THE EXPRESSION OF RHIZOMES IN *LOTUS CORNICULATUS* L.

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ABSTRACT

Broadleaf birdsfoot trefoil (*Lotus corniculatus* L.) is a popular cross-pollinated, perennial legume cultivated for pasture, or hay and silage production. It does not cause bloat and can be managed to reseed to maintain stands, but significant losses occur when stands decline from disease. Wild birdsfoot trefoil with underground rhizomes was discovered in Morocco. This paper describes research to: 1) compare the morphology and anatomy of rhizomes with aerial stems, 2) determine if rhizomes could be successfully transferred to domesticated germplasm, and 3) determine the inheritance of rhizomes. Morphological and anatomical differences between rhizomes and aerial shoots of five accessions *L. corniculatus* from Morocco are described. Rhizomes were successfully transferred from the Moroccan germplasm to domesticated cultivars. Rhizome initiation and production was variable and may be affected by plant age and size. Full expression of rhizomes was observed under field conditions. Rhizome expression in *L. corniculatus* is controlled by the single dominant gene, *R*, but number and length of rhizomes may be influenced by quantitative effects with additive gene action. Since rhizome production and plant persistence are related, rhizomes may aid persistence of birdsfoot trefoil, lessening reliance on reseeding to maintain productive stands.

KEYWORDS

Broadleaf trefoil, rhizomes, lotus, inheritance

INTRODUCTION

Birdsfoot trefoil (*Lotus corniculatus* L.) is a tetraploid (2n=4x=24) forage legume grown extensively in the United States, Canada, South America and Europe (Beuselinck and Grant, 1995). Stand persistence depends on natural reseeding and individual plant persistence (Beuselinck, 1988; Beuselinck et al., 1994). Persistence in humid regions of North America is shortened by root- and crown-rotting diseases, and reduced natural reseeding (Beuselinck et al., 1984). In southern latitudes of North America, seed production of birdsfoot trefoil is unreliable due to climatic conditions that negatively affect natural reseeding (Beuselinck and McGraw, 1988; Beuselinck et al., 1994). Recent acquisitions of *L. corniculatus* germplasm accessions from Morocco are unique in that they produce rhizomes (Beuselinck, 1989; Beuselinck et al., 1996) which may prove useful in increasing birdsfoot trefoil persistence because new plants, vegetatively generated by rhizomes, could replace dead and diseased plants.

The objectives of this research were to: 1) compare the morphology and anatomy of *L. corniculatus* rhizomes with aerial stems, 2) determine if rhizomes could be successfully transferred to domesticated birdsfoot trefoil germplasm, and 3) determine the inheritance of rhizomes.

METHODS

Vegetative propagules of individual genotypes were collected from five sites in Morocco by Beuselinck (1989). The five genotypes were assigned temporary accession numbers (G31272, G31273, G31276, G31298, and G31317) by the USDA-ARS Regional Plant Introduction Station, Geneva, NY. Accession numbers used in this paper refer to the original genotype collected in Morocco and maintained by vegetative propagation. Morphological, anatomical, and genetic studies were conducted on the Moroccan accessions, or a subset of accessions, to determine their taxonomic placement, sexual compatibility with other *L. corniculatus*, and the inheritance of rhizomes. A complete presentation of the methods used for taxonomic and cytological comparisons, and crossing behavior can be found in Beuselinck et al. (1996). Methods used to characterize morphological and anatomical differences between *L. corniculatus* rhizomes and aerial shoots are described in Li and Beuselinck (1996). Nualsri and Beuselinck (1996) describe the methods used to determine the inheritance of rhizomes in *L. corniculatus*.

RESULTS AND DISCUSSION

Characterization of rhizomes. The five accessions from Morocco were tetraploids with somatic chromosome numbers of 2n = 4x = 24. They exhibited rhizomatous growth and keyed taxonomically as *L. corniculatus* (Beuselinck et al., 1996). Morphological and anatomical differences between rhizomes and aerial shoots of *L. corniculatus* are described in Table 1. A detailed description of differences is found in Li and Beuselinck (1996). Aerial shoots bearing foliar leaves have a photoassimilating function. Rhizomes, on the other hand, are not assimilating organs, but may function as storage organs of photoassimilates for later plant growth (Saldivar et al., 1992; Weaver, 1963). Gebrehiwot et al. (1996) found that rhizomes of *L. corniculatus* were sinks for simple sugars with a mean TNC accumulation of 250 g kg^{-1} dry matter when sampled in the fall. Rhizomes provide growing points under the soil surface where they are protected from temperature extremes and prolonged drought (Weaver, 1963). Previously, the only *Lotus* species described as producing rhizomes was *L. uliginosus* Schkuhr (syn. *L. pedunculatus* Cav.)

Rhizome transfer. Rhizomes were successfully transferred from the Moroccan germplasm to domesticated cultivars of birdsfoot trefoil (Beuselinck et al., 1996) and to an autogamous *L. corniculatus* background (Nualsri and Beuselinck, 1996). Generally, when a Moroccan accession was used as a maternal parent in crosses, pods were set, but few seeds were produced and these were generally non-viable. Progeny derived from a *L. corniculatus* cross with a Moroccan accession morphologically resembled their maternal parent, but all F_1 progeny produced rhizomes regardless of maternal parent.

Rhizome expression. Greenhouse growing conditions did not promote full rhizome expression, but when transferred to the field, full expression of rhizomes was observed (Beuselinck et al., 1996; Nualsri and Beuselinck, 1996). Rhizome initiation and production was variable and may be affected by plant age and size. In *L. uliginosus*, size of the canopy has been reported to affect rhizome expression (Wedderburn and Lowther, 1985).

Inheritance of rhizomes. Rhizome expression in *L. corniculatus* is controlled by the single dominant gene, *R* (Nualsri and Beuselinck, 1996). Rhizome expression by F_2's of G31276 x AG-S4 (an autogamous *L. corniculatus* parent) and backcrosses to AG-S4 (BC_2) closely fit 3:1 and 1:1 dominant:recessive ratios (P=0.90-0.75 and P=0.50-0.25, respectively). Although results indicated a single dominant gene controls rhizome expression in *L. corniculatus*, the fit to an expected 3:1 dominant:recessive ratio for the F_2 and a 1:1 ratio for BC_2 could be explained by two hypotheses: 1) a single dominant, disomically inherited allele, or 2) a single dominant allele in a tetrasomic condition on the basis of random chromosome segregation. Number and length of rhizomes may be influenced by quantitative effects with additive gene action.

Value of rhizomes. Well-developed rhizomes are an important feature of established *L. uliginosus* plants for new lateral shoot production and over-wintering (Sheath, 1981; Wedderburn and Gwynne, 1981). Vegetative reproduction through rhizomes can maintain and multiply adaptable genotypes (Snaydon, 1985). Improved persistence of rhizomatous *L. corniculatus* is expected because vegetative clones generated from rhizomes could replace diseased or dead plants and plants would be expected to spread within a pasture via rhizomes (Beuselinck et al., 1996). Since rhizome production and plant persistence are related, rhizomes may aid persistence of birdsfoot trefoil, lessening reliance on reseeding to maintain productive stands.

REFERENCES

Beuselinck, P.R. 1988. Fungi associated with birdsfoot trefoil. *Lotus* Newsl. **19**: 11-14.

Beuselinck, P.R. 1989. *Lotus* spp. expedition in Morocco. *Lotus* Newsl. **20**: 31.

Beuselinck, P.R., B. Li and J.J. Steiner. 1996. Rhizomatous *Lotus corniculatus* L. I. Taxonomic and cytological study. Crop Sci. **36**: 179-185.

Beuselinck, P.R., E.J. Peters, and R.L. McGraw. 1984. Cultivar and management effects on stand persistence of birdsfoot trefoil. Agron. J. **76**: 490-492.

Beuselinck, P.R., J.H. Bouton, W.O. Lamp, A.G. Matches, M.H. McCaslin, C.J. Nelson, L.H. Rhodes, C.C. Sheaffer and J.J. Volenec. 1994. Improving legume persistence in forage crop systems. J. Prod. Agric. **7**: 287-322.

Beuselinck, P.R. and R.L. McGraw. 1988. Intermediate flowering and reproductive success in birdsfoot trefoil. Crop Sci. **28**: 842-845.

Beuselinck, P.R. and W.F. Grant. 1995. Birdsfoot trefoil. Pages 237-248 *in* R.F. Barnes, D.A. Miller, and C.J. Nelson, eds. Forages, 5th Ed., Vol. 1: An introduction to grassland agriculture. Iowa State Univ. Press, Ames, Iowa.

Gebrehiwot, L., P.R. Beuselinck, and C. Nualsri. 1996. Rhizome formation and carbohydrate accumulation in rhizomatous birdsfoot trefoil. Page 111 *in* Agronomy Abstracts. ASA, Madison, WI.

Li, B. and P.R. Beuselinck. 1996. Rhizomatous *Lotus corniculatus* L. II. Morphology and anatomy. Crop Sci. **36**: 407-411.

Nualsri, C. and P.R. Beuselinck. 1996. Inheritance of rhizomes in birdsfoot trefoil. Page 93 *in* Agronomy Abstracts. ASA, Madison, WI.

Sheath, C.W. 1981. *Lotus pedunculatus*: an agricultural plant. N.Z. Grassld. Assn. **21**: 161-167.

Snaydon, R. W. 1985. Aspects of the ecological genetics of pasture species. Pages 125-152 *in* J. Haeck and J. W. Woldendorp, eds. Structure and functioning of plant populations, 2. North-Holland Publishing Company, Amsterdam, Oxford, New York.

Weaver, J.E. 1963. The wonderful prairie sod. J. Range Manage. **16**: 165-171.

Wedderburn, M.E. and D.C. Gwynne. 1981. Seasonality of rhizome and shoot production and nitrogen fixation in *Lotus uliginosus* under upland conditions in south-west Scotland. Ann. Bot. **48**: 5-13.

Wedderburn, M.E. and W.L. Lowther. 1985. Factors affecting establishment and spread of grassland Maku '*Lotus*' in tussock grassland. Proc. N.Z. Grassl. **46**: 97-101.

Table 1
Morphological and anatomical differences between rhizomes and aerial shoots of *L. corniculatus* L.

Rhizome	Aerial shoot
MORPHOLOGY	
Horizontal	Vertical
Subterranean	Aerial
Adventitious roots present	Adventitious roots absent
Scale leaves	Photosynthetic leaves
ANATOMY	
Chloroplasts absent in cortex cells	Chloroplasts present in cortex cells
No endodermoid layer to delimit cortex and central vascular cylinder	Endodermoid layer delimits cortex and central vascular cylinder
Large cortex and small pith	Small cortex and large pith
Few vascular bundles	More vascular bundles