Amphicarpy in the Tropical Legume *Centrosema rotundifolium*: A Research Project in Eastern Venezuela

S. Müller
University of Hohenheim, Germany

R. Schultze-Kraft
University of Hohenheim, Germany

I. Rodríguez
Fondo Nacional de Investigaciones Agropecuarias, Venezuela

The XIX International Grassland Congress took place in São Pedro, São Paulo, Brazil from February 11 through February 21, 2001.

Proceedings published by Fundacao de Estudos Agrarios Luiz de Queiroz

ID # 14-03

AMPHICARPY IN THE TROPICAL LEGUME *Centrosema rotundifolium*: A RESEARCH PROJECT IN EASTERN VENEZUELA

S. Müller[1,2], R. Schultze-Kraft[1] and I. Rodríguez[2]

[1]University of Hohenheim (380), D-70593 Stuttgart, Germany (biodiv@uni-hohenheim.de);

[2]Fondo Nacional de Investigaciones Agropecuarias (FONAIAP), CIAE-Anzoátegui, Apartado 212, El Tigre, Anzoátegui, Venezuela

Abstract

Amphicarpy is a particular reproduction mechanism by which a plant can produce both above-ground and below-ground seeds and thus has the potential to contribute to an enhanced persistence of a plant population. It can be found in a range of tropical legumes, e.g. in several *Centrosema* species. The balance between above- and below-ground seed production is evidently influenced by environment and management factors but these influences are not well known. In the case of perennial tropical legumes, in addition to seed production shifts the allocation of resources affects also the production of tuberous roots as storage organs. A research project in El Tigre, Eastern Venezuela, investigates the extent to which resource allocation is influenced by five management (= environmental stress) factors: plant density, associated grass, fertilization, cutting intensity, and fire. The species chosen for this research is *Centrosema rotundifolium*, a perennial, moderately productive legume which because of its amphicarpy-based persistence and its adaptation to sandy and acid, low-fertility soils has a potential as pasture plant and for soil conservation on sandy savanna soils of the dry-subhumid tropics

Keywords: Resource allocation, plasticity, persistence, soil conservation, dune stabilization, seed production

Introduction

In the tropics, legumes have a high potential as forage plants for the improvement of pastures, prevention of soil erosion, and for soil improvement. Poor plant persistence is a major constraint to the impact of legume-based pastures, and the search for species and development of varieties with improved persistence mechanisms are a continuing research challenge. In this context, maintenance of a soil seed bank plays a major role (Jones and Carter, 1989). It has been suggested that amphicarpic legumes, which due to their particular reproduction mechanism have the potential to continuously replenish a grazing-independent soil seed bank, deserve research attention and that the factors influencing their below-ground seed production be investigated (Schultze-Kraft et al., 1997). In this paper, a current project researching the effects of several management factors on the amphicarpy of the tropical legume *Centrosema rotundifolium* is presented.

Amphicarpy

Amphicarpy is a special form of dimorphism where in addition to usual above-ground reproduction, a plant is able to produce below-ground seeds. The latter develop from subterranean peduncles which grow from the nodes of trailing stems right into the soil where they branch out and produce very small, cleistogamous, below-ground flowers. Amphicarpy is a two-fold reproduction strategy that improves the probability of survival of a population: Whereas above-

ground reproduction allows gene recombination and provides the possibility to colonize new habitats, below-ground reproduction ensures the persistence at a given site (Cheplik, 1987; Schmidt et al., 1996).

So far, amphicarpy has mainly been studied by botanists and ecologists, mostly in grasses (Cheplick, 1987) or annual legumes (Schnee and Waller, 1986; Christiansen et al., 1996). It is known to occur in as many as 17 plant families, among them in 15 tropical, subtropical and temperate genera of the Leguminosae, predominantly in the Phaseoleae and Vicieae tribes (Schultze-Kraft et al., 1997). In the genus *Centrosema*, amphicarpy has been recorded in four species: *C. bracteosum*, *C. grazielae*, *C. rotundifolium* and *C. venosum* (Schultze-Kraft and Schmidt, 2000).

The species

Centrosema rotundifolium Mart. ex Benth. is a perennial species from sandy, low-fertility soils of the dry-subhumid and semiarid tropics of Brazil. It has a prostrate growth habit and develops thickened roots (storage organs) with regrowth meristems. Its agronomic potential has been studied on oxisols in Colombia (Schultze-Kraft et al., 1994; Schmidt et al., 1996) and Venezuela (Rodríguez et al., 1998) including the description of the species and its reproduction mechanism, dry matter yields, nutritive value, above- and below-ground seed production and the effect of soil texture on amphicarpy. In summary, *C. rotundifolium* is well adapted to sandy and acid, low-fertility soils, is of medium dry-matter productivity and medium nutritive value. Below-ground seed production is favored by sandy soils where seed yields as high as 1.3 t/ha were recorded. Beside its potential as moderately productive but persistent pasture legume, the species may play a role in soil conservation such as sand-dune stabilization.

The problem

The work done with *C. rotundifolium* suggests that the species is able to react to stress situations caused by environment changes, by modifying the plant's allocation of resources in favor of either below-ground or above-ground reproduction and/or the production of tuberous roots as an additional survival mechanism. This plasticity and its underlying mechanisms are not well understood nor is there sufficient knowledge about the influence of the major practice-relevant environment and management factors on the expression of amphicarpy.

The project

The project is a German-funded (DFG-BMZ) research cooperation between the University of Hohenheim and the Fondo Nacional de Investigaciones Agropecuarias (FONAIAP). It consists of a series of field experiments that are carried out at the FONAIAP research station Centro de Investigaciones Agropecuarias del Estado Anzoátegui (CIAE-Anzoátegui) in El Tigre, Venezuela (8°51' N, 64°12' W, 265 masl). The soil is a very sandy (92% sand), acid (pH 4.9) and low-fertility (P 0.8 ppm, organic matter 0.6%) oxisol. Mean annual rainfall is 1040 mm with a distinct dry season from December to April.

The stress factors under study are considered to be relevant for the establishment and management of pasture plants in savanna environments. The factors and their experimental treatments are: (1) Nutrient stress (soil fertility): P levels from 0-100 kg/ha; (2) intraspecific competition: plant densities from 1-100 plants/ha; (3) interspecific competition: associations with the regionally common grasses *Andropogon gayanus*, *Brachiaria brizantha*, *B. decumbens*, *B. dictyoneura* and *Digitaria swazilandensis*; (4) defoliation frequency: cutting at 4-, 8-, and 16-

week intervals; and (5) fire stress: effect of vegetation burning at the beginning, middle, and end of the dry season. The duration of the different experiments varies according to the respective objectives.

In each experiment, in addition to above- and below-ground dry-matter production, above- and below-ground reproduction parameters (above-ground floral buds, flowers, pods, and seeds; below-ground peduncles with cleistogamic flowers, pods, and seeds) are determined at 12-week intervals. Furthermore, roots are separated into (a) thickened storage roots and (b) other roots, and their dry weight and root length density are measured. At the beginning of the second rainy season, emerging seedlings and the regrowth from mother plants are counted.

There are three additional experiments on (1) morphological and physiological differences between plants from below- and from above-ground seeds; (2) the soil improving potential of *C. rotundifolium* as a ley; and (3) the performance of the legume when sown into a *Brachiaria dictyoneura* pasture (on-farm trial).

Expected results

Results from this project are expected to broaden the knowledge about amphicarpy as a mechanism of plasticity of resource allocation, and about its contribution to the persistence potential of *C. rotundifolium*. They should also provide a basis for follow-up research on amphicarpy in general and on amphicarpic, perennial pasture legumes in particular.

References

Cheplick, G.P. (1987). The ecology of amphicarpic plants. Trends in Ecology and Evolution **2**: 97-101.

Christiansen, S., Abd el Moneim A.M., Cocks P.S. and Singh M. (1996). Seed yield and hardseededness of two amphicarpic pasture legumes (*Vicia sativa* ssp. *amphicarpa* and *Lathyrus ciliolatus*) and two annual medics (*Medicago rigidula* and *M. noeana*). Journal of Agricultural Science (Cambridge) **126**: 412-427.

Jones, R.M. and Carter E.D. (1989). Demography of pasture legumes. Pages 139-156 in G.C. **Marten A.G., Matches R.F., Barnes R.W. and Brougham R.J.** Clements and G.W. Sheath, eds. Persistence of forage legumes: Proceedings of a trilateral workshop held in Honolulu, Hawaii, July 1988. American Society of Agronomy, Inc., Madison, Wisconsin, USA.

Rodríguez, I., Schultze-Kraft R., González S., López V. and Romero A. (1998). Centrosema: una leguminosa forrajera promisoria para las mesas orientales del país. FONAIAP Divulga **60**: 45-48.

Schmidt A., Schultze-Kraft R., Maass B.L. and Herrmann, R. (1996). Aspects of the amphicarpy of the tropical pasture legume *Centrosema rotundifolium* Mart. ex Bentham. Pages 44-48 in W. Schoeberlein and K. Foerster, eds. Yield and Quality in Herbage Seed Production. Proceedings, Third International Herbage Seed Conference, 1995, Halle (Saale), Germany.

Schnee, B.K. and Waller D.M. (1986). Reproductive behaviour of *Amphicarpaea bracteata* (Leguminosae), an amphicarpic annual. American Journal of Botany **73**: 376-386.

Schultze-Kraft R., Keller-Grein G., Cárdenas E. and Díaz Bolívar F. (1994). Potencial de *Centrosema rotundifolium* como leguminosa forrajera. Pasturas Tropicales **16**: 2-8.

Schultze-Kraft R., Schmidt A. and Hohn, H. (1997). Amphicarpic legumes for tropical pasture persistence. Proceedings of the XVIII International Grassland Congress, Winnipeg and Saskatoon, Canada, Vol. 1, pp. 1-13 to 1-14.

Schultze-Kraft R. and Schmidt A. (2000). Amphicarpy in species of the legume genus

Centrosema from South American savannas. Pages 409-411 in S.-W. Breckle, B. Schweizer and U. Arndt, eds. Results of Worldwide Ecological Studies. Proceedings of the 1st Symposium of the A.F.W. Schimper-Foundation est. by H. and E. Walter, Hohenheim, October 1998. Verlag Günther Heimbach, Stuttgart, Germany.