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Use of isotopic discrimination (δ^{13}C and δ^{15}N) for screening drought tolerance of legume grassland plants.

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Objectives of the study

As a consequence of Global Changes, perennial pastures have to face more and more extreme climatic conditions such as longer drought periods which impact forage production and, as a consequence, reduce the sustainability of livestock systems. In that context it is important to evaluate the capacity of grassland species to tolerate water shortage. This point is of major interest for Fabaceae, the most frequent family after Poaceae in grassland ecosystems, since they allow application of N fertilizer to be reduced while maintaining acceptable production levels.

Methodology

In that purpose, we set 2 experiments which aimed at screening the drought tolerance of grassland species

(i) in 2012 we grew, on soil columns, 14 Fabaceae and 6 grasses under controlled environment in a greenhouse under four growth conditions, by crossing two levels of both Phosphorus and water availability;

(ii) in 2013, 24 Fabaceae and 4 Poaceae were seeded in a common garden on 2 m² plots and grown under full water availability; in both experiments, species were randomly distributed in 4 repetitions blocks.

The 2012 greenhouse experiment view and the 14 first Fabaceae species

Some results of the greenhouse in 2012

We find a significant impact of the growth conditions on the %N and δ^{15}N (mean values from -1.15 to -0.36 ‰), but no on the grass species (mean value range from δ^{15}N = +3.12 to +3.62 ‰). Water was a higher limitation factor compared to Phosphorus.

Results plot 2014-2015

On the field site, with no limitation of water, the surprise was that same Mediterranean species, like Anthyllis montana, Astragalus monspessulana and Coronilla minima, present highly positive δ^{15}N values (from +5.54 to +9.24 ‰).

This result was found for both 2014 and 2015. These plants also displayed the higher C/N values (>15).

Stable isotopes analysis

Stable isotopes as δ^{13}C values are good indicators for drought tolerance which could information to select plant species in function of their water use efficiency, productivity and photosynthetic yield. As we screen Fabaceae species, the δ^{15}N values have been used to monitor their productivity and needs.

At harvest shoots were sampled and dried at least 48H (60°C) to determine above ground biomass. Stable isotopes δ^{13}C and δ^{15}N abundances were measured subsequently on ground material

Stable isotopes analysis

Isotopic results influence of water stress

In the Leaf Dry Matter Content (LDMC) plot versus the leaf isotopic δ^{13}C content, we can clearly see the effect of the water stress given less negative values, i.e. showing a lesser photosynthetic activity.

For the δ^{15}N, the same tendency is observed, that could suggest a worse efficiency of rhizobium nodules.

Conclusion

There is very few investigations about the use of nitrogen isotopes for the study of grass land plants.

M. Unkovich (New Phytologist 2013) has shown that isotope discrimination of δ^{15}N provides new insight into biological nitrogen fixation.

In our case, the positive δ^{15}N values find for the Mediterranean species could indicate that these plants, in these growing conditions, are no more able to fix correctly the Air N₂. Further measurements will be made on roots and nodules.

Reference:


Aknowlegements: Legumip program (2014-2016)

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