ASPECTS OF THE AMPHICARPY OF THE TROPICAL PASTURE LEGUME *CENTROSEMA ROTUNDIFOLIUM* MART. EX BENTHAM

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Introduction

Detailed description and basic knowledge of the reproduction mechanisms are essential for the introduction and evaluation of new legumes with forage potential in the tropics in order to overcome the bottle-neck of seed availability and to improve seed quality (FERGUSON, 1994). According to this fact the reproductive systems of *Centrosema rotundifolium*, a little-known species in the tropical pasture legume genus *Centrosema*, were studied. The species originates from sandy soils in subhumid/semiarid Northeast and Central Brazil and shows amphicarpy, which means a specialised form of dimorphism found in a number of plant species where some of the fruits/seeds are produced below the soil surface on specialised reproductive structures in addition to aerial fruits on the same individual. Amphicarpy, known since 1601 by botanists and ecologists, is a phylogenetically young, and very variable phenomenon (CHEPLICK, 1987). The objectives of the research presented here were (1) to provide a detailed description of *C. rotundifolium* and the biological expression of amphicarpy, (2) to evaluate the effect of different soils and cutting regimes on the amphicarpic reproduction system, and (3) to study possible differences between subterranean and aerial seeds.

Materials and Methods

Three field experiments were conducted at Carimagua in the eastern lowlands of Colombia on a sandy soil site (Alegría) and a site with sandy loam (Yopare) during the rainy seasons 1993 and 1994. (1) To provide a detailed description of the reproductive mechanisms and possible soil effects, 4-week-old seedlings (accession CIAT 25120) were transplanted from jiffy pots to 12 plots of three space-planted seedlings. Planting distance between the seedlings within and between plots was 1.50 m. The experimental design consisted of randomised blocks with four replicates (RCBD). The 12 plots/replicate were considered as treatments and defined as time between transplantation and harvest (4, 11 - 21 weeks). Fertiliser was applied for rapid and adequate plant growth. At harvest, plants were completely digged out and the soil was searched for any plant material. The attributes measured and discussed in the following are, related to aerial plant parts: no. of buds/plant, and related to subterranean plant parts: no. of peduncles/plant and root dry matter (DM) (g/plant). Linear regression analysis was performed for each parameter and the slopes were compared by analysis of variance between the two sites. Additional plant characteristics were described and discussed by SCHMIDT (1994).

(2) A second experiment was carried out in order to determine possible effects of cutting regime on amphicarpic reproduction. The treatments consisted of different cutting intensities, every 4 weeks (12 plots), 6 weeks (8 plots), and 10 weeks (6 plots) after an uniformisation cut. Parameters were measured as mentioned in experiment (1). There were three replicates in a completely randomised block design. Analysis of variance was performed and Duncan´s Multiple Range Test was applied.

(3) After preliminary greenhouse experiments concerning total germination rates and germination from different soil depths (SCHMIDT, 1994), a field experiment was conducted on the sandy soil site at Alegría. To evaluate the differences of germination capacity from different soil depths (1, 6, 10, 15, 20, 25, 30 cm), aerial and subterranean seeds were sown in plots (35 seeds/plot) in three replicates (RCBD). Plots measured 42x56 cm, with a distance of 15 cm between plots. Number of emerged seedlings/plot was observed. Analysis of variance was performed.

Results

Centrosema rotundifolium, shows in the initial stages of its development, an erect growth habit, which is followed by a creeping, stoloniferous one. Subsequently a large number of secondary adventitious roots appear at the basal ends of the stem nodes. These roots penetrate the soil and grow initially to strong adhesive and later on to large thickened storage roots (savannah plant). Root depth down to 50 cm was measured and heavy infection by *Bradyrhizobium* was observed. Besides aerial buds, flowers and pods with 3-5 small seeds, *C. rotundifolium* produces simultaneously peduncles at the apical ends of the stem nodes and at the main root. They penetrate the soil, branch out, and develop a large amount of buds, which got a similar shape as the aerial ones but have a whitish purple colour. Aerial, chasmogamous flowers depend on tripping insects (self- or cross-pollinated) whereas subterranean flowers are cleistogamous (self-pollinated). Subterranean pods contain 1-2 large seeds, which are heavier and darker in colour, and at least in the first few days, they germinate faster than aerial seeds. Ripe aerial pods are dehiscent and release the seeds to further dispersal through water, wind or animals. Subterranean seeds, located in the first 18 cm of the soil, build a seed bank from where they will emerge when conditions are favourable (Fig. 3)

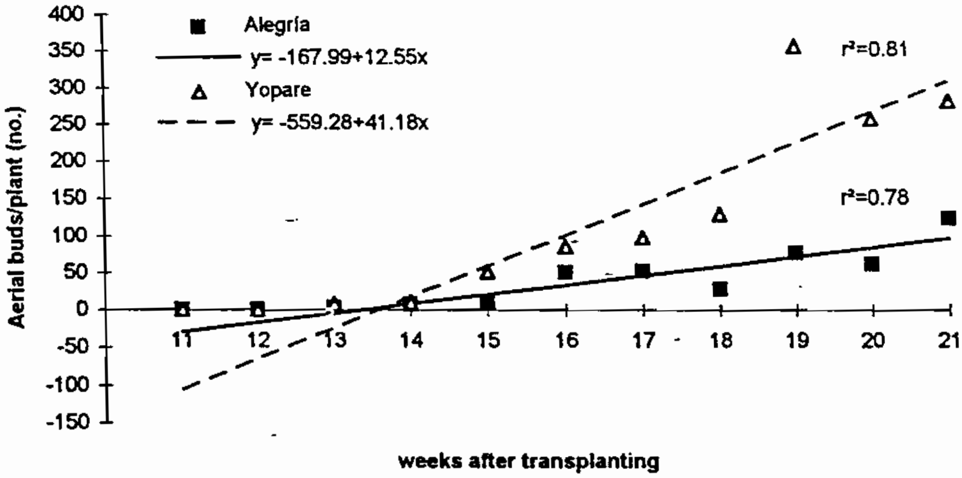

Fig. 1: Development of aerial buds per plant at two contrasting sites ($p<0.05$)

Significant differences in the reproductive behaviour was observed between the two contrasting sites. On the sandy loam site, Yopare, aerial reproduction was favoured while subterranean reproduction was significantly less. The no. of aerial buds/plant was significantly higher at Yopare than at Alegría (Fig. 1). On the contrary more subterranean peduncles were produced at Alegría ($-65.57+5.99x$; $r^2=0.60$) than at the sandy loam site, Yopare ($-28.26+2.10x$; $r^2=0.84$), while aerial reproduction was lower. Root DM at Yopare was significantly higher than at Alegría (Fig. 2).

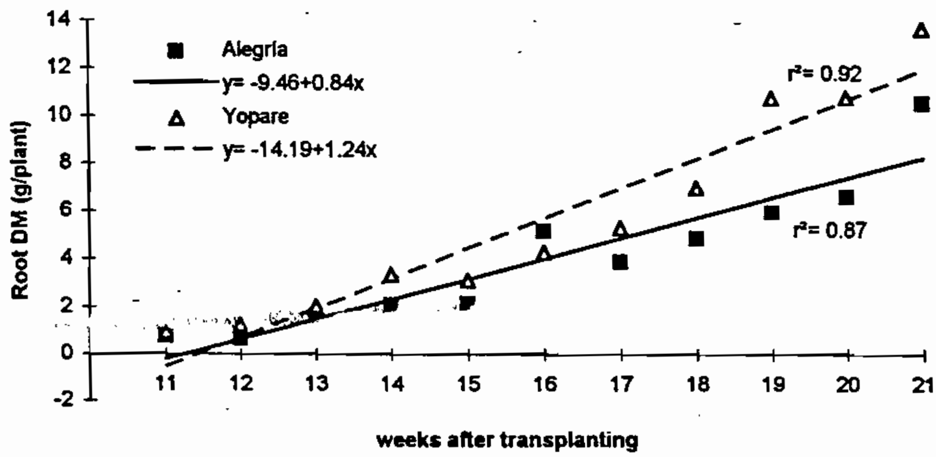

Fig. 2: Development of root DM of *Centrosema rotundifolium* on two contrasting soils ($p<0.05$)

Data of experiment (2) indicate that, at both sites, under higher cutting intensities both no. of aerial buds and no. of subterranean peduncles increased within the treatments. Comparing the two sites results of experiment (1) were confirmed.

In experiment (3) the no. of emerged seedlings decreased with deeper seed depths for both seed origins from 34 seedlings (97%) at 1 cm sowing depth to 5 (14%) at 30 cm. No significant differences between aerial and subterranean seeds were observed.

Discussion

The results confirm for *C. rotundifolium* the high capacity to adapt to different environmental conditions, as reported for amphicarpic plants in general (ZEIDE, 1978; CHEPLICK, 1988). It was shown that plants change their reproductive system on compact sandy loam soils, where they are unable to penetrate the soil with subterranean peduncles. Instead, they alter resource allocation towards producing more aerial flower buds and storing more energy in the main roots in order to compensate for the lack of underground reproduction, due to soil texture, and thus ensure plant persistence. The reproductive strategy of the species, by which subterranean seeds ensure the persistence of a population at a given spot and aerial seeds provide the possibility to colonise other spots, improves the probability of survival and, thus, seed production under changing or unfavourable environmental conditions. These features provide a high security in seed production where subterranean seeds ensure both the production even under varying field conditions and the persistence of the species over years. Furthermore *C. rotundifolium* should be grazed sometimes in order to stimulate seed production.

Summary

Centrosema rotundifolium Mart. ex Bentham is a little-known species in the tropical pasture legume genus *Centrosema*. This amphicarpic species originates from sandy soils in subhumid/semiarid Northeast and Central Brazil. The seed production mechanisms of the species were studied in field experiments in the eastern lowlands of Colombia and a detailed botanical and morphological description of the amphicarpic behaviour of *C. rotundifolium* was produced. There were significant effects of soil texture and cutting intensity on the resource allocation between subterranean and aerial seed production: the former was lower and the latter was higher on a heavier soil (loam) where, in contrast to a sandy soil, subterranean peduncles could not penetrate the ground. In general, plants tended towards increased reproduction under higher intensity of use. Regarding seeds from the two positions, subterranean seeds are larger, heavier, darker in colour and at least in the first few days, they germinate faster than aerial seeds. But there were neither significant differences in total germination rate from different sowing depths (1-30 cm) nor in subsequent plant growth or yield parameters. The results confirm for *C. rotundifolium* the high capacity to adapt to different environmental conditions through their seed production mechanisms, reported in literature for amphicarpic plants in general. The reproductive strategy of the species, by which subterranean seeds ensure the persistence of a population at a given spot and aerial seeds provide the possibility to colonise other spots, improves the probability of survival and, thus, seed production under changing or unfavourable environmental conditions.

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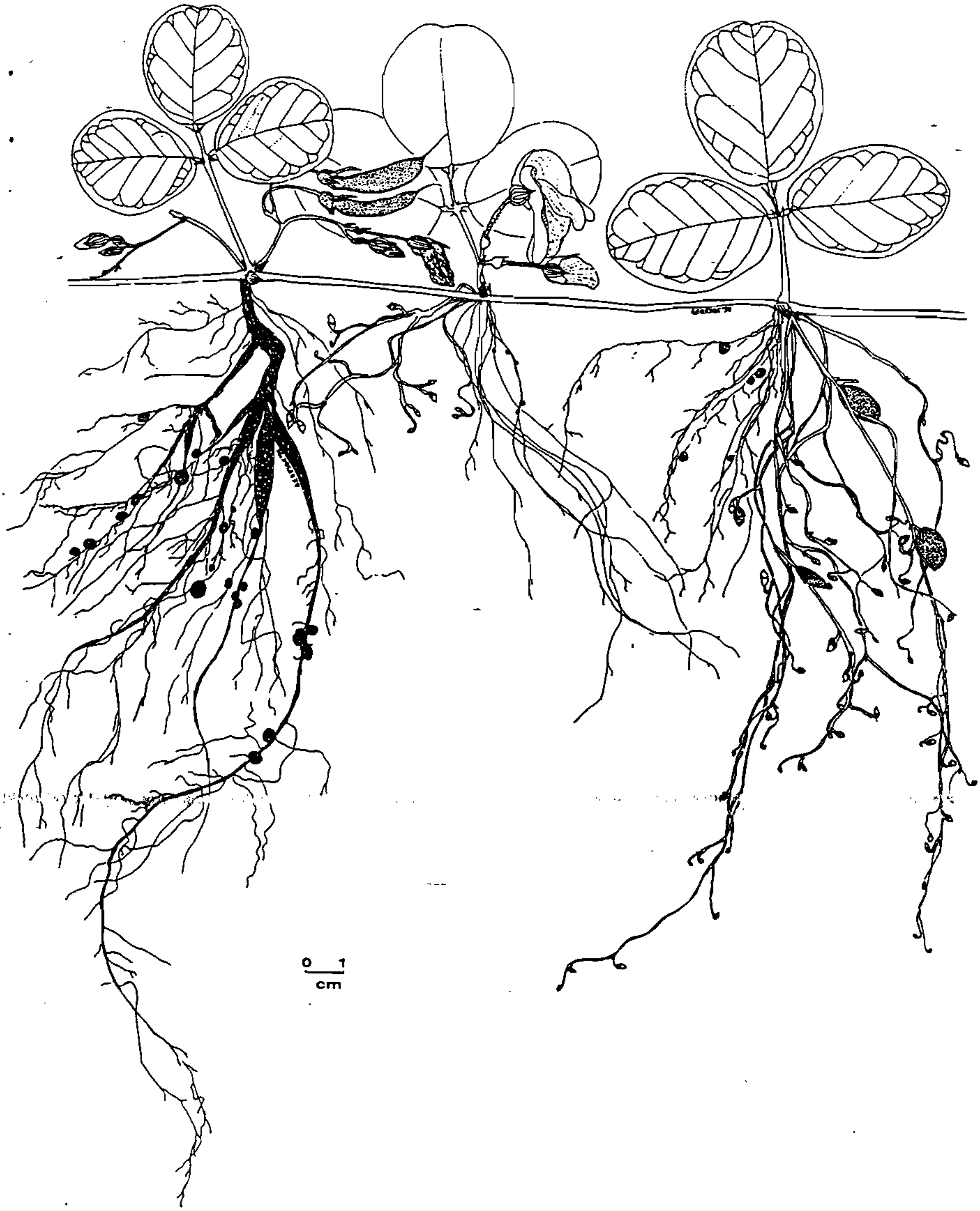
Fig. 3: Indicate aerial (AB) and subterranean (SB) buds, peduncles (P), aerial (AP) and subterranean (SP) pods of *Centrosema rotundifolium* Mart. ex. Benth. (drawn by G. Escobar, 1994)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