DEPARTMENT OF AGRICULTURE, SOUTH AUSTRALIA

Agronomy Branch Report

Data bank and gene preservation in annual species of the genus Medicago L.

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Report No. 66

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1. Introduction

At a joint meeting of officers of the Division of Plant Industry of C.S.I.R.O., Waite Agricultural Research Institute and the South Australian Department of Agriculture in 1972, it was urged that those State Organisations most appropriately concerned with the evaluation and documentation of specific plant material, be responsible for its preservation.

As a result, the South Australian Department of Agriculture has accepted the responsibility for the conservation of as wide a range of genetic diversity as can be gathered together of both wild and domesticated genotypes of the annual species of Medicago.

Since this decision the establishment in 1974 of an International Board for Plant Genetic Resources attached to the Genetic Resources Unit of F.A.O. in Rome has been a welcome step forward in the conservation, exploration and documentation of the world's plant genetic resources.

The International Bank for Rural Development, F.A.O. and others are to be commended in taking this action.

Of particular interest to Southern Australia is the preservation and long term conservation of wild species adapted to the temperate climatic regions of the world such as the Mediterranean Basin.

Agricultural production in Southern Australia is influenced largely by the nitrogen status of the soils on which various crops are grown, hence the specific interest in annual legumes.

Atmospheric nitrogen fixation by symbiosis with the appropriate Rhizobium species on annual legumes results in substantial increases in soil nitrogen.

In particular, annual Medicagos have been of immense value in this respect in South Australia's ley farming systems. This practice forms the foundation to the State's agriculture.

This preliminary paper indicates the South Australian Department of Agriculture's work on the classification of 2266 genotypes of annual medics grown between 1968 and 1971 respectively.

Subsequent papers will provide in greater detail the specific characters relevant to the various species along with summaries of an additional 2500 genotypes grown between 1972 and 1975.

2. The soil/climate relationship in South Australia

The choice of the best adapted legumes for nitrogen fixation is largely influenced by two major factors.

2.1 pH of the soil

2.2 the extent and duration of rainfall of the region.

Light and temperature usually do not limit the development of medics in South Australia.

(Low winter temperatures are a considerable hazard in many Middle East areas and elevated areas of the Mediterranean Basin).

Seventy per cent or more of the agricultural area of South Australia has soils developed from calcareous parent material.

The relative levels of minor and major soil nutrients, particularly phosphorus and calcium greatly influence rate of growth and the choice of the right basic legume for the environment.

Approximately 55% of the soils based on calcareous parent material receive less than 375 mm of mean annual rainfall which has a winter incidence coinciding with the period of lowest temperature as indicated in Figure 1 for the localities of Ceduna, Kyancutta and Lameroo respectively.

The mean growing season (April-September) rainfall of 150 mm in the lower rainfall areas to 350 mm in the higher rainfall areas, indicates that 60-70% of the total annual rainfall is effective for plant growth.

This relatively low effective rainfall associated with a drought frequency of 65-20% in similar regions often imposes severe stresses on plant growth.

To make substantial growth and fix atmospheric nitrogen under these limiting conditions, the legume must not only be capable of growing normally on alkaline soil, but also be capable of completing its life cycle from seed to seed in the short period of time of moisture availability.

Plants with life cycles adapted to these limitations have been found in the annual species of the genus Medicago.

3. Previous collections

Early collections by Neal-Smith, Donald and Miles, and seed received by exchange programmes indicated the inter-specific variability within the genus, and gave some evidence of the intraspecific variation within such species as truncatula.

An extensive collection made in the Mediterranean Basin by the author in 1967 was grown (in part) in nursery rows in 1968 and it soon became evident that a detailed classification of the whole collection was necessary to measure and document this variability.

4. Current evaluation work in South Australia

Initial quarantining and evaluation is being conducted at the Parafield Plant Introduction Centre, 18 km north of Adelaide, the mean annual rainfall of which is 450 mm and the mean July air temperature, 10.5°C.

The soil is a red-brown earth with neutral soil reaction.

As a consequence of the variability expressed in 1968, 37 morphological and 16 agronomic characteristics listed in Tables 1 and 2 were used to compare the relationship of one genotype to another. Wherever possible comparison with a standard cultivar was made within species.

The standard cultivars used were:

M. truncatula	cv. Jemalong
M. littoralis	cv. Harbinger
M. rugosa	cv. Paragosa
M. scutellata	- South Australian commercial seed (no cultivar)
M. tornata	cv. Tornafield

The cultivar Jemalong was used as a control for all other species for which there is no commercial cultivar.

In an attempt to link together the relative genotype performance in different years, appropriate 'control' lines were selected within species to be regrown the next time its respective species is grown. These 'controls' include such characteristics as:

best seedling vigour

earliest flowering

latest flowering

These 'controls' were initially selected from within the species grown in 1968 and subsequently added to as additional accessions with these attributes arise from year to year.

The seven most important agronomic characteristics used in the classification were:

seedling vigour

winter production

period to flowering

period to maturity

seed production

spininess of pod

changes in seed coat permeability

These characteristics are influenced by environmental factors. The collation and analysis of these data has been made possible by computer processing.

5. Summary of the data collected

During the four year period 1968-71 herein reported, 2266 different genotypes of 20 of the possible 28 species of annual Medicago have been characterised and assessed.

Within these 20 species, 39 of the currently recognised 41 sub species are represented.

It is inappropriate to present all data here, details are available from the author on request. However, a summary of the seven major characteristics listed above is presented in Table III.

It is important to note that of one of the major criteria for selection of improved cultivars, viz. seedling vigour, 15% of the accessions rated better than the control cultivar.

Similarly the characteristic of better winter growth is expressed in 39% of the accessions rating better than the control.

The time of floral initiation and seed production were also considered important and 26% of the accessions are earlier flowering and 40% have better seed production than their respective controls.

Perhaps a disappointing feature of the overall assessment is that only 16% of the accessions had more than 20% permeable seed by mid April, the factor of greatest limitation to the consistent high density of annual medic pasture from year to year.

6. <u>Gene variation</u>

In breeding new herbage plant cultivars, much of the success depends upon the variability of the basic material with which the programme has been initiated. Whether breeding for use under existing conditions or adaption to a changed environment, success depends largely on the recombination of several variable characteristics.

Changes in environment demand changes in adaption, hence the need to conserve existing genetic variability for future generations involved in developing cultivars for changed conditions.

The process of economic and social chamge is inevitable. However, a serious side effect is the increasing threat to existing genetic resources brought about by monocultural practices of crop and pasture production, changed levels of soil fertility, cropping frequency and stocking rate intensities all interacting to reduce the enormous variety of types of plants which existed prior to this era of so called 'agricultural progress'.

The proposed introduction of the legume - cereal ley farming system to countries with similar climate and soils to Southern Australia is but one reason why conserving genes will be important. Thus these areas should be thoroughly explored so that their genetic resources are salvaged before they are lost for ever through the agency of competition by advanced cultivars.

The initiative shown by the International Biological Programme in offering its cooperation to the F.A.O. Panel of Experts on Plant Exploration and Introduction should be encouraged in the light of current knowledge of waning genetic resources. International cooperation is urgently needed to survey, collect and document all potential crop and pasture species currently subject to either extinction by modern cultural and chemical technology or relegation into obscurity by competition of improved sown species and changed nutritional levels of the soil.

As a consequence of the concern shown by this Department, small samples of first generation pod material of the 2266 genotypes under question and others are being set aside for long term storage for use by future agronomists and plant breeders as the necessity arises.

The seed is being preserved as unthreshed seed in the pod to maximise longevity believing that seed coat impermeability will allow the seeds to live for periods of 30-40 years if stored under dry and cool conditions.

Future collections of seeds will be stored in a similar fashion until even better conditions of humidity and temperature control are known.

Meanwhile, additional supplies of both threshed and unthreshed material are being maintained for use by current genotype evaluators and plant breeders.

7. The future programme

The collection, documentation and preservation of genetic resources is a continuing programme and the data herein presented represents but an introduction to the subject.

The maintenance of viability and genetic purity of 5000 genotypes of one genus is a major task but will ensure that the world's genetic resources in *Medicago* are being preserved for posterity.

Table I

37 morphological characteristics used to classify the 2266 genotypes of annual Medicago species at Parafield Plant Introduction Centre, 1968-71.

1. Habit
2. Internode length
3. Branching
    - 3.1 Primary
    - 3.2 Secondary
    - 3.3 Tertiary
4. Foliage size
5. Leaf marker
    - 5.1 Position
    - 5.2 Shape
    - 5.3 Colour
6. Leaflet
    - 6.1 Margin
    - 6.2 Shape
    - 6.3 Hairiness
7. Stem
    - 7.1 Colour
    - 7.2 Hairiness
8. Stipule
    - 8.1 Colour
    - 8.2 Hairiness
    - 8.3 Venation
    - 8.4 Shape
9. Peduncle: Petiole ratio
10. Petiole
    - 10.1 Colour
    - 10.2 Hairiness
11. Peduncle
    - 11.1 Colour
    - 11.2 Hairiness
12. Calyx
    - 12.1 Hairiness
    - 12.2 Teeth shape
13. Corolla
    - 13.1 Colour and venation
    - 13.2 Length
14. Floret number
15. Fruit number
16. Pod
    - 16.1 Emergence
    - 16.2 Coil number range
    - 16.3 Coil direction
    - 16.4 Hairiness
    - 16.5 Shape
    - 16.6 Nature of spininess
17. Seed
    - 17.1 Colour
    - 17.2 Shape

Table II

16 agronomic characteristics used in classifying the 2266 genotypes of annual *Medicago* species at Parafield Plant Introduction Centre, 1968-71.

1. Period to first flowering
2. Period to last flowering
3. Node number at first flowering
4. Period to first maturity
5. Period to last maturity
6. Period to leaf marker cessation
7. Period to death of plant
8. Seedling vigour
9. Herbage yield - 6 scores at 3 weekly intervals
10. Leaf area index
11. Pod
    - 11.1 yield
    - 11.2 weight
    - 11.3 degree of spininess
12. Seed
    - 12.1 yield
    - 12.2 weight
    - 12.3 permeability changes at 5 x 3 weekly intervals after late January.

From this data, other important characteristics such as maturation period, seed/pod ratio and number of seeds per pod can be calculated.

Table III

MEDICAGO ACCESSIONS WITH SIX MAJOR AGRONOMIC AND SEED PERMEABILITY DATA COLLECTED AT PARAFIELD PLANT INTRODUCTION CENTRE - 1968-71

YEAR	SPECIES	ACCESSIONS	CHARACTERISTICS						
			A	B	C	D	E	F	G
1968	M. littoralis	257	25	n.a.	32	6	17	6	2
	M. rugosa	32	5	n.a.	16	14	7	0	9
	M. tornata	32	0	n.a.	1	0	29	0	10
	M. truncatula	207	51	n.a.	108	77	70	70	1
	Sub. total	528	81	-	157	97	123	76	22
1969	M. aculeata	73	10	7	9	1	4	50	11
	M. blancheana	18	14	13	6	9	1	18	0
	M. constricta	15	0	0	3	1	0	1	1
	M. littoralis	25	1	0	2	1	1	2	13
	M. murex	10	1	2	0	0	2	4	2
	M. rigidula	87	0	0	1	2	3	14	9
	M. rotata	23	4	5	6	13	1	23	0
	M. rugosa	8	0	3	4	4	1	0	3
	M. scutellata	68	1	19	13	20	19	0	17
	M. tornata	16	0	9	3	3	10	0	4
	M. truncatula	99	25	14	26	19	19	22	30
	Sub. total	442	56	72	73	73	61	134	90
1970	M. aculeata	51	0	11	10	0	18	47	18
	M. constricta	17	0	0	4	3	0	2	9
	M. littoralis	56	0	2	5	5	2	9	38
	M. orbicularis	192	9	27	3	10	128	0	8
	M. rugosa	10	3	6	2	2	3	0	7
	M. tornata	45	0	11	0	0	2	0	33
	M. truncatula	107	2	8	28	17	49	40	49
	M. turbinata	69	0	20	31	1	24	68	3
	Sub. total	547	14	85	83	38	226	166	165
1971	M. arabica	16	2	2	0	0	1	1	6
	M. disciformis	19	0	0	1	1	0	0	0
	M. granadensis	8	8	7	0	0	2	0	0
	M. intertexta	65	65	62	14	0	53	3	0
	M. littoralis	38	1	0	6	4	0	2	8
	M. polymorpha	505	96	423	236	263	420	190	43
	M. praecox	6	0	0	4	3	0	0	2
	M. rugosa	3	0	2	1	1	2	0	3
	M. tenoreana	1	0	0	0	0	0	0	0
	M. tornata	14	7	5	1	2	0	0	5
	M. truncatula	74	7	12	16	4	24	27	20
	Sub. total	749	186	513	279	278	502	223	87
	TOTAL	2266	337	670	592	486	912	599	364

n.a. = not available

A. Seedling vigour greater than control.

B. Winter production greater than control.

C. Flowering earlier than control.

D. Maturity earlier than control

E. Seed production greater than control.

F. Pod spininess less than control.

G. Impermeable seed less than 80% in mid April.

Mean monthly rainfall and temperature data at three selected sites in South Australia.

Fig. 1