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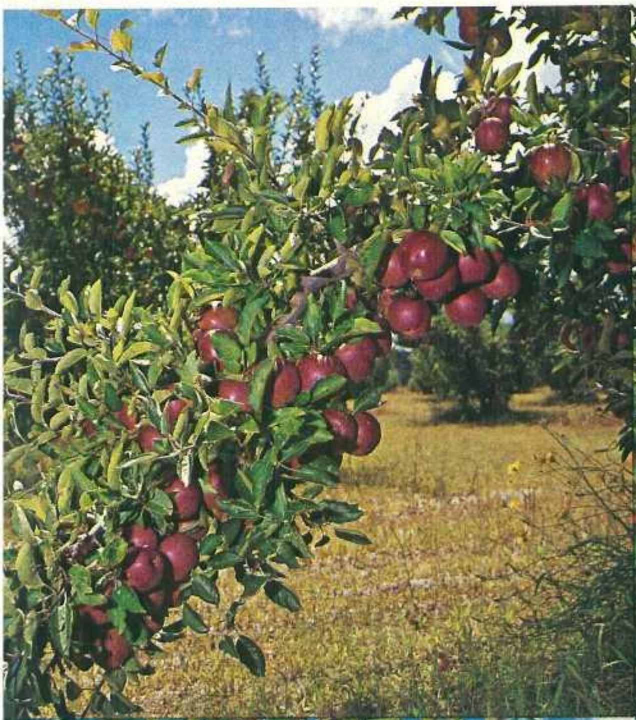

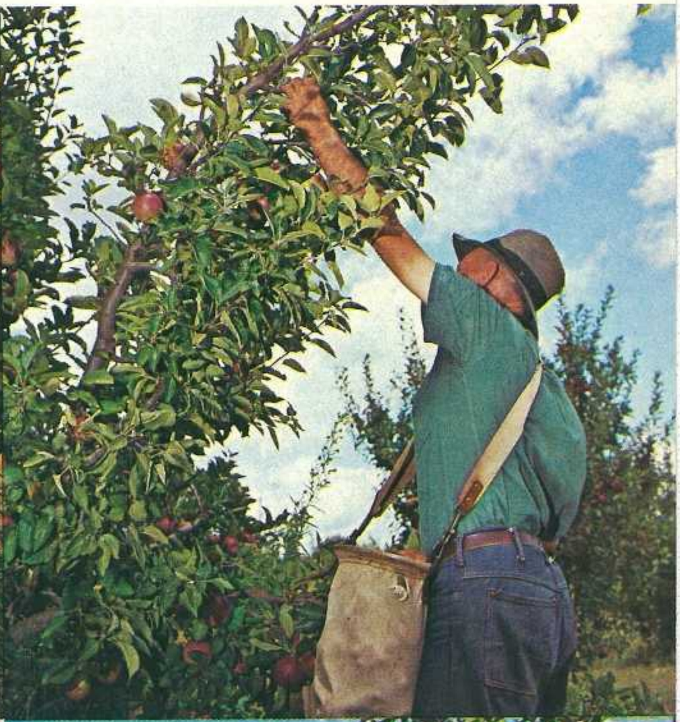

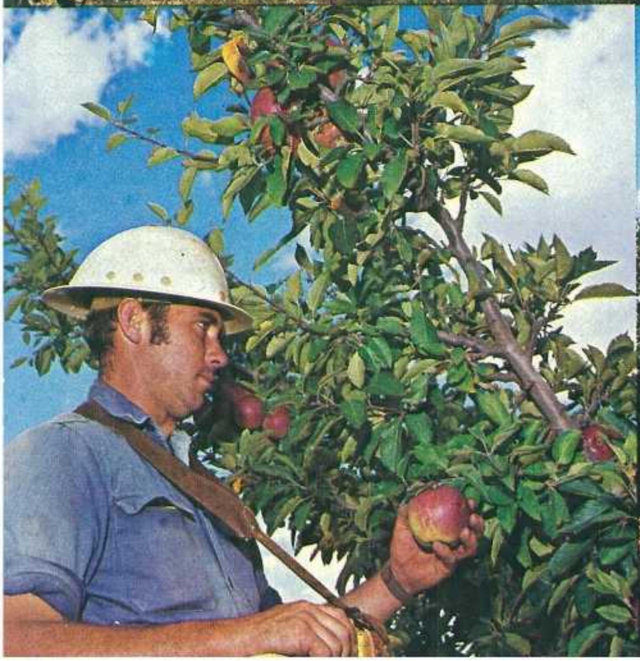

School project notes

APPLES

THE APPLE *(Malus sylvestris,* fam. *Rosaceae)* is indigenous to Asia and is believed to have its origin in the Caucasus Mountains, which lie between the Black and the Caspian Seas.

Climate

Climatic factors restrict commercial apple growing in Queensland to the Stanthorpe district, for though its latitude of 28·5 deg. is only 5 deg. south of the Tropic of Capricorn, an elevation of 760 to 915 metres above sea level provides the necessary winter chilling requirements of the trees.

Production

In 1975, approximately 6 025 hectares of trees yielded 38 344 tonnes of fruit. The highest production recorded to date was 47 900 tonnes in 1971. Although new plantings have decreased in recent years, it is expected that production will increase and should reach 57 500 tonnes in 1979.

Varieties

The apple industry in Queensland is based primarily on three varieties—Granny Smith, Delicious and Jonathan.

Granny Smith originated as a seedling at Eastwood (New South Wales) about 1868. The fruit is a uniform green in colour, becoming yellowish-green at full maturity. A full yellow colour, however, is generally a sign of over-maturity. It is excellent for culinary purposes and is becoming increasingly popular as a dessert apple. The fruit matures between mid March and mid May at Stanthorpe and has a longer storage life than any other locally-grown variety. The tree grows vigorously and consistently bears good crops.

Delicious is a very attractive red apple, commonly striped but often red all over. It matures over a relatively short period during February and March, and is used as a dessert fruit. The storage life of the fruit is slightly less than that of the Granny Smith variety.

Jonathan is usually a red apple grown mainly as a dessert fruit. The crop matures during early February to late March.

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Contents

QUEENSLAND DEPARTMENT OF PRIMARY INDUSTRIES

Of particular interest

Items of news recently released by the Minister for Primary Industries, the Hon. V. B. Sullivan, M.L.A.

DISEASE ERADICATION ALLOCATION

THE Queensland Government has agreed to provide special allocations from Consolidated Revenue totalling $482,500 to support, during 1976-77, the Australia-wide brucellosis and tuberculosis disease eradication schemes for livestock.

This allocation would be in addition to the $647,500 budgeted in the Stock Fund for salaries and costs incurred by Departmental staff associated with the campaign.

The Commonwealth Government will continue its fianancial support for the schemes, including a new provision to compensate owners for cattle ordered to be destroyed because of brucellosis.

This is part of an eight-year programme designed to achieve provisional freedom from this disease throughout Australia.

Compensation also will apply for complete, or partial, depopulation of heavily-infested holdings where, in the opinion of the Chief Veterinary Officer, complete slaughter might be a better disease control procedure for both diseases than individual testing.

Compensation values for affected cattle have been reduced to levels more in keeping with present farm gate prices.

Additionally, compensation will applv to horses affected with brucellosis and ordered to be destroyed as part of a herd eradication programme.

The revised compensation values (with the actual return to owners in brackets) are:—

Tuberculosis: Bulls and dairy cows, $120 ($90); beef cows, oxen and steers, $60 ($45); weaners of either sex, $30 ($22.50).

Brucellosis: Bulls and dairy cows, $120; beef cows, $60; female weaners, $30; horses, $25 (the same values will be received by the owners).

Compensation will apply only to animals found to be affected by either disease during testing carried out as part of an approved herd eradication programme, or to meet compulsory requirements for entry to a prohibited area.

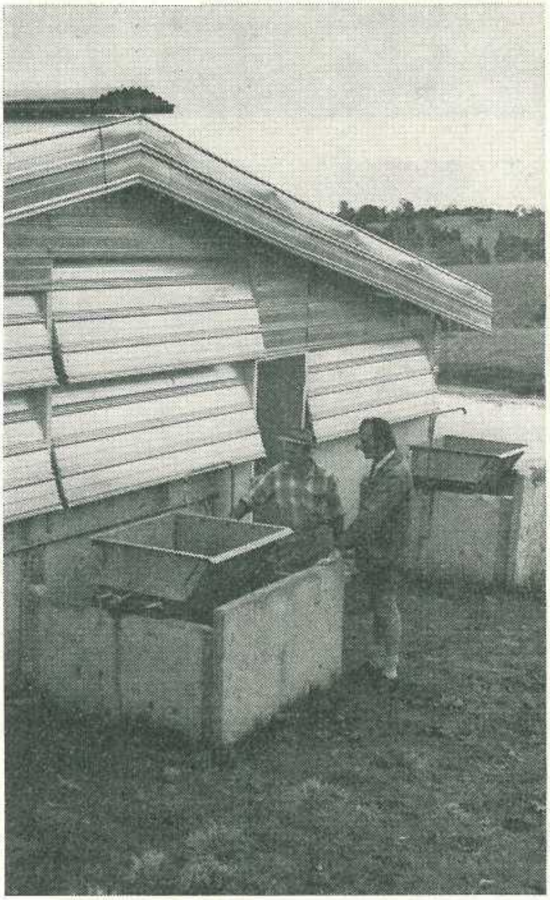
As previously, the Commonwealth Government will contribute 50% of the cost of tuberculosis compensation, the State Government 25% and owners the remaining 25%.

However, with brucellosis, the Commonwealth will pay 75% and the State Government will meet the balance, which means there will be no difference between the compensation value and actual return to owners.

Flushing piggery wastes

by N. E. REINBOTT,
Pig and Poultry Branch.

TODAY, intensive housing of pigs with fully or part slatted floors is the accepted practice. Provided pen dimensions and stocking rates are normal, the dung or urine either falls or is tramped through the slatted floor. Flushing with water is the most economic and efficient way of removing these wastes from the building.

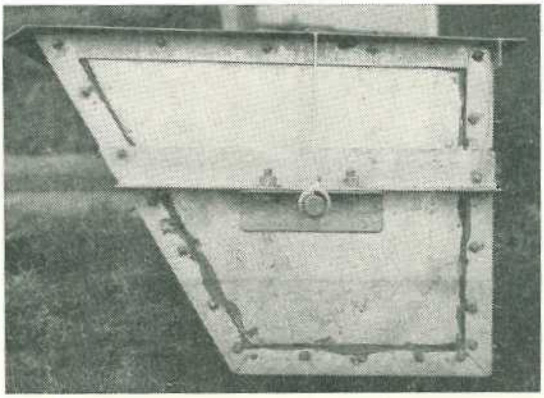


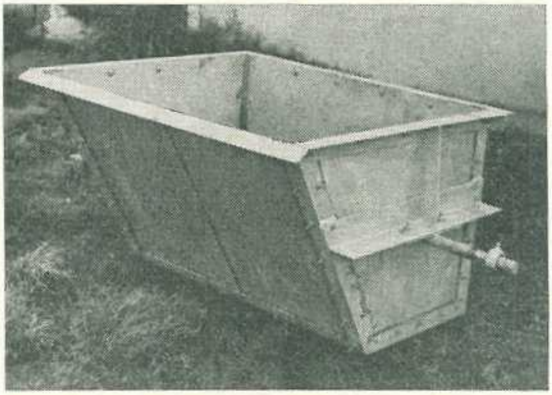
Mr. H. Dull, a Boonah pig grower, and Mr. N. Reinbott of the D.P.I. inspecting the flushing tanks located at the end of the shed. The tanks are mounted 1.07 m above the trench floor.

Problems of conventional pits

Conventional pits necessitate storage of wastes in water, as effluent, for varying periods of time. This practice has a number of disadvantages:

- Pit dimensions must be sufficient to collect effluent for a number of days. This adds to the capital cost of the building.
- Partial digestion of the effluent occurs which causes gas formation, principally carbon dioxide, ammonia, hydrogen sulphide and methane. Normal ventilation does not always remove these gases.
- Research has shown that atmospheric ammonia levels as low as 10 p.p.m. have depressed feed intake and daily liveweight gain.





TOP. End view of flushing tank showing the general construction. Note the angle iron axle support and the short, adjustable axle mounting.

BOTTOM. Perspective view of flushing tank showing the overall shape.

- Presence of odorous gases (ammonia and hydrogen sulphide) makes working conditions uncomfortable.
- Hydrogen sulphide and ammonia dissolved in water are great contributors to corrosion of metal roofs and fixtures. The presence of dust in a piggery accelerates this corrosion.
- Successful management of conventional pits requires constant attention to emptying frequency.

Flushing overcomes problems

Daily removal of effluent from the building reduces the formation of gas. This can be accomplished by using the flushing system.

Mr. H. Dull, a Boonah pig grower, has successfully used such a system for two years.

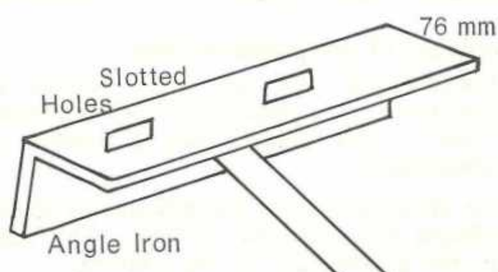
The system consists of a flushing tank which automatically and regularly dumps its load of water into a sloped trench under the slatted floor. The force of the water flushes out the manure.

The tank, which has one sloping side, is slowly filled with water. When sufficiently full, the weight of the water alters the point of balance and the tank tips, dumping the water into the trench.

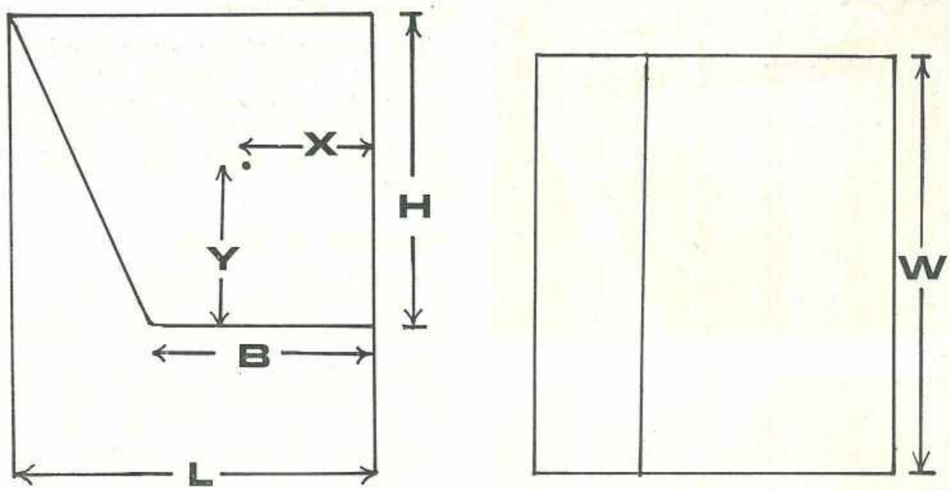
The flushing tank construction

The tank is constructed of 1·6 mm (16 gauge) sheet metal on a frame of 51 x 51 x 3 mm (2 x 2 x ⅛ in.) angle iron. A piece of 76 x 76 x 6·5 mm (3 x 3 x ¼ in.) angle iron is welded across each end to serve as a mount for the axle.

The 33 mm (1¼ in.) diameter axle is welded to a short length of similar sized angle iron and the two are bolted together through horizontal slots. The slots allow the axle to be shifted forwards or backwards to locate the desired pivot point.



The axle is welded to angle iron in which slotted holes are drilled. This allows the axle to be shifted forwards or backwards to locate the desired pivot point.



Tank dimensions and location of pivot point.

TANK DIMENSIONS FOR VARIOUS TRENCH LENGTHS

Trench Length m	Capacity Litre/Metre of Tank Width	Internal Dimensions mm				
	W	B	L	H	Y	X
24—36	500	457	914	762	394	368
18—24	400	457	838	610	317	330
Less than 18	300	457	762	508	267	305

The location of the pivot point is critical to the proper filling and dumping of the tank. The measurements listed in the diagram above are approximate because of variation in the weights of metals used in construction.

Note that the centre of the axle is located 13 mm ($\frac{1}{2}$ in.) above the centre of the tank when measured from top to bottom. This is a constant figure regardless of tank depth. If the tank dumps before it is full, shift the axle towards the front edge. If it overflows without dumping, move the axle towards the back edge.

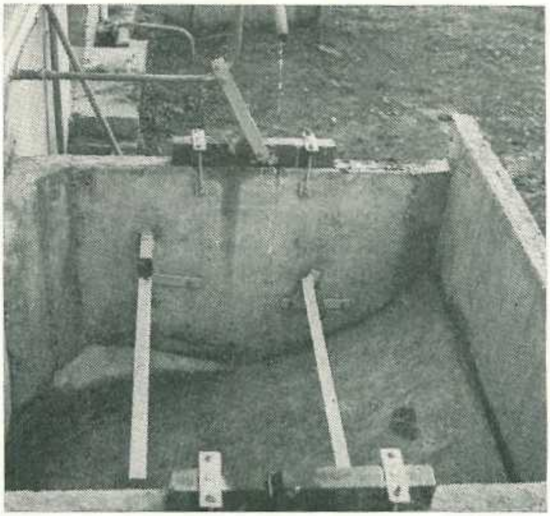
For the tank to fill properly and return to an upright position after dumping, two pairs of hard rubber stoppers are needed. The back stoppers support the tank in a horizontal, upright position for filling.

Considerable pressure is applied to this support until just before dumping. The front bumpers stop the tank's rotation at a position about 127 mm (5 in.) below the point at which all contents would just empty.

If the tank is allowed to rotate beyond this point, it will not return to an upright position for refilling.

The width of the tank should be the same as the width of the flushing trench. Allow clearance on each side of the tank for axle mounting and ease of operation.

When properly adjusted, the tank will dump and return to the refilling position automatically. The frequency of dumping can be controlled by regulating the flow of water into the tank. The capacity of the tank depends on the length of the trench to be flushed.



TOP. Because of a sloping front, the point of balance shifts when the tank is filled.

CENTRE. The tank then dumps the water into the trench.

BOTTOM. A view of the curved spillway underneath the tank.

Mounting the tank

The velocity of the water is critical to the efficiency of the flushing system. For this reason, it is preferable to mount the tank at least 1 metre (3 ft.) above the trench floor and dump the water back against a curved spillway.

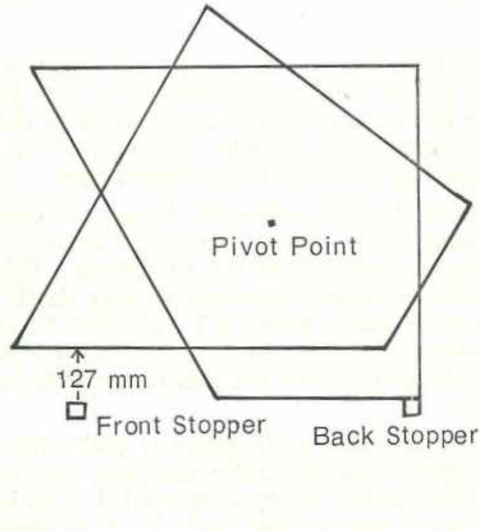
Frequency of flushing

Stocking density governs the frequency of flushing. The more frequently a trench is flushed, the less solid matter accumulates.

Experience on the property of Mr. Herb Dull has shown that flushing night and morning in the dry sow shed and farrowing sheds is adequate to remove manure and control odours. But in a grower shed where more manure accumulates, it is suggested to flush three times a day at eight hour intervals.

Flushing trench

The floor of the flushing trench should be trowelled to a steel float finish. The floor must be level from side to side to prevent the flush water from veering to right or left. Allow at least 230 mm (9 in.) of clearance between the bottom of the first slat and the floor of the trench so that the flow of water will not be impeded.



Location of front and back stoppers.

Trenches with a 2% floor slope have worked very successfully, but there is some evidence to suggest that lesser slopes could be used.

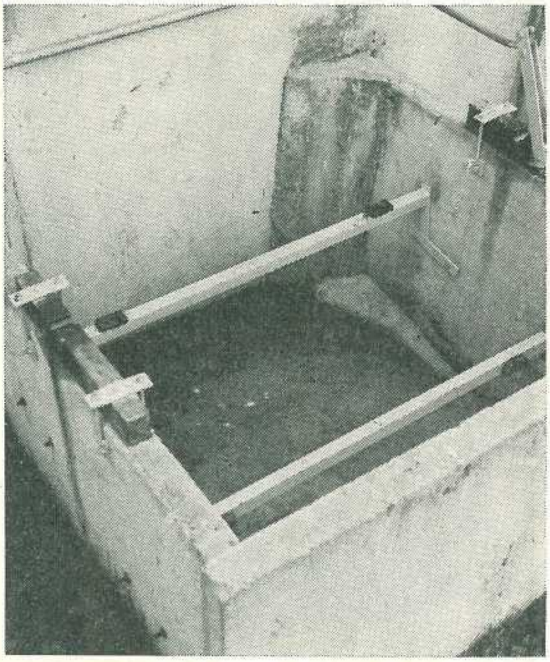
The floor of the pen should overhang the trench by 75 mm (3 in.) so that manure falls into the body of the trench. Without this lip there is a tendency for manure to adhere to the trench wall.

The effluent should be conveyed from the building to the pond in a trench of similar or slightly smaller dimensions.

Pouring the sloped trench

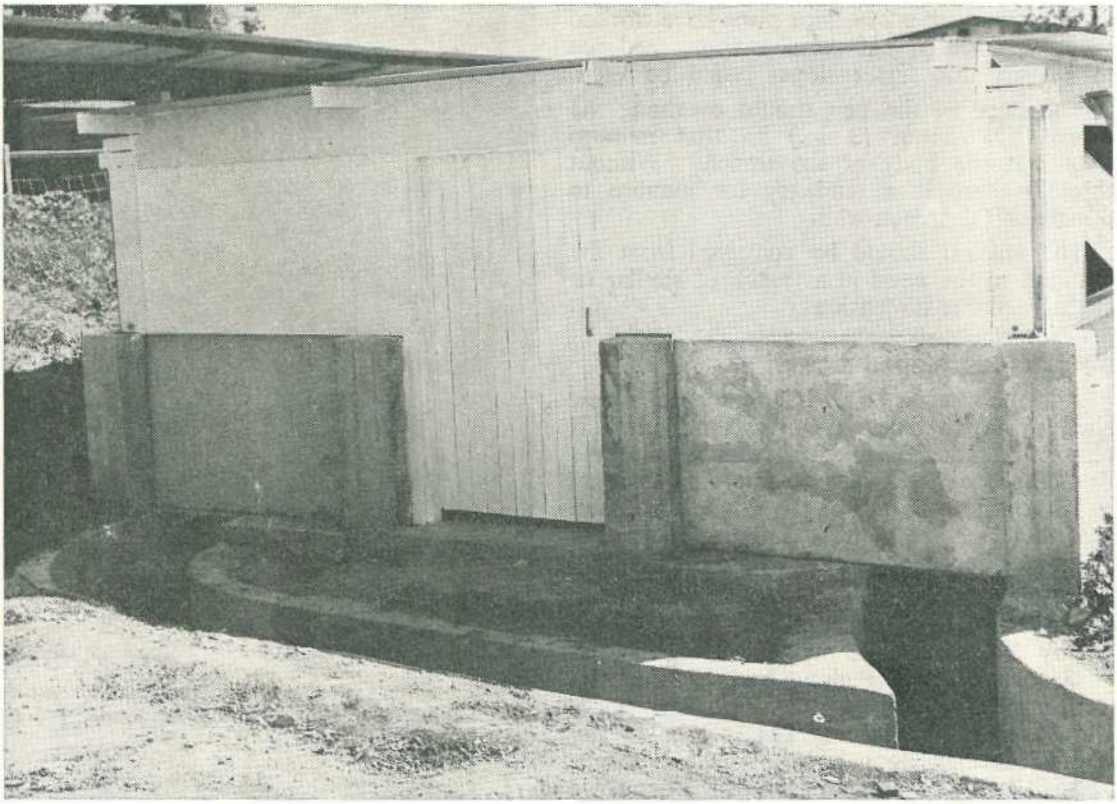
A sloped surface can be poured in a new shed or in an existing conventional pit. If remodelling, fill the old pit with sand to the desired grade level. Wet the sand and compact it. Starting at the top of the slope, make sure that there will be at least 230 mm (9 in.) of clearance between the slats and the finished floor level.

The floor of the trench can then be set out by driving 75 x 25 mm (3 x 1 in.) stakes at 2 metre intervals along each side of the trench so there will be a uniform 2% slope. Cut the stakes off 32 mm (1¼ in.) below the desired finished floor levels. Place a length of 25 NB (1 in.) pipe on each of the two rows of stakes. The concrete can be screeded on the two pipes. Pull the pipes to the next support as pouring progresses. The stakes can be left embedded in the concrete.



ABOVE. A further view of the spillway showing the trench entrance. The front and back stoppers are also visible.

BELOW. In this tank, the axles are fitted into grooves in a piece of timber which is bolted to the spillway box.



The effluent is carried from the building to the manure pond in a trench of similar or smaller dimensions.

How far can effluent be flushed?

The practical limit appears to be somewhere between 30 metres (100 ft.) and 45 metres (150 ft.), but it may be possible to flush over longer lengths if sufficient flushing water is provided. Buildings over 30 metres (100 ft.) in length can be flushed from both ends to a centre drain

Water usage

Experience to date suggests that less water is used with flushing than with a properly managed conventional pit system. In locations where the water supply is limited, the flushing system can be combined with recycling from the manure pond to limit water usage to a minimum.

MINIMIZE GRAIN RESIDUES

by M. BENGSTON, Entomology Branch.

WITH more people becoming aware of the effects of insect infestation, ease of cleaning is an important feature in the design of new grain handling machinery and equipment.

Surveys have shown that grain residues in machinery frequently contain insects and are an important source of infestation for newly-harvested grain. Since treated grain residues provide an opportunity for the further development of resistance to insecticides, the aim should be complete removal of grain residues rather than treatment.

Growers are very conscious of the difficulties in cleaning existing machines. New machinery should be designed to allow complete removal of all residues of grain, grain dust and straw.

The Australian Grain Infestation Liaison Committee has been working to develop design guidelines to help minimize the problem. This Liaison Committee comprises representatives from the Australian Wheatgrowers Federation, the Commonwealth Department of Primary Industry, State Departments of Agriculture and the Tractor and Machinery Association.

The following guidelines are recommended to grain growers for use as a yardstick to compare the new machinery on the market.

GENERAL CONSTRUCTION FEATURES

All machinery and equipment used in the handling of grain and grain products should be designed so that no grain or residue will remain lodged or caught in any part of the machinery after use.

It is very difficult to design a machine which has a satisfactory degree of self-cleaning. For this reason, it is essential to make provision for operators to clean all grain or residue from machinery.

An essential design aim should be to keep the time and effort required for cleaning to a minimum.

Desirable design objectives are:

- The provision of self-shedding ledges. Flat ledges should be avoided.
- The elimination or sealing of all seams, joints, and crevices where grain or residue may lodge.
- The shielding of shafts, bearings and drive mechanisms so that the wrapping of heads and straw is prevented.
- The sealing of tube ends so as to prevent the ingress of grain or residue.

SPECIFIC DESIGN FEATURES

Header harvesters

REEL.—The reel should be designed in such a way that heads cannot be caught up or become stuck in the bats or pick-up fingers.

CROP DIVIDERS.—The crop dividers should not collect grain or residue in joints or crevices on flat surfaces or between the divider and the header front casing.

PLATFORM AUGER ASSEMBLY.—The auger stripper plate should be shaped so as to make it self-shedding of grain or residue.

Clean-out doors should be provided when platform augers are fitted with retractable fingers.

CUT CROP ELEVATOR ASSEMBLY.—The casing should be designed so as to incorporate easy cleaning features such as provision for the removal of full width and full length top and bottom panels.

Features should be incorporated to prevent wrapping of straw around the top and bottom shafts and sprockets of the cut crop elevator.

STONE TRAP.—Provision for the ready removal and cleaning of the stone trap and other devices in this general area should be made.

THRESHING DRUM AND CONCAVE AREA.—Sufficient access should be provided to permit cleaning all round the threshing drum and concave without it being necessary to remove them.

When a grain tray or grain conveyor is fitted between the drum and the sieves, the tray should be readily removable. Alternatively, adequate means must be provided so that all grain or residue can be cleaned-out of the grain conveyor.

AUGERS AND CASINGS.—Casings should be capable of being cleaned of any grain or residue by such means as withdrawing through the side of the machine or by hinging the lower section of the casing along the horizontal axis.

Ends must be fitted with detachable covers.

Elbows should have inspection doors or covers.

Closed augers should have a full width access door underneath.

Open augers should have a form of sliding door so as to readily permit cleaning of all grain or residue.

FAN CASING.—Access must be provided to the exterior and interior of the fan casing so that all grain or residue can be removed.

Access should be through full width, hinged panels wherever possible.

STRAW WALKER CURTAIN ATTACHMENT.—This attachment should be designed so as to give a self-shedding action for grain or residue.

STRAW WALKER CRANKSHAFTS.—Crankshafts should be designed so as to prevent the wrapping or build-up of straw between the shaft, bearings or walker attachments.

GRAIN ELEVATORS.—Inspection doors with quick release clamps should be provided at each end.

CLEANING SCREENS AND GRAIN SCREEN COVERS.—Screens and covers should be fitted with quick release clamps to facilitate removal.

GRAIN BINS AND SCREENINGS BOX.—Readily removable top covers should be provided.

Readily removable shutters should be fitted for cleaning purposes where the auger casing cannot be fitted with a full length, hinged trough.

GUARDS.—In general, these should be of a swing-out type fitted with quick release clamps. Horizontal or flat ledges should be eliminated where practicable in favour of self-shedding surfaces.

Quick release clamps used for fastenings or covers should be designed to avoid corrosion and seizure of components.

Note: Many types of clamps presently in use rust or seize in place and do not allow quick release without the use of tools to free them.

Grain handling equipment

AUGERS AND CASINGS.—Some means of reversing the auger rotation should be provided so as to enable efficient cleaning.

Seams, joints and crevices should be eliminated or sealed in areas where grain or residue may lodge.

Ends should be fitted with detachable covers and elbows with inspection doors or covers.

Where U-section casings are used in horizontal augers, the lower section of the casing should be hinged about the horizontal centre line in order to allow the semi-circular portion to be swung down for cleaning.

When circular casings are employed in horizontal augers, the complete casing sections should be capable of being withdrawn from around the auger flight for cleaning. An alternative is the provision of suitable openings in the casing to enable thorough cleaning.

In respect of under-floor augers, and in addition to the design features set out in respect of horizontal augers, sufficient access should be provided to enable any grain or residue dropped after cleaning-out the auger casing to be removed manually.

Closed augers should have a full width access door underneath.

Open augers should have a form of sliding door so as to readily permit cleaning of all grain or residue.

BUCKET ELEVATORS AND PITS.—Elevators should be self-cleaning to the extent possible but should have adequate access in the structure to permit efficient manual cleaning if the need should arise.

Adequate access should be provided at the bottom of the pit for any grain or residue to be cleaned-out manually.

If necessary, a special compartment sealed-off with a sliding door can be built into the pit to provide the desired access.

Bulk grain equipment

TRUCK, FIELD AND AUGER BINS.—All seams in bulk handling equipment—truck field and auger bins, etc. should be sealed to the extent necessary to prevent the accumulation of grain or residue.

Internal and external strengthening members should be designed for self-shedding of grain or residue.

Sliding doors and slide channels on truck bodies, field bins, etc. should be completely accessible for cleaning purposes.

Where permanent or portable augers are fitted to field bins, hoppers, etc., the same design features should be included as outlined in respect of augers and casings.

The emptying hopper on conical base bins or silos should permit and facilitate complete cleaning-out after each withdrawal of grain or residue or feed mixes.

SILOS AND ON-FARM STORAGE SHEDS.—All surfaces should be of a self-shedding type and, wherever possible, structural members should be on the outside and so designed that grain or residue will not lodge on them.

Manual access for cleaning purposes should be provided.

All wall, floor and ceiling joints should be sealed completely to prevent the ingress of moisture or insects and to allow for fumigation when required.

Fine wire mesh screens should be installed over ventilators or air ducts to prevent the ingress of insects and provision should be made for sealing to allow for fumigation.

Wherever possible, storage facilities should be designed so as to be completely self-emptying.

Withdrawal hoppers should be designed so that they may be completely cleaned-out.

Grain processing, drying and cleaning equipment

GRAIN DRYERS.—The design features outlined for augers and casings, bucket elevators and pits, silos and on-farm storage sheds should be applied in the design of grain dryers.

HAMMER MILLS AND FEED MIXING UNITS.—Ready access to the mill chamber should be provided so that all grain or residue or milled materials can be easily cleaned-out.

The design features covering the components as outlined in earlier sections should be applied.

COMBINE DRILLS.—Grain boxes should be designed so that all compartments are completely self-emptying.

Metering devices and sowing tubes should be designed to prevent grain or residue lodging in joints or on ledges.

SEED CLEANING AND SEED DRESSING EQUIPMENT.—Equipment should be designed to give ease of cleaning to the standard required for pure seed work.

Making grain sorghum pay

by P. B. WYLIE and G. D. STIRLING,
Agriculture Branch.

INTEREST in grain sorghum in the drier grain growing areas of the Western Downs and Maranoa has grown rapidly in recent years. Planted areas have increased more than ten-fold in the last decade. On many properties, grain sorghum is as important as wheat.

Growing grain under dryland conditions with less than 600 mm of rain a year is a challenge. In the Near South-west region around 60% of this rain falls in summer. Despite this, summer cropping is more difficult than winter cereal production.

WHY GRAIN SORGHUM?

Grain sorghum is the predominant summer crop due to its drought hardiness and the present good returns. However, it needs to yield half as much again to compare with profits from wheat at present (August, 1976) grain prices. In the past, average grain sorghum yields have only been slightly above those of wheat. In the last few years, improvements have been made in the crop husbandry of grain sorghum and many growers are now receiving similar profits from grain sorghum as from wheat.

Other benefits from diversification into grain sorghum production include:

A good stand of wide row sorghum on the property of Mr. C. McLennan (left) in the Miles district.

in the Near South-west

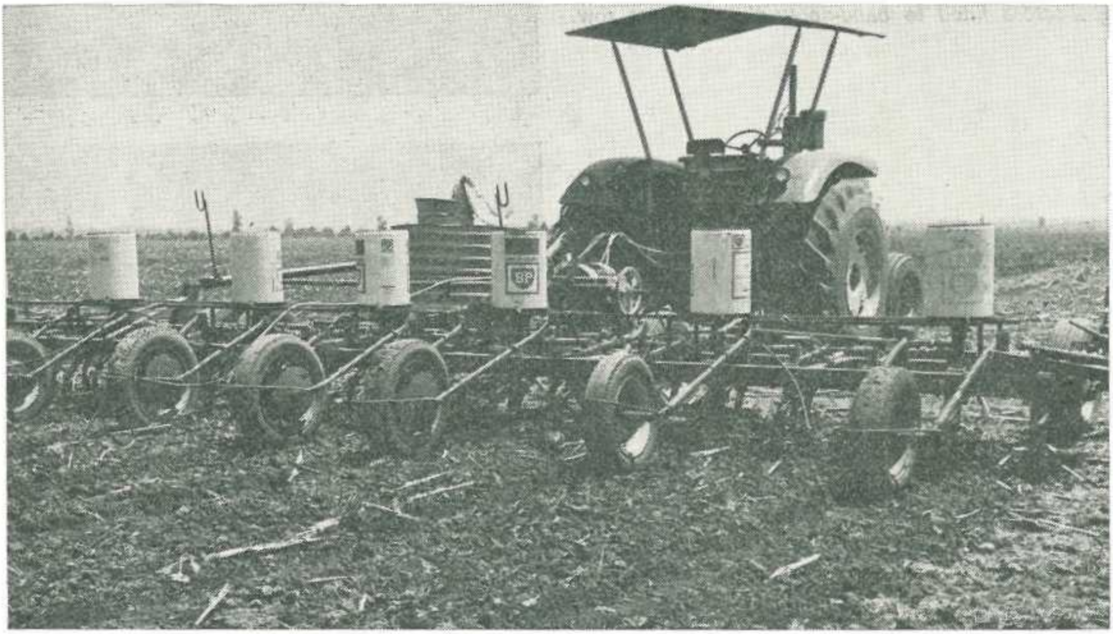
- Variability in income can be reduced by combining grain sorghum and wheat in a cropping programme. A poor crop of one will often be offset by a good yield of the other. In this way, the chance of making a loss from crop production in any one year is reduced.

- Growing winter and summer crops will spread the workload and machinery requirements. Two-thirds of the costs of cropping are those fixed costs of owning and replacing machines. Achieving good utilization of plant will increase profit by spreading these fixed costs.

- Crop rotation is another important reason for growing both winter and summer crops. Changing a paddock from one to the other every few years will aid weed control. Wild oats is just one of the troublesome weeds which can largely be kept under control in this way.

YIELDS AND PROFITS

Getting good yields is the key to profits from grain sorghum growing. Yields of 1 tonne per hectare will return profits in the vicinity of $25. Better sorghum growers are probably averaging as much as 50% higher yields. At this level, profits jump to $52 per hectare, a 100% increase.

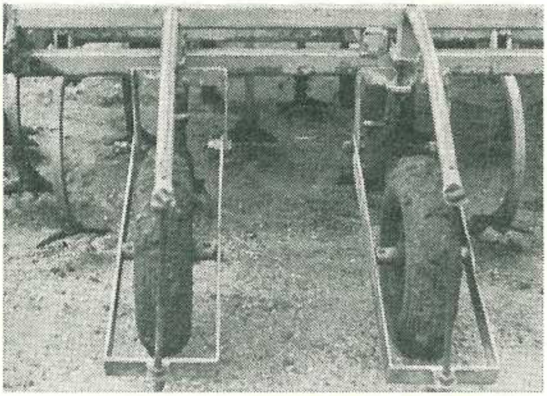


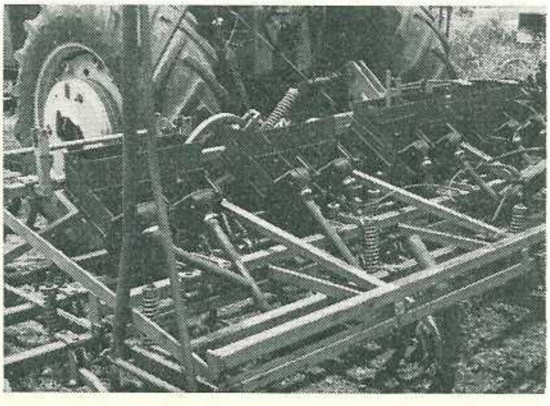
A Shearer wideline cultivator modified for sorghum planting on the Hill Brothers' property at Yelarbon. Combine seed distributors have been attached to oil drums to produce row planting units.

These home-made presswheels have herbicide applicators fitted to band-spray the sorghum row.

occur during crop growth. During these periods, the crop is dependent on stored soil moisture. If the crop runs out of moisture before rain falls, yields will suffer.

Fallowing to store as much soil moisture as possible is vital if good yields are to be achieved. Weed growth needs to be controlled and the soil kept in a good condition where it will absorb rain without sealing and losing moisture through run-off.





TOP: Presswheels can easily be fitted behind most planters to improve germination.

BOTTOM: This cultivator has been converted into a very useful sorghum planter by the addition of unit planters.

These figures are calculated on a farm price of grain sorghum of $55 per tonne. The total costs of growing grain sorghum are estimated at $30 per hectare. This consists of $10 per hectare variable costs including fuel and $20 per hectare fixed costs incurred in owning and replacing machinery.

Good yields are achieved by paying attention to the details of grain sorghum growing. In the drier areas, time of planting, varietal selection, weed control and fallowing are the major details requiring attention.

MOISTURE THE KEY

Yields of grain sorghum usually reflect the amount of moisture stored in the soil at planting. So often, dry spells of several weeks

Keeping the soil condition rough and receptive to rain is also important for erosion control. Planting in January means that the seedbed is vulnerable to storm rains in November and December. To overcome problems if the seedbed is still rough at planting, presswheels are a very worthwhile investment. When the soil is rough or dry, presswheels can aid considerably in getting a good strike which is so important for high grain sorghum yields.

WHEN TO PLANT

Grain sorghum grown in the drier areas of Queensland is mostly planted in December and January. The risk of damage by heatwaves to sorghum at flowering is the main reason for delaying planting until this time. Rainfall distribution and variability are also important.

HEATWAVES

Hot weather at the flowering stage can cause a reduction in the amount of grain set by grain sorghum. Heatwaves, severe enough to cause damage, consist of 3 or more consecutive days with temperatures in excess of 38°C.

Heatwaves are more frequent and severe in the drier grain sorghum growing districts of the State. They are particularly significant in the grain sorghum areas of the Western Downs and Maranoa.

The incidence of heatwaves in the region is highest during the months of December and January. Table 1 shows that crops planted in October and November will flower during the worst heatwave period. This prevents safe planting until late December.

RAINFALL AND EVAPORATION

Rainfall increases in both amount and reliability during the months of January and February throughout most grain sorghum growing areas. Rainfall during the flowering period is important for good yields. As the planting date is delayed in January, the chances of receiving good rain at flowering are reduced.

A lower evaporation rate in late summer tends to balance the tapering-off in rainfall. During the cooler weather, the grain sorghum crop will use less soil moisture.

Rainfall and heatwave patterns combine to produce an optimum planting period comprising the last week in December and the first 2 weeks in January.

At Roma, planting would have been possible during this period in 27 years out of the 40 years between 1921 and 1960. In another 10 of those years, planting rains occurred in the 3 weeks following the second week of January, leaving only 3 years in those 40 without planting rain.

MIDGE

Damage from midge insects at flowering is a major factor influencing the planting time of grain sorghum on the Darling Downs. As the season progresses, midge numbers build-up rapidly and cause large yield reductions in late-planted crops.

The main threat is to grain sorghum crops which are planted several weeks after others in the same locality. This means that if grain sorghum planting does not begin until January in western districts, then it is likely that only the plantings from late January onwards will be badly affected by midge.

Exceptions to this will occur if other hosts for the midge exist near the crop. Sorghum almum is the main host to watch and a build-up of midge could occur on this plant in early summer.

EARLY PLANTINGS

Early planting of grain sorghum is sometimes contemplated if the wheat season has been poor and some areas have not been planted. The earliest time is mid September when the risk of frost has almost passed and soil temperatures have risen to give good germination.

If plantings in early October are being considered, medium to early maturing varieties should be used to reduce the risk of heatwave damage. This risk increases considerably in plantings made later than early October.

The short period during late September and early October is not a good one for planting rains. At Roma, planting rain is likely to fall during this time only 10 years in 40. October and November rainfall is notoriously erratic and drought periods are common.

TABLE 1

RAINFALL AND HEATWAVE INCIDENCE AT ROMA

Planting Time	Total Rainfall for 3 months mm	Total Evaporation	Rainfall during Month of Flowering mm	% Chance of Heatwave in Month of Flowering
Mid September	150	654	55	17
Mid October	187	745	70	40
Mid November	214	754	81	47
Mid December	220	688	71	20
Mid January	194	580	66	3
Mid February	150	473	32	..

Source: Bureau of Meteorology

VARIETIES

A large number of grain sorghum varieties are available commercially. All varieties can give very high yields, far in excess of average for the Near South-west region and it is on other characters which emphasis needs to be placed. Varieties vary in maturity; some have better resistance to lodging and others more tolerance of stress conditions.

MATURITY

Grain sorghum varieties differ considerably in the time they take to mature. This is in turn affected by climatic factors and the time they are planted. Grain sorghum planted in early spring will take at least 2 weeks longer to mature than if planted in mid-summer.

The problem in trying to compare varieties of different maturities is that the timing of rainfall in any particular season will determine which will be the best. In a short season with a dry finish, the faster maturing varieties may yield well. Where rainfall is interspaced with long dry spells, the longer maturing varieties are better suited.

It is difficult to suggest that one maturity class is better than another provided very fast and very late maturing varieties are avoided. The very fast maturing varieties and the very late maturing types have not yielded as well in the Near South-west region as the medium to late types. Lodging varies with maturity and early maturing types are more prone to this problem.

A cultivator tine fitted with a planting shoe.

Planting time can influence the varietal selection. Late maturing types are preferred in December while medium to early varieties would be a better choice towards the end of January.

The selection of varieties of different maturities should be considered with midge problems in mind. Planting varieties with different flowering times together can allow midge to build-up and cause damage to the later flowering variety.

Different maturities can also be used to advantage in midge control. If, for example, planting was interrupted for a week by wet weather, it could be worthwhile to continue with a variety which flowers a week earlier.

LODGING

Lodging usually follows moisture stress in the later stages of crop growth. The grain sorghum plant may cease growth before the grain is ripe and some varieties can lodge easily.

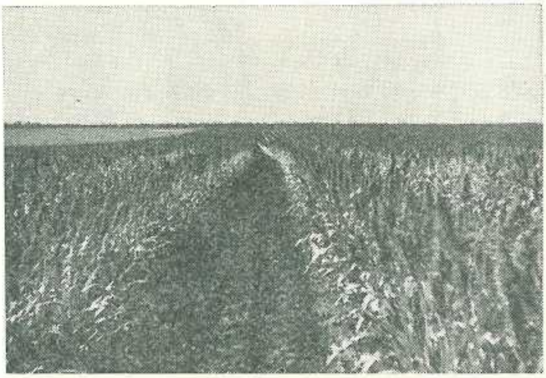
With a January planting, the conditions for lodging are present in most years. The dry weather which is often experienced after March usually ensures a dry finish to the grain sorghum crop. The problem is aggravated by the length of time the crop stands in the field until the grain is dry enough to harvest. Cool weather in April and May can lengthen this time considerably.

Resistance to lodging is one of the main features on which varieties are selected for drier areas. Several grain sorghum varieties stand well under conditions of moisture stress. These are listed in our recommendations.

Lodging can also be caused by factors other than moisture stress. Fungus rots can cause grain sorghum plants to weaken and lodge. This problem is usually associated with wet weather close to harvest and all varieties can be affected.

VARIETY SUGGESTIONS

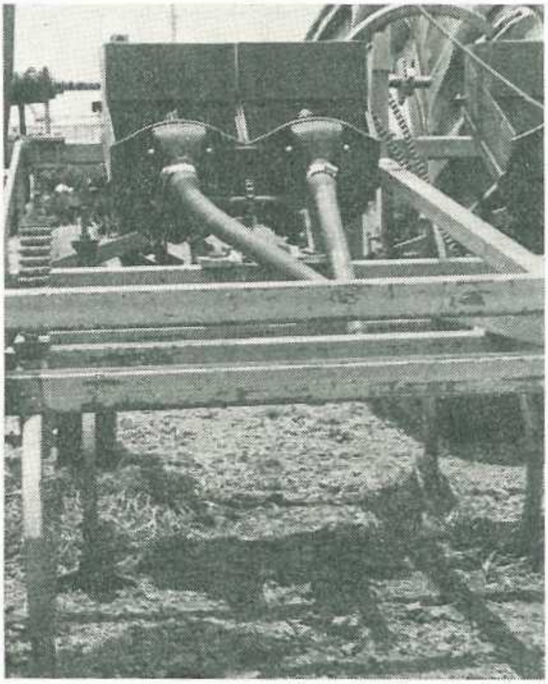
Over the past few years, the variety Q5161 has proved to be a consistently good performer in the drier grain sorghum areas. Over the past five years in trials at Roma, it has outyielded the old favourite Alpha by 48%. Sunlover is a variety closely related to Q5161 and has a similar performance.



This crop of Sunlover grain sorghum planted in wide twin rows on the property of Mr. J. McWilliam in the Roma district yielded 2 tonnes per hectare.

Grain sorghum in a row spacing trial at Roma. These are twin rows 35 cm apart with 143 cm between the rows. The variety is E 57.

Inter-row cultivation is a cheap, effective way of controlling weeds in grain sorghum.



For inter-row cultivation, the planting tines and adjacent cultivating tines can be removed. This cultivator is set-up for twin rows.

Excellent standability has given E57 a good reputation over many years. Its yield performance is considerably better than Alpha but not quite as good as some of the newer hybrids.

Dorado and the closely related variety TE Y101 have given good yields in recent years. Lodging resistance, however, is not quite as good as the other varieties mentioned.

Pride (formerly PMI) has yielded well in the last two seasons and stands-up well.

TABLE 2

SORGHUM VARIETIES FOR DRIER AREAS

Variety	Maturity	Lodging Resistance
Q5161	Medium—slow	Good
Sunlover ..	Medium—slow	Good
Dekalb E57 ..	Medium—slow	Good
Dorado	Medium—slow	Above average
TE Y101 ..	Medium—slow	Above average
Pride	Medium	Above average
Dorado E ..	Medium—quick	Above average
Goldrush ..	Medium—quick	Above average

Dorado E and Goldrush are two earlier maturing varieties which could have a place in future grain sorghum plantings. They can both do well under dry conditions and are above average in lodging resistance.

WEEDS—WIDE ROWS

Weeds use moisture and cause serious losses of grain yield. Growing grain sorghum in narrow rows helps to smother weeds but usually this is not completely effective. In most years, rain falls too soon after planting for sorghum to suppress weeds. In these years, weed control is vital for good yields.

Cultivation and chemicals can be used to control weeds. The choice of these depends upon the weed problem, available machinery and the cost of control.

INTER-ROW CULTIVATION

Inter-row cultivation of weeds is the cheapest method. The gains in yield from a single cultivation a month or so after planting can return many times the cost. Occasionally, two cultivations might be required for good weed control.

Cultivation has the advantage that all weeds are controlled and it can be performed as required. On the other hand, weather problems can sometimes hold-up cultivation and chemical control may be necessary.

Planting machines can be used for inter-row cultivation. The planting tine and the tine on either side are removed for weeding. On most combine planters, this leaves a gap of 30 cm. This is wide enough to control most of the weeds.

A wide range of machines are being used by grain sorghum growers for inter-row weeding. Linkage toolbars or cultivators are the most precise but trailing cultivators can be used. At Roma, one grower has been using a 7 m trailing cultivator with good results.

CHEMICAL WEED CONTROL

If planting in wide rows for inter-row cultivation has not been carried out then chemicals can be used. Even if cultivation is available, chemical control can sometimes pay in spraying weeds in the grain sorghum row where cultivation cannot reach.

Several different herbicides can be used. The choice of herbicide and timing of application will depend mainly on the weed problem expected.

Annual grasses

Annual grass weeds such as barnyard grass and Urochloa (liverseed grass) are common problems in sorghum crops. They can have a severe effect on yields if not controlled.

The chemical atrazine applied at planting can give pre-emergent control of most annual grasses. Unfortunately, Urochloa is one which is not fully controlled. Application rates of 3 to 4 kilograms per hectare of 80% product costing up to $20 per hectare are required. This outlay is not usually a proposition when it is applied before the extent of the problem is evident. Band spraying grain sorghum rows using less than one-third of this amount could be considered where a large grass problem is expected.

Atrazine is much less effective against grasses when used as a post-emergent spray. However, with the exception of Urochloa, very small grass plants with three leaves or fewer can be killed.

Broad-leaf weeds

Many broad-leaved weeds occur regularly in grain sorghum crops. Thornapple, mintweed and pigweed are some of the most common weeds.

2,4-D amine

2,4-D amine is the cheapest chemical for post-emergent use. It will control most weeds except Datura or thornapple.

Grain sorghum should be sprayed with 2,4-D at the most tolerant stage, when the plants are between 10 and 25 cm high with secondary roots developed. Under rapid growing conditions, this period may only be a couple of weeks.

The recommended rate of application, which should not be exceeded, is 1 100 ml of 50% product per hectare. Weeds such as Noogoora burr, mintweed, speedy weed and tar vine can be controlled with 2,4-D amine. Best results are achieved when weeds are small and actively growing.

Tordon 50-D

Tordon 50-D can be used to give control of thornapple. Normal recommendations give 1 400 ml per hectare as the amount of Tordon 50-D to use for thornapple control. This rate will provide residual control against further germinations of thornapple. This amount is quite expensive (approx. $8 per hectare) and some grain sorghum growers have achieved short term control with half this rate.

Application of Tordon 50-D should be restricted to the same growth stages as for 2,4-D.

(Tordon 50-D is the trade name of Dow Chemical (Aust.) Ltd.)

Dicamba

This herbicide known by the trade names, Banex and Banvel and Lane Dicamba, can give control of mintweed. Dicamba has been effective in most cases against thornapple but requires mixing with 2,4-D for control of some other broad-leaf weeds.

Band-spraying the sorghum row with atrazine has been effective in controlling Urochloa. The inter-row will soon be cultivated.

The timing of application must be the same as for 2,4-D. More experience is needed with this chemical in the Near South-west region before its full uses and limitations are known in this environment.

Atrazine

Atrazine can give good control of most annual broad-leaf weeds. In commercial situations, application rates as low as 1·4 kg of 80% product per hectare have been found to give short term control of most weeds at a cost of approximately $6 per hectare.

Atrazine has a number of advantages over 2,4-D and Tordon 50-D for post-emergent weed control. In some cases, these can outweigh any cost advantage 2,4-D might have.

The tolerance of grain sorghum to post-emergence application of atrazine is probably greater than alternative herbicides giving greater safety against damage to the crop.

Atrazine can be applied earlier and better weed control will result if the weeds are sprayed while small.

SPRAY DRIFT

Herbicide spray drift can be a problem particularly with 2,4-D amine 50% and Tordon 50-D. Susceptible crops such as soybeans, sunflowers, cotton, cowpeas and home gardens can be seriously affected by this spray drift. Atrazine is less likely to cause spray drift problems.

Grain sorghum growers should take every precaution to minimize damage to adjoining crops from herbicide spray drift.

WIDE ROW SPACINGS

The use of row spacings wider than 35 cm is considered mainly to allow weed control by inter-row cultivation. It has been suggested that wide row grain sorghum will use moisture more efficiently and give better yields in drier years. While there has been some evidence to support this, trials carried out in Queensland have shown little or no difference in yield.

The results of three trials in the Roma district in 1976 have shown no difference in yields of grain sorghum planted in different row spacings up to 2 m. Although the wide rows produced less plant material, they did not yield better from the expected reduction in moisture use.

The results available suggest that at yield levels of 2.5 tonnes per hectare no yield disadvantage is shown by planting sorghum in 1 m rows or 2 m twin rows. More trial work is needed to confirm or refute slight yields depressions in 2 m single rows.

In these drier areas, with a large flexibility of row spacings, other factors become important.

- **Ease of cultivation** is much greater with wide rows. This is particularly so if large tractors with wide tyres, trailing implements and sharp corners in rows following the contour are present.
- **Uniformity of flowering** has been observed to be improved by wide rows. This is due mainly to a marked reduction in tillering. Reducing the flowering period by several days may mean either reduced midge damage or one less spraying is required.
- **Fertilizer placement.** Efficiency is highest when fertilizers are placed in concentrated bands. Placement in relation to the row is also of interest. Phosphate close to the row and nitrogen between rows may maximise the response of grain sorghum to small amounts of fertilizers containing these elements.
- **Weed control.** Where weed problems are anticipated, atrazine can be used as a band spray over the row. The wider the row spacing, the smaller the cost of this treatment per hectare.
- **Erosion risks.** Erosion potential will be increased with wide row sorghum. This will be affected by planting time. Most of the erosion potential of summer rain has passed by mid February, the time when January-planted crops start to provide soil cover. The effect of wide rows on erosion with crops planted at this time will therefore be quite small.

With these considerations in mind, there are two main alternatives for row-cropping grain sorghum. The first is planting in single rows of 90 to 105 cm to suit tractor wheel spacings. The second is twin row sorghum with two rows 18–45 cm apart and up to 2 m between the twin rows.

Pastures in basaltic uplands—

their use and management

by R. GANNON, Beef Cattle Husbandry Branch and
J. HINDS, Dairy Field Services.

THE basaltic uplands on the Western Darling Downs consist of both scrub and forest soils. These lands are fertile and capable of producing more fodder with introduced pasture. In this article, the authors discuss the success of a dairy farmer and graziers turning-off vealers and yearlings. The principles underlying development and maintenance of pastures on these soils are also described.

Let us look at three situations in the area where improved pastures make major contributions to the feed programmes. The views expressed are those of the stock owners.

Messrs. R. V. and N. J. Blanck operate a 192 hectare dairy farm in the Sunnyvale area. An intensive piggery is run in conjunction with the dairy.

Beginning with a C.E.S.G. demonstration area in 1965, Bob and his wife built up to an area of 82 hectares of improved pasture. They exhausted their full entitlement under the Dairy Pasture Subsidy Scheme.

Supplementary feed at 4·5 kg of grain plus 4 oz. of urea per cow per day is supplied.

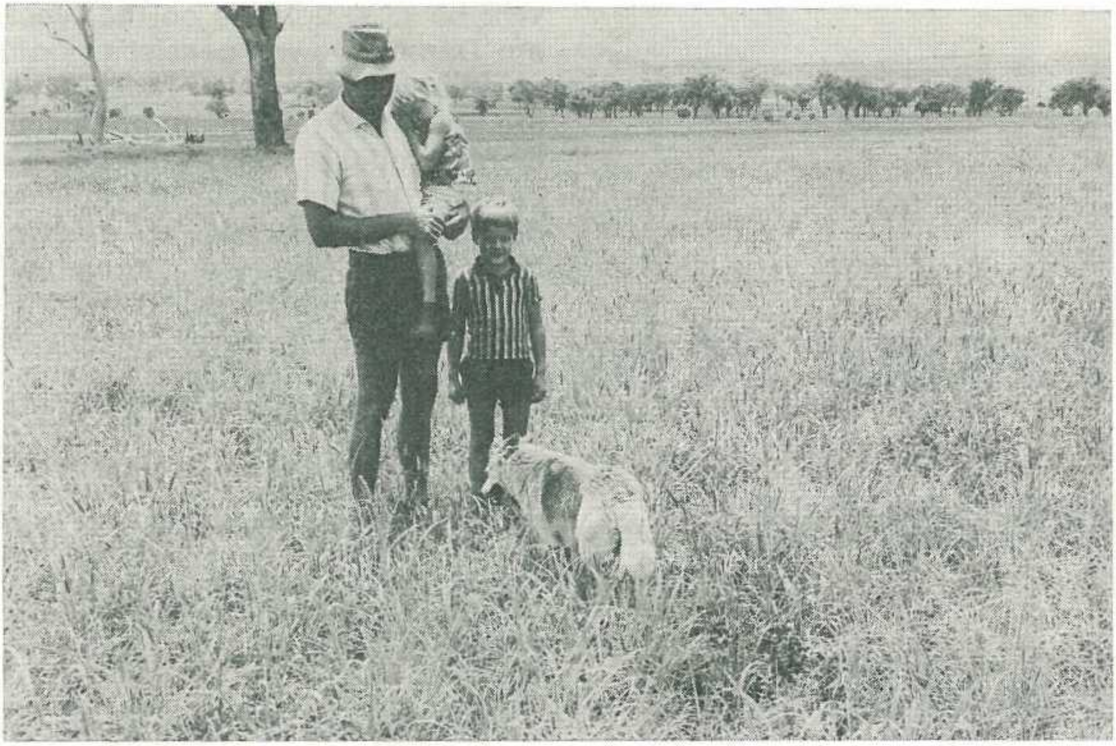
In one production recording year, a total of 80 dairy cows averaged 145 kg butterfat per cow per lactation. This is better than the average production per cow for recorded herds for the Darling Downs region.

Bob estimates that 65% to 70% of roughage used on the farm is derived from improved pastures. Green panic and lucerne are the only species used.

Oats and barley are planted each winter. The oats is for winter fodder while, in favourable winters, the barley is harvested for grain.

Summer fodder crops are not planted. Grain crops are planted and harvested for grain in favourable years. If the summer remains unfavourable, stock graze off the failed grain crops.

Carrying capacity is 130 head comprising dairy cows, replacement heifers and younger heifers.



Mr. Kevin Berwick, "Errol Park", Bell and his two children standing in a stand of Gayndah buffel coming into seed head for the first time. Mountain coolibah typical of the area is seen in the background.

Bob says that improved pastures respond quickly to rain. Stand-over improved pastures are far superior to stand-over native pastures. Besides improved pastures can cope with mint and other weeds so prevalent in the area.

Mr. Col Hopper, of Porters Gap, is a beef producer specialising in vealer turn-off.

On his property an area of 300 hectares has been planted to Rhodes grass, green panic and Numbank buffel.

Cropping extends to winter oats and sweet sorghum for the autumn period.

Col rotates stock through small paddocks. He reserves a paddock for weaners and uses some stand-over pastures.

Comparing native pastures with improved pastures, Col finds stocking rates increase from 1–3·5 hectares for native pastures, to 1–1·5 hectares for improved pastures. Under similar management, vealers on native pastures dress 140 kg while vealers from improved pastures have a dressed weight of 180 kg.

In the Porters Gap area, when moisture is available, Numbank buffel will provide limited green feed during winter months.

Mr. John Kirkwood owns a 720 hectare property in the Cooranga North area. Green panic and snail clover have been planted on 120 hectares. Beef production is the only enterprise with turnoff aimed especially at fat 12–15 month old animals.

Stocking rates are estimated at 1–3·5 hectares for native pastures and 1–2 hectares for improved pastures. Weight gains are 1 kg per day from August to April from improved pastures.

John uses a grazing system under which dry cows follow cows and calves or young, fattening animals. He does not believe in grazing pastures below a height of 15 cm.

Previously, crops were winter oats and sweet sorghum in the summer. As the area of improved pastures is increased, John proposes to dispense with summer cropping.

John made the following points: Rhodes grass will not persist in the area. Burning of pastures is not tolerated. The use of fertilizers is not considered an economical undertaking.

Little is known of the productivity of pasture mixtures in the area. However, the foregoing does demonstrate the usefulness of improved pastures in feed programmes. Sown pastures are becoming increasingly important in animal production. On most properties their main role in addition to producing lush feed in summer will be to provide good quality roughage during the winter-spring period. This will support cropping programmes by filling in feed gaps and supplying the needs of special classes of beef cattle and milking cows. Further integration of sown pastures and fodder crops to fulfil animal requirements can be expected throughout the basaltic uplands.

The area

The basaltic uplands of the Western Downs extend as foothills of varying width to the Bunya Mountains. In the Wambo Shire they cover some 60 700 hectares and extend into shires to the east. The uplands are a fertile region and their agricultural limitations are chiefly of a physical nature. For example, steepness and outcrops of basalt. The area is classified into two broad soil types—

This green panic pasture was established as a C.E.S.G. demonstration 9 years ago by Messrs. R. V. and N. J. Blanck, Sunnyvale, Bell. The pasture has been grazed heavily and stock removed one week. Some stone is evident.

(a) Basaltic Upland Scrub.

(b) Basaltic Upland Forest.

There are, however, several different soil types within these areas. Broadly, these are the dark heavy soils and lighter red soils.

Both areas are given over to mixed farming, with beef and grain of equal importance in the scrub and beef the major income earner in the forest land. Some dairying is carried on in the forest areas but is of more importance in the scrub areas.

Grain and fodder crops are restricted to the lower areas but some cultivation is carried out on the slopes. The upland or high areas generally are restricted to pastures and hence livestock production.

Scrub properties are smaller, but this is changing to some extent as properties amalgamate. In the first areas, pastures cover extensive areas and properties are usually larger. Size of scrub properties varies from 160 hectares to 600 hectares. In the forest, the range is from 240 hectares to 2 400 hectares.

The average annual rainfall is 104 mm with a seasonal distribution of 2:1 summer to winter. In the most northern areas in the mountains the average annual rainfall extends to 120 mm. The accepted period for frosts is April–September with June, July and August the most prevalent months.

The following soils map of the Wambo Shire serves also as a locality sketch. Basaltic Upland Scrub are predominantly reddish to brown soils with some black soils. The vegetation is mainly softwood scrub characterized by bottle trees. Cypress intrusions occur. Basaltic uplands forest soils are largely black with some reddish to brown soils. The vegetation typical to the area is mountain coolibah.

Pasture establishment presents greater difficulties in forest soils in comparison to scrub soils. This is because of the cracking and self mulching nature of the black soils.

Both areas are prone to basalt outcrops.

Improved pastures

Improved pastures are grown in these areas but, as beef and dairy are major income earners, larger areas of improved pastures than already exist can be expected.

The scrub areas do contain fair acreages of improved pastures, the main species being green panic, buffels, Rhodes grass and some lucerne. This is not surprising as the native species are spear grass, wire grass, some blue grasses and annuals. In both scrub and forest, Rhodes grass was planted following initial development. Some of these areas of Rhodes grass stands have since deteriorated. It is probably a combination decline in scrub fertility and droughts in the 1960's which have been the cause of the deterioration. The scrub areas are moving back into improved pastures and at present there are some good stands of green panic, Rhodes and buffel. Some of these are on both the heavy and lighter soils.

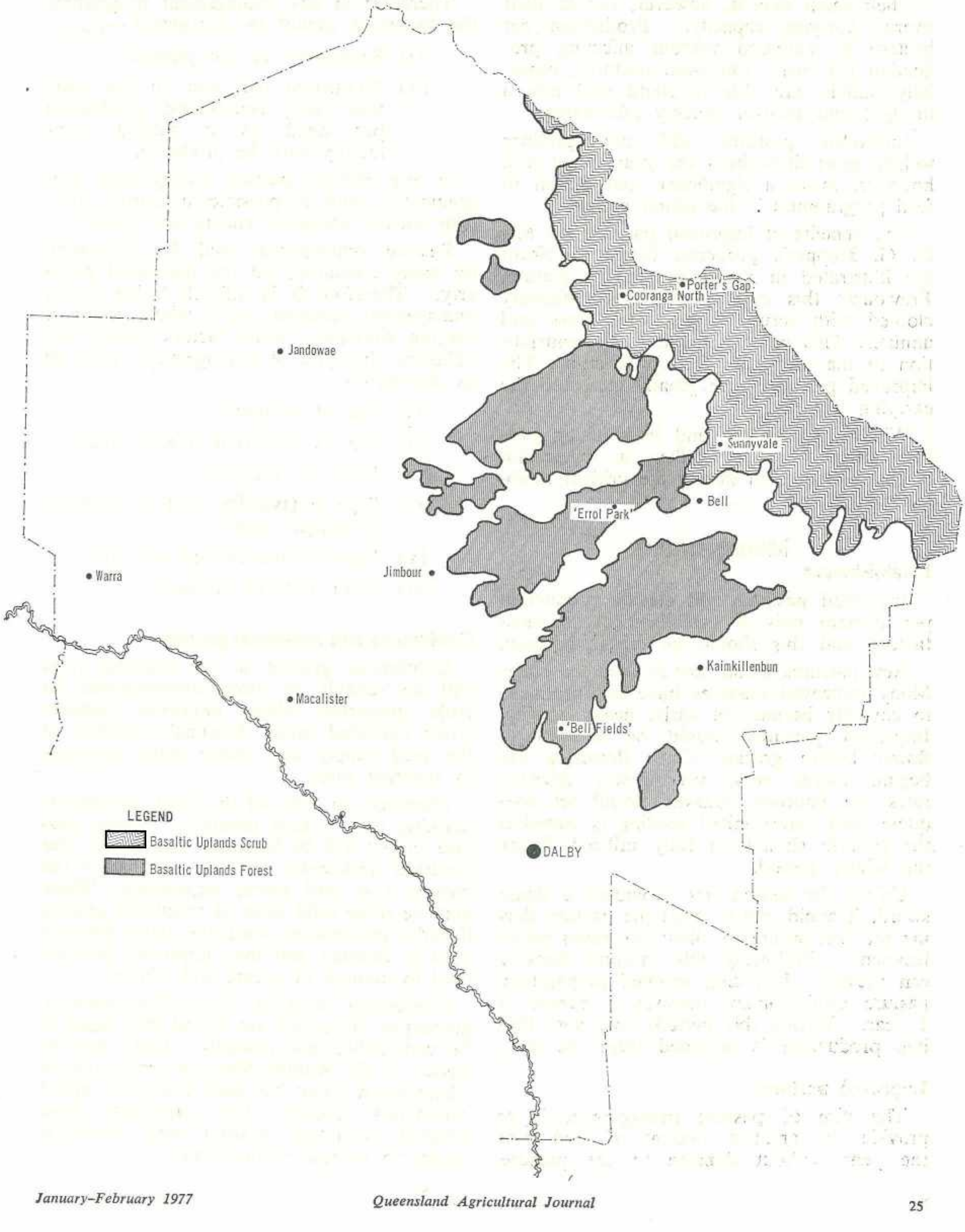
On the forest areas where native grasses are of better quality, the areas of improved pastures are more limited. The areas on the forest soils which have been planted to improved pastures, mainly green panic, are the lighter soils such as at "Bellfields" on the Bell road.

The heavy, black basaltic upland forest soils support little improved pasture. Producers with experience on these heavy soils mostly agree that the common improved grasses are difficult to establish and growth is not satisfactory. Perhaps *Panicum coloratum* spp. would perform more satisfactorily on these heavy soils.

Value of improved pastures

Most people know the limitations of native pastures especially the lower quality species. Native pastures grow rapidly when temperatures are high and moisture adequate then decline almost as rapidly in quality and palatability. They provide stock with a submaintenance ration from May to September. There are exceptions when winter/spring rains are above average and quality annual herbage growth is produced.

The quality of improved pastures is at least equal to, and mostly better than, native species during the winter and spring. Hayed off, improved pastures are of better quality and palatability. Improved pastures will respond to rains in winter and light falls in spring.


Porter's Gap
Cooranga North
Jandowae
Sunnyvale
Bell
'Errol Park'
Jimbour
Warra
Kaimkillenbun
Macalister
'Bell Fields'
LEGEND
Basaltic Uplands Scrub
Basaltic Uplands Forest
DALBY

Their main benefit, however, lies in their overall carrying capacity. Production per hectare is increased without affecting production per head. Improved pastures, especially buffels, are able to stand well into a drought and recover quickly afterwards.

Improved pastures will not produce weight gains throughout the year. They will, however, make a significant contribution to feed programmes in the winter/spring.

The benefits of improved pastures on Mr. D. G. Hopper's property, Cooranga North are illustrated in the accompanying picture. Previously this country was predominantly clothed with scrub bushes, wire grass and annuals. This country made small contribution to the property's feed programme. The improved pastures have greatly increased the carrying capacity.

Windrowing timber and establishing pasture strips were undertaken as protection against soil erosion during the critical establishment period.

Management

Establishment

Improved pastures will elevate production per hectare only if establishment is satisfactory and this should be the initial aim.

New pastures *should not be used too early*. Many improved pastures have not produced to capacity because of early, heavy grazing. Improved pastures should be allowed to flower before grazing. Once flowering has begun, unless very, very heavy stocking rates are imposed, grasses should set adequate seed. Once initial seeding is complete the pasture should be fully utilized during the winter period.

Unless the season has promoted a dense sward, it could pay to spell the pasture during the first spring to allow maximum establishment. Following this, normal stocking can prevail. Including seedbed preparation, pasture establishment involves a period of 1 year. During this period, only very limited production is obtained from the area.

Improved pastures

The aim of pasture management is to provide the greatest amount of feed over the year without damage to the pasture.

Therefore in any management programme the following should be considered:—

(i) Persistency of the pasture

(ii) Production per acre, at the same time not overlooking production per head as a salable commodity must be produced.

In any efficient pasture management programme, it must be possible to control stock. This means adequate fencing and water.

Pasture management will be influenced by many conditions on the individual property. Therefore it is difficult trying to set management standards for a whole group of varying situations. Some factors which may influence the type of management could be as follows:—

(i) Size of property

(ii) Size of improved pasture area

(iii) Type of enterprise

(iv) Type of pasture, that is mixtures or straight stands

(v) Type of country and soil type

(vi) Other fodders produced.

Continuous and rotational grazing

Continuous grazing at set stocking rates will be suitable in most circumstances on large properties where improved pastures cover extended areas. Seasonal variation in the feed supply may cause some variation in stocking rates.

However, on some of the larger properties, stocking rate is kept constant. There, pasture supply will be balanced with stock. The producer anticipates his feed supply for the coming year and stocks accordingly. There may be some mild form of rotational grazing if native pastures are used; the native pastures used in summer and then improved pastures used in autumn or spring and winter.

Continuous stocking does allow selective grazing so if species are mixed they need to be compatible and palatable. There are instances in the Wambo Shire on scrub country where green panic has been eaten out under continuous grazing. The producers have adopted rotational grazing with beneficial results in pasture maintenance.

When lucerne is included in grass legume mixtures, rotational grazing will form the basis of management to allow survival of the lucerne. Lucerne can be grazed out of a pasture mixture in 12 months under continuous grazing. Lucerne for maximum life as a pasture component needs short, intensive grazing with a recovery period of several weeks.

It must be understood that rotational grazing is clearly distinguished from subdivision as such. Subdivision of the pasture land on a property into an adequate number of paddocks is necessary for ease of management. Pasture maintenance, parasite control, separating classes of stock, seed production, fodder conservation and many other parts of management demand subdivision.

Up to a point, the more paddocks the better. However, there is no justification for imposing a strict rotational system of grazing instead of set stocking. This applies particularly under Queensland conditions of feasts and famines. Most research work indicates insignificant differences in production per acre between rotational and continuous grazing at similar stocking rates. Some experimental evidence, however, does show that at very high stocking rates a rotational system results in more conversion of the available forage to livestock production. There may be some pasture rationing and increased production per acre but production per head may be sacrificed. Depending on the area and actual use of the pasture, management for maximum utilization may be unwise in variable environments.

Other systems

Other systems of management are available for the more intensified situations.

Green panic established and maintained in a stony situation. Outcrops of basalt occur frequently. This pasture is 9 years old.

Deferred grazing may be used when the pasture area is small or when a particular group of animals may need preferential treatment. Where areas of improved pasture are small, the grazing may be deferred to a specific time. Improved pastures can generally be deferred, for example for late autumn or early winter feed because of their higher quality when hayed off compared with native pastures. Again, deferred grazing of an area may be used for a specific line of animals, such as weaners, to provide preferential feed treatment. This practice of deferred grazing for various reasons is even used in the more extensive areas.

One drawback is that feed is not used when it is high in quality. However, we must look at feed over a full 12 months and plug the gaps and therefore this system has many merits.

Strip grazing is definitely applied to the more intensive situations. Greater production per acre with some deterioration in production per animal is achieved. Such a system could be used where the improved pasture area is limited or the pasture produces tremendous bulk and the producer wants to achieve as much from a limited area as possible. Frequent defoliation under intense grazing enhances the leaf to stem ratio. This simultaneously improves the digestibility of the sward.

Zero grazing offers maximum utilization per acre and lower waste. Production per head is lower. This system has little to offer as returns to extra capital outlayed may be disappointing.

Heavy stocking

The effect of heavy stocking rates on the botanical composition of the pasture varies with the species used. Buffels will withstand heavy stocking while the effect on green panic will depend on the soil type. Rhodes grass is very prone to heavy stocking especially in the dry periods and stands can deteriorate.

Renovation

The purpose of renovation is to break up root-bound pastures, loosen hard soils and destroy weeds. It is advisable to carry out tillage operations when moisture is present. Tillage can vary in intensity from lucerne to full scale ploughing. Mr. L. Skerman, at Kaimkillenbun and Mr. W. Horrocks, at Maclagan, both favour intense treatments. It appears to be the general practice to disturb the soil every 3 years.

Fertilizers

Growth responses to applications of nitrogenous fertilizers to established pastures are not in doubt. However, there is some doubt about response being of economic importance. It is conceded that, where pastures are established on old and worn out farm-land, the application of nitrogen is essential. There is little evidence to indicate that phosphate is limiting in the area.

Trials are now being conducted by Mr. L. Skerman, of Kaimkillenbun and Mr. R. Blanck, of Sunnyvale. These trials are attempting to evaluate responses to the application of 67 kg of nitrogen per hectare. Sulphate of ammonia which provides sulphur as well as nitrogen is being compared with nitram which provides nitrogen only.

Persistence

The persistence of improved pastures is often discussed. The life of pastures appears to be influenced by the standard of management. Indications are that sound management can maintain a pasture for an indefinite period. Messrs. Skerman and Horrocks own large areas of improved pastures more than 20 years old. Messrs. Blanck and Hopper have had their pastures down for more than 9 years. Over-grazing in periods of drought can result in the loss of a valuable asset in the form of improved pastures.

Using the pasture

The main economic advantage in improved pastures lies in their higher carrying capacity. A high production per acre is obtained without loss in individual animal performance and without increasing drought risk. Maximum utilization is probably unwise in this variable environment, and a compromise has to be reached between animal production per acre and provision of fodder to provide insurance against drought.

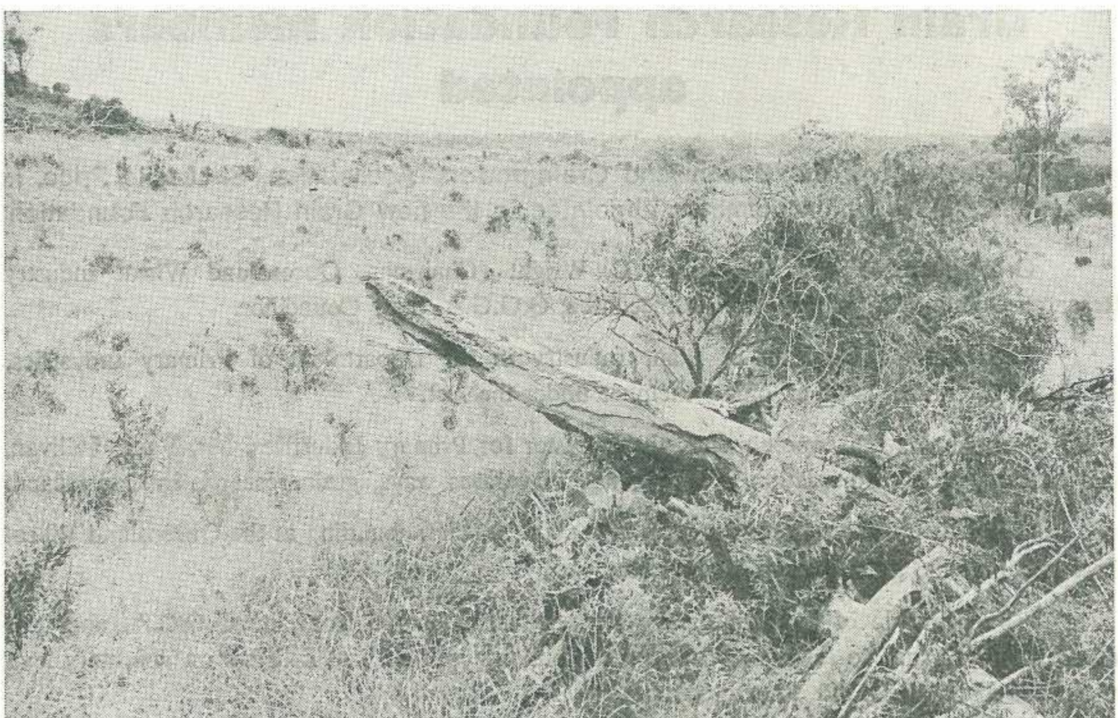
Although cropping plays an important role in animal production in the basaltic uplands, improved pastures have a major part to play. Carrying capacities are increased supplementing crop fattening or crop usage programmes. Incomes tend to stabilize.

Stocking rates

The greatest influence on the productivity of a pasture as a unit is the overall stocking rate. Unless a pasture is grossly understocked, as the stocking rate is increased the output per animal goes down. However, up to a certain point, the output of animal production per acre of pasture increases with stocking rate. In other words, the pasture unit is carrying more animals, each producing somewhat less than their maximum. The net result is that more forage is being turned into meat or milk.

The stockowner has many other herd management considerations which may influence this situation. He should keep it in mind as a fundamental yardstick in his attempt to get the greatest returns from improved pastures. He should also remember that his pasture will deteriorate if stocked past the most favourable rate.

The limit to the stocking rate is usually set by the resources of the farm to carry the herd through the leanest period of the year. That is late winter and spring.



Green panic and lucerne established 6 years ago on the property of Mr. D. G. Hooper, Cooranga North. The soft wood scrub was pushed into windrows to prevent erosion on the steep slopes. The windrows will be planted at a later date.

If he relies completely on perennial pastures, the producer has to be content with gross under-utilization. In such a case, the stock have to be balanced against the feed for the rest of the year following the wet season. The producer will under-utilize his perennial pasture during a relatively short growing season. This enables the herd to select a maintenance diet from a mass of mediocre forage during the critical months.

However, as feed programmes become more planned and improved species are planted, the alleviation of this position should result and both pasture and crop will be used more effectively.

Stocking rates on the improved pastures in the basaltic uplands at present is 1 beast to 1·2–2·0 hectares for year round grazing depending on the individual property. However, these figures are being increased as feed programmes are being planned and pastures are used at certain stages.

Pastures in feed programmes

It is unlikely that any perennial pasture in this area will give high beef or dairy production on a year-round basis. Growing crops in the hope of providing a continuous supply of fodder is often disappointing. The crux of the problem appears to be how best to use or integrate both crops and pastures—native and improved, summer crops and winter crops—to maintain a continuous supply of feed.

Areas of native pastures dominated by inferior species should be used when they are immature and growing vigorously in the summer. Areas of improved pastures can then be used in the winter and spring when they are superior in quality to such native pastures.

Grain Research Foundation members appointed

The President of the Queensland Graingrowers' Association, Sir Leslie Price, is one of three Association members appointed to the new Grain Research Foundation.

Other members are Messrs. D. C. Wright (Chairman, Queensland Wheat Industry Research Committee) and J. W. Brimblecombe, Q.G.G.A. State Councillor.

The Director, Division of Plant Industry in the Department of Primary Industries, Mr. B. L. Oxenham, is an ex officio member under the Act.

Announcing the appointments, the Minister for Primary Industries, Mr. V. B. Sullivan, said the aim of the Foundation was to assist, in various ways, grain research in Queensland.

'The first objective is construction of a plant breeders' building at the Queensland Wheat Research Institute at Toowoomba,' he said.

'The principle of establishing the Foundation emanated from the Q.G.G.A. and it is intended that finance to assist in providing the building will be provided from a voluntary levy subscribed by Queensland wheatgrowers.'

Mr. Sullivan added that the Foundation members had been appointed for three years from December 6 this year.

Milk Enzymes and Udder Infection

by B. KITCHEN, Otto Madsen Dairy Research Laboratory.

One of the major effects of bovine mastitis is to alter the gross composition of milk and so make it unsuitable for processing into such products as cheese, milk powder and butter. These gross compositional changes are well documented but changes in some of the more minor constituents are not as well known. A project to study these minor compositional changes in mastitic milk, particularly in the enzyme content of milk, is being undertaken at the Otto Madsen Dairy Research Laboratory in Brisbane. The research is being supported financially by a grant from the Australian Dairying Research Committee.

Enzymes in milk originate from either the secretory cells of the mammary gland, white blood cells or blood plasma and in many cases the amount of a particular enzyme in milk directly reflects the state of health of the udder. By routine monitoring of special enzymes in the milk of individual animals, an estimation of the level of udder infection can be obtained. Over the past 2 to 3 years, new enzymatic tests have been developed at this laboratory. They are currently being assessed in relation to their application in mastitis control.

One such enzymatic test has proved to be extremely valuable in the routine diagnosis of abnormal udder secretions. This procedure has been coined the *NAGase test,* since the enzyme measured is called *N-acetyl-β-D* glucosaminidase. This new test is rapid (80 samples per hour for one operator), simple, inexpensive ($20 for 100 tests) and it could be adapted for use as a field test. The method could also be fully automated and used exclusively as a laboratory test. The problem of age of sample is not encountered in this test, and thus in this regard it is superior to the currently used Wisconsin Mastitis Test (WMT).

Our increased knowledge of some of these minor biochemical changes in mastitic milk is helping to develop more definitive diagnostic aids for the detection of udder disorders and will ultimately be valuable in designing better control procedures for the treatment of mastitis and also in rapid detection of abnormal milk which can be channeled away from certain milk processing operations.

Wine production research

THE Australian wine industry is growing rapidly and there is every indication that this growth will continue.

Increasing national interest in wine has made Queensland producers keen to sell table wines on the open market. As a result, wine grape production has increased due to greater plantings in established grape areas and also expansion into adjacent areas. To support this industry expansion, the Department of Primary Industries started a programme of wine production research in 1969.

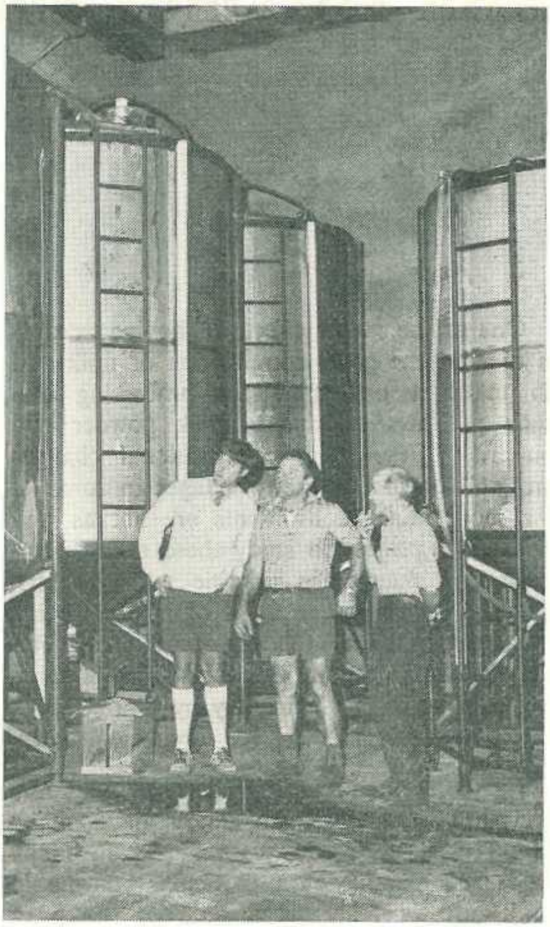
This programme is investigating the potential of areas with a twofold objective; firstly to select which wine grape varieties grow best in these areas and secondly to define the quality of wine they produce.

Until recently, the only significant commercial producer of wine in Queensland was the Romavilla Winery at Roma. Over the last few years, the Granite Belt wineries have rapidly increased production.

Wine has been made on the Granite Belt for many years in small wineries operated by families of recent European origin. These wines, which were made from table grapes, were mainly sold to a limited clientele of European migrants.

Queensland's production of wine has been growing and is now about 400 000 litres a year. However, this is less than 0·5 per cent. of the total Australian production and is far short of the amount consumed in this State.

The production of quality wines is easiest with grapes grown under the correct combination of climatic conditions. Temperature during the growing season and rainfall distribution are the most important climatic factors. Districts with cool growing seasons are best for the production of high quality table wines.



Gino Zanatta showing Jim Breinl his stainless steel fermentation tanks.

by C. WINKS and J. D. BREINL, Horticulture Branch.

ABOVE: Dennis McEvoy separating skins from wine in a pilot scale Willmes press at the Department's Hamilton laboratories.

BELOW: Calvin Winks displaying a fine crop of Shiraz grapes.

The temperatures of the areas under study can best be defined by the system of heat summation calculations devised by Professor Winkler of California. Using this system, these areas can be compared with established areas in the wine industry as shown in Table 1.

TABLE 1

HEAT SUMMATION—GROWING SEASON (BASE 10°C)

	Degree-days
Bordeaux (France)	1,328
Barossa Valley (Kapunda)	1,889
Granite Belt (Stanthorpe)	1,890
Hunter Valley (Cessnock)	2,262
Warwick	2,383
Inglewood	2,707

(Data prepared from climatic averages)

This table shows that the Granite Belt compares favourably with other centres, while Warwick is nearly as well-suited. Inglewood has a heat summation similar to the warmest regions where wine grapes are grown.

In wine grape growing, the distribution of rainfall is more important than the total rainfall. Excessive rainfall during the growing season encourages the development of fungus disease. Rainfall before harvest can cause splitting and mould growth development in fruit with consequent loss in quality.

Most wine districts in Australia have a winter rainfall pattern with dry growing seasons and harvest periods. South-east Queensland has a summer rainfall distribution as shown in Table 2.

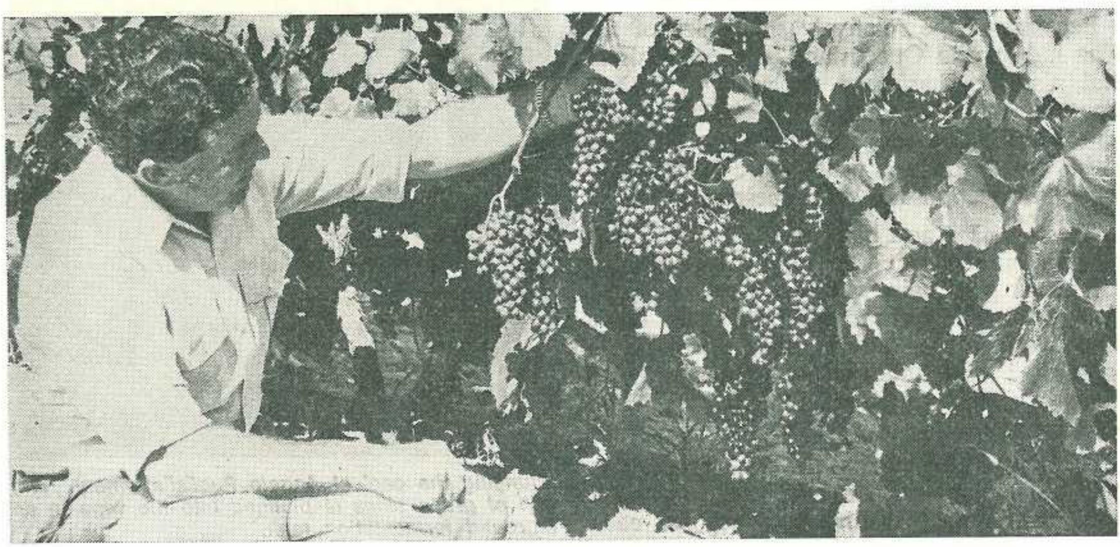


TABLE 2

RAINFALL DATA (IN MILLIMETRES)

	Winter	Summer	Harvest	Total
	(Nov. to Apr.)	(May to Oct.)	(Aug. to Oct.)	
Burgundy (France)	323	404	196	727
	(May to Oct.)	(Nov. to Apr.)	(Feb. to Apr.)	
Barossa Valley (Kapunda)	328	163	76	490
Granite Belt (Stanthorpe)	277	404	165	681
Hunter Valley (Cessnock)	290	411	211	701
Warwick	239	396	152	635
Inglewood	257	399	168	656

This rainfall distribution is not considered to be a major problem as south-east Queensland shows the same distribution pattern as the well-established Hunter Valley region. In this area there has been a good record of successful harvests over many years.

In 1969, only a limited number of wine grape varieties was available and the quality of these was suspect because of severe infection with grapevine leafroll virus. Since then, an extensive range of varieties has been introduced, including the best virus-free clones available in Australia.

Trial work was commenced in 1971 with plantings at the Granite Belt Horticultural Research Station at Applethorpe and the Inglewood Field Station. In the following year, a trial was planted in a commercial vineyard at Ballandean on the Granite Belt. A further trial was planted in the Warwick area in 1973.

Because of the relatively small size of the wine industry in Queensland, the emphasis in trial plantings has been on varieties with a reputation for producing premium quality wines. Some varieties used for the production of bulk and fortified wines were included to define production levels in these varieties.

The stage has now been reached where some information is available on two trials. Cropping figures for the main varieties (see Table 3) show yields and commercial production levels which compare favourably with figures from established interstate areas. Further yield increases can be anticipated as vines reach full development.

The second objective of the wine production research, that of wine quality evaluation and definition of wine quality potential for each district under study, is being conducted in Brisbane at the Sandy Trout Food Preservation Research Laboratory, Hamilton. Here, grapes from trial plots are processed into wine and the quality of the wine is tested.

'Plunging the cap' at Angelo Puglisi's winery. The cap of grape skins is plunged into the wine in an inground fermentation tank.

TABLE 3

CROPPING DATA YIELDS

—	1976 Crop		Total Crop (3 seasons)	
	Av. Weight per vine	Tonnes per hectare	Av. Weight per vine	Tonnes per hectares
	kg		kg	
Granite Belt Horticultural Research Station—				
Cabernet Sauvignon	4·9	8·5	8·8	15·2
Shiraz	5·8	10·0	8·7	15·0
Pinot Noir	3·6	6·3	4·2	7·3
Rhine Riesling	9·3	16·1	14·6	25·3
Semillon	4·9	8·5	10·8	18·6
Sauvignon Blanc	0·3	0·5	0·6	1·1
Inglewood Field Station				
Cabernet Sauvignon	10·4	18·0	14·6	25·4
Shiraz	10·9	18·9	15·5	26·8
Pinot Noir	5·6	9·7	8·5	14·7
Mataro	12·8	22·2	18·9	32·8
Rhine Riesling	7·7	12·4	12·0	20·8
Semillon	6·5	11·1	10·6	18·3
Sauvignon Blanc	7·8	13·6	10·6	18·4
Frontignan	10·2	17·6	13·7	23·8

As grapes mature, their sugar content increases and their acidity decreases. For good quality wine, grapes should be harvested when sugar levels are about 20% for white grapes and 22% for black grapes. Their acid levels should fall within the range of 0·6 to 1·0%. Wines made from grapes with sugar and acid levels different from these values cannot indicate the quality potential of the variety.

The past two seasons were abnormally wet and this has caused problems in susceptible varieties. Premature quality deterioration combined with delayed maturation made it necessary to harvest some varieties before they reached desirable sugar and acid levels. No winemaking was attempted with the most affected varieties.

In general, black-fruited varieties fared better than white-fruited varieties and late maturity varieties were better than early varieties. Rain caused damage in both areas, but crops at Inglewood were less affected than those on the Granite Belt. However, it would be unwise to judge the performance of wine grapes on these abnormal seasons when table grape harvests have been favourable for many years.

Since 1975, useful quantities of grapes for winemaking research have been available from trial plantings. Before this, work was directed towards evaluating small scale winemaking techniques. Now the grapes are processed using modern pilot scale wine-making equipment.

Once the wine has been stabilised and clarified, it is stored in bottles until needed for judging.

As wine is a complex beverage, experienced judges are needed to judge its quality. Trials are underway to select judges from staff at the S.T.F.P.R.L. These judges and local winemakers will assess the quality of the wines. They will decide which varieties are most suited to each area.

Officers of the Department are working closely with winemakers on the Granite Belt to pass on the winemaking technology available from wine production research. With the increased usage of wine grapes and the adoption of modern techniques there has been an impressive improvement in wine quality.

Granite Belt wines are now entered in the Royal Brisbane Show. Over the past few years, four winemakers have been awarded medals including several gold medals.

Muscle abscesses . . . a serious problem

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

A growing number of deep seated abscesses in primal cuts has caused concern in Queensland meatworks. The discoveries are normally made during the boning and slicing process and have involved the rump, loin, striploin and silverside, topside and blade.

Similar abscesses have also been reported in slaughter pigs.

Cause

It appears from specimens forwarded for laboratory examination, that the main cause is oil-based injections. Brucellosis strain 45/20 and vibriosis vaccinations are suspected.

Blackleg and tick fever vaccinations and treatment for ephemeral fever (especially slaughter bulls) have been traced in other cases. Dirty needles have been found to cause abscesses as has improper spaying techniques.

There is no question that these vaccines are needed for the health of stock so the argument becomes one of how and where to place the injection.

In Queensland, vaccinations with vibrio and strain 45/20 have been limited officially since 1973 to subcutaneous injections in the neck. However, until recently, manufacturers have continued to recommend intramuscular injection in information sheets. This has now been changed.

Repercussions

Meat companies jealously guard their markets as well as meeting demanding meat industry regulations. The discovery of an abnormality of this nature is costly—both in time and money.

Initially with export beef, the whole day's production is isolated and subjected to re-inspection. If the product is being frozen there could be a delay of up to a fortnight in freezer turnaround.

Re-inspection is based on a sampling plan. If the sample fails inspection the product is automatically rejected from the US/Canada markets which attract the highest prices. In extreme cases the product becomes bone meal or fertilizer.

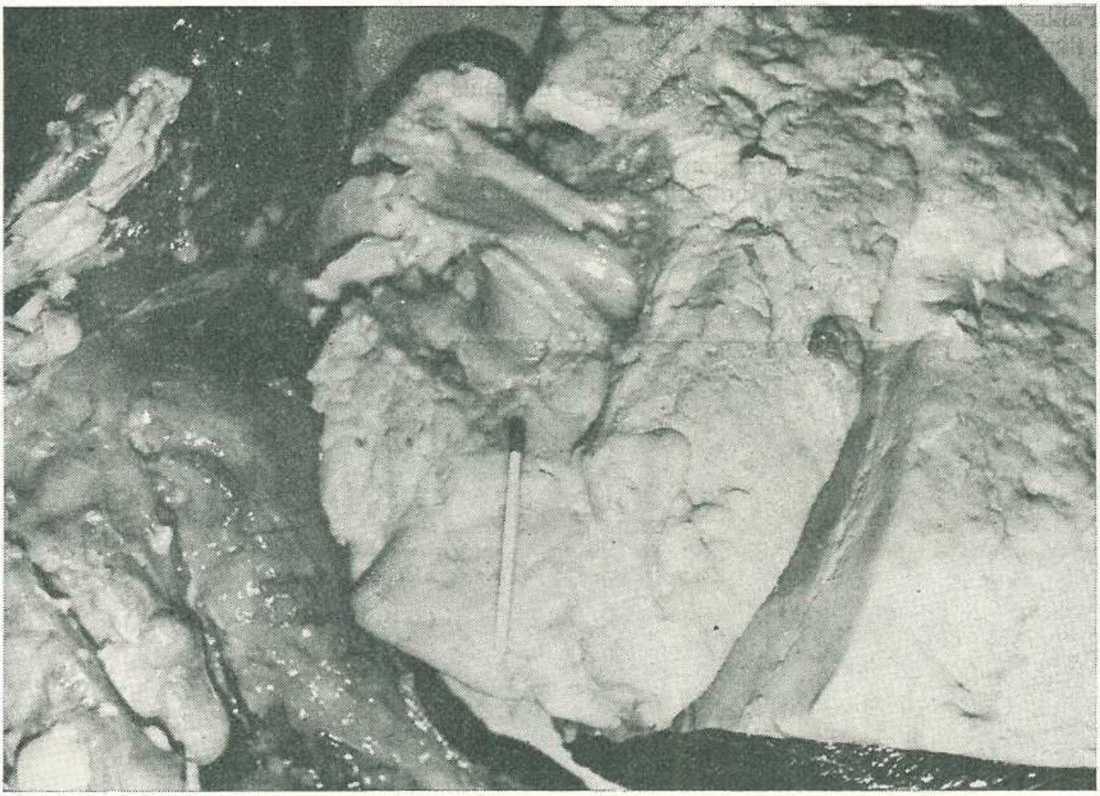
If the abnormality remains undetected until reaching export destinations, implications are far worse. The consignment may be rejected and this could lead to loss of markets and tighter export controls.

Case histories

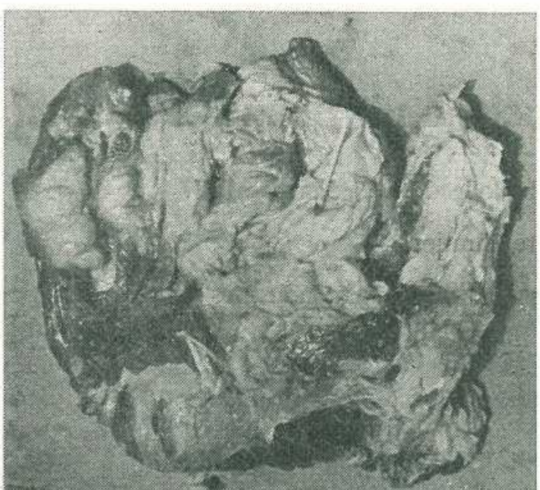
The lengths one company went to prevent repetition of the above procedures may demonstrate the seriousness with which they regard this problem.

After a series of abscess discoveries every brand from a large saleyard draft (over 400) was recorded and correlated with the carcass until the incriminating one was found. Needless to say this brand was ignored at future sales.

The same company in another instance still employ extra trimmers and quality control staff to process beef from a contract property with a history of muscle abcesses. This is in addition to tightened on property control.



Above, Below: Examples of abscesses caused by oil-based injections.



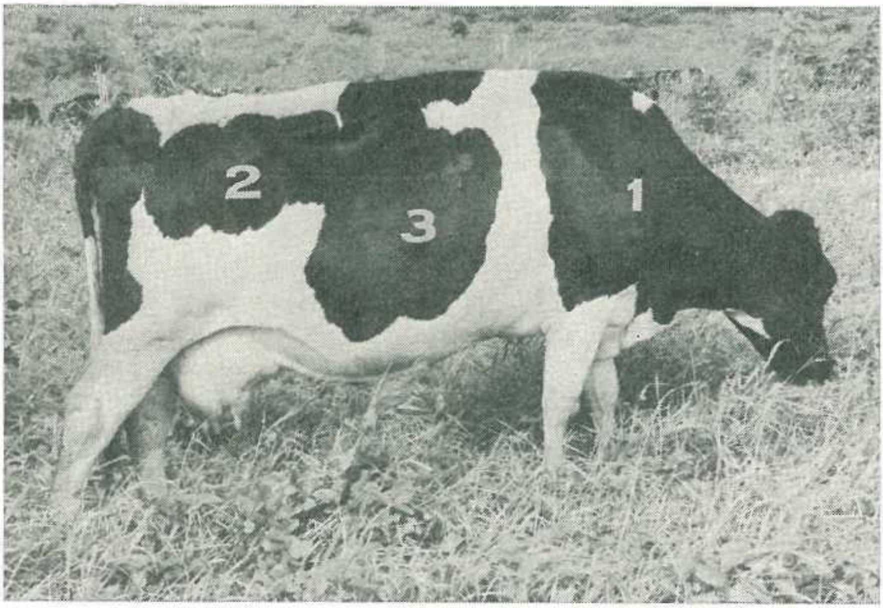
A report from a property in the Gympie area involved all adult female cattle after they were inoculated with 45/20. These included beef breeders and dairy cows. The beef breeders were inoculated in the neck while the dairy cows were injected in the rump. Of the 130 dairy cows treated approximately half reacted with abscesses, 50 of which had to be opened for drainage. The beef cattle injected in the neck, showed no reaction.

Control

Ideally, meatworks would like to see a uniform inoculation site—the neck for example, because of its low economic value and ease of access in trimming.

Failing the neck, the next best position is the flank or paralumbar fossa. If the two first sites are impractical, the rib area is the third choice. These are marked, in order of preference on the picture below—

Slaughtering and Meat Inspection Branch of the Department of Primary Industries is at present engaged in surveying all cases of abscesses reported in meatworks, in particular incidents where numbers of animals are involved and where the origin of the animals can be ascertained. Follow-up action is intended.



Three preferred positions for injections.

Have you lodged your stock and brand returns?

These returns and fees are due and should be lodged by 31 January 1977.

Brand returns are required to retain brand registration.

Returns are available from your local Department of Primary Industries' office.

Annual Medics in Queensland

by N. M. CLARKSON, Agriculture Branch.

ANNUAL medics belong to the genus *Medicago,* which also contains the perennial species *Medicago sativa* (lucerne). Unlike lucerne, they complete their life cycle in one year, germinating from seed in autumn, growing through winter and spring, and setting seed and dying in early summer.

Several medic species were accidently introduced into Australia by early settlers in the 1800s and these have spread widely by natural means, often in wool. The common naturalized medics in Queensland are burr medic (*Medicago polymorpha*) and woolly burr medic (*M. minima*). These are often seen on roadsides. Other species which occur less frequently in southern Queensland are cutleaf medic (*M. laciniata*), button medic (*M. orbicularis*) and black medic (*M. lupulina*). Additional species are found in southern States. Subsequently, medics have been developed as pasture plants in southern Australia. Our present commercial varieties come partly from selections from these wild or naturalized species and partly from introductions by State Departments of Agriculture and CSIRO.

Annual medics are among the few temperate legumes which are valuable in pastures in inland southern Queensland. They are easy to establish and inexpensive because they grow each year from their own seed. This article describes their characteristics, where they are useful, and how to grow them.

The role of medics

Annual medics are useful for the following purposes:—

As a grazed protein supplement. Because they grow in winter when grasses are dormant and deficient in protein, medics can reduce winter weight losses of livestock, raise wool and beef production, and raise the fertility of animals mated in spring.

To improve soil nitrogen fertility. Medics gradually improve soil fertility by fixing nitrogen from the atmosphere. Like other legumes, their roots develop nodules containing the *Rhizobium* bacteria which do this important job. The added nitrogen promotes grass growth. In areas of adequate winter rainfall the improved summer and winter pasture growth can support a higher overall stocking rate.

As a winter forage crop. Medics, like oats, may be grown as a winter grazing crop either on their own or with oats. They will provide high quality winter grazing without lowering the soil nitrogen fertility, and can be valuable on soils where oats need nitrogen fertilizer.

As drought feed. The reserves of seed pods built-up in favourable seasons are rich in protein and will sustain sheep for long periods. The pods are of little value to cattle because they cannot get at them; however, cattle can obtain useful grazing from dead medic material for a short time after the plant dies.

For soil conservation. Their persistence, drought tolerance and ability to colonize eroded areas make them useful pioneer plants. By providing nitrogen for grass growth, they may accelerate the restoration of protective ground cover.

There are, however, some weaknesses which reduce the value of medics:

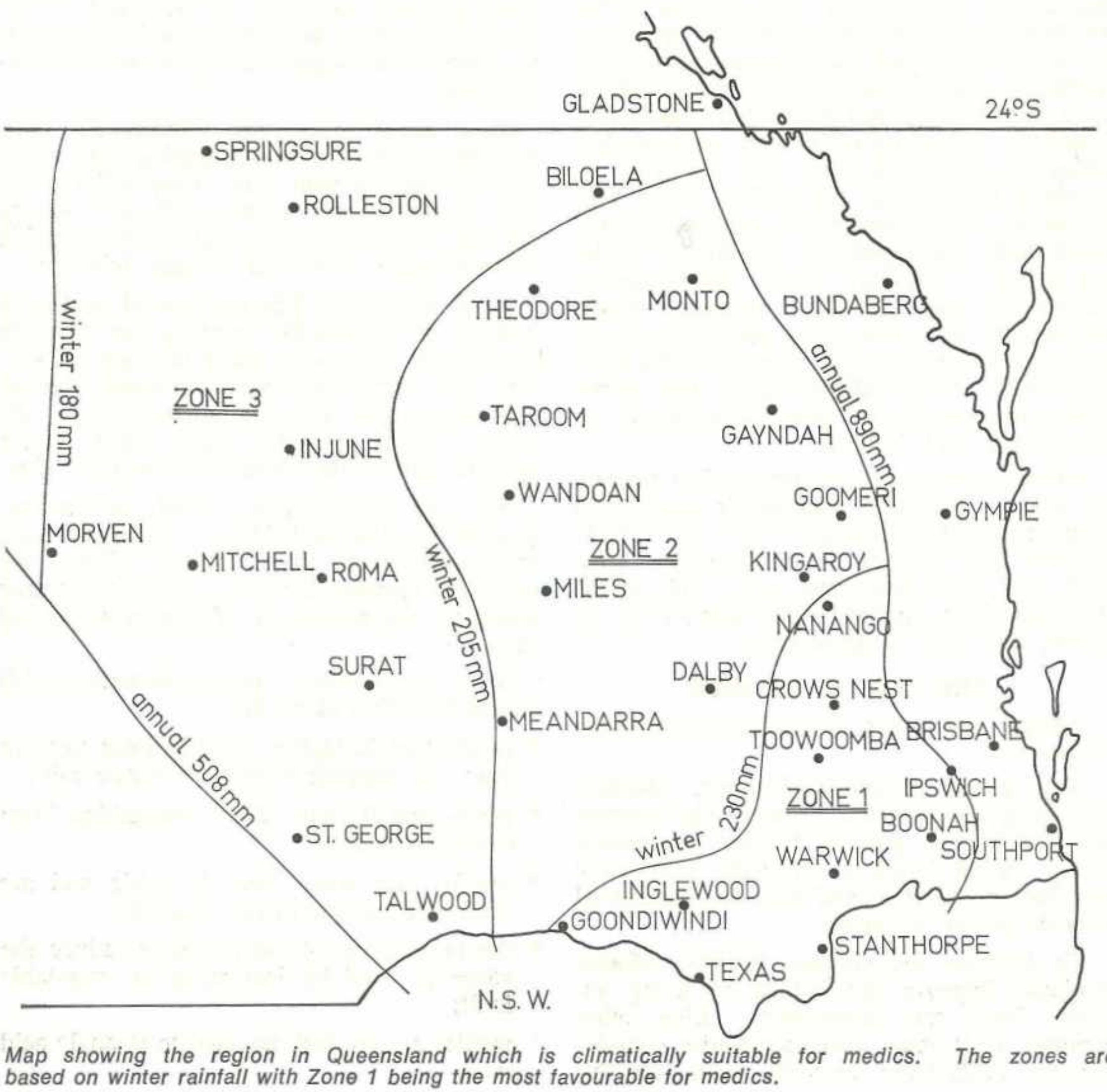
- production is highly variable from year to year and depends mainly on winter rain;
- production is reduced by competition from summer grasses;
- medics can cause bloat in cattle and are similar to lucerne in this respect;
- the spiny pods of some medics reduce the value of wool by increasing the vegetable fault;
- medics are not well adapted to strongly acid soils.

Climate

Because they are annuals which grow in winter, medics need good germinating rain in autumn or early winter and adequate follow-up rain to make useful growth. Many species also need a period of cool temperatures to induce flowering so seed is produced for the next season. The seed dries out during summer and becomes 'hard' and dormant.

This prevents germination in summer when conditions are unfavourable for medics. The seed crop gradually loses its dormancy so that by autumn a small proportion can germinate. Hard-seededness is important for the survival of medics through dry winters when seed may not be produced.

Using long-term averages for winter rainfall (April to September) a map has been drawn of the areas in Queensland where medics are adapted. To the east of this area they are unable to regenerate and compete with better adapted coastal species, especially as most of the soils are too acid for them. To the north and west their growth is limited by high temperatures and low winter rainfall, which prevent seed set.



Map showing the region in Queensland which is climatically suitable for medics. The zones are based on winter rainfall with Zone 1 being the most favourable for medics.

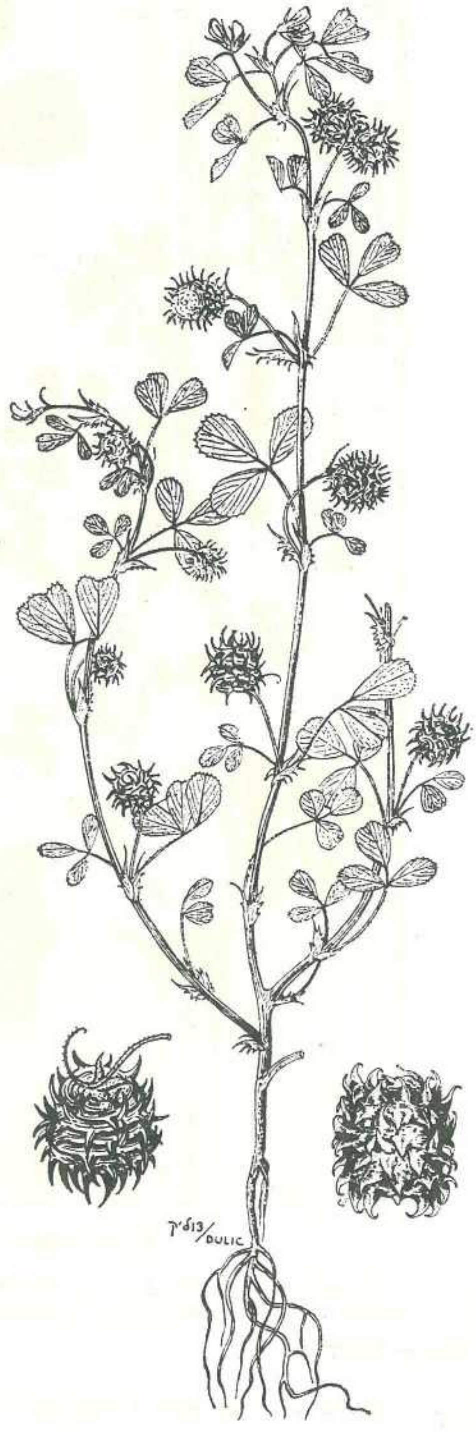
The area can be divided into three zones based on winter rainfall. Zone 1 is the most favourable area, receiving more than 230 mm in winter. It covers part of the South Burnett, West Moreton and the south-eastern Darling Downs. Winter temperatures are cool enough for excellent growth and adequate flowering to occur, particularly west of the Great Dividing Range.

Zone 2 occupies a substantial part of central and southern inland Queensland and is moderately favourable for medic growth. It receives an average of 205 to 230 mm of rain in winter. Minimum temperatures in winter are similar to those in the south-eastern Darling Downs, but the maximum temperatures increase in a regular pattern from south to north. Rainfall in the south is therefore more effective because of lower evaporation, making this area the most favourable in the zone.

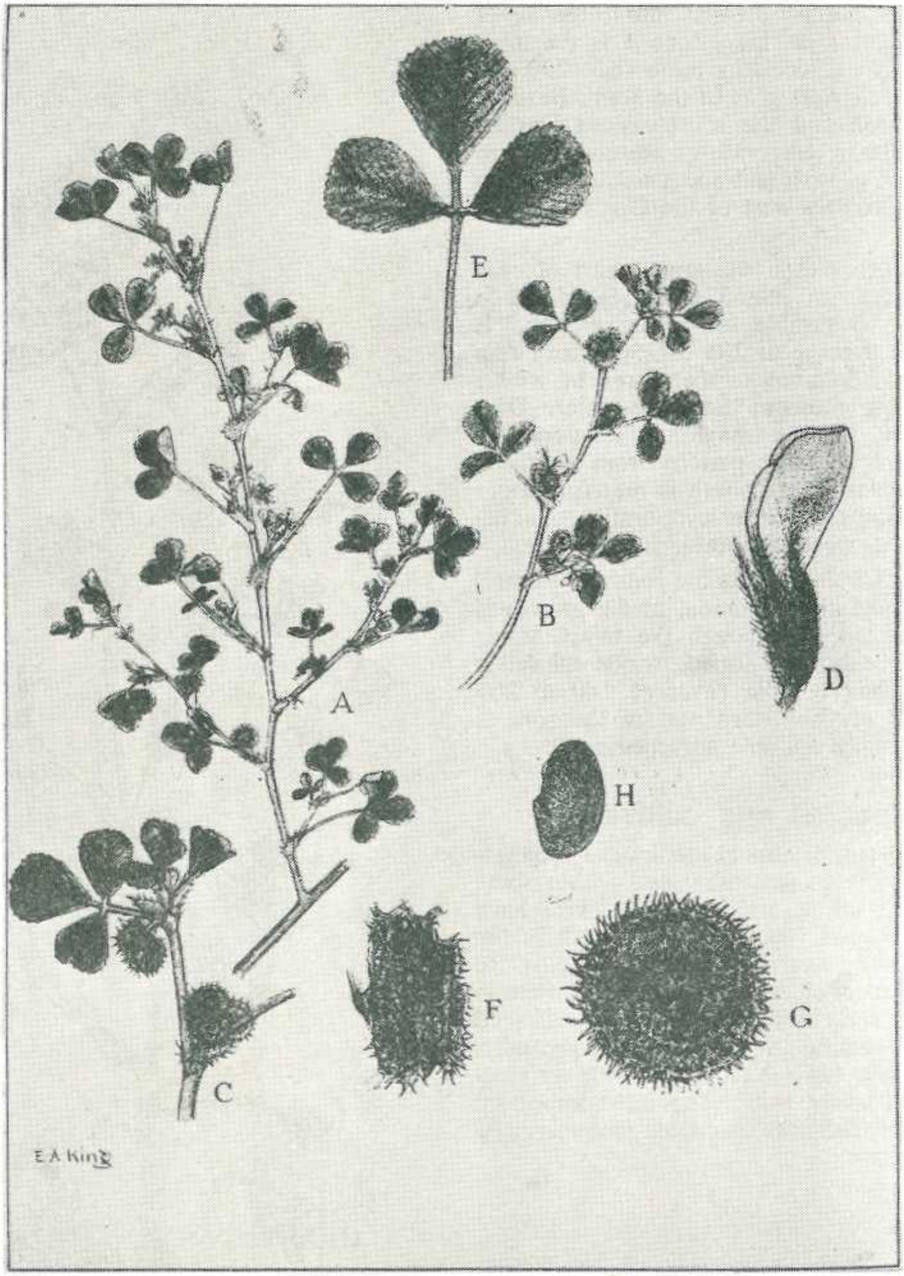
In Zone 3 which covers the southern Central Highlands and the Maranoa, medic growth is more restricted. Although the temperatures are similar to those in Zone 2, winter rainfall is lower and less reliable (average 180 to 205 mm). The north-western part of the zone is only marginally suitable for medics.

Species and cultivars

Seven species of annual medics are commercially available in Australia, and within some species there are several cultivars. These have been developed by research workers in southern and western Australia, firstly to obtain a range of flowering times so that in drier areas early flowering types will set seed before the summer dry period, and secondly, because some types have been more productive on particular soils. The most important species and cultivars available commercially are as follows:



Medicago truncatula—barrel medic.



BURR MEDIC *(Medicago polymorpha)*

A., B. & C. Sections of flowering branches showing pods in various stages of development—reduced.

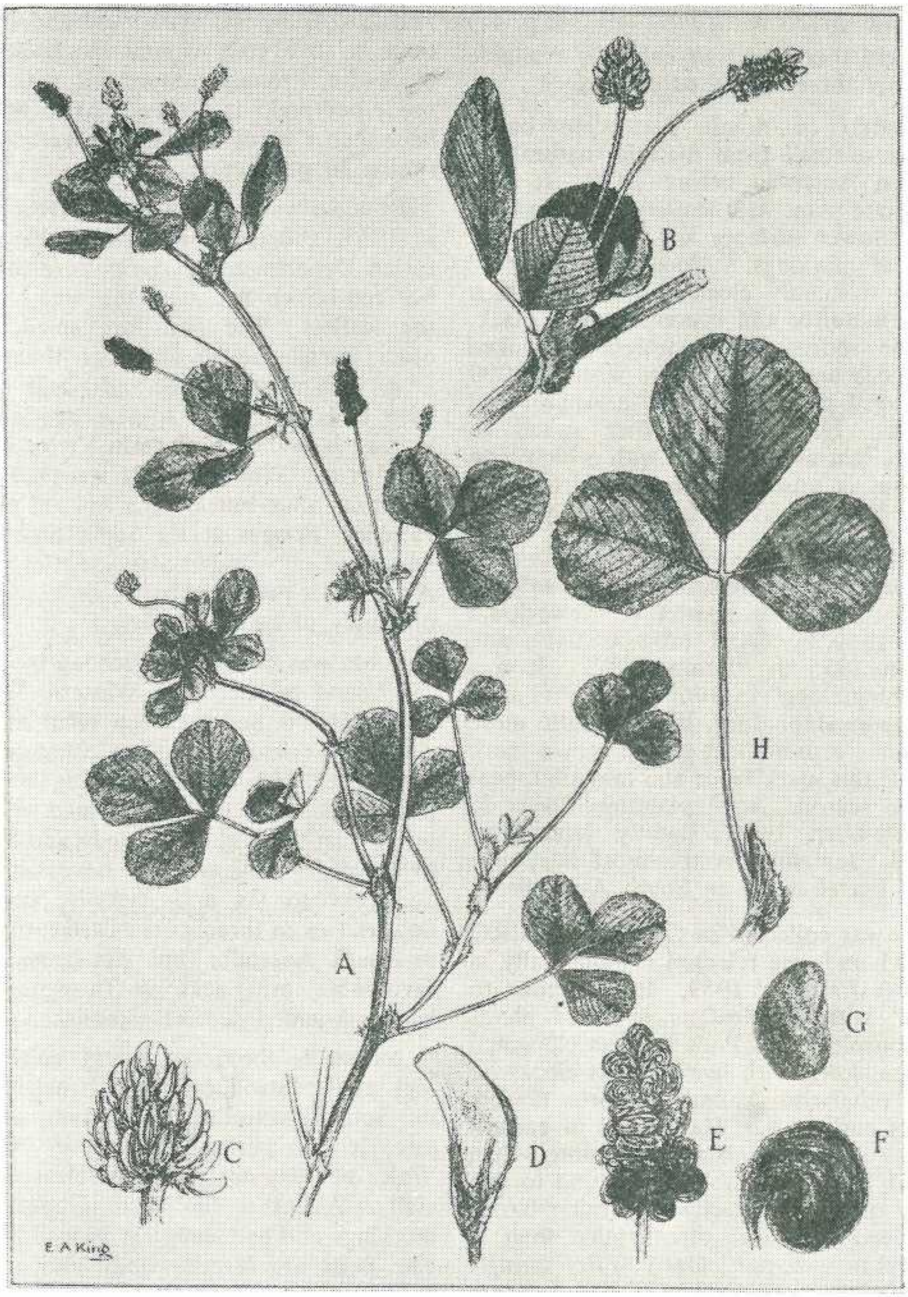
D. Flower—enlarged.

E. Leaf—about natural size.

F. & G. Seed capsule (2 views)—enlarged.

H. Seed—enlarged.

(This drawing and the next were reproduced from 'And Pastures New' issued by Australian Fertilizers Limited.)



BLACK MEDIC, ENGLISH TREFOIL OR YELLOW TREFOIL *(Medicago lupulina)*

A. Flowering branch—reduced.
B. Flowering branch—about natural size.
C. Head of flowers—about natural size.
D. Flower—enlarged.
E. Seed head—enlarged.
F. Seed capsule—enlarged.
G. Seed—enlarged, not fully ripe.
H. Leaf—about natural size.

Barrel medic (*Medicago truncatula*) (see p. 41)

At present there are four cultivars available with another three in limited supply.

HANNAFORD or South Australian barrel medic was selected from material naturalized in southern Australia before 1920. It is a semi-prostrate plant with leaflets hairy on both upper and lower surfaces and having practically no leaf markings. Pods are cylindrical with 4 to 6 mainly clockwise spirals which harden at maturity and become almost black. They bear short almost straight unhooked spines. Seeds are creamy white with 300 000 per kg. April plantings flower in August and September. Hannaford is best suited to medium to light alkaline soils with a high lime content, but is unsuitable for heavy textured and water logged soils. It is moderately tolerant of high salinity.

JEMALONG was selected on "Jemalong" station in the Forbes district of New South Wales in 1939 by CSIR (now CSIRO) and released in 1955 as "Strain 173". It was renamed "Jemalong" in 1966. It is similar in appearance to Hannaford, but is a little more erect and has a prominent purple-brown mark on the leaf; this mark fades and may disappear late in the season. April plantings flower in early September, being slightly later than Hannaford. Jemalong is the most adaptable variety of barrel medic in South Australia.

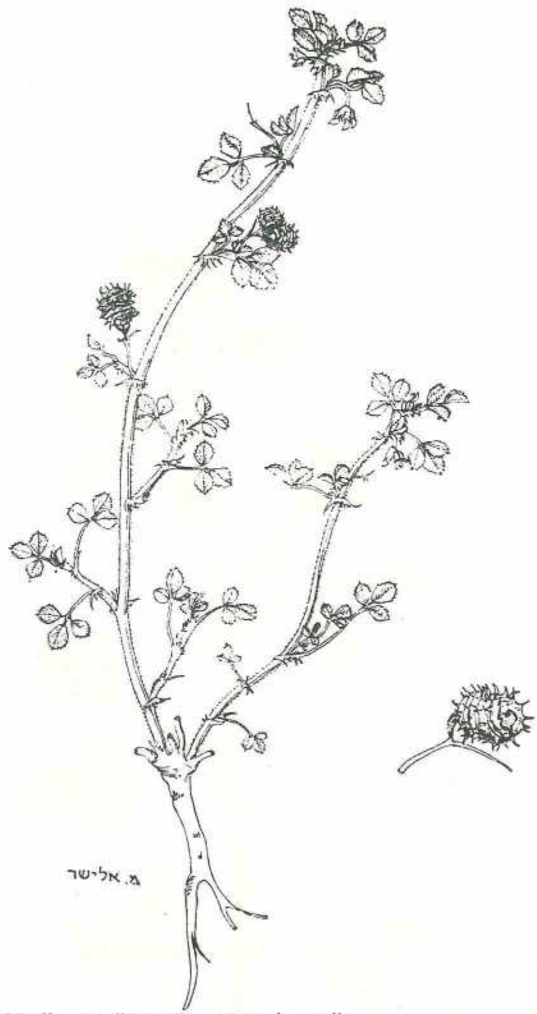
CYPRUS was collected in Cyprus by CSIRO in 1950–51 and was released commercially in Western Australia in 1959. It is similar to Hannaford with the leaflets of most plants having a purple fleck. Pods are less elongated than in Jemalong, with five to eight clockwise coils, but otherwise similar. Cyprus flowers two weeks earlier than Hannaford in eastern Australia. It grows better in winter than Hannaford, but is less able to respond to late rains after onset of maturity than other barrel medics. Seed yields are often higher than in other barrel medics, particularly in dry springs. It is adapted to a wide range of soil types.

CYFIELD was bred from parents which included the cultivar Cyprus by Dr. A. J. Millington and Mr. C. Gishubl in Western Australia to combine early flowering with large seeds and absence of spines. It was released in 1969, but has not been widely grown. The pods are spineless, cylindrical and hairy, with three to five coils wound clockwise or anticlockwise, strongly compressed, with six to ten seeds per pod. It flowers two to three weeks later than Cyprus in Western Australia, and is similar in production.

BORUNG was collected by CSIRO in Tunisia in 1951, and tested and released by the Victorian Department of Agriculture in 1970. It has red-brown flecks on the under surface of the leaflets. The pods are smaller than in other barrel medics, broader than they are long, with two to three-and-a-half anti-clockwise coils and four to five seeds per pod. Borung is finding a place in Victoria on black soils in the Wimmera. It responds better to late rain after burrs have ripened than other varieties, flowers at the same time as Jemalong, and out-yields other varieties. In South Australia it produces better on clay soils than on sandy or saline soils.

GHOR was collected in Jordan by CSIRO in 1967, and registered in Western Australia in 1972. It has not yet been released commercially. The leaflets show a characteristic yellow blotch with a brown edging in the upper part, and have deeply serrated margins on young plants. Pods are woody and larger than in the older cultivars, and have sturdy spines and four to six anti-clockwise coils. Ghor flowers two to three weeks earlier than Cyprus in South Australia, but can grow longer in favourable spring seasons. In winter growth it has out-yielded several established cultivars.

AKBAR is the most recent cultivar to be registered. Introduced from Israel in 1966 by the South Australian Department of Agriculture, it has performed well in New South Wales but has not yet been released commercially. Akbar is similar to Ghor in its leaf markings and leaf margins, as well as its pods. The pods are large, woody and spiny, with four to five anti-clockwise coils. It is intermediate in flowering time between Cyprus and Jemalong, and has shown superior winter and total herbage production and pod yield. It has also regenerated well. Akbar is aggressive with superior seedling vigour and ability to dominate naturalized burr medic.



Medicago littoralis—strand medic.

Strand medic (*M. littoralis*)

HARBINGER is the only cultivar of this medic available, although other strains are naturalized in Australia. It was introduced from California by CSIR in 1941 but probably originated in Iran. Released in Victoria in 1959 for use in the Mallee, it is similar to the barrel medics but the leaflets are small, light green without markings, and the two side leaflets are rounded. The pods are also smaller, discoid or cylindrical with flattened ends, three to four anti-clockwise coils and small or no spines. Harbinger is similar in appearance to the barrel medics and early maturing, flowering at about the same time as Cyprus. It has higher winter yields than the late maturing barrel medics, and comparable spring yields. It grows on soils suited to barrel medics and on more sandy alkaline and slightly acid soils where barrel medic will not grow. Harbinger is extremely sensitive to waterlogging.

Gama medic (*M. rugosa*)

PARAGOSA is the only cultivar of this species. It is derived from an introduction made by CSIR in 1939 from Portugal, and was released in South Australia in 1966. The leaflets have no markings, and the spineless pods are flat and disc-shaped, with conspicuous radiating veins and anti-clockwise coiling, usually with two seeds per pod. Paragosa needs a 5-month growing season and fairly high rainfall, and produces best on heavy alkaline soils. It is superior to other species on the grey and brown soils of heavy texture of South Australia. While flowering earlier than Hannaford in South Australia, it is the latest flowering medic in Queensland. The proportion of hard seeds which soften in summer is higher than in Hannaford, but lower than in subterranean clover. Paragosa requires a different *Rhizobium* inoculant from all other annual medics, and this is commercially available.

Disc medic (*M. tornata*) (see p. 46)

There are two registered cultivars of this species of which one is commercially available.

TORNAFIELD was bred from two accessions of *M. tornata* by Drs. J. P. Simon and A. J. Millington at the University of Western Australia and released in that State in 1969. Its distinguishing characteristics are the clusters of flowers (eight to fifteen) borne on a rather long stalk, and its pods which are disc-shaped and spineless, with two to three anti-clockwise coils having radial and lateral veins on the surface. Tornafield flowers 2 to 3 weeks later than Cyprus. It grows better than any other commercial medics on acid sandy soils in Western Australia and produces more seed than Harbinger. Yields in South Australia have been poorer than with barrel medics, with best results on sandy soils, particularly on solodized solonetz soils.

MURRAYLAND was collected by CSIRO from a volunteer stand of naturalized *M. tornata* at Pooncarie in south-western New South Wales. It was registered as a cultivar in 1971, but has not been released commercially. Differing from Tornafield in being strictly prostrate, with pods having four to five coils and cylindrical shape, this cultivar has only four to six flowers on each stalk. It flowers one week earlier than Tornafield and has shown drought tolerance on deep fine sands with topsoils ranging in pH from mildly acid to strongly alkaline. It grows well on soils of moderate phosphate status. Softening of hard seeds in summer is quite rapid.

Snail medic (*M. scutellata*) (see p. 47)

There are no recognized cultivars of snail medic, although it is produced commercially. It has been naturalized since at least 1907, but may have been deliberately introduced. Snail medic is semi-erect with large serrated leaflets. Pods are almost globular, 12 mm in diameter resembling a snail, and composed of five to eight spineless cup-shaped coils. It grows well on neutral to alkaline soils of both heavy and light texture, and has done best on black soils in the Noarlunga area of South Australia. It is inferior to barrel medics on soils containing free lime. Under good conditions seed produced is very hard and may result in poor regeneration. It produces well in winter and spring and matures a little earlier than Hannaford.

Burr medic (*M. polymorpha*) (see p. 42)

There are no recognized cultivars of this species, although it is available commercially. One of the earliest accidental introductions to Australia, burr medic was first noted by Alan Cunningham around 1822, and is thought to have come via Norfolk Island. It has been spread by sheep over many areas including the Darling Downs and south-east Queensland.

The commonest type is variety *vulgaris*. April plantings flower in August–September. Leaflets are unusual in being without hairs on the upper surface. The mature pod is discoid to cylindrical, with one-and-a-half to three-and-a-half anti-clockwise coils in a loose spiral bearing two rows of stiff erect hooked spines. Seeds are smaller than in many medics.

Medicago tornato—disc medic.

Burr medic is adapted to soils of medium to high fertility and rich in lime, but is also found on relatively poor soils and is widespread. It produces good herbage in winter and spring and large quantities of pods. The pods readily tangle in wool because of the long hooked spines. This species has generally been replaced in improved pastures by other medics.

Other medic species of minor importance

These include species found in semi-arid areas or which are of lower productivity and not commercialized.

Spotted burr medic (*M. arabica*)

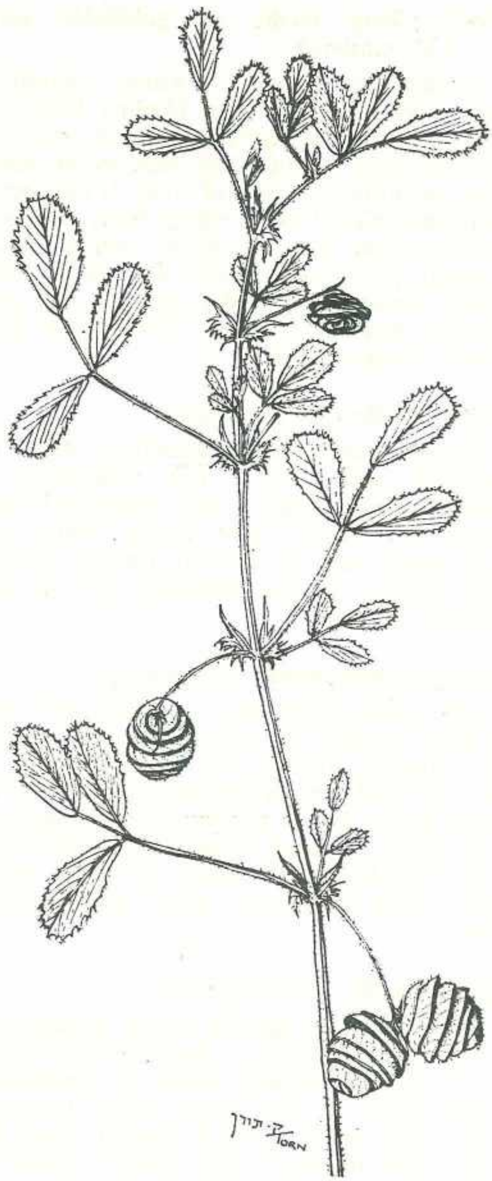
This species grows on acid soils of good fertility and prefers mild winters. It is used in U.S.A. as a green manure and fodder crop for one year. In eastern Australia it occurs only on deep, well-drained, fertile soils in favoured areas such as hollows, from the coast to the western slopes, but is not found in Queensland. Pods are spined, and regeneration is poor. It grows in areas where either subterranean clover or white clover is already available and more efficient.

Cutleaf medic (*M. laciniata*)

This species is widely naturalized in the same areas as the two burr medics, and is found on medium and fine textured soils of moderate to good fertility in lower rainfall areas. It occurs sporadically in Queensland. In Israel it occurs in areas receiving only 50 mm of rain annually. Its leaves have cut out margins, resembling insect damage. Pods are globular to barrel shaped and have hooked spines.

Black medic or English trefoil (*M. lupulina*)

A native of cooler moister areas of Europe and Asia, this species is not as well adapted to Mediterranean climates as other medics. It is late maturing, occasionally lives over more than one season, and prefers neutral to alkaline soils, being intolerant of acidity. Commercialized to some extent in Canada and U.S.A., and a little in Australia where it is also naturalized, it is most abundant on heavy soils in Tasmania and on the basaltic tablelands of New South Wales and southern Queensland. Flowers are borne on an erect stalk, and pods are oval and almost black, containing one seed each (see p. 43).



Medicago scutellata—snail medic.

Woolly burr medic or goldfields medic (*M. minima*)

Woolly burr medic is widely naturalized and is widespread on the Darling Downs. It is adapted to less fertile and lighter soils and more drought resistant than burr medic, and is more plentiful in semi-arid areas. It also occurs in higher rainfall areas where burr and barrel medics grow but is usually minor. It is a small plant with woolly or whitish hairy stems, leaves and pods, and is less productive than burr medic. Pods have long, slender hooked spines.

Button medic (*M. orbicularis*)

Button medic has distinctive large flat spineless pods. It is not widespread in Australia, occurring on well structured black earths in central New South Wales and occasionally on the eastern Darling Downs. The species is late maturing with a long growing season.

Small leaf burr medic (*M. praecox*)

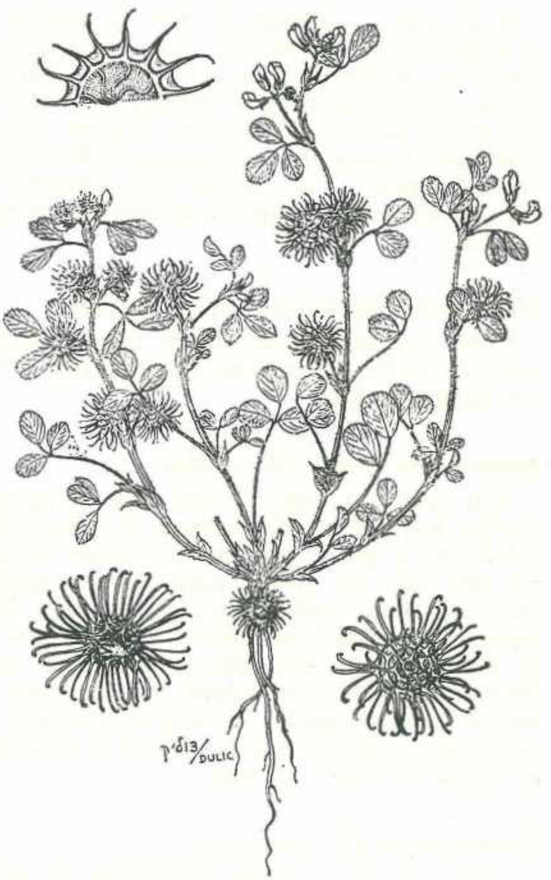
This medic resembles a small-leaved form of burr medic. It occurs on soils of low to moderate fertility, the hard soils of the Riverina and on red-brown earths in New South Wales, but is not found in Queensland. It is small, lacking competitive ability and often found on the fringe of other medic areas. The pods are small with hooked spines.

Calvary medic (*M. intertexta*)

This is a rare species found occasionally in Victoria and Western Australia, but not in Queensland. Leaflets have a prominent purple mark on the base, unlike Jemalong barrel medic whose mark is central. Pods are larger than in any other medic, covered in intermeshed spines which obscure the coils, and resembling a spiny sea urchin. The seeds are black.

The identification of medics

Most medics are easily identified by their pods. The key at the end of this article provides a method of identification. Commence at the beginning and choose from alternatives until a solution is reached.



Medicago minima—woolly burr medic or goldfields medic.

Soils

With correct fertilizing, inoculation and lime-pelleting of seed, medics can be productive on a wide range of soils. They prefer neutral to alkaline soils (pH 6·5 to 8·5) with a moderate to high clay content and a high natural lime content. The best Queensland soils for medics are the black earths of the Warwick-Toowoomba-Dalby area, the grey, brown and red clays which include the brigalow areas and the treeless downs country west of Roma, and the basaltic loams of the eastern Darling Downs.

FOOT-AND-MOUTH DISEASE

EVERY precaution is taken by the quarantine authorities to guard against the entry of exotic animal and plant diseases into Australia.

However, it would be wrong for the quarantine service to bury its head in the sand and say—'No exotic disease will ever enter Australia'. It is illegal for any boat or plane to enter Australia without quarantine and customs examination and clearance, but with our vast coastline, illegal entry is still possible.

Air travel means that every day several hundred people land in Australia within hours of leaving countries with animal diseases that would cripple our economy if introduced here.

Foot-and-mouth disease would jeopardise our exports of meat, wool, dairy products and livestock. The map shows how few countries in the world are free of the disease. Affected countries include Indonesia which is less than 1 600 kilometres from Australia.

The countries shown in black on the map are—

- Free of foot-and-mouth disease.
- Expected to remain free of the disease due to their geographical position and animal quarantine controls.
- Countries that have adequate surveillance of stock to ensure that an introduction of foot-and-mouth disease would be detected early.

These countries can therefore be considered to be 'safe' countries.

Some other countries are free of foot-and-mouth disease at present, but are more likely to have it introduced than the 'safe' countries.

(Note: the description 'safe' country is not an official designation.)

Contingency plans have been drawn-up for action should any exotic disease be diagnosed. Rapid eradication depends upon early recognition. Stock inspectors and veterinary officers are constantly on the look-out for such diseases, but stockowners see their stock most frequently.

Cloven hoofed animals, cattle, sheep, pigs, deer and goats, are susceptible to foot-and-mouth disease. Affected animals drool saliva from the mouth and are lame. This drooling of saliva is due to the pain of vescicles (fluid-filled blisters) that develop in the mouth and on the tongue. The vescicles rupture after approximately 24 hours and become raw ulcers. Lameness is due to similar vescicles that develop on the feet—especially in the cleft between the digits. Vescicles also appear on the teats.

Affected animals do not eat, are dejected and have a high temperature during the early stages of the disease. There is often a characteristic smacking of the lips in cattle. A dairy herd may produce only half the normal quantity of milk compared with the previous 24 hours.

In pigs, the most obvious abnormality is on the snout, but pigs also have foot and mouth vescicles. Many epidemics of foot-and-mouth disease have started in pigs.

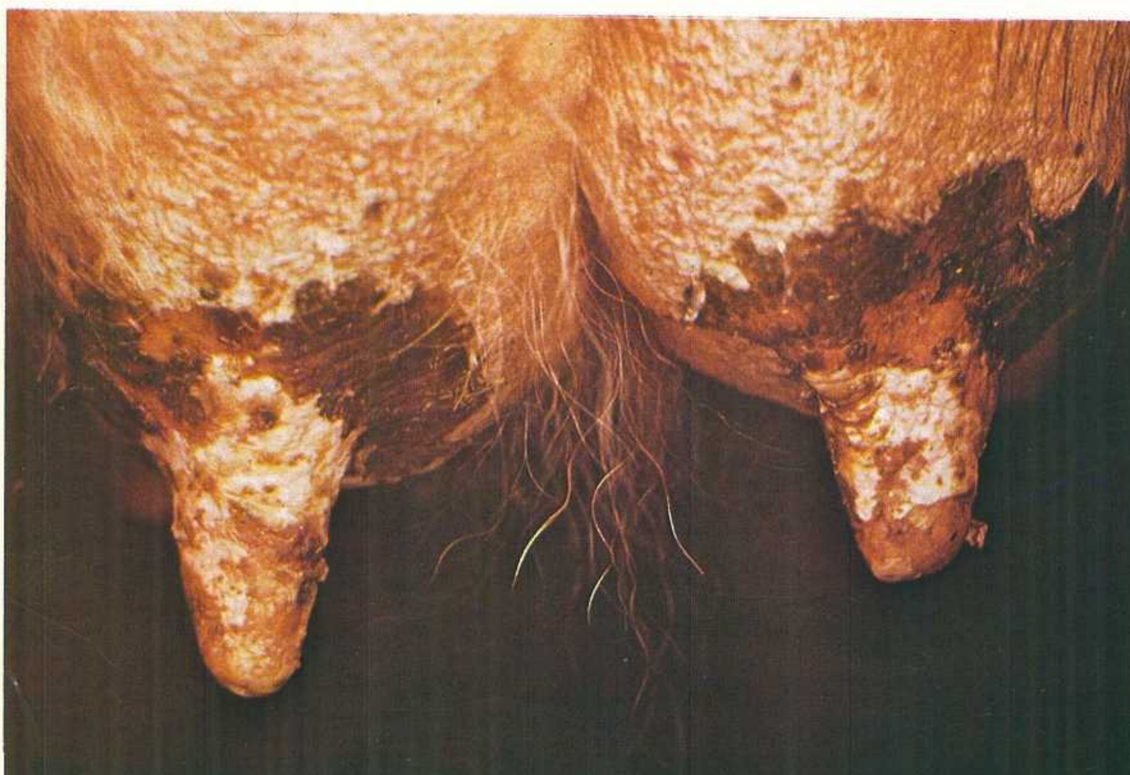
Early detection of any exotic disaese introduced into Australia is vital and therefore depends on stockowners to protect their livestock industries by being aware of the signs. Study the photographs carefully.

If you ever suspect that you have foot-and-mouth disease on your property, phone the D.P.I. and a stock inspector or veterinary officer will call immediately. Officers of the D.P.I. would rather be called out many times on false alarms than hear a stockowner say: 'Well, I thought it could have been foot-and-mouth disease a week ago but did not want to make a fool of myself'.

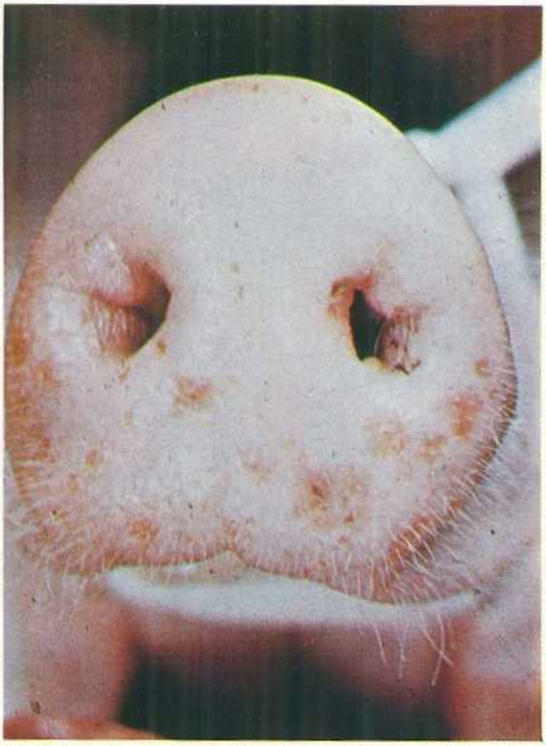
by W. R. Webster,
Veterinary Services Branch.

Left: A vescicle or fluid-filled blister on the tongue of a beast. These vescicles are present for only approximately 24 hours before they rupture.

Right: When vescicles rupture, the raw tissues underneath are exposed. In this picture, the raw areas or ulcers on the gum and the tongue are shown.

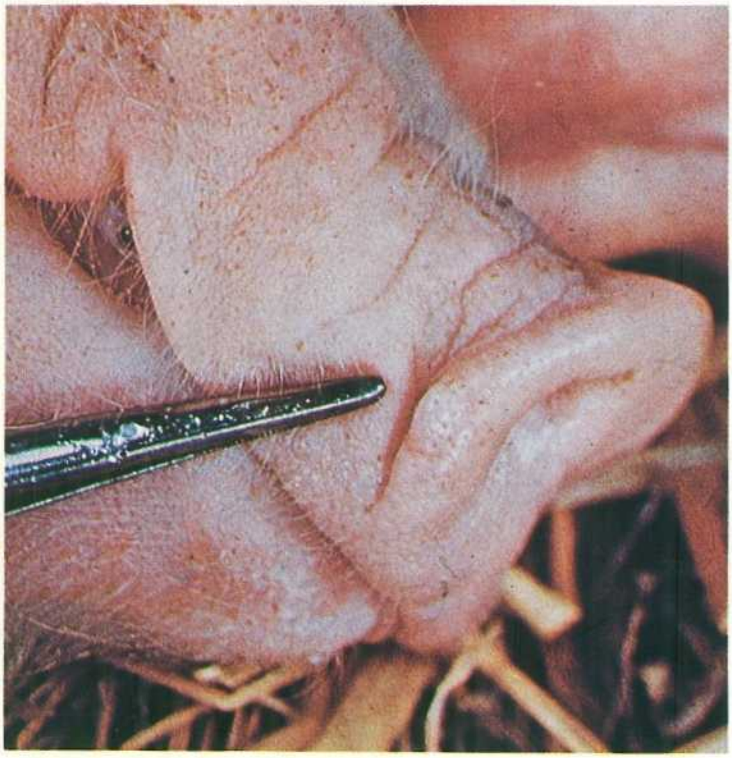


Lesions on the teats and udder of a cow. These lesions are at a later stage and healing has begun.



Above left: an unruptured vescicle on the edge of a pig's snout.

Above right: a recently ruptured vescicle on the foot of a sheep. Vescicles also occur in the cleft between the digits.



Left: ruptured vescicles on a pig's snout. Pigs also show lesions on their tongues and feet.

Often, the first sign of foot and mouth disease is a beast drooling saliva. Other diseases also have this symptom but lameness and drooling of saliva, especially when seen in several animals, is characteristic of foot and mouth disease. Drooling of saliva alone, without lameness, warrants a closer examination of affected stock.

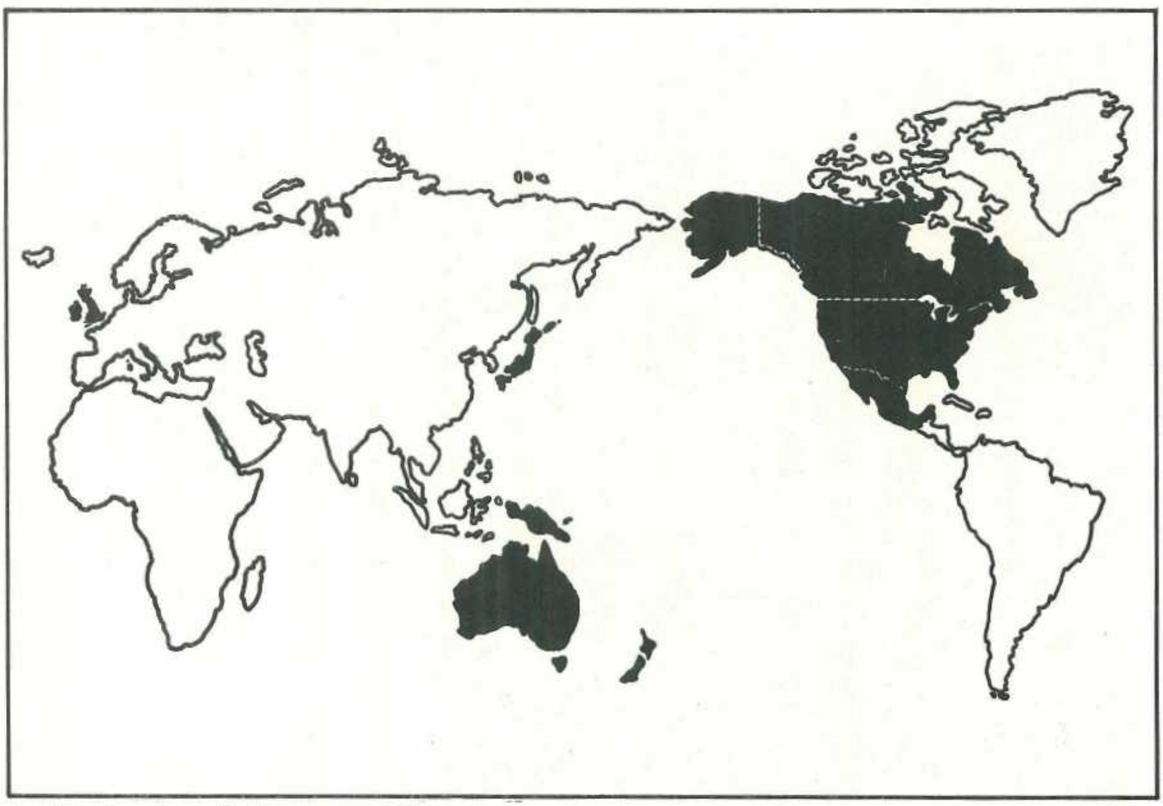


TABLE 1

SOIL REQUIREMENTS AND RECOMMENDATIONS FOR ANNUAL MEDICS IN QUEENSLAND

Scientific name	Common name	Registered cultivar	Naturalized in Queensland	Commercially available	Soil requirements	Recommendations in Queensland areas
M. truncatula ..	Barrel medic ..	Hannaford	No	Yes	Medium to light alkaline soils	Replaced by Jemalong
		Jemalong ..	No	Yes	Widely adaptable ..	Use in all mixtures
		Cyprus ..	No	Yes	Widely adaptable ..	Use in all mixtures
		Cyfield ..	No	Yes	Similar to Cyprus ..	Untested
		Borung ..	No	Yes	Clay loams and clays	Untested
		Ghor ..	No	No	Similar to Cyprus ..	Untested
		Akbar ..	No	No	Similar to Cyprus ..	Untested
M. littoralis ..	Strand medic ..	Harbinger	No	Yes	Widely adaptable, more suited to sandy and slightly acid soils than the barrel medics	Use in all mixtures
M. rugosa ..	Gama medic ..	Paragosa ..	No	Yes	Heavy alkaline soils	Trial sowings on heavy soils
M. tornata ..	Disc medic ..	Tornafield	No	Yes	Better adapted to acid sandy soils than other medics	Trial sowings on acid, sandy soils
		Murrayland	No	No	Similar to Tornafield	Untested
M. scutellata ..	Snail medic ..	..	No	Yes	Neutral to alkaline soils of heavy and light texture	Use on most soils except acid, sandy soils
M. polymorpha	Burr medic ..	..	Yes	Yes	Widely adaptable ..	Encourage in areas where naturalized. Sow alternative cultivars in other areas
M. minima ..	Woolly burr medic	..	Yes	No	Widely adaptable particularly on low fertility, light-textured soils	Encourage in areas where naturalized
*M. lupulina** ..	Black medic ..	..	Yes	Yes	Prefers neutral to alkaline soils of moderate to heavy texture	Encourage in areas where naturalized

* Sometimes perennial.

The soil adaptation of the various medics is summarized in Table 1, based on experience from all medic areas in Australia. For Queensland conditions, Jemalong, Cyprus and Harbinger are recommended as the basic cultivars because of their adaptation to a wide range of soil types.

Snail medic is also recommended for all but the acid, sandy soils. A mixture of up to three cultivars is recommended because different seasons favour different cultivars.

Nutrition

Medics obtain most of their nitrogen from the atmosphere. They obtain their other mineral elements from the soil. These elements are grouped as 'major' and 'minor', according to the amounts required for normal growth.

The major elements with their symbols in brackets are phosphorus (P), potassium (K), sulphur (S), and calcium (Ca). Most soils have adequate potassium, but phosphorus and sulphur levels are often inadequate. These are usually increased by applying superphosphate. For severely sulphur-deficient soils such as those derived from basalt, other fertilizers containing extra sulphur are available.

Medics require much more calcium than tropical legumes. Acid soils such as granite are sometimes deficient and may require lime, particularly if the pH is below 5·5. Heavy-textured, alkaline soils such as the black earths have high levels of available calcium.

The minor elements are required in only trace amounts. These are molybdenum (Mo), copper (Cu), boron (B), zinc (Zn), magnesium (Mg), manganese (Mn) and cobalt (Co). The most important of these is molybdenum which is often deficient in Queensland soils. It plays a vital part in the fixation of nitrogen from the atmosphere and should be applied as Mo superphosphate where a deficiency is likely. Deficiencies of the other elements are less common and require special fertilizer.

Flowering time and yield potential

The flowering behaviour and productivity of most of the commercial medics have been studied in an experiment at Warwick where a series of plantings was made every month for two years. The experiment was irrigated so that the effects of temperature and day-length on flowering and yield potential could be observed without interference from moisture stress.

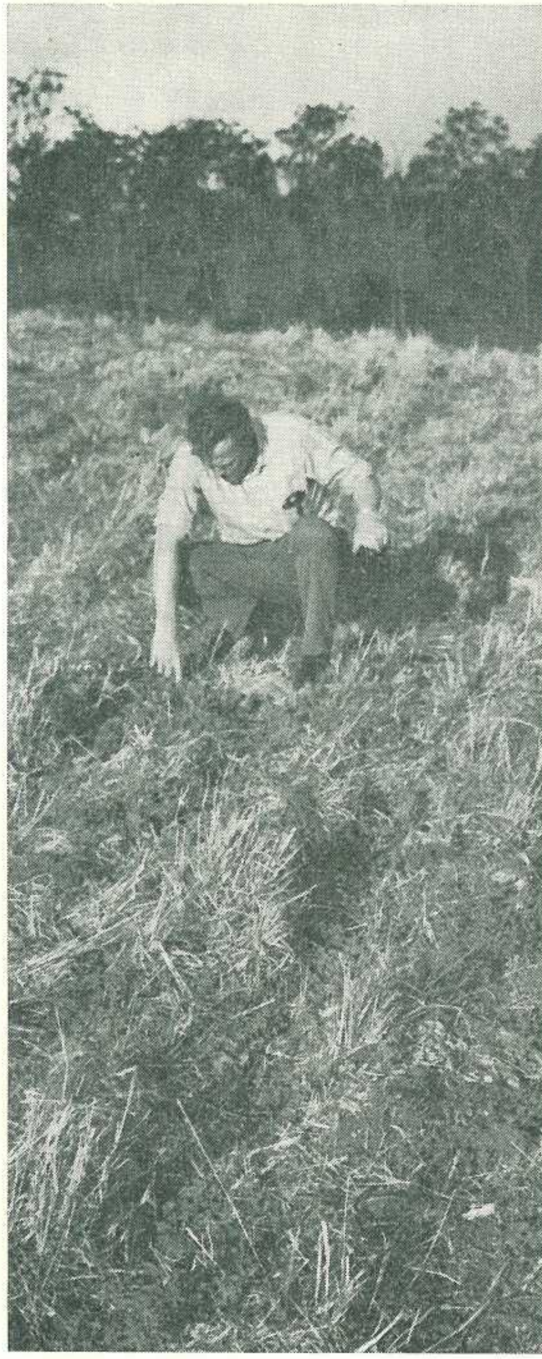
Sulphur fertilizer has greatly improved this natural stand of black medic and burr medic used for cattle grazing near Toowoomba.

The observations of flowering showed that in order of increasing lateness of flowering the cultivars are snail medic, Cyprus, burr medic, Harbinger, Tornafield, Jemalong and Paragosa. In dry years, the early flowering cultivars are more likely to set seed.

Differences in flowering time between cultivars are largest in autumn plantings and small in winter plantings. This means early flowering cultivars are more likely to set seed only in years when germinating rains occur in autumn.

Plantings in late winter flower faster than other plantings. This offsets the adverse effect of the shorter growing season and suggests that late winter could be a good time to sow medics with summer grasses. Also, if germinating rains do not occur until August, the rapid flowering still gives all medics a good chance of setting seed.

Green panic sown into naturalized burr medic makes a good dairy pasture on red soils near Crows Nest. Sulphur fertilizer is essential for both grass and legume.



This run-down Rhodes grass pasture on red soil near Crows Nest has been renovated and oversown with Jemalong barrel medic.

UPPER. A 6-year-old stand of Cyprus barrel medic regenerating under a wheat crop on brigalow country south of Miles.

LOWER. A pasture of Rhodes grass and medics on bull oak—ironbark solodic soil west of Dalby. Successful growth of medics on this soil requires superphosphate, lime and trace elements.

The results of the yield harvests showed that ranked in order of decreasing yield potential the cultivars were Jemalong, snail medic, Harbinger, Cyprus, burr medic, Tornafield and Paragosa. The best cultivar at Warwick was Jemalong because of high yields and superior frost resistance.

The highest yield recorded was from Jemalong planted in June (10 000 kg per ha). June and July plantings were the most productive with active growth ceasing in late October to early November and mid November respectively. Autumn plantings were set back markedly by cold weather and frosts. Under milder conditions, plantings in April and May would be more productive. Yields from summer plantings were very low.

The cultivars did not differ as much in length of growing season as in flowering time. Again, the differences were greatest in autumn plantings and negligible in late winter plantings. It appears that the growing season could be extended by using mixtures of varieties with different maturities only in years when germinating rains occur in early autumn. In practice, the season may also be extended by successive germinations.

Establishment

Although medics are easy to establish, thorough weed control and adequate fallowing improve establishment. Seed should be inoculated with the correct *Rhizobium* peat culture (available from seed merchants). For most medics it is the same as that used with lucerne but Paragosa requires a special inoculant. Directions on the packet should be followed closely.

Lime-pelleting the seed of all cultivars is essential in acid soils with a pH below 6·0 to protect the inoculum from soil acidity. Pelleting also gives protection from sunlight, dehydration and acidic fertilizers on other soils. Fertilizer is more effective when drilled in close to the seed, but bulk spreading, particularly of sulphur and heavy rates of lime, is satisfactory especially if carried out before planting.

Seeding rates of 2 to 4 kg per ha are generally suitable. Higher rates can be used for pure stands and lower rates (down to 1 kg per ha) in mixtures with grasses. Once established, medics build-up seed reserves of their own. Strongly regenerating stands commonly have over 100 kg per ha of germinating seed.

Seed may be applied with a combine using a small seeds box, or a large seeds box where other seed is included. It may also be mixed with fertilizer provided the seed has been lime-pelleted. Sod seeders and spinners can be used successfully where full cultivation is not possible, such as on steep or stony ground. Seed germinates best from a depth of 1 to 2 cm but has been successfully sown with cereals to 5 cm on heavy soils.

Methods of establishment

PLANTING ON A FULLY-PREPARED SEEDBED FOR PERMANENT PASTURE (*all three zones, see map*) gives the most reliable results. In plantings without summer-growing species, the best planting time is April to July. Where summer grasses are included, it is better to establish the medics first in autumn, then cultivate in the following summer and sow the grass separately. The cultivation will not harm the medic pods in the soil.

Planting the mixture in February is a compromise alternative to allow the grass to establish before winter. However, grass seed which does not germinate before winter often will not establish in spring. Planting of mixtures containing a grass in August should also be successful provided that spring weeds are not a major problem.

PLANTING ON A FULLY-PREPARED SEEDBED AS A WINTER GRAZING CROP (*Zones* 1 *and* 2) is the same in the first year as the above method, but in later years, the medics will regenerate from their own seed. To obtain high production, the land should be fallowed through summer until April or May when natural regeneration will produce excellent growth on stored moisture. (For more information on this practice on the Eastern Downs, see the article by L. R. Loader in the *Queensland Agricultural Journal,* December, 1974.)

ESTABLISHMENT WITH A WINTER CEREAL CROP (*Zones* 1 *and* 2) such as oats, wheat or canary is a possibility. The cover crop may be grazed or harvested for grain. This method enables rapid pasture establishment where a crop-pasture rotation is used. Because the cover crop is a strong competitor for moisture and light, the planting rate should be reduced to 15 to 20 kg per ha with medics at 4 kg per ha.

Where the grain crop has higher priority, normal planting rates are preferred for weed control and high grain yield. However, as this reduces the medic seed crop, the medics should be leniently grazed in the first year of the pasture phase to allow build-up of seed.

SOD-SEEDING INTO ESTABLISHED GRASS PASTURES (*Zones* 1 *and* 2) using strongly-built sod-seeders is another method. Best results are expected with late autumn and early winter sowings when the grasses are dormant. Heavy grazing prior to sowing reduces grass competition.

This method is sometimes less reliable than the use of a fully-prepared seedbed but is useful where good native or sown grass pastures are already established. The reliability of establishment is related to winter rainfall and is therefore less in drier areas.

BROADCASTING SEED ON THE SURFACE (*Zone* 1) depends on high winter rainfall because there is no control of competitive grasses. The seed is also exposed to dehydration and light, and there is no seedbed. In the highest winter rainfall areas of the eastern Darling Downs near Toowoomba, the method has had considerable success.

One reason for its popularity is that by avoiding soil disturbance there are no weed problems. Seed may be applied from the air or by ground spinner following early winter rains. Only a proportion of the seed sown will establish but this can be sufficient to give adequate stands in subsequent years.

Use of a chemical desiccant such as paraquat may improve growth in the first year. If sprayed on the pasture a few weeks before planting time, the chemical kills grass top growth and so reduces competition for moisture.

ENCOURAGEMENT OF NATURALIZED MEDICS (*mainly Zone* 1) which sometimes remain unproductive because of nutritional stress is also possible. Correction of the nutrient deficiency is the only treatment necessary to establish productive pastures. The outstanding example of this is the correction of sulphur deficiency on the shallow, black earths and basaltic loams of the eastern Darling Downs. In experiments carried out by the Department of Primary Industries at Toowoomba, the average yield of burr medic and woolly burr medic between 1966 and 1969 was increased from 1 169 kg per ha to 3 108 kg per ha with annual dressings of sulphur fertilizer. In this situation, the establishment of new commercial cultivars is not warranted and is very difficult because of the competition from established medics.

Management

Grazing

Regeneration and winter growth are better if the bulk of summer pasture growth is removed by heavy grazing in autumn before germinating rains occur.

In Zone 1, continuous grazing does not appear to adversely affect establishment or seed set. In Zones 2 and 3, reduced grazing pressure during seedling establishment and again during seed set will encourage seed production. Over-grazing with sheep may lead to a smaller seed crop and exhaustion of seed pod reserves in long, dry periods. Cattle do not cause the same damage to the sward because they do not graze as closely and cannot pick up the burrs.

Bloat

Annual medics sometimes cause bloat in cattle. Experience of farmers with snail medic on the eastern Darling Downs suggests that this variety is less troublesome than burr medic. The risk of bloat is much less after flowering when the plants are more readily eaten by stock. This risk can be reduced by using anti-bloat agents in the drinking water.

This 7-year-old stand of Jemalong barrel medic on a hard-setting brigalow-belah soil east of Meandarra is heavily stocked with sheep every year.

Harbinger medic growing well without fertilizer on sandy cypress pine country north of Goondiwindi.

Renovation

On hard-setting soils, a single chisel ploughing in autumn greatly improves medic growth. It buries a proportion of the seed and reduces grass competition and runoff. This treatment applied annually raised the average medic yield at Texas (Zone 1) from 1 700 kg per ha to 2 800 kg per ha over a 4 year period.

Hay-making (mainly Zone 1)

Medics make excellent quality hay. The best time to cut the crop is when the first pods are mature. This will allow time for the plants to make most of their growth without maturing too far. The crude protein content at this stage is generally 15 to 20%, but this falls rapidly as the stand matures. Cutting is easier if the soil surface is level and an erect type such as snail medic is used.

Seed production

Most of the medic seed used in Australia is produced in South Australia where pure stands are grown in rotation with winter cereals. In Queensland, there have been few attempts to produce seed but in Zone 1 and the southern part of Zone 2 this should be possible by growing the medic as a self-regenerating, annual crop after a summer fallow. The main difficulty would probably be the harvesting in years with a wet, early summer which would produce weeds and also make threshing of damp pods very difficult.

Seed production requires a firm, level paddock free from obstructions, dry weather for harvesting, adequate weed control, and specialized seed harvesters. After choosing a suitable paddock, the area should be fallowed in the same way as for other winter crops.

Sowing is done between April and July using at least 7 kg per ha of seed. Many weeds can be controlled before planting by use of a pre-emergent herbicide such as the proprietary products 'Treflan' or 'Balan'. Other weeds may require spraying after emergence, for example with 2,4–DB which at low rates has little effect on medics.

The crop should be rolled before flowering commences, preferably when the soil is moist, to give a firm, level soil surface for seed harvesting. Except in very dry seasons, moderate grazing before flowering commences will increase seed yields. Nearly all seed harvesting is done with commercially-produced harvesters which suck up the pods, thresh them and clean the seed. Final cleaning is done on stationary seed cleaners.

In South Australia, medic seed is produced under a Certified Seed Scheme with inspection of crops by the Department of Agriculture. No such scheme exists in Queensland. Seed is marketed through co-operatives, seed merchants and by direct selling. Seed is sold within Australia and for export, with prospects of expanding markets in the Mediterranean basin.

With an average price of 55c per kg and an average cost of production around $63 per ha, a yield of 118 kg per ha of seed is required to cover costs. Top growers have achieved yields of 400 kg per ha and gross margins of $156 per ha. In Queensland, the profitability is likely to be reduced considerably by lower average seed yields. Costs would also be higher because of the lower reliability of seed crops.

Medic zones in Queensland

This section deals with regional experience and recommendations in each of the three zones shown in the map.

In estimating the productivity of medics, a yield of 1 000 kg per ha is regarded as indicating quite a good year. Yields as low as 300 kg per ha are still useful, particularly in drier areas where stocking rates are lower.

Zone 1 (winter rainfall exceeding 230 mm)

Productivity of medics

This is the most favourable climatic zone for medics in Queensland, with yields of dry matter estimated to exceed 1 000 kg per ha in half to two-thirds of years. Useful growth occurs in most years. The climatic potential for medic production with adequate water recorded at Warwick is approximately 10 000 kg per ha. The highest yields under dryland pasture conditions have been estimated at 6 000 kg per ha, with average yields estimated at 1 500 to 3 000 kg per ha. Annual medics should be included in all pasture sowings.

Toowoomba–Warwick

The most successful medic pastures in Zone 1 have been the naturalized burr medic and woolly burr medic in native pastures in the Toowoomba–Warwick area where naturalized black medic is also useful.

These grow on shallow black earths and require annual autumn dressings of sulphur at 25 kg per ha. This may be applied as bulk gypsum (170 kg per ha); sulphur-fortified superphosphate (100 kg per ha); or coarse, agricultural sulphur (25 kg per ha). Bulk gypsum and coarse, agricultural sulphur are the cheapest sources but the gypsum is difficult to spread. Where phosphorus deficiency also occurs, sulphur-fortified superphosphate should be used.

Where medics are not naturalized, aerial sowing into undisturbed grassland has been successful, particularly in the Cambooya Shire. Work by CSIRO has shown that rough cultivation before broadcasting seed improved establishment, but had no effect on persistence in later years.

In this area, medics are also used as an annual forage crop with or without oats.

Crows Nest

Black medic (*M. lupulina*) is naturalized on the chocolate, basaltic soils. Sown pastures of black medic are not as highly regarded as the naturalized pastures. This suggests that the strains are different. These soils are suitable for the recommended medic cultivars.

Boonah and Nanango

Work by CSIRO has shown that medics grow and persist well in both these dairying areas. The average yield of Jemalong at Boonah during 1967 to 1969 was 1 800 kg per ha (prairie soil originally under silver-leaf ironbark). At Nanango, the average yield during 1965 to 1970 was 860 kg per ha (solodic soil originally under narrow-leaf ironbark). On both sites, the cultivars Harbinger

Standover buffel grass with medics provides an alternative to oats as winter feed for cattle in the Roma district.

and Cyprus were similarly productive, while snail medic was less productive on the solodic soil.

Warwick–Stanthorpe–Inglewood

On the granite soils, rose clover (*Trifolium hirtum*) is used in preference to medics. The best medic growth achieved in the Department's experiments has been from Harbinger and Cyprus (2 200 kg per ha). Jemalong has not regenerated as well and snail medic has grown poorly. On these acid soils, seed should be thoroughly inoculated, lime-pelleted, and sown with 250 kg per ha of Mo superphosphate, and preferably with 250 kg per ha of agricultural lime. Marginal deficiencies of potassium, copper and boron sometimes occur. Pastures should receive 125 kg per ha of superphosphate annually for best results.

On traprock soils, medics planted with lucerne will persist after the lucerne dies out and will promote extra grass growth. At Karara, Jemalong and snail medic have been the most productive.

At Texas, the average yield of Hannaford barrel medic fertilized annually with superphosphate between 1966 and 1970 was 1 699 kg per ha in undisturbed, native pasture and 2 783 kg per ha in native pasture which was chisel ploughed annually in the autumn. On most traprock soils, medics should receive 250 kg per ha of Mo superphosphate at planting and an annual dressing of 125 kg per ha.

Zone 2 (winter rainfall 205–230 mm)

Productivity of medics

This zone is moderately favourable for medic growth with yields of dry matter estimated to exceed 1 000 kg per ha in one-third to one-half of the years and useful growth in more than half the years. The range of yields is likely to be from zero to 4 000 kg per ha, with the southern half of the zone being more favourable for medics. The zone includes most of the central and southern brigalow areas and large areas of infertile, solodic soils. These will be used as examples illustrating the range of conditions in the zone.

Brigalow areas

Brigalow soils are mostly heavy-textured, moderately to highly fertile, and suitable for medics. Because of initially high nitrogen status, these soils can support productive pastures based on sown grasses alone.

However, medics have two potential uses. The first is to provide high quality dietary protein in winter, and the second is to offset the slow loss of organic matter and nitrogen which occurs under annual cropping.

The value of annual medics for cattle was demonstrated by CSIRO in a grazing experiment at 'Tarewinnabar' station during 1963 to 1966. Steers grazing native pastures containing naturalized burr medic and woolly burr medic stocked at a beast to 1·9 ha were able to maintain or increase weight in winters of 110 to 129 mm rainfall. Sheep have also responded to lucerne and medics in both native and sown pastures at Meandarra on a gilgaied brigalow clay.

The main medic cultivars were tested on a gilgaied clay soil at Meandarra by CSIRO during 1966 to 1968. The outstanding cultivar was Cyprus which produced 3 300 kg per ha in the wet 1968 winter. Harbinger, Jemalong and snail medic were less productive but grew well. These cultivars are all suitable for brigalow areas and should be included in sown pastures for both short term and long term use. Low rates of Mo superphosphate may be beneficial as deficiencies of phosphorus and molybdenum are known to occur.

Solodic areas

The solodic soils are the most infertile in the region and, in their virgin state, are unsuitable for medics. Although the better soils are used for limited cropping, pastures will be essential for long term stability. While pure grass pastures may be grown with nitrogen fertilizer, legume-based pastures appear to offer the only hope of economic pasture improvement.

There are three types of solodic country in the zone. The most fertile type comprises clays and clay loams supporting poplar box (*Eucalyptus populnea*) which have been used for grain crops. Cyprus, Harbinger and Jemalong medics should be included in pasture mixtures based on buffel grass, Rhodes grass, green panic and lucerne.

Fertilizer requirements are an initial dressing of Mo superphosphate at 250 kg per ha with annual maintenance dressings of 125 kg per ha of superphosphate.

On the deeper, sandy-surfaced solodics supporting cypress pine (*Callitris columellaris*) the annual medics, rose clover (*Trifolium hirtum*) and serradella (*Ornithopus* spp.) supplement lucerne and Siratro as the possible legumes. In addition to Mo superphosphate, the fertilizer should include copper and zinc, and on very acid sands (pH 5 or less) the medics also require lime at 1·2 t per ha.

The solodics supporting bull-oak (*Casuarina luehmannii*) and ironbarks (*Eucalyptus* spp.) are deficient in the same elements. Work by CSIRO has shown that the impermeable clay subsoil limits the growth of Siratro, but does not affect medics because of their shallow root system.

Pastures based on Rhodes grass, Siratro and the medic cultivars Jemalong, Cyprus and Harbinger require the same fertilizers as those on the cyprus pine solodics. Annual medics will respond to applications of lime well in excess of the minimum recommended rate. The economics of development using these pastures will depend on their animal production which is now being measured.

Kingaroy–Gayndah–Monto

Burr medic and black medic are naturalized in parts of this area and application of superphosphate may increase yields. The volcanic and softwood scrub soils are suitable for medics which persist after lucerne dies out, for example in wet areas. Medics may be useful as a supplement to other sown species for dairying and beef production.

Zone 3 (winter rainfall 180–205 mm)

Productivity of medics

This area is the least favourable for medics. Yields exceeding 1 000 kg per ha are estimated to occur in less than one-third of the years, with useful growth in up to half the years. The expected yield range is from zero to 3 000 kg per ha.

Annual medics have been grown on a wide range of soils. Work by the Department of Primary Industries has shown that the cultivars Harbinger and Cyprus were able to set more seed and persist better than Jemalong in the Roma area where earliness of flowering is important for survival. Snail medic grew best on heavy soils.

Cyprus barrel medic sown into an established buffel grass pasture on red soil box-sandalwood-belah country west of St. George.

Brigalow areas

The comments made for Zone 2 apply here.

Solodic areas

Because of the less favourable climate, development of these areas is more difficult. Poor persistence of Rhodes grass in dry years, lower productivity of medics and the high cost of fertilizer are major problems.

Roma–St. George

This area contains light to moderate-textured, red earths and red-brown earths which although of low fertility, are suited to buffel grass. Medics are of value here in providing nitrogen for maintenance of buffel pastures. A mixture of Harbinger, Cyprus and Jemalong should be included in new sowings at 1 to 2 kg per ha. Where medics are to be introduced into an established buffel pasture, the area should be heavily grazed in autumn and oversown in May to July. A rough cultivation before sowing will improve establishment and growth in the first year. Low rates of superphosphate (125 kg per ha) may be valuable in improving medic growth.

Biloela–Springsure

Heavy, cracking clay soils in the area present severe establishment problems for tropical grasses, but not for medics. Studies with medics in this area are at a very early stage. A study of climatic records, however, suggests that medics could have a role and are worth testing, particularly in the eastern areas.

Experiments by the Department at Biloela have highlighted the high seed yield and hard-seedness of woolly burr medic which make it adaptable to the harsh environment. Although the persistence of cultivated medics is not certain, they may be worth establishing in native pastures as a low cost legume for wet winters. Naturalized woolly burr medic may respond to superphosphate.

Conclusion

Annual medics are adapted to the winter conditions of a large part of southern, inland Queensland. They have a potential for use in the sheep and cattle industries which has yet to be realized. Their main application is as winter-growing pasture legumes supplying a grazing protein supplement when summer pastures are of poor quality. They also add nitrogen to the soil which stimulates grass growth.

Medics are easy to establish. The seed is cheap and readily available from southern Australia. They make useful growth on most soils except the very acid types, provided that adequate winter rain is received. Good medic seasons are estimated to occur in up to two-thirds of the years in the wetter south-east, ranging down to less than one-third of the years in the drier western and northern districts.

Acknowledgements

The research on medics carried out at Warwick was financed by the Australian Wool Research Trust Fund. Drawings were provided by the Hebrew University, Jerusalem, and the identification key was modified from the Western Australian Department of Agriculture Bulletin No. 3874.

KEY TO SPECIES OF MEDICAGO (*Modified from W. Aust. Dept. Agric. Bull.* 3874)

	See Item
1. Pods spineless	2
1. Pods spiny	9
2. Pods single-seeded, black, with only the end coiled, flowers 10 to 50, crowded on a long stalk which elongates further in fruit	*M. lupulina* (black medic)
2. Pods many-seeded, (rarely single-seeded) fully coiled, less than 10 flowers ..	3
3. Coils overlapping and enclosing one another, pod olive-shaped, resembling a snail	*M. scutellata* (snail medic)
3. Coils not enclosing one another	4
4. Pods lozenge-shaped, coils concave, distinct veins on outer margins	*M. rugosa* cv. Paragosa (gama medic)

	See Item
4. Coils not as above	5
5. Coils up to 15 mm wide, flat and thin at edge, seed coat rough, radicle almost as long as cotyledons, seeds almost triangular	*M. orbicularis* (button medic)
5. Coils less than 10 mm wide, edges not thin, seed coat smooth, radicle less than the length of the cotyledons, seeds oval or kidney-shaped	6
6. Burrs small (3 to 5 mm diam. x 2·5 to 4 mm high), no partitions between seeds, stipules hairy on both sides, burr smooth or with very tiny spines	*M. minima* var. *brevispina* (goldfields medic)
6. Burrs 4·5 to 8 mm diam. x 2 to 10 mm high, with partitions between seeds, stipules hairy on lower side only	7
7. Edge of dry burr smooth, 4 to 12 flowers on stalk much longer than corresponding leaf stalk	*M. tornata* cv. Murrayland (4–6 flowers) and cv. Tornafield (7–12 flowers) (disc medic)
7. Edge of dry burr with indentations between bases of vestigial spines, flower stalk longer or shorter than leaf stalk	8
8. Upper surface of leaf hairless, surface of burr coil with many distinct strongly curved radiating veins, few or many burr coils, wing petals longer than keel	*M. polymorpha* var. *brevispina* (burr medic-spineless form)
8. Upper surface of leaf very hairy, surface of burr coil with few, almost straight radiating veins, wing petals shorter than keel	*M. truncatula* cv. Cyfield (barrel medic)
9. Burr coiling clockwise when viewed from either end	*M. truncatula* cv. Cyprus and cv. Hannaford (barrel medic)
9. Burr coiling anticlockwise	10
10. Seeds black, burrs 20 mm long with long entangled spines like a sea-urchin, leaves with basal purple mark (fading in fruiting plants)	*M. intertexta* (Calvary medic)
10. Seeds brown or yellow, burrs and leaves not as above	11
11. Edge of each burr coil with four ridges and three grooves and long slender spines, leaves almost triangular with small upper central mark or wide basal mark	*M. arabica* (spotted medic)
11. Leaves and burrs not as above	12
12. Adjacent coils not in contact at all, or loosely pressed together	13
12. Adjacent coils firmly pressed together	16
13. Adjacent coils not in contact, wide spaces between coils, edge of coil thick and shiny when green	*M. praecox* (little leaf burr medic)
13. Adjacent coils in loose contact	14
14. Upper surface of leafy hairy, burrs with long slender spines ending in a pronounced hook	*M. minima* var. *minima* (woolly burr medic)
14. Upper surface of leaf hairless	15
15. Leaves often with deeply cut edges, wing petals shorter than keel, no partitions between seeds, radicle longer than half the length of the cotyledons, spines slender	*M. laciniata* (cutleaf medic)
15. Edge of leaves smooth or with fine teeth, wing petals longer than keel, with partitions between seeds, radicle equal or shorter than half the length of the cotyledons, few or many burr coils, spines long or short	*M. polymorpha* var. *polymorpha* and var. *vulgaris* (burr medic)
16. Burrs with long, thin, curved spines, without indentations between spine bases along edge of coils	*M. littoralis* var. *littoralis* (strand medic)
16. Burr spines short or long, with thick bases, with indentations between spine bases (particularly distinct in young burrs)	17
17. Burrs flattened cylindrical with very short spines, 3 to 4 coils, 3 to 5 flowers ..	*M. littoralis* cv. Harbinger (strand medic)
17. Burrs barrel-shaped, with short or long spines, usually 2 to 3 flowers	18
18. Leaves with central wedge-shaped purple mark (fading in fruiting plants), burrs elongated, barrel-shaped with 5 to 8 coils and short spines	*M. truncatula* cv. Jemalong (barrel medic)
18. Leaves and burrs not as above	19
19. Leaves with red-brown flecks numerous underneath, sparse on top (fading with age), leaf margin slightly serrated, 2 to $3\frac{1}{2}$ coils per burr	*M. truncatula* cv. Borung (barrel medic)
19. Leaves with a yellow-brown blotch near their apex, margins deeply serrated (both disappear in fruiting plants), 4 or more coils per burr	20
20. Flower stalk much shorter than adjacent leaf stalk, burrs large and woody with strong spines $2\frac{1}{2}$ to 3 mm long	*M. truncatula* cv. Akbar (barrel medic)
20. Flower stalk equal in length to adjacent leaf stalk, burrs slightly smaller, spines $1\frac{1}{2}$ to $2\frac{1}{2}$ mm	*M. truncatula* cv. Ghor (barrel medic)

Disease organisms for pest control

What is their potential?

by R. E. TEAKLE, Entomology Branch.

Disease organisms provide one of the newer tools for the selective and environmentally non-harmful control of insect pests. Their use, in association with other forms of natural control, can help alleviate the problems of pesticide resistance and persistent residues.

UNTIL recently, biological control of insects referred almost exclusively to the use of parasites and predators to combat pest species.

The chief advantage of biological control agents are that they are self-perpetuating, non-polluting and flexible means of pest regulation. A new facet of biological control, known as "microbial control", is developing as we gain greater understanding of the regulatory role of natural and artificially applied diseases in insect populations and improved technology for the mass-production of disease microbes.

Natural disease

In nature, spectacular disease outbreaks occasionally occur, but more often the effects of disease are more subtle and difficult to perceive. Some diseases lead to the rapid disintegration or desiccation of the affected insects. Others, such as certain protozoan diseases, cause interference to the development and function of the insects and exert a long-term debilitating effect on the insect population.

Natural diseases cannot be relied on to protect a crop, as efficient spread normally requires high insect populations. Effects usually occur too late for crop losses to be avoided. However, by anticipating the pest build-up and artificially disseminating disease organisms, farmers can sometimes check pest populations. For example, in the United States virus-killed cabbage loopers can be collected in the field, macerated in water and sprayed on to the crops before significant damage has occurred. Applications at the rate of as little as 25 virus-killed larvae per hectare have been found to be effective.

Long-term effects on exotic insects

Disease organisms attracted early attention by their capacity, when introduced into exotic insect populations, to cause long-term reductions similar to those in rabbit populations with the introduction of myxomatosis. For example, the European spruce sawfly, accidentally introduced into North America, began to reach high populations and threatened extensive spruce forests in the 1930s. A virus which occurs naturally in European populations was accidentally introduced with batches of natural parasites. It spread rapidly and has saved many valuable acres of spruce forest. The virus has persisted and is still a major factor controlling this insect.

Similarly, in the United States the milky disease bacillus, *Bacillus popilliae,* provides the most successful means for combating the introduced Japanese beetle, the soil-inhabiting larvae of which are serious pests of pastures and field crops. Spores of the disease organism have been produced commercially in live larvae for approximately thirty years. The spores persist in the soil for long periods and spread of the disease is achieved by movement of the larvae in the soil and by the activities of other insects, rodents and birds. It is probably true that the use of persistent and selective disease organisms offers the best approach to the control of many soil-inhabiting insect pests.

Short-term control

The development of microbial insecticides for short-term control has been inhibited by the remarkable post-war success of the synthetic organic pesticides. However, since about 1960 preparations of a bacterium, *Bacillius thuringiensis* have been available commercially and have survived such formidable competition. *B. thuringiensis* meets the criteria of high virulence, low cost of production and safety for non-target organisms usually required in the selection of disease organisms for microbial control. Preparations of *B. thuringiensis* are available to the home gardener and are registered in Queensland for use on cole crops, fruit trees and vines and tobacco. These preparations, such as 'Dipel' and 'Thuricide', contain bacterial spores, and also diamond-shaped protein crystals, produced by the bacterium, which are toxic to many types of caterpillar. When ingested with contaminated food, the crystals cause rapid gut paralysis and the insect ceases feeding almost immediately. Death, however, may not occur for two to four days. Beneficial insects such as pollinators or natural enemies are not directly affected.

B. thuringiensis is produced by fermentation from basic raw materials. No instances of the development of resistance have been recorded, and present strains are considerably more active than the original ones used and hence lower dosage is required. The spores and crystals have low persistence on the crops and are not normally regenerated in infected insect populations, so, as with the chemical insecticides, repeat applications are required. As preparations of *B. thuringiensis* are exempt from residue tolerances, they can be applied until the harvest of the crop. Cost of the material, imported from the United States, is relatively high, but could be greatly reduced with increased sales volume and by local formulation of the raw material.

Insect viruses

At the moment, insect viruses are considered to hold greatest promise for microbial control and a number are being developed for this purpose. This requires painstaking study of the nature and characteristics of the virus and testing to establish safety and efficacy on the crop. One only has achieved registration in the United States. As with *B. popilliae,* the viruses possess the capacity to spread through host insect populations. This is helped by the tendency for some types of infected larvae to move to the top of the plant before dying. Shortly after death, they disintegrate, releasing masses of virus.

Virus production requires living insects or cells. The WHO and FAO have recommended that two types only, the nuclear polyhedrosis and granulosis types, which occur embedded in protective crystalline protein, be considered as pesticidal agents. They show a high level of specificity for their host insects and have never been shown to infect higher animals, including humans, despite their widespread occurrence. Over 20 diseases of these two types have been recorded in insects including armyworms, loopers and other caterpillar pests in Queensland.

Preparations of a nuclear polyhedrosis virus from the *Heliothis* caterpillar, also known as the cotton bollworm, corn earworm and tobacco budworm, are registered for use on cotton in the United States and are being tested in Australia. The virus proves to be highly infectious to local pest *Heliothis* species in the laboratory but the results of field testing of early formulations on cotton were generally disappointing largely owing to low persistence on the plant. A problem associated with the use of viruses is their inactivation by sunlight. More recent formulations are reported to have a greater protective capacity and prolong the life of the virus.

Other viruses which have been tested with some success in Australia include granulosis viruses specific for the codling moth, potato tuber moth and the cabbage white butterfly.

The fungi

These are undoubtedly the most spectacular of the insect disease organisms and in function most resemble the 'contact' insecticides. However, their requirements for moisture for spore germination and finally spore production on the surface of the infected insect is a serious handicap on non-irrigated crops.

Nevertheless, several are being developed overseas for insect control. These include *Beauveria bassiana*, which infects a wide range of insects and which is used against the Colorado potato bettle in the U.S.S.R. *Nomuraea* (*Spicaria*) *rileyi* occurs widely in such insects as the corn earworm, armyworm, loopers and cluster caterpillars enveloping larvae with a blue-green velvet layer of spores. This fungus is also being developed for use on soybeans and other crops in the United States. Species of *Entomophthora*, whose spores are "fired off" often producing a light halo around the infected insect, commonly infect aphids, the house fly, and a range of caterpillars, and may become amenable to artificial production with improved technology.

The Protozoa

Protozoa, such as the spore-forming microsporidia, are widespread in insect populations. Infections tend to be chronic rather than acute, and effects on insect populations debilitative rather than destructive. They could, however, prove valuable in long-term control programmes. *Nosema locustae*, a pathogen of grasshoppers, is one of the protozoa being investigated overseas.

What are the long-term prospects for the use of disease organisms to control insect pests? It is not envisaged that microbial agents will replace chemicals but that they will play an important supplementary role. Occasions on which they could be employed include:

- when the development of pesticide resistance has rendered chemical control ineffective;
- where restrictions are imposed concerning the use of an effective pesticide, e.g. before harvest to reduce residue levels or in the presence of unacceptably high levels of pesticides in the environment;
- when selective, non-disruptive control measures are needed for integrated pest management programmes.

The selection of more virulent strains and improved technology for their production would make their use increasingly attractive. A search for special additive or synergistic effects when disease organisms are used in combination with low doses of chemicals is also being made. Disease organisms requiring living systems for their production, such as viruses and microsporidia (protozoa), are now produced in live insects.

However, already cell lines adapted for growth in relatively simple media are available and it is not unlikely that a reduction in production costs by the use of cell cultures may soon be feasible. Improvements in methods of application and formulation, including the use of baits and adult transmission of the disease, are important aspects also receiving attention.

The exploitation of these natural, selective and biodegradable resources has hardly begun. The realisation of their potential will result from a co-operative effort by scientists, governmental agencies, industry and the farming community.

Soybeans in the Central and Upper Burnett

by I. ROMANO and J. C. KERR, Agriculture Branch.

High-yielding varieties and an increase in prices have made soybeans increasingly popular in the Central and Upper Burnett.

Since 1971, the area sown has increased from trial areas to over 500 ha at Monto and 860 ha around Gayndah and Mundubbera for the 1974–75 crop.

At Monto the bulk of the crop is grown on the alluvial soils of Three Moon Creek and Splinter Creek. One successful crop has also been grown on the Burnett River alluvials at Eidsvold.

At Mundubbera and Gayndah most of the crop is grown on the alluvial soils of the Burnett and Boyne Rivers. The remainder is grown under rain-grown conditions on the Binjour and Gurgeena plateaux.

Although the average rainfall for the growing period appears adequate (Table 1), it is too variable to ensure consistently good dryland crops. As a result, supplementary irrigation is generally used. In a good growing season in 1976, dryland crops at Monto yielded up to 3·7 tonnes/ha.

VARIETIES

Variety trials have shown that the popular varieties Bragg, Davis and Wills are well suited to the region. They yield well and have good disease resistance. The results of three trials conducted at Monto are shown in Table 2.

However, Davis will shatter if left unharvested for more than two weeks after maturity, so a grower relying on contract harvesting should grow an alternative recommended variety.

SOILS, FERTILIZERS AND NODULATION

The clay loams and sandy loams of the Burnett River system are ideal for soybeans. They present no nodulation difficulties and fertilizers are not generally required.

Growers should remember that soybean nodule bacteria do not exist naturally in Queensland soils and it is essential to inoculate the seed before planting soybeans for the first time in any field. It may be advisable, or even necessary, to inoculate subsequent crops of soybeans.

Nodule bacteria are easily killed by sunlight and high temperatures. Inoculum should be stored in a cool place and the inoculated seed should be kept in a shady situation until put into the planter. It is advisable to plant seed as soon as possible after inoculation and that no more seed than can be planted in half a day should be inoculated at any one time.

LAND PREPARATION AND TILLAGE

Cultivation should be designed to produce a medium-fine, compact seedbed free of weeds, sticks and rocks.

Cultivations to control weeds are necessary until the plants are large enough to shade the soil sufficiently to suppress weed growth.

Where weeds are a major problem, trifluralin (sold under the trade name Treflan) is frequently used on irrigated crops. The continued use of this herbicide has successfully controlled grass weeds but has assisted in the establishment of non-susceptible, broad-leaf weeds. These broad-leaf weeds have become so bad at Monto that soybeans are no longer a propostion on some farms. Bentazon (sold under the trade name Basagran) could prove useful in controlling weeds which become troublesome after crop emergence.

TIME OF PLANTING

Day length governs flowering and, if planted too early, soybeans tend to develop large bushy plants. Under good conditions these soybeans are capable of high yields but if dry conditions are encountered, yields are drastically reduced. Conversely, late plantings flower before the plants have had time to produce sufficient vegetative growth and again yield suffers. In practice a compromise is reached and a planting date between these two points is used.

In the Central and Upper Burnett the ideal planting time is mid December. However, successful crops have been planted as late as the end of January. Planted in mid December, the variety Bragg would flower in about 50 days and the variety Hill about a week earlier.

On no account should crops be sown in November. In the past, rain-grown crops sown in late November have made tremendous vegetative growth, run into dry weather, and then produced very little grain. Sown one month later, these crops would have produced payable yields.

ROW AND PLANT SPACINGS

Rain-grown crops can be planted in rows spaced 65 to 105 cm apart with earlier plantings at the wider spacings and later plantings at the narrower spacings.

Where irrigation is available narrower row spacings in the range of 35 to 75 cm can provide higher yields.

Choice of inter-row spacing will depend on whether herbicides or inter-row cultivations are to be used for weed control. If cultivations are intended then the row spacing will have to be wide enough to permit passage of the necessary machinery.

Messrs. I. Romano and Roy Schimke inspect a crop of Bragg soybeans grown at Three Moon Creek near Monto.

PESTS AND DISEASES

Although many diseases affect soybeans, few have caused widespread damage to soybeans in Queensland. Bacterial pustule and wildfire have been the most important diseases so far encountered and these can be avoided by growing soybean varieties resistant to them. Semstar is susceptible to these diseases and growers are advised to avoid growing this variety.

Full details of soybean diseases found in Queensland and their control are available in the *Queensland Agricultural Journal,* June, 1974, Vol. 100, p. 194.

While many insects feed and breed in soybeans the most important in the Central and Upper Burnett are the green vegetable bug and the lucerne crown borer. Because of its situation within the stem of the plant, the lucerne crown borer is very difficult to kill with insecticides and the best control measure is crop rotation.

Green vegetable bugs can cause significant losses in soybean crops if they are present in numbers from flowering onwards. Attacks on the flowers and young pods result in the loss of these fruiting units. Attacks on older pods may result in the termination of development of individual seeds or in severe loss of quality through seed being mis-shapen or shrivelled. In uncontrolled situations, the pest can cause severe yield reduction.

Green vegetable bugs can be controlled by chemical sprays. Endosulphan at 750 g active constituent per hectare, or methomyl at 425 g active constituent per hectare, is recommended. Growers are advised to examine their crops twice a week from flowering onwards and apply insecticides only when pest levels warrant protection. The presence of one adult bug every few metres or a cluster of immature bugs every 10 metres of crop row would warrant spraying.

A boom spray with inter-row dropper attachments will deposit spray into the crop canopy better than an overhead boom spray. Aerial applications are the least effective but they are infinitely superior to no protection at all.

IRRIGATION

The main problem in producing good soybean crops in the Central and Upper Burnett has been the lack of moisture at pod-filling. The shortage of moisture at this stage is more critical than that at flowering according to trials conducted in the United States. So, if only one irrigation is to be given, it needs to be carefully timed. In the Monto area, soybeans are usually given a 10 to 12 cm irrigation at flowering. However, at Gayndah and Mundubbera most crops are irrigated at least two or three times.

On fallowed land there is usually sufficient moisture available to grow the crop to the flowering stage before moisture stress occurs. In a double cropped situation, moisture stress can occur before flowering if rainfall is erratic.

HARVESTING

As the plant matures the leaves fall leaving a plant framework with exposed, ripening pods. The crop should be inspected regularly from this stage and harvesting begun without delay when the seeds have matured.

Combine harvesters will harvest soybeans satisfactorily and manufacturers' recommendations for drum speeds and concave adjustment should be followed.

If harvesting losses are to be reduced to a minimum, the crop must be cut low but not so low as to contaminate the seed with soil. The ground speed of the harvester should be kept low and the peripheral speed of the reel should be about 125% of the ground speed. Harvesting should not be delayed after the seeds have matured as shattering can occur in some varieties as the plants are cut.

YIELDS

Dryland crops have not been wholly successful to date, and average yields would be about 1 tonne per hectare. However, with supplementary irrigation on fallowed ground, yields of 2 to 2·5 tonnes per hectare are easily attainable. One crop at Monto grown on old lucerne ground in 1974 and given two irrigations yielded 4·4 tonnes per hectare.

SEED HANDLING AND STORAGE

Excessive handling of soybean seed, particularly with augers, causes damage to the seed coat and reduces germination. The germination percentage of soybean seed deteriorates in storage, the drop depending on temperature and seed moisture content.

Seed intended for future plantings should not contain more than 10% moisture and should be kept in cool, dry conditions.

FODDER AND HAY

Soybean may be used for grazing or can be made into hay if few pods are set and expected grain yields are uneconomic. When used for these purposes soybean is equivalent to lucerne in nutritive value.

If soybeans are to be used for hay, the recommended time to cut is when the seed is half-developed.

TABLE 1

AVERAGE GROWING SEASON RAINFALL (MM)

Month	Monto	Mundubbera	Gayndah
December ..	118·0	99·3	107·1
January ..	114·3	108·2	107·0
February ..	136·8	100·0	111·1
March ..	88·9	69·1	79·2
Totals ..	458·0	376·6	404·4

TABLE 2

SOYBEAN VARIETY TRIALS AT MONTO
Yields in kg/ha

Variety	1972–73	1973–74	1975–76	Means
Bossier	..	..	3 305	..
Collee	..	..	2 978	..
Davis	2 422	1 332	3 458	2 404
Bragg	2 785	1 342	2 650	2 259
Flegler	2 277	1 326	3 101	2 235
Wills	2 325	1 276	3 076	2 226
Hill	2 495	1 283	2 476	2 085
Semstar ..	2 277	940	3 034	2 084
Semmes ..	2 688	1 444	..	2 066
Leslie	2 470	1 176	..	1 823
70/39	..	857	2 789	1 823
Hood	2 228	1 333	..	1 781
Hampton ..	1 768	864	2 650	1 761
Pickett	872	1 102	..	987
Means	2 202	1 189	2 952	..

NOTES—

The 1972–73 trial was irrigated prior to planting and received good follow-up rainfall.

The 1973–74 trial received 100 mm of rainfall in the first two days after planting and very little later in the growing season.

The 1975–76 trial experienced excellent growing conditions throughout.

No fee on brand return

Your brand return is required so that the Brands Directory can be revised.

This prevents cancellation of your brands.

A fee is not required with this return.

A watertube level with a difference

by R. F. S. KELSEY,
District Adviser in Soil Conservation,
D.P.I., Nambour.

Why guess at levels when for a few dollars you can make an appliance that is accurate and simple to use?

THE principle of the watertube level is as old as the pyramids. Clear plastic tubing has simplified its construction.

The modified extension leg suggested at the end of this article, makes the surveying of a graded line (one with a percentage rise or fall) just as simple as marking a level line.

Material

The level consists of two strips of timber —152 cm by 40 mm x 20 mm (approximately 5′ of 2″ x 1″). These rods are marked in centimetres. Two dressmakers tapes, one secured to each rod, save a lot of time marking. Tapes with the metric markings only (1–152 cm) are obtainable. These are easier to read than tapes with both metric and imperial markings (by putting the 1 cm marking at the top of the staff the numbering is right-way-up. Note—a survey staff is normally marked from the bottom to the top).

A 13 metre length of 10 mm clear plastic tubing is sufficient to give readings up to 10 m apart (1·5 m will be taken up by the attachment of the hose to each rod).

A base plate, say 40 x 40 mm, will provide a better footing for the rods.

A small plug for each end of the hose is desirable. *These must be removed when taking levels.*

Construction

The open ends of the hose are attached to the top ends of the rods and secured to them for approximately two-thirds of their length.

The hose is now filled with water to within 15–20 cm of each end, making sure that there are no air bubbles in the hose. Laying the hose out up-hill from the filling point quickly removes bubbles.

Running a Line without Modified Leg

The level may now be used to mark a level or graded line.

First hold the two staffs together and with plugs removed from the hose check the height of the water column.

Holding the staffs together to check water height. If the tops of water column don't agree there could be a bubble in the hose.

To mark a level line, one staff is then held on a selected starting point. The other staff is taken to the extent of the hose (being careful not to stretch it) and moved to positions up or down until both staffs register the same reading. At that point the ground beneath each staff will be on the same level. Because of hose stretch, accidental water spillage etc., the readings need not be identical with those taken before the start. This is of no importance. The line can now be continued by moving the first staff to the point just located by the second staff—and so on—marking each level point in turn.

To mark a graded line with say, a 2% fall, the readings on the staff must differ by 20 cm with the rods 10 m apart. Some water may have to be removed from the hose. First hold the two rods together. If the water reading is 23 cm on each then the readings for the 2% grade line will be approximately 13 and 33 cm. The 33 cm will be on the high ground and must lead to the up grade direction. If running downhill, the 13 cm reading will lead. (Remember that the staffs have been numbered from the top down—as stated above.)

Always remove the plugs from the hose ends. Placing a finger over the end during movement will restrict spillage.

The modification

A simple modification will enable a line to be run on a desired gradient with matched readings on each rod. This overcomes problems of water height variation (due to hose stretching etc.) or when a big gradient—say 5%—is being used. Here one rod will have a high reading (say 11 cm) while the other will be 61 cm (only 91 cm from the ground).

An additional piece of 40 x 20 mm timber 1 m long has holes drilled in it, or slotted so that it can be bolted to one rod to enable extensions of 0, 5, 10, 20, 30, 40 and 50 cm to be made to that rod. (The small 40 x 40 mm base plate will now be attached to the base of the 1 m extension and not to the rod itself).

A line with a set percentage rise or fall can now be run simply by extending the adjustable rod for the desired percentage fall. Water level readings will now be the same on each rod. For example if a 20 cm extension is used, the extended rod will be on ground 20 cm lower when readings on both staffs are the same. This will be a 2% (1 in 50) grade if the staffs are 10 m apart. Similarly, extensions of 5, 10 and 40 cm will give grades of 0·5, 1 and 4 per cent.

In areas where small percentage gradients are desired such as 0·2%, 0·3% etc., it is suggested that the extension rod be slotted rather than have the holes drilled in it. This would enable fine adjustments. The percentage fall can be marked on the back of the main rod. A 1 cm extension will give a 0·1% grade (at 10 m readings). A 4 cm extension will give 0·4%.

Remember—no bubbles in hose—remove plugs from hose to take readings—the extended rod (or the low reading if no extension) will be on the low ground—it must lead on a downhill grade.

Surveying the line. The extended leg will be on the lower ground when the water columns agree.

Such tasks as levelling spouting or facia boards, the bottom of post holes or house stumps are made easy with this level. For the latter task it may be necessary to remove the rods and just use the hose—particularly for low buildings.

With a minimum of experience you will be surprised how quickly a graded or level line can be surveyed with this simple yet accurate instrument.

Adjusting the extension leg to the desired gradient. The percentage gradient is marked on the staff above the extension leg.

CHANGING YOUR ADDRESS?

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

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

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

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

Part 7

Guide to Soils and Plant Nutrition

by N. G. CASSIDY.

In this section

Organic fertilizers

COMPARED with concentrated, artificial fertilizers, *animal manures* are weak and so they are safe to use at very heavy rates of application.

Moreover the nutrient elements present are slowly released in soluble form by the process of decomposition. This increases their safety, and so "fertilizer burn" is very unlikely.

Other "safe" fertilizers are compost, guano, blood and bone.

Animal manures are bulky when fresh, because they contain as much as 85% of moisture. Table I shows that even dry manure, which has been protected from leaching by rain, has a low content of plant nutrients. It would take 2·5 tonnes of dried manure per hectare to provide the N and P requirements of an average crop, and K would still be short-supplied.

It is relevant here that in animal excreta whereas the nitrogen is equally divided between faeces and urine, almost all the phosphorus and calcium is contained in the faeces, and most of the potassium is in the urine.

It is conceded that on a mixed farm, the nutrient applied as fertilizer and feeding stuffs are largely recovered in the manure to the extent of 40% of the nitrogen and 75% of the phosphorus and potassium.

TABLE 1

GUIDE LINES TO THE VALUE OF ORGANIC FERTILIZERS

Note that the *total* content of nitrogen, phosphorus and potassium is specified. This becomes available to plants only as decomposition proceeds.

Organic material	Nitrogen	Phosphorus	Potassium
	% of moist or of moisture-free material		
Animal manures—			
Cattle (86% moisture)	0·6	0·09	0·38
Horse (76% moisture)	0·7	0·09	0·46
Sheep (68% moisture)	1·0	0·17	0·83
MEAN VALUE (moist)	0·8	0·12	0·56
MEAN (moisture-free)	3·5	0·5	2·5
Poultry (75% moisture)	1·4	0·44	0·40
MEAN (moisture-free)	6·0	1·8	1·6
Bat guano (moisture-free)	8	2	2
Plant materials—			
Compost (moist)	0·5	0·3	0·6
Compost (moisture-free)	1·0	0·7	1·3
Green manure (moisture-free)	2·40	0·19	1·67
Sugar cane trash (moisture-free)	0·40	0·07	0·60
By-products—			
Sugar Mill mud (Filter cake) (moisture-free)	1·5	0·6	0·2
Molasses	0·7	0·07	4·0
Distillery waste (Dundar)	0·6	0·07	5·4
Rice hulls	0·29	..	..
	0·2	0·02	..

Compost

Compost and leaf litter contain only about half the nutrients that are present in farmyard manure of the same moisture content. So they have to be applied at very heavy rates if the needs of crops are to be met. Such a system would be quite impracticable if crops are exported off the land.

Compost that is derived only from legumes will have a higher nitrogen content and a more favourable C/N Ratio than normal compost. Such material results from a *green manure* crop, which is one that is allowed to grow just to maturity, and is then ploughed into the soil. The favourable conditions of succulent plant material and a low C/N ratio soon produce good compost within the soil. This practice conserves the fertility of the soil.

Guano is an organic manure of only local importance. It is formed from the droppings of bats in caves, or of sea birds on islands. It is very variable in composition, and as the moisture content is often high, it also suffers from the disadvantage of bulkiness. In moisture-free form it is a moderately concentrated fertilizer.

The presence of *minor elements* is an important feature of all organic manure, compost, leaf litter and even of rock phosphate and agriculture limestone. Table 2 provides guide lines to these sources of trace elements. At the same time it shows that the soluble, manufactured fertilizers (ammonium sulphate, potassium sulphate, potassium chloride and sodium nitrate) are practically devoid of trace elements. Chilean sodium nitrate is a natural substance and it contains many minor elements, notably boron.

The other virtues of organic matter have already been mentioned and these should be referred to and reconsidered here because of their undoubted importance in plant nutrition.

TABLE 2

GUIDE LINES TO SOURCES OF MINOR (TRACE) ELEMENTS

——	Fe	Mn	Cu	Zn	B	Mo	
			(Parts per million in dry substance)				
Animal manure	..	410	62	120	20	..	U.K.
	..	470	50	78	24	..	Yugoslavia
	..	210	16	96	20	2·4	Canada
Superphosphate	..	10	50	150	10	..	Mean (U.K. and Yugoslavia)
Rock phosphate (calcined)	..	1 750	90	650	..	..	Christmas Island
Agricultural limestones ..	..	330	< 10	30	5	..	U.S.A. (variable)
Soluble fertilizers— $(NH)_2SO_4$, $NaNO_3$, K_2SO_4, KC1	..	< 10	< 10	< 10	< 10	..	United Kingdom
Plant leaves—							
Orange	120	30	70	30	40	5	U.S.A. 3–7 months
Coconut (mean) ..	75	20	2	9	10	..	Good orchards
Soybeans (mean) ..	156	74	14	40	50	..	U.S.A.
Deciduous fruits (Mean)	130	80	17	(18)	70	..	South Africa
Maize—							
(Minimum)	76	31	7	16	6	0·2	
(Maximum)	750	128	19	66	16	1·4	

Artificial fertilizers

AN understanding of the composition of fertilizers is vital for all those who buy or use them. First it is necessary to understand the method of expressing the concentrations of plant nutrients. This is done by stating the percentage of each element that is an active ingredient of the particular brand of fertilizer.

Nitrogen (N), phosphorus (P), and potassium (K) are the usual elements to be considered, but others may be concerned (Mo, Cu, Zn) in the more complex fertilizers.

The *Percentage Formula* of a mixed fertilizer is derived in the following way. The table below shows the N,P,K, content of various single ingredients. Suppose ammonium sulphate (20%N) is mixed with a superphosphate (8%P) and potash sulphate (40%K) at the rate of 100 parts by weight of each, plus 100 parts of an inert filler—

Quantities by weight (units)	Total	N		P		K
Ammonium sulphate	100	20		—		—
Superphosphate ..	100	—		8		—
Potash sulphate ..	100	—		—		40
Filler	100	—		—		—
Final mixture ..	400	20		8		40
%Formula of mixture		5	:	2	:	10

This mixed fertilizer would have the formula 5–2–10. If applied at 2 000 kilograms per hectare it would provide 100 kgN, 40 kgP and 200 kgK per hectare.

This kind of analysis enables a buyer to find out what he pays for the separate ingredients to be made into a mixed fertilizer. He can also decide which would be the cheaper of two fertilizers that have different formulae, *but might both be suitable* for his purpose.

A high "% formula" can result in freight savings e.g. ammonium sulphate might be replaced by less than half its weight of urea.

Fillers are needed in making fertilizers of low % formulae, but they also serve to condition the fertilizer against becoming damp in moist atmospheres. "Carriers" aid in the incorporation of very small amounts of trace elements.

The percentage formula does not completely characterize a fertilizer mixture. Some substances are more hygroscopic than others, and the following table shows how some of the most common fertilizers will take up moisture.

The salt index concerns the tendency to provide high osmotic pressure in the SOIL SOLUTION.

Fertilizer	Hygroscopic rating*		Salt Index
Calcium nitrate ..	Very high	54	..
Ammonium nitrate ..		41	105
Ammonium sulphate ..	High	30	96
Sodium nitrate		28	100
Urea		28	75
Potassium chloride ..	Moderate	16	114
Potassium nitrate ..		10	74
Potassium sulphate ..	Low	4	46
Ammonium hydrogen phosphate	Very low		30
Superphosphate ..	Very low		8

* (100—Relative humidity just sufficient to cause moisture-absorption).

Calcium nitrate and ammonium nitrate may become "deliquescent", i.e. wet from water taken out of the atmosphere.

Ammonium sulphate is only hygroscopic when it contains free sulphuric acid. (It then becomes damp, but not *wet*).

Potassium salts are much less hygroscopic than the corresponding sodium or ammonium salts.

Note that mixtures of fertilizers may be more hygroscopic than the separate materials.

Potassium sulphate and also phosphate fertilizers have low values for moisture absorption.

The *best conditions* for manufacture and storage of fertilizers are:—

- Low initial moisture content of all ingredients.
- Granulation i.e. avoidance of small particle size.
- Coating of very soluble constituents with diatomaceous earth or other conditioner.
- Incorporation of not less than 5% of a low density material such as diatomaceous earth, kaolinitic clay, bark dust etc. (Alternative to the above).
- The use of plastic inner containers, to exclude moisture.

- Store in conditions that are as dry, weather-proof and air-tight as possible.

The results of carelessness in preparation and storage may be:—

- Wet fertilizer that cannot be handled by distributing machinery.
- Fertilizer that cakes hard in the bags.
- Corrosion of metal parts that come into contact with fertilizer.

The following figure provides a guide to the mixing of different kinds of artificial fertilizer.

MIXING POSSIBILITIES OF STRAIGHT FERTILIZERS

□ Can be mixed

■ Cannot be mixed

☒ Can be mixed under conditions, i.e. if distributed not later than 3 days after mixing.

	1 Calcium Nitrate	2 Sodium Nitrate	3 Mixture of Ammonium Sulphate and Nitrate	4 Calcium Ammonium Nitrate	5 Sulphate of Ammonia	6 Nitro Chalk	7 Superphosphate	8 Basic Slag	9 Rhenania phosphate, Roechling phosphate	10 Sulphate of Potash Magnesia (Patentkali), Sulphate of Potash	11 Kainit, 40%, 50% and 60% Potash Salts	12 Doublesuperphosphate
1 Calcium Nitrate	□	☒	☒	☒	☒	☒	■	☒	☒	☒	☒	☒
2 Sodium Nitrate	☒	□	□	☒	□	☒	☒	□	□	□	□	☒
3 Mixture of Ammonium Sulphate and Nitrate	☒	□	□	□	□	■	□	■	☒	□	☒	□
4 Calcium Ammonium Nitrate	☒	☒	□	□	□	■	☒	■	☒	☒	☒	□
5 Sulphate of Ammonia	☒	□	□	□	□	■	□	■	☒	□	□	□
6 Nitro Chalk	☒	☒	■	■	■	□	■	□	□	□	☒	□
7 Superphosphate	■	☒	□	☒	□	■	□	■	■	□	□	□
8 Basic Slag	☒	□	■	■	■	□	■	□	□	□	□	□
9 Rhenania phosphate, Roechling phosphate	☒	□	☒	☒	☒	□	■	□	□	□	□	□
10 Sulphate of Potash Magnesia (Patentkali), Sulphate of Potash	☒	□	□	☒	□	□	□	□	□	□	□	□
11 Kainit, 40%, 50% and 60% Potash Salts	☒	□	☒	☒	□	☒	□	□	□	□	□	□
12 Doublesuperphosphate	☒	☒	□	□	□	□	□	□	□	□	□	□

In order to save work the farmer, before distribution, can himself mix for a certain crop the fertilizers which are to be applied all at the same time. Certainly all fertilizers do not tolerate mixing. The above diagram indicates which fertilizers can or cannot be mixed. From this it will be seen that the potash fertilizers can be mixed with practically all other fertilizers.

Grassed sports grounds

THE problems with sports grounds often arise right at the beginning when the area is being marked out and levelled. Almost always there is some cutting and filling to be done. This leaves raw subsoil at the surface (or even rock) in some places, whilst others may then have a considerable depth of soil. If this condition is not alleviated there will always be great differences in the growth of grass and in all aspects of care and maintenance.

The raw subsoil area should be harrowed, and covered with a layer of well-rotted cotton-seed waste, bagasse, mill-mud, bark dust, leaf litter etc. before top-dressing with soil. These materials will restore organic matter without creating a weed problem.

Alternatively a slurry of paper pulp containing a grass seed mixture and some fertilizer, may be applied through a hose.

The seed is thereby given good protection during the germination period, and early growth is promoted by the fertilizer.

The rest of the treated area may also need to be top-dressed with soil. The organic wastes help to prevent compaction.

Top-dressing material should first be tested for its physical condition by watering some of the dry material until it is moist, yet not wet. A sample is then made into a little cake about 4 x 3 x 2·5 cm and allowed to dry completely. If it will not break up into unconsolidated material, without heavy pressure, it is unsuitable. A sandy loam material is preferred for top dressing because it spreads easily and immediately works its way down through any existing grass.

It is advisable to test the top-dressing soil also for salt content, whilst sawdust materials should be checked for any excess borax, which may have been used against wood-borers. Where large areas are concerned a knowledge of the nutrient status of the soil will allow the best fertilizer mixture to be chosen.

For a hard-wearing turf the frequent use of nitrogen and skimping on phosphorus *must be avoided*. Unless the soil is well endowed with phosphorus the percentage formula of the fertilizer to be used should not be of a higher ratio of N : P than 10 : 5. An application of 5 kg 10–5–0 fertilizer per 100 sq. metres could be broadcast after the first spring rains and another after the main wet season.

Whenever possible it is best to *mow* sports fields as soon as the grass reaches 3·5–5 cm and to ignore the calendar. There are two good reasons for this. Firstly, the small yield of clippings can be left where it falls: this will save on fertilizing and avoid risk of potassium defiiciency if tall grass material never has to be removed from the fields. Secondly, this regime preserves plant food reserves in the root-crown, there is no set-back to the grass, and no bare patches are exposed for the development of future problems.

A high-grade sports field can only be maintained if there is a good water-supply, with regular use of it as required. Under frosty but dry winter conditions, early morning sprinkling may be beneficial: but for regular watering, a soil probe should be used to prevent a water penetration of only a few cm in one place and perhaps more than 30 cm in another.

Preparation of cricket wickets is a special problem. The following discussion refers to the actual wicket area, not the out-field. The out-field area (except in so far as the cricket pitch is moved from side to side in order to recondition it) can be treated like any other sports field.

The principles that apply are different from those of agricultural pastures because a level, compact, hard-wearing surface with a short grass covering is the only aim. A heavy clay soil layer and regular rolling are the inescapable means of achieving this.

Ten cm of suitable clay soil is sufficient for replacing of the natural topsoil in the area where the wicket is likely to be developed.

The natural subsoil must support good root growth and it may therefore need phosphate fertilizer. It must have good internal drainage, and for a high-grade wicket this involves 'tile' drainage. Porous agricultural drainage pipes 7·5 cm in diameter are laid at about a metre below the surface in trenches packed with vitrified (not powder) ash, or coarse gravel. The packing in each trench should reach up to the black clay of the wicket area. The drains are laid 10 to 15 metres apart on a 1% gradient, across the natural fall of the area. The pipe lines are then connected to a main and finally to a larger earthenware pipe with a free outlet beyond the cricket field.

The soil for a wicket must have certain characteristics. It needs to be a heavy clay which cracks rather than goes loose on top, when it is very dry. It will naturally have low permeability. A certain amount of sodium (say 10%) may make up part of the cations and some calcium carbonate nodules may be present. When such a clay is maintained in a reasonably moist condition and rolled frequently, it provides the firm surface resistant to abrasion which is required of a wicket. The required clay may occur as a B horizon from which surface horizons must first be carefully removed.

Soil salinity can be a problem of wickets, especially when underground water is used for watering. Water with 1 300 p.p.m. soluble salts has been used without any accumulation of salt when the internal drainage was good. (Good surface drainage only sheds run-off and this by itself is insufficient).

When salt has accumulated, ponding of water on the surface is necessary for some days so as to wash the salt through to the drains. Tests on the drainage water can help in following the process. A salt level of 500 p.p.m. Cl (1·4 m.e. NaCl per 100 g soil) in the imported soil is acceptable.

The only defence against the risk of salt is to use the least saline water if a choice is possible, and especially to avoid many short sprinklings of the wicket. Watering should be light, but continuing until the drains begin to run.

As in all cases of the science of growing plants the right species must be chosen in the first case. Under a range of Australian conditions the couch grass *Cynodon dactylon* has been most successful for wickets and the inclusion of winter grasses when seeding would appear to be unnecessary.

Bowling greens also have special problems. The original preparation is almost a matter of civil engineering. A very efficient system of tile drains, with their associated envelope of gravel or clinker must first be laid down.

The necessary top soil can be entirely imported because of the small area concerned: it needs to have good internal drainage; and finally the surface for grassing needs to be laid and well-settled so that subsidence will not occur anywhere. The final levelling must be as near perfect as possible, in all directions.

Maintenance is a matter of experience and judgment as well as science. When continuous trampling has compacted the surface too much, renovation by removing vertical cores of soil and filling the holes with sand, becomes necessary. At other times top-dressing only may be appropriate.

Club-houses sometimes shade parts of the greens and this makes the area prone to weeds, especially in winter. Worm-casts are ruinous and appropriate insecticides must be used.

Organic fertilizers are not recommended because they encourage insects and earthworms.

Technique of pot experiments

THE cultivation of plants in soil, sand or water culture (usually in pots, in a greenhouse or glasshouse) is complementary to experimentation by means of field trials.

In water culture the plants grow in a solution of inorganic salts: the same applies to sand culture, in which a sterile sand merely provides support for the plants. When soil is used, the object is to simulate field conditions as closely as possible; and this is not difficult as far as the addition of fertilizers is concerned.

However, the chief weakness of pot experiments lies in the divorcement of a relatively small sample of soil from the main bulk, both laterally and in depth. In practice an associated factor is the physical treatment applied to this sample. It usually happens that the larger the scale of glasshouse operations the more severe is the treatment. In an endeavour to obtain uniformity in the potting soil, a bulk sample is often dried and then put through a machine such as a concrete mixer. Often the soil is even ground mechanically, so that it can be sieved. When such soil is filled into pots and re-wetted it may have little resemblance in physical structure to the soil in the field.

There is no doubt that the ideal method is to take a bulk sample when the field is moist but not wet; then to break this up by hand just sufficiently to obtain mixing by roll-turning on a large mixing sheet, and to fill this immediately into the pots. How this can best be approximated, in large scale experiments with many replications, is a problem for each experimenter.

The technique of pot experiments requires many precautions.

The matching of plant species with pot sizes is important. Vegetable beans can be expected to grow naturally in a pot that is 20 cm deep, but it would be foolish to expect this of lucerne after the seedling stage.

In all cases (just as in field trials) extraneous factors must be removed. Thus legume seed must be inoculated with *Rhizobium* culture; any known or suspected deficiency (e.g. P, Zn etc.) that is not under investigation, must be removed by a basal treatment to all pots, including the control or "no treatment" pots.

Air temperatures must be controlled within the limits of what may be expected under field conditions. Sophisticated systems are now available (at a price) for the stabilization of many such factors as temperature, humidity, air movement and light intensity.

Other systems are available for automatic watering and for the dispensing of culture solutions.

Pests and diseases can usually be held in check better in a glasshouse than in the field.

When *water* or sand *culture* is used, effective *aeration* must be maintained artificially. These systems are therefore more difficult to operate. For example, very fine sand can make it hard to achieve satisfactory moisture content and air content simultaneously. Most of the sand particles should be larger than 0·5 mm. It is often better to use plastic granules.

An air pump connected to an electric timer supplies a stream of air to each pot for a short period, and the cycle is repeated many times daily.

Pots of porous earthenware are unsuitable because they cannot be used a second time. Soluble salts from a prior experiment will always be retained in the walls, and may vitiate any subsequent experiment.

Glazed earthenware is expensive. Plastic is the best for most purposes. Polyethylene will become brittle after long exposure to light: polystyrene is better.

Students can carry out valid experiments using tin cans (all of the one size) painted inside with bituminous paint to prevent corrosion.

Plastic bags may be inserted as liners for all work with trace elements.

Culture solutions of many different formulae are in use, and none could be claimed to be the ideal, because of the differing needs of plants. One solution that has been widely and successfully used is that of Arnon & Hoagland. It consists of the following (anhydrous) salts in grams per litre: 0·61 KNO_3, 0·66 $Ca(NO_3)_2$, 0·12 $NH_4H_2PO_4$, 0·49 $MgSO_4$. This provides a solution of the major elements as follows:—

Nutrient	Concentration
	m.e. per litre
Nitrate	14
Ammonium	1
Phosphate (H_2PO_4)	1
Potassium	6
Calcium	8
Magnesium	4
Sulphate	4

Trace elements are added as borax, manganous chloride, zinc chloride, copper nitrate and ammonium molybdate. These supply boron and manganese at 0·5 ppm: zinc 0·05 ppm: copper 0·02 ppm and Molyndenum 0·01 ppm.

Iron is added separately once or twice a week as ferric tartrate, to give 0·33 ppm Fe. For some species e.g. barley, B and Mn should be reduced to half.

The pH of the solution remains steady if more ammonium phosphate is added whenever phosphate needs replenishing; but complete renewal of the solution is required from time to time. It was found with tomato plants that 1 litre of culture solution would produce 8 grams of dry matter (say 35 g of green material).

Under subtropical conditions, it has been found that smaller pots of 15 cm top dimension produce 2·5 grams of dry matter per pot per month, using a number of different crops (Kikuyu grass, *Setaria sphacelata,* dwarf sorghum, rice).

Water. A normal city water supply can be used when the experimentation is only with N, P and K fertilizing. In other cases a purified water supply is necessary and this is most easily done by a water-softener (which will take out Ca and Mg) or better by a *deionizer* which will remove all of the cations and anions, except a little bicarbonate and silica.

The deionizer has the advantage that it removes trace elements. Some idea of the efficiency of these exchange resins is shown by the following:—

The deionizer is capable of purifying ordinary laboratory distilled water, which always contains some heavy metals carried over in the condensing steam.

Impurities (ppm)	Copper	Lead	Zinc
Laboratory distilled water (No. 1)	0·200 0	0·055 0	0·02
Redistilled water (Pyrex)	0·001 6	0·002 5	0·00
No. 1 through cation exchange (once)	0·003 5	0·001 5	0·00
As above (five times)	0·000 0	0·001 0	0·00

Tap water gave the following results when passed through a deionizer consisting of Amberlite IR–100 and Amberlite IR–40.

——	Total (ppm)	Silica (ppm)	Calcium (ppm)	Copper (ppm)	Iron (ppm)
Tap water	309	24·0	48	0·008	0·05
Deionized	27	22·8	0·01	0·002	0·002

The deionized water proved quite suitable for plant culture trials.

The size of things

THIS section aims at giving the principal dimension of various objects in the soil-plant system. It also shows the relation between the units of measurement.

Things which are too small to see with the naked eye, but can easily be examined under an ordinary microscope, are measured in "microns".

$$1 \text{ micron } (\mu) = \frac{1}{1\,000} \text{ millimetre or } 10^{-3} \text{ mm.}$$

Particles slightly smaller than a micron can be examined in this way.

The *Angstrom* unit (sometimes known as a 'tenth-metre') is used where the object is too minute to be seen under the ordinary optical microscope.

1 *Angstrom* (A°) $= 10^{-10}$ metre $= 10^{-8}$ c.m. $= 10^{-4}$ μ.

The wave length of visible light $= 0 \cdot 4$–$0 \cdot 8$ micron $=$ 4 000–8 000 A°.

The optical microscope is restricted in viewing very small objects, by the length of the light waves. The electron microscope uses electrons of size 4 x 10^{-9} μ instead of light rays. The lenses of the optical microscope are replaced by electrical circuits. The electron is the smallest stable particle in atoms.

The electron microscope can examine objects down to about 5A° but cannot be used to "see" atoms. Ions of sodium and calcium have a radius of only 1 A°, and other atoms are of the same order of magnitude.

Colloidal particles come within the size range 20–2 000 A°. They cannot be seen directly with an optical microscope but can be examined indirectly by reflected light in Dark Field Microscopy.

Soil clay by definition is less than 2 microns or 20 000 A°. Only a portion of it is colloidal in size. A clay of good structure will show little colloidal suspension when gently stirred with water.

Plant cells are of the order 50 x 150 microns. The cell wall is about 5μ thick, then there is a layer of protoplasm 2μ wide, and the rest of the cell is the vacuole.

Stomata or leaf pores are mostly on the under-side of the leaves. Some examples are given below.

Cyclic salt particles are mainly in the range 0·1–10 microns. Larger (macro) particles in the atmosphere near the sea coast soon fall to ground level.

Filter papers have pores of the following sizes:—

Fast-filtering ("open") 3·5– 5 microns
Slow-filtering ("close") 0·5–1 microns.

Wool fibres come within the range
15 to 25 microns in diameter.

"Smog" particles are commonly within the range 0 to 1 micron.

The size and the number of stomata affect the ability of leaves to absorb particulate matter, such as dust of various kinds, atmospheric salt particles, and those emitted by internal combustion engines.

Examples are given below to show the variations that are possible.

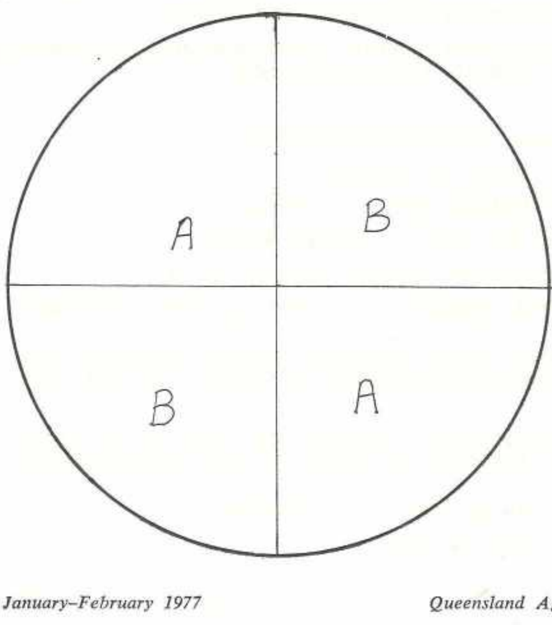
STOMATAL DIMENSIONS AND FREQUENCIES ON LEAF SURFACES

Species	Dimensions of Stomata		Number per sq. mm.	
	Overall (microns)	Opening (microns)	Upper surface	Lower surface
Banana	35 x 30	25 x 17	20	160
Breadfruit	20 x 16	15 x 5	Nil	420
Coconut	40 x 25	30 x 15	Nil	180
Cacao	12 x 12	4 x 4	Nil	690
Fern	60 x 40	60 x 10	Nil	40
Mango	7 x 7	6 x 1	Nil	800
Orchid	40 x 40	15 x 7	Nil	65
Papaw	10 x 5	8 x 2	Nil	760
Sugar cane	30 x 5	25 x 4	190	270

How to sample soils and plants

IDEALLY, *soils* should be sampled horizon by horizon in order to characterize each layer that goes to make up the whole profile. In academic studies this is the usual procedure. For more practical purposes, i.e. the growing of plants, a soil needs to be assessed by sampling to the depth of the root zone. This means that whereas for irrigated pasture 20 or 30 cm would be an appropriate depth, for mature coconut palms one metre would be a more realistic sampling-depth.

Whatever the depth, the method of procedure is the same. A hole with vertical sides is dug, the loose soil being all rejected. A slice is then taken vertically from one of the sides and the whole of this constitutes the sample. This slice must have a uniform thickness from top to bottom. It is gathered up from the bottom of the hole and placed in a plastic bag. If paper bags are used, wet soil will sooner or later burst out of the bag thus spoiling the sample. (Paper bags may also cause contamination with boron). About one kilogram of soil is ample. Should a smaller sample be needed, the soil is well-mixed and spread out on clean paper etc. (not on a bag contaminated with fertilizer.) It is then *"quartered"* in the following fashion. Two opposite quarters e.g. B–B, are rejected: the other two are remixed to form the final sample. This sub-sampling procedure can be repeated if a still smaller sample is all that is needed.



One such soil sample is unlikely to represent accurately the average composition of a whole field of soil. There are many reasons for this. The soil may not be of a homogeneous nature because of its method of formation. Animal manure or urine may have affected one place in the field, but not another that is only a few metres away. Fertilizer may have been spilled in places; or may have been applied, not broadcast but in rows only. It is therefore necessary to take more than one sample. Ten samples could be taken from one paddock, mixed, and then subsampled down to one sample, which may then give a good average sample. It is more revealing to take say, three entirely separate samples, and analyse each one separately. This increases the analytical work required, but it also provides a measure of the non-uniformity that exists. It enables one paddock to be mathematically distinguished from another, if such a difference exists. The first method does not provide this discrimination with certainty.

It has been found that adjacent plots as small as 10 x 5 metres can differ by 50% in nutrient-element content. The following figures are hypothetical (but quite realistic) values for two paddocks on the same farm sampled at six different places.

Paddock A	Paddock B
125 ppm	302 ppm
125	78
100	60
80	50
65	45
60	20

	A	B
Mean value for all six samples	92	92
Mean, omitting the lowest value	99	86
Mean, omitting the highest value	107	51

It will be seen that A is moderately uniform but B has a figure of 302 ppm which is highly suspect. Indeed the omission of the lowest value in each case does not alter the apparent similarity as judged by the mean value: but omission of the suspect figure shows clearly that Paddock B in reality has only about half the fertility of Paddock A, in the nutrient element under consideration.

Plants need more care, and some additional knowledge is a pre-requisite, if truly representative samples are to be obtained. It is first necessary to understand the distribution of elements within the species or plant concerned. Since plants, unlike soils, are discrete organisms the distribution of one element may not be the same as that of another.

Special sampling for a particular element could therefore be necessary. The plant-part to be selected should be one that is sensitive to changes in the amount of the element available to the plant. At the same time the plant part should not be of an age to be actively undergoing the process of translocation of nutrients, because this occurs only when senescence has begun.

The final result can be seen in an article by one worker in which up to 12 ways of sampling are given for each of 59 species.

From a utility point of view it is desirable to sample during the vegetative period of a plant, if it is intended to influence the yield of the current crop by an immediate application of fertilizer.

In sampling, say, the most recently-matured leaves of a plant crop, the same principles may be used as for soil samples. That is to say, more information is obtained by analyses of three separate samples taken at random than by one composite sample made up of ten separate samplings.

When a very precise value for the *yield* of say, a cereal crop is desired, it is best to proceed as follows:

Select at random five groups each containing five sheaves. Lay each group out in order of increasing size.

Take the first sheave of the first group, the second sheave of the second group and so on. These five sheaves will make a single representative sub-sample, which can now be weighed for the assessment of the true yield.

Glossary of terms used in this series

AEROSOL: Colloidal particles in the atmosphere.

ACID: A substance that produces hydrogen ions, (H cations) when dissolved in water. See ALKALI, ION.

ALKALI: A substance that produces hydroxyl ions (OH ions). The opposite to an acid. Water itself produces minute amounts of hydrogen and hydroxyl and is neutral i.e. it is neither acid nor alkaline.

ALKALINITY: The presence of alkali: in soils this involves the presence of sodium ions.

ANION: An ion carrying negative charge e.g. hydroxide, chloride, sulphate, nitrate, phosphate, bicarbonate, carbonate. When combined with hydrogen ion they form the corresponding acid.

ANION EXCHANGE, See EXCHANGE.

ANAEROBIC: Without air, and therefore short of oxygen. The opposite is aerobic.

ANGSTROM (A°): Unit of length in ultra-microscopic work. See page 80.

AMINO-ACIDS: Organic acids containing nitrogen; the building blocks of protein.

ANTAGONISM: This occurs when one element inhibits the uptake of another element.

ATOM: The smallest chemical building block: with an electric charge it becomes an ion.

BAR: Unit of pressure: approximately the same as normal atmospheric pressure at sea level. (1 000 millibars).

CATION: An ion carrying positive charge e.g. hydrogen, sodium, potassium, calcium, magnesium, zinc, copper. Combined with hydroxyl ion they form hydroxides ("alkalis" or "bases"). See next entry.

CATION EXCHANGE, See EXCHANGE:
Cations carry positive electric charges and are thus attracted to the soil clay which carries negative charges. A large amount of introduced cation can replace or "exchange for" other cations that are already present.

CHARGE: A quantity of electricity, often associated with an ION, or a COLLOID.

CHLOROSIS: Changing of green colour (of leaves) usually to yellow.

COLLOID: In solution, such a substance is dispersed as particles which are larger than molecules, but too small to settle out. They carry electric charges.

CUTICLE: A waxy substance covering the surface of leaves.

CONCRETIONS: Hard, rounded, lumps in the soil: separate in form and composition from the main fabric: usually found in middle or lower horizons.

DICOTS: (Dicotyledons). Flowering plants in which the seedling has two seed leaves or cotyledons. e.g. beans.

DISPERSION, DISPERSED: Complete separation into individual particles, as for example clay. (Deflocculated.)

ELECTRICAL CONDUCTIVITY: Ability to carry an electric current. The opposite of resistance or resistivity. The unit is the reciprocal ohm or mho.

EQUIVALENT (WEIGHT): A chemically equivalent amount, peculiar to each atom or compound.

EROSION: The removal of soil in a field, either by wind or flowing water.

EXCHANGE: The replacement of an ion on the surface of a colloid by another ion of the same kind i.e. cation for cation or anion for anion.

ENZYME: A protein, present in small quantity but producing an important effect. Each enzyme has a specific effect in plant growth.

FLOCCULATION: Opposite to dispersion. The aggregation or clumping together of separate particles.

FRIABLE: The consistency of soil when there is a good crumb structure. When individual particles form aggregates or crumbs, the moist soil is neither gritty nor sticky to the touch, nor does it soil the hands.

GROWTH DILUTION: A decrease in nutrient content that results when plant growth outstrips nutrient uptake.

GYPSUM: Calcium sulphate containing water of composition. Usually occurs as crystals that are barely visible, but very large ones are possible.

HUMATE: The anion of humic acid, a somewhat indefinite but typical component of decomposed soil organic-matter.

HYDRATION: A union between water molecules and some other substance.

INDUCED DEFICIENCY: One that was not present until another element was added. The result of an imbalance of nutrients.

INDICATOR PLANT: One that shows characteristic symptoms of a nutrient deficiency.

ION (Cation, anion): An atom or group of atoms carrying electric charge. Salts, acids etc. dissociate in water into two parts, cation and anion (q.v.). The number of units of charge (1, 2, 3 etc.) is equal to the VALENCE.

LATOSOL: A highly developed and strongly leached soil, typical of the tropics.

LATTICE: The framework of a crystalline substance, there being more empty space than atomic particles. An expanding lattice increases in volume by absorbing water into the empty space.

METABOLISM: The over-all result of the growth processes, involving the fixation of energy as plant-substance.

MONOVALENT: Carrying one electric charge and therefore possessing a single chemical "bond". Divalent, trivalent and higher valencies are possible.

MONOCOTS (Monocotyledons): Flowering plants in which the seedling has only one cotyledon or seed-leaf. e.g. grasses.

MOLECULE: A compound made up of atoms, either of the same kind or of different kinds.

MHO: The unit of electrical conductivity (q.v.). The reciprocal of the ohm.

NODULES: Separate, rounded particles in the soil, having their own particular composition quite different from that of the surrounding soil. Usually in the size range 1 mm to 1 cm. Ironstone and lime are the most common. (Rhizobia nodules are of course plant tissue.) See PLANT NUTRIENTS.

NUTRIENTS, See PLANT NUTRIENTS.

OSMOSIS: The tendency of two different solutions to equalize their contents of solute by diffusion, when separated only by a semi-permeable membrane. Diffusion may be of water only, or of water and solute. The solute is commonly a salt but may be sugars, alcohols etc.

OSMOTIC PRESSURE (of a salt solution): The pressure, or "head" of water that will just stop pure water passing through a membrane into a given salt solution. (The membrane must be pervious to water but not to salt.) It is usually measured in terms of normal atmospheric pressure or BARS.

OXIDE: A compound of oxygen with another element e.g. iron.

PED: A natural aggregation of soil particles. The most favourable are crumbs 2–5 mm in size, but much larger prisms or even columns are possible.

PHOTOSYNTHESIS: The synthesis of organic compounds by green plants, from water and carbon dioxide, using the energy supplied by sunlight.

PROFILE: The verticle face of a soil, which is exposed when a pit is dug down to rock level.

PLANT NUTRIENTS: The elements necessary for plant growth; (in this work, excluding carbon, hydrogen and oxygen).

PROTEIN: A complex organic compound made up of many amino acids.

RECYCLING OF NUTRIENTS: The natural process by which each generation of plants dies and decomposes to produce plant foods for the next. Fresh nutrients are only contributed by the slow weathering of rocks, by the nitrogen of legumes, and by artificial fertilizers.

RHIZOBIA: Nitrogen-fixing bacteria which live in nodules on the roots of leguminous plants.

ROOT ZONE: The volume of soil containing the majority (say 85%) of the plant roots. Most importantly the *depth* of soil necessary to achieve this.

SENESCENT (especially of leaves): Refers to the condition before death or abscission occurs.

SALT: Salt in general, is used here for the presence of such in the soil. A salt results from the union of a cation and an anion such as sodium and chloride. See ION.

SALTING: Any increase in the soil-salt that is likely to depress plant growth. It may refer to total salt throughout the profile or to a damaging concentration of salt near the soil surface.

SURFACE TENSION: The result of the mutual attraction of molecules in a liquid. Molecules at the surface experience a force towards the centre of the mass of liquid. On a non-wetting surface this causes water to shrink up into (spherical) drops.

SOIL SALINITY: The presence of excessive amounts of salt in the soil.

SOIL SOLUTION: The water (and whatever may be contained in it) that is in equilibrium with the soil. The quality of water for a given soil mass will vary. If the water is separated when the soil is saturated, this is known as the SATURATION EXTRACT. When soil is treated with a much larger quantity of water the separated liquid is simply a soil extract.

SOLUTE: The substance which has been dissolved, in a solution.

SPECIFIC GRAVITY (Relative density): The weight of a substance compared with weight of an equal volume of water. Apparent Specific Gravity (and not true Sp.Gr.) is involved if the substance is one such as soil, flour, sugar, which contains some air.

STOMATA: Leaf pores. A pair of guard cells embraces each stoma.

THRESHOLD VALUE: A critical percentage (or range) dividing a situation of good response from one of no response. (The beginning of the steep slope of the curve of plant growth.)

TRANSPIRATION: The escape of water vapour from plants, principally by evaporation through the stomata of the leaves.

TRANSLOCATION: The movement or transfer of plant foods from one part of the plant to another.

VALENCE (VALENCY): Combining-capacity of atoms or groups of atoms. See MONOVALENT. DIVALENT ions have two units of charge and two chemical bonds. TRIVALENT (aluminium, iron) have three units, and so on.

WATER-TABLE: The upper level in the soil zone at which there is saturation with water.

WILTING POINT: The soil moisture content at which a plant wilts, but recovers quickly when watered.

Trickle Degreening of Citrus Fruits

by K. R. JORGENSEN, Horticulture Branch.

IN 1968 the Department of Primary Industries introduced the trickle system of degreening to the Queensland citrus industry. Today, the technique is used in almost all major degreening rooms in Queensland (more than 50) and in several large packing sheds interstate as well.

The trickle system, with controlled temperature and humidity, degreens fruit in 60% of the time taken by the previous standard method: the "shot" method. It also reduces green mould development and fruit shrinkage in the degreening room, and virtually eliminates degreening room burn.

Citrus growers find that the trickle system is more convenient to use because it runs automatically without the twice-daily attention needed by shot method rooms. It also degreens fruit at a constant rate so they can predict exactly when fruit will be degreened and ready for packing.

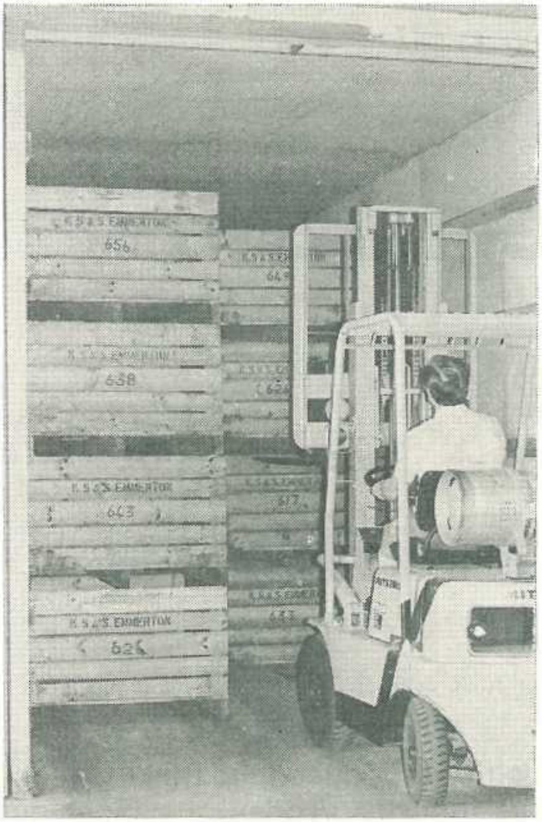
Why degreen citrus?

Citrus fruits require degreening because they often ripen internally before there is any appreciable change in the colour of their rinds. Fruit which are still green outside even though quite palatable inside do not sell well. It is therefore necessary for the citrus grower to speed up the colouring process before offering the fruit for sale.

The process of changing the colour of the rind is called degreening because it involves the destruction of the green pigment, chlorophyll, allowing the yellow colours of the carotenoid pigments to show through. It is a natural process which is simply speeded-up by exposing the fruit to low concentrations of ethylene after harvest.

The shot method

In the shot method of degreening which was used previously, fruit were loaded into an air-tight room, a shot of ethylene was introduced, sufficient to raise the ethylene concentration to 250 to 1 000 ppm, and the doors were closed up tight.



Trickle degreening is essential where fruit are bulk handled. The faster rate of degreening means that only half the number of bulk bins and half the volume of degreening room space is required compared with the old shot method.

Every 8 to 12 hours, the room was unsealed and the stale air allowed to escape. The room was then recharged with ethylene and resealed. These procedures continued twice daily for up to 7 days.

Some shot method rooms were charged with acetylene generated by the action of water on calcium carbide, instead of with ethylene.

Shot method rooms degreened fruit slowly because the conditions in them were often not conducive to the maximum rate of degreening or to good fruit quality. The following problems arose:—

- Carbon dioxide produced by the respiration of the fruit accumulated in the closed atmosphere and gradually slowed down the degreening process.
- The ethylene, being a very penetrative gas, gradually leaked out of the room and was no longer available to promote degreening.
- The room temperature was generally too low for maximum degreening rate but just right for high rates of green and blue mould development.
- Low humidity in the room after each ventilation period caused the fruit to transpire water, losing size and firmness in the process.
- Early in each citrus season, some fruit were damaged by degreening room burn and could not be sold.

This burn appears to have been caused by fine droplets of water condensing on the fruit as the room cooled overnight. The water dissolved spray residues and dirt already on the fruit to produce a concentrated solution which burnt the rind.

The overall effect of the shot method was a slow rate of degreening, shrinkage of the fruit and an actual loss of fruit due to mould and degreening room burn.

Trickle system introduced

The first shot method room to be converted for trickle degreening was one on the property of Mr. John McIntyre of Gayndah. This room was converted in time for the start of the 1969 citrus season.

After conversion, it degreened early Navel oranges in 3 days when an adjacent shot method room took 5 days. There was no degreening room burn (a continual problem with the room previously) and the fruit emerged with better size and appearance. Green mould losses were reduced because there was no infection of fruit in the degreening room.

By the end of 1969, four trickle degreening rooms were in operation in the Gayndah district and many growers were interested in the new system. Field days were then held by the Department of Primary Industries at Gayndah and Beerwah to explain the benefits of the trickle system and literature was prepared detailing the method of installing it.

Today all major citrus orchards in Queensland use the trickle system of degreening. Some have converted their existing shot method rooms, while others have built new rooms when they installed bulk handling.

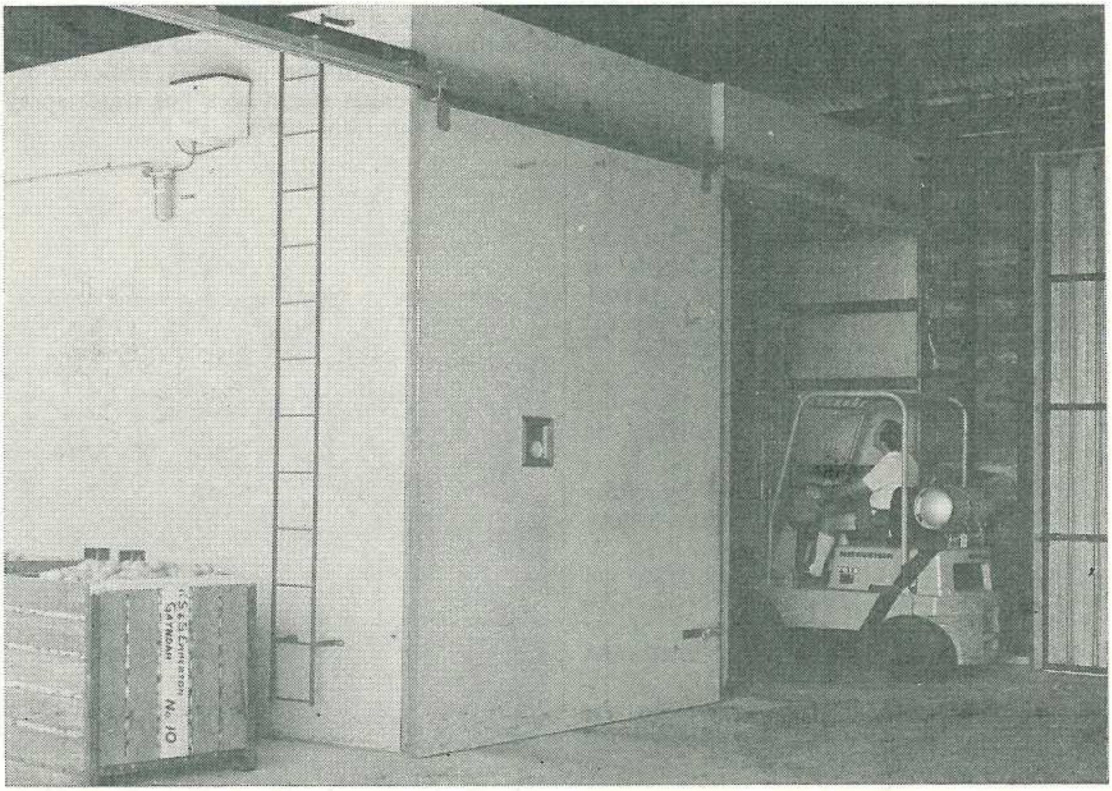
Because the trickle system degreens fruit quicker than the shot method, fewer rooms need to be built and fewer bulk bins are needed to store fruit during degreening. This compensates for the extra cost of the special equipment used in trickle degreening with controlled temperature and humidity.

Some trickle systems have been installed in tents made of cloth or plastic hung from the roof of the packing shed. These systems are cheap to build but the power costs for heating are high when degreening is done during cold weather because the tent is not well insulated.

All systems use the same principles, however, of controlling carbon dioxide levels, ethylene levels, temperature and humidity.

Carbon dioxide control system

The heart of the trickle system is a fan which circulates the air and ethylene around the fruit in the degreening room. The fan is also used to draw a small flow of fresh air into the room through an adjustable intake, which is let into the walls of the room near the fan. This fresh air forces out an equal volume of stale, CO_2 laden air through gaps left around the door of the room.



Trickle degreening was introduced to Australia by the Department of Primary Industries in 1968. It is now used in all major citrus degreening rooms in Queensland and in many interstate.

The most convenient position for the ventilation fans is the space between the ceiling of the room and a false ceiling which is installed below the true ceiling. The false ceiling seals against the sides of the room and finishes 45 cm short of the ends of the room. The position of the fan and false ceiling is evident in the cross section plan on this page.

The fan is let into a wall which extends across the ventilation space from one side wall to the other. When the fan is operating, air is drawn up from one end of the room, across the ventilation space between the two ceilings and blows through to the other end of the room. The return flow of air passes through the body of fruit on the floor of the room.

A fan capable of moving approximately one room volume per minute is sufficient. In existing shot method rooms being converted to trickle degreening, there may not be sufficient head space to include a false ceiling. In that case, the fan and air flow ducting can be installed above the room.

The air intake is let into the true ceiling of the room near the suction side of the fan so that fresh air is sucked in from outside when the fan operates. An adjustable gate on the intake allows the intake flow to be adjusted to 1% of room volume per minute.

The ethylene system

When the room is filled with fruit and closed up, an initial charge of ethylene is given which is sufficient to provide a concentration of 10 ppm in the room. As the fan sucks in fresh air, some of this gas is lost along with the stale air which is forced out. Sufficient gas is therefore trickled into the room to provide 10 ppm of ethylene in the intake air.

This ethylene flow is measured by either passing the ethylene through a float-in-tube flow meter or by passing it through a simple bubble jar made from a gas-tight glass jar filled with kerosene. The bubble jar is calibrated by collecting the output from it under an inverted glass measuring vessel filled with water.

A solenoid valve is connected into the ethylene line after it leaves the ethylene gas cylinder and pressure regulator. The valve is used to shut off ethylene flow whenever the fan is switched off.

Heating system

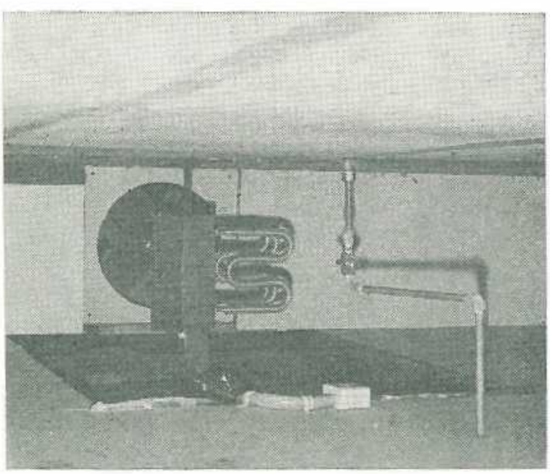
A temperature of around 29°C is required in the room for optimum degreening rate and minimum green mould development. This temperature can be maintained by installing electric fin tube heaters in front of the fan and wiring them through a thermostat.

To conserve heat the rooms are insulated. One method is to build the walls out of two sheets of hardboard separated by an air gap containing a sheet of reflective building paper.

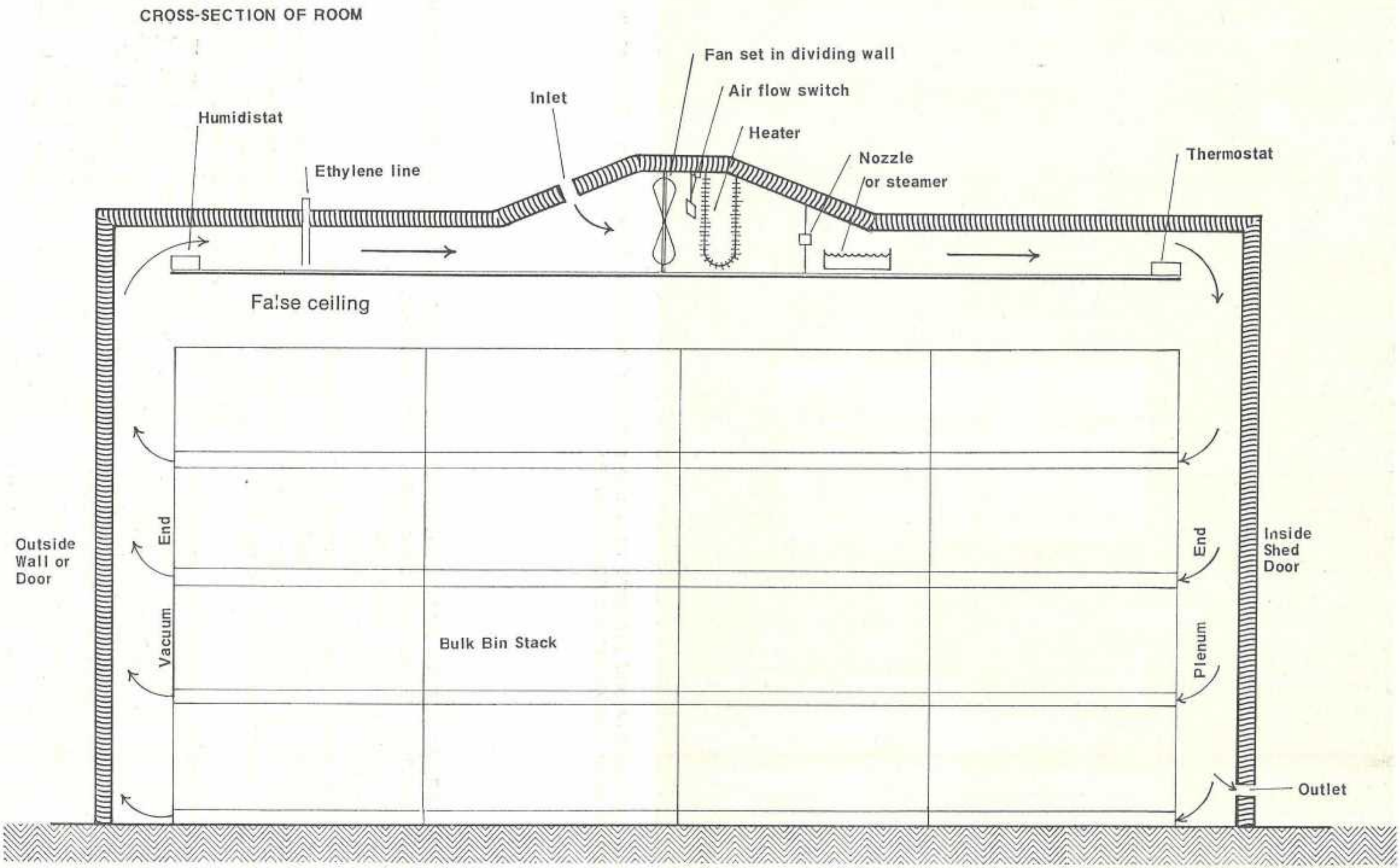
Another method is to apply spray-on insulating foam to walls made of a single sheet of hardboard or metal. This foam can also be used to insulate and seal old shot method rooms that are being converted to the trickle system.

Humidification system

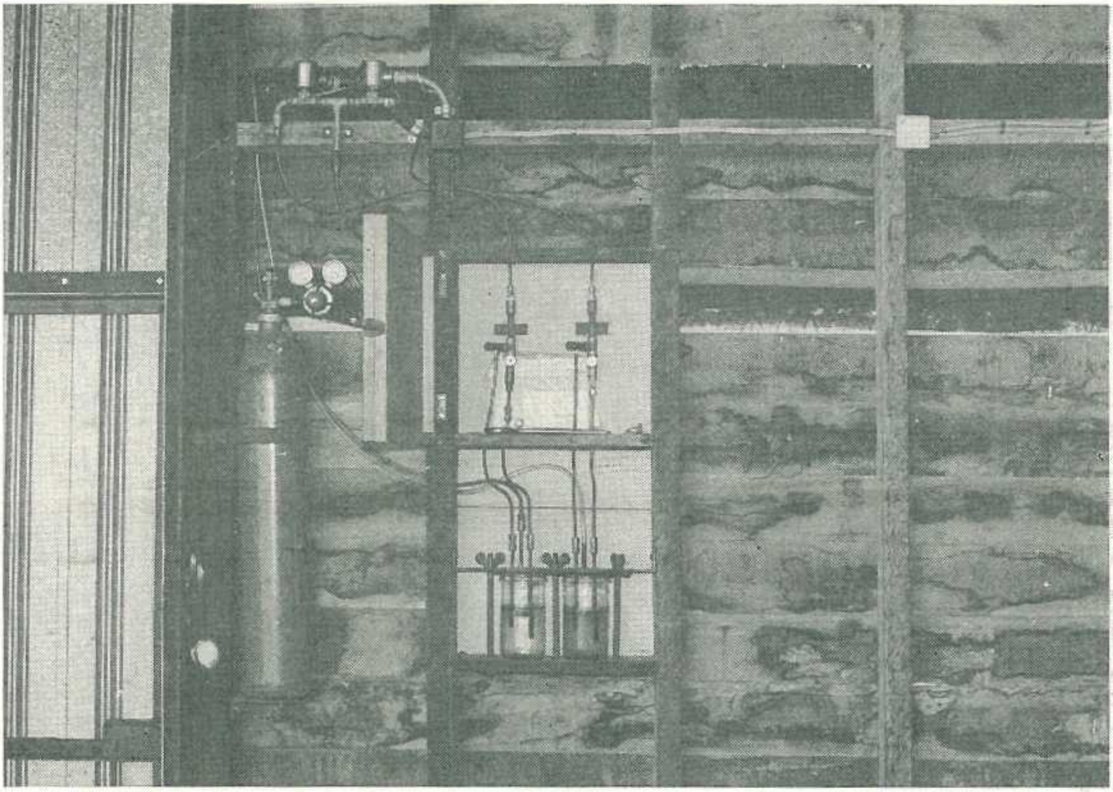
The humidity in degreening rooms should be maintained at around 95% R.H., if moisture loss from the fruit is to be prevented. Humidification of the room is achieved by introducing either steam or a fine water spray into the room atmosphere.



The air circulation, heating and humidification equipment is installed out of the way in the space between the true ceiling and a false ceiling.



Cross-section plan of complete trickle degreening room showing the position of ventilation, heating and humidification equipment.



One ethylene gas cylinder and pressure regulator can feed several trickle rooms. Each room requires its own solenoid valve, bubble jar and control valves.

The steam can be simply generated in an electric kettle mounted in the ventilation space above the false ceiling and connected to a cistern to maintain the water supply. To generate the fine water droplets required for spray humidification, a pneumatic atomising nozzle connected to a filtered water supply and a supply of compressed air is set up above the false ceiling.

These humidification systems are most conveniently operated by an automatic humidistat. Unfortunately the cheap, hair-type humidistats do not have a long life in the humid, dusty conditions of a degreening room. More expensive electronic humidistats can be used or the humidification system can be controlled manually. Alternatively, a low capacity steam system can be left to run continuously in dry weather.

Control system

To ensure complete safety in the operation of trickle degreening rooms they are wired so as to "fail safe" should the fan cease to operate because of mechanical or power failure. The electrical authorities in Queensland have given permission for standard (non-flame-proof) electrical equipment to be used in rooms that are so protected instead of the much more expensive flame-proof equipment required in shot method rooms. They also require that the ethylene controls are under lock and key.

The fail-safe wiring includes a micro-switch activated by a vane positioned in front of the fan. When the fan is blowing the vane closes the micro-switch which is interlocked with all three control circuits: heating, humidification and ethylene flow. If the fan ceases to move air for any reason, all control circuits shut off.

The trickle system is extremely safe to operate because it requires only a 10 ppm concentration of ethylene whereas the explosive concentration in air is 30 000 ppm.

Operating the room

Once a trickle system room is adjusted, operating it is a very simple process. Fruit is placed into the room, the doors are shut and the electric controls are switched on. The room is given an initial charge of ethylene and from then on it runs itself automatically. Indicator lights in the electrical control panel show when the heating and humidification systems are switching on and off.

The trickle system degreens citrus fruit quickly and well, with minimum losses from mould and burn. It also degreens at a fixed rate allowing operators to plan their packing program with confidence.

The trickle system may also have advantages in other post harvest ethylene treatments such as ripening tomatoes and ripening bananas.

International Congress for Adelaide

THE XXVI International Congress of Apiculture will be held in Adelaide this year, from October 13 to 19. The venue for the Congress will be the Adelaide Festival Centre for the performing arts.

Hosts for the Congress, the Federal Council of Australian Apiarists' Associations, extend an invitation to all interested in any of the many facets of beekeeping to attend this first-ever Congress of Apiculture to be held in the Pacific area.

A feature of the Congress will be a series of events designed to give participants an insight into the many aspects of Australian beekeeping and its unique honey flora and into the Australian way of life.

The programme has been developed so each session will deal with an important major topic that will be of interest and value to beekeepers throughout the world. At least one session will be devoted to a special topic that the organising committee considers appropriate. One session will be devoted to general papers.

A highlight of the programme is a field day at the famous Barossa Valley, the premier wine-producing area of Australia.

Further information on the Congress may be obtained by writing to: The Secretariat, International Congress of Apiculture, G.P.O. Box 2609, Sydney, N.S.W., 2001.

School Project Feature

Australian Beekeeping

Australia is a great country for honeybees and for beekeepers.

The first honeybees reached Australia by sailing ships in 1812—none was native to Australia because those that moved eastward through Asia did not reach the isolated continent.

Conditions for beekeeping in Australia have led to the development of a migratory style of beekeeping based on a relatively small operation of some 800 beekeepers with over 200 hives and up to 3 000 hives, producing over 80% of all Australian honey. All beehives have to be registered with the State Departments of Agriculture.

Australian beekeeping in the main is dependent on the unique native flora which may produce very heavy yields of quite distinctive honeys. The climate, generally, is one of hot summers and mild to cool winters so that bees may breed all through the year. Many of our important native honey producing plants flower in the cooler parts of the year so that by moving their hives about the country, our beekeepers may harvest honey all the year round. In this way a beekeeper in Western Australia, operating 400 single queen, eight frame Langstroth hives, harvested an average of 357 kg of honey per hive.

Nevertheless, Australian beekeepers have their problems. Some species of Eucalypts flower only once in 2 to 4 years and the amount of nectar they yield is extremely variable.

Some of the most important nectar producing trees are unusual in that bees cannot obtain any pollen from them. Often in the dry environment no other pollen-producing plants are available and bees stop breeding. Nectar may drip from the flowers to the ground but the bees do not forage because they cannot breed.

Other species of natural flora produce so much pollen that the broodnest becomes restricted and the strength of the colony declines unless the beekeeper takes some preventive steps. On one such occasion one pollen trap yielded 2 kg of pollen in one day. Some of these honey flows may last for several weeks and continual attention is necessary to ensure that the colony can maintain maximum rates of broodrearing.

Many of the pollens of the native flora appear to be detrimental to bees and since the bees are not usually able to gather a variety of pollens there are many nutritional problems.

A unique feature of beekeeping in South Australia is the Kangaroo Island Ligurian bee. This bee, which represents what is probably the last remnant of the Italian bee as it occurred in its homeland a century ago, was introduced at that time to the Island which has always been a sanctuary with no other bees allowed thereon.

An interesting discovery was that of an isolated population of what is understood to be the original European Black bee which was introduced to Tasmania about 120 years ago.

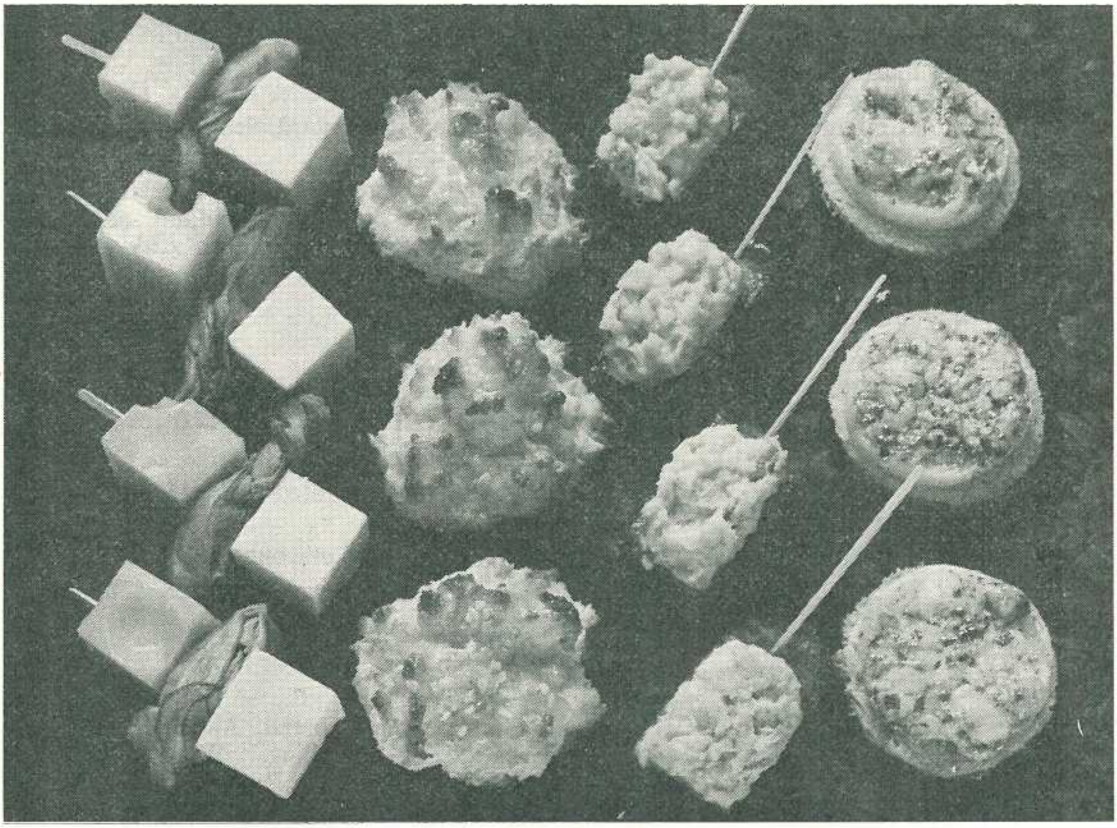
The beekeeping industry in Australia is highly mechanised at beekeeping and packer levels. Furthermore, it has many singular characteristics and the beekeepers are necessarily inventive. Due to the high yields of honey, the rough and often isolated areas in which they must work and the long distances that have to be travelled, Australian beekeepers have developed distinctive types of approach and technique that will be of great interest to their counterparts from all other parts of the world.

Article provided by the Secretariat, International Congress of Apiculture to be held in Adelaide in October, 1977.

Snappy Cheese Snacks

GRATE it, cream it, bake it, or slice it, call upon Australian cheese whether bland Ricotta, robust Parmesan, tasty Cheddars, piquant blue vein, smooth cream cheese, mild Mozzarella and nutty Swiss. All are individualistic in flavour and texture yet quickly and easily complement fancy-shaped, cut, sliced bread, selected commercially packed or home-made savoury biscuits.

Quick Oyster Picks, Sesame Bites, Mustard Pickle Kabana, Blue Onion Crisps.



For a surprise, try quick oyster picks and mustard pickled kabana—two unusual cheese ideas using canned oysters and kabana as snack bases.

In all recipes a standard 250 ml measuring cup and 20 ml tablespoon are used. All measurements are level.

★ ★

Walnut snaps

The Walnut Biscuits

2 oz. butter

1 egg

1 cup plain flour

½ teaspoon salt

½ cup finely chopped walnuts.

Cream butter till smooth. Mix in egg and 1 tablespoon of flour. Work in remaining flour and walnuts to make dough. Knead lightly on floured board. Roll out into an oblong shape, ⅛" thick. Cut into 1½" squares. Place on lightly buttered baking tray. Bake at (400°F) for 10 minutes. Makes approximately 3 dozen.

The Dip

Beat together—

2 oz. Australian blue vein cheese,

4 oz. Australian cream cheese.

Mix in—

2 tablespoons brandy.

Serve with the biscuits.

★ ★

Curried ricotta shapes

Beat together—

8 oz. Australian Ricotta cheese,

1 teaspoon Madras curry powder.

Pipe rosettes or pile onto salted dry biscuits. Garnish each with a small pickled onion. Makes approximately 1½ dozen savouries.

Sesame bites

1½ cups self-raising flour

1 tablespoon baking powder

pinch salt

approximately 1 cup milk

melted butter

1 cup freshly grated Australian Parmesan cheese

¼ cup toasted sesame seeds, tossed in dry pan till golden brown.

Sift dry ingredients into a bowl. Mix in remaining ingredients to make a soft dough. Place a teaspoon of mixture onto baking tray. Bake at (450°F) for 10 minutes. Remove and immediately brush with melted butter. Sprinkle with salt if desired. Makes approximately 3½ dozen.

★ ★

Mustard pickled kabana

½ stick kabana, halve lengthwise, cut into 1½" lengths

2 oz. Australian cream cheese

1½ tablespoons mustard pickles

paprika.

Cream cheese till smooth then beat in pickles. Pile or pipe onto cut side of kabana. Place a toothpick into each end. Sprinkle lightly with paprika. Makes approximately 20 savouries.

★ ★

Tuna celery triangles

Combine together—

½ cup finely grated Australian Parmesan cheese

¼ cup prepared mayonnaise

1, 6 oz. can tuna, drained and flaked

½ cup chopped celery

16 thin slices white or brown bread

softened butter.

Butter slices of bread. Make 8 sandwiches using all of the filling. Wrap in foil and refrigerate overnight. Remove crusts and cut into triangles. Makes 32 triangles.

Quick oyster picks

1, 8 oz. can oysters, drained and rinsed

2 oz. Australian Swiss cheese, cut into cubes

2 oz. Australian cream cheese, cut into cubes.

Allow two oysters, a cube Swiss cheese and a cube cream cheese per toothpick. Count oysters then estimate the size of each cheese cube to be cut.

★ ★

Cardamon cheddar fingers

2 cups finely grated Australian matured Cheddar cheese

1 egg

½ teaspoon ground cardamon

¼ teaspoon ground cummin

⅛ teaspoon cayenne pepper

6 thin slices white bread

little melted butter.

Beat egg and spices together. Mix into cheese thoroughly. Brush baking tray with melted butter. Place bread slices onto baking tray and brush with butter. Spread spiced cheese onto bread. Bake at (400°F) for 10 minutes. Remove from oven. Sprinkle with salt. Remove crusts then cut into fingers. Serve immediately. Makes 18 savouries.

Blue onion crisps

melted butter.

5 thin slices white bread.

10 thin slices white onion.

ground cloves.

2 oz. crumbled Australian Blue Vein cheese.

Using a plain 2″ round cutter, cut two rounds from each slice of bread. Brush baking sheet with butter. Arrange bread rounds on top. Brush each with butter and top with a slice of onion. Brush with more butter. Sprinkle each with pinch ground cloves, then top with cheese. Bake at (350°F) for 15 minutes. Makes 10.

★ ★

Red and gold canapes

melted butter.

4 thin slices white bread, crusts removed, cut diagonally into 4 triangles.

1 medium tomato, peeled, seeds removed, chopped finely.

¼ teaspoon dried basil leaves.

salt and pepper to taste.

½ cup finely grated Australian Mozzarella cheese.

Brush flat baking sheet with butter. Place bread triangles on tray and brush each with butter. Mix tomato, basil, salt and pepper together. Spread onto bread. Sprinkle cheese on one half of triangle only. Bake at (400°F) for 10 minutes. Makes 8.

Q.A.J. subscription changes

On 1 January this year, new subscription rates were introduced for the Queensland Agricultural Journal.

The new rates are—Ordinary—$6.90 per annum

Concession rate—$2.30 per annum

Also, no more than 2 years' subscription may be taken out at any one time.

S. R. HAMPSON, Government Printer, Brisbane

AVOCADO ROOT ROT

ROOT ROT, caused by the fungus *Phytophthora cinnamomi* is the most serious disease of avocadoes in Queensland.

In recent years, it has caused the death or decline of thousands of trees in the south-east corner of the State.

Symptoms

Trees of any size may be affected. Leaves turn pale-green and wilt. This is followed by leaf fall and dieback. In the final stages of the disease, the tree is reduced to a bare framework of dying branches. Death may take from a few months to several years. It is not uncommon for declining trees to set heavy crops of small fruit.

Under healthy trees, white, succulent feeder roots are plentiful. However, under severely diseased trees, roots are few in number, black and decayed.

The root rot fungus sometimes causes trunk cankers which are watersoaked, white, gummy areas near the base of the trunk. When the outer bark is removed, brown, discoloured wood will be seen.

Under conditions of severe waterlogging, a rapid decline of trees may occur. The foliage rapidly wilts and dies and the tree is left covered with a canopy of brown, dead leaves.

Spread

The fungus causing root rot is a water mould which thrives in waterlogged soils. Water is required for spore production, movement of swimming spores through the soil and root infection.

The root rot fungus is widespread in south-east Queensland, but is not present in all soils. It is commonly introduced in diseased nursery trees.

The environment plays a very important role in the appearance of root rot symptoms in avocado. Trees may decline rapidly in sandy soils low in nutrients and organic matter but show no symptoms on deep, fertile soils. Symptoms do not appear unless there is an upset in the balance between the water requirements of the leaves and the capacity of the roots to absorb water. To control root rot, it is important to achieve this balance from the start and maintain it throughout the life of the plantation.

Control

1. Plant disease-free nursery trees which have been propagated in sterilized potting mixtures from pathogen-free seed and irrigated with phytophthora-free water. If disease-free nursery trees are not available, sow pathogen-free seed and graft *in situ*.

2. Use well-drained soils. High fertility does not compensate for poor drainage.

3. Apply frequent, light dressings of lime or dolomite.

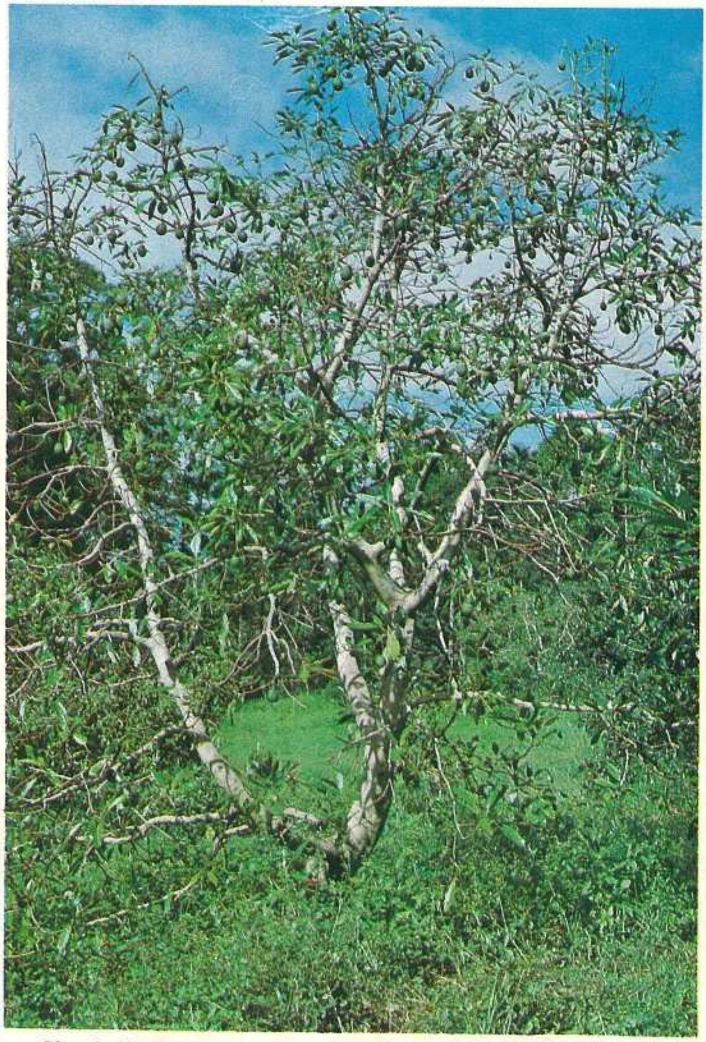
4. Use organic sources of nitrogen.

5. Avoid clean cultivation and grow cover crops throughout the year to maintain high organic matter levels. Maintain a deep, open mulch around the trees.

—compiled by N. T. Vock, Plant Pathology Branch.

(Further information may be obtained from your nearest Plant Pathology Branch office or by writing to the Director, Plant Pathology Branch, Department of Primary Industries, Meiers Road, Indooroopilly, Q. 4068.)

AVOCADO ROOT ROT



Classical root rot symptoms—light green drooping leaves, heavy leaf fall and twig dieback.

Trunk canker.

Root systems from an affected seedling (left) and a healthy seedling (right).

Rapid decline due to root rot under severe waterlogging.