# *Medicago truncatula* cultivars

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## *Medicago truncatula* cultivars

The chapter deals with a brief account of *Medicago truncatula* cultivar development in Australia and annual medic improvement in south of France. Key agronomic and morphological characters of the cultivars developed and a general agronomy on annual medics is covered.

## 1. Australian cultivars

### 1.1 Background

*Medicago truncatula* Gaertn. (barrel medic) is an important pasture species in southern Australian cereal-livestock zone. It provides feed for livestock as well as benefiting the following cereal crop by improving soil fertility through nitrogen fixation and also by providing disease break for various cereal root pathogens. In common with other self-regenerating annual *Medicago* spp., barrel medics have relatively high levels of hardseededness, which enables them to persist through cropping phases and to regenerate in subsequent years as pasture. Generally barrel medics are well adapted to neutral to alkaline (> pH $_{(water)}$ 6.5) soil types ranging in texture from sandy loams to clays. Barrel medic is estimated to be grown on over 4.5 million hectares in Australia (Hill and Donald, 1998).

Early released cultivars were based on direct plant introductions and selections from introduced accessions (Crawford *et al* 1989). Resistance to the pasture aphids, bluegreen aphid (BGA), *Acyrthosiphon kondoi* and spotted alfalfa aphid (SAA), *Therioaphis trifolii*, has received a high priority in the improvement of annual medics. This was prompted by the invasion of these aphids in the late 1970's, which caused widespread devastation of annual medic pastures (and alfalfa, *M. sativa*) and a significant reduction in pasture productivity and persistence (Crawford *et al* 1989). Screening of exotic germplasm led to the identification of aphid resistant accessions. These accessions have been used in backcrossing programs to improve existing adapted varieties. Mogul was developed from Borung (Anon 1993 a), Caliph from Cyprus (Anon 1993 b), and Jester from Jemalong (Anon 2000). Jester possesses resistance to both BGA (Fig.1) and SAA, while Mogul and Caliph have resistance to SAA and moderate resistance to BGA. The near-isogenic lines (Mogul-Borung; Caliph-Cyprus; Jester-Jemalong) are a valuable resource for genetic studies.


**Fig 1.** Jester demonstrating good resistance to bluegreen aphid compared to Jemalong (susceptible).

*M. truncatula* accessions have also been used as donor parents in the development of aphid resistant cultivars of other annual medic species such as *M. littoralis* and *M. tornata*. Current breeding objectives include selecting for tolerance to soil residues of the Group B sulfonylurea herbicides, powdery mildew (*Erysiphe trifolii*) resistance and tolerance to root-lesion nematode (*Pratylenchus neglectus*).

## 1.2 Cultivar descriptions

The origin and key characteristics of *M. truncatula* cultivars in Australia are presented in Table 1. The link to the website below (Register of Australian Herbage Cultivars) contains detailed information regarding most of the cultivars in Australia. A full morphological description and the agronomic uses and merits of each cultivar (except Jester) are presented.
http://www.pi.csiro.au/ahpc/legumes/legumes.htm See also the link below for access to the Australian Government (IP Australia) Plant Breeders Rights (PBR) database of PBR varieties
http://www.ipaustralia.gov.au/pbr/index.shtml

## Table 1. Key agronomic and morphological features of barrel medic (*M. truncatula*) varieties commercialised in Australia

| Cultivar (Year released or registered) | Preferred soil texture | Average annual rainfall[1] (mm) | Days to flowering[2] | % hardseed[3] | Pod coil direction[4] | No. of whorls | Pod length (mm) | Seeds /pod | Pod spine[5] | BGA[6] resistance | SAA[7] resistance | Pn[8] resistance | Boron[9] tolerance |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Hannaford (1939)** | Sandy loams to loams | > 300 | 100 | - | C | 4 – 6 | - | 8 - 10 | 10 | S | S | - | - |
| **Jemalong (1955)** | Sandy loams to clay loams | > 350 | 110 | 80 - 90 | A | 5 - 7 | 7 – 9.5 | 8 - 11 | 10 | S | MS | - | S |
| **Cyprus (1959)** | Loams to clays | > 275 | 90 | 80 - 90 | C | 4 - 6 | 5.2 – 7.7 | 5 - 8 | 10 | S | R | - | MT |
| **Borung (1970)** | Loams to clays | > 350 | 105 | 70 – 80 | A | 3.5 - 4.5 | 4 - 6.5 | 4 - 6 | 10 | S | S | - | S/VS |
| **Paraggio (1982)** | Sandy loams to clay loams | > 350 | 110 | 65 – 75 | C | 4 - 6 | 5.5 - 8 | 6 - 9 | 10 | R | MS/MR | MR | T |
| **Sephi (1984)** | Sandy loams to clay loams | > 350 | 110 | 80 - 90 | C | 3-4 | squat L < D | 7 - 9 | 12 | R | R | - | T |
| **Parabinga (1986)** | Loamy sands to clay loams | > 275 | 90 | 80 - 90 | C | 4.5 – 6 | 6 – 9 | 6 - 9 | 12 | R | MS | MR | MT/T |
| **Mogul[A] (1992)** | Loams to clays | > 350 | 105 | 70 – 80 | A | 3.5 - 4.5 | 5 – 7 | 5 - 7 | 10 | R | MR | MR | S/VS |
| **Caliph[A] (1993)** | Loams to clays | > 275 | 90 | 85 – 95 | C | 3.5 - 5.5 | 5.4 – 7.9 | 5 - 8 | 10 | R | R | R | T |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Jester**[A] **(2001)** | Sandy loams to clay loams | > 350 | 110 | 80 – 90 | A | 5 – 7 | 7 – 9.5 | 8 - 12 | 10 | R | R | MR | MS/S |

**Legend**

[1] Lower limit of adaptation for average annual rainfall (mm)

[2] Approximate days to flowering after a May (South Australia) sowing

[3] **A**pproximate percentage (%) hardseededness levels in the autumn following seed set (subject to environmental variation)

[4] Direction of pod coiling (IBPGR, 1991)

[5] Pod spine rating based on Jemalong as a standard '10' (IBPGR, 1991)

[6, 7] Bluegreen aphid (BGA) and spotted alfalfa aphid (SAA) resistance based on glasshouse ratings of plants 4-6 weeks old (S – susceptible; MS – moderately susceptible; MR – moderately resistant; R – resistant)

[8] *Pratylenchus neglectus* root lesion nematode resistance based on field ratings (Ballard *et al*, 2006)

[9] Boron tolerance based on glasshouse ratings on plants grown from seedling to flowering (VS – very sensitive; S – sensitive; MS – moderately sensitive; MT – moderately tolerant; T – tolerant)

## 1.3 Agronomy

**Establishment**
In Australia, annual medics are typically established by sowing dry (from about April onwards) before the normal opening rains, into cereal stubbles which are ideally free of weeds and which have had good weed control the previous year. Alternatively they are under-sown at low rates with the cereal crop or sown alone into a moist and weed-free seedbed soon after the break of the season.

**Seeding rate & sowing**
They are typically sown at a seeding rate of 4-10 kg/ha, depending on the cultivar seed size and situation. Higher seeding rates improve competition against weeds, achieve full ground cover more quickly and allow for earlier grazing in the first year. Individual cultivars may be sown at lower rates if being used in mixtures of varieties with different maturity, adaptation and hardseededness characteristics in an attempt to overcome seasonal, soil and rotational variability.
Being relatively small-seeded, the target sowing depth for annual medics is about 1-2 cm, with press wheels or covering devices such as harrows or prickle chains being used to help ensure good seed-soil contact and thus improved germination, emergence and establishment.

**Inoculation**
Inoculation of barrel medic seed with group AM rhizobium is generally recommended to growers and especially if the recent medic history in the particular paddock has been poor and/or the soil $pH_{(water)\ is}$ below 6.5. If the paddock has had a healthy stand of medic in the past two years the background rhizobium levels are likely to be high and response from inoculation is unlikely. Good nodulation of the root system is essential to maximise nitrogen fixation for the benefit of both medic and any subsequent crops.

**Nutrition**
An adequate supply of phosphorus is critical for maximum pasture legume growth and is often the single most important macronutrient limiting annual medic growth, especially on some of the relatively infertile alkaline soils of the Australian wheat-sheep zone. Medic pastures are either top-dressed with phosphate fertilisers or more typically must derive their requirements from residual phosphorus applied in the cereal phases of the pasture/cereal rotation.

Other important elements include the micronutrients, zinc, copper, molybdenum and cobalt, the latter three being directly involved in nitrogen fixation processes.

**Weed control**
It is important to maximise seed set in the establishment year of annual medics in order to build up soil seed reserves and thus to maximise persistence and productivity in subsequent regeneration phases. To achieve this, competition from weeds needs to be minimised as much as possible. Early removal of grasses with grass selective herbicides is widely practiced in Australia and results in improved pasture growth and reduced carry-over of cereal root diseases such as *Gaeumannomyces graminis* var. *tritici* (Take-all) and cereal cyst nematode, *Heterodera avenae* (CCN). Some broadleaf weeds may also be controlled with selective herbicides.

Less selective means of weed control are also practiced such as grazing, spray-grazing (low rates of phenoxy herbicides combined with high stocking rates) and spray-topping (low rates of glyphosate or paraquat applied to flowering grasses to prevent seed-set).

**Herbicide tolerance**

Legumes in general are very sensitive to soil residues of sulfonylurea (SU) herbicides, which are currently widely used in the cropping phase of many Australian farming systems. Some of these herbicides have quite long plant-back periods before legumes can be safely grown, especially in low rainfall regions with alkaline soils (eg 24 months). It is hypothesised that the widespread presence of these SU soil residues has been a contributing factor to a decrease in annual medic pasture productivity in recent decades. This issue has been addressed in the strand medics (*M. littoralis*) with the recent (2006) release of a new variety, Angel[A], which has good tolerance of sulfonylurea herbicide residues. This trait is now also being introgressed into *M. truncatula* with the objective of releasing SU residue tolerant barrel medic cultivars in the near future.

**Pest and diseases**

In addition to the pasture aphids (BGA, SAA and cowpea aphid), redlegged earth mite (*Haleotydeus destructor*) and lucerne flea (*Sminthurus viridus*) can also cause significant damage to annual medic pastures, both at the seedling and flowering stage, and must often be controlled with the application of insecticides.

Fungal diseases that can cause significant damage at times include *Rhizoctonia solani*, *Phoma medicaginis* and *Erysiphe trifolii* (powdery mildew).

*Pratylenchus neglectus* root lesion nematode (RLN) is a commonly occurring root pathogen across the wheat/sheep zones and while annual medics are generally rated as being moderately resistant (i.e. as a host, they do not cause an increase in the pathogen), they are however relatively intolerant in that their productivity can be significantly reduced in the presence of RLN.

**Grazing management**

Correct grazing is critical in maximising medic seed production for subsequent regeneration phases (Fig. 2) and in controlling weeds. Ideally grazing is deferred at the break of the season (depending on feed availability elsewhere on the farm) until the germinating medic plants are well established (approximately 6 leaves) and the ground is covered - around 1000 kg/ha dry matter or 2.5 to 3 cm height for a dense pasture. Paddocks are typically ‘set stocked’ where the grazing pressure is maintained during winter to control upright grasses and weeds and to encourage prostrate growth until ground cover is complete. In early spring it is sometimes necessary to increase grazing pressure to prevent overly bulky or rank pastures, which are more susceptible to moisture stress and foliar fungal disease. During flowering, grazing pressure is ideally reduced (or removed) to a level that still promotes leaf, runner and flower production whilst maximising pod and seed set. At this point, livestock can be transferred to spray topped grass pastures, or used to put extra pressure on weedy paddocks. Also as the grain harvest commences, valuable grazing is obtained from the stubbles remaining after harvest. When this is exhausted sheep are then re-introduced into the senesced pasture paddocks for late summer/autumn grazing but careful monitoring is required, as over-grazing of dried residues and pods can lead to soil erosion and reduced future pasture regeneration.

**Fig. 2.** Paraggio barrel medic regenerating through previous year's cereal stubble at Mallala, South Australia

## Commercial seed production

When mature, annual medic pods generally fall to the ground, which makes harvesting by conventional means impossible. Instead commercial seed growers use specialised vacuum harvesters (Fig. 3) to suck the pods from the soil surface and then to thresh and clean the seed (similar to commercial subclover harvesting). Paddock preparation is critical in achieving good yields of clean seed and the harvesting process itself is very slow, all of which contributes significantly to the final cost of the seed. Dryland seed yields typically average around 350 – 400 kg/ha and the cost to farmers of certified seed of a variety protected by Plant Breeders Rights is about $4.50/kg.

**Fig.3.** Suction harvesting of annual medics

## 2 USE OF ANNUAL MEDICS IN THE SOUTH OF FRANCE

The genus *Medicago* is native from the Mediterranean Basin, and the South of France is the northern part of area of distribution of *Medicago truncatula*. *Medicago polymorpha, rigidula, minima and orbicularis* are very frequent in the calcareous soil with a basic pH in South of France.

French National Institute for Agricultural Research (INRA) selected 4 cultivars that can be used in three main domains in South of France:

(1) To improve the quantity and quality of forage in rangeland for sheep rearing in the dry Causses ( foe example sheep rearing, for ewe's milk cheese "Roquefort");
(2) To maintain soils around infrastructures: roadsides, railway lines embankments and disturbed areas;
(3) To avoid soil erosion from rainfalls and winds, reduce the use of herbicides, limit infiltrations of pesticides in soils and enhance underground life in slopping vineyards;

These cultivars are well adapted to the dry and cold Mediterranean regions. French Mediterranean regions covers 12% of France (around 7 million hectares). It includes Languedoc-Roussillon, Provence–Alpes-Côte d'Azur and Corse administrative regions. The regions are mainly costal except in Corsica or in the north of extreme South of France. One of the main characteristics of all these regions is the importance of winter rainfalls (more than 40% annual rainfall) with cold temperatures, that reduces the possibilities for vegetative growth.

The four cultivars were developed at Montpellier plant breeding department and are under Plant Breeder's Right (UPOV) since 1997. They belong to three species: *Medicago truncatula*, *Medicago polymorpha and Medicago rigidula*. Table 2 summarizes their main characteristics.

Annuals medics could be cultivated in non-Mediterranean regions such as the Western part of France where winter temperatures are not too cold and would allows an annual legume growth period in fall and spring. They could also be used as a spring annual forage legume crop throughout France, in place of *Vicia* or *Pisum*, to produce hay. In this case, high-producing cultivar with erect growth must be selected (for example from species *Medicago scutellata*).

**Table 2. Key features of French annual medic cultivars**

| Cultivar<br>Year released/registered | Species | % Hard-seed | Pod coil | Weight of 1000 seeds | Growth habit | Leaf markers/comments | Seed set | **Days from sowing to first flowering** | **Winter growth** | **Frost susceptibility** |
|---|---|---|---|---|---|---|---|---|---|---|
| Salernes<br>Ref : F83005A-MPG<br>PBR | *Medicago truncatula spp truncatula* | 30 to 50 % | A | 2.8 g | prostrate | Leaflet shape: ovate<br>Leaflet marker: red fleck | Medium to good (700 to 900 kg/ha) | Medium (185-195) | 4.0 | 5.8 |
| Mauguio<br>Rel: F34004-MPG<br>PBR | *Medicago polymorpha spp vulgaris* | 30 to 50 % | A | 2.4 g | Semi-erect | Leaflet shape: obovate<br>Leaflet marker: nil | Good (800 to 1,000 kg/ha) | Medium (180-195) | 3.1 | 4.4 |
| Ampus<br>Ref: F83005A-MPG<br>PBR | *Medicago rigidula spp cinerascens* | 30 to 50 % | A | 3.3 g | Very prostrate | Leaflet shape: cuneate<br>Leaflet marker: nil | Medium (600 to 800 kg/ha) | Late (185-210) | 3.7 | 3.8 |
| Kalambaka<br>Ref:<br>PBR | *Medicago rigidula spp cinerascens* | 30 to 50 % | A | 3.0 g | Prostrate | Leaflet shape: cuneate<br>Leaflet marker: small red fleck | Medium (600 to 900 kg/ha) | Late (190-205) | 4.1 | 3.2 |

**Legend**
**PBR**: cultivar under Plant Breeder's Right (UPOV)
**% hardness**: All theses genotypes have relatively poor hard seeds rate (between 30 to 50 %).
**Pod coiling** A : anticlockwise ; C : clockwise
**Winter growth** and **frost susceptibility** have been tested in very hard frosts conditions, in nursery spaced plants. Mean of 30 plants by population or cultivar.
Tested during winter 1986-87: Absolute minimum temperature on soil -17°C.
Mean temperature of second period of ten days of January 1987 -3.5°C.
**Winter growth**: 1 nil to 9 very important
**Frost susceptibility**: 1 very tolerant to 9 susceptible

**Agronomy**
Establishment: annual medics establish well if sown between 15 of August and 15 of October at a period favourable to rainfalls with enough temperature to favour a rapid establishment. Sow into a fine, moist and weed-free seedbed, at 1-2 cm deep and ensure a good seed-soil contact using a press or a covering device.

**Seeding rate**
Sow at 20-30 kg/ ha that is 2 to 3 grams per square meter, sowing depends on the situation (the finer the seedbed the less seeds are needed and at the opposite the more stones in the vineyard the more seeds must be sown). Prefer a mixture of species rather than one to help overcome seasonal and disease variability.

**Inoculation**
As *Medicago* is native in the South of France there is usually no need for inoculation as long as soil pH (water) is over 6.5. Have a look around the fields to ensure that annual medics are present (*Medicago minima, Medicago polymorpha* and *Medicago orbicularis* are very frequent).

**Regeneration**
The year of establishment is very important for a good regeneration. Seed set must be maximized during this year by reducing weed competition as much as possible. Due to seed hardness, one regeneration can provide enough seeds for more than 4 years of germination. Each year, the seed stock in the soil increases and if weed competition is well managed the regeneration may last for 8 to 10 years.

**Weed control**
With new regulations about the E.C. vineyards, fewer and fewer herbicides are allowed in the French vineyards. Yet, it is still possible to use some contact herbicides in the Summer when medics are dead and seeds protected in their pods, or an alternative solution for weed control is cutting the summer weeds before their flowering or seed setting.

**Vineyards**
During the first year, it is better not to allow grazing in order to maximize seed setting. In the first year of regeneration, light grazing is possible during Fall and Winter since it can help to keep the plants short. Grazing must stop by February to enable the plants to flower and set seeds by April–May.

**Fig.4.** Medics grown in vineyards in South of France. Photo taken in February (winter).

## References

Anon (1993a). *Plant Varieties Journal*. March 1993, **6** (1) 23.

Anon (1993b). *Plant Varieties Journal*. March 1993, **6** (1) 26.

Anon (2000) *Plant Varieties Journal*. Editors, Hossain,T *et al*., June 2000, **13** (2) 40.

Ballard RA**,** Hutton RE, Taylor SP, McKay AC, Howie, JH (2006). Field resistance of annual pasture legumes to the root lesion nematode, *Pratylenchus neglectus*. Australasian Plant Pathology **35**, 303-308.

Crawford EJ, Lake AWH, Boyce, KG (1989) Breeding Annual *Medicago* species for semiarid conditions in southern Australia. *Advances in Agronomy* **42**, 399-437.

IBPGR, (1991). Descriptors for Annual *Medicago*. International Board for Plant Genetic Resources, Rome, Italy.

Masson P & Gintzberger G, 1986. Enherbement des vignobles en climat Méditerranéen : perspectives d'utilisation des légumineuses annuelles. Pages 145-152 *in Proceedings du 2ème Symposium International sur la culture de la Vigne*, Montpellier, France.

Prosperi JM, 1993. Selection of annual medics for French Mediterranean regions *in* Introducing Ley Farming to the Mediterranean Basin, *Proceedings of an*

*International Workshop,* 26-30 june 1989, Perugia, Italy. Ed S.Christansen, L. Materon, M. Falcinelli & P. Cooks.. International Center for Agriculture in the Dry Areas.

Properi JM, Angevain M & Mansat P, 1987. Objectifs de la sélection des Medicago annuelles pour la zone méditerranéenne française. *Proceedings 5th meeting of Sub-Network on Mediterranean Pastures.* FAO-European cooperative network on pasture and fodder crop production. 13-17 october 1987, Montpellier, France.

Prosperi JM & Soussana JF, 1984. L'amélioration pastorale des parcours de garrigues par sursemis. Premiers résultats. *Fourrages* 99:83-110.

Rochon JJ, Goby JP & Gintzberger G, 1988. Utilisation de prairies à luzernes annuelles pour la production hivernale d'agneaux en plaine du Roussillon. *Fourrages* 116:409-418.