# Agronomic performance of annual self-reseeding legumes and their self-establishment potential in the Apulia region of Italy

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## Abstract

*The agronomic performance, biological nitrogen fixation (BNF) ability and self-establishment potential of seven species of annual self-reseeding legumes were investigated in Apulia region, Italy. For the first cropping cycle (2005-2006) preliminary results showed that* Trifolium spp. *performed better than* Medicago spp. *Among the seven species, five were more suitable to the site's conditions.* T. angustifolium *and* M. polymorpha *gave the best results.* T. angustifolium *fixed 131.7 kg ha$^{-1}$ year of nitrogen ($^{15}$N isotope dilution method), produced 1976 kg ha$^{-1}$ of seeds and 8.7 t ha$^{-1}$ of dry matter (DM).* M. radiata *and* M. rigidula *were the less performing. During the second cropping cycle (2006-2007) results showed that* Trifolium spp. *self-established better than* Medigaco spp. *Regenerated species appeared to sustain optimum level of BNF.* Again T. angustifolium *was the best performing species producing the highest DM (7.7 t ha$^{-1}$) and fixing nitrogen (146.7 kg) N ha$^{-1}$ symbiotically. In contrast,* M. polymorpha, *was the less performing (0.3 t ha$^{-1}$ of DM and 11.5 kg ha$^{1}$ of BNF) while* M. rigidula *and* M. radiata *did not regenerate. Given the overall performance of all species, it was determined that* T. angustifolium *had the greatest potential for further development in this environment.*

## Introduction

Successful establishment of annual legumes is achieved only with the use of varieties that have both high persistence and high productivity within the specific environment in which they are used (Rochon *et al*., 2004). In the Mediterranean areas, native ecotypes are more persistent and better adapted than commercial varieties (Fara *et al.,* 1997). Self-reseeding annual legumes can play an increasingly important role in Mediterranean organic farming systems. They are flexible components within the whole farm systems, and can be used as cover crop, living mulches, green manure and forage crops to increase economic, environmental and social sustainability (Caporali *et al*., 2004). Nitrogen fixed by legumes is the main nitrogen source in organic farming systems (Loges *et al*., 2000). Moreover, in order to design strategies for optimizing management of biological nitrogen fixation (BNF) for maximal production with minimal nitrogen pollution of water resources, it is essential that nitrogen inputs by legumes and the subsequent fate of this nitrogen be quantitatively assessed (Unkovich and Pate, 2001).Therefore, the agronomic performance, ability of nitrogen fixation and self-establishment potential of seven self-reseeding legumes (four *Trifolium* species *as* well as three *Medicago* spp.) were investigated in

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comparison with *Trifolium subterraneum* cv. Antas *(T.su.)* used as reference crop during the period between autumn 2005 and spring 2007 in South of Italy.

## Materials and methods

The experiment was carried out at the experimental field of IAMB located in Apulia region, South of Italy (41°03'16"N, 16°52'45"E, 72 m a.s.l.). Apulia region is characterized by a Mediterranean climate with humid mild winter and hot dry summer. Precipitation varies from 400 to 500 mm/ year and is mainly concentrated between October and April. Annual average temperature ranges from 15 to 16 °C, with a maximum of 35°C recorded in July and a minimum of 0°C in January (IAMB's Agrometerological Station). The soil type was a sandy clay. Soil pH was 8.1, soil organic matter 1.6%, P and K (0-20 cm) were approximately 85 and 514 mg $kg^{-1}$, respectively at experimental site.

Seven accessions of annual self-reseeding legumes (*Trifolium angustifolium (T.a.), T. campestre (T.ca.), T. cherleri (T.ch.), T. stellatum (T.st.), Medigago polymorpha (T.p.), M. rigidula (M.ri.) M. radiata (M. ra.*) and two reference crops *Trifolium subterraneum (T.su)* cv. ANTAS (Crl1) and Barley *Hordeum vulgare* (Crl2) (as reference for $^{15}N$ isotope dilution method) were arranged in a randomised completely block design with four replicates. Each block was composed of 9 plots of 9 $m^2$.

Legumes were sown in November 2005 at a rate of 28 kg $ha^{-1}$. The first growth cycle extended over seven months until the end of May 2006. Legumes were left on the field over the summer after seed production. In autumn (October 2006), legumes self-established after the first rain and grew until April 2007. Legumes were then incorporated (no cutting regime) as a green manure for further investigation.

During the two growing cycles, plant height and crop ground cover were measured every two weeks. Before full-flowering stage April 2006 and March 2007, BNF was quantified using $^{15}N$ isotope dilution method (Unkovich and Pate 2001). In each plot, a quadrat of 2.25 $m^2$ was identified and two grams of ammonium sulphate $(^{15}NH_4)_2SO_4$ diluted in 10 liters of water were sprayed. At the end of each growing cycle a representative sample per plot was used to measure DM, seed yield (only for the first cycle) and $^{15}N$ (mass spectrophotometer) for BNF quantification. Statistic analysis was performed on each variable by analysis of variance. The observed measurements average were compared according to Duncan test.

## Results and brief discussion

Highly significant differences of DM production were obtained between *T.a*, *T.ca*, *M.p.* and *T. su* (Crl1) in which Crl1 showed the lowest DM value. Highly significant differences were also observed between the Crl1 and *M.ri* and *M. ra,* in which Crl1 showed a higher value (Tab.1). The lowest DM production of *M. p.* and *M. ri.* were far inferior to these reported by Walsh *et al.*, (2001) in a study for annual medic production, with large differences in experimental design and sites conditions (i.e. soil pH=6.1) in Western Australia.

Amount of BNF ranged from 0.7 to 147 kg $ha^{-1}$ (Tab.1 & 2) and this is confirming results of Peoples *et al*., (1998) and Evers (2003).

*T. a.* resulted in the highest BNF (146.7 kg $ha^{-1}$ year), *M. p.* and *T. ca*. resulted in the lowest amounts (11.5 and 9.9 kg $ha^{-1}$ year) in the second cropping cycle while (90 and

70 kg ha$^{-1}$ year) in the first, respectively. This is due to the high DM production of *M. p.* and *T. ca*. in the first cropping cycle (5.5 and 5.1 t ha$^{-1}$) in comparison with only (0.3 and 0.3 t ha$^{-1}$) in the second cycle, respectively. A clear reduction in BNF was also determined for *T.ch*. and *T. st*. for the second cropping cycle.

**Tab. 1:** Agronomic performance of annual self-reseeding legumes (at the end of the 1st growth cycle November 2005- May 2006)

| Species | Plant height (cm) | Crop ground cover (%) | DM (t ha$^{-1}$) | Seed yield (kg ha$^{-1}$) | BNF (kg ha$^{-1}$ year) |
|---|---|---|---|---|---|
| *T. angustifolium* | 43.4 b | 100 a | 8.7 a | 1976 a | 131.7 a |
| *T. campestre* | 33.9 b | 100 a | 5.1 b | 472 cd | 66.7 c |
| *T. stellatum* | 32,6 c | 100 a | 3.2 c | 683 d | 35.2 d |
| *T. cherleri* | 28.5 cd | 99 a | 3.6 c | 1089 b | 47.2 d |
| *M. polymorpha* | 55.6 a | 100 a | 5.5 b | 732 c | 89.6 b |
| *M. rigidula* | 23.6 d | 53 b | 0.9 d | 60 e | 1.9 e |
| *M. radiata* | 6.1 e | 8 c | 0.2 d | 22 e | 0.7 e |
| *T. subterraneum* cv. Antas (Crl1) | 51.4 a | 100 a | 2.8 c | 527 cd | 32.6 d |

Means with different letters are significantly different (Duncan test, α=0.05)

Highly significant differences were assessed between *T. a*. and *T. su.* (Crl1) for mainly DM and BNF in which the Crl1 showed the lowest value. Highly significant differences were also obtained between the Crl1 and the rest of the tested species in which the Crl1 showed the highest value (Tab. 2).

**Tab. 2:** Self-establishment of annual self-reseeding legumes (at the end of the 2nd growth cycle September 2006- April 2007)

| Species | Plant height (cm) | Crop ground cover (%) | DM (t.ha$^{-1}$) | BNF (kg ha$^{-1}$ year) |
|---|---|---|---|---|
| *T. angustifolium* | 40.6 a | 97.5 a | 7.7 a | 146.7 a |
| *T. campestre* | 3.0 c | 20.6 b | 0.3 c | 9.9 d |
| *T. stellatum* | 6.8 b | 63.8 b | 1.2 c | 39.6 c |
| *T. cherleri* | 7.0 b | 55.0 b | 1.7 c | 40.8 d |
| *M. ploymorpha* | 3.8 c | 4.6 b | 0.3 c | 11.5 c |
| *M. rigidula* | Not regenerated | | | |
| *M. radiata* | | | | |
| *T. subterraneum* cv. Antas (Crl1) | 39.8 a | 100.0 a | 5.4 b | 125.2 b |

Means with different letters are significantly different (Duncan test , α=0.05)

Generally, the legumes (except *T.a)* did not perform as well during the second cropping cycle compared to the first. This result confirms the results of an experiment conducted by Thorup-Kristensen and Bertelsen (1996) in Denmark, as well as the results of another experiment conducted in Italy at Mediterranean Agronomic Institute of Bari (IAMB) (Al-Bitar, 2005). These results are not only based on the amount of nitrogen fixed, but also on others parameters like legumes plant height, crop ground cover and DM production.

## Conclusions

The genus *Trifolium* appeared better adapted to the pedo-climatic conditions of the studied area than the genus *Medicago*. Both *Medicago radiata* and *Medicago rigidula* did not regenerate while *Medicago polymorpha* regenerated very poorly. We conclude that *Trifolium angustifolium* is suitable for Apulian conditions due to highest BNF and rapid soil covering. After their incorporation, all legumes treatments (except *T. ra.* and *T. ri.*) showed a positive precrop effects on all growth parameters of the subsequent crops (Zucchini and lettuce) compared to controls without legumes preceding. *T.a* induced the best effect on the zucchini and lettuce crop yields (42.66 and 48 t $ha^{-1}$ ) respectively. Consequently, *T.a.* may play an important role in managing soil fertility and be considered as a key-element in enhancing field biodiversity. It can further be recommended to integrate *T.a* as a winter cover crop, for the purpose of green manure, in apulian organic cropping systems (i.e. rotation of organic vegetable crops).

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