UNUSUAL ADAPTATIONS FOR P NUTRITION, IN ORDER TO MAINTAIN N_2 FIXATION IN TWO CAPE FLORISTIC REGION (CFR) INDIGENOUS LEGUMES *VIRGILIA DIVARICATA* AND *V. OROBOIDES*

Prepared by Anathi Magadlela and Waafeka Vardien

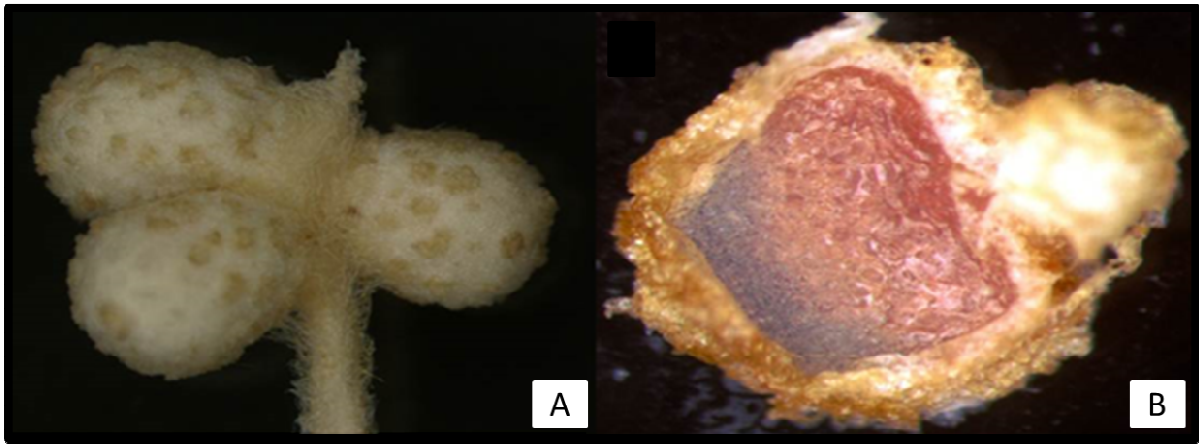
Among the plant families indigenous to the fynbos, Leguminosae is one of the most species-rich families. Nevertheless it has been reported that legume species are mostly absent in the mature fynbos in the Cape Floristic Region, South Africa. The fynbos has adapted to regulated fires which maintain both the ideal microclimate for the vegetation and to disrupt the nutrient cycle associated with tree dominated vegetation. The post-fire changes in the soil nutrient dynamics could be one of the most important factors limiting legumes in the mature fynbos. Fynbos legumes are considered to be short-lived post fire colonizers in the fynbos ecosystem due to a temporary flush of nutrient availability. In addition, fynbos soils are characterized as leached, acidic sandy soils associated with low nutrient concentration, specifically with regards to phosphorus (P) and nitrogen (N). P is generally present in micro molar concentrations or less in the fynbos soils. These are extremely low concentrations to drive the P-requiring metabolic processes, considering that P is the main energy driver during symbiotic N fixation and that P deficiency is a critical constraint for legume growth.

Growth of *Virgilia divaricata* (A) seedlings and (B) plants in the glasshouse at the Department of Botany at Zoology, Stellenbosch University

The role of P and N nutrition in the root-nodule physiology of indigenous CFR legume species is poorly understood with regards to the functional adaptations in nutrient-poor soils. As such, two students of the DST/NRF-Centre for Tree Health Biotechnology (CTHB) based

at Stellenbosch University under the supervision of core team member, Prof Alex Valentine, have centred their research on the nodule physiology of two related fynbos indigenous species, *Virgilia divaricata* and *V. oroboides*.

Anathi Magadlela investigated the role of low P in N acquisition pathways and their associated energy and carbon costs in *V. divaricata* and *V. oroboides.* The results of this study showed that under P deficiency, the two CFR tree legumes had different adaptations to low P which may influence nutrient acquisition in their naturally low-P environments. *V. divaricata* maintained its growth during P deficiency, whereas *oroboides* showed a decline in growth. The decline was related to lower P uptake, which resulted in an alteration in the below ground biomass and allocation, which consequently affected the N nutrition and C costs of growth. In contrast, *V. divaricata* maintained its P nutrition, photosynthetic costs and increased its nodule allocation to the benefit of N nutrition.



A: External view of *Virgilia divaricata* root nodules. B: Sectioned *Virgilia divaricata* root nodule containing leghaemoglobin (pink colouration) indicating the nodules are actively fixing nitrogen

Waafeka Vardien assessed the flexibility of P recycling and distribution within the nodules during P-deficiency and resupply and their effect on N nutrition in *Virgilia divaricata*. Morphological and physiological adaptations to P-deficiency were observed in this study. Decreased plant growth and nodule production with parallel increased root to shoot ratios are some of the plastic features exhibited in response to P deficiency. Plants resupplied with P resembled those supplied with optimal P levels in terms of growth and nutrient acquisition. Under low P conditions, plants maintained an increase in N_2-fixing efficiency despite lower levels of orthophosphate (Pi) in the nodules. This can be attributed to two factors: i) an increase in iron (Fe) concentration under low P, and ii) greater acid phosphatase activity in

both the roots and nodules under low P. These findings suggest that *V. divaricata* is well adapted to acquire N under P deficiency, owing to the plasticity of its nodule physiology.

The findings of Anathi and Waafeka show that *V. divaricata* and *V. oroboides* have unusual adaptions for maintaining N_2-fixation under P-poor conditions. These adaptations include integrated mechanisms that have not been previously reported for model legumes species. The implications of these findings are that the *V. divaricata* tree species may have competitive advantage in the fynbos P-poor ecosystems. This is interesting as *V. oroboides* trees are more specifically associated with P-poor soils than is *V. divaricata*, but the latter species is known to invade the margins of the Fynbos. Therefore the discovery of the mechanisms used by *V. divaricata* during P-stress might provide better insight into nutrient acquisition strategies for legume trees growing in nutrient-poor ecosystems. Furthermore, this will be of biotechnological importance to crop improvement in P-poor soils and may assists in conserving tree legume species indigenous to the Cape Floristic Region.

For more information please consult the following published work:

- Magadlela A, Kleinert A, Dreyer LL and Valentine AJ. 2014. Low-phosphorus conditions affect the nitrogen nutrition and associated carbon costs of two legume tree species from a Mediterranean-type ecosystem. Australian Journal of Botany. http://dx.doi.org/10.1071/BT13264
- Vardien W, Mesjasz-Przybylowicz J, Przybylowicz WJ, Wang Y, Steenkamp ET and Valentine AJ. 2014. Nodules from Fynbos legume *Virgilia divaricata* have high functional plasticity under variable P supply levels. Journal of Plant Physiology. http://dx.doi.org/doi:10.1016/j.jplph.2014.08.005