16·4	18·3	19·5	20·7	22·6	24·7
July 23	14·3	17·0	18·8	20·0	21·2	22·9	25·3
July 30	14·7	17·7	19·5	20·7	21·8	23·6	26·0
August 6	15·0	18·5	20·2	21·4	22·6	24·4	29·7
August 13	17·0	19·2	21·0	22·2	23·4	25·1	28·3
August 20	16·9	19·8	21·6	22·9	24·1	25·9	29·9
August 27	17·9	20·7	22·5	23·7	25·0	26·8	30·0
September 3	19·1	21·5	23·3	24·6	25·8	27·6	30·2
September 10	20·1	22·4	24·3	25·6	27·0	28·9	33·9
September 17	20·2	23·4	25·5	26·9	28·4	30·5	35·2
September 24	21·7	24·3	26·4	27·8	29·3	31·4	34·8
October 1	19·8	25·2	27·4	28·8	30·3	32·4	35·5
October 8	22·3	25·8	28·1	29·6	31·1	33·4	36·7
October 15	22·0	26·5	28·8	30·4	31·9	34·2	37·0
October 22	25·9	27·5	29·7	31·2	32·7	34·9	39·2
October 29	25·8	28·2	30·5	32·1	33·6	35·9	39·7
November 5	25·4	29·0	31·3	32·9	34·4	36·7	39·4
November 12	25·7	29·7	31·9	33·4	34·9	37·1	38·9
November 19	26·1	30·4	32·4	33·8	35·2	37·2	38·9
November 26	28·8	30·7	32·8	34·2	35·7	37·7	41·2
December 3	27·0	30·8	33·0	34·5	36·0	38·3	40·1
December 10	26·9	31·1	33·4	34·9	36·5	38·8	42·0
December 17	28·1	31·3	33·6	35·2	36·8	39·1	42·2
December 24	27·3	31·2	33·7	35·3	37·0	39·4	43·2

TABLE 12—DALBY

Weekly mean maximum temperature (°C) for a given risk

Week Beginning	Lowest Observed	Percentage Risk					Highest Observed
		90	70	50	30	10	
January 1	27·2	28·6	30·7	32·2	33·6	35·7	40·0
January 8	25·0	28·3	30·5	31·9	33·4	35·6	38·3
January 15	26·4	28·2	30·3	31·8	33·2	35·4	38·0
January 22	25·9	27·8	30·0	31·5	33·0	35·2	37·7
January 29	22·4	27·5	29·8	31·3	32·8	35·0	37·6
February 5	25·4	27·8	29·9	31·3	32·7	34·8	37·1
February 12	24·8	27·8	29·9	31·3	32·6	34·7	37·6
February 19	25·6	27·7	29·7	31·0	32·3	34·3	37·8
February 26	25·7	27·4	29·3	30·5	31·8	33·6	37·7
March 5	23·2	27·0	28·8	30·1	31·4	33·2	36·1
March 12	25·2	26·7	28·5	29·7	30·8	32·6	35·7
March 19	24·6	26·4	28·0	29·1	30·2	31·9	33·5
March 26	23·4	25·8	27·3	28·4	29·5	31·1	32·4
April 2	23·3	25·1	26·7	27·8	28·8	30·4	32·0
April 9	22·6	24·3	25·9	26·9	27·9	29·5	32·9
April 6	21·1	23·6	25·0	26·0	27·0	28·5	33·1
April 23	20·6	22·8	24·2	25·1	26·0	27·4	29·8
April 30	21·0	22·1	23·4	24·3	25·2	26·5	28·7
May 7	19·8	21·0	22·4	23·3	24·2	25·6	27·1
May 14	16·7	19·8	21·3	22·3	23·3	24·8	27·5
May 21	15·7	18·7	20·3	21·3	22·4	23·9	26·0
May 28	14·7	18·1	19·6	20·6	21·6	23·1	27·9
June 4	16·2	17·6	19.0	20·0	21·0	22·4	24·0
June 11	15·8	17·0	18·5	19·5	20·5	22·0	23·4
June 18	13·4	16·3	17·9	19·0	20·1	21·8	24·9
June 25	12·8	16·1	17·7	18·8	19·8	21·4	24·0
July 2	13·9	16·0	17·5	18·6	19·6	21·2	22·7
July 9	14·3	16·1	17·6	18·6	19·6	21·1	22·6
July 16	15·1	16·3	17·7	18·7	19·7	21·1	22·3
July 23	13·6	16·6	18·0	19·0	20·0	21·5	22·8
July 30	14·0	17·2	18·7	19·7	20·7	22·1	23·3

TABLE 12—DALBY—*continued*

Weekly mean maximum temperature (°C) for a given risk

Week Beginning	Lowest Observed	Percentage Risk					Highest Observed
		90	70	50	30	10	
August 6	15·5	17·9	19·3	20·3	21·2	22·7	28·2
August 13	17·1	18·4	19·9	20·8	21·8	23·2	25·5
August 20	16·7	18·8	20·4	21·4	22·4	24·0	27·6
August 27	16·8	19·6	21·2	22·3	23·4	24·9	27·2
September 3	17·9	20·4	22·1	23·2	24·3	25·9	28·5
September 10	19·5	21·1	22·8	24·0	25·2	26·9	30·2
September 17	18·9	21·7	23·5	24·7	25·9	27·7	31·2
September 24	20·2	22·4	24·2	25·5	26·7	28·5	31·5
October 1	20·8	23·3	25·2	26·5	27·8	29·6	31·2
October 8	22·2	23·9	25·9	27·2	28·6	30·6	33·7
October 15	21·2	24·5	26·5	27·9	29·2	31·2	33·1
October 22	23·5	25·4	27·3	28·7	30·0	31·9	34·2
October 29	23·5	26·1	28·1	29·4	30·8	32·7	36·7
November 5	23·6	26·4	28·5	30·0	31·4	33·6	37·7
November 12	23·8	26·8	29·0	30·5	32·0	34·2	37·8
November 19	24·7	27·4	29·4	30·8	32·2	34·3	36·4
November 26	25·2	27·6	29·7	31·1	32·5	34·5	39·3
December 3	24·9	27·9	30·0	31·4	32·9	34·9	38·4
December 10	24·5	28·3	30.4	31·8	33·2	35·3	38·8
December 17	25·8	28·4	30·5	31·9	33·3	35·4	37·4
December 24	24·6	28·5	30·6	32·0	33·5	35·6	39·6

TABLE 13—EMERALD

Weekly mean maximum temperature (°C) for a given risk

Week Beginning	Lowest Observed	Percentage Risk					Highest Observed
		90	70	50	30	10	
January 1	28·2	30·6	32·9	34·4	36·0	38·3	39·9
January 8	27·1	30·1	32·5	34·1	35·7	38·0	40·3
January 15	25·5	30·1	32·3	33·9	35·4	37·6	40·1
January 22	25·4	29·7	32·0	33·5	35·1	37·3	43·5
January 29	26·7	29·5	31·8	33·3	34·8	37·0	39·8

TABLE 13—EMERALD—*continued*
Weekly mean maximum temperature (°C) for a given risk

Week Beginning	Lowest Observed	Percentage Risk					Highest Observed
		90	70	50	30	10	
February 5	26·0	29·5	31·7	33·2	34·7	36·9	39·3
February 12	24·0	29·4	31·7	33·2	34·7	37·0	40·7
February 19	27·5	29·4	31·5	33·0	34·4	36·6	38·9
February 26	27·2	29·0	31·1	32·6	34·0	36·1	39·8
March 5	25·1	28·7	30·8	32·2	33·6	35·6	38·3
March 12	26·3	28·8	30·7	32·0	33·2	35·1	38·0
March 19	26·6	28·6	30·4	31·6	32·8	34·5	36·7
March 26	24·5	28·1	29·8	30·9	32·1	33·8	36·7
April 2	25·0	27·7	29·3	30·4	31·5	33·1	35·2
April 9	23·7	27·1	28·7	29·8	30·8	32·4	36.0
April 16	24·6	26·4	28·0	29·0	30·1	31·6	33·7
April 23	23·4	25·7	27·2	28·2	29·2	30·7	33·0
April 30	23·3	25·0	26·4	27·4	28·4	29·8	31·0
May 7	22·1	24·0	25·5	26·5	27·5	28·9	30·9
May 14	20·4	22·8	24·4	25·5	26·6	28·2	30·9
May 21	18·6	21·7	23·4	24·6	25·7	27·4	29·6
May 28	17·9	21·1	22·7	23·8	24·9	26·6	29·3
June 4	18·3	20·7	22·2	23·3	24·4	25·9	26·9
June 11	18·0	20·2	21·8	22·8	23·9	25·5	27·9
June 18	17·5	19·7	21·3	22·5	23·6	25·2	27·3
June 25	18·6	19·6	21·2	22·2	23·3	24·9	26·5
July 2	17·0	19·4	21·0	22·1	23·2	24·8	27·9
July 9	17·7	19·5	21·1	22·2	23·3	24·9	27·9
July 16	17·5	19·8	21·4	22·4	23·5	25·1	28·1
July 23	18·8	20·3	21·9	22·9	24·0	25·6	27·2
July 30	19·0	20·9	22·5	23·6	24·7	26·3	29·6
August 6	18·7	21·5	23·1	24·2	25·3	26·9	30·1
August 13	20·0	22·2	23·7	24·8	25·9	27·5	30·7
August 20	18·8	22·8	24·4	25·5	26·5	28·1	31·9
August 27	23·1	23·6	25·1	26·2	27·2	28·7	32·0
September 3	22·3	24·2	25·7	26·8	27·8	29·4	31·5

TABLE 13—EMERALD—*continued*

Weekly mean maximum temperature (°C) for a given risk

Week Beginning	Lowest Observed	Percentage Risk					Highest Observed
		90	70	50	30	10	
September 10	21·2	25·2	26·7	27·8	28·8	30·4	34·8
September 17	24·8	26·3	27·8	28·9	30·0	32·6	35·5
September 24	23·8	26·8	28·5	29·6	30·8	32·4	35·9
October 1	24·2	27·4	29·2	30·4	31·7	33·5	36·3
October 8	24·9	28·0	29·9	31·2	32·4	34·3	35·9
October 15	25·6	28·5	30·4	31·7	33·0	34·9	37·0
October 22	28·3	29·2	31·0	32·3	33·6	35·5	38·5
October 29	26·0	29·6	31·5	32·9	34·2	36·1	39·9
November 5	24·6	30·1	32·1	33·4	34·8	36·7	40·5
November 12	27·1	30·6	32·5	33·9	35·2	37·1	39·4
November 19	25·7	30·9	32·7	34·0	35·2	37·0	38·8
November 26	29·2	31·1	33·0	34·2	35·5	37·3	40·7
December 3	27·3	31·2	33·2	34·6	35·9	38·0	40·4
December 10	27·0	31·1	33·2	34·7	36·1	38·3	42·7
December 17	27·6	31·0	33·2	34·6	36·1	38·2	41·2
December 24	25·8	30·9	33·1	34·6	36·0	38·2	39·1

TABLE 14—GOONDIWINDI

Weekly mean maximum temperature (°C) for a given risk

Week Beginning	Lowest Observed	Percentage Risk					Highest Observed
		90	70	50	30	10	
January 1	27·5	30·2	32·5	34·1	35·7	38·0	40·5
January 8	25·9	30·1	32·5	34·1	35·7	38·0	41·5
January 15	28·1	30·2	324	34·0	35·5	37·8	43·0
January 22	26·0	29·9	32·2	33·8	35·3	37·6	42·0
January 29	24·8	29·9	32·0	33·5	35·0	37·1	40·6
February 5	27·3	29·8	31·9	33·4	34·8	36·9	39·2
February 12	26·0	29·3	31·5	33·1	34·6	36·8	39·3
February 19	27·0	28·7	31·1	32·7	34·3	36·7	38·6
February 26	28·2	28·5	30·6	32·0	33·4	35·5	33·1

TABLE 14—GOONDIWINDI—*continued*

Weekly mean maximum temperature (°C) for a given risk

Week Beginning	Lowest Observed	Percentage Risk					Highest Observed
		90	70	50	30	10	
March 5	23·5	28·2	30·0	31·3	32·6	34·4	37·5
March 12	24·8	27·9	29·6	30·8	32·0	33·7	37·1
March 19	26·0	27·5	29·1	30·3	31·4	33·0	34·9
March 26	24·3	26·6	28·3	29·4	30·6	32·2	33·4
April 2	23·2	25·7	27·4	28·5	29·6	31·2	33·0
April 9	23·4	24·7	26·3	27·4	28·5	30·2	32·0
April 16	22·6	23·8	25·4	26·5	27·6	29·2	32·7
April 23	19·5	22·9	24·5	25·6	26·7	28·2	30·2
April 30	20·3	21·7	23·3	24·4	25·5	27·1	25·2
May 7	18·0	20·0	21·7	22·8	23·9	25·6	27·5
May 14	16·4	18·7	20·5	21·7	22·8	24·6	26·5
May 21	15·7	17·8	19·5	20·7	21·9	23·7	25·3
May 28	14·5	17·2	18·9	20·0	21·1	22·8	26·8
June 4	14·3	16·9	18·4	19·4	20·5	22·0	23·1
June 11	15·5	16·3	17·9	19·0	20·1	21·6	24·2
June 18	12·8	15·6	17·3	18·4	19·6	21·3	24·3
June 25	13·8	15·4	17·0	18·1	19·2	20·8	22·4
July 2	12·4	15·2	16·8	17·9	19·0	20·6	22·3
July 9	12·0	15·2	16·8	17·9	18·9	20·5	22·2
July 16	13·1	15·4	16·9	17·9	19·0	20·5	21·5
July 23	13·0	15·7	17·3	18·3	19·4	20·9	23·6
July 30	12·8	16·3	17·9	18·9	20·0	21·5	24·1
August 6	14·9	17·1	18·6	19·6	20·6	22·1	28·7
August 13	15·6	17·7	19·2	20·3	21·3	22·8	25·8
August 20	15·8	18·2	19·8	20·9	22·0	23·6	27·7
August 27	16·4	19·1	20·7	21·8	22·9	24·5	26·6
September 3	18·4	19·8	21·4	22·5	23·7	25·3	28·6
September 10	18·3	20·5	22·3	23·6	24·9	26·8	28·8
September 17	17·5	21·4	23·5	24·9	26·3	28·3	31·7
September 24	18·7	22·2	24·3	25·7	27·1	29·1	33·5

TABLE 14—GOONDIWINDI—*continued*

Weekly mean maximum temperature (°C) for a given risk

Week Beginning	Lowest Observed	Percentage Risk					Highest Observed
		90	70	50	30	10	
October 1	20·1	23·2	25·2	26·6	28·0	30·1	32·6
October 8	23·1	23·9	26·0	27·5	29·0	31·1	34·6
October 15	21·5	24·5	26·8	28·3	29·8	32·1	35·2
October 22	22·4	25·4	27.7	29·2	30·7	32·9	37·6
October 29	19·8	26·0	28·4	30·0	31·6	33·9	36·2
November 5	21·7	26·6	29·0	30·7	32·3	34·7	37·3
November 12	22·1	27·2	29·7	31·3	33·0	35·4	39·2
November 19	21·1	28·0	30·3	31·9	33·4	35·7	38·1
November 26	27·2	28·6	30·9	32·4	34·0	36·3	40·3
December 3	25·4	29·0	31·3	32·9	34·4	36·7	38·7
December 10	25·8	29·4	31·7	33·3	34·9	37·2	40·4
December 17	26·7	29·9	32·1	33·6	35·2	37·4	40·1
December 24	23·4	30·0	32·3	33·9	35·5	37·8	40·2

TABLE 15—ROMA

Weekly mean maximum temperature (°C) for a given risk

Week Beginning	Lowest Observed	Percentage Risk					Highest Observed
		90	70	50	30	10	
January 1	28·0	30·5	32·9	34·5	36·2	38·6	40·2
January 8	25·0	30·2	32·7	34·4	36·1	38·6	41·2
January 15	25·7	30·2	32·6	34·2	35·9	38·3	42·2
January 22	25·3	29·7	32·2	33·9	35·6	38·1	42·2
January 29	23·4	29·6	32·0	33·7	35·3	37·8	40·1
February 5	26·9	29·6	32·0	33·6	35·2	37·6	40·0
February 12	24·3	29·1	31·6	33·4	35·1	37·6	41·1
February 19	25·3	28·8	31·2	32·9	34·6	37·1	38·8
February 26	26·2	28·8	31·0	32·5	34·0	36·1	38·2
March 5	23·6	28·3	30·5	32·0	33·5	35·6	37·6
March 12	24·5	28·1	30·1	31·5	32·9	35·0	38·9
March 19	24·6	27·7	29·6	30·9	32·2	24·0	33·8
March 26	23·4	27·0	28·8	30·0	31·2	32·9	35·8

TABLE 15—ROMA—*continued*

Weekly mean maximum temperature (°C) for a given risk

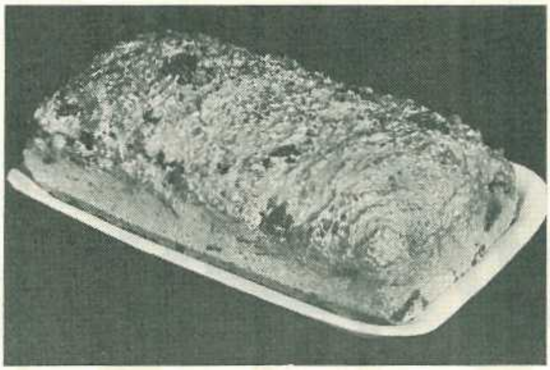
Week Beginning	Lowest Observed	Percentage Risk					Highest Observed
		90	70	50	30	10	
April 2	23·4	26·4	28·1	29·2	30·4	32·0	34·9
April 9	23·6	25·6	27·2	28·3	29·5	31·1	34·1
April 16	22·2	24·7	26·3	27·4	28·4	30·0	31·8
April 23	20·8	23·8	25·3	26·4	27·4	29·0	32·3
April 30	21·6	22·9	24·4	25·4	26·4	27·9	29·4
May 7	20·3	21·8	23·3	24·3	25·3	26·8	29·6
May 14	17·8	20·5	22·1	23·2	24·3	25·8	27·6
May 21	16·8	19·4	21·0	22·2	23·3	24·9	27·0
May 28	15·0	18·7	20·3	21·4	22·5	24·1	27·7
June 4	15·4	18·1	19·7	20·8	21·8	24·3	23·9
June 11	16·5	17·5	19·2	20·3	21·4	23·0	25·0
June 18	14·5	16·9	18·6	19·8	21·0	22·7	25·9
June 25	14·1	16·8	18·4	19·6	20·7	22·4	23·9
July 2	13·8	16·7	18·3	19·4	20·6	22·2	24·6
July 9	14·1	16·7	18·3	19·4	20·5	22·1	23·8
July 16	14·6	16·9	18·5	19·6	20·7	22·3	24·4
July 23	15·3	17·4	19·0	20·1	21·2	22·9	25·5
July 30	15·4	18·1	19·7	20·8	21·9	23·6	25·5
August 6	16·0	18·8	20·4	21·5	22·6	24·2	30·1
August 13	19·0	19·5	21·1	22·0	23·2	24·8	26·9
August 20	16·5	20·0	21·7	22·9	24·0	25·7	29·7
August 27	19·0	20·9	22·6	23·7	24·9	26·5	29·5
September 3	20·3	21·5	23·3	24·4	25·6	27·4	30·2
September 10	20·4	22·5	24·3	25·5	26·8	28·6	32·7
September 17	20·7	23·5	25·5	26·8	28·1	30·1	32·7
September 24	21·6	24·2	26·2	27·5	28·9	30·9	33·6
October 1	22·2	24·9	27·0	28·5	29·9	32·0	34·0
October 8	21·6	25·5	27·7	29·1	30·6	32·8	35·2
October 15	21·8	26·2	28·4	29·9	31·3	33·5	35·7
October 22	25·4	27·2	29·2	30·7	32·1	34·1	36·6

Table 15—Roma—*continued*

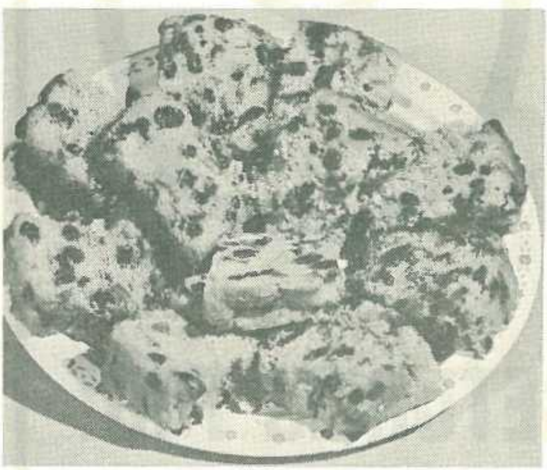
Weekly mean maximum temperature (°C) for a given risk

Week Beginning	Lowest Observed	Percentage Risk					Highest Observed
		90	70	50	30	10	
October 29	24·7	27·9	30·0	31·5	32·9	35·0	40·0
November 5	24·5	28·5	30·6	32·1	33·6	35·8	39·2
November 12	24·6	29·1	31·2	32·7	34·2	36·4	39·6
November 19	25·3	29·6	31·7	33·1	34·5	36·5	38·4
November 26	27·6	30·0	32·1	33·5	34·9	37·0	40·5
December 3	25·7	30·1	32·4	33·9	35·5	37·7	40·7
December 10	26·9	30·3	32·6	34·2	35·8	38·1	41·3
December 17	26·2	30·4	32·7	34·3	35·9	38·2	40·8
December 24	27·6	30·5	32·9	34·5	36·1	38·5	41·1

Sweet potato slices.



Sweet potato loaf.



Sweet potato fruit cake.

Sweet potato recipes

THE following recipes were provided by a group of ladies associated with sweet potato growing in the Deception Bay District, Queensland.

The recipes all contain as an ingredient the new orange-fleshed sweet potato called Centennial which is gaining popularity throughout the east coast of Australia.

As can be seen below, these new sweet potatoes not only make an attractive baked or boiled vegetable but can also be used to make many other appetizing dishes.

Sweet Potato Scones

1 cup mashed, cooked sweet potato
2¾ cups S.R. flour
1 cup sugar
1 tablespoon butter or margarine
1 egg
1 pinch salt

Cream together sugar and butter, beat in egg, blend in mashed sweet potato (still warm) then mix in flour and salt. Moisten with milk if necessary. Bake in hot oven for 8 to 10 minutes.

Sweet Potato Loaf

1 cup mashed, cooked sweet potato
2 cups S.R. flour
½ cup bran
¾ cup brown sugar
1 cup seeded dates
1 tablespoon treacle

Blend all ingredients together and then add 1 cup warm water. Stir well and cook in a loaf tin in a moderate oven for 40 minutes.

Sweet Potato Slice

PASTRY

115 grams (4 oz) butter
1 cup sugar 1 egg
½ teaspoon ground ginger
1 cup plain flour
1 cup S.R. flour
½ cup cornflour
Pinch salt

FILLING

2 cups mashed, cooked sweet potato
2 eggs 1 cup sugar
1 level teaspoon salt
¼ teaspoon ground nutmeg
1 teaspoon cinnamon
1 cup milk
2 tablespoons butter

PASTRY. Cream butter and sugar, add egg and beat well. Sift dry ingredients and mix in to form a soft dough; press into baking tray and set aside.

FILLING. Beat eggs slightly, add sugar, salt, spices and milk. Add butter to mashed sweet potato and blend with egg and milk mixture.

Pour on to unbaked pastry and bake in moderate oven 30 to 40 minutes (until filling is firm).

Sprinkle with coconut, cool and cut into slices. When to be used as a dessert, sprinkle with cinnamon before cooking and omit coconut. Serve with custard or cream.

Sweet Potato Fruit Cake

1 cup cold, mashed, cooked sweet potato
225 grams butter
2½ cups S.R. flour
1 cup sugar
pinch salt
2 eggs
1 level teaspoon each of mixed spice and ginger
1 packet mixed fruit

Blend butter and sugar into a cream; add eggs one at a time and beat well. Add sweet potato, flour, salt, spices and mixed fruit. Mix well and bake in a moderate oven for 2 hours.

Sweet Potato Spread

A quantity of mashed, cooked sweet potato
1 tomato
1 egg
¼ teaspoon mixed herbs
1 medium onion
1 teaspoon margarine
1 tablespoon breadcrumbs

Peel onion and tomato, cut up finely and place in saucepan with margarine and simmer for 10 minutes.

Beat egg in basin; add breadcrumbs and herbs; add contents to mixture in saucepan and boil 1 minute. Remove from stove, add pepper and salt to taste and enough sweet potato to form a desirable consistency for a spread or dip.

Tuna Cakes

1 small tin Tuna
1 cup mashed, cooked sweet potatos
1 grated onion
½ cup breadcrumbs

Mix all ingredients together; roll into balls and then press flat; cover with breadcrumbs; heat small quantity of cooking oil in pan and fry till brown on both sides.

Sausage Loaf

500 grams pork sausage meat
1 grated onion
1 cup cooked, mashed sweet potato
Salt and pepper to taste
1 cup breadcrumbs
1 small grated carrot
1 large egg

Mix all ingredients together and place in greased bar tin; sprinkle top with breadcrumbs and bake in a moderate oven for 1 hour.

Savoury Pie

1 tablespoon butter
¾ cup S.R. flour
1 cup mashed, cooked sweet potato
1 tablespoon cornflour
1 egg
Salt to taste
Quantity of cooked savoury mince, breadcrumbs and grated cheese.

Sift cornflour, S.R. flour and salt; rub in butter; add egg and mashed sweet potato. Chill for 30 minutes; roll out and line pie dish. Fill with savoury mince; top with grated cheese and breadcrumbs; bake in moderate oven for about 30 minutes.

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Foliar symptoms of copper deficiency in wheat

Recently, copper deficiency has been confirmed in wheat in the Miles, Tarà and Yelarbon districts.

The symptoms

The number and complexity of the symptoms increase as the deficiency becomes more severe. Usually, mild copper deficiency affects grain production more than vegetative growth, but both are equally affected when the deficiency is severe.

- WILTING. Even with ample water, affected plants often wilt due to structural weakness in stems and roots. This symptom is usually the first to occur and is common in young plants in the late tillering to early stem elongation stage of growth.
- LEAFTIP DIEBACK. The next symptom after wilting is that the ends of the youngest leaves die, turn a light brown colour and become tightly twisted (plate 1). The basal part of the upper leaves may develop a yellow-green colour while the lower, older leaves remain dark green and appear healthy (plate 1).

These symptoms can develop in young plants at the early stem elongation stage of growth (plate 2). As the plants mature, the youngest leaves die, leaving a stunted plant with dead upper leaves and some green lower leaves. Isolated plants of healthy appearance sometimes occur adjacent to plants which are nearly dead from copper deficiency.

- EARTIP DIEBACK. Sometimes, the top of the ear is sterile and turns white or yellow. The remainder of the ear stays green but may not set grain. This symptom is very similar to weathertip caused by lack of moisture or frost damage.
- WHITEHEADS AND DELAYED MATURITY. In some instances, eartip dieback results in whiteheads where the whole ear dies. The stems and leaves may remain green well after healthy wheat has completely dried off (plate 3).
- MELANISM. Where maturity is delayed, the stems sometimes develop blackening or melanism (plate 3). When these plants eventually die, the straw remains black and darkens with age.
- EAR BRANCHING. Ears which develop on late tillers sometimes show excessive development of lower spikelets. This results in a branched appearance to the ear (plate 4).
- UPPER NODE TILLERING. Late tillers sometimes develop from the nodes well above ground level.

Correcting the deficiency

Copper deficiency in wheat can be corrected by applying copper sulphate either to the soil as a fertilizer or to the foliage as a spray.

- SOIL APPLICATION. Copper sulphate is applied to the soil at 10 to 20 kg per ha with the seed at planting. If deficiency symptoms still appear, a foliar spray of 2% copper sulphate (2 kg copper sulphate in 100 litres of water per hectare) should be applied immediately.
- FOLIAR SPRAYS. An alternative remedy is two foliar sprays of 2% copper sulphate. The first spray is applied 3 to 5 weeks after the wheat seedlings emerge. The second spray can be applied at any time from the growth stage when the ear just begins to swell the stem of the plant to when the plant is in the boot stage.

The foliar sprays have little residual value and must be applied each year, whereas the soil dressing can last at least 2 years and perhaps much longer. However, under Queensland conditions, two foliar sprays may give more reliable control of the deficiency than soil dressings.

Test strips

Farmers who suspect that their crops are copper deficient, are advised to spray copper sulphate on test strips. The test strips provide a patch of healthy wheat against which the rest of the paddock can be compared.

The spray is best applied at any time before the crop flowers. The best rate is 2 kg of copper sulphate in 100 litres of water per hectare. The ends of the strips should be marked with pegs. The strip should be harvested separately from the rest of the paddock so that yields can be compared to see if the plants responded to additions of copper. When copper is severely deficient, response to added copper is spectacular and harvesting to measure the result may not be required (plate 5).

by N. J. Grundon, Queensland Wheat Research Institute

Foliar symptoms of copper deficiency in wheat

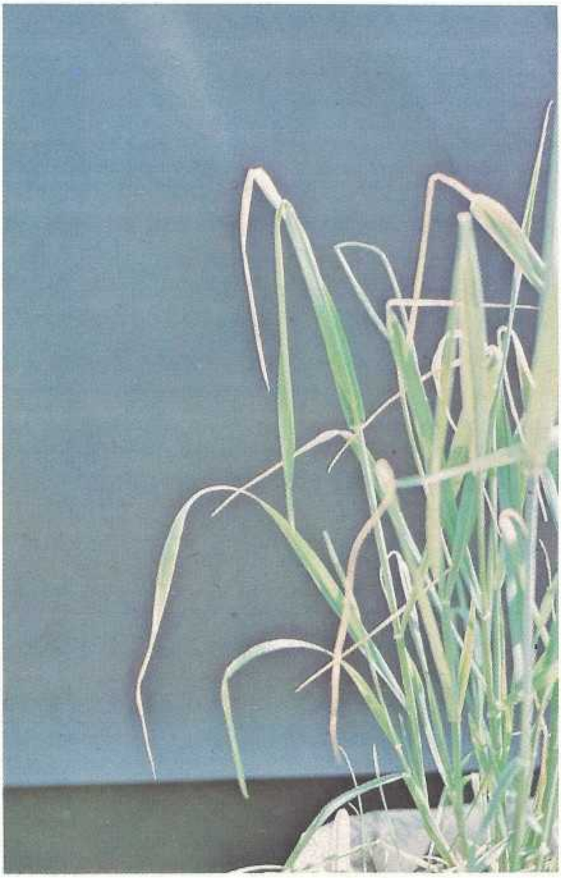

Plate 1. Leaftip dieback symptoms on wheat. Note the pale colour of upper leaves, death and sharp twisting of leaf tips.

Plate 2. Leaftip dieback is an indicator of copper deficiency in this young crop of wheat.

Plate 5 (right). Effect of two foliar sprays of 2% copper sulphate on wheat in 1977. The unsprayed crop on the right has almost died from copper deficiency.

Plate 3. Copper deficiency can produce whiteheads and delay maturity in wheat. The plant on the left has received two foliar sprays and has set grain and dried off. The plant on the right has not received any copper. Note the dead heads with no grain and green leaves on this plant.

Plate 4. Branched ears sometimes appear on late tillers on copper deficient wheat plants. Note the lower ears on the plant on the right.