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DEPARTMENT OF AGRICULTURE, SOUTH AUSTRALIA

Agronomy Branch Report

MINI-CONFERENCE

ANNUAL MEDICS:

Establishment, management and general utilization.

Convenor:

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Senior Plant Introduction Officer.

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AGRONOMY BRANCH MINI CONFERENCE

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EVOLUTION OF LEGUME-CEREAL FARMING SYSTEMS - THE SUCCESSES & SHORT-COMINGS

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1. INTRODUCTION:

The legume-cereal rotation or ley farming system, as we know it in South Australia, developed between the 1930's and 1960.

In broad terms it started in the 1930's, developed in the 1940's and really got established in the 1950's. Prior to this period the cereal lands had been through an exploitive phase, with frequent cropping on fallow.

Under this system much of the soil's natural fertility was exhausted, soil erosion in some areas was acute, and soil structure had been broken down and disease, such as Take-all, had become a serious problem.

With the development of the ley farming system came a reduction in fallow, increased use of superphosphate, increased barley acreage and an increase in the importance of livestock on cereal farms.

Possibly the real period of rapid progress was from the late 1940's to the early 1950's.

Some indication of this development can be seen from the following average wheat yield trends in South Australia:-

Table 1:

Ten Year Periods	Ten Year Mean Yields
1930-31 - 1939-40	11.1 bushels/acre
1940-41 - 1949-50	12.9 bushels/acre
1950-51 - 1959-60	17.5 bushels/acre
1960-61 - 1959-70	17.5 bushels/acre

Cereal yields have tended to have lifted from about 1948 onwards, and while no doubt many factors are involved, the impact of ley farming was probably the most significant one.

*(This paper has not been converted to metric units because of the nature and previous publication of the data).

2. THE IMPACT OF LEY FARMING:

With the introduction of legume-cereal rotations in the cereal areas, fallowing declined and pasture legumes were sown or volunteered over a wide area.

These grew quite prolifically in many areas stimulated by higher phosphate applications. As well as supporting more sheep, these legume based pastures replenished depleted organic matter reserves and lifted soil nitrogen levels. The increase in soil fertility was reflected in increased cereal crop yields and higher stocking capacities.

However, attempts to establish and maintain legume pastures were not uniformly successful throughout the cereal areas. The most impressive results were achieved on the grey, sandy and loamy mallee soils, and the black earths (the medic areas). Here the medics, barrel and burr established readily. Rotations were adapted and the alternate year cropping system was established with barley acreage increasing. To some extent this short rotation system was developed out of necessity in areas such as Yorke Peninsula where water supplies were limited. Because of the ability of medics to set a high percentage of hard seeds, they regenerated readily after one or even two cereal crops.

It was not, however, all spectacular success - on the hardier red brown earth soils of the north and transitional solonetz soils, volunteer pastures only contained sparse legume growth.

In these situations it was found necessary to sow early strains of subterranean clovers. These pastures were more difficult to establish and furthermore, they needed to be resown after each period of cropping. This lack of legume pasture development in the red brown earth zone was reflected in rate of soil fertility build up and subsequent affects on cereal yields as compared with the mallee soil areas.

3. YIELD INCREASES DUE TO LEY FARMING:

The difference in the rate of soil fertility development between the medic soils and the harder red soils can be seen by comparing yield increases from the 1930-40 period with the 1950-60 period in comparative hundreds in the Mid North and northern Yorke Peninsula (see Fig. 2).

Table 2:

County & Hundred	Years	Wheat Yield bushels/acre		Barley Yield bushels/acre	Total Wool lb.
County Daly:					
Cameron	1931-40 1951-60	14.4 23.9	(+ 9.5)	11.8 26.6	194,100 375,000
Ninnes	1931-40 1951-60	14.1 25.8	(+11.7)	16.1 29.2	104,000 376,600
Wiltunga	1931-40 1951-60	13.7 25.4	(+11.7)	13.4 28.1	168,300 413,500
County Stanley: (Western)					
Everard	1931-40 1951-60	10.2 21.4	(+11.2)	7.6 21.5	72,400 180,900
Stow	1931-40 1951-60	10.7 21.6	(+10.9)	9.9 22.5	58,500 213,000
Goyder	1931-40 1951-60	12.4 23.3	(+10.9)	10.5 22.5	133,000 296,800
County Stanley: (Eastern)					
Upper Wakefield	1931-40 1951-60	22.9 21.4	(- 1.5)	19.4 21.9	304,000 557,000
Stanley	1931-40 1951-60	22.8 23.8	(+ 1.0)	24.0 22.2	269,000 470,000
Clare	1931-40 1951-60	21.1 22.8	(+ 1.7)	17.0 21.2	234,000 826,000
Milne	1931-40 1951-60	21.5 22.6	(+ 1.1)	10.0 21.2	362,000 544,000

As can be seen the increase in wheat yield per acre in the Mallee soil zones of County Daly and County Stanley are in the range of 9-11 bushels per acre over this 30 year period. On the other hand, on the red brown earth soils in the Hundreds of the eastern part of County Stanley, wheat yields have only marginally risen 1-2 bushels per acre.

This general picture extends to other areas and a similar situation exists in the Lower North. Below is a comparison of County Light and County Gawler. County Gawler is predominantly mallee soils which readily grows medics, while the main part of County Light is red brown earth soils and more suited to subterranean clovers.

Table 3: Comparative Production in Counties Gawler & Light

County	Period	Acres Sown to Cereals (Wheat & Barley) 1,000 acres	Average Wheat Yield Bushels/ acre	Increase Bushels/ acre	Wool Production Average for 10 Years 1,000 lb.	Increase in Wool Production %
Gawler	1931-40 1951-60	152.5 140.0 (8.2% decrease in acreage)	15.75 23.8	8.1	139.14 355.59	155.5
Light	1931-40 1951-60	101.5 65.4 (35% decrease in acreage)	17.42 19.79	2.3	178.5 441.0	147.0

In County Light (rainfall 18-20") the average wheat yield was a little better than 19.7 bushels an acre in the ten year period to 1960. Comparing this with the average over a similar period ending 1940 we find an increase of only 2.3 bushels an acre. Whereas in County Gawler (rainfall of 15-17") the average yield jumped 8.1 bushels per acre during the same period.

Now referring to wool production in Table 3. At first glance it would appear that the wool production increase in both counties has been fairly similar. But it must be remembered that the acreage sown to wheat and barley in County Gawler only decreased 8.2 per cent, compared with a 35 per cent drop in County Light. In other words, there was a much smaller proportion of country available for sheep production in County Gawler, consequently its wool production per acre increased considerably.

4. OTHER FACTORS:

The figures quoted of course, only give the general picture of what the impact of ley farming systems has been.

Within each area there has been considerable variation in the quantity and quality of legume pastures and their consequent impact on soil fertility.

There are some additional points that appear relevant.

4.1 In the R.BE. zone there are numerous examples of individual properties where sowing of subterranean clovers has brought about increases in soil fertility and production at least equal to the gains made in the medic areas. The development of the farming system based on subterranean clover pastures has met with some setbacks over the years, such as unsuitable varieties, higher costs, problems with establishment methods, and dry years in critical years for resowing pastures. It is ovvious that there is still considerable progress to be made in the red brown earth zone.

4.2 In the mallee soil zone, there have been further gains since the initial impact of medic pastures which was based on Hannaford barrel and burr medics. Harbinger and Jemalong have further extended the range of soil types in these regions which can grow highly productive medic pastures.

The main problem in these areas at the present is maintaining highly productive medic pastures by assessing seed set and resowing at adequate rates whenever seed reserves fall below desirable levels.

5. CONCLUSIONS:

The evolution of legume-cereal farming systems has revolutionised our production in the cereal areas of South Australia since the late 1930's. The major gains have been made in the medic areas however, there is sufficient evidence to expect that similar gains can be made in the subterranean clover areas. Since the initial impact of ley farming our rate of progress has tended to level off. This means many refinements can be made to further develop our ley farming system to higher levels of production. I feel it is necessary to lift our horizons in relation to acceptable levels of production in many of our cereal areas - perhaps this will be achieved at this conference.

6. REFERENCES:

French, R.J., Matheson, W.E. & Clarke, A.L. - Soils and Agriculture of Northern and Yorke Peninsula Regions of South Australia. Bulletin No. 1.68.

Webber, G.D. - Clovers Will Lift Soil Fertility and Production. S.A. Journal of Agric., June, 1964.

Discussion

A comment was made that since the years 1950-60 increase in wheat yields has levelled off.

Since this period there has been a big expansion in new country- especially on Eyre Peninsula. The lower production from this newer land has contained average production. This year we may see the interest in increasing fertility level stimulated.

Three people involved in the change to an emphasis on legume pastures were : Mr. Alf Hannaford, Sir Allan Callaghan and Professor H.C. Trumble. Alf Hannaford produced the first commercial medic seed, and the other two were the ones who stimulated Hannaford to commercialize seed production.

The very rapid expansion in the use of medic pastures in the 50's was understandable. Farmers' thinking had changed during the 30's and 40's, but they had been hampered by superphosphate restrictions and lack of water on Eyre Peninsula.

Medics were used as far back as 1931 - in the Strathalbyn district there were bloat problems with cows on medic pastures in that year.

The history of barrel medic is recorded in the Herbage Plant Register. Medic seed was reaped on the Minnipa Research Farm in 1950.

County Stanley has shown little increase in wheat yields over the years. Pasture legume sowing was not widely practised despite our extension efforts - special legume meetings and using the change in county yields compared with other countries.

The legumes sown in the district often failed due to poor sowing techniques and lack of insect control. Interest in them waned due to the need for resowing, the failure of Bacchus Marsh and the fact that fallowing gives worthwhile responses.

Another factor involved is the interest in Dwalganup in the 1940's - and then reports of oestrogen problems came from Western Australia.

Dwalganup was widely sown after this period because it does well on Cu and Zn deficient country.

In the figures presented to us, the increase in wool cut in County Stanley is due to the increased area devoted to sheep.

The important message from this paper is that wheat yields have levelled out in the 60's, and in the early 70's the peak wheat yield in a good season has not increased.

Two further factors are involved.

1. Main reason for the change to ley farming was the price structure for rural commodities. High wool prices and barley prices led to high incomes, high super usage and an emphasis on livestock.

2. In the problem legume areas (County Stanley) when legumes were first sown in the district, they had 2 years of drought and Bacchus Marsh failed. Also when legumes were being promoted seed prices were high.

Our propaganda has often coincided with high prices of seed.

THE MONETARY VALUE OF ANNUAL MEDICS IN VARIOUS ENTERPRISES AND ENVIRONMENTAL CONDITIONS

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District Agronomist.

Can a monetary value be put on annual medics? It will be suggested in the introduction that it is impossible to give a clear cut value in dollars and cents because there are so many other reasons for increased production. Also it was most difficult to obtain specific information concerning the value of medics in any enterprise.

An endeavour has been made to put a monetary value on medics either as a direct gain or as a saving or reduced cost of production.

Other technological and management practises have gone hand in hand with the medic evoltuion. Two of the main ones have been increased superphosphate rates and higher yielding cereal varieties.

These alone would have increased production without the introduction of improved medic cultivars.

In the livestock situation there has been a steady improvement in wool weights and quality from better breeding and management. This would have taken place regardless of medics BUT the large increase in stocking rates can be attributed to the introduction and success of medic pastures.

After several years of a successful medic pasture development programme there are two distinct types of benefits. The more obvious one is increased returns from higher stocking capacities with sales of wool, livestock, hay and in some years pasture seeds.

These immediate gains can be measured to some degree in dollars and cents but the increases cannot all be attributed to medics. Fertilizer use, better management and crop rotations all have some effect on the final results.

In addition to these visible gains there are the delayed benefits which accrue over the years as the medic pastures develop. Soil fertility level rises and increases cereal production.

Medic pastures give benefits in the following ways.

1. IMPROVED SOIL FERTILITY

Medics being legumes have the ability to fix atmospheric nitrogen, so increase the amount of soil N available to plants.

2. IMPROVE SOIL STRUCTURE

The build up of organic matter in the soil improves structure and moisture holding capacity. This could reduce cultivation costs.

3. CONTROL OF WEEDS

A heavy medic pasture reduces weed problems in following cereal crops e.g. Barley grass, saffron thistle, also reduced cultivation and weedicides costs.

4. DISEASE CONTROL

The pasture phase, especially when Medic dominant, reduces host plants of cereal diseases and so reduces affect of disease on cereal production.

5. ROTATIONS

Medic pastures allow for closer cereal rotations and so increases total production.

6. IMPROVES QUALITY OF GRAIN

Grain protein is related to the level of nitrogen in the soil. This could mean a premium paid for wheat or additional wheat over and above quota allotted. Reduces or eliminates mottled grain.

7. LIVESTOCK

Improvements in returns from livestock have taken place from increased stocking rates, wool production and introduction of cattle.

Now how is this converted into monetary value.

Perhaps soil fertility can be measured by increased yield. Victorian figures quote a .336 t/ha increase in wheat yields attributable to medics.

.336 t @ $40.34 t = $13.55/ha

S.A. yield increases quoted by farmers range from .336 t to .672 t/ha

.336 t @ $40.34 t = $13.55/ha

.672 t @ $40.34 t = $27.10/ha

The Victorian figures show a profit margin of approx. $2.47/ha on 259 hectare farms when medics are used to build fertility in the rotation where fallowing is practised.

It has been recorded that medics build soil N levels from 80 to 112 kg/ha. Straight comparisons with beg ed N give equivalents of 80 kg N/ha = 370 kg Sulphate of Ammonia @ $42.60 tonne = $15.76/ha 112 kg N/ha = 530 kg Sulphate Ammonia @ $46.60 tonne = $22.58/ha or urea.

80 kg N/ha = 170 kg Urea
@ $83.15 tonne = $14.13/ha
112 kg N/ha = 240 kg Urea
@ $83.15 tonne = $20.20/ha

Improved soil structure

How can this be measured in dollars? One farmer has quoted it in this way. Reduced cultivation costs because cropping area can be broken up with combine instead of a plough. The cost saved is quoted at $1.48/ha.

It is impossible to put a value on organic matter and improved moisture retention, except in terms of increased yield.

Control of weeds

The value in this field has been measured by the reduced cultivation necessary to control weeds. From one to two cultivations could be saved at a value of $1.23/ha to $2.47/ha.

Weedicide costs could be greatly reduced especially for control of saffron thistle.

1750 ml/ha Amine 50 (saffron) = $1.85/ha

457 ml Amine 50 (turnip) = $0.48/ha

saving of $1.36/ha.

Disease control can only be valued as increased yield. Information is not available to assess this in monetary terms, because yield increases would vary.

Rotations

The development of medic pastures allows the following change of rotations.

P.P.P.W. under natural pastures
P.P.W. as medics are developed
P.W.P.W. under medic pastures
or P.W.B. under medic pastures.

To demonstrate the increased value under the different systems let's put an average yield of 18 bushels of wheat/acre and 20 bushels barley/acre yield over a 12 year period.

P.P.P.W.	=3 crops @ 1.200 t/ha	= 3.600 t	@ $40.00	=$144.00/ha
P.P.W.	= 4 crops @ 1.200 t/ha	=4.800 t	@ $40.00	=$192.00/ha
P.W.P.W.	= 6 crops @ 1.200 t/ha	=7.200 t	@ $40.00	=$288.00/ha
P.W.B.	= 4 W crops @ 1.200 t/ha	=4.800 t	@ $40.00	=$192.00/ha
	= 4 B crops @ 1.350 t/ha	=5.400 t	@ $29.00	=$156/ha
				$348.00

The most intensive rotation has an increased value of $204.00/ha over the widest rotation and the 2 year a $144.00/ha increased value

Translating this into Gross Margins per acre the comparisons are as follows.

Wheat G.M./ha 1.200 t/ha @ $40.00 t = $30.50 ha

Barley G.M./ha 1.350 t/ha @ $29.00 t = $15.80 ha

			Total G.M./Acre
P.P.P.W.	3 crops @ $30.50 =		$91.50
P.P.W.	4 crops @ $30.50 =		$122.00
P.W.P.W.	6 crops @ $30.50 =		$183.00
P.W.B.	4 W crops @ $30.50 =	$122.00	
	4 B crops @ $15.80 =	$ 63.20	$185.20

The intensive rotation of P.W.B. gives an increased G.M. of $93.70 over the widest rotation of P.P.P.W. in the 12 year period, or $63.20 above the popular rotation of P.P.W.

Grain Quality

Medic pastures increase the N level in soils, this in turn improves grain protein. Since 1965/66 a premium has been paid on delivery of hard wheats. The premium during 1965/66 to 1969/70 averaged just over $2.02 t. It is anticipated that it will rise for harvests since then. A premium of $2.94/t to $3.30/t is paid for prime hard.

High N levels also reduce the amount of mottling which could mean the difference between acceptance as hard or F.A.Q.

Nitrogen from Medic pastures could give an increase of $2.47/ha to $3.21/ha as a premium paid for Hard.

LIVESTOCK

7.1 Stocking rates

Since the introduction of medics there has been a rather spectacular increase in the carrying capacity of many farms. Firstly in sheep numbers and secondly in the last ten years the introduction of cattle.

Sheep numbers have risen by from 25% to 250% on individual farms.

With the introduction of cattle the D.S.E.'s have risen from approx. $\frac{5}{8}$ per ha to $2\frac{1}{2}$ per ha.

Typical examples are as follows

7.1.2 1962 250 wethers = approx. $\frac{5}{8}$ D.S.E./ha
1972 920 wethers = approx 2.5 D.S.E./ha

On today's inflated prices Gross Margins for wethers at high and low wool prices are $12.50 and $8.50 respectively. So an increased carrying capacity of $1\frac{7}{8}$ D.S.E. would give an increased value of $23.42 (high) and $15.92 (low).

7.1.3

	High	Low
1951-55 $\frac{5}{8}$ D.S.E.	7.80	5.30
1966-72 $1\frac{1}{4}$ D.S.E.	15.62	10.62
1973- $1\frac{7}{8}$ D.S.E.	23.42	15.92

The increased value being $15.62 and $10.62.

7.2 Because stocking rates have risen, so wool production has increased, but there has also been a steady increase in wool weight per head. A combination of these two has given an increase of wool produced per acre.

7.2.1 An example is as follows

1962 5,216 kg Wool = 5 kg/ha

1973 9,525 kg Wool = 7 kg/ha

7.2.2 The average price for wool in 1962/63 was 98.37 cents/kg 11,500 lbs = 5216 kg = $5,131.00

Average price in 72/73 was 178.07 cents 21,000 lbs 9525 kg = $16,961.00

7.2.3 Using the average price per kg of approx. 95 cents there was an increased value on this farm of $9048 - $4955 = $4093 representing $3.28/ha

...en years because wool prices were
...ices attractive there was a sharp
...e numbers in the medic growing

Increased fodder production from medics made it possible for most farmers to introduce cattle without having to reduce sheep numbers. This had the effect of increasing D.S.E.'s by ¼ to 1/3 on many farms.

On the debit side, lush medic pastures in 1973 were responsible for cattle losses from bloat.

8.1 Fodder Conservation

Successful medic pasture development has made it possible to produce large quantities of conserved fodder, mainly in the form of hay, in the years of high rainfall.

The economics of conserved fodder in form of silage or hay could be doubtful when compared with grain. Especially in our low rainfall districts, although with the introduction of cattle, hay is necessary.

8.1.2 High protein fodder reserves are available in the form of medic pods. There are no costs involved in conserving this fodder. What is its monetary value?

9.1 Small Seeds Production

In the years of high rainfall such as 1973 medic pastures produce large quantities of seed. Seed harvesting has been a successful and profitable venture in these years. The dry land medic areas have produced many tons of seed. This has increased cash returns to many farmers and also speeded up the development of medic pastures with farmers harvesting seed for own use.

Yields have ranged from 112 kg/ha to 448 kg/ha with a return of from 44 to 66 cents per kg to the farmer.

Gross return has ranged from $49.00 to $295.00 per hectare.

Average gross margins are comparable to wheat.

SUMMARY

From the research of information and the processing of values it was evident that some of the greatest gains from medic pastures were intensification of cereal cropping, closer rotations and large increases in stock numbers.

Considerable cereal yield increases plus better quality have been related in some degree to medic development and given monetary gains.

Other monetary gains or savings have been reduced costs of seed bed preparation and weed control.

Apparently the monetary value of medics is not recognised by many of the farming community because there are still thousands of acres that have not been sown.

Even in the areas of general acceptance there is a greater need for better methods of establishment, higher seeding rates and more frequent resowing.

Discussion

Soil N build up appears to be due to the roots of clover plants and not the tops - this has been shown by some work with sub-clovers. It appears that it does not matter whether you graze, cut for hay, or leave the herbage there, the soil increase in nitrogen will be much the same.

Medics have helped to improve grain quality, but the premium for hard wheat has been so small that it has not been worth anything.

EVOLUTIONARY HISTORY, DISTRIBUTION AND NOMENCLATURE OF ANNUAL MEDIC SPECIES

E.J. Crawford
Senior Plant Introduction Officer.

1. Introduction

I have included this segment in the form of a classification segment as I feel that everyone who is involved with what is one of the most important plants in our agriculture, should have a better background knowledge of the development of the genera to the stage of current knowledge.

Some understanding of the taxonomic background and climatic and edaphic distribution of the various species is necessary in order to gain a full appreciation of the true adaptive potential of any specie.

2. History

Early records suggest that annual medics were first cultivated in Persia from whence they were brought to Europe c.400 B.C.

Movement was most likely along the early trading routes by camel train.

Little was known about species before the 16th century, but *Medicago truncatula* and 'other annual species' were reported in gardens in England by Gesner, in 1561.

Miller, in 1731, reported that *M. orbicularis* and *M. scutellata* were common in English gardens and that their seed was frequently sold in seed shops in London.

Probably the most important early contributions made to the taxonomy of annual medics were those of Desrousseaux (1791), Willdenow (1802) and Seringe (1825) before Urban produced his monograph on *Medicago* in 1873. The outstanding value of Urban's contribution was the recognition of the value of venation of the surface of the pods in the identification and classification of species.

Recent research by Shinners (1956), Nègre (1956 and 1960) and Ooststroom and Reichgelt (1957 and 1958) have clarified earlier nomenclatural anomolies.

The most complex recent work on taxonomy of the genus is that conducted by Heyn between 1954 and 1963 and is recognised today as the authority on the annual species of *Medicago*.

As a result of this work, twenty eight annual species are recognised today. Of these, fourteen have various subdivisions resulting in a total of fifty one subspecies in the genus.

3. Geographical distribution

Many of the species have become adventitious over a vast area of the Old and New Worlds, their distributions being recorded in latitudes as far as 58°N in Sweden to 4°N in Ethiopia and from 30°W in the Azores to 30°E in Bangla Desh.

Although not native in the Southern hemisphere, some species have been recorded in South America for over 200 years.

The spurious distribution of the species in their native habitat can be allied to the nature of the raw wool trade over the centuries, hence the more diversified distribution of the species <u>minima</u>, <u>laciniata</u>, <u>arabica</u> and <u>polymorpha</u>.

4. Natural habitat of the commercialised species

As the annual medic species are more or less regarded as weeds in most other parts of the world, little has been written about limitations to their distribution. However, some botanists and plant collectors have recorded soil types and climate of the area in which specimens have been collected and there is considerable uniformity in this reporting.

4.1 Soil

4.1.1 *M. littoralis* is recorded almost exclusively from sandy sea-shores. This has also been confirmed by the writer's details of 111 lines collected between Israel and Portugal in 1967.

4.1.2 *M. tornata* occupies a similar habitat and is often found growing in association with *M. littoralis*. It is, however, also found on less calcareous inland sands and sandy loams.

4.1.3 *M. truncatula* is recorded on heavier soils, often terra rossas, basaltic and alluvial soils. However, exceptions do occur and *M. truncatula* is occassionally found growing in association with *M. littoralis* and *M. tornata*.

In some regions of their natural habitat, introgression between *M. truncatula* and *M. littoralis* and between *M. truncatula* and *M. tornata* adds to the confusion in classifying an already complex group.

The infusion of truncatula genes into the littoralis/tornata complex somewhat tempers their respective soil specificities.

Local evidence of the relative adaptability of Harbinger strand medic to a greater range of soil types than those found on the littoral of South Australia is further evidence of such introgression.

4.1.4 M. rugosa like M. scutellata is restricted to heavy clay and clay loams, often grey self mulching soils to white pipe clay extremes. They usually occur on fallow or in fields under cultivation, a characteristic not uncommon with M. scutellata in Australia.

4.2 Altitude

All five species can be classed as relatively low altitude species with only M. truncatula being recorded in altitudes as great as 800M.

Again this point has been confirmed by the writer who rarely saw M. truncatula above such altitudes. Consequently tolerance to severe frost is low as is rate of growth in low temperature environments.

4.3 Rainfall

Climatically, the Mediterranean Basin is essentially an environment of winter wet and summer dry, our commercialised species rarely occurring in regions above 1000 mm total annual rainfall. Naturally altitude affects rainfall where mountain ranges merge into the sea but these areas are usually edaphically unsuited to annual medic species e.g. South-Western Anatolia in Turkey.

4.4 Other factors influencing distribution

Besides the physical nature of the soil as mentioned above, the chemical status in terms of element balance and availability affect germination (if pH is less than 4.5) and subsequent development (if imbalance results in nutrient deficiency). Lack of soil calcium and available phosphate severely restrict distribution.

Aspect and site location may influence seedling emergence and survival in situations of poor drainage and poor aeration.

Similarly, lack of oxygen due to waterlogging may adversely affect <u>Rhizobia</u> survival and so inhibit nodulation.

Length of growing season restricts distribution of late flowering species.

Tolerance to drought may be affected by depth of the root system.

Spininess of pod has been mentioned as one of the earliest recognised means of distribution.

Seed coat impermeability inhibiting digestion in the animal rumen results in the distribution of small seeded species and ensures longevity of the species within the region of existence.

5. Local development

None of the annual medic species are indigenous to Australia.

Although ten species have been recorded as naturalised in Australia as a result of accidental introduction, serious consideration should be given to whether <u>M. orbicularis</u> and <u>M. scutellata</u> existed in Australia before deliberate introduction as a fodder plant just prior to the turn of the century.

The earliest recording of recognised annual medics in Australia is that of <u>M. polymorpha</u> by Taylor who referred to its distribution by squatter's sheep from 1820 onwards.

The ten naturalised species in terms of importance and distribution in South Australia prior to deliberate sowing of present day recognised cultivars include:-

5.1	<u>M. polymorpha</u>	(var. <u>polymorpha</u> (var. <u>vulgaris</u> (var. <u>brevispina</u>	- common burr medic - common burr medic - spineless burr medic
5.2	<u>M. minima</u>	(var. <u>minima</u>	- woolly burr medic
5.3	<u>M. truncatula</u>	(var. <u>truncatula</u> (var. <u>longeaculeata</u>	- barrel medic - barrel medic
5.4	<u>M. scutellata</u>		- snail medic
5.5	<u>M. praecox</u>		- small leaf burr medic
5.6	<u>M. arabica</u>		- spotted burr medic

5.7 <u>M. orbicularis</u> 'marginata' type - button medic

5.8 <u>M. littoralis</u> var. <u>littoralis</u> (rare)-strand medic

5.9 <u>M. laciniata</u> (rare) - cut-leaf medic

5.10 <u>M. intertexta</u> (var. <u>ciliaris</u> (rare)-calvary medic
(var. <u>intertexta</u> (rare)-hedgehog medic

6. <u>Current cultivars</u>

The deliberate development of cultivars within five of the ten naturalised species commenced with the recognition of the value of barrel medic by Trumble as early as 1931. The commercialisation of seed harvested from naturally occurring stands at Noarlunga in 1937 (subsequently named Hannaford barrel medic) was the forerunner to the improvement of pastures in the main cereal growing areas.

An appreciable area of Southern Australia was sown with seed and pod of Hannaford in the ensuing 18 years that preceded the commercialisation of the next medic cultivar, viz. Jemalong barrel medic.

During the 18 year period since the release of Jemalong, a further five cultivars have been commercialised three of which being cultivars of previously non-commercialised species.

Currently recognised commercial cultivars include:

6.1 <u>M. littoralis</u> - Harbinger strand medic

6.2 <u>M. rugosa</u> - Paragosa gama medic

6.3 <u>M. tornata</u> - Tornafield disc medic

6.4 <u>M. truncatula</u> - (Borung barrel medic
(Cyprus " "
(Hannaford " "
(Jemalong " "

Recently registered cultivars of <u>M. tornata</u> (Murrayland) and <u>M. truncatula</u> (Cyfield and Ghor) have not been released commercially to date.

In addition to the above species, <u>M. scutellata</u>, snail medic, is commercialised without cultivar status and <u>M. polymorpha</u>, common burr medic is available as a byproduct of other small seed production.

7. <u>Nomenclatural changes</u>

Although several species have experienced changes in nomenclature over the centuries, the two currently of concern in South Australian agriculture are:-

7.1 Medicago truncatula previously M. tribuloides

7.2 Medicago polymorpha previously

7.2.1 M. denticulata

7.2.2 M. hispida var. apiculata
var. denticulata
var. nigra
var. reticulata
var. terebellum.

7.2.3 M. lappacea

At cultivar level, no changes have taken place since commercial barrel and barrel 173 were renamed Hannaford and Jemalong respectively in 1966.

Discussion:

It was revealed that the M. rigidula species had been found above 3000m altitude in contrast to the generally low altitude species normally seen in South Australia. The species of medic thought to be possibly M. rigidula from coastal areas south of Pt. Pirie had been identified as being M. truncatula var. longeaculeata.

The M. polymorpha or burr medic does not have a cultivar within the species. It is a very widespread variety and a valuable one from a fodder point of view. It is probably the most adaptable of all the annual medics, being capable of producing seed under rainfall as low as $2\frac{1}{2}$" - as in Chile - up to excess levels. It will grow on a wide range of soils with better tolerance to salinity and water logging than most others. Nodulation is usually good also. However it has proved to be unreliable in regenerating due to a high incidence of hard seed.

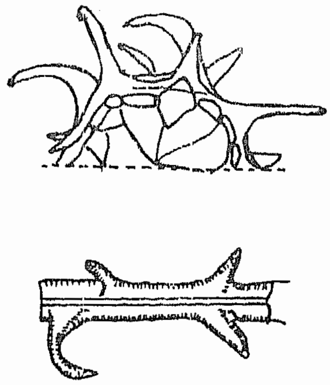
Wool buyers consider the pod contamination of wool is a disadvantage, although the processors apparently are not so concerned.

On display during conference were growing plants representing all the annual medic species, most being in flower with some carrying pods in varying stages of development.

Pod samples of 48 of the 51 medic sub species were shown, together with pressed herbage specimens.

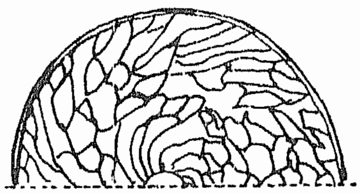
POD VENATION OF COMMERCIAL MEDIC SPECIES

A.

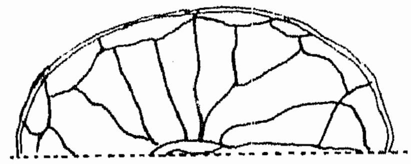


B.

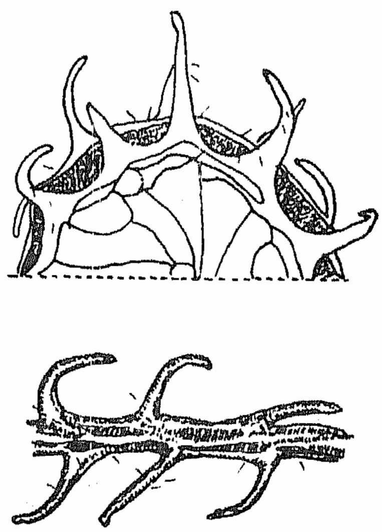
C.



D.



E.



A. M. littoralis

B. M. rugosa

C. M. scutellata

D. M. tornata

E. M. truncatula

(after Ooststroom, Riechgelt(1957) & Heyn (1963))

ATTRIBUTES OF THE VARIOUS CULTIVARS OF ANNUAL MEDICS

M.J. Mathison

Senior Research Officer,
Plant Breeding.

In this paper reference is made to brief descriptions of cultivars released or registered for potential release and of other annual medics in common use in pastures. These descriptions are published in the '<u>Register of Australian Herbage Plant Cultivars</u>' C.S.I.R.O. Canberra 1972 (and supplements) and '<u>Herbage Plant Species in Australia</u>', C.S.I.R.O. Canberra 1967 - both compiled by C. Barnard. (Demonstration material of live plants, dried pods and seeds is displayed).

These published descriptions are very valuable to our knowledge about the cultivars and as aids to identification but their limitations do need to be recognised. For the most part the information has been gained from plants raised in greenhouses and transplanted into rows (for seed production) at a single locality in a given state. Even when the utmost care has been taken to standardise procedures to eliminate experimental errors, and to reduce sampling errors to an acceptable standard the description is still that of the phenotype, not the genotype. It is to be remembered that the phenotype is contributed to by the genotype, the environment, and genotype by environment interactions. Thus the descriptions published are for the cultivar grown under a particular set of conditions at a particular site(s) in particular years. The phenotypic attributes most altered are quantitative attributes.

Because of genotype by environment interactions some genotypes appear to change from one environment to another for particular quantitative attributes whereas others do not. An example of this is the attribute 'weeks to flower' (summarised in table 1) where in the Herbage Plant Register there are apparent discrepancies reported between states. Looking at another attribute 'seed size' (see table 1) only a single approximate figure is given. This figure is quite relevant to the set of growing conditions from which it was derived but should only be used as a guide to comparative size of seeds of the cultivars.

To illustrate this further the attribute 'percentage seed weight in pods' is shown in table I for cultivars grown in different environments. At Northfield differences between years are more evident for Tornafield and Paragosa than for Cyprus and Hannaford. When more sites are used a wider range of values and a greater amount of genotype by environment interaction becomes evident. At Belalie for example the lowest percentages are recorded but percentages for Paragosa are not reduced to the same degree as for the other cultivars.

Some environments (sites) give greater changes from season to season than others in the ranking order of cultivars for a particular quantitative attribute. For example (in table II) at Northfield very markedly different ranking orders occur for 'seed yield' in the year of sowing. At some mallee sites the order is almost unchanged from year to year for this attribute. In assessing attributes of cultivars it is therefore very important to know which sites are most seasonally stable for ranking order and which are very unstable. Clearly, fewer years of assessment should be needed at the more seasonally stable sites. In the choice of sites for assessing introduced and bred medics for the South Australian wheatbelt seasonal stability, together with characteristic orders of cultivars, at a site has been used for the attributes 'seed yield' and 'herbage yield'.

Another aspect of assessing the worth of attributes of cultivars is the weighting to be placed on particular attributes. For example it is evident (in table III) that under a wide range of site by season combinations the cultivar Borung has comparatively high herbage yields in the year of sowing. However, seed yields of Borung do not follow the same trend (table IV). If a medic is to be sown each time in pasture, then there is some justification in sowing Borung rather than say Jemalong. In the usual self regenerating system, seed yield, percentage soft seed, and percentage of soft seeds establishing, all help to determine subsequent forage yields. Observations so far indicate that Jemalong or another cultivar is equal or better at most sites. Another example of the difficulty in placing a weighting on a single attribute is with 'seed yield' and the cultivar Ghor. Seed yields of Ghor are often the highest at wheatbelt sites in the year of sowing. However, it has a very high proportion of hard seeds resistant to the oversummer temperature fluctuations which cause breakdown of hardseededness in other cultivars - consequently the seeds remain impermeable to water entry so that regeneration has been extremely poor even after two summers.

In conclusion, the published descriptions are a useful guide to the attributes of cultivars, especially qualitative attributes, providing the limitations of the data are recognised. In assessing the worth of the attributes the method of assessment needs to be under conditions resembling as closely as possible the environment and management system in which cultivars are to be used. Since it is impossible to assess cultivars for an infinite number of years at all localities some guidance is needed to the best compromise between assessing at all sites or at only one site. A study of ranking orders for important quantitative attributes at sites typical of extensive regions of usage can be of some help.

Table I

Attributes of annual medic cultivars

Cultivar	Weeks** to flower	Seed ** size no./mg	Percentage seed weight in pods *N 70	*N 71	*B 71	*M 71
Hannaford	15	320	31.9	30.8	22.1	27.8
Jemalong	16	300	33.9	30.2	23.8	29.1
Cyprus	12-13	265	29.1	28.3	22.3	27.9
Cyfield	14-15	220	29.7	26.5	22.2	26.3
Borung	15-16	300	31.7	24.3	22.4	28.3
Ghor	8-10	190	-	31.1	18.3	21.9
Harbinger	12½-13	425	36.6	33.5	26.9	36.5
Paragosa	14	160	42.7	36.2	31.8	31.3
Tornafield	14-15	240	50.6	37.4	35.7	45.6
Murrayland	13-14	396	-	-	-	-
Snail	14-15	130	35.0	33.6	27.9	31.1

*from sward experiments at Northfield (N), Belalie (B), Mundoora (M) in 1970, 1971

**Extrapolated from "Register of Australian Herbage Plant Cultivars" (1972) and supplements, "Herbage Plant Species in Australia" (1967) Barnard, C. C.S.I.R.O. Canberra and "A Manual of Australian Agriculture"(1966) 2nd ed. Molnar, I, Heinemann, Melbourne.

Table II

Ranking order of medic cultivars for yield of seed in the year of sowing at (16.8 kg/ha) Northfield 1970 to 1972

Year	1970		1971		1972	
Rank	Cultivar	Yield kg/ha	Cultivar	Yield kg/ha	Cultivar	Yield kg/ha
1	TORNAFIELD	960	HANNAFORD	920	SNAIL	560
2	CYFIELD	720	CYFIELD	920	CYPRUS	440
3	HARBINGER	680	GHOR	800	GHOR	400
4	HANNAFORD	640	SNAIL	800	BORUNG	360
5	PARAGOSA	600	JEMALONG	720	HARBINGER	280
6	BORUNG	600	CYPRUS	720	JEMALONG	280
7	CYPRUS	560	BORUNG	440	CYFIELD	280
8	JEMALONG	560	PARAGOSA	400	HANNAFORD	240
9	SNAIL	560	TORNAFIELD	400	TORNAFIELD	200
10	--	-	HARBINGER	400	PARAGOSA	120

Table III

Winter to spring herbage dry matter yield (kg/ha) comparisons cv Borung v others in the year sown (at 16.8 kg seed/ha).

	*N 68 a	N 68 b	H 68 a	H 68 b	M 68
BORUNG	3367	9172	1240	8111	3217
MEAN	3056	9871	1118	6904	2224
BEST	3744 PARA	10925 PARA	1542 PARA	8111 BORU	3217 BORU
JEMALONG	2889	8751	872	7722	2822
LSD 5%	337	NS	341	779	226
	N 69	H 69	M 69	WS 69	WSL 69
BORUNG	9602	6648	1801	3426	2569
MEAN	9912	6304	1862	2786	2021
BEST	11570 CYPR	7708 HARB	3315 HARB	3426 BORU	2778 SNAI
JEMALONG	9801	6107	2444	3106	2009
LSD 5%	NS	NS	600	811	419
	O 69	Wu SL 69	B 69	C 69	
BORUNG	9218	1773	6088	4833	
MEAN	7744	1865	5177	4648	
BEST	9486 PARA	2167 SNAI	6088 BORU	5199 SNAI	
JEMALONG	7875	2005	5505	4495	
LSD 5%	1551	407	765	679	

*a. First cut, b. Second cut, (68) 1968, (69) 1969.

(B) BELALIE, (C) CALTOWIE, (H) HORNSDALE, (M) MUNDOORA, (N) NORTHFIELD, (O) OWEN, (WS) WANBI SAND, (WSL) WANBI SANDY-LOAM, (WuSL) WUNKAR SANDY LOAM.

(BORU) BORUNG, (CYPR) CYPRUS, (HARB) HARBINGER, (PARA) PARAGOSA, (SNAI) SNAIL.

Table IV

Seed yield (kg/ha) comparisons cv Borung v Others
in the year of sowing (at 16.8 kg/ha)

	*N 68	H 68	M 68	N 69	H 69
BORUNG	1437	797	519	382	572
MEAN	1787	899	641	466	729
BEST	2156	950	802	603	864
	PARA	CYPR	HARB	PARA	SNAI
JEMALONG	1500	918	772	351	726
LSD 5%	219	NS	91	129	208

	M 69	WS 69	WSL 69	O 69	69 WuSL
BORUNG	670	396	518	816	234
MEAN	850	456	481	873	302
BEST	1133	608	648	1045	469
	CYPR	HARB	HARB	HANN	CYPR
JEMALONG	789	466	448	892	191
LSD 5%	171	107	88	185	76

	B 69	C 69	69 Wu S	K 69	L 69
BORUNG	700	693	324	612	33
MEAN	647	643	322	855	98
BEST	831	799	470	1426**	315***
	SNAI	PARA	HARB	TORN	TORN
JEMALONG	651	478	229	614	50
LSD 5%	193	126	114	197	56

*(68)1968 (69) 1969

(B) BELALIE, (C) CALTOWIE, (H) HORNSDALE, (K) KADINA, (L) LAMEROO (M) MUNDOORA, (N) NORTHFIELD, (O) OWEN, (WS) WANBI SAND, (WSL) WANBI SANDY-LOAM, (WuS) WUNKAR SAND, (WuSL) WUNKAR SANDY LOAM.

(BORU) BORUNG, (CYPR) CYPRUS, (HANN) HANNAFORD, (HARB) HARBINGER, (PARA) PARAGOSA, (SNAI) SNAIL, (TORN) TORNAFIELD.

**HARBINGER 989 kg/ha was next best

*** " 266 " " " "

Discussion

The cultivar Ghor (M. truncatula) has been established in trials on Eyre Peninsula at Buckleboo, Pygery and Mudamuckla. This cultivar will commence flowering in 7-8 weeks from germination, much earlier than the Cyprus variety, and under ideal spring conditions, the maturation period is longer than Cyprus.

The cultivar Murrayland (M. tornata) has proved rather hard to thresh satisfactorily, the pods tending to break into single whorls still enclosing the seed - a disadvantage for seed production.

In assessing or evaluating a particular aspect such as seed production or winter herbage production, the methods used should be as near as possible equal to those used, or likely to be used, under the varying environmental influences to be found in the districts where the cultivar can be used.

Seed yields give variable rankings from year to year, the reasons sometimes being rather obscure. At Northfield on plots resown in each year 1970, 1971, 1972, Paragosa gave seed yields of 600, 400 and 120 kg/ha respectively. Similar variations are evident between varying trial sites for any one cultivar, e.g. at Belalie 200 kg/ha and at Lameroo 440 kg/ha were produced by Ghor.

Slides were shown depicting differences in regeneration of different cultivars, Jemalong's capabilities showing up prominently. However a warning was given re the time of viewing and the drawing of any conclusions when comparing differences between cultivars and/or lines within trials.

OPTIMISING MEDIC PRODUCTION

Collated by N.R. Matz,
District Agricultural Adviser,
Kadina.

(From papers presented by District Agronomists)

Optimum medic production in the mallee soil areas of the cereal belt is influenced by a number of factors.

Stubble density - dense stubbles and "walker tracks" must be cleaned up early mainly by way of livestock, or as a last resort by burning, so as to allow effective hard-seed breakdown and to prevent "blanketing" of germinating seeds at the "break". May be this treatment could also be extended to cover the possible problems of toxins (produced in the breakdown of cereal stubbles) affecting germinating seeds.

Species for soil type and season - paddocks, that when last into pasture had shown the first signs of poor regeneration following what was considered to be a reasonable break, should be resown to the particular species of medic best suited to the soil type (e.g. Hannaford which is well suited to the grey and rubbly limestone mallee soils). The seasonal aspect must also be taken into account e.g. Harbinger and Cyprus which have shown superiority on the sandy and heavy mallee soils in the very early districts.

There's no doubt in my mind, that part of the success story in the production of optimum stands comes from the establishment of mixtures of medic, a fact also born out on Upper Eyre Peninsula.

Paragosa Rhizobium inoculant should be taken into account on some soil types.

Seeding rates - depending on paddock seed reserves, rates of between 4 to 5 kg/ha and 8 to 10 kg/ha should be scratched into the stubble dry during late March to the end of April to maintain productive stands. A light crop of grazing oats or barley of around 33 kg/ha is usually sown with the medic to boost early feed.

Several offic rs wrote of the need for "furrows" in light soils prone to drift and/or where theyare "water repellant".

The full value of medics in the farming districts of the "Lower Murray Basin" is not appreciated otherwise better methods of establishment would be adopted. (The most popular method to date has been the sowing of medics under a cereal crop). Higher seeding rates and more frequent resowing would take place, if stubble sowing was practised.

<u>Fertilizer application</u> - regardless of whether superphosphate is being applied as a top-dressing or at resowing, at least 60 to 100 kg/ha should be applied to each pasture paddock, the actual rate depending mainly on the average annual rainfall of each district.

One officer wrote of a Rowland Hill who in 1925 wrote about "Topdressing of Pasture Land". "Being absolutely convinced that to produce our best returns from cultivated crops, we have to apply superphosphate, we should not hesitate in applying the same to improve our crops which are not cultivated. By the topdressing of pasture land, a greater number of stock can be carried, and what is still more important, these stock will do better and relish such feed produced.

Had he known of the importance of clover which developed in the late 1930's-early 40's, I am sure he would have said "By the topdressing of pasture land, <u>not only</u> a greater number of stock can be carried, and what is still more important, these stock will do better and relish such feed produced, <u>but also</u> soil fertility and soil condition will be greatly improved enhancing the prospects of maximum returns from cultivated crops". The assumption here of course is that available, residual phosphorus levels are below par to the level required for good pasture growth.

<u>Pest control</u> - a reduction of up to 50% or more in seed set and the production of winter food is considered possible, where insects particularly in <u>Sitona</u> weevil, cockchafer, red-legged earthmite and lucerne flea are present. So that generally speaking control of these insects should be carried out to prevent this possible loss of production and seed set, <u>where it's warranted</u>.

<u>Grazing weed control and topping</u> - heavy grazing too soon after germination can be detrimental to medic establishment. Judicious grazing should therefore be practised aimed at leaving each stand relatively short as flowering time approaches. With carefully controlled grazing during the flowering, podding and residue stages, maximum seed reserves can be achieved for future regeneration.

One officer wrote "Every effort should be made to keep the pasture self regenerating rather than relying too heavily on resowing. It can be more economical to ensure that 50 kg of seed is carried over in the soil rather than sow 5 kg."

Few herbicides can be safely used for weed control in medic pastures, so that medic dominant stands can best be achieved by heavy seeding rates or by having good paddock seed reserves, topping and good grazing management, where no herbicide or economic weed treatment is available.

Haycutting - will affect the seed set of medic stands to about 30 per cent of the normal. Because of this, stands for hay should generally be cut at the early flowering stage and not too short, so as to give every chance for regrowth - the extent of which will naturally be governed by seasonal conditions.

Rotation - medic regeneration is best achieved on an alternate year cropping programme, as the cropping phase places the medic seed in a better environment to germinate and establish. Seed reserves tend to reach low levels, when paddocks are cropped for more than two years in succession, and after poor pasture years, so that when seed reserves are in doubt, resowing with medic seed must be undertaken to complete the cycle in maintaining optimum stands.

Discussion

Some doubts were expressed as to the effectiveness of straw spreaders behind straw walkers of harvest machines. There still seemed to be strips in stubble paddocks with no real medic growth, even in this year of relatively ideal weather for germination and growth. How much effect cereal stubble breakdown and the resulting influence any toxicity levels may have was stated to be rather an academic point, but was acknowledged as possibly having some influence - research writings were mentioned. The germination of lost grain from machines was also proving competitive to medic growth.

It was felt that mixing of cultivars at seeding had some use in some situations, particularly where soil type vari tions occurred within paddocks. In some districts this is further emphasised according to seasonal weather influences. However mono pastures are usually easier to manage. The price factor of available seed may also influence which cultivar may be sown. Of considerable bearing on the use of a mixed or mono pasture is the end use of the pasture - whether it be for animal production purposes; soil fertility and physical improvement reasons; or for seed production.

These 3 points will also have an influence on the seeding rate together with the price factors. Harrowing left too late after sowing in conjunction with a cereal cover crop caused more damage to the medic seedling than any value gained for other purposes. The possibility of the carryover of cereal diseases on cover crops was pointed out. Methods of establishment suggested for use included using a rib roller to compact heavier cloddy soils to give better covering of seed and more efficient use of moisture. Also the broadcasting of seed and fertilizer on light sandy soils before stock is used for grazing and trash break up. The depth of sowing preferred seemed to be within the 1 to 3cm level, most medic seeds having about a 5cm limit of hypocotyl development.

Establishment with a grain cash crop seemed a doubtful practice where weeds may prove a problem. The medic is a very sensitive plant to most sprays used for weed control. It was suggested that the cropping phase of rotations be used for weed clean up programs, then follow with medic sown the following season. However experience in one district seemed to suggest lighter spray rates could be used at appropriate growth stages, although weather influences such as frost may cause trouble.

Fertilizer application rates and methods seemed variable, some areas applying all fertilizer with the cereals and none on pastures. In other districts some fertilizer was being applied every year. However the economic situation of producers has quite an influence on what actually takes place.

Economics were also concerned over spraying for insect pests, attitudes being whether to spray at all, when and how often; the use to which the pasture would be put having a considerable bearing on decisions made.

The frequency of resowing seemed to be a matter of experience and judgement according to the use intended. Annual resowing was recommended for seed production and harvest or seed reserve build up, but less often if a good seed set was apparent during the first season. It was suggested it may be worthwhile to hand water a small patch in the paddock concerned when in doubt. This could be done sufficiently early in autumn - late summer to assess any germination and a decision made in time to take any action required for resowing if and when necessary. However some doubts were expressed as to any real benefit being obtained.

Reference Publications mentioned included:

Establishing Pastures under Cereal Crops
by D.S. Mitchell
(The Pastoral Review - 19th July 1967)

The Bacteria of Decomposing Cereal Straw, and their Effects on Plant Growth.
by V. Iswaran and R.J. Harris,
Division of Microbiology, Indian Agricultural Research Institute, New Delhi and C.S.I.R.O., Division of Soils, Adelaide, S. Aust.

Emergence of _Medicago_ _tribuloides_ on Moderately Acid Soils
by C.R. Kleinig
Australian Journal of Agricultural Research, 1965.

FACTORS AFFECTING REGENERATION OF ANNUAL MEDICS

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1. Introduction

The ley system of farming with annual medics is seen in its most intensive form as a moderately heavily stocked pasture of one year duration in between cropping with cereals for one, sometimes two and occasionally three successive years. The best medic pastures are virtually pure stands fixing as much nitrogen as possible, which provide as much early winter grazing as possible, and which produce an abundance of seed.

To achieve pure stands it may be necessary to have a very dense germination of medic in order to compete with other pasture components - for example burr medic, the burrs of which are undesirable as contaminants of wool. Germination of burr medic could be at as high a density as equivalent to sowing seeds at several hundred kg/ha.

As in sub clover, winter herbage production of medics is highly dependent on a high density of plants up to an optimum level. Seed production has a lower but less critical value for optimum density. In fact the upper levels of the ranges for optimum density for seed production do reach moderately high values depending on the location and type of season. For example in a low rainfall mallee environment (Walpeup, Vic) the high values for optimum seed yields of medic range from about 150 to 1000 plants 1 sq. metre in different seasons (Amor 1965). In a better environment (Yorke Peninsula) the values are 1,000 to 1,500 plants/sq. metre (Burton 1964). These densities if sown with say Jemalong seed of 100% germination and establishment would need rates of about 6 to 40 kg/ha and 40 to 60 kg/ha respectively.

The very high densities which may be needed early in the season (to achieve pure stands and for early winter herbage production) will often be reduced to the moderately dense stands best suited for seed production. This can come about by interplant competition and grazing management.

However, unless the medic pasture is deliberately sown each time, the only way of achieving the goal of initial high density is through natural regeneration from previously established pasture. Regeneration in the broad sense being re-establishment at a given density.

2. Some factors affecting regeneration

The factors considered here are only some of the important factors affecting regeneration. Whereas some are quite critical 'sieves' which must be passed through others are compensatory and some interact with others. It is important that due consideration is given to all of these types of factors when trying to analyse a problem or devise management systems involving regeneration.

2.1 Seed Population Density

Clearly a very high density of seed is needed. This will have been largely determined by the choice of a suitable cultiv ar, the seasons in which seeds were produced, and the management both in the year(s) of seed production and in cropping year(s). With suitable cultivars and management seed yields of about a hundred kg/ha should be obtainable in the poorest situations in the cereal belt. In extremely favoured situations about 2,000 kg/ha could be achieved. Management for high seed yield is dealt with in other papers.

The effects of cropping years will be seen as a depletion of seed through germinations and a reduction or cessation of medic seed production depending on the degree of competition from the crop, and the weed control practices used.

2.2 Soil Physical and Chemical Factors

Soil pH, salinity, nutrient status, structure and pasture may all affect regeneration, either directly or in combination with other factors. In a review of soil factors affecting the natural distribution of annual medics Robson (1969) concluded that no single factor could be considered the major causal one.

For example although medics do best on neutral to alkaline soils(pH 7 to 9+) they will grow on acid soils as low as pH 4.8 but don't produce as much seed (Aitken and Davidson 1954). Low pH probably does not affect the plant directly, but rather through effects on rhizobial relationships (Robson and Loneragan 1970). In another situation moderately acid soils were shown to have a deleterious effect on seedling emergence through providing a favourable environment for pathogenic organisms (Kleinig 1965).

In saline situations burr medic is much more tolerant than barrel (Greenway and Andrew 1962).

Annual medics have a much greater requirement for phosphorus than many other annuals (e.g. almost 5x more than for sub clover) (Rossiter 1966). On alkaline <u>calcareous</u> soils it is probably barrel medic's better ability to obtain P in the presence of high Ca that accounts for its superiority over sub clover (Robson and Loneragan 1970).

With high P, and high N, and no or low stocking, grass will achieve dominance whereas with high P medic may dominate (Rossiter 1966). In his review of Mediterranean type annual pastures Rossiter also quotes work which indicates a high requirement for K by barrel medic, and for S by burr medic (relative to grasses).

Soil structure is important both for penetration of roots from seeds on the surface and for emergence from below (for example difficulties with hard setting red brown earths). It is also influences whether larger and/or light weight burr types can escape grazing animals and whether seed is incorporated below the surface (e.g. Snail and Paragosa medics in self mulching cracking clays). Some sandy soils are better environments for some cultivars e.g. Harbinger, but the reasons for this are far from clear. Other sandy soils provide the conditions for organisms causing 'non wetting' problems.

Soil texture is allied with structure and influences aeration, the likelihood of waterlogging, and a range of moisture relationships. These not only concern the concepts of suction competition between the soil and the plant root but also the area of contact between seed and water (Collis-George and Sands, Sedgley, et al in Rossiter 1966, and McWilliam et al 1970).

2.3 Time of break of season and type of break

The time, amount, and distribution of rainfall are obviously key factors which inter-relate with the soil factors (especially physical), the medic seed and seedling growth characteristics, and other biological factors. Early literature on this factor is adequately reviewed by Amor (1965a) and Rossiter (1966). This literature covers aspects such as amount of rainfall needed, in which months, the composition of pasture and tendency to medic dominance with moderately early breaks (March-April-May) and grass and other species dominance with late breaks when effective nodulation may not occur until spring.

More recent investigations indicate important differences within annual medics. For example if very light falls of rain occur when temperatures are high Paragosa medic may germinate a large proportion of germinable seed (47%) whereas Jemalong (8%) and especially Harbinger (4%) germinate only a little. At lower temperatures these differences are less pronounced, and with abundant moisture there are no differences (Table 1).

Clearly a medic with the characteristic of Paragosa is at a disadvantage if no other mechanism, such as hardseededness (or impermeability to water), is present to prevent germination in unfavourable conditions for continuing growth.

There may be other germination conditions important for regeneration of different annual medics. Preliminary studies with other annuals have shown between and within species difference in germination response to high temperatures depending on whether they occur in the day the night or both day and night (Hallett et al 1971). These sorts of differences certainly will influence the type of competition offered by other genera and partly explain the types of pasture composition reported in some of the early literature.

Within the annual medics marked differences in speed of germination, and rate of radicle extrusion have been noted by those of us working with large numbers of genotypes in the plant introduction and breeding programmes. Undoubtedly part of the success of Jemalong is due to its more rapid germination and radicle extrusion than some other cultivars.

2.4 Biological Factors - other than weed competition and grazing management.

Unsatisfactory rhizobia, destructive insects, damping off fungi, mice, and plant litter are biological factors of importance. In general, rhizobial problems with medics in S.A. are restricted to new land and certain cultivars with a strain requirement different from barrel medic (e.g. Paragosa and Murrayland). Table 2 shows the lack of response to inoculation at Northfield. However marked differences in host-strain symbiotic relationships do exist in the annual medics (Brockwell and Hely 1966) and their study may reveal problems we have not recognised.

Destructive insects such as red legged earth mite, lucerne flea, seed wasps and sitona weevil are 'dealt' with in Mrs. Moulden's paper. Genotypic differences in susceptibility do occur for at least some of these insects.

Rossiter (1966) refers to reports by Andrew (1963) and Kleinig (1965) of damping off fungi affecting the establishment of medics. It is probable that many of our poor regeneration examples are partly contributed to by these types of organisms.

Mice are a well known cause of problems on Yorke Peninsula and some other parts of the State. However, the damage they can do is probably greater than many of us realize. For example they will selectively graze seed of M. rugosa lines and of Harbinger. Pods on plots with 440 kg seed/ha were completely emptied.

Plant litter is widely accepted as a problem restricting moisture and light penetration and hence regeneration of most annuals. Less well known are the insulating effects on reducing hardseededness (defined in 2.6) and the effects of toxins in the litter. Cereal, grass, and other weeds have been shown to sometimes contain toxins inhibiting germination Rossiter (1966). As is reported by Mr. Kloot, he has in preliminary studies shown an inhibiting effect on germination of Jemalong by water extracts from wireweed Polygonum aviculare. This may be a very important factor in poor regeneration on both the solodised solonetz soils and some of the red-brown earth soils in 'problem country'. It is one litter factor which requires more than a simple grazing management practice.

2.5 Management factors

These include grazing and burning to remove litter, and grazing for best seed production and are dealt with by other speakers. Cultivation is a management practice which has a marked effect on regeneration but is largely unexplained (Rossiter 1966). Probably in the context of cereal ley farming it has the following beneficial effects;

- it places seed into parts of the soil profile where moisture conditions for good germination and good establishment are less exacting than if left on the surface
- it breaks up all soil surface structure where this is a problem for radicle penetration
- it increases aeration and effectiveness of rainfall
- it increases the availability of N as nitrate
- it is usually accompanied by superphosphate application and placement and so increases available P. (Footnote 1).
- it may in some circumstances bring up older seed into a position near the soil surface where hardseed breakdown is more effective (see Section 3).
- it may have the effect of breaking up associations of pathogenic fungi, and may disperse 'Bands' of germination inhibitors.

2.6 Seed and Seedling Characteristics

Physiological seed dormancy lasting for more than a few weeks is a common factor in sub clover but is very rare in annual medics, certainly this is true for the cultivars. Occasionally samples of fresh snail medic seed have germination delayed by a week or two if at constant moderate temperatures. Even this may be unimportant in the field if diurnal temperature fluctuations will allow germination - they do for some - other genera (Hallet *et al* 1971).

Rapid speed of germination and seedling vigour have been briefly mentioned in relation to the success of Jemalong as a cultivar. They are extremely valuable attributes in years where no clearly defined seasonal break occurs, where the opening rain is concentrated in a brief time period, and where there is likely to be competition from other annuals.

As is well known seedcoat impermeability to water (hardseededness') is the most important single factor acting as a barrier to germination of annual medics in the field in South Australia. However, all the foregoing factors must be considered when examining the topic of regeneration.

Footnote 1: Rudd & Barrow (1973) show that superphosphate placed near the seed is twice as effective as when topdressed at sowing, and 4 times as effective as in March before the opening rains.

Commonly encountered levels of impermeability in mid summer in new seasons barrel medic seed are 0.4% to 10.2% after good seasons and 3.6% to 18.4% after drought years (Burton 1964).

The initially high levels of impermeability of some cultivars such as Cyprus remain very high throughout the autumn. In Paragosa, much impermeability has broken down by mid summer and considerable amounts (up to 50%) may breakdown by late April. (data from E.J. Crawford and R.J. Banyer).

3. Factors affecting seed coat impermeability

Factors affecting seedcoat impermeability, especially annual medics, have been reviewed by Burton (1964) Quinlivan (1971) and Mathison (1972).

3.1 Genotypic differences

In brief, there are genotypic differences for initial hardseededness within other legume genera but these have not yet been demonstrated in annual medics. There are apparent differences among annual medics in the rate of breakdown of impermeability (as already indicated between Cyprus and Paragosa). These differences have been difficult to demonstrate in controlled environmental conditions. Nevertheless they do occur in the field - although the differences between barrel medics were not great - hence the problem of improving regeneration through seeking genotypes with better breakdown. This ideal is considered to be somewhere around 20-30% breakdown by mid April but not much before (Fig. 1). This should leave a reservoir of impermeable seed to carry through cropping years (Crawford 1970, 1971, Mathison 1972).

3.2 Environmental Factors

3.2.1 Induction of Hardseededness

This assumes that the genotype is hardseeded. About 3 weeks after pollination, the precursors of impermeability are layed down in the seedcoat. Slow maturity enhances the deposition of impermeable substances, moisture stress interrupts it - this gives rise to environmentally induced variations in both initial hardseededness (percentages of seeds) (Table 3a) and breakdown over summer (Table 3b).

As maturity proceeds, the seed loses moisture until at about 12-14% moisture content it becomes impermeable to water entry in a 14 day germination text (Fig. 2). At moisture contents between 12-14% and about 6-8% it is possible for seed to become permeable again if left long enough in a humid environment. This is referred to as 'reversible impermeability' and water can enter such permeable seed at random over the seedcoat surface.

Below 6-8% moisture content seed does not take up moisture in a humid atmosphere and is said to be irreversibly or fully impermeable. The only way for such seed in the burr to become permeable in the field is for a weakening of part of the seedcoat. This occurs at the point called the Strophiole. This point of entry for water can be seen in the copy of photographs from Rural Research 77.

3.2.2 Breakdown of hardseededness

The breakdown of impermeability of seeds in the burr observed to occur in the field results from a period of fluctuating temperatures (Table 3b), usually of at least 3 months duration. Temperatures involved are of the order of 50-60°C by day and 10-15°C by night. These temperatures only affect fully impermeable (very dry) seeds. In other climates exposed to heavy frosts further impermeability breakdown can occur. Many reports of other factors exist in the literature. However many of these probably involve experimentation with incompletely dry seeds and so probably also involve some reversal of impermeability by high humidity (Fig. 2).

In experiments conducted by Burton (1964) he found humidity had no effect on breakdown. But he did obtain enhanced breakdown with a combination of high humidity and widely fluctuating temperature. This does not normally occur in the field as rainfall in summer usually reduces the maximum temperature. However further experimentation may show whether this phenomenon occurs with fully dried seeds.

In general, summer temperatures in South Australia (e.g. Fig. 3) are high enough to reach full impermeability early in summer but not as early as in W.A.

Ripening conditinns are probably generally better than in W.A. too - giving greater deposition of impermeable substances and seed coat strength.

Therefore 'hardseed' is more of a problem with medics regenerating in S.A. than in W.A. In other parts of Australia other factors such as high humidity probably result in more 'reversible' changes occurring.

3.2.3 Other natural phenomena affecting impermeability

About 3% of seeds which are eaten by ruminants pass through in a viable condition. Some of these will have been scarified by acid treatment. Virtually all other fully impermeable seeds in the field must be broken down by temperature fluctuations before they can germinate.

Fungal attacks have <u>not</u> been shown to be responsible for breakdown.

In the field modifications to the environment can have their effect; <u>either</u> by delaying loss of moisture - e.g. cultivation buries seeds in moist ground, weedcover or stubble insulates against drying out <u>or</u> by enhancing the loss of moisture and full exposure at the soil surface (where temperature fluctuates most). By removing topcover as early as possible in spring e.g. haycutting, stubble grazing etc (see Fig. 4), or by cultivating to bring up old previously buried seeds regeneration can be enhanced.

4. Management Systems to Optimise regeneration

4.1 Choice of genotype

Late maturing genotypes do not necessarily produce lines with improved regeneration characteristics - in fact flower abortion is more likely if this approach is tried as a means of improving regeneration.

Very early maturing genotypes do not necessarily produce better regeneration either, despite the fact that they may have a short period of maturity and a long exposure to summer conditions.

Recent introductions of barrel medics from Tunisia appear to have 'breakdown' characteristics like those sought but do not have great seedling vigour. Breeding has been started between these and winter vigorous but poor regenerating material.

In the short term the answer is to choose a well adapted cultivar with characteristics as near as possible to the ideal for regeneration. In many cases this will be Jemalong because of reliability for seed production, slightly enhanced seedcoat impermeability breakdown, compared with say Cyprus, and rapid germination and establishment.

4.2 System of Establishment

The traditional system of establishment under a crop is not to be preferred because of poorer seed yields due to crop competition, the danger from herbicide sprays, stubble residues insulating the seeds, generally poor 'breakdown' of the new seeds, and likely competition from other medics and weeds.

Establishment in the stubble is to be preferred. This entails: weed control, in the previous crop(s), removal of stubble late in summer to keep other medic seed 'hard', sowing at as high a seeding rate as can be afforded (i.e. up to 60 kg/ha) in keeping with stocking rates, sowing as near to the seasonal break (April) as possible, sowing at about 1.25 cms depth or as near to as possible, (see Table 4 for sowing depth principles) sowing with superphosphate (and if necessary the correct rhizobia). Grazing management needs to avoid over-stocking too early after establishment, after the onset of flowering and during the first summer. The following year should be a crop year with careful attention to weed control. It is probably better to kill all medics in the first crop in order to reduce seed reservoirs of competing 'old' medics. It is probably also fairly risky to exceed one year in crop, as seed losses are not all accounted for by germination in the autumn-early winter period.

4.3 Maintenance management

This may involve some resowing if good seed yields have not been achieved - this aspect receives further attention - in Mr. R. Norton's paper.

In general short rotations should be practiced and once a good reservoir of seed exists IN and not on the soil it should be practical to graze dry residues quite heavily in summer. Generally removal of most ground cover will be desirable early in summer to assist hardseed breakdown. Phosphate levels should be kept up in the cropping phase at least.

4.4 Possible Future Maintenance Management

Further attempts to increase the potential hardseed breakdown through breeding is quite in keeping with the management systems preferred above. If all new seed remains hard through the first summer quite a large tying up of nitrogen occurs - probably well in excess of 10% of that fixed. The release of some of this as germinated seed killed by cultivation or herbicide should be beneficial to the crop.

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Table 1 - Germination with simulated rainfall on a sandy soil (data from Boyce and Saunders (1971)).

Day/Night Temperature °C	Germination % after 15.2mm 'rain' (60 points) Paragosa	Jemalong	Harbinger
21/21	98.3	100.0	88.1
27/21	98.5	94.4	50.6
32/21	46.8	7.7	3.7

Even with 7.6mm rainfall (30 points) more than 25% of Paragosa seeds germinated whereas less than 5% of Jemalong and Harbinger seeds did.

With ABUNDANT RAINFALL all 3 cultivars germinated fully throughout the temperature range.

Table 2 - Herbage yields (prior to flowering) in swards at Northfield 1969

Cultivar	Yield in gms/3,600 sq. cms			Mean Yield kg/ha
	Uninoculated	Inoculated	Inoculated + nitrogen at 3rd trifoliate leaf stage	
Harbinger	1255	1148	1336	5770
Paragosa	1109	1045	1197	5171
Cyprus	1402	1265	1481	6401
Snail	1423	1326	1122	5974
Hannaford	1081	1294	1061	5302
Jemalong	1098	1271	1161	5448
Borung	1497	1366	1486	6711
Tornafield	1101	1145	1160	5188
Cyfield	1216	1156	1217	5539
Mean	1242	1224	1247	5723
	Differences not significant at 5% level of probability for inoculation treatments			LSD 5% = 677 LSD 0.1% = 1190

Table 3 - Effect of Moisture Stress during maturation on reducing HARDSEED development in Jemalong (Burton 1964).

	Germination Percentage	
	No stress	Stress
a. Initial	2.3	40.0
b. After 1 month of alternating temperature 60°C/10°C	8.2	62.5

Table 4 - The principle of seed size - maximum hypocotyl length and how this affects seedling emergence from different depths of soil, from Black (1956).

	Emergence time (if at all!)		
	Seed size (mg.)		
Sowing depth cms.	<3.0	5.0	8.0
1.25 (½ in.)	day 4	day 4	day 4
3.2 (1¼ in)	day 6	day 5	day 5
5.1 (2 in.)	-	day 6	day 6
Maximum hypocotyl extension cm.	3.7	5.2	6.7

Figure 1 The relation between seed permeability and time of year for Paragosa, Cyprus and an ideal cultivar.

(Mathison 1972)

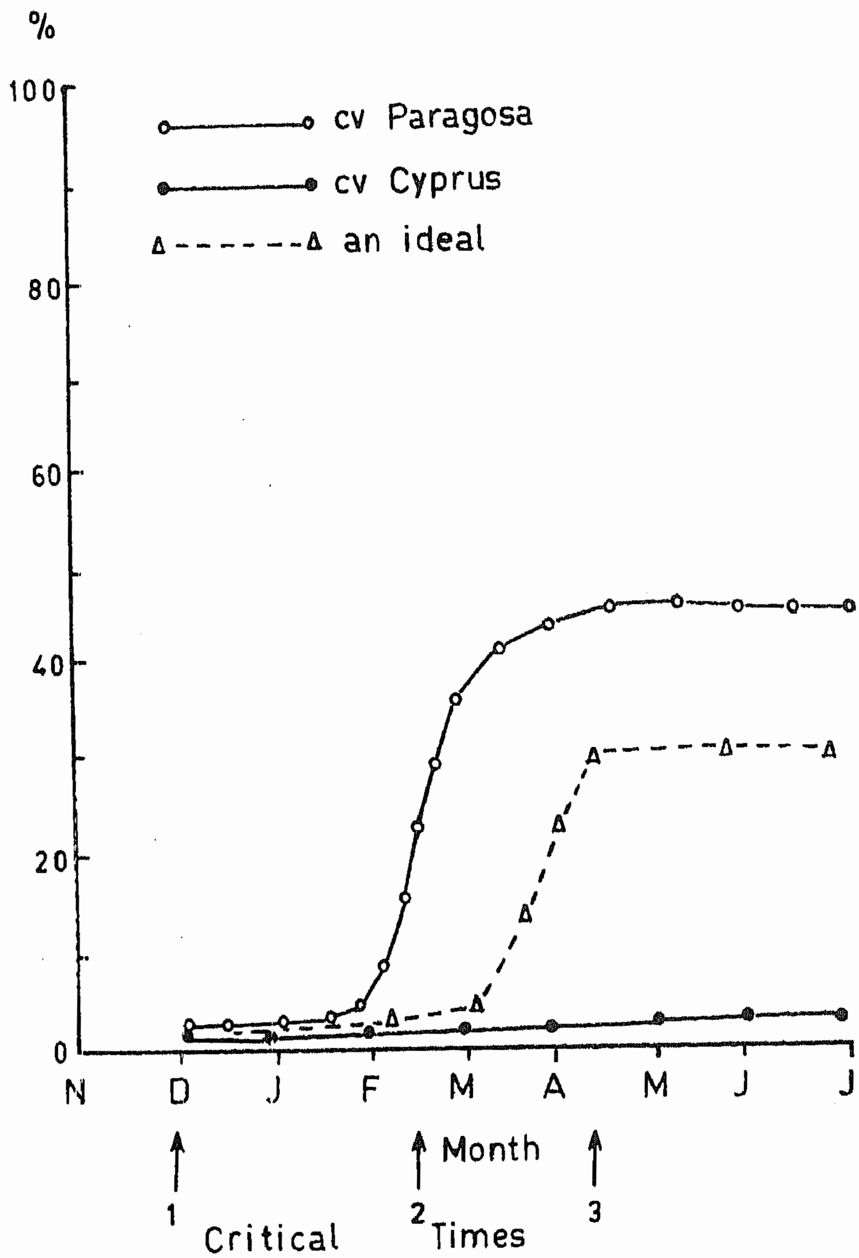


Figure 2: Generalised Relationship - Seed moisture content and seedcoat permeability.

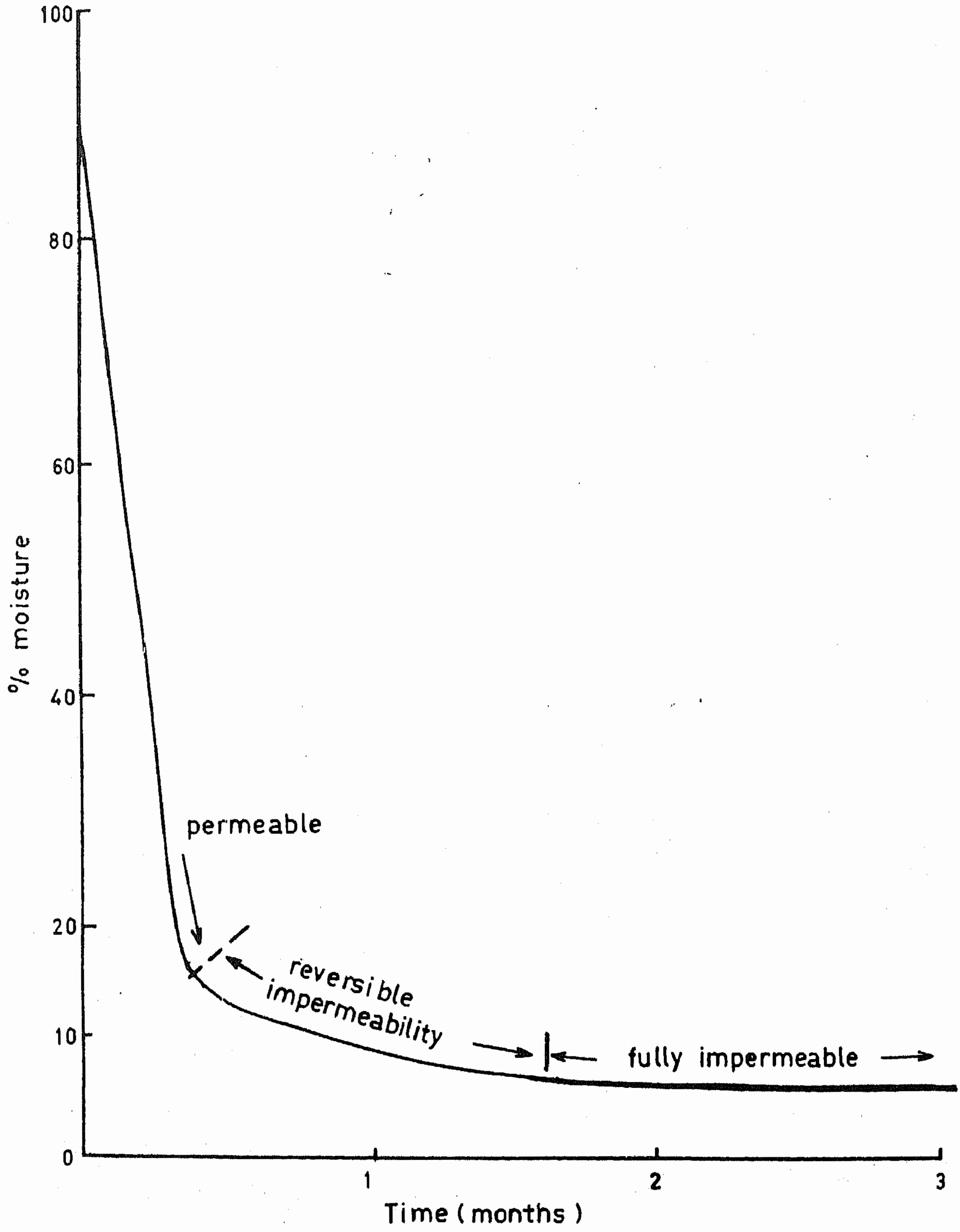


Figure 3: Mid summer soil temperatures at Northfield

(Mathison 1972)

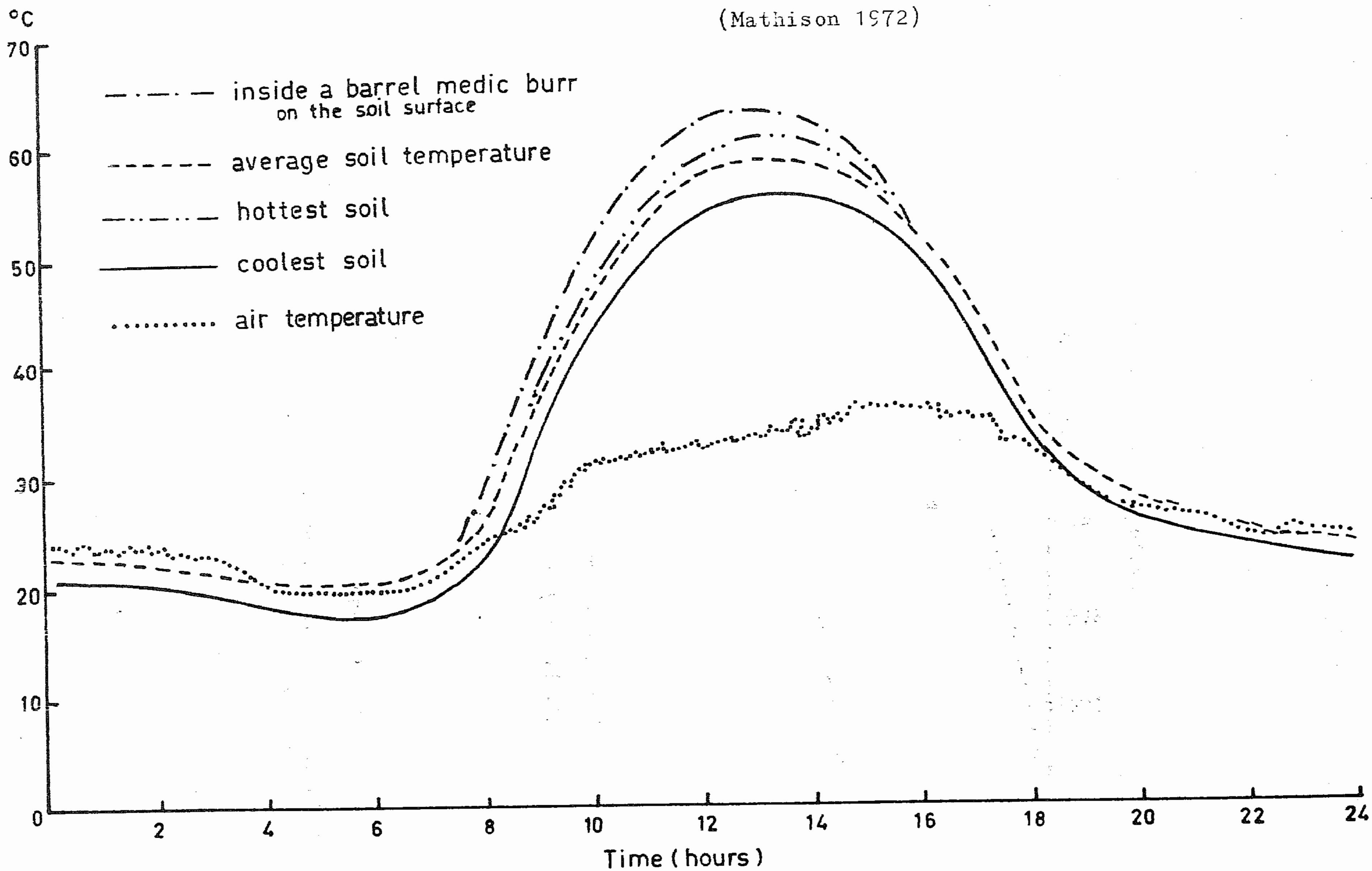
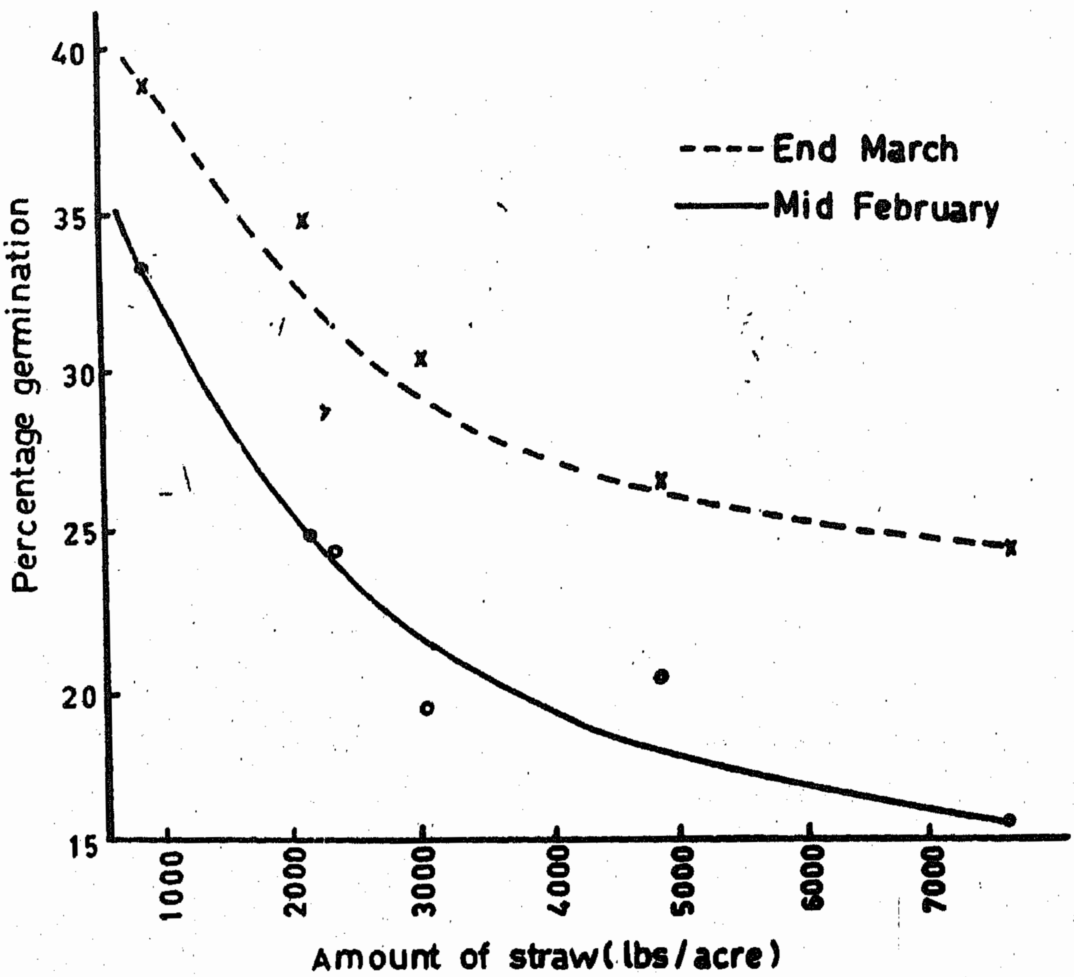


Figure 4: Graphs showing the effect of varying amounts of cover on seed permeability in *M. truncatula*.

(Burton 1964)



Discussion

Mr. Mathison's statement that seed density should range from 40 kg/ha to 60 kg/ha brought considerable comment from the extension officers particularly as it was suggested that to make sure good medic stands were established after a cereal year, medic seed of the amounts stated should be actually sown.

The feeling amongst extension officers was that the cost was excessive and that in good medic localities, natural regeneration was generally sufficient to re-establish medic pasture. The sowing of medic seed following cereal crops in areas where medics were poorly established was agreed too but here again the rates of 40 kg/ha to 60 kg/ha were considered unacceptable to most farmers.

On this particular point, Mr. McAuliffe in summing up at the finish of the conference suggested that ideally the choice of a gerotype which would consistently regenerate naturally for a particular locality would be the ideal situation to attain.

The effect of climatic conditions on the production of hard seed i.e. high percentage of hard seed produced in good years and low percentage under stress or drought conditions was discussed.

The production of hard seed would adversely effect subsequent short term germination where medic pastures had only recently been introduced but where medics had been established over several years, seed from previous medic crops should ensure reasonable germination.

continued in part 2