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Cover: Drought is the single greatest menace to Queensland's Primary Industries. See 'The cost of drought' in this issue. Photograph by B. J. Fillery.

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Less dipping . . . more property development

by A. H. Milles, Beef Cattle Husbandry Branch

Oakey Creek Station is a beef cattle property of 6 000 ha, running 2 000 head of cattle, approximately 30 km west from Monto. About 800 breeders are carried and all steers are turned off at 3 to 3½ years of age.

Tick infestation was regarded as a major problem on this property during the 1950s and 1960s. Dippings were carried out approximately ten times each year. This exercise involved about 100 days a year spent mustering, that is, more than one-third of all working time.

One of the penalties with such frequent mustering and dipping was a severely restricted amount of time available for timber control, fencing, and maintenance of water facilities, yards and buildings. While the Price family was developing an interest in the potential of legume-based pasture, the continued dipping regime jeopardized pasture establishment by constant interruptions.

This article is an account of how a change in tick control strategies brought an opportunity to establish extra improved pasture.

Breed of cattle and management

Traditionally, Hereford cattle had been bred at Oakey Creek. It was not until the early 1960s that the Price family had a look at the possibility of introducing *Bos indicus* blood into the Oakey Creek breeding herd. A decision was made in 1962 to change the breeding programme. Since then, *Bos indicus* based bulls of mainly Brahman type have been introduced in order to try and overcome certain weaknesses in the previously all-British herd.

The chief weaknesses were seen to be the poor performance of British breeders under drought stress, slow weight gain by a large proportion of the steers, a fairly high calf mortality due to dingoes and low tick resistance.

All of these production areas improved as the Brahman content of the breeding herd increased. In addition to the features already mentioned, crossbred calves were found to outperform their straight British contemporaries. Steers were sold a year earlier at the same weight and the incidence of cancer eye had fallen dramatically among breeders.

By the mid 1970s the herd was approximately five-eighths Brahman in content and the full implications of the tick resistance of the cattle was becoming self-evident.

New developments

As a result of keeping in touch with the latest trends in parasite control, the Prices began to adopt a less stringent dipping schedule. Allowing their cattle to demonstrate their tick resistance, seemed to make good sense to Kerian and Wayne.

From 1972, the frequency of dipping started to drop by an average of two dippings a year. By 1978, dipping had virtually ceased. The Prices believe that the better productivity and easy care possible with *Bos indicus* cattle were the major factors that helped them to stay viable during the beef depression of 1974-78.

As a direct result of a marked reduction in time spent mustering and dipping, a project involving the establishment of 280 ha of legume-based pasture was commenced during 1977.

Time saving effected

The time saved as a result of the radical change in tick control management amounted to 240 man-days per annum by 1978. Prior to the start of a reduction in dipping frequency, the ten musters involved an average of three men for 10 days, that is, 300 man-days annually.

Since ceasing to dip, musterings have been reduced to four partial musters per annum. These musters have entailed a total of 60 man-days. The four have been for the purpose of branding (two), weaning and pregnancy diagnosis. Apart from these, mustering has been confined to gathering in sale cattle and moving growing cattle into fattening paddocks.

Value of savings

Using the current standard of \$40 per day for casual stockmen, the value of time saved annually now amounts to \$9 600 per annum (240 man-days).

The savings of labour and chemicals are shown in table 1.

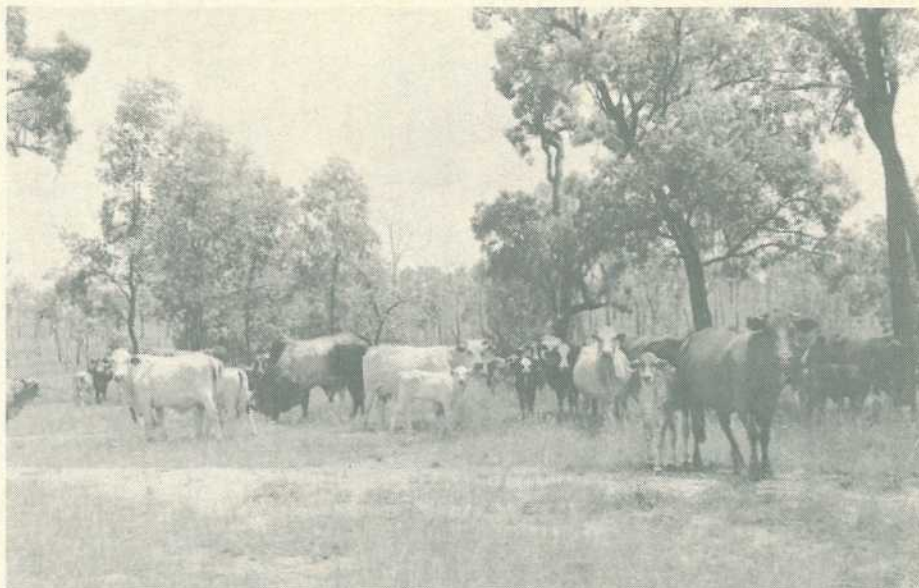
Those who stress the advantages of an all-British breeding herd, should still recognize that mustering and dipping can become so constant as to preclude all worthwhile property improvement. This includes timber regrowth control which significantly affects carrying capacity, turn-off and net return.

Time saved in terms of reduced mustering can readily and effectively be spent in many other ways. In addition to more time becoming available for property improvement, profitability of the whole operation is significantly increased through improved growth rates and reduced losses through drought, cancer eye and dystocia.

Return from legume-based pasture

The Price family established 280 ha of siratro/buffel pasture in 1977. Savings in dipping largely made this approach possible.

Granite soils supporting a siratro/buffel pasture support and fatten a steer to 1.2 ha. Bodyweight gain from these pastures averages 0.4 kg per head per day. This gives an annual gain of 146 kg per beast.



A typical breeder group on Oakey Creek. Note the impressive muscle development of the steer calf on the left of the photograph.

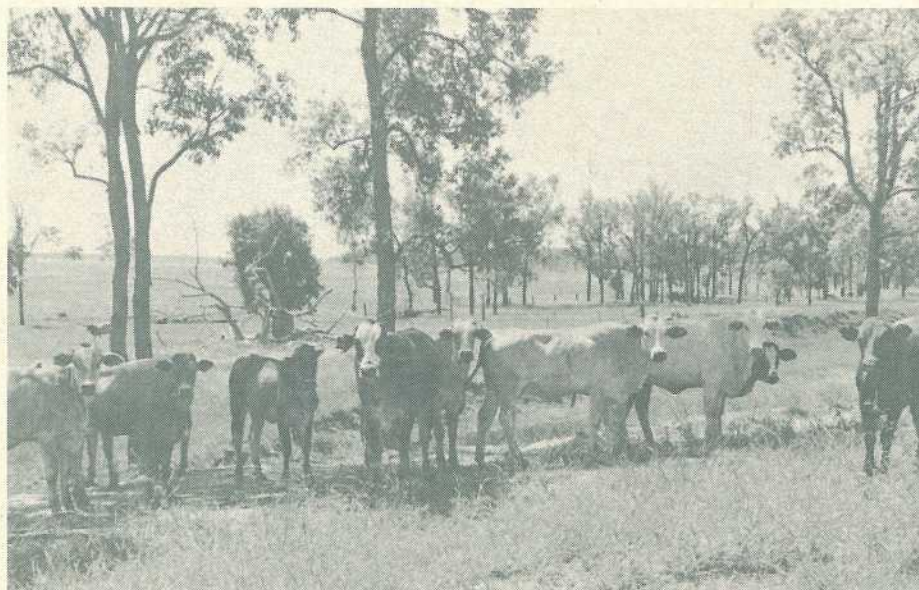


A typical Oakey Creek breeder whose genetic characteristics are ideally suited to breeding calves that finish as 600 to 650 kg bullocks at around 40 months of age.

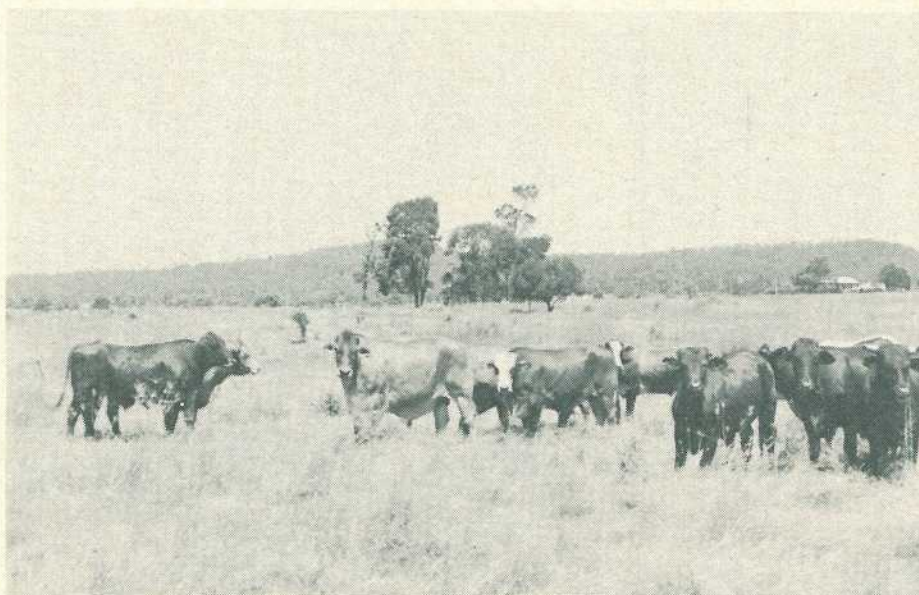


A pair of Zebu X Santa Gertrudis calves running on open savannah spear grass granite country.

Crossbred heifers 18-months-old showing Zebu, Hereford and Shorthorn characteristics. In the background is part of the 280 ha of legume-based, introduced pastures consisting of siratro and Biloela buffel grass.



An attractive mob of 650 to 750 kg crossbred bullocks showing a good genetic combination of Zebu, Santa Gertrudis and Hereford. They are finished off on introduced green panic and Rhodes grass pasture.



The export bullock on the right hand side of the photograph is an outstanding example of a Santa Gertrudis X Hereford. It is well in excess of 850 kg bodyweight.

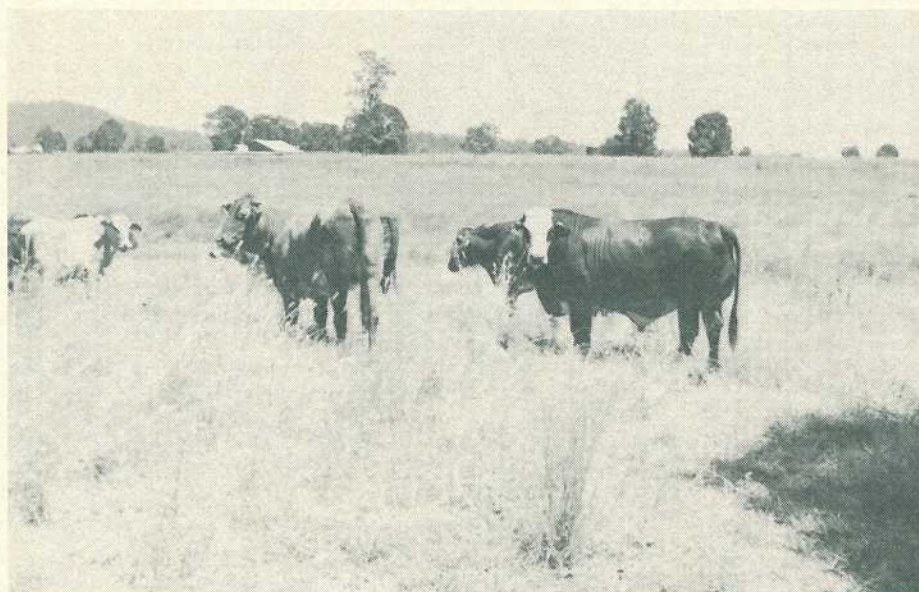


TABLE 1
Saving of Labour and Chemicals

Year	Actual musters	Man-days Saved	Labour Saving at 1981 prices \$	Chemical saving at 1981 prices \$	Total saving at 1981 prices \$
1972-1973	10	60	2 400	800	3 200
1973-1974	8	120	4 800	1 600	6 400
1974-1975	6	180	7 200	2 400	9 600
1975-1976	4	240	9 600	3 200	12 800
1976-1977	2*	240	9 600	3 200	12 800
1977-1978	2*	240	9 600	3 200	12 800
1978-1979	2*	240	9 600	3 200	12 800

* Actually four half musters of 15 man-days each (3 x 5). Full musters involve 30 man-days (3 x 10).

† Based on 20c per adult equivalent per dipping.

TABLE 2

Spear grass production system		\$
80 steers in 12 months gain 110 kg/hd at 70c/kg—80 x 110 x 0.7	=	6 160
Additional fencing, water facilities	=	..
Introduced grass/legume (buffel/siratro) pasture system		\$
235 steers in 12 months gain 140 kg/head at 70c/kg	=	23 030
Less 35 t of superphosphate at \$120.50/t		4 218
Annual depreciation assuming the pasture gives 5 years of high grade production, assuming establishment costs at \$94/ha	=	5 264
Additional fencing, water facility, etc., at \$6/ha	=	1 680
Removal of suckers, regrowth, etc., at \$3.50/ha	=	980
		<u>\$12 142</u>
Margin	=	10 888
Additional profit over speargrass		4 728
Assuming total outlay at \$94/ha		26 320
Then return on capital invested		18%

Beef production per ha is about 122 kg, which at 70 cents per kg liveweight is \$85 per ha. At 80 cents per kg, the return increases to \$97 per ha.

Production from 280 ha of pasture can be reasonably expected to return \$24 000 to \$27 000 annually.

In low phosphorus situations, an annual dressing of 126 kg per ha of superphosphate is necessary to maintain the legume content. This represents the biggest single maintenance cost (\$15 per ha). Other costs such as additional fencing and/or water facilities are minor when costed over say 10 years; probably, \$6 per ha per annum would be generous.

Otherwise, costs of maintaining legume-based pastures are little different to those entailed in properly-managed native pastures, the assumptions being the maintenance

of correct stocking levels and attention to any suckering that may occur. Thus the annual gross margin is in the order of \$18 000 to \$21 000 annually.

Return from black spear grass/granite soils

Timber-treated granite soils of the Central/Upper Burnett are usually capable of carrying an adult beast to 3.5 ha.

On the granite soils which are characteristic of much of the western areas of the inland Burnett, 280 ha of spear grass could normally be expected to carry about 80 steers.

Brahman/British breed steers can be expected to make annual gains in the order of 100 to 120 kg per hd on spear grass. Straight British breed steers in this environment will produce less.

At a grazing pressure of a steer to 3.5 ha, this gives about 30 kg per ha

liveweight gain, which at previously mentioned values is worth about \$6 000 to \$7 000 from 280 ha.

Conclusion

The likely returns from pasture improvement are summarized in table 2.

The release of labour from mustering and money saved on chemicals markedly contributed towards the establishment of the first area of pasture. Obviously, money generated from this project can be used to establish further areas.

An intangible benefit of improved pasture is that cattle can be sold at higher weights. This often attracts premium prices.

I gratefully acknowledge the considerable amount of time and information supplied by Mr Wayne Moxham-Price and Mr Kerian Price of Oakey Creek Station.

All-weather farm roads

by C. E. G. Holt, Engineering Services Section

This article discusses the need, the design standard and the economic viability of the provision of all-weather roads in various farming situations.

These situations overlap in their requirements in some aspects and in others have their own individual characteristics because of the industries involved.

The four main types of road considered are:

- Dairy farms with on-farm milk storage tanks, where the need is for all-weather year-round access roads and turning areas at the dairy premises.
- Grain farms with facilities for on-farm handling and storage of grain where the need is for all-weather seasonal access roads when delivering from on-farm storage to terminals.
- Poultry broiler farms. Here, the need is to provide heavy-duty all-weather roads of short lengths for

the use of large feed-stock vehicles in frequent use and for the transport of the poultry and poultry products in and out of the farm. They must be all-weather and be capable of uninterrupted usage. Horticultural farms with packaging sheds and cold storage facilities require similar access roads and the capability of uninterrupted use.

- General farm roads, where the need is to provide the means for all-weather mobility for the owner around his property. Here, the question is one of economic balance, that is, either providing all-weather roads, or alternatively using four-wheel-drive vehicles designed specifically for off-road use.

An appraisal of common requirements for all types of farm roads is dealt with initially before the specific requirements of the four types already mentioned are considered individually.

Planning

The all-weather on-farm road must be designed and constructed to carry out the function for which it is intended. The farm road layout should be closely integrated with the total farm plan. This involves the consideration of road alignments in relation to soil conservation works and fence lines.

A badly chosen road alignment can interfere quite drastically with erosion control. As a permanent feature with a relatively heavy capital investment component, it should be planned very carefully.

Limitations

The load and axle limitations placed on the type or class of vehicle using the farm road will be the same as the statutory limitations placed upon registered motor vehicles by the road authorities, as the vehicle will also be using public roads.



A well-formed all-weather farm road.

The statutory limits refer to the following characteristics of the vehicle:

- Maximum length
- Maximum width
- Maximum height
- Permitted number of axles
- Permitted axle loads and tyre pressures.

A brochure which is published by the National Association of Australia State Road Authorities and obtainable from the Queensland Main Roads Department, describes the limitations imposed on the maximum mass and dimensions, etc., of registered road vehicles in Queensland.

Geometric design

In considering the standards of the geometric design of a road, the main factors involved are:

- The type and class of vehicle to use the road.
- The expected volume of traffic (vehicles per day).
- The speed of travel which it is intended to cater for (generally known as the 'design speed').

The design elements that can be determined as minimum values without relating to a design speed are:

WIDTH OF ROADWAY

This will depend on the track width of the vehicle, plus an allowance for the shoulder and some lateral tracking of the vehicle on the road.

RADIUS OF HORIZONTAL CURVES

These will vary greatly according to the terrain but generally should be made as large as possible for ease of travel. An absolute minimum radius for turning circles in farm yards would be 22 m.

GRADIENTS

These should be limited to a maximum steepness which will allow the full use of the vehicle's load-carrying potential within safety requirements. In general, a maximum gradient of 10% should be aimed at.

Pavement construction

The class or thickness of pavement or load-bearing structure required for the road will depend on the types of earth foundation or subgrade encountered along the line of the road. The proposed type of vehicle to be used is also important, particularly with regard to the allowable loading.



An example of poor construction and lack of drainage.

Another factor will be the source of base course material and its cost; this should be as close as possible. The pavement material should be of full width; the provision of wheel tracks only is poor construction practice for a number of reasons.

Drainage

The provision of good drainage is vital and the design of the drainage should be carefully considered in initial planning and also in relation to proposed or existing soil conservation measures.

Maintenance

The degree of maintenance required will depend on the amount of initial capital investment put into the structure, and the actual usage, taking into consideration both loads and frequency. In general, maintenance such as the filling of pot-holes and opening up of blocked drainage should be carried out immediately the need becomes apparent.

Heavy maintenance will largely be in the form of re-surfacing with gravel and the need for this could show up in the course of intensive use such as the transporting of grain to a terminal during harvesting. Periodic grading of the surface with a motor grader will be the most beneficial form of maintenance if hire can be arranged (usually from the local Shire Council).

Construction methods

Construction methods will depend largely on the machinery available to the farmer.

The use of Local Shire Council equipment, if it can be hired, is often the cheapest and best way to form the road.

Obtaining gravel from Council gravel pits can also be very useful if the pit is reasonably close at hand and the Council are using it themselves. In this case, the farmer can either use his own trucks or hire trucks to haul in material for the gravel surface, while the Council loader is in operation.

It should also be borne in mind that smaller contractors are available, who will normally carry out most of the work listed above, though the price will generally be higher than using Local Council plant.

Within the framework of the factors mentioned previously, earthworks should be kept to a minimum, so that if possible they can be carried out with equipment available on the farm. Small bull-blades attached to farm tractors can carry out a great deal of work, depending on tractor size. However in many cases, it will be necessary to hire a small bulldozer to carry out work from cut to fill.

Earthworks are the basis of a satisfactory farm road and it is well worth investing available capital in achieving a satisfactory alignment before the rest of the work is carried out.

On long slopes, drainage should be carefully looked at and side drains formed to a length where they will not build up a volume of water so as to cause erosion. This can be prevented by periodically spilling the



One of the problems associated with poor planning—lack of drainage.



No capital investment leads to high maintenance costs.



An example of pot-holing where vehicles tend to stop and start before traversing the grid.

water out to the side in a flat channel and then letting it spread over the surrounding land.

Careful attention should be paid to the inlet and outlet areas of inverts and culverts where required. If at all possible, they should be paved with gravel to prevent erosion and constructed with well-tapered inlets and outlets to reduce velocities.

Pot holes at gates which require to be frequently opened and closed are liable to develop quite quickly due to the constant starting and stopping of vehicles at these points. This causes a faster deterioration of the surface. It is sound practice to keep a small stockpile of gravel at these points so that when the situation warrants it, a few shovel loads can be placed in the developing fault.

Cost estimates

These will naturally vary within areas and differing types of work. However, certain indicators can be established for general guidance and the forming of an estimate. Estimates given by outsiders as a construction price based on a 'cost per square metre' are invariably found to be excessively high.

Break down the construction cost as follows and assemble the estimate from the individual elements.

Earthworks

If using hired plant, after establishing firm hourly rates, estimate the time required for each type of machine to carry out earthworks as pegged out for construction.

An experienced contractor should be able to assist in giving rough figures if difficulty is found in estimating times for these operations. Establish total expected cost of plant hire after multiplying hourly hire rates by estimated time requirements for each piece of equipment.

Gravel base course

Establish a price for an acceptable gravel base material at the pit and, based on haul distance, at site of works. The Shire Engineer will, in most cases, be the most accurate source of this information.

Calculate the volume of gravel required based on the pavement thickness, the width (including shoulder if needed) and the length of road. Allow an additional 20% of this volume to give the total loose quantity required. Multiply this volume by the unit price at site to obtain a lump sum for total price of gravel.

Allow an additional amount for spreading and rolling based on plant hire costs.

Drainage works

Establish the length and size of each pipe culvert which is required on the proposed farm road.

- (A) Obtain a cost for the pipe requirement delivered to site from the nearest manufacturer.
- (B) Allow a lump sum equal to the cost of the pipe for bedding, laying, jointing and backfilling.
- (C) Obtain from the local Shire Engineer a figure for the volume of concrete required for headwalls for each size of pipe. (M.R.D. Standard Tables). Obtain a price for this volume of concrete from the nearest ready mixed concrete supplier delivered to the site of works. Allow an equal sum for forming up boxing, pouring and finishing. Check with the local Shire Engineer if this total estimated cost is considered realistic.

Obtain a total estimate by adding together (a), (b) and (c). If this is found to be too high for the economics of this situation, give consideration to the construction of an invert in place of the pipe culvert. However, this should be avoided if possible due to lower serviceability and higher maintenance costs for the invert.

After totalling up the three main sections of the estimate add on 10% to this total for contingencies. After carefully making the estimate do not try to prune it if it looks too high (table 1).

Dairy farm access roads

An all-weather road from the boundary of the property to the milk storage tanks is required. In general, this should be a one-way road of good standard to the pick-up point, with a turning circle so that excessive manoeuvring of the tanker is unnecessary.

Preferably, the vehicle should be able to drive up to the milk shed, hook up to the tank, draw the milk out and continue to the exit without any need for backing in or out.

The distance from the milk shed to the farm boundary should be kept to a minimum for reasons of economy, but this will depend on the farm layout. Existing layouts where backing in is necessary should be closely examined and modified if possible with a view to establishing an effective, functional turning circle.

Stock should be kept away from the turning circle and milk shed area as dung adhering to the truck's tyres can and does create a health hazard.

Geometric standards

- The paved road width should be a minimum of 4 m. This is the lowest allowable for single lane width under N.A.A.S.R.A. policy for rural roads.
- The turning circle should be of a minimum radius of 22 m.
- The maximum grade which a loaded truck could be expected to negotiate at a low speed should be 10%.
- The length of approach road in relation to the farm lay-out should be kept to a minimum for reasons of economy.

Pavement thickness

The pavement thickness should be kept at the minimum which will give reasonably maintenance-free service. In general, the provision of an all-weather gravel surface pavement will be the most expensive element in the road.

For a dairy farm access road, it will pay to construct the final required pavement thickness in the initial phase and thus keep maintenance to a minimum. The access road will be used two or three times a week and constant minor maintenance would be a nuisance and could tend to be neglected.

Pavement thickness can only be determined after accurate laboratory tests on the foundation material. However, this is considered as inappropriate for minor roads of this nature and a more empirical selection of thickness can be made, such as for 'heavy' vehicles:

On black soils—min. 300 mm

On red soils—min. 200 mm

On natural gravels—min. 100 mm

See table 2 for further details of required pavement thicknesses.

If, after being put into service, these thicknesses are found to be inadequate, additional material may be added as a maintenance operation.

The type of material chosen for the pavement is also very important and in a higher class of roadbuilding

TABLE 1

Example of a Cost Estimate

Hire of bulldozer for earthworks 12 hrs at \$25 per hour	\$300
Hire of grader for forming and shaping road base 10 hrs at \$20 per hour	\$200
Provide and place gravel for pavement 500 m ³ at \$4	\$2,000
Provide and install 600 mm pipe culverts 12 m length at \$50/m	\$600
Provide concrete and construct headwalls 6 m ³ at \$50/m ³	\$300
	\$3,800
Allow 10% for contingencies	\$380
TOTAL	\$4,180



Road wear increases where vehicles are required to reverse and manoeuvre.

would require a laboratory analysis to ensure conformity with M.R.D. standards.

In the case of farm roads, availability is the prime factor and local knowledge and experience are important. In general, a well-graded granular material should be looked for with sufficient binder to prevent the surface becoming 'bony'.

Also, large stones should be avoided as they will become troublesome while trying to achieve a smooth surface, and about 75 mm diameter should be the maximum allowed size. Too much clay will lead to slipping on the surface and even possible bogging down in wet weather. The general rule is higher initial capital cost to keep maintenance low.

Drainage

Drainage of the dairy access road should be properly constructed so that ponding and puddling does not occur either on the road surface or within the turning circle. Lack of proper drainage will soon lead to rapid and expensive deterioration of the road pavement.

Grid

A properly designed and constructed cattle grid must be installed at the entrance to the property: this is mandatory under the "Dairy Produce Act". A suitable design is shown in figure 1.

Grain farm access roads

The requirement for the all-weather access road on a grain-growing property differs from the dairy farm in that its use is mainly seasonal.

Depending on the handling methods adopted, the actual detailed requirement may differ from farm to farm. However, it is envisaged that as a minimum requirement there will be an all-weather access to on-farm storage or handling facilities. This may be considered as the terminal on-farm point.

From this point the requirement would be to transport the harvested grain off the property with a maximum safe speed and minimum inconvenience from weather conditions.

Geometric standards

In this case, the aim is to keep the standard as high as possible as a quick turn-round between farm and

central terminal is a primary objective. To achieve this, the following should be sought:

- Maximum width could be kept to 4 m, but reasonable shoulders of at least 1 m width should be provided to allow vehicles proceeding in opposite directions to pass without discomfort.
- Curves to be kept to the maximum radius attainable, but no attention should be paid to finer points such as laying out transition curves to link straight lengths with circular arcs.
- Grades should be kept as flat as possible, consistent with the earth works not becoming too heavy, and therefore expensive for a seasonal road.

Pavement thickness

This can be constructed to a lower standard than that advocated for the dairy farm situation. However, during heavy usage, quick maintenance measures could become necessary and these should be provided for beforehand (for example, gravel stockpiles on hand ready to be used if a failure commences, especially in wet weather).

During the off-season, incipient failure areas can be detected and the maintenance work of re-gravelling can be carried out.

Drainage

Again, in this situation, the forethought put into drainage planning and implementation before construction will pay dividends and keep major failures in the pavement to a minimum. As previously pointed out, the position and type of drainage lines must be co-ordinated with the overall soil conservation plan for the property.

Poultry and horticultural farm roads

The provision of a system of good quality all-weather roads within a poultry or horticultural farm complex is essential for the continuous operation of feed delivery vehicles, abattoir and refrigerated trucks throughout the year.

The necessity for good drainage for the protection of the road foundation and the imported pavement material should be the over-riding consideration in the planning and construction of the roads. In the vicinity of sheds with large roof areas, the water must be kept away from the service roads by means of guttering, down pipes and collector drains (preferably underground, piped).

The provision of an adequate surface course or gravel pavement to carry the heavier vehicles which are now used should be given a high priority.

Lengths of service road within these farms are generally found to be relatively short and the use of inadequate pavement thicknesses and poor quality materials will lead to surface failures in wet season conditions. It is therefore considered false economy.

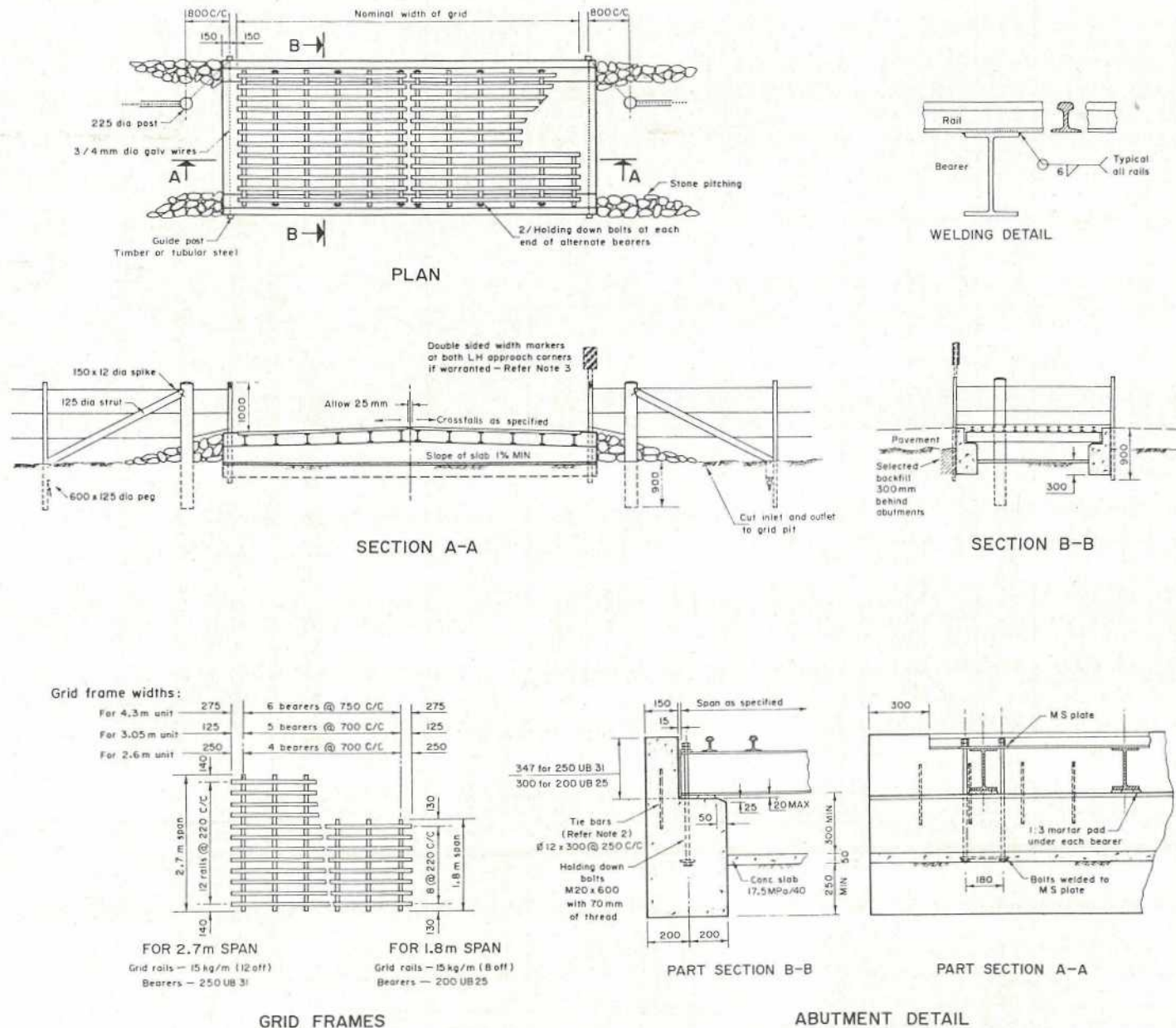
Checking the soil conditions and using a pavement thickness for heavy vehicles as shown in table 2 are necessary. The use of gravel which conforms to the M.R.D. 'D' class specifications is also important.

General purpose roads

This item covers a large area of possibilities and no overall ruling can be formulated to cover them all. The first consideration must be the necessity or otherwise to make any individual track all-weather for conventional vehicles.

The deciding factor in this will be a balance between necessity and cost. The following information should be considered before deciding if all-weather access roads are required or whether a four-wheel-drive vehicle could be used to carry out all the required functions:

- What is the length of essential all-weather capability required for actual cartage of crops, fodder, etc., in conventional drive vehicles all year round?
- Considering the above defined length and known soil conditions, what type and volume of pavement material would be required to achieve an all-weather road and how much would this gravel cost?
- What length of access roads could be serviced by a four-wheel-drive vehicle with limited load-carrying capacity on an unsurfaced track?
- What earthworks and drainage will need to be carried out regardless of whether the decision is to surface for all-weather traffic or not?
- What is the capital cost and annual maintenance of a four-wheel-drive vehicle against the capital cost and maintenance of providing all-weather surfacing. Include a bonus for the fact that the four-wheel-drive vehicle can be used for many other purposes. A close examination of the answers to these questions and a balance of the cost items should give a fair indication of the economic viability of the construction of all-weather roads for general use.



- NOTES**
- Standard sizes of grids for normal installation are shown below. For other widths, where specifically approved,
 - even numbers of standard units should be used where possible
 - elsewhere even numbers of non-standard units should be used. These should vary from the standard units only in the width of the unit and the number and spacing of the bearers. The standard width may be varied as required, provided the bearer spacing does not exceed 750 mm, and the rail overhang does not exceed 275 mm.
 - Abutments, if cast in two sections, should have a tied construction joint level with the underside of the mortar bearing pad.
 - Width markers are required only when the clearance from the normal pavement edge (i.e. excluding tapers) to the guide post is less than 600 mm for a 7.4 m pavement width.

800	6.8
1000	6.2
1200	5.6
1800	3.8

 No width markers are required for the standard grid installations in Note 1.

STANDARD GRID WIDTHS		
Pavement width, m	Formation width, m	Grid units to use
3.8, 5.6	8.6	2/4.3m units
6.2	8.6, 9.8	2/4.3m units
6.8	10.4, 11.6	4/2.6m units
7.4	12.2, 13.4	4/3.05m units

STANDARD GRID SPANS	
1.8m or 2.7m only	

SPAN, m	Unit	2.7			1.8		
GRID WIDTHS, m		8.6	10.4	12.2	8.6	10.4	12.2
Bearers	250 UB 31	No	12	16	20	12	16
	200 UB 25	No				12	16
	Mass	kg	1004	1339	1674	540	720
Grid rails 15kg/m	No	24	48	48	16	32	32
	kg	1548	1872	2096	1032	1248	1464
	Total mass of grid frames	kg	2552	3211	3870	1572	1968
Tie bars $\phi 12 \times 300$ (if required - Note 2)	No	72	86	100	72	86	100
	kg	19.1	22.9	26.6	19.1	22.9	26.6
Holding down bolts (bolt, washer, nut, lock-nut)	No	24	32	48	24	32	48
	kg	32.5	43.3	65.0	32.5	43.3	65.0
	M.S. Plates 230 x 75 x 10	No	24	32	48	24	32
Concrete 17.5 MPa/40	Abuts	m ³	5.2	6.2	7.2	5.0	6.0
	Slab	m ³	1.0	1.2	1.4	0.6	0.7
	Backfill of abutments*	m ³	3.3	3.9	4.6	3.3	3.9
Fence posts 225 dia	No	2			2		
Guide posts	No	4			4		
Struts & pegs 125 dia	No	2/ To suit fence			2/ To suit fence		
Fence spikes $\phi 12 \times 150$	No	2			2		
Wire 4mm dia	m	36			36		

* Calculated for 600mm depth.

All dimensions are in mm except where shown otherwise.

MAIN ROADS DEPARTMENT	
MOTOR GRID	Drawing No. III3

Figure 1.

TABLE 2

Base-course thickness required for existing sub-grade (in situ material) types

Description for field Identification	Sub-grade types	Sub-groups	Shrinkage or Swelling	Drainage Properties	Value as a road foundation	Recommended base course thickness for
Generally easily identifiable by visual inspection	Boulders and cobbles	Boulder/gravels	Almost none	Good	Good to excellent	Heavy vehicles—100 mm Medium-shape only Light-shape only
Generally easily identifiable by visual inspection. A medium to high dry strength indicates some clay is present. A negligible dry strength indicates the absence of clay	Gravel and gravelly soils	Well-graded sand gravel with little or no fines	Almost none	Excellent	Excellent	Heavy—100 mm Medium-shape only Light-shape only
		Well-graded sand gravel with small clay content	Very slight	Practically impervious	Excellent	Heavy—100 mm Medium-shape only Light-shape only
		Uniform gravel with little or no fines	Almost none	Excellent	Good	Heavy—200 mm Medium—100 mm Light-shape only
		Sand gravel with excess of fines	Almost none	Fair to practically impervious	Good to excellent	Heavy—100 mm Medium-shape only Light-shape only
Majority of particles can be distinguished by eye. Feel gritty when rubbed between fingers. A medium to high dry strength indicates some clay present. Low dry strength indicates absence of clay	Sand and sandy soils	Well-graded sands with little or no fines	Almost none	Excellent	Excellent to good	Heavy—100 mm Medium—shape only Light—shape only
		Well-graded sands with small clay content	Very slight	Practically impervious	Excellent to good	Heavy—100 mm Medium-shape only Light-shape only
		Uniform sands with little or no fines	Almost none	Excellent	Fair	Heavy—250 mm Medium—150 mm Light—100 mm
		Sands with excess of fines	Almost none to medium	Fair to practically impervious	Fair to good	Heavy—250 mm Medium—150 mm Light—100 mm
Soils not gritty when rubbed between fingers. Cannot readily be rolled into a thread when moist. Exhibit dilatancy.	Fine-grained soils of low plasticity (silts)	Silts, rock flour silty fine sands with slight plasticity	Slight to medium	Fair to poor	Fair to poor	Heavy—300 mm Medium—250 mm Light—200 mm
		Clayey silts (inorganic)	Medium	Practically impervious	Fair to poor	Heavy—300 mm Medium—250 mm Light—200 mm
		Organic silts of low plasticity	Medium to high	Poor	Poor	Heavy—300 mm Medium—250 mm Light—200 mm
Soils which can be readily rolled into threads when moist. Do not exhibit dilatancy. Show some shrinkage on drying	Fine-grained soils having medium plasticity	Silty clays (inorganic) and sandy clays	Medium to high	Fair to poor	Fair to poor	Heavy—300 mm Medium—250 mm Light—200 mm
		Clays (inorganic) of medium plasticity	High	Fair to practically impervious	Fair to poor	Heavy—300 mm Medium—250 mm Light—200 mm
		Organic clays of medium plasticity	High	Fair to practically impervious	Poor	Heavy—300 mm Medium—250 mm Light—200 mm
Soils which can be readily rolled into threads when moist. Greasy to the touch. Show considerable shrinkage on drying. All highly compressible soils	Fine-grained soils with high plasticity	Highly compressible soils	High	Poor	Poor	Heavy—300 mm Medium—250 mm Light—200 mm
		Clays (inorganic) of high plasticity	High	Practically impervious	Poor to very poor	Heavy—400 mm Medium—350 mm Light—300 mm
		Organic clays of high elasticity	High	Practically impervious	Very poor	Heavy—400 mm Medium—350 mm Light—300 mm

NOTE: Heavy vehicles, tandem axle trucks up to 33 t all up weight.
Medium vehicles, single axle trucks up to 15 t with dual tyres.
Light vehicles are utilities, four-wheel-drive vehicles, etc.

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Bullocks	\$400
Bulls	\$400
Cows	\$200
Calves	\$40
Heifers	\$150
Steers	\$250
Weaners	\$100

If a cow died, the loss was \$200 or if a cow was a forced sale for \$150 then the opportunity loss was \$50.

Feed stored on the property was costed at its original price or production cost. In a strict sense, the stored fodder should be costed at its market value when it is used. The gain in value of the stored fodder should be assigned to the fodder storage activity on the property. However, costing stored feed at the original price allows any saving due to fodder conservation to be reflected in the cost of feeding during a drought when purchased feed can be expensive.

The cost of drought

by I. F. Whan, Economic Services Branch

Solutions to drought problems are as inevitable as drought itself. There will always be some people who will offer the answers to all drought problems after a few minutes' solid thinking.

A longer period of thought, however, often makes you very sceptical about these 'solutions'. If everyone pursued the same course of action in terms of, say, feeding or selling, the benefits of the particular strategy may be eroded by its popularity. In addition, the strategy recommended may not suit any particular individual's situation or approach to drought.

The effects of drought on cattle production can be reduced by sound on-farm management practices such as seasonal calving, early weaning and segregation and strategic feeding when the drought is judged to be starting.

Despite good management, a drought still costs money when measured against the average production year and its true significance lies in how much the drought costs.

Drought survival from a financial and business point of view means minimizing the extent of cash and opportunity costs incurred compared to an average year.

In this article, the cost of drought in 1980 is determined for seven beef properties in the Goondiwindi area using different drought strategies.

The effects of the drought on the taxation position of each property are not shown. These results are a record of the actual and implied costs incurred by particular cattle enterprises in a given year of a severe drought.

The cost of this drought is measured in terms of non-recoverable losses which include the loss of income not obtained (opportunity loss) from forced sales, the opportunity loss from deaths, agistment payments, purchased feed, droving, freight and extra labour and materials.

Only costs specifically associated with drought are included. Cost figures used for freight and droving exclude any government rebate which applies in respect to fodder and stock movement in a drought declared area.

To provide a common basis for property comparison, total costs of the drought were divided by the number of breeding cows run on the property before the drought started. This allows inter-property comparisons to be made on a cost per breeding cow basis.

Opportunity losses applying to forced sales and deaths are estimated by using a standard set of prices. The prices used are considered to be conservative saleyard levels which applied to stock in good condition during 1980.

The case studies

Seven case studies were undertaken to examine differing approaches used by beef producers to drought. The results of the studies are presented in table 1. This table shows the forced sale losses and numbers sold on each of the properties, the deaths and the opportunity loss of the deaths, and the other costs incurred as a result of the drought. Finally, the table shows the drought cost per breeder for each property so that comparisons can be made.

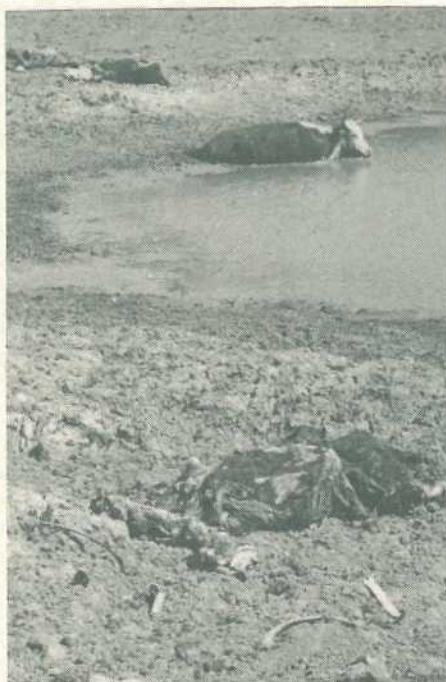
The property of case study 1 ran about 550 breeders prior to the drought. After natural feed supplies were exhausted, a heavy sell-off programme commenced. About 1 000 backward cattle were sold between June and October 1980. The average price received was \$87.50 per head.

Despite this level of sales, animal losses were still substantial and some feed was purchased. Case study 1 incurred a loss of \$224 per breeder. In spite of this, the producer actually had a reasonable cash income in 1980. The opportunity losses (estimated to be \$108 000) will show up in future years as either low turn-off or in the cost of purchasing replacement breeders.

About 380 breeders were usually run on case study property 2. The major drought strategy was agistment in Central Queensland. The cattle failed to adjust to the new conditions and died in large numbers; an entire herd of calves was lost. A loss of \$264 per breeder was incurred.

TABLE 1
Summary of Drought Costs—Goondiwindi Properties

Case study	1		2		3		4		5		6		7	
—	No.	\$	No.	\$	No.	\$	No.	\$	No.	\$	No.	\$	No.	\$
FORCED SALES														
Cows	410	43 506	..	..	80	2 605	..	..	..	..	..	..	7	164
Steers	153	21 690	..	..	33	3 067	64	1 280	..	..	49	3 209	32	3 673
Weaners	378	12 750	..	..	..	..	..	..	..	..	58	417	..	..
Bulls	10	630	..	..	..	..	..	..	..	..	..	..	1	16
Calves	4	40	..	..	1	7	..	..	..	..	..	..	..	..
Heifers	..	..	..	..	6	170	8	344	..	..	..	..	23	1 377
FORCED SALE LOSSES		78 616				5 849		1 624				3 626		5 230
Deaths—														
Cows	100	20 000	244	48 800	19	3 800	5	1 000	800	160 000	..	..	33	6 600
Steers	..	..	..	..	4	1 000	..	..	..	..	..	..	..	..
Heifers	..	..	..	..	1	150	..	..	..	..	..	..	5	750
Weaners	51	5 100	84	8 400	..	..	..	..	300	30 000	..	..	..	..
Calves	125	5 000	230	9 200	2	80	..	..	450	18 000	..	..	..	..
Bulls	..	..	..	..	..	..	..	..	..	..	..	..	..	..
DEATH LOSSES		30 100		66 400		5 030		1 000		208 000		..		7 350
LIVESTOCK LOSSES		108 716		66 400		10 879		2 624		208 000		3 626		12 580
OTHER COSTS														
Droving	..	..	..	..	..	..	..	..	..	..	..	..	..	33 850
Agistment	..	..	7 mths	14 763	..	..	..	1 236	..	..	Failed wheat crop	1 500	..	7 641
Purchased and stored feed	..	11 650	..	2 000	..	22 486	..	7 660	..	126 000	..	6 294	..	7 685
Extra wages	..	2 600	..	2 000	..	3 044	..	..	..	4 050	..	..	..	..
Extra fuel	..	..	..	..	..	1 000	..	800	..	2 000	..	..	..	980
Freight (before rebate)	..	..	..	15 000	..	..	..	..	..	..	..	..	..	12 651
Animal costs	..	..	..	..	..	Preg. test	..	470	..	..	..	..	Bruc. test	995
Feeder costs	..	..	..	..	..	Depreciation	..	1 600	..	Materials	700	..	..	..
Irrigated crops	..	..	..	..	..	..	..	..	..	..	..	40	..	..
TOTAL OTHER COSTS		14 250		33 763		28 600		9 696		132 750		12 584		63 802
TOTAL COSTS		122 966		100 163		39 479		12 320		340 750		16 210		76 382
BREEDERS BEFORE DROUGHT	550		380		350		250		1 700		450		320	
COST PER BREEDER		224		264		113		49		200		36		239



The effects of drought can be reduced by sound management practices.

Case study property 3 ran about 350 breeders before the drought. The main drought strategy used was intensive feeding which substantially succeeded in maintaining numbers and output. During 1980, 327 head

were sold—some of the sales being 'forced' when measured against the benchmark figures used in this analysis. For this property, the opportunity cost per breeder was \$113. This producer purchased or had stored feed to the value of \$30 186 during 1980. At the end of 1980 about \$7 700 worth of feed was stored on the property.

Case study property 4 relied on an intensive hand-feeding programme. Much of the feed used was stored on the property before the drought. The drought opportunity cost was \$49 per breeder for the normal-sized herd.

An intensive feeding programme was started on case study property 5 in June 1980 but it commenced too late to prevent hundreds of cows dying. Losses were eventually stopped in July 1980 by feeding 15% protein pellets with hay.

Case study 6 was different to the other properties surveyed in its having a reasonable irrigation capacity. Until 1980, 38 ha of *sorghum almum* were irrigated and then 60 ha of oats were irrigated until October. The irrigated area fully supported 240 cows, about half the cows normally run on the property.

A mob of 240 weaners were hand fed while 50 heifers and 70 cows

survived on native pasture and failed wheat crops. Cost per breeder was \$36.

Case property 7 normally runs about 320 breeders. Its main drought measure was droving on stock routes in northern New South Wales. Linked with droving were other expensive measures such as forced sales, hand-feeding and agistment. Cost per breeder was \$239.

Conclusions

No attempt is made to suggest which is the best, or worst, drought strategy of those that are described here. This survey was undertaken to provide some estimate of the costs incurred by drought-affected properties in the Goondiwindi area.

The survey showed that the 1980 drought was a financial disaster for many cattle properties in this area as four of the seven properties incurred costs of \$200 or more per breeder.

Some of these costs represent transfer payments to other people, for example, agistment money. The losses due to death and forced sales represent a complete and irretrievable loss to the individual. These losses always take a considerable time to recover after the drought breaks.

Forage workshop book now available

'Forage Evaluation—Concepts and Techniques', Edited by J. L. Wheeler and R. D. Mochrie

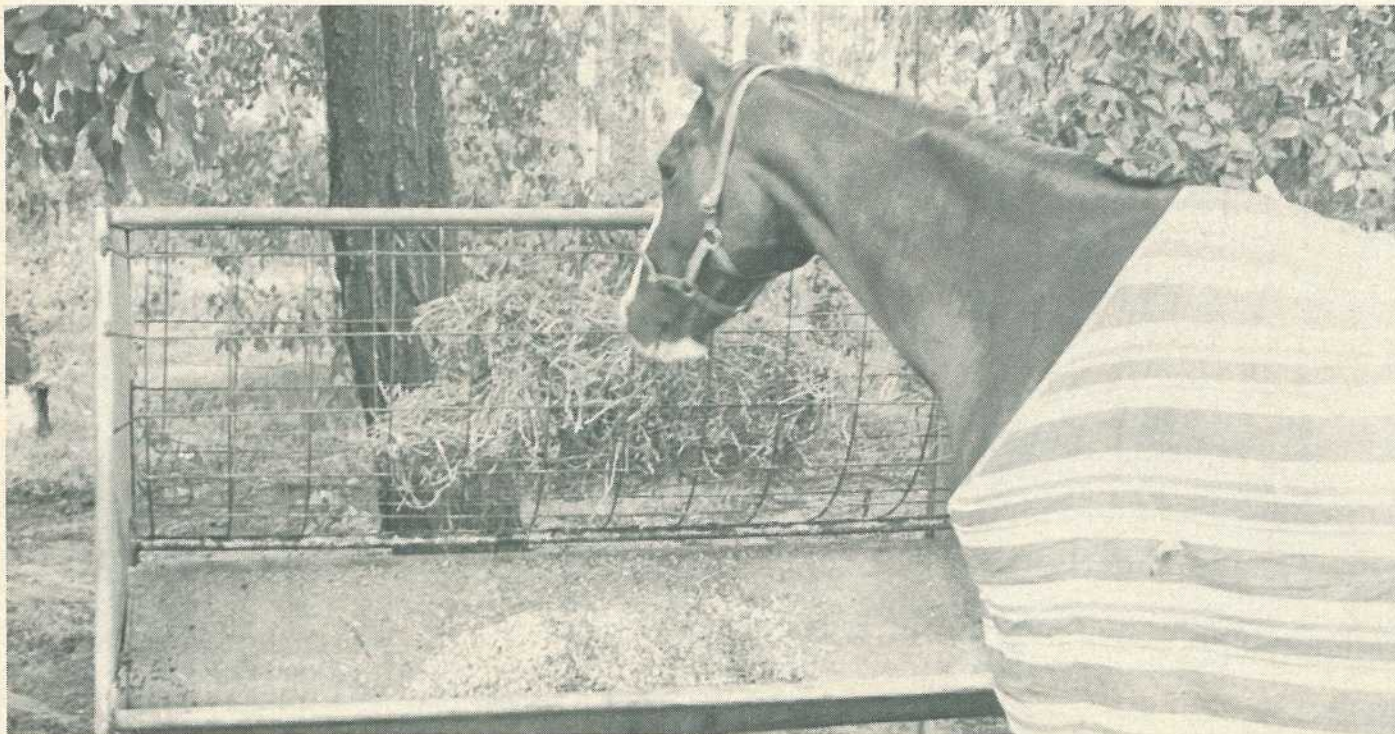
For some years now, the U.S./Australia Co-operative Science Program has fostered the staging of joint workshops in various areas of rangelands and agricultural science.

The latest of these was a workshop on 'Forage evaluation and utilization—an appraisal of concepts and techniques' held at Armidale, N.S.W., 27 to 31 October, 1980. This workshop was held because ruminant livestock in the United States and Australia rely so heavily upon forages. It was considered desirable to discuss the techniques and underlying research philosophies used in evaluating and utilizing forages.

This book of 582 pages is the proceedings of that workshop, edited by Dr J. L. Wheeler of the CSIRO

Pastoral Research Laboratory, Armidale and Dr R. D. Mochrie of North Carolina State University, Raleigh, NC. It shows how scientists in each country approach the measurements of the components of pasture and animal production, conduct grazing experiments and evaluate pasture.

There are six sections on the use of forage, evaluating forage in the laboratory, evaluating forage with confined animals, evaluating forage with grazing animals, constructing grazing systems, and synthesis. These sections include reviews describing current practices and shorter articles that report relevant research. This book is available from the CSIRO Editorial and Publications Service, 9 Queens Road, Melbourne, Victoria 3004, or from your local bookseller. The recommended retail price is \$25.00.



Feeding the club pony

by M. A. Burns, Beef Cattle Husbandry Branch

The main function of food is to provide energy—energy for work and movement and energy for all the chemical processes that go on in the animal's body.

As well as providing energy, food must also supply the animal with protein which is essential for the formation and repair of body tissues.

In addition to energy and protein, there are several minerals which are essential for proper health and production. Not only is it necessary that they be present in adequate amounts but also that they be in correct balance in the diet. This is particularly true of calcium and phosphorus which make up the greater part of the skeleton (or bones) of animals and are the main ones to be considered in the diet of the horse.

Horses doing hard work excrete considerable quantities of salt (sodium and chlorine) in their sweat and consequently need more salt than idle horses. They should be fed 30 to 60 g of salt daily or given free access to a salt lick.

Vitamins are essential for proper health. Vitamin A is a very important one and high quality green feed is an excellent source of this vitamin

as is fresh, well-cured hay. Provided horses have access to green feed, vitamin A deficiency is not likely to occur. However, horses which are fully hand fed for long periods on fodders which have been stored for a long time could suffer a deficiency.

Finally, an adequate supply of good, clean, palatable drinking water is an essential part of a horse's diet. Before nutrients can be absorbed into the body, they must be in solution. There is a constant drainage of water going on in the body, particularly during work. Deficiency of water hampers digestion and is liable to cause colic, and affect the general health of the horse.

The chief requirement of a horse doing muscular work is a liberal supply of energy. However, the protein, mineral and vitamin requirements are not appreciably increased by hard work and are little more than those required when the horse is idle.

On the other hand, brood mares need liberal amounts of protein, minerals and vitamins during pregnancy. When they are nursing foals, their nutrient requirements are even greater. Young, growing horses need a much greater proportion of protein

than mature work horses as well as more calcium, phosphorus and vitamins.

Feeding in practice

Pasture is the main source of food for most horses in Queensland.

In the young and growing stage, these pastures provide sufficient nutrients for most classes of horses but when mature they often fall short of normal requirements. The working capacity and body condition of the horse suffers accordingly.

If there is not sufficient pasture available and/or the pasture is in an advanced stage of maturity (flowering-seeding) then it may be necessary to introduce supplementary or even complete hand feeding.

The body condition of the horse and the amount of work performed should be used as a guide to the level of hand feeding necessary.

Foodstuffs

Materials used for feeding horses fall into two classifications—concentrates and roughages.

Concentrates

These comprise foods high in nutritive value and low in fibre content. They may be divided into two main groups:

- Energy rich—the various grains and molasses.
- Protein rich—those of plant origin, that is, the various oil seed meals such as linseed, soybean, peanut, cottonseed meals and those of animal origin such as meat meal etc.

The oilseed meals are generally palatable and impart 'bloom' to the horse's coat and are particularly useful when preparing horses for show. The meals of animal origin are much less palatable and except for powdered milk are not often used for horse feed.

Roughages

These are higher in fibre content and lower in nutritive value than concentrates. They include all plant materials and can be classified into:

- Dry roughages—such as the legume hays which include lucerne, soybean, cowpea and greenpea are usually high in protein; the cereal hays of which oaten and wheaten are more commonly used in horse feeding and which are similar in energy but lower in protein content than the legume hays, and pasture hays which are made from the various grass or grass/legume mixtures.

- Succulent roughages—which include all plant materials in the growing stage and which contain high levels of moisture. Green grass, for instance, is classed as succulent roughage.

Comparing foodstuffs

Foodstuffs should be compared on the basis of their nutritive value and the cost per food unit. In comparing the nutritive value of various materials it should be remembered that different foods may contain different levels of moisture (for example, green crops and hay). Therefore, they should be compared on the same percentage of dry matter (D.M.) basis. For simplicity this is best done on a 100 per cent D.M.

The commonly fed grains have about the same D.M. content, usually around 90 per cent. Therefore they can be compared without adjusting the D.M. back to 100 per cent. Likewise, hays have about the same D.M. levels, usually around 90 per cent.

Oats is undoubtedly the best and safest of the grains to feed the horses and is the standard with which other grains are compared. Because of its higher fibre content it is slightly lower in energy than most other grains such as maize, sorghum, wheat and barley. One kilogram of oats is equivalent to 0.9 kg of these grains.

Thus slightly more oats has to be fed than would be the case with these other grains.

Wheat bran and wheat pollard are also useful energy concentrates. Pollard is equal to oats and grain in energy while bran is lower and about 1.25 kg of bran is equal in energy value to 1 kg of oats. However, pollard and bran should only be fed in small amounts.

Molasses is another useful energy feed. It is highly palatable and is the cheapest energy feed in coastal areas. 1.25 kg of molasses is equal in energy value to 1 kg of oats. Up to 2 kg (1.25 L) of molasses can be fed daily to horses.

Legume hay is undoubtedly the best hay from a nutritional point of view. It is about equal in energy to the cereal hays (oaten and wheaten) but is much higher in protein and contains more calcium. Well-cured grassy lucerne hay is a good palatable roughage for horses and can often be purchased more cheaply than lucerne hay on a cost per food unit basis.

What and how much to feed

This will depend on:

- The quantity and quality of pasture available.
- The amount of work the horse is performing.
- The body condition of the horse.

The following is a guide to the level of work being performed by a horse:

Hard work—5 to 8 hours per day riding

Medium work—3 to 5 hours per day riding

Light work—1 to 3 hours per day riding

Idle—little or no work.

Young, growing pastures of good quality will supply sufficient nutrients for all classes of horses and supplementary feeding is not necessary.

Once pastures have matured (flowered-seeded) they fall short of the nutrient requirements of most horses and some level of hand feeding is necessary and will increase with the level of work. (This usually extends from late autumn (April-May) until late spring (October-November).)

Very often, pastures are overgrazed and while they may be adequate in nutritive value there is not sufficient to satisfy the horses's appetite. This calls for supplementary hand feeding.

TABLE 1

Daily Quantities of Feed per 100 kg Liveweight (Full hand-feeding)

Type of Work	Concentrates (kg)	Hay or Chaff
Hard	1—1.5	1
Medium	0.75—1	1—1.25
Light	0.5—0.75	1.25—1.5
Idle	some if roughage is low quality	1.5

TABLE 2

Approximate Liveweight of Horses (In good body condition)

Type	Height (Hands)	Liveweight (kg)
Shetland	8—10	200—230
Pony	10—12	230—270
Galloway	14	270—360
Light hack	14—16	360—450
Heavy hack	16—17	450—550

Note.—1 hand = 10 cm

When horses are being hand-fed as well as being allowed paddock grazing, the supplementary ration can consist almost entirely of concentrates.

When full hand-feeding is employed, then the rates of roughage to concentrates can be balanced according to the needs of the horse in relation to the work performed.

The minimum daily roughage requirement of the horse is about 0.5 per cent of body weight (that is 0.5 kg of roughage for every 100 kg of liveweight). Thus a 400 kg horse requires at least 2 kg of roughage (hay-chaff or equivalent) daily.

Table 1 gives a guide to full hand-feeding.

Example

Assume your Club pony is 12 hands high and is performing light work (which is about the level of a normal club pony):

Weight = 250 kg

Daily ration

Concentrates—1.25 to 2 kg

Hay—3 to 3.75 kg

Assume that you decide to use oats grain and grassy lucerne hay:

Thus you would feed the pony 1.25 to 2 kg of oats and 3 to 3.75 kg of hay each day.

This could be divided into two feeds per day fed night and morning.

Remember

The body condition of your pony provides a good guide as to whether it is getting sufficient feed.

If you want to improve its body condition (get fatter) then increase the amount of concentrates.

At all times introduce the pony to concentrates gradually and do not make sudden changes to the diet.

Worms are unwelcome guests in the horse, and the pony will not 'do well' if it carries a lot of worms. Regular worming is necessary.

Brucellosis Tested Swine Herds (as at 30-6-81)

Aboriginal & Islanders Advancement Dept., Cherbourg, Murgon	L.W.	Kajewski R. E. & M. D., 'Robmar' Stud, Acland ..	L.
Batterham P. & N., Raby Park, Inglewood	L., L.W.	Kanowski A. R., Exton Pechey, Via Crows Nest...	L.W.
Bool R. A. & B. E., 'Rossvale Stud', M.S. 223, Nobby	L.W., L.	Kanowski S. E., Miecho Pinelands, Via Crows Nest	T.
Brosnan D. J., 'Bettafield', Mt Murchison, Biloela ..	L.W., L.	Kemph Family Trust, Highland Plains, Via Oakey ..	L., L.W., XL
Cochrane S. Mrs., 'Stanroy', M.S. 465, Cambooya ..	B.	Kimber I. E. & C. C., 'Splenda View', Coalstoun Lakes, M.S. 698, Biggenden	L.
Cotter N. J., 'Olaroy', Goomeri	L.W.	Kruger V. F. & B. L., 'Greyhurst', Goombungee...	L.W.
Dean G. F. & A. M., Home Creek, Wooroolin	L.W., L., B.	Kuhl V. & C. A., 'The Mounts', Boodua, M.S. 222, Oakey	L.W.
Diete Pty. Ltd., 'Ettrock', Ingoldsby, Via Gatton...	X.	Law R. R. & L. M., 'Summerset', M.S. 757, Kingaroy	L.W., L.
Douglas O. F. (Mrs.) & Son, 'Greylight', Goombungee	W.	Learmont R. S. & R. I., 'Scotlea', P.O. Box 102, Monto	L.W.
Duncan C. P. & B. J., Colley, Flagstone Creek, Helidon	L.W.	Lorenz C. J., M.S. 499, Toowoomba	L.
Duncan J. A. & B. L., Ma Ma Creek, Via Grantham	L.W.	Lucas T. J., M.S. 243, Kingaroy	L.W.
Fletcher B. R. & M. J., 'Par-En-Eri', P.O. Box 71, Mundubbera	L.W., L.	Ludwig A. L., 'Beau View', Cryna, Via Beaudesert ..	B.
Forman, V. & N., 4 Butler Rd, Logoon Pocket, Via Gympie	L.W., L.	Mathieson K., P.O. Box 138, Ideraway, Gayndah ..	L.W.
Forster I. S. & D. E., Westbrook	H.B.	Neuendorf W., M.S. 794, Kalbar	B.
Fowler K.P., 'Northlea Stud Farm', Hogg St, P.S. 1436, Toowoomba	L., L.W.	Nielsen Nominees, 'Miandetta', M.S. 162, Warwick	X.
Fowler M. R. & J. E., 'Donna Lyn', M.S. 195, Pittsworth	L.W.	O'Connor D., Rollingstone	L., L.W. X
Fowler N. E. P. & M. P., c/- Kewpie Enterprises, Kingaroy	L., L.W., X	Patch G. R. & B. J., 'Kiara', Bell	L.W., L., X
Franke K. H. & B., 'Delvue', Cawdor, Crows Nest ..	L.W.	Peters L. A., 'Moonlight', Bongeen	L.
Freeman W. A., 'Trevlac', Rosewood	L.W.	Queensland Agricultural College, Lawes	B., L.W.
Geysing N. E. & J., 'Oakhurst', Via Maryborough ..	L.W.	Research Station, Biloela	B.
Goodwin S. C., 'Winderia', M.S.F. 571, Murgon	L.	Research Station, Hermitage, Via Warwick	B.
Goschnick G. F. & R. F., & Pearce W. M. & K. J., 'Echoes', Bancroft, Via Monto	L.W.	Robin A. B., Blaxland Rd, Dalby	L.W., L.
Grayson D. G., 'Wodalla', Killarney	L., L.W.	Ruge A. F. & V. M., 'Alvir' Stud, Biggenden	L.W.
Grundy A. H. & R. N., 'Markwell Piggeries', M.S. 499, Toowoomba	L. L.W.	Savage L. E. & E. J., 'Ideraway', Gayndah	L.W., LX
H.M. Prison, Etna Creek, Via Rockhampton	L.W.	Scicluna C. & Sons, 'Coondulla Stud', Robertson Park, Murry Upper	L., L.W.
H.M. State Farm, Numinbah	B., L.W.	Sharp D. W. & L. J., 'Arolla', Lavella, Via Millmerran	L.W., L.
H.M. State Farm, Palen Creek, Beaudesert	L.W.	Smyth & Heness, 'Moorilla', Goomeri	L.W., L.
Handley G. R., 'Locklyn Stud', M.S. 741, Helidon ..	B.	Heness R. D. & B. M., 'Russley', Goomeri	L.
Hinchliffe P. & R. K., 'Oakview', Milman, Via Rockhampton	L. L.W.	Strang & Little, Boona Road, Bundaberg	L.W., L.
Jones K. B. & I. R., 'Cefn', M.S. 544, Clifton	L.W., L.	Trout L. B. & L. J., 'Caminda', Crawford, Via Kingaroy	L., B
Kajewski C. & D. I., 'Glenroy', Glencoe, Via Toowoomba	L.W., L.	Westbrook Training Centre, Westbrook	B
		Willett L. J., 'Wongalea', Irvingdale, M.S. 232, Bowenville	L.W., L.
		Williamson K. R. & M. A., Cattermul Ave, Kalkie, Bundaberg	L.W., L.

KEY

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

Controlling bacterial spot in plums

by J. B. Heaton, Plant Pathology Branch

Bacterial spot, caused by the bacterium *Xanthomonas campestris* pv. *pruni*, is a serious disease of plums on the Granite Belt.

Japanese plums especially the cultivars Doris, October Purple, Santa Rosa, Mariposa, Red Ace and Shiro are very susceptible. Wilson, Narrabeen and Burbank are less susceptible. President, King Billy, Sugar Prune and other European plums are resistant.

Among other hosts of the bacterium are the peach cultivars Starking Delicious, Halehaven and Maygold and the apricot cultivars Newcastle and Trevatt.

Disease symptoms

Symptoms develop on vegetative buds, leaves, twigs, branches and fruit.

Greasy lesions appear on the rapidly-growing young branches in spring. These become elongated, depressed, and tan in colour. Cracks may form in the lesions and develop into open cankers from which gum exudes.

As the branches grow, these cankers become rough and raised (plate 1). In advanced stages of the disease, depressed cankers with gumming are evident on large branches. Severely affected branches often wilt and die back in summer.

Angular yellow spots develop between the leaf veins, especially near the mid-rib. The spots darken with age, fall out and leave shot holes. The tips of severely affected leaves yellow and redden before falling.

Fruit spots are at first circular and greasy but become sunken and dark brown to black as fruits enlarge. The centres of the fruit spots frequently crack and ooze gum.

Plate 1—Bacterial spot cankers on plum shoots.



Spread of the disease

The bacteria are spread by rain from diseased trees to adjacent trees through the growing season.

At leaf fall in the autumn, bacteria enter leaf scars and remain dormant until late winter when the buds swell. Bacteria then spread from the scars and branch cankers formed in the previous season.

During wet weather in the spring, bacteria are washed from cracks in branch cankers to the young twigs and foliage. New branch cankers and leaf spots develop. Bacteria invade and kill young swollen buds and may blight young branches. Further spread occurs in spring and early summer and affects leaves, twigs, branches and fruits.

Research

Since 1935, the time of application and efficacy of many chemicals have been tested in field trials. These include Bordeaux mixtures, various other copper fungicides, sulphur, sodium salicylanilide, lime sulphur, captan-dodine mixture, streptomycin sulphate, tartaric acid and the experimental fungicides RH893 and 2, 2-dibromo-3-nitropropionamide.

Copper fungicides were the most effective. Copper oxychloride, copper oxychloride plus 0.5% white oil, copper hydroxide, copper oxide and Bordeaux gave up to 90% control of bacterial fruit spot and 70% control of bacterial leaf spot. Experiments showed that three sprays at budswell, 7 to 10 days later and at leaf fall were required.

An additional early full bloom spray with a copper fungicide

damaged the trees especially during hot, dry weather in early summer and did not increase the level of control. Symptoms of phytotoxicity included leaf burn, shot-hole, defoliation, twig dieback and severe russet.

In the absence of more effective chemicals, further progress in control of bacterial spot of plums must rely on the development of more resistant plum cultivars.

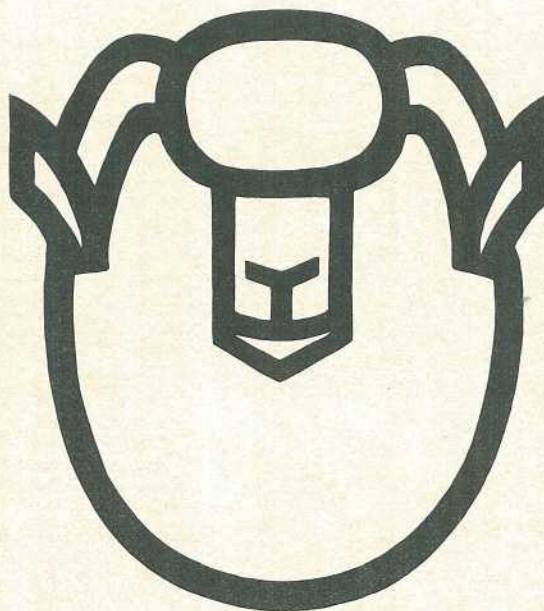
Recommended Spray Schedule

Time of application	Chemical
Budswell	Bordeaux 1.5:1* or Copper oxychloride 750 g/100 L water
7-10 days later	Bordeaux 1:1 or Copper oxychloride 500 g/100 L water
30-50% leaf fall	Bordeaux 1:1 or Copper oxychloride 500 g/100 L water

* To make Bordeaux 1.5:1, dissolve 1.5 kg copper sulphate in 90 L of water. Stir 1 kg fresh hydrated lime into a bucket of water and slowly add to the dissolved copper sulphate with agitation. Make up to 100 L with water.

To make Bordeaux 1:1, use 1 kg copper sulphate and 1 kg hydrated lime.

SHEEP
SHEEP
SHEEP



NEED BRAND RETURNS TOO!

Frost and its effect on safflower

by K. J. Jackson and J. Berthelsen, Agriculture Branch

Safflower is a major winter crop in Queensland's Central Highlands. Although the crop is adapted to the region, the planting date is most important for maximizing yields and avoiding frost injury at certain growth stages.

In 1978, approximately 10% of the safflower crop planted on the Central Highlands was destroyed by frost because of incorrect planting dates.

This article briefly describes the weather conditions causing frost to occur, the factors affecting its severity, the processes involved with frost damage and the extent of this damage at the various growth stages of safflower. The selection of a correct planting date for safflower in Central Queensland to maximize yield while reducing frost risk is also discussed.

Cause of frost

During the day, the ground is heated by short wave radiation from the sun. Loss of heat from the ground by long wave radiation occurs during the day and night.

The occurrence of frost on the Central Highlands is a result of this radiation from the ground and consequent chilling of the air in contact with it. Such frosts are known as radiation frosts, and occur when low humidities and air temperatures coincide with cloudless skies and minimum air movement.

These weather conditions usually occur during winter under or about the centres of high pressure (anti-cyclone) systems which at this time develop considerable intensity and frequently spread over wide areas causing frosts on many successive nights.

In this article, we define light frosts as those that occur at ground level at a screen temperature of 2°C and heavy frosts as those at ground level (or extending to a height of 1 m) occurring at a screen temperature of 0°C. Screen temperatures are recorded at 1.25 m above the ground.

Frost incidence and severity

The incidence and severity of frost is not due to any one factor but to the complex interaction of a number of the following factors:

Weather factors

The extent to which the temperature of the air at ground level is lowered is dependent upon the moisture in the atmosphere and the amount of air movement.

- Frosts are more severe when there is low atmospheric moisture near ground level. Moisture in the atmosphere slows the rate of radiation of energy to space by absorbing it and thus raising the atmospheric temperature. 'Hoar frosts' which are characterized by their white appearance due to the freezing of moisture in the air near ground level are less severe than 'black frosts' which occur at lower levels of atmospheric moisture at ground level. They are characterized by the black appearance of severely damaged vegetation.
- Wind mixes the cool air near the land surface with the warm air above. This reduces the risk of frost. Therefore, there is a greater risk of frost when the wind drops at night.
- Rapid thawing causes greater damage than slow thawing. This is evidenced by the greater damage on parts of plants facing the rising sun. Cloud cover at sunrise after a frost will therefore reduce damage.

Soil factors

Heat loss from the soil surface by radiation is affected by the colour, compaction and moisture of the soil.

- Light-coloured soils radiate less energy than dark-coloured soils. Consequently, air temperatures during the night above dark soils are lower than those above light soils.
- Cultivation or self-mulching of the soil surface allows more air to enter the soil. This air reduces the upward flow of heat in the soil which can result in lower temperatures at the soil surface and greater frost incidence.
- Moisture in the soil reduces frost incidence by allowing an increased flow of heat through the soil. It also maintains higher levels of moisture in the surrounding air.



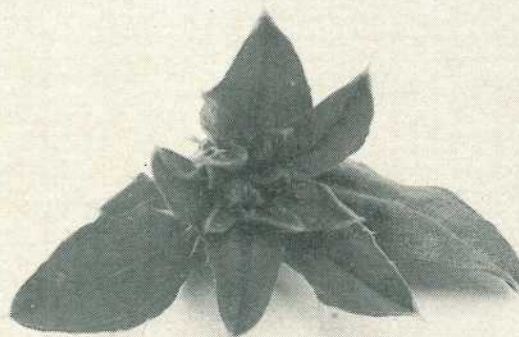
Rosette.



Elongation.



Branching.



Early budding. Note bud size in photograph at right.

Plant factors

Plants intercept long wave radiation from the ground and this energy is re-radiated from the plant tops. Thus frost damage is most likely to occur at the radiating surface at the top of plant canopies.

- Early stages of growth are usually less susceptible than later stages of growth. In the early stages of growth, the growing point of many crop plants is protected by leaves.
- Variations to frost damage between varieties within a particular crop exist.

- Plants can be hardened to frost damage to some extent if they are first subjected to a number of low temperatures before frost occurs. In those years when frosts occur prior to any conditioning to low temperatures, damage can be expected to be greater.
- Plant height at the time of frost occurrence affects the degree of damage. The temperature of the bare soil surface is higher than the air in contact with it, and the lowest temperature occurs at some height above the ground. This height varies, but has been found to be about 15 cm in the

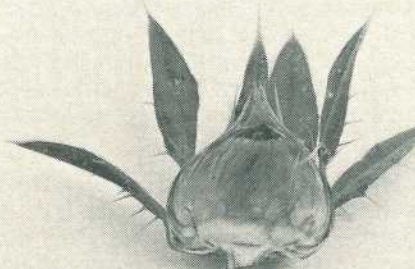
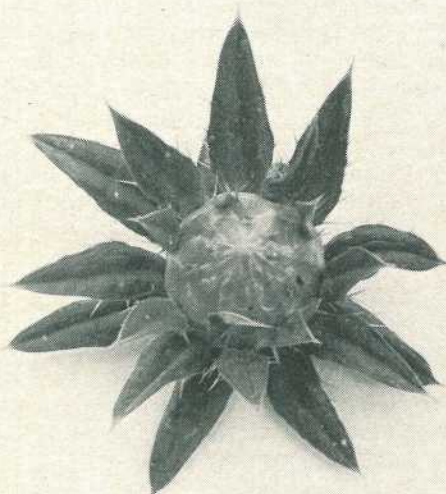
open and 30 to 100 cm inside crops depending on plant population and height of crops.

- Diseased plants have been noted to be more susceptible than healthy plants.

Topographic factors

Topographic features such as land slope and vegetation influence movement of air and the rate and extent of heating and cooling of the soil surface.

- Low areas are usually more susceptible than high areas. This is often quite noticeable on slopes



Late budding. The bud size at this stage is shown on the right.

where damage decreases from the bottom of the slope to the top.

- Slopes with an easterly or northerly aspect are assumed to be more subject to frost damage than those facing south or west. This is presumably because the former slopes are exposed to the rising sun and hence thaw more quickly. The sun also moves off these areas earlier in the day.
- Contours, wind breaks and uncleared scrub can cause impedence to airflow thus increasing the degree of damage to adjacent protected areas.

The most important of the factors influencing the occurrence of frost in safflower on the Central Highlands include the presence of high pressure systems and low rainfall during the winter, dark soils with self-mulching surfaces and the massing of cold air at the bottom of the sloping terrain.

Frost injury to plant tissue

At first, frost damage was thought to result from the formation within the cells of ice crystals which rupture the cell walls and consequently kill the plant tissue. While rupture of cell walls is still recognized as a process involved in frost damage, physical stress that occurs within the plant cells as water moves out of the cells during freezing and back into the cells during thawing is now considered to be the major damaging process.

Rapid freezing and thawing are considered more destructive than slow freezing and thawing as the former places more stress on the cell contents. The effect of rapid thawing is demonstrated by the fact that plant tissue exposed to the morning sun is more affected than similar tissue protected from the sun.

Frost damage at various growth stages

Rosette

After emergence, safflower grows in a rosette form. At this stage, the growing point is protected by a mass of developing leaves at ground level. The duration of this stage depends on time of planting with the stage being longest during the short, cold days of winter. The plant is quite tolerant to frost at this stage, but symptoms of slight damage may be observed.

Elongation

After the rosette stage, the plant rapidly gains height as the stem of the plant develops. The plant is now more susceptible to frost than at the rosette stage as the growing point is more exposed and the plant is growing into a layer of air that is colder than the air immediately above the soil surface. Damage at this stage often appears at the top of the plant. The plant compensates for this loss by producing extra branches below the damaged tip of the plant.

Branching

Branching usually commences from the leaf axils near the top of the plant. The duration of branching is governed mainly by temperature. As this increases, branching is reduced. Associated with the development of lateral branches from the leaf axils on the main stem is the development of buds at the terminals of these branches.

Also, at this stage, a number of branches and buds are initiated at leaf axils along the lateral branches. Provided reserves of subsoil moisture are still available at this stage, crops are able to withstand frost damage although severe frosts can cause some loss in final yield.

Budding

As the plants continue to branch, buds of the terminal of the main stem and the terminals of the lateral branches develop into distinct flower buds or heads surrounded by numerous spiny bracts. As the head increases in size, the surrounding bracts open outwards to form a circular array of bracts at the base of the head. Partial compensation will occur for frost-damaged heads if the heads are in the early stages of development. However, frost damage to buds just prior to flowering can result in complete yield loss.

Flowering and seed filling

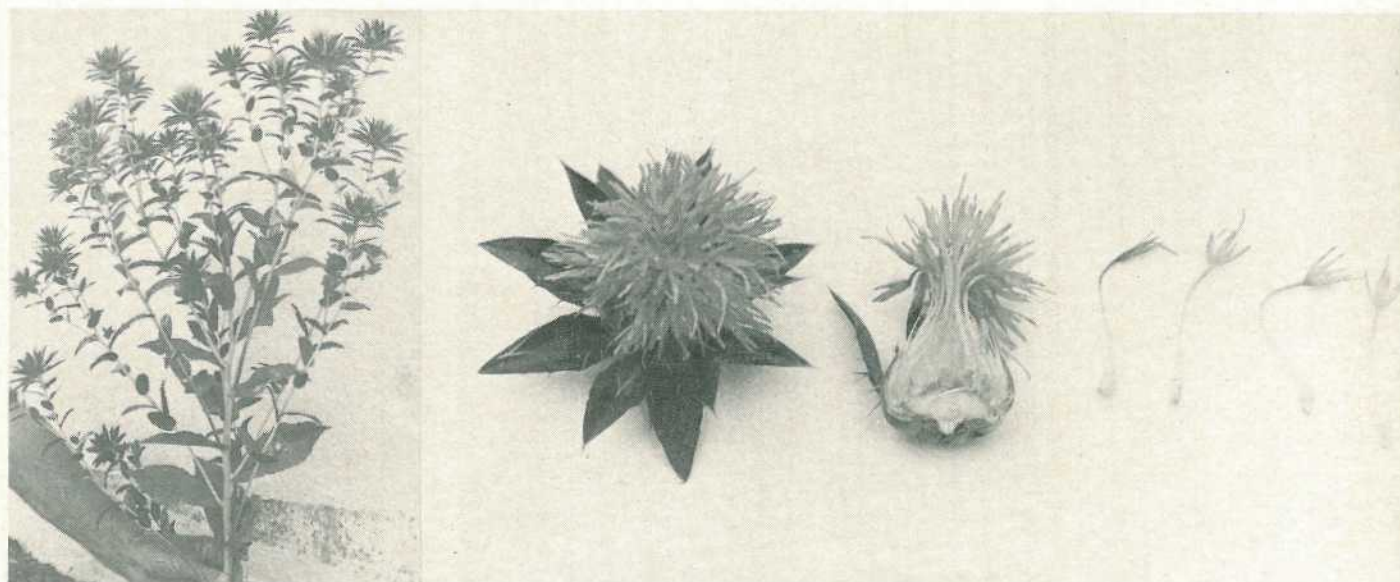
Flowering of individual heads lasts 3 to 4 days, while the flowering time of the whole plant depends on plant density and planting time. At the recommended planting rate of 120 000 to 150 000 plants per ha planted mid May to mid June, flowering of the whole crop normally takes 3 weeks.

The crop is highly susceptible to frost during flowering and complete grain loss can be expected if heavy frosts occur during this stage.

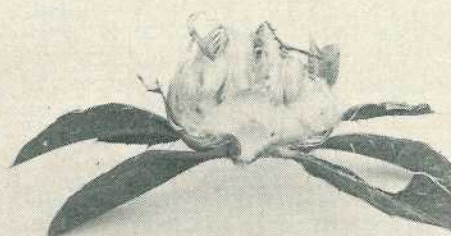
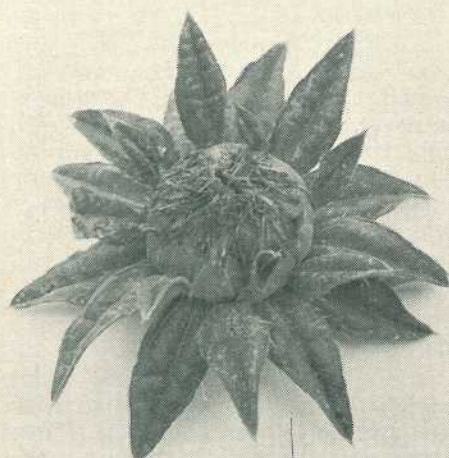
After flowering, it takes approximately 3 weeks for the fertilized seeds to reach maturity. Frost during this stage interferes with seed filling. This results in the production of lighter seed.

Planting to avoid frost damage

Clearly, safflower is susceptible to frost. The crop, however, can be grown successfully in winter on the Central Highlands if certain precautions are taken. These include selecting the correct planting date, and avoiding planting in low-lying areas. If these precautions are observed, there will only be small losses in the extremely cold seasons.



Flowering. Initial seed development is shown at right.



Seed filling.

The recommended planting date for the commercial varieties Gila and Saffola G-27 on the Central Highlands is mid May to mid June. Earlier plantings can result in complete loss due to frost, while yields decline with later plantings.

On the Central Highlands, plantings made in early April will commence flowering in late July/early August while late April plantings

will flower in late August/early September. Frosts are still prevalent in the region at these flowering dates.

Table 1 illustrates that if flowering takes place in the week commencing 30 July at Emerald there is a 44% chance of getting a light frost (2°C) on at least 1 day of the week and a 29% chance of getting a light frost on 2 consecutive days.

Plantings made at the recommended planting time are in the elongation and early branching stage during late July and early August with flowering taking place in late September and early October.

Table 1 shows that there is only a 1% chance of having a light frost at Emerald in the week commencing 17 September and no chance of frost in the following week.

TABLE 1

Emerald—Frost Occurrence and Duration Probabilities (%)

Temperature °C	3			2			1			0			-1			-2		
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	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
March 26.....	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
April 2.....	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
April 9.....	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
April 16.....	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
April 23.....	3	1	0	1	0	0	1	0	0	1	0	0	0	0	0	0	0	0
April 30.....	5	1	1	3	1	0	1	0	0	1	0	0	0	0	0	0	0	0
May 7.....	5	3	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
May 14.....	9	5	1	5	3	1	1	1	0	0	0	0	0	0	0	0	0	0
May 21.....	18	8	4	10	3	1	4	0	0	4	0	0	1	0	0	0	0	0
May 28.....	23	8	0	10	3	0	5	1	0	4	0	0	1	0	0	0	0	0
June 4.....	38	20	5	20	9	1	14	4	1	11	4	0	5	0	0	0	0	0
June 11.....	35	23	13	29	14	6	13	5	4	6	4	3	3	3	0	3	0	0
June 18.....	52	28	13	32	18	6	17	10	1	13	6	0	6	3	0	3	0	0
June 25.....	54	30	20	38	20	13	27	15	6	20	8	5	9	5	5	4	1	1
July 2.....	58	37	20	39	28	14	24	18	8	20	13	5	14	9	3	8	3	1
July 9.....	61	41	23	47	27	18	35	14	10	27	9	4	14	3	1	3	0	0
July 16.....	59	42	29	48	34	19	43	23	11	33	16	8	19	13	3	9	4	0
July 23.....	66	47	32	57	34	19	42	19	8	33	11	6	16	6	3	4	1	0
July 30.....	66	43	29	44	29	16	33	15	8	25	8	4	13	3	3	4	1	0
August 6.....	54	29	15	41	19	10	24	8	1	13	5	0	8	1	0	1	0	0
August 13.....	41	22	14	27	14	5	15	8	3	11	5	3	6	3	3	3	3	1
August 20.....	30	11	3	22	5	0	6	0	0	5	0	0	3	0	0	0	0	0
August 27.....	15	8	3	9	5	3	4	3	0	4	1	0	1	0	0	1	0	0
September 3.....	9	3	0	3	1	0	1	1	0	1	1	0	1	0	0	0	0	0
September 10.....	9	1	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
September 17.....	3	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
September 24.....	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
October 1.....	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
October 8.....	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
October 15.....	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
October 22.....	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
October 29.....	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
November 5.....	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Safflower frost damage symptoms

Frost damage in safflower crops on the Central Queensland Highlands can be disastrous. To help growers recognize the extent of damage, this article discusses the symptoms at the various growth stages and their importance.

Rosette

Damage occurs to the youngest exposed tissue surrounding the developing bud or growing point. Usually a whorl of five leaves is affected. The oldest and most exposed leaf of the five is damaged at the base. A gradation of the position of the damage from the base of this outer leaf to the tip of the inner leaf occurs. This pattern corresponds with the exposed sections of these leaves around the developing bud.

The pattern is often more obvious in later growth stages when the affected leaves are fully expanded. The yellow banding caused by the frost is due to the presence of scorched or blanched cells or tissues, and a distortion and puckering of leaf tissue. Where the damage is pronounced on one edge of the leaf, which frequently occurs, the leaf curves towards the damaged side.

The first few leaves emerging subsequent to those showing banding

are often distorted. The plant grows quite normally after this damage, usually with no resultant loss in yield.

Blistering and bronzing of upper leaf surfaces on the youngest leaf tissue is indicative of light frost damage. The surface on the underside of damaged leaves is often ruptured under these circumstances.

Elongation

Damage at this stage from light frosts is similar to that which occurs in the rosette stage. Damage from heavy frosts may result in the death of the top 5 to 8 cm of the plant. This damage is usually evident immediately after the frost when the tips of the plants will droop and wilt. Within 2 to 3 days the tips will blanch and desiccate resulting in a sharp contrast with the remaining green plant.

With severe frosts (below -2°C screen) plants may be damaged almost to ground level. However, provided adequate moisture is available, the plant can survive. In this case, the plant branches from ground level and while maturity will be delayed, satisfactory yields can be expected.

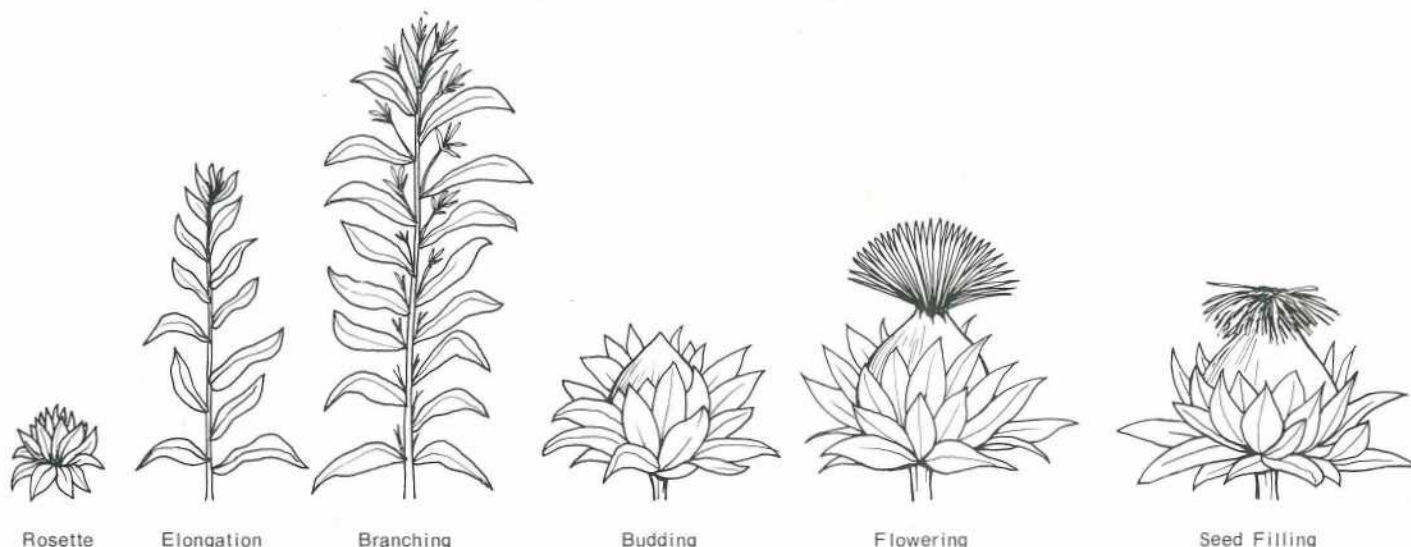
Frequently, stem damage is associated with terminal leaf damage. The stem damage is characteristically greatest on the side facing the early morning sun. Symptoms include corking and death of surface cells, sometimes with splitting and callous growth in outer tissues, often at the point of leaf attachment. In some cases the fleshy main vein of the leaf is ruptured.

The pith of the main stem often shows brown discoloration due to the collapse of tissue. Callous tissue frequently forms in the pith subsequent to injury. The stem damage and collapse of the pith result in bending of the stem due to uneven growth before a normal upright growth habit is redeveloped.

Branching

Light frosts at this stage can cause loss of terminal buds on the upper laterals as well as the terminal bud on the main stem. This loss often results in compensatory growth which can at least maintain the original yield potential of the plant. Heavy frosts may cause loss of whole branches which reduces eventual yield.

Sequence of Safflower Growth Stages



Safflower frost d



Damage to the youngest exposed tissue.



Sequence of leaves showing normal leaf on left then progression of damage from base of second leaf to tip of sixth leaf and back to normal on seventh leaf.



Bronzing and blistering of youngest leaves after frost.



Result of severe frost showing damage to stem at ground level.



Desiccation of leaf tissue and stem splitting apparent 3 to 4 days after a heavy frost.



Frost damage causing main stem splitting.



Splitting of stem and blackening of adjacent stem tissue 1 to 2 days after heavy frost.



Frost damage to central stem (centre) resulting in compressed bracts.



Compressed appearance of bracts on frost-damaged bud (left) are in contrast to those on undamaged head (right).



Frost damage to terminal head of a branch which may be confused with insect or disease damage. Note normal appearance of smaller head which has developed subsequent to frost occurrence.



Frost damaged crop showing brown discoloration and necrosis of the leaves and stems.

Damage symptoms



of upper surface of
leaf.



Light frost damage showing crinkled upper leaves.



Heavy frost causes the tops of plants to wilt.



single leaf
damage.



Damage to tip of main stem
and tips of lateral branches.



Twisting of branches caused
by uneven growth following
frost damage to stems.



bud on main stem
for head development.



Normal bud on left and damaged bud on right.
Note circle of damaged tissue in dissected bud on right.



failed to flower. Note
disease by secondary fungi
on plants.



Effect of greater frost incidence on lower part of
slope denoted by brown strip where the crop has
been killed.



Flowering pattern in safflower showing some
heads about to flower, some flowering and the
remainder seed filling.

Safflower frost damage symptoms



Damage to the youngest exposed tissue.



Sequence of leaves showing normal leaf on left then progression of damage from base of second leaf to tip of sixth leaf and back to normal on seventh leaf.



Bronzing and blistering of upper surface of youngest leaves after light frost.



Light frost damage showing crinkled upper leaves.



Heavy frost causes the tops of plants to wilt.



Result of severe frost showing damage to stem at ground level.



Dessication of leaf tissue and stem splitting apparent 3 to 4 days after a heavy frost.



Frost damage to single leaf causing main vein rupture.



Damage to tip of main stem and tips of lateral branches.



Twisting of branches caused by uneven growth following frost damage to stems.



Splitting of stem and blackening of adjacent stem tissue 1 to 2 days after heavy frost.



Frost damage to terminal bud on main stem (centre) resulting in no flower head development.



Normal bud on left and damaged bud on right. Note circle of damaged tissue in dissected bud on right.



Compressed appearance of bracts on frost-damaged bud (left) are in contrast to those on undamaged head (right).



Frost damage to terminal head of a branch which may be confused with insect or disease damage. Note normal appearance of smaller head which has developed subsequent to frost occurrence.



Frost damaged crop that has failed to flower. Note brown discoloration caused by secondary fungi attacking the frost-damaged plants.



Effect of greater frost incidence on lower part of slope denoted by brown strip where the crop has been killed.



Flowering pattern in safflower showing some heads about to flower, some flowering and the remainder seed filling.

Damage by frost at this stage results in wilting and eventual death of terminal growth and branches. Stem splitting of lateral branches resulting in distorted growth of the plant also occurs. Scorched leaves along the lateral branches, particularly on the side of the plant exposed to the morning sun, are often observed.

Budding

Frost damage during bud development takes different forms. If it occurs early in the developing bud, no obvious head exists. All that is present is a compressed arrangement of bracts which often continue to remain green. Later damage appears as a partially-formed head that ceases to grow. The bracts remain compressed in an upright position instead of opening outwards. Again the bracts often remain green. This damage can go unnoticed yet it is detrimental to yield as little if any compensation takes place when damage occurs to well-developed heads.

The extent of damage can be assessed by first looking at the

terminal of the main stem and then at the heads on the terminals of the main lateral branches which emanate from the leaf axils at the top of the plant. These are the heads that will be first affected by frost.

A more definitive method of determining the damage at this stage is to slice the suspected damaged heads at the base with a sharp blade. Internal tissue of undamaged heads is white to pale yellow, while damaged heads will be marked by a brown discolouration either in one segment of the base or the whole base.

The central bracts of these damaged heads may be lighter in colour and more compressed than the central bracts of undamaged heads. Sometimes, the bracts wilt and die. This gives the impression of insect or disease attack to the damaged head.

Heavy frost during the late budding stage can cause total loss of the crop. When this occurs, the crop fails to flower and slowly turns yellow. This gives the impression of approaching maturity. If rain falls, the crop rapidly turns brown as

secondary fungi attack the damaged plant tissue.

Flowering and seed filling

Heavy frosts at flowering result in complete crop loss. Light frosts destroy pollen in flowering heads, preventing fertilization. As an individual flowerhead flowers over a period of 3 to 4 days, frost on any one day can reduce the number of seed set in a particular head. Where partial seed set occurs, a head often develops a 'parrot beak' form due to the uneven development of the head. No compensation takes place for any heads lost once flowering commences.

Although frost can prevent fertilization of all florets in a head, the hulls or seed coats can continue to form normally. Often this damage is not noticed until the empty seed hulls blow out the back of the header at harvest.

As safflower flowers over a 3 to 4 week period, some heads are flowering while seed filling is occurring in others. Frost damage to the later heads results in lighter seed being produced.



Peanut growing in the South Burnett

by P. N. Vance, Agriculture Branch

The South Burnett is the major peanut producing area in Queensland with some 23 500 t produced from 20 340 ha in 1979-80. This was just over half of the State's production.

While the area sown has almost doubled over the past 20 years there has been no increase in yield which has levelled at around 1.2 t per ha. The area in North Queensland is expanding considerably. It produced 26% of the crop in 1978-79.

Almost the entire Australian crop is produced in Queensland which completely supplies the domestic market. Exports are generally insignificant, although 40 per cent of the large 1978-79 crop was exported.

The peanut plant (*Arachis hypogaea*) is a low-growing annual legume which is susceptible to frost. Two distinct plant types, bunch types and runner types, exist. The commercially grown varieties, Virginia Bunch and Red and White Spanish, are bunch types.

A breeding programme has commenced which aims to produce varieties of high yield and quality with good disease resistance and suitable plant types for both irrigated and dryland conditions. Drought tolerance is an important characteristic as peanuts are mainly produced under dryland conditions.

The three varieties Virginia Bunch, Red Spanish and White Spanish grown are used almost entirely for the confectionary trade. In recent years, the large kernels of Virginia Bunch have attracted a premium price on the world markets.

The importance of producing a quality crop cannot be overemphasized. Growers are paid a premium for quality, and quality is most influenced by disease control and the harvesting and drying operations.

Crop rotation and the release of improved varieties are the main avenues of improving yield and quality above the current plateau now existing in the South Burnett. Irrigation will also improve yields and quality but opportunities in the South Burnett are very limited.

Climate, irrigation and soils

Peanuts are susceptible to frosts which usually occur from May to September. The growth period of the crop depends on the variety—Red and White Spanish mature in 15 to 18 weeks and Virginia Bunch in 19 to 22 weeks. The preferred planting time is mid October to early December, and crops sown at this time mature after the main summer rains.

Peanuts are relatively drought tolerant but moisture stress will slow plant growth. Adequate soil moisture is particularly important from flowering to maturity to set a large number of pods and to maintain peanut quality.

In the dryland situation, the crop will often respond to alternate wet and dry conditions by flowering continuously and frequently setting a small number of pods. This results in uneven maturity and makes the decision of when to harvest quite difficult.

Where irrigation is available, the first watering should be applied soon after flowering commences. The soil moisture levels should then be maintained until the crop matures.

Techniques of irrigation are not well established at present but travelling irrigators and fixed lines are being used on smaller areas. The opportunity for flood irrigation is limited to Red and White Spanish peanuts on the friable black clay loams alongside creeks, but some farms are building dams to serve lower-lying sites.

Peanuts will grow on a range of soils but harvest losses can be very serious in hard-setting soils. Friable soils are preferred and the red basaltic soils are ideal. Good crops have also been grown on sandy soils.

Crop rotation

The frequency of peanut cropping varies with locality, soil type and the financial position of the farmer. Peanuts return very little organic



The Peanut Marketing Board's offices and storage facilities at Kingaroy.



Peanut flowers.

matter to the soil, and soil structure deteriorates under continuous peanut cultivation. Soil compaction may also increase as weed and disease control practices require many tractor operations. Disease incidence also increases under peanut monoculture.

Suitable rotation crops are maize, grain sorghum, oats, barley, wheat and millets. Maize is the preferred summer crop on suitable soils.

A long-term research programme is examining whether maintenance of soil structure, fertility, or perhaps a lowering of disease pressure or other factors are responsible for the increased yields from crop rotation. This research should identify suitable rotations for the area.

Land preparation

A weed-free seed bed in suitable tilth for planting must be prepared as peanuts are a very poor competitor.

Most farmers use offset discs to chop and incorporate previous crop stubbles. This is normally followed by a chisel ploughing to get depth into the cultivation. On forest soils, the depth of ploughing is limited to the depth of the topsoil (150 to 200 mm) while on some scrub soils a deeper working is possible and sometimes necessary to break up hard pans.

These workings are followed by a heavy harrowing or offset discing to further break down clods and incorporate stubble. This may be repeated but depending on rainfall and weed growth, a scarifying in early spring may suffice.

Fertilizer application and pre-planting grass herbicide application are often combined. The herbicide is applied through a boomspray and incorporated by the combine drill applying the fertilizer and light harrows.

A further cultivation may be needed for broadleaf weed control before planting but a cultivation at planting is usually sufficient.

The planting tilth can be somewhat coarser than for many other smaller-seeded crops. Clods of up to 40 mm in diameter can be tolerated.

An important part of land preparation in the South Burnett is the maintenance of contour banks and waterways.

A conservation cropping system for the South Burnett has been defined (*Queensland Agricultural Journal* May-June 1980). Some advantages of a conservation cropping system are reduced workings with obvious fuel savings, reduced erosion and increased ability of soil to take up water.

The sowing of peanuts into winter cereal stubble has been less successful than into summer crop as volunteer winter cereal plants can be a major weed and the level of stubble influences the effectiveness of the pre-planting soil-incorporated herbicides.

There has also been a noticeable reduction in white mould (*Sclerotium rolfsii*) in situations where stubble has been left on the surface.

Fertilizers

While peanuts grow on relatively infertile soils they are frequently rotated with crops having a higher nutrient demand. If these crops are adequately fertilized, the residual nutrients particularly phosphorus and potassium are often adequate for peanuts.

Calcium and acidity

Calcium is required in much higher quantities by peanuts than by other crops. It is most important for both high yields and quality.

The varieties differ in their sensitivity to soil acidity. Red and White Spanish tolerate more acid soils (pH 4.5) than Virginia Bunch which cannot be satisfactorily grown below pH 5.

Acid soils are frequently low in calcium and, in these situations, the application of 2 to 5 t per ha of lime or dolomite at least 6 weeks before planting will correct both problems. This treatment should last for up to 5 years depending on the rate applied and the soil type.

Where the soil pH is 5.5 to 6.5 and calcium levels are less than 1 000 p.p.m., applications of lime or gypsum to the pegging zone at 250 to 600 kg per ha near to or soon after planting will correct the deficiency. Correct placement is essential as the calcium is taken up by the peg and developing pod.

Gypsum should be used on calcium deficient soils with pH above 6.5 as liming could raise the pH to an undesirable level.

Calcium and potassium

The uptake of calcium and potassium by peanuts is inter-related. An excess of potassium when a seemingly adequate level of calcium exists can induce a calcium deficiency resulting in pops or empty shells. The condition does not occur where the calcium level is above 1 500 p.p.m. However, lime or gypsum should be applied to soils with calcium levels between 1 000 and 1 500 p.p.m. and a potassium soil level in excess of 300 p.p.m.

Potassium

The use of potassium fertilizer has increased in recent times due to the cropping of less fertile sandy forest soils and also to the preference for maize, which has a higher potassium requirement than other cereals, as a rotation crop. The maintenance of soil potassium levels at an adequate level for maize will generally ensure enough carry-over for peanuts.

However, in some very deficient soils, direct application of potassium to peanuts will be required.

On sandy soils with less than 50 p.p.m. potassium, 20 kg per ha of potassium should be applied. In clay loam soils, the application of 10 to 30 kg per ha is recommended at soil levels from 50 to 100 p.p.m. Deficiency symptoms will be more pronounced in dry years and are characterized by a squat plant habit and marginal firing of the leaves.

Phosphorus

The phosphorus requirement is usually covered by application to the rotation crop. If the soil test is below

10 p.p.m., 20 kg per ha of phosphorus should be applied with at least half banded within 5 cm of the seed at planting. If the soil test is 10 to 20 p.p.m., 10 kg per ha of phosphorus should be broadcast before planting. If the soil test is above 20 p.p.m., no phosphorus is required.

Nitrogen

Nitrogen application is not recommended. It may improve the crop colour in situations of excessive stubble or wetness but a yield response is not likely. The first crop of peanuts in a sandy soil may require inoculation with the cowpea strain of inoculum but responses are not likely elsewhere.

Other elements

Responses to sulphur or trace elements have not been observed in the South Burnett so far. The change to higher analysis compound fertilizers which are more cost competitive and are easier to handle but have a lower sulphur content, may lead to sulphur deficiencies in the future.

Choice of fertilizers and placement

Where direct application to the peanut crop is required, superphosphate and muriate of potash are still the cheapest forms of phosphorus and potassium.

Depending on the relative degree of deficiency, one or the other can be broadcast or drilled presowing, or placed 5 cm from the seed at planting. Placing the fertilizer in contact with or below the seed may reduce establishment due to a direct burning of the seed with potassium or

soil moisture loss through increased disturbance of the seed bed by the fertilizer tine.

The commercial fertilizer Q1, (7.3% P, 8.3% K, 8.1% S, 16.3% Ca) while being a more expensive source of phosphorus and potassium, is often convenient in marginal situations. It also provides useful quantities of calcium and sulphur for maintenance of overall soil fertility.

Planting

Plant spacing, seeding rate and depth

Peanuts are planted in rows 914 mm apart. At this spacing, the distance between plants within the row should be 200 mm for Virginia Bunch and 150 mm for Red and White Spanish. Assuming 80 per cent establishment, planting rates in the range of 40 to 50 kg per ha are required for normal seed sizes in the range of 1 200 to 1 600 per kg for Virginia Bunch and up to 2 000 per kg for Red and White Spanish.

All peanut machinery is designed to operate on the 914 mm row spacing. Unit planters are used. The peanut kernel is very susceptible to damage and should be handled with care at all times. Boxes with duplex inclined plates which gravity feed the seed to the planting boot are commonly used.

Air planters are not common although a few people prefer them. Loosened seed coats can often block the air holes and 'misses' result. Sharp angles on delivery shoots can also damage seed in air planters. A planter which moves the seed slowly and drops it from as low a height as possible is ideal.

The seed should be sown 50 to 70 mm deep. However, when soil moisture is marginal, deeper planting at 100 to 125 mm using narrow moisture-seeking tines and press-wheels will give good establishment.

Seed purchased from the Peanut Marketing Board has been treated with a mixture of captan and PCNB which protects the seed and seedling from fungal attack. It does, however, make the seed sticky under certain conditions and can even block cells in the planting plates. To ensure accurate planting and good establishment, the plates should be checked and cleaned if necessary at the end of each day. Mixing graphite or soap flakes with the seed has minimized this caking effect.

Weed control

Few agricultural crops are as sensitive to weeds as peanuts. The crop has a very low growing habit



Above and below. The Department's peanut Breeder, Dr Ray Shorter, cross-pollinating in the glasshouse at the J. Bjekle-Petersen Field Station at Kingaroy and inspecting breeding lines after harvest. The peanut industry is supporting this research.





Rod-weeders are a useful addition to the chisel plough. They give good weed control while the chisel plough works at depth.

and provides little natural competition. Weeds also interfere with harvesting and heavy infestations, particularly of weeds with large fibrous root systems, have prevented the harvesting of crops.

Most of the soils used for peanuts have been under cultivation for many years. They carry a range of grass and broadleaf weeds which can be successfully managed using a combination of mechanical and chemical treatments.

Pre-planting soil-incorporated herbicides

A weed-free seed bed is essential. However, most growers assume they will have a grass weed problem and apply one of the pre-plant soil-incorporated herbicides, pendimethalin, trifluralin or vernolate.

These herbicides can be applied several weeks before planting but control only a few broadleaf species. Others are usually checked with shallow-set mid-mounted cultivators at planting. Rates and weeds controlled are given in table 1.

Incorporation

These herbicides have to be incorporated to prevent loss of the chemical at the surface by photodecomposition or volatilization and also to place the herbicide where it is most effective. The method and degree of incorporation varies with each herbicide.

Vernolate is very volatile and must be incorporated immediately after spraying, preferably with spraying and incorporation done in the same operation. Double-discing in different directions is required.

Trifluralin is less volatile than vernolate but must be incorporated within 4 hours. Tined implements are generally sufficient for incorporation and often a combine with trailing light harrows is used. One shallow incorporation with harrows should be avoided as it may cause a concentration of the chemical in a narrow band and insufficient lateral mixing.

Pendimethalin is less volatile than trifluralin but must be incorporated by a tined implement or combine within 24 hours.

Research has shown these herbicides to be affected differently by amounts of stubble. In conservation cropping systems, ground stubble

covers in the range of 20 to 30 per cent were tolerated and the herbicides gave good weed control. It appears that even higher levels of stubble may be tolerated if a proportion of the herbicide is sprayed subsurface.

Crop injury

Vernolate can cause some crop injury with cupping and distortion of seedling leaves, particularly on light sandy soils. It is registered for use only on the red soil types in South Queensland.

Trifluralin and pendimethalin have not caused any yield or quality reductions when applied as recommended. Pendimethalin was originally planned as a pre-emergence treatment but affected quality when dry conditions followed application. Both herbicides can reduce yield and quality under certain circumstances if applied in excess of the recommended rates. There is also a risk of damage to subsequent winter cereal crops in double crop situations from trifluralin residues. Barley is more tolerant of these residues than wheat or oats.

Pre-emergence herbicides

At or immediately after planting, the herbicides alachlor, 2,4-D amine and acifluorfen can be applied to the bare soil surface. Alachlor, at 4.5 L per ha of the commercial product Lasso can control grass weeds for 6 to 8 weeks. However, it is not generally recommended in southern Queensland under dryland conditions, as results have been variable.



Ground-operated 'Micronair' spray rig. This recently-introduced equipment precisely controls pesticide application.

Acifluorfen, a new product, at 3.0 to 4.0 L per ha of the commercial product Blazer 2L will give control of some annual grasses and broad-leaved weeds but its comparatively high cost will restrict its immediate use to a post-emergence treatment.

2, 4-D amine at 4.5 L per ha of 50 per cent product controls most annual grasses except Mossman River grass. It also controls broad leaf weeds, except Noogoora burr for 4 to 7 weeks depending on prevailing weather conditions. It is best applied to a moist, level surface and must not be incorporated.

These treatments have the advantage that they can be banded over the peanut row, and reduce costs. However, many farmers prefer not to be concerned with handling sprays at the very demanding time of planting. They are safe to use in the crop but very heavy rain after 2, 4-D application can result in some temporary crop damage.

Post-emergence herbicides

Inter-row cultivation is usually carried out within the first month after sowing. This removes any weeds which have emerged between the crop rows. Where the early herbicide treatment has not maintained control within the crop row, the soil is sometimes hilled to smother these weeds. This practice is discouraged as it may promote disease attack.

Most farmers use one of the five post-emergence herbicides—acifluorfen, bentazone, dinoseb, MCPB or 2, 4-DB, for broadleaf control. The first three are direct contact herbicides while the latter two are translocated phenoxy herbicides. None leave residues in the soil. Rates and weeds controlled are given in table 2.

A new post-emergence technique using a 'rope wick weeder' is being evaluated for the treatment of problem weeds using non-selective

chemicals in the growing crop. The weeder applies a very concentrated herbicide solution through ropes on to any weeds which are taller than the crop. Because the treatment is only applied to the weeds it contacts, it is relatively inexpensive. At this stage, however, no herbicides are registered for use in this way.

Diseases and their control

Under conditions favouring diseases, yield losses can be quite considerable. Harvested yield is the product of plants per ha x pods per plant x % harvested x individual pod weight. All four yield components can be affected by disease.

Quality, an important influence on the overall return to the grower, can also be adversely affected by diseases.

Seedling diseases

Pre-emergence rots can result in the decay of germinating seeds before emergence. They are most commonly caused by a grey, furry fungus (*Rhizopus arrhizus*) or a black, sooty fungus (*Aspergillus niger*). Crown rot, which commonly kills seedlings soon after emergence, is also caused by *Aspergillus niger*. Seedlings collapse at or just below ground level.

Both *R. arrhizus* and *Aspergillus* spp. are common in the soil and are also seed-borne. At times, they can be extremely serious. Preventive measures include the use of high quality seed of good germination and the treatment of seed with fungicides such as a mixture of captan and PCNB.

Correct storage and handling of the seed is also important and seed roughly handled before planting or damaged by bad planter box design may be more susceptible to attack. Mechanical damage to the emerging crop by cultivation should also be avoided.

Stem, peg and pod rots

These are caused by the fungus *Sclerotium rolfsii*. It attacks seedlings but the loss of pods from mature plants is usually more important. The rot develops as strands of white fungal threads on the pods, pegs and stems and around the crowns of the plants. The threads often produce small, roundish, white to brown sclerotes which resemble radish seed. These can persist in the soil for at least 4 years. Often the threads radiate in fans on the soil surface and grow on fallen leaves and trash around the crown of plants. Single stems or entire plants can be killed and diseased pods decay.

The disease appears to be more severe under continuous peanut cropping and could be related to the depletion of soil organic matter rather than an actual build up in the disease. High organic matter status appears to make the fungus less aggressive on the crop. A rotation which ensures that peanuts are not grown in the field for at least two seasons is therefore one form of control. Green manuring with a winter cereal has also been found to be beneficial by some growers.

Correct cultural practices which avoid hilling of the soil around the plant crown and associated burying of leaves and weeds, and control of foliage diseases to prevent leaf fall all help reduce *Sclerotium rolfsii* levels. Chemical control has not been effective in local research.

If infection does spread, the timing of harvest becomes critical to avoid excessive loss of nuts and deterioration of quality.

Verticillium wilt

This disease is caused by the fungus *Verticillium dahliae* and is more serious on fertile soils. Symptoms first appear as irregular patches of light green or almost white colour in the leaves, particularly on the edges. These patches often become scorched and affected plants may

TABLE 1

Pre-planting Soil-Incorporated Herbicides

Herbicide	Trade names	Rate of application (prod./ha)	Weeds controlled	Duration of control
Trifluralin	Several	1 400 ml (sandy soil) 2 100 ml (clay soil)	Most annual grasses, pig-weed, fat hen, dwarf amaranth, red-shank, red-root, and green amaranth	Up to 14 weeks
Vernolate	Vernam	3 500 ml	Summer, crows-foot, barnyard and urochloa grasses, fat hen, red-shank, and suppresses wandering jew and nut grass	6 to 8 weeks
Pendimethalin	Stomp 330E	3 000 ml	Most annual grasses, pig-weed and dwarf amaranth	Up to 14 weeks

wilt. Streaks of reddish-brown discolouration are observed in the water conducting tissues of the tap root and stems.

Diseased plants may have a reduced yield, ripen prematurely and are prone to other diseases such as *Sclerotium* rot. The growing of grain crops for at least 5 years will reduce the incidence.

Control of susceptible weeds such as stinking roger, cobbler's pegs, noogoora burr, anoda weed and red shank and removal of infected peanut hay is also important. Because of the uneven maturity of individual plants, growers may have difficulty selecting the correct time to harvest.

Minor soil-borne diseases

There are a number of diseases caused by soil-borne fungi which are less commonly encountered but can be quite serious in affected crops.

Black rot caused by *Calonectria crotalariae* is becoming more widespread but has caused economic damage in only a few instances. As all legume crops are susceptible, rotation with gramineous crops is an important control measure.

Diplodia blight is caused by the fungus *Diplodia natalensis*. Symptoms are characterized by black stems on which small, raised, black dots appear. Diseased tissue may shred and turn grey and infection usually results in the death of the plant and a reduced plant stand.

The disease is usually confined to areas which have been severely eroded or heavily cropped in the past, resulting in poor soil fertility and structure and low organic matter status. Peanuts should not be sown where the disease is serious and a pasture phase introduced into the cropping system.

Rhizoctonia rot is caused by the fungus *Rhizoctonia solani*. Pegs are attacked and decay while the pods are dusty brown on the outside with a light brown weft of the fungus within the shell. It can also attack and kill seedlings. Control measures are as for *Sclerotium rolfsii* and include crop rotation and avoiding hilling the soil when inter-row cultivating the crop.

Sclerotinia rot caused by *Sclerotinia sclerotiorum* attacks the plant near the ground and causes a light grey fungal rot which shreds the stem. Black, hard, irregular-shaped sclerotes are produced on the surface of the plant, inside the stems and occasionally inside pods. Although it is not widespread, losses of up to half the stand have been recorded.

Peanuts should not be planted in paddocks where the disease has been serious. Wet situations, patches of unusually heavy soil and cold weather usually favour the disease. Sunflowers are very susceptible and can result in a build up of sclerotes particularly in late sown crops maturing in the cooler months. Peanuts should not be planted after infected sunflowers.

Charcoal rot caused by *Macrophoma phaseoli* has only occurred in isolated circumstances most commonly on lighter soils where the crop is more prone to stress.

Foliage diseases

The foliage diseases of peanuts—leafspot, rust and net blotch—are those about which growers are more frequently called upon to make decisions largely because effective controls are possible. These decisions influence land preparation and crop hygiene activities during the off season, and require regular assessment and action during the growing season.

Leaf spot is caused by two fungi *Cercospora arachidicola* and *Cercosporidium personatum* which are often referred to as early and late leaf spot respectively because of the time at which they traditionally infect the crop. The fungi cause dark brown to black spots on the leaves and will be first evident on the oldest leaves.

Rust, caused by the fungus *Puccinia arachidis*, was first recorded in Queensland in the Atherton Tableland in April, 1973 but was not observed in the South Burnett until February 1976. The fungus produces minute, reddish pustules often first seen on the lower surface of the older leaves.

Net blotch caused by *Didymosphaeria arachidicola* is at first seen as a spreading area of fine, net-like,

TABLE 2

Post-emergence Herbicides

Herbicide	Trade Names	Rate of Application (product/hectare)	Weeds Controlled	Remarks
Acifluorfen	Blazer 2L	1000– 2000 ml	Many common broadleaf weeds such as anoda weed, bellvine, cobbler's pegs, thornapples and wild gooseberry	Spray while weeds are small and ensure thorough weed coverage. Use the highest rate for mixed weed populations.
Bentazone	Basagran	1500– 2000 ml	Wandering Jew, anoda weed, pigweed, bellvine, morning glory, thornapples, starburr and noogoora bur	Spray after the crop is 12 cm high while weeds are still small (four to six leaves) and ensure thorough weed coverage. It is much safer to handle than dinoseb.
Dinoseb	Several 20% Several 40%	5600–11000 ml 2800– 5500 ml	Many common broadleaf weeds such as bellvine, wild gooseberry, thornapples and cobbler's peg	Apply before flowering and before weeds are 15 to 20 cm high. The chemical has a direct contact effect; killing weeds in 24 to 48 hours. Some leaf scorch may occur but the peanuts recover rapidly. Scorch is more likely under hot, dry conditions. Handle with care as it is fairly toxic to humans.
MCPB 40%	Tropotox Nufarm Metacide	1400– 2800 ml	Many annual broadleaf weed seedlings such as noogoora burr, stinking roger, apple-of-peru, and bellvine	MCPB and 2, 4-DB can be applied from 1 week after crop emergence until flowering and are best applied when conditions for crop growth are good and rain is not likely within 24 hours. Peanut plants usually show symptoms of spray damage which eventually disappear, but some yield reduction is possible. For application during or after flowering use the lower rate of MCPB.
2, 4-DB	Embutox Selectone Nufarm Buticide	1400–2100 ml	Similar to MCPB. It also controls spiny emex and thornapples	

silver lines which later turn dark brown on the upper leaf surface with healthy tissue between. This then extends to the lower surface at the same time gradually losing the net appearance and merging to form a grey-brown blotch.

All three diseases can be serious as they reduce effective leaf area and can cause leaf fall. They can also encourage other diseases such as *Sclerotium* rot to attack the plants.

Leaf spot and net blotch overwinter on volunteer plants and debris from the previous crop while rust can only survive on living volunteers. Elimination of these sources of inoculum is an important part of control by at least delaying the start of infection. Rotation with other crops is also advantageous.

Wet, warm conditions favour the build up of leaf spot and rust in a crop while net blotch appears to be more favoured by cooler conditions. The widespread occurrence of frosts in the South Burnett provides some check on the growth of volunteers, but as it cannot eliminate the disease entirely, crops must be monitored each season.

Chemical control of foliage diseases

Peanut growers need to make three decisions in the fungicidal control of leaf spots, rust and net blotch—which fungicide is best to use, when and how often it should be used.

When should spraying start?

Application of fungicide is necessary when infection is quite evident in the crop, and weather conditions are suitable for spread of the diseases. The requirements for infection include warm conditions and leaves kept wet by dew or rainfall for at least 4 hours. As fungicide can provide 10 to 14 days protection for the crop (the shorter period during wet weather), respraying will not be necessary during this period.

If rust control is not required, spraying is not recommended within 4 weeks of harvest as yields will not be affected by other leaf infections at this time. Protection against rust, if necessary, should be maintained until 14 days before harvest and care needs to be taken if there is any likelihood of a delay in harvest.

The number of fungicide applications to the crop and their timing cannot be predetermined, but require frequent, conscious decisions by the growers, depending on weather conditions and the level of disease

already present. It is not necessary to maintain a completely disease-free crop, as low levels of disease do not cause significant losses of yield.

The choice of fungicides

One of the recommended protectant fungicides should be the basis of the season's spray programme. These fungicides will control all important leaf diseases of the crop but protectant fungicides do not eradicate existing infections.

The two protectant fungicides recommended for use in peanuts are chlorothalonil sold as Bravo and fentin hydroxide sold as Duter. If rust is the only disease present, the application of mancozeb sold as either Dithane M45 or Manzate 200 will provide protection at a lower cost.

If leaf spot infection has occurred while the foliage was not protected by a fungicide, application of benomyl sold as Benlate within 3 days of infection can eradicate it if the infection was heavy enough to warrant eradication. Visible leaf spot infections are at least 10 days old. Benomyl will not eradicate or protect against rust and net blotch and its use in combination with a protectant fungicide is recommended.

There have been instances of resistance to benomyl. There will be less chance of this building up if benomyl sold as Benlate within 3 days of infection can eradicate it if the infection was heavy enough to other diseases. When eradication is required, 140 g per ha of Benlate together with the usual rate of protectant fungicide is recommended.



The mini column test for aflatoxin at the Peanut Marketing Board's laboratories.

Spray water quality

South Burnett water supplies are notoriously of poor quality. There is a scarcity of knowledge about which characteristics of water influence the efficacy of fungicides.



Dinoseb may scorch leaves.

The 'controlled droplet application' technique of applying pesticides requires less than one-tenth the volume of water used by conventional equipment as the controlled droplet size gives much improved coverage of the leaf. The use of high quality water (for example, tank water) would then become feasible.

Research over 3 years has indicated the potential of this technique and on-farm trials are proceeding in the 1981 season.

Virus diseases

Spotted wilt

This disease is caused by the tomato spotted wilt virus. Leaf symptoms range from light mottling to severe mottling and ring patterns. Severe distortion of leaves and stunting of plants is common. Yields from affected plants are commonly reduced by about 90 per cent and the kernels are invariably mis-shapen and discoloured and have little economic value.

Frequently, 1 to 2 per cent of a crop is diseased but occasionally restricted areas with up to 60 per cent infection have been observed. Field incidence is related to the presence of hosts such as stinking roger and cobbler's pegs which act as sources of this virus and from which it is spread by thrips.

The incidence of this disease is reduced by controlling these alternative weed hosts within the crop and on contour banks, waterways and headlands.

Bunchy plant

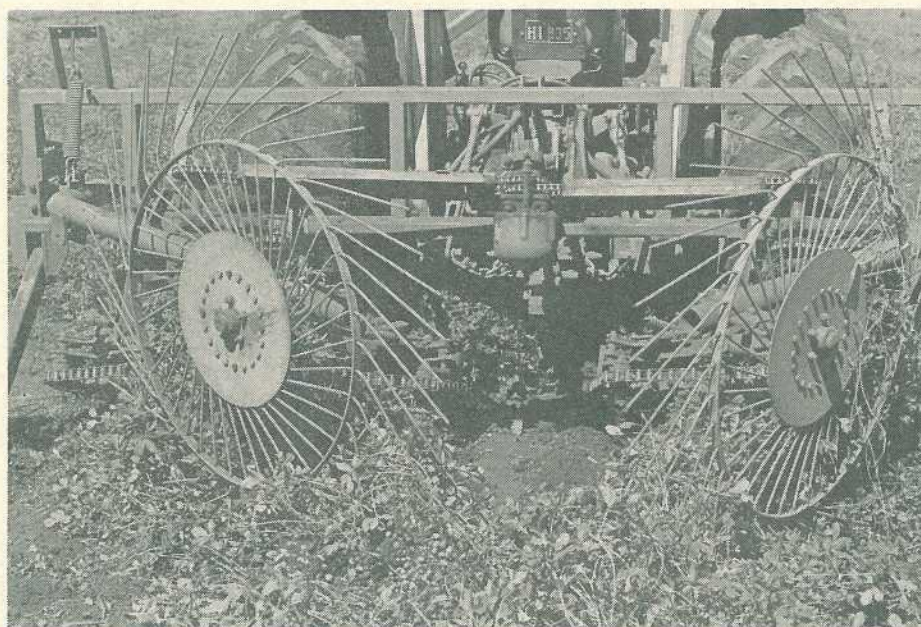
The tomato big bud organism causes bunchy plant disease. The organism is spread by a leaf hopper and affects a wide range of hosts. Affected peanut plants have sterile pegs which curve upwards. Abnormal development of the flowers often occurs and the flowers are replaced by green shoots and miniature leaflets from the base of other leaves. The plants take on a light green, bunchy leaf appearance. The disease is widespread but occurs in only a low percentage of plants and is of no economic importance.

Peanut mottle

The peanut mottle virus causes a range of symptoms which are usually difficult to detect. The most characteristic symptom appears on the leaves which are about second and third from the terminal leaf of a branch. Well-defined, dark green areas occur in a light green leaflet.



Above and below. Cutting, pulling and windrowing at Goodger.



The virus is widespread, seed-borne, readily spread by aphids, and can affect a fairly wide range of legumes. Control measures are not practical.

The detection of significant levels of aflatoxin in peanuts harvested in 1977 resulted in the introduction of tests to determine the level of aflatoxin in kernels and ensure the high quality of marketed peanuts.

Toxic spoilage of peanuts

The growth of the fungus *Aspergillus flavus* and similar fungi on peanut kernels can result in the production of aflatoxin, a highly toxic substance. The fungi are common in soils and *A. flavus* was once a common cause of seedling losses.

Moisture stress during the growing season is a major contributing cause of high levels and incidence of aflatoxin. Delayed harvesting, pod damage and improper drying practices also increase the risk of infection with a likely build up in aflatoxin and pre and post-harvesting management are critical.



Left. The tyre puller in action.

There are many unknowns associated with this condition and considerable research is being undertaken.

Nematodes

Root-knot and root-lesion nematodes are common pests of peanuts. Despite their prevalence, severe damage has been found in fewer than 10 per cent of the peanut plantings in Queensland. The root-knot nematode *Meloidogyne hapla* develops in roots, pegs and pods. The formation of small galls, each with one or more side roots produces densely-matted root systems in heavily-infested plants.

The root-lesion nematode *Pratylenchus brachyurus* produces lesions on the roots, the underground portion of the stem, the pegs and the pods. Lesions begin as small, discoloured flecks where one or more nematodes have entered the plant. They increase in size until eventually large portions of the stem and roots are destroyed. Injury to the pegs leads to many pods remaining in the ground at harvest. Root-lesion nematode injury can be diagnosed with certainty only by laboratory examination of diseased plants.

Nematodes reduce plant size, yield and rhizobial nodulation. The production of unsightly spots on the shells by both root-knot and root-lesion nematodes makes them unsuitable for the nut-in-shell trade.

Severe nematode injury in peanut plantings usually occurs on land where peanuts have been grown too frequently in the rotation. The first step in control is to increase the interval between peanut plantings.



Below. Side raking at Merlwood.

Root-knot and root-lesion nematodes have different host ranges and crops that reduce one pest may favour the other. For example, maize will reduce an infestation of root-knot nematodes and increase root lesion nematodes. Soybeans will increase an infestation of both species.

Insect pests

There are a few minor pests which are sometimes encountered. However, control is rarely warranted. Among them are *Heliothis*, white grubs, lucerne seed web moth, peanut mite and jassid. They are discussed in more detail in a recent article 'Insect

pests of peanuts in Southern Queensland' by J. W. Turner in the *Queensland Agricultural Journal* of March-April, 1980.

Harvesting, drying and handling

Harvesting operations must be timed correctly and the specialized equipment used must be correctly adjusted.

When to harvest

This decision is not easy. Peanuts flower over a long period so at harvest, some pods will be over-mature, some mature and some

immature. The pods are underground and the maturity of the nuts under a crop cannot be determined at a glance.

Peanuts should be cut and pulled when the greatest number of pods showing darkened veins on the inside of the shell can be obtained. This will vary depending on soil and weather conditions during crop growth. It is important to pull and check the pods of several plants in a particular block to determine when to harvest.

Timely pulling is most important to optimize returns. Pulling too early will result in lightweight kernels and many immature pods in which the kernels shrivel and are only suitable for crushing for oil. Late pulling can cause yield losses through rotting of pegs and sprouting of the kernels particularly in the Spanish varieties.

Over-mature pods are very susceptible to rain and mould damage, both before and after pulling.

Researchers are yet to develop a simpler, more reliable method of determining maturity than hand threshing and visual appraisal of the kernels and pods. However, two of the most promising recently-developed methods from the U.S.A., the argentine maturity index, and the ratio of kernel weight to hull weight are being studied locally at present.

Cutting and pulling

Two or four row mid-mounted cutter bars are passed under the pod clusters to cut the tap roots and loosen soil around the plants. The cutters are followed by rear-mounted pullers that compress the tops and raise the plants at the same time. Two or four rows of plants are pulled and laid in a single continuous row.

Cutters and pullers are usually used as a unit. Cutters have extended angled blades and are either stump jump or have shear bolts to prevent damage when rocks or roots are encountered. Best results are obtained with cutters when soil moisture is such that soil will not stick to the pods or to the cutter blades yet is not so dry that it is hard and cloddy.

Occasionally, a crop will be ready to cut and pull when soils are extremely wet. An on-the-spot decision is then required to gauge whether more of the crop will be lost through inefficient pulling or whether more will be lost by waiting until the soil is partly dry by which time some pods will have rotted or germinated.

Locally made p.t.o. driven pullers are of two distinct types. One type has two endless chains which grasp peanut tops and lift plants out of the soil. The second has a number of car-type wheels fitted with pneumatic tyres rotating in contact. These wheels remove plants from the soil and lay them in rows.

Recently imported digger-shaker-inverter units are sometimes used on sandy soils. They have similar digging blades to the local units, a pick-up and elevating mechanism to lift the plants and shake the dirt loose, and a windrowing inverting component to turn the plants upside down and place two rows together in a windrow.

After pulling

Usual practice is to allow the plants to wilt but not dry out. Where the rows have not been windrowed at pulling, two or four rows are raked into one windrow. This operation is carried out with a side delivery rake and the rake must be set accurately and used carefully so that the pods are not removed from the plants.

If cutting when the soil is too moist is unavoidable, excessive soil can adhere to the pods lengthening field curing time and increasing the weather risk.

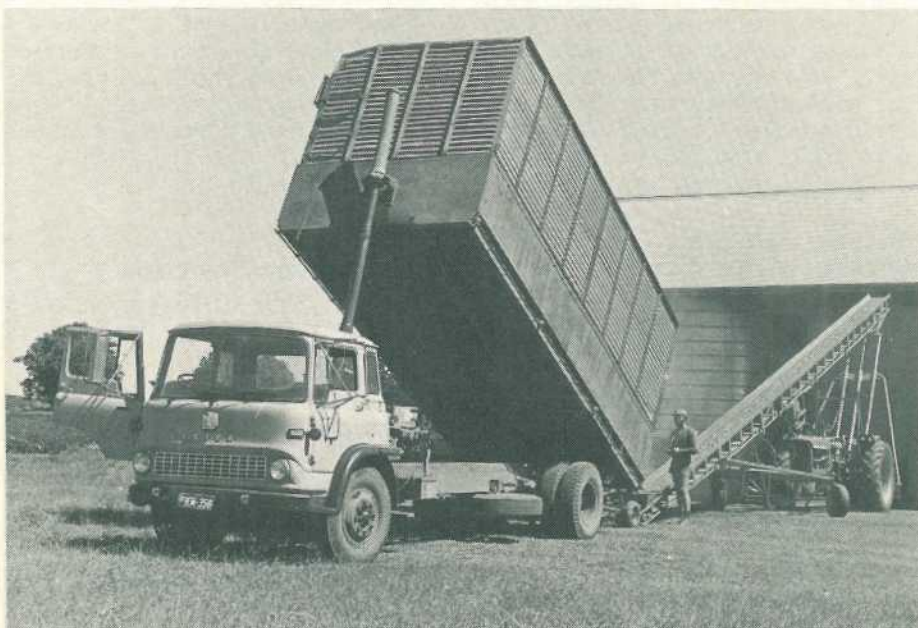
Fluffers may be used to remove some excess soil and loosen the windrows. These lift the plants



Threshing at Coolabunia.



Tipping from thresher to bin.



Delivery from bulk bin to on-farm storage.

gently, shake them and put them back on the soil. They may be used only before plants become dry and brittle, otherwise pegs will be broken and nuts lost.

Damage to pods by tractor wheels and through incorrect setting and speed of operation during cutting, pulling and raking must be avoided or deterioration of the kernels will be serious and rapid. Bushes can be heaped on the ends of windrows and better quality pods can be produced by running one or two windrows parallel to the headlands. This has the added advantage of providing room for manoeuvring threshers.

Curing

Field curing of peanuts is now kept to a minimum to produce crops of high commercial quality. Artificial drying is widely used and reduces the risk of a build up of aflatoxin-producing moulds.

Under favourable weather conditions, the crop will be ready to thresh 2 to 5 days after pulling when the moisture content should be 20 to 25 per cent so that the pods thresh with a minimum of damage. This moisture level is too high for safe storage and the crop must be artificially dried to 12 per cent moisture.

Where artificial drying is not readily available, the crop may be windrowed for 7 to 14 days or even longer. In these situations, the moisture level may fall below the safe storage level of 12 per cent. However, it will often not reach this level and arrangements for contract drying before storage or delivery must be made. The risk of infection by mould if the crop is left too long in the windrow cannot be over emphasized.

Threshing

Pick up threshers, which are usually p.t.o. driven, are manufactured locally although some are also imported. These remove the nuts from the plants, clean the sample and deliver the nuts to a bulk bin. The trash is either spread over the ground surface or left in rows for later baling.

Peanut threshers are expensive, specialized machines. Not all growers have sufficient area to warrant owning one but growers dependent on contractors may not be able to get their crop threshed at the proper time.

Most growers commence threshing when the dew has completely dried from the plants in the morning. The windrow should flow evenly and smoothly into the thresher without falling apart or being pushed ahead. Proper synchronization of the pick up head and forward speed is essential to prevent pods from falling off the plants.

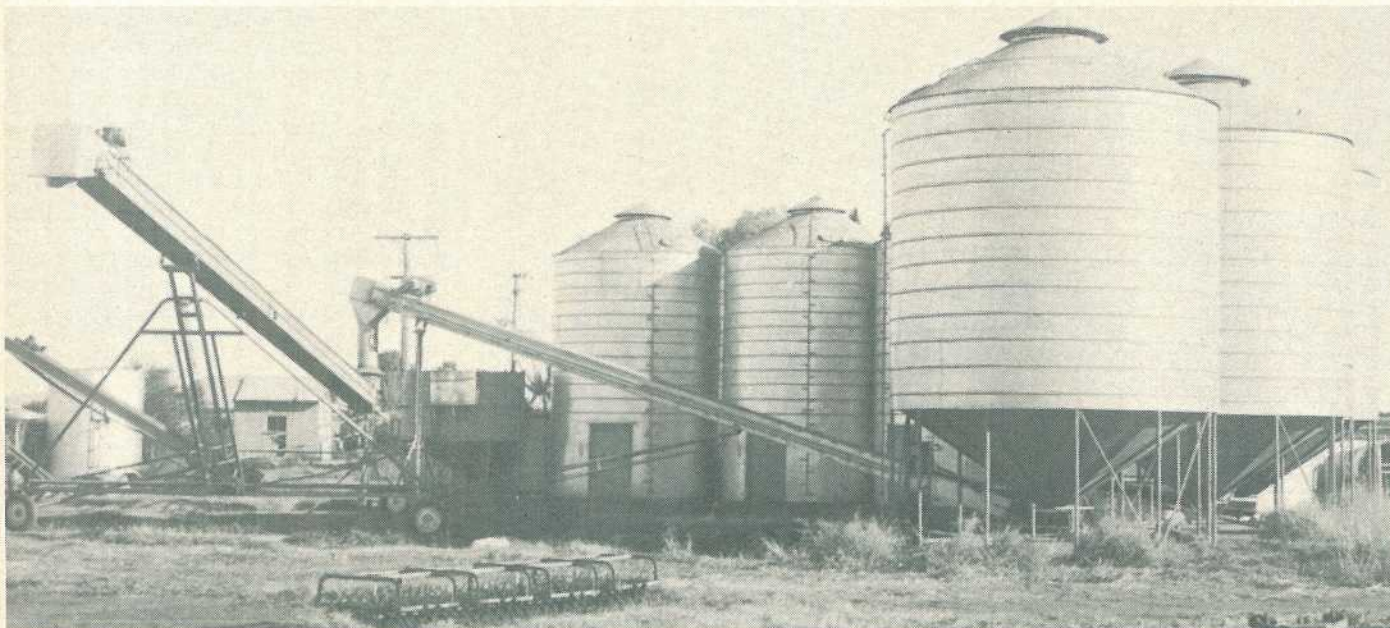
The threshing action should remove all the peanuts from the plants with a minimum of plant breakage or else the short pieces will fall through with the peanuts and overload the cleaning screens. Air flow should also be correctly adjusted to achieve as clean a sample as possible.

Pre-cleaning

Growers are docked for delivering uncleaned pods, so producing a clean sample is important. Cleaning is also important where artificial drying is used. Dust and impurities can form a central column in the bulk bin. This restricts the air flow and makes drying difficult. Pre-cleaning units using a combination of both screens and airflow are commonly used between the field and drying bins.

Drying

Drying is aimed at reducing the moisture content of the peanuts to a safe level for storage thus preventing mould and aflatoxin production and insect damage. However, over-rapid



A modern drying, handling and storage facility.

drying can cause off-flavours and split and baldy kernels during processing.

Peanuts should be continuously dried from within 3 hours of threshing until below 13 per cent moisture content with an airflow sufficient to ensure that the drying front is above the top of the peanuts. This requires an air volume per minute 10 to 12 times the volume of peanuts being dried.

The specifications for peanut drying are quite different from conventional grain driers. However, units to cope with both crops have been designed locally. Only gravity or elevators should be used to move peanuts as augers and air blasts can cause considerable damage.

Heat should not be used unnecessarily. The air temperature should be kept to 35°C or not more than 8°C above ambient temperature. The overall drying rate should not exceed 0.5 per cent per hour. The aim should be to have the drying air at between 50 to 75 per cent humidity. Shallow, even depths of peanuts are essential for satisfactory results, especially if the drying fan capacity is small.

Heat sources can be either electric, LP gas or oil supplementing the heat from the power plant driving the fan. Contamination of the pods with engine exhaust gases must be avoided.

Economics

The profitability of peanuts make it the most attractive of the field crops grown in the South Burnett.

The crop is being grown by an increasing number of specialist producers who are steadily expanding their scale of production. New areas were opened up in the 1970s when cattle prices slumped but much of this has now reverted to pasture.

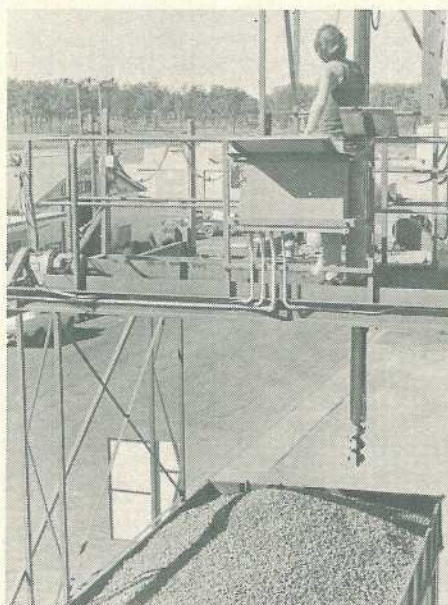
Factors mitigating against the expansion of the crop include the specific soil type and machinery requirements of the crop and the rotation requirements which restrict the growing of peanuts to every second year or less frequently on old cultivation in order to maintain long term profitability.

The medium-sized producer is committed to continued production because of his overhead costs but the ever increasing variable costs of production, and the demand for labour compared with other crops make the crop less attractive.

Variable production costs

A guide to the variable production costs for the 1980-81 season are given in table 3.

Lower costs and higher yields are the obvious aims of all growers. The higher yields are being achieved with



Above and Right. Sampling for moisture and aflatoxin tests at the Peanut marketing Board in Kingaroy.





Sample grading for quality.

wider rotations and irrigation and perhaps an improved variety will contribute. Lower costs should result from the use of wider rotations where fertility, weed and disease problems will be minimized. The requirement for fungicides is considerably reduced in a drier year but this may be offset by a lower potential yield.

Marketing

The peanut crop is sold to processors mainly as edible kernel or as oil grade. A small quantity of selected Virginia Bunch is also sold as nut-in-shell.

The bulk of the crop is handled by the Peanut Marketing Board based at Kingaroy with depots at Gayndah and Tolga serving the Central Burnett and the North Queensland crops, respectively. A number of small, privately-owned dehulling plants clean, shell and grade peanuts for the interstate trade.

The move to wider rotations in the South Burnett is seen as one way of producing a more stable high quality crop less affected by the irregular weather pattern which has made production so variable and irregular in the past. This will also facilitate the marketing of the crop in the future.

TABLE 3

Variable Production Costs

Item	Main Range (\$/ha)	Typical (\$/ha)
Seed	42-50	46
Fertilizer	0-70	35
Pre-emergence herbicide	9-26	9
Post-emergence herbicide	6-40	13
Insecticides	0-20	0
Fungicides	9-80	47
Aerial spraying at \$7 each	0-35	14
Machinery (including cutting, pulling and raking)	26-52	40
TOTAL PRE-THRESHING VARIABLE COSTS	92-373	204
		Typical Cost (\$/tonne)
Contract threshing		30
Contract pre-cleaning and drying		30
Contract cartage		8
Total threshing and post threshing variable costs		68

TYPICAL TOTAL VARIABLE COST = \$204/ha + \$68/tonne

Gross margin

Yield (kg/ha)

		1200	1800	2400
Price (c/kg)	38	170	358	545
	42	218	430	641
	46	266	502	737

Improved control of apple powdery mildew

by J. B. Heaton, Plant Pathology Branch

Powdery mildew caused by the fungus *Podosphaera leucotricha* is, next to black spot, the most important disease of apples in the Granite Belt.

The most susceptible cultivars are Jonathan, Gravenstein and Granny Smith.

Control depends on regular spraying with fungicides during the season combined with winter pruning to remove diseased twigs.

Warm, humid weather in spring may lead to severe outbreaks of the disease on new foliage. Hot, dry weather in midsummer prevents further build up of the disease but it may increase in late summer if cooler, humid weather occurs.

Powdery mildew has been very severe in recent years. The disease has built up during prolonged periods of warm, humid weather. There has also been an increased carry-over of the disease in some orchards where light winter pruning

has left more diseased twigs on the trees than previously.

The disease

The fungus grows as a surface parasite on leaves, growth shoots, twigs, blossoms and fruits. It extracts nutrients from the underlying plant tissues. This surface growth of the fungus or mildew consists of fungous threads and spores, clumped together in grey-white patches which resemble talcum powder.

Spread

The fungus overwinters in diseased buds and resumes growth in spring, infecting new leaves and blossoms as they develop. Infection is favoured by temperatures between 19 and 25°C and high relative humidity. Spores produced in very large numbers by the fungus are spread by the wind to adjacent apple foliage where further infection may occur. The risk of infection lessens as summer temperatures rise, mildew spores being short lived at temperatures above 28°C.

Research

In trials conducted in the Granite Belt between 1972 and 1974, benomyl, benomyl plus summer oil, binapacryl, carbendazim, dinocap, oxythioquinox, lime sulphur, sulphur and thiophanate-methyl gave very good control. Benomyl plus summer oil, however, damaged leaves.

In 1975, experimental fungicides A3561, A3565 and A3566 supplied by I.C.I. Australia Ltd. were tested as eradicant treatments during dormancy. Very good mildew control was obtained but it was accompanied by severe leaf and fruit damage.

In a trial conducted between 1977 and 1979 two new fungicides, bupirimate and metiram plus nitrothalisopropyl (trade name—Pallinal) gave better control than the recommended sulphur treatment. These two fungicides are now included in the 1980-81 district spray schedule.

Spray Schedule for 1980-81

Time of application	Fungicide	Rate/100 L water
1. Blossom break.....	Binapacryl 50% (Morocide*)	100 g
2. Full bloom	or Bupirimate 25% (Nimrod*).....	60 ml
3. Petal fall.....	or Dinocap 20% (Karathane*).....	100 g
4. 3 weeks after petal fall.....	or Pallinal*.....	200 g
	or Oxythioquinox 25% (Morestan*).....	50 g
5. 6 weeks after petal fall.....	or Wettable sulphur 80%.....	375 g
6. Mid January.....		

* Trade names.

Electrical stimulation—better meat for country consumers

by D. J. Taylor, Slaughtering and Meat Inspection Branch

Electrical stimulation is a process which can be used effectively in small country slaughter houses. This allows country people to benefit from the advantages of modern research that are usually reserved for larger centres.

Demonstrations have already been carried out in the Central Burnett at Gayndah and Gin Gin.

This has led to the purchase of two extra low voltage stimulators which are now in use at Gayndah and Mundubbera.

Electrical stimulation

Electrical stimulation involves the application of an electric current to the beef carcass soon after the animal has been stunned. In smaller country slaughter houses this is done with a rectal probe used immediately after stunning.

The unit (plate 1) consists of a transformer and printed circuit board to produce the recommended pulse output and automatically time the stimulating sequence, plus the rectal probe.

The only control is an on-off switch; a meter and a small light indicate correct operation. The low voltage delivered is 25 volts for the first 30 seconds, 35 volts for the next 30 seconds and 45 volts for the last 30 seconds—a total of 90 seconds duration.

Power supply

Power supply is by 240 volts mains supply. The machine may also be used in conjunction with a generator or lighting plant which would normally be used on small appliances.

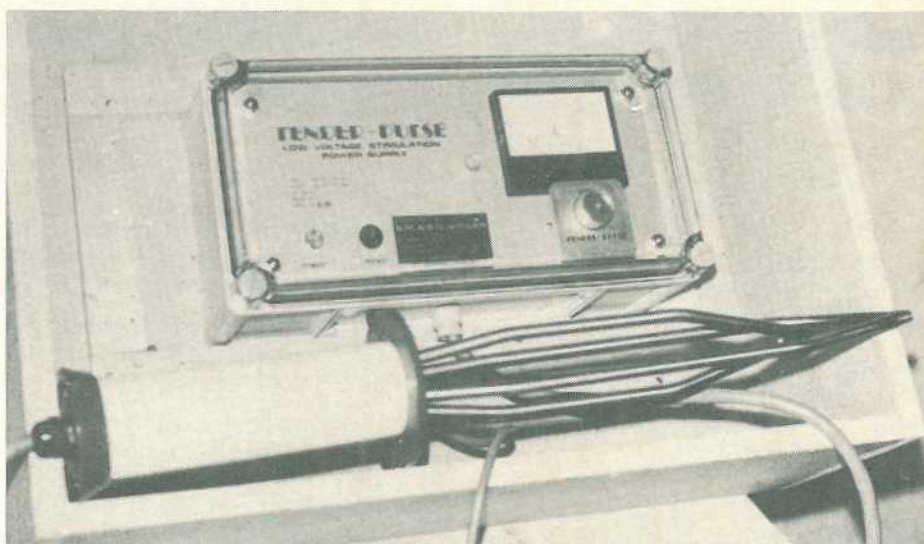


Plate 1. Extra low voltage system. Note the box which protects the unit when it is not in use.



Plate 2. Probe insertion. In this case, the animal was stuck immediately prior to the probe being inserted.

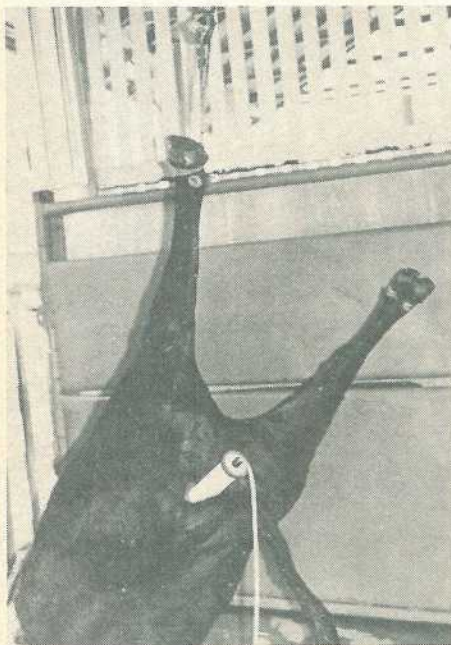


Plate 3. An animal receiving voltage. Note the stiffness of the legs.

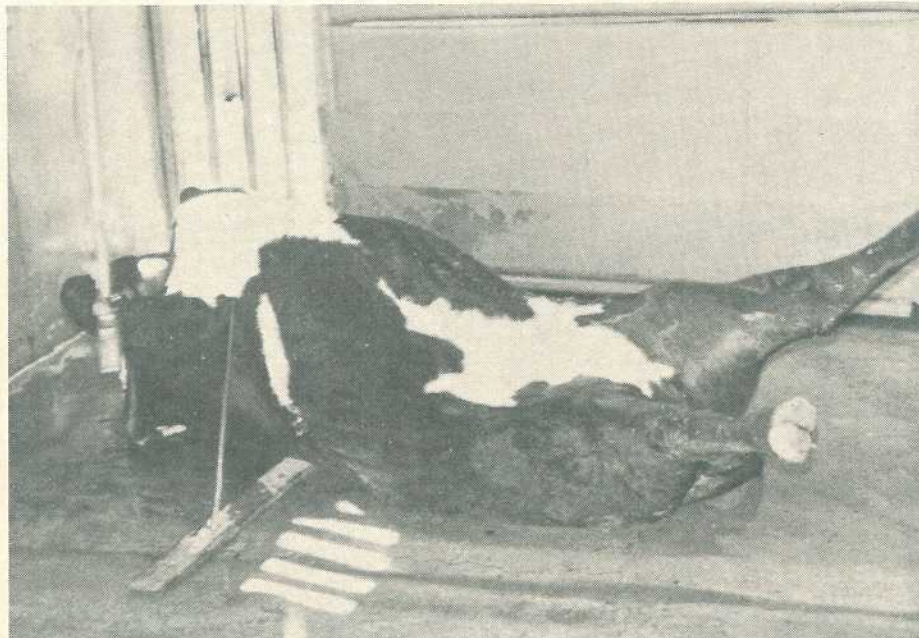


Plate 4. Stimulated carcass in readiness for the normal dressing procedure.

Safety

The State Electricity Authority has issued a certificate of suitability (No. C5352Q).

Safety is no problem as this is an extra low voltage system. The animal can actually be touched while being stimulated.

Operation

The animal is humanely stunned, shackled and partly hoisted. The probe is inserted in the rectum to the handle stop (plate 2). The animal is then stuck and the power is switched on—it bleeds as the process takes place.

Note: The above process has also successfully been carried out in a class 3 slaughter house on the floor as the animal bleeds and is not hoisted. However, if the animal can be hoisted, the operation is more simple and there is no chance of the probe slipping out.

The body of the animal will generally stiffen (plate 3) with fore and hind legs stretched out.

After the process, the animal is positioned in preparation for normal dressing procedure (plate 4).

The only visible change at this stage is that the hind feet may be a little more difficult to sever at the joint. However, operators using the extra low voltage stimulator claim this is not a great problem.

Advantages

- There is a much better bleeding out of the animal.
- 'Cold shortening' of the meat is prevented.
- The product has a longer storage life.
- The dressed carcass and the cuts of meat have a more uniform colour.
- There is a more rapid ageing of the meat. It is claimed that this

process is equivalent to 2 weeks' ageing.

- Very little change is required to normal slaughter house procedures.

The particular machine illustrated is in use at Gayndah and costs around \$650.00 on site.

Some larger meatworks have systems in operation which cost between \$20,000 and \$30,000 and the meat from these works is identified by a green ribbon brand.

Electrical stimulation will not alter toughness due to age. However, the opportunity exists for the supply of more tender meat to the consumers in country areas.

Further information may be obtained from your local Slaughtering and Meat Inspection Branch officer through the local D.P.I. Office or from C.S.I.R.O., Cannon Hill.



Weed control in the Emerald Irrigation Area

by W. D. Hamilton and W. H. Hazard, Agriculture Branch

The Emerald Irrigation Area (E.I.A.) in Central Queensland was established following the completion of the Fairbairn Dam on the Nogoa River in 1972.

Irrigation commenced in 1972-73 with the supply of irrigation water through a channel system to 13 farms. There are now 48 farms receiving water through the channel distribution system and 15 farms privately diverting water from the Nogoa River.

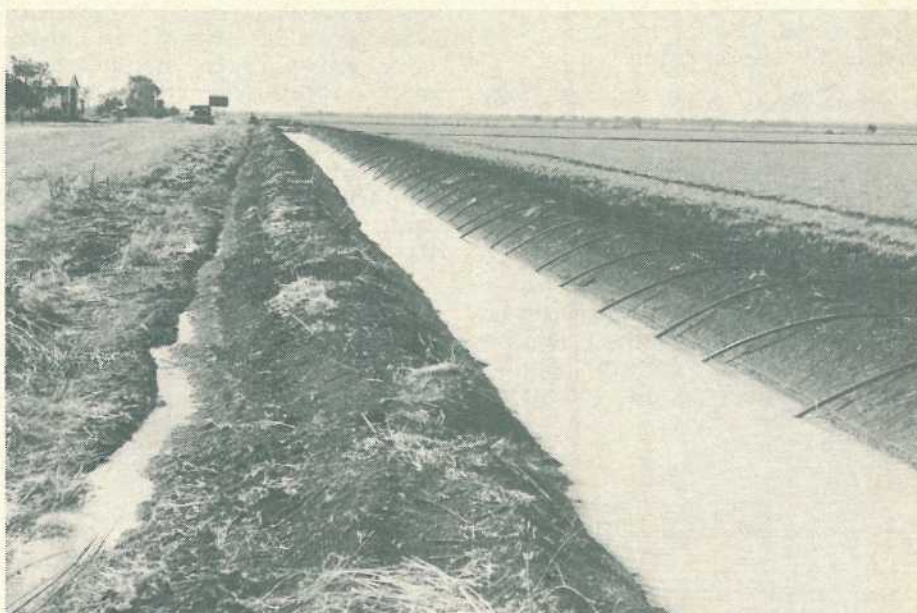
Weeds have become an important problem in the E.I.A. Weeds, particularly annual summer weeds, cause production losses and farmers incur additional expense in their control.

Farm hygiene is essential in any weed control programme and control of some weed species should be approached on a district basis either to control those widespread throughout the E.I.A. or to reduce the spread of potential problem weeds.

Chemical and cultural weed control techniques need to be integrated. Slashing, for example, should be used in situations where grass cover is desirable. Inter-row cultivation is very effective in summer crops but herbicides which selectively remove weeds from the crop may also be needed. Despite the current costs of labour, hand chipping is very useful for isolated weed infestations.

Cotton, soybeans and wheat are the main crops grown in the E.I.A. In 1980-81, some 6 500 ha of cotton, 1 000 ha of soybeans and 2 000 ha of wheat were grown. Cotton will continue to be the major crop while current returns are maintained.

The weeds and the herbicides that selectively control them in soybeans and cotton are outlined in table 1.



Weed-free head ditches allow water to flow freely and permit easy use of siphons.



A weedy head ditch. Compare this with the photograph above.

Weeds in cotton

In cotton, weeds not only compete with the crop for moisture, sunlight and nutrients, but heavy weed infestations reduce picking efficiency and can lower the grade of the lint. Small cotton plants do not compete well with weeds and inter-row cultivation and pre-emergence herbicides are essential.

Inter-row cultivation should be carried out when the weed seedlings are small. Good control can be achieved by cultivating weeds between the rows and smothering weeds in the cotton rows. Several cultivations are usually required. They should be carried out sufficiently frequently to remove all weeds and should continue until the cotton is too tall for implements to straddle the cotton plants.

Annual grass weeds such as sweet summer grass, known locally as annual summer couch (*Brachiaria eruciformis*), can be a problem. Trifluralin is recommended for the control of grass species. It also controls seedlings of *sorghum alnum*.

Annual broad-leaved weeds can be controlled with fluometuron. Diuron and prometryne control similar weeds but under certain conditions

can cause more damage to cotton plants. Prometryne has particular advantages when bellvine (*Ipomea plebeia*) is a problem.

These herbicides should be applied as a post-planting pre-emergence treatment. This usually means application with a nozzle mounted on the planter behind each row. A 30 cm band is applied over the row on to moist soil. Most annual broad-leaved species are controlled but some weeds such as Noogoora burr (*Xanthium pungens*) and thornapples (*Datura* spp) which can germinate from depth show some resistance.

Sesbania pea (*Sesbania cannabina*) is satisfactorily controlled with fluometuron. In areas of particularly heavy sesbania pea infestations, a 'lay-by' spray will give improved control. This involves mounting spray equipment on the cultivation rig and directing a spray on to the soil beneath the growing cotton plants when they are more than 10 cm tall.

Noogoora burr and grassy sorghum weeds can be controlled with MSMA as a post-emergence directed spray.

Weeds in soybeans

Soybeans are competitive with most weed species. Planting the crop into a moist, weed-free seed bed and obtaining good plant cover is usually effective. Narrow (50 cm or less) row spacing encourages early plant cover and an adequate plant population of soybeans usually suppresses weed growth 3 to 4 weeks after crop emergence.

Inter-row cultivation is economical and effective in controlling weed seedlings between the rows. Two cultivations are common, one before the first post-planting irrigation and one after.

Trifluralin and pendimethalin are effective in controlling annual grass weeds. Bentazone and acifluorfen are effective post-emergence herbicides being particularly useful for controlling Noogoora burr, thornapples and bellvine.

Weeds in wheat

Broad-leaved plants that usually grow in summer are the major weeds of wheat at Emerald. African turnip weed (*Sisymbrium thelungii*) and sowthistle (*Sonchus oleraceus*) are two of the few traditional winter weeds that are troublesome in wheat. Wild oats (*Avena* spp.) do not occur in the E.I.A. at present.

TABLE 1

Guide to the Susceptibility of Some Weeds of the E.I.A. to Herbicides

Botanical name	Common name	Trifluralin* 2-3 L/ha	Fluometuron 4-6 L/ha	MSMA 1.4-2.8 L/ha	Bentazone 1.5-2 L/ha
<i>Abutilon</i> spp.	Annual grasses	S	MS	MS	NS
<i>Abelmoschus ficulneus</i>	Flannel weeds	NS	..	NS	..
<i>Acanthospermum hispidum</i>	Native rosella	NS	S	..	PS
<i>Amaranthus</i> spp.	Starbur	NS	S	..	S
<i>Corchorus trilocularis</i>	Amaranthus	S	S	PS	PS
<i>Cucumis</i> sp.	Native jute	NS	S	..	S
<i>Chenopodium album</i>	Paddy melon	NS	S	..	..
<i>Datura</i> spp.	Fat hen	S	S	PS	S
<i>Helianthus annuus</i>	Thornapples	NS	MS	NS	S
<i>Hibiscus trionum</i>	Sunflower	NS	S	PS	S
<i>Ipomoea lonchophylla</i>	Bladder ketmia	NS	S	..	S
<i>Ipomoea plebeia</i>	Cowvine	NS	MS	..	PS
<i>Nicandra physalodes</i>	Bellvine	NS	MS	MS	S
<i>Oxperculina turpethum</i>	Apple of Peru	NS	S	..	S
<i>Parthenium hysterophorus</i>	Onion vine	NS	NS	..	..
<i>Physalis angulata</i>	Parthenium weed	NS	S	S	PS
<i>Physalis minima</i>	Annual ground cherry	NS	..	MS	NS
<i>Portulaca oleracea</i>	Wild gooseberry	NS	..	..	NS
<i>Salvia reflexa</i>	Pigweed	S	S	S	S
<i>Sesbania cannabina</i>	Mintweed	NS	PS	..	NS
<i>Solanum nigrum</i>	Sesbania pea	NS	S	MS	NS
<i>Sonchus oleraceus</i>	Blackberry nightshade	NS	S	..	S
<i>Trianthema portulacastrum</i>	Sowthistle	NS	S	..	..
<i>Tribulus terrestris</i>	Black pigweed	S	S	..	NS
<i>Xanthium pungens</i>	Caltrop	MS	S	S	..
	Noogoora burr	NS	MS	S	S

S = Susceptible

MS = Moderately susceptible

PS = Probably susceptible

NS = Not susceptible

.. = Not known

* Pendimethalin at 3 to 4.5 L/ha and nitratin at 1.5 to 2.2 kg/ha perform similarly to trifluralin.



This head ditch was treated with the residual herbicide diuron at the beginning of the season before weeds emerged.

Wheat is normally sown into dry soil and then irrigated. This 'irrigating-up' allows weeds to germinate with the crop. Volunteer plants of sunflowers and soybeans flourish in most Emerald winters as the area is relatively free of frost. Volunteer cotton and annual summer broad-leaved weeds such as Noogoora burr, thornapples, bladder ketmia (*Hibiscus trionum*) and bellvine are also often a problem.

Dicamba and 2,4-D amine are the most useful herbicides to use to control these broad-leaved weeds. These herbicides must be applied at the correct stage of crop growth. If applications are made too early or too late, crop damage can occur. Yield suppressions in excess of 10 per cent have been measured where these herbicides have been applied at the incorrect stage.

2,4-D amine is a particularly useful herbicide but it should be used only when the wheat crop is at the tillering stage (figure 1). This is usually from 30 to 40 days after planting in the E.I.A. At this stage, the plants have tillered but have not commenced jointing.

Dicamba or dicamba + MCPA can be used from the commencement of crop tillering to mid tillering or 20 to 30 days after planting. These herbicides are useful when weeds such as sunflowers germinate with the crop and provide competition at a very early stage. Occasionally, an early treatment may require follow-up applications of herbicides if a second weed emergence occurs.

Weed control in non-crop areas

Control of weeds in channels, head ditches, tail drains and headlands is important both because of the nuisance value of the weeds and their potential to spread to cultivation. Slashing is worthwhile because it

controls many weeds and also prevents erosion by maintaining surface cover. Cultivation of some non-crop areas is also worthwhile in accessible problem areas and in areas where bare soil is desirable such as those adjacent to head ditches.

Sesbania pea in this head ditch has been sprayed with diuron.



Herbicides are useful where the area to be treated is inaccessible to slashing or cultivating machinery. Two basic groups of herbicides are used in these situations.

- **Knockdown**—These herbicides give a quick kill of most weeds. Paraquat, diquat, glyphosate and MSMA are commonly used. Paraquat is more effective against grass weeds, whereas diquat is more effective against broad-leaved weeds. They can be used in combination. MSMA is particularly useful where Noogoora burr is a problem. Glyphosate is effective against perennial grasses and in the E.I.A. is commonly used in weedy sorghum control.
- **Residual**—These herbicides can provide long-term weed control or what is sometimes referred to as soil sterilization. Diuron, bromacil and hexazinone are examples. Although they will give top kill of standing vegetation, they are most effective when applied to bare soil and subsequent rainfall washes them into the soil. They are then taken up by the roots of germinating weeds. These herbicides must be used carefully as they can damage nearby desirable plants. They are also subject to surface wash causing damage to desirable plants at some distance down slopes.

Particular problem species

Several weeds are particularly important in the E.I.A. because they are either difficult to control or because they are potential problem weeds. An understanding of these weeds and the special methods that can be used on them will assist in their control.

Sorghum alnum was introduced into the Emerald district as a pasture species as it was one of the few grass species that would establish in the heavy cracking clay soils. Although it is a relatively short-lived perennial when grown as a pasture, it thrives in irrigated fertilized situations.

It can grow from rhizomes but usually it is spread by seed. Johnson grass (*Sorghum halepense*) is similar, but it has larger white or reddish rhizomes.

Some of the weedy sorghum species have shattering seedheads and seeds of some off-types can remain dormant for extended periods. These remain in the soil and germinate in subsequent seasons.

Trifluralin when used at standard rates will control weedy sorghum seedlings but not plants that grow from rhizomes. MSMA will remove top growth but the plants can often regenerate from the crown if well established. MSMA is particularly useful for controlling weedy sorghums in cotton. Glyphosate can also be used for controlling weedy sorghums but it is non-selective and cannot be applied in crops other than as a spot spray or by a rope wick applicator.

Farm hygiene on a district-wide basis can help in controlling weedy sorghum species. If roadsides, channels, head ditches and drains are kept free of the weed, control in crops will be easier. Weedy sorghums do not compete well with many other grasses. They grow well in disturbed areas along roadsides, where the road graders have removed competition from other grasses and a firm and often well-watered seed bed

is created. Slashing in these situations provides satisfactory control. Two or three slashings may be required in the first summer but usually once a sward of another species is established, weedy sorghums cease to be a pest.

Sesbania pea grows prolifically throughout the E.I.A. It is a particular problem in low-lying or waterlogged areas and grows well in alluvial soils. Apart from its ability to compete with crops, this weed is a nuisance at harvest and contaminated cotton attracts a 10 c per kg penalty.

It is a tall, robust annual weed that seeds prolifically. Fluometuron gives good control in cotton, but rates of 6 L per ha of the commercial product are required.

A new herbicide, phenisopham, is effective against seedling sesbania pea as an overall post-emergence spray, but at current costs is not attractive. There is no herbicide at this stage that will give adequate control of sesbania pea in soybeans.

Noogoora burr is probably the most common weed in Queensland and at Emerald can be a pest in winter as well as in summer crops. This weed seeds prolifically. Each burr that forms on the plant contains two seeds each in a separate compartment. One of these seeds germinates in the first year, the other remaining dormant until a subsequent favourable season.

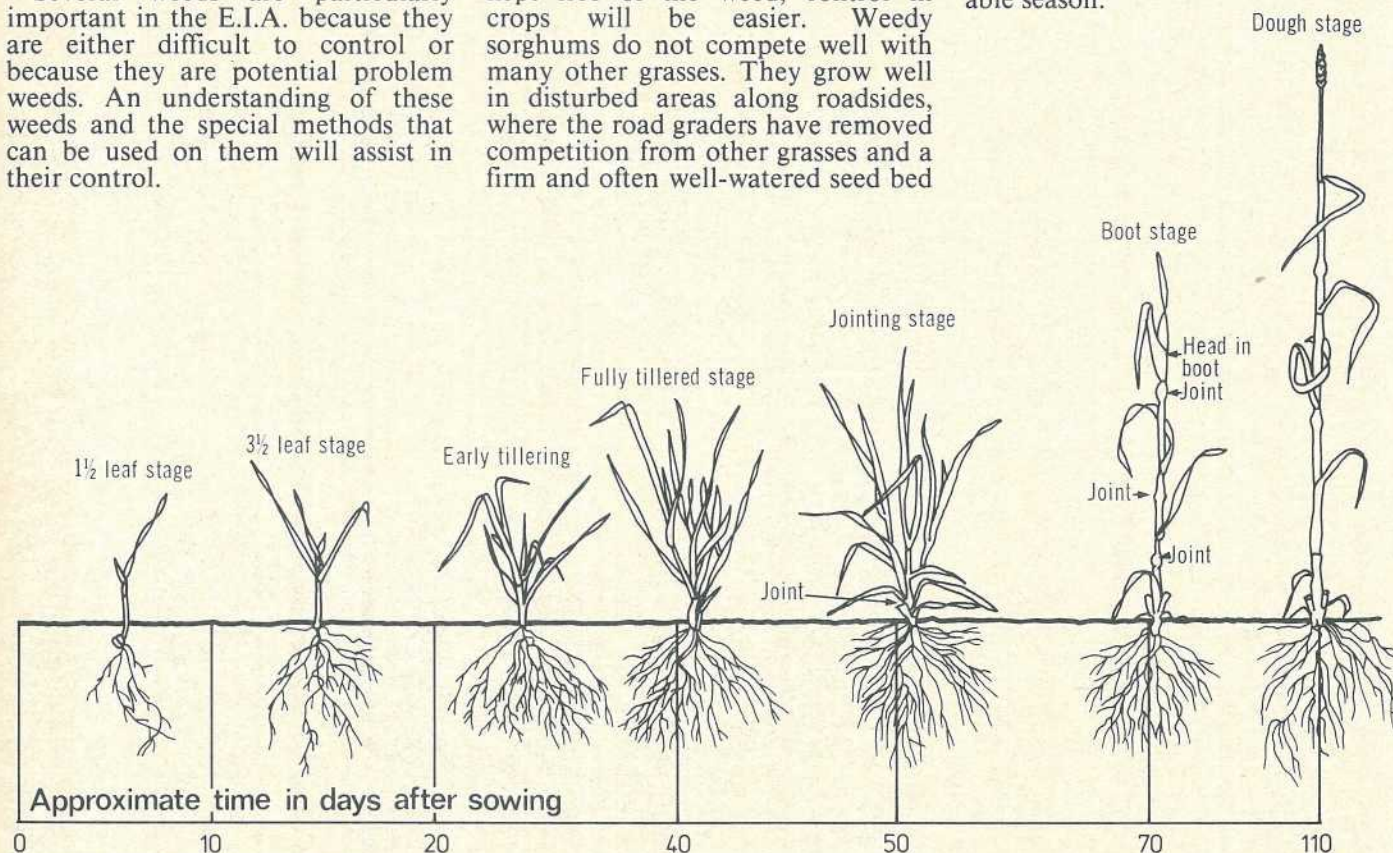


Figure 1. Growth stages of wheat.



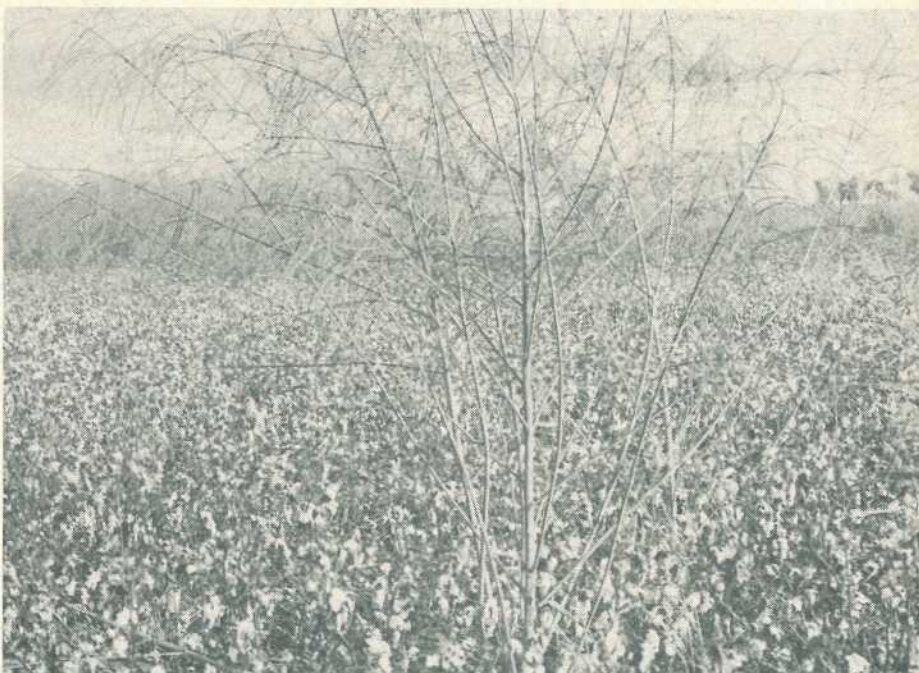
The senior author, David Hamilton, in a weed-free cotton crop in the Emerald Irrigation Area.

This makes control extremely difficult. The burrs can be spread by machinery and livestock and by running water. Although it is moderately susceptible to many pre-emergence herbicides, its ability to germinate from depth allows it to escape the action of these chemicals.

In cotton, MSMA as a post-emergence directed spray gives good control, particularly if the weed is not too large. A second application is sometimes required if a second emergence occurs following irrigation or rainfall. In soybeans, bentazone and acifluorfen are particularly effective while in wheat, 2,4-D amine and dicamba give good control. Destruction of any noogoora burr in the channel or water supply system is of particular importance in the control of this weed.

Native rosella (*Abelmoschus ficulneus*) and bladder ketmia (*hibiscus trionum*) are similar in their sensitivity to herbicides. Native rosella grows vigorously on the black earths on relatively little weathered basalt (open downs soils) but it is occasionally a problem on the black earths on deeply weathered basalt (scrub soils).

Bladder ketmia grows on all soil types in the E.I.A. Both weeds are susceptible to 2,4-D amine and fluometuron but tolerant of trifluralin, MSMA and bentazone. When fluometuron is used to control these species in cotton, correct application of the herbicide is essential.



Sesbania pea infestations in cotton make harvesting difficult and reduce yields. Contaminated raw cotton attracts a penalty of 10c per kg.



Weedy sorghums such as *sorghum alnum* are a major problem in the E.I.A.

Annual summer couch is the most common annual grass weed in the Central Highlands. This weed forms a carpet in areas of heavy infestation and can be very competitive with some crops. Trifluralin gives good control in cotton and soybeans.

Parthenium weed (*Parthenium hysterophorus*) has become an important weed of grazing lands in the Emerald district. It has not developed as a weed of cultivation. It can, however, spread rapidly in overgrazed or bare areas. It has a scattered distribution throughout the E.I.A. but to date has not become a problem in crops.

Perennial weeds have been a severe problem in isolated areas in the Central Highlands. Some of the species included in this group are Peak Downs curse (*Polymeria longifolia*), grey rattle-pod (*Crotalaria dissitiflora*), raspweed (*Haloragis aspera*), blue Heliotrope (*Heliotropium amplexicaule*) and quena (*Solanum esuriale*).

These species can all regenerate from their extensive underground root systems and control with herbicides is sometimes difficult. Shallow cultivation also fails to control these pests because of their ability to regenerate from their root systems.

Deep cultivation is effective in controlling these weeds. Spot spraying isolated infestations with herbicides such as picloram and 2, 4-D amine and glyphosate has been used with variable results.



Rope wick applicators are being used to control tall-growing weeds in cotton and soybeans.

Herbicide use

Although herbicides can greatly assist in the control of many of these weed species, special care is required with their use.

2,4-D amine, for example, is effective on some broad-leaved weeds but cotton and soybeans are particularly sensitive to this herbicide. Even a slight drift of these chemicals away from the target area and on to a sensitive crop can cause considerable damage.

The use of recommended application rates is essential. Insufficient

herbicide application will result in inadequate weed control and excessive rates can cause crop damage. This is particularly important when using fluometuron, prometryne or diuron.

If these herbicides are applied to cotton crops as a post-planting pre-emergence spray and rain falls immediately after planting, reduced plant stands may result. Complete loss of plant stands has occurred. Lower rates are required on sandy soils and higher rates on clay soils and paddocks with a range of soil types may become patchy if rain falls after planting.

Application equipment must apply herbicides accurately. Variations in output between nozzles on a boom spray should not exceed 10 per cent. An even spray pattern is also essential and drips from fittings should be avoided. Agitation of the spray tank is also required with some herbicides.

In addition, some herbicides are particularly difficult to clean out of spray equipment. Even thorough cleansing and soaking in ammonia solution will sometimes fail to remove residues of 2,4-D amine completely from spray equipment. If equipment used to apply 2,4-D amine is then used to apply insecticides to cotton, crop damage may result.

Mechanical incorporation is essential for herbicides such as trifluralin. If incorporation is not carried out correctly, weeds will grow from clods or areas where the herbicide has not mixed well with the soil.



Use of pre-emergence herbicides would have avoided this weed infestation in cotton.

Herbicide residues can also be a problem in subsequent crops. In the E.I.A., fluometuron and diuron have caused losses when sensitive crops have been sown immediately following cotton. Damage is usually most

severe in the areas where excessive rates were applied in the previous crop. Wheat, soybeans, sunflower and sorghum are all sensitive to residues of fluometuron.

Labels on all of these products carry the necessary information on rates of application, methods of application, residue hazard and precautions. REMEMBER: READ THE LABEL.

TABLE 2
Herbicides Used in Emerald Irrigation Area

Chemical Common Name	Trade Name	Chemical Common Name	Trade Name
Trifluralin.....	Several products	Acifluorfen.....	Blazer 2L
Pendimethalin.....	Stomp 330E	Dicamba.....	Several products
Nitralin.....	Planavin 75	2,4-D amine.....	Several products
Fluometuron.....	Cotoran 80WP	Dicamba + M.C.P.A.....	Banvel M
	Flowable Cotoran	Paraquat.....	Grammoxone
Diuron.....	Several products	Diquat.....	Reglone
Prometryne.....	Gesagard 50	Glyphosate.....	Roundup
MSMA.....	Daconate	Bromacil.....	Hyvar X
	Lane MSMA	Hexazinone.....	Velpar
	Herbicide	Phenisopham.....	Verdinal
Bentazone.....	Basagran	Picloram + 2,4-D amine.....	Tordon 50D

New veterinary publications

Pictorial Anatomy of the Cat, revised edition, illustrations and text by Stephen G. Gilbert

The 'Pictorial Anatomy of the Cat' is a book which should prove invaluable to all veterinary surgeons.

Disigned as a dissection guide in comparative anatomy or in mammalian anatomy, this book has many special features which make it ideal as a reference work.

Complete dissecting instructions and descriptive text have been adapted to the pictorial approach. Realistic illustrations are drawn directly from dissections and are designed to point out important features with the aid of labelling and numbered keys and the use of diagrammatic marginal illustrations (which are labelled directly).

Anatomical relationships are fully described and illustrated with numerous lateral views showing relationships not seen in the standard ventral dissection. Arteries, veins, and nerves are shown in red, blue and yellow respectively for easy identification.

Integrated text and self-explanatory plates ensure that no other text is required. Each subject is illustrated by a small marginal diagram so that it is never necessary to turn another page to see an illustration of the subject under discussion. There is a set of definitions of descriptive terms provided, and a comprehensive index ensures ready reference.

The price of this book is \$7.95. It is available from University of Queensland Press, P.O. Box 42, St. Lucia, Qld. 4067.

Elements of Horsehoeing, second edition, by J. A. Springhall

This is a straightforward, well-illustrated book on how to shoe a horse. It is written in simple language and guides the reader through each step involved with the aid of detailed descriptions and photographs.

'Elements of Horseshoeing' covers all aspects of horseshoeing—from a knowledge of the anatomy of a horse's hoof, the construction and removal of a shoe, foot preparation, and fitting and nailing on, to a final discussion of the shoeing of thoroughbred racers, trotters, and pacers. Incorrect shoeing procedures and common faults occurring at any stage of the process are also outlined and discussed.

This practical manual is essential for all members of pony clubs, equestrians, graziers, blacksmiths and for all those who have an interest in horses.

Dr John Springhall is senior lecturer in Animal Husbandry at the University of Queensland and has also acted as consultant to the government on problems of livestock nutrition.

This publication costs \$4.95 and is available from University of Queensland Press, P.O. Box 42, St. Lucia, Q. 4067.

Lucerne aphids and their natural enemies

by R. J. Corcoran and D. A. Ironside, Entomology Branch

About 4 years ago, two new insect pests of lucerne and related crops were recorded for the first time in Queensland—the bluegreen aphid and the spotted alfalfa aphid. Both pests are now spread throughout the southern half of the State.

Plate 1. The spotted alfalfa aphid (*Therioaphis trifolii* f. *maculata*) is yellowish in colour with rows of dark spots across the body.

This pest is usually found on the underside of the lower leaves of the plant where it feeds by sucking sap. During feeding, a toxin is injected into the plant. This kills susceptible varieties very quickly. However, many lucerne varieties with a high level of resistance to spotted alfalfa aphid are now available.

Plate 2. Seedlings of susceptible lucerne varieties are killed rapidly by spotted alfalfa aphid.

The first sign of damage is a yellowing or whitening of the leaf veins known as veinal chlorosis. With continued feeding the leaves yellow, curl, die and drop.

Plate 3. The bluegreen aphid (*Acyrtosiphon kondoi*) varies from green-grey to green-blue in colour and the adults are 2 to 3 mm long.

Infestations are usually found on the upper part of the plant. Highest populations occur during autumn/winter but numbers are reduced dramatically in spring.

The insects suck the juice from the plant and symptoms of damage include misshapen and yellowed leaves and stunting of the plants. Seedlings are very susceptible and are readily killed.

Plate 4. Moist conditions favour the spread of *Entomophthora planchoniana*, a fungal disease of bluegreen aphid.

Infected aphids become swollen and discoloured reddish-brown and normally adhere to the underside of the leaves. They may be covered later with a velvety layer of fungal spores which are shot out and stick to other aphids. The spores germinate and produce fungal threads which penetrate the body of the aphid and thus repeat the cycle of infection.

The disease appears to be a significant factor in the seasonal disappearance of the bluegreen aphid in spring and a closely allied disease organism *zoophthora radicans* is a major factor in the control of spotted alfalfa aphid.

Plate 5. *Trioxys complanatus* is a small wasp parasite introduced into Australia from California. It is now established in all areas where its host, the spotted alfalfa aphid, occurs.

The adult wasp inserts an egg into the aphid and the parasite larva feeds on the body contents until they are consumed completely. A pupa is then formed. At this stage all that remains of the aphid is its expanded skin containing the wasp pupa. This is called a mummy. The adult wasp emerges from the skin and the cycle is thus continued.

Plate 6. Although many predators attack both lucerne aphids, one of the most common is the transverse ladybird (*Coccinella repanda*). Both the adult beetles and the larvae feed voraciously on the aphids as well as on other small insect eggs and larvae.



Lucerne aphids and their natural enemies



Plate 1. Spotted alfalfa aphids on lucerne.

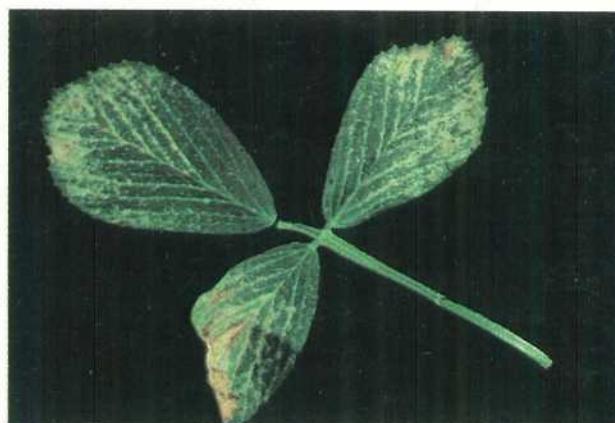


Plate 2. Veinal chlorosis of lucerne leaflets caused by spotted alfalfa aphids.



Plate 3. Bluegreen aphids on lucerne.



Plate 4. Bluegreen aphids affected by *Entomophthora* fungus.



Plate 5. *Trioxys* adult and parasitised mummy of spotted alfalfa aphid.



Plate 6. Transverse ladybird adults and larva—lucerne aphid predators.