

Review Article

**VAJRADANTI- A REVIEW OF TRADITIONAL USES,
PHARMACOLOGICAL PROPERTIES AND ITS
IN VITRO CONSERVATION**

Rani A.¹ and Kumar S.²

¹Department of Biotechnology, Mewar University, Chittorgarh, Rajasthan, India

²Mata Basanti Devi School of Biosciences and Biotechnology, Agra, (U. P.) India-282 007

*Author for Correspondence

ABSTRACT

This article represents traditional uses of medicinal plant *Barleria* commonly called Vajradanti which is widely distributed throughout the hotter part of India. Different plant parts of Vajradanti used in various diseases. Laboratory studies have demonstrated that all the plant parts or extract used in the treatment of gastrointestinal disorders, curing digestive troubles, hepato-protective, anti tress, and immune-restorative properties, treating fever etc. In present investigation we have observed that extract of leaf and whole plant is used to cure nervine disorders, liver disorders.

Keywords: *Barleria*, *Gastrointestinal Disorders*, *Hepatoprotective*, *Immunorestorative*, *Nervine Disorders*

INTRODUCTION

Barleria prionitis (L.) or Porcupine flower or Vajradanti widely distributed throughout the hotter part of India. The plant is especially well known for treating bleeding gums and toothache because of its antidontalgic property known as ‘Vajradanti’. *Barleria* is an erect, prickly shrub, usually single-stemmed. It belongs to family Acanthaceae.

Barleria is the third largest genus of Acanthaceae with 300 species (Balkwill & Balkwill, 1997; Mabberley, 2008) distributed chiefly in the tropical and subtropical parts of the world. Karthikeyan *et al.*, (2009) enumerated 29 species whereas Balkwill & Balkwill (1997) reported 32 species from India. *Barleria* can be easily distinguished from other genera of Acanthaceae. *Barleria* has combination of three characters: Calyx 4- with 2 large outer segments and 2 smaller inner ones, spheroid, honey-combed pollen grains and the predominance of double cystoliths (calcium oxalate crystals) in the epidermal cells. The whole plant, leaves, bark, stem, flower and roots are used for a variety of purposes in traditional Indian medicine. It is widely planted as an ornamental and cultivated in Asia as a hedge plant (Burkill 1985).

Whole-plant extract of *Barleria* contains a number of active compound classes like alkaloids, terpens, flavonoids, glycosides, lignins, phenolics etc., which have shown potent therapeutic activities against several diseases (Saadabi *et al.*, 2006; Mukherjee *et al.*, 2009; Agrawal *et al.*, 2011; Gantait *et al.*, 2011). *Barleria* also shows various pharmacological effects such as antimicrobial, anthelmintic, anti-fertility, antioxidant, anti-diabetic, anti-arthritis, hepato-protective, diuretic, cytoprotective, antidiarrhoeal, analgesic, antileukemic, anti-inflammatory and hypoglycemic properties without any toxic effects. Extracts of the plant have also been shown to effectively suppress the fungus *Trichophyton mentagrophytes* under *in vitro* studies (Panwar *et al.*, 1979).

Methanolic extract of plant shows anti-inflammatory (Singh *et al.*, 2005; Amoo *et al.*, 2009) and antispematogenic effect without affecting the general metabolism of body (Verma *et al.*, 2005). Extracts of the plant are incorporated into herbal cosmetics and hair products to promote skin and scalp health (Prakruti, 2002, Vaipani, 2002).

Bark powder given in cough and bark juice in ‘anasarka’ root paste applied on boils and glandular swellings (Chopra *et al.*, 1996, Khare, 2007). Bark extract is effective in controlling candidiasis and other oral fungal infections (Aneja *et al.*, 2010). The extract of *Barleria* plant has been found to possess a wide range of pharmacological properties. Extracts of the plant have also been shown to effectively suppress the fungi *Trichophyton mentagrophytes in vitro* (Panwar *et al.*, 1979).

Review Article

Classification

Kingdom: Plantae
Division: Magnoliophyta
Class: Magnoliopsida
Order: Scrophulariales
Family: Acanthaceae
Genus & Species: *Barleria prionitis*

English Name: Porcupine flower

Vernacular Names: (Sanskrit)Vajradanti,; (Hindi) Kala Bans, Piabansa, (Urdu) Pila Bansa, Piya Bansa; (Bengali) Peetjhanti; (Gujarati) Kantashila (Kannada) Mullugorante; (Malayalam) Chemmulli, Varelmutti; (Marathi) Kalsunda, Kholeta, Koranta, Pivala-Koranta; (Odia) Daskeranta; (Tamil) Semmulli; (Telugu) Mullugorinta Chettu.

Distribution / Range: *Barleria* is genus of 300 species (Mabberley, 2008). It is a native of Tropical East Africa and Asia including India, Indonesia, Malaysia and the Philippines. It is widely cultivated in many tropical countries including Hawaii and Puerto Rico (Liogier, 1997). It has been cultivated throughout the world as an ornamental plant, and has escaped from gardens in many regions including Mauritius, Hawaii, Puerto Rico and Papua New Guinea. *Barleria* has some beneficial properties that undoubtedly have helped increase its distribution:

Morphology: Vajradanti is a member of Acanthaceae family and exists as both herbs and shrubs (Balkwill & Balkwill, 1997). Vajradanti is an erect, spiny shrub, usually single-stemmed, growing to about 0.6 - 1.8 m tall. The older stems and branches are stiff and smooth and light brown to light grey in colour. Younger stems are somewhat quadrangular in cross-section and greenish in colour. The oppositely arranged leaves are up to 3-10 cm long and 1.5 - 4 cm wide and oval-shaped though narrow at both ends and hairless or slightly hairy. The base of the leaves is protected by three to five sharp, pale coloured spines, 10–20 mm long. The yellow–orange tubular flowers are found bunched tightly together at the top of the plant, but they also occur singly at the base of leaves. Flowers sessile, often solitary in lower axils, becoming spicate above, 3 – 4.5 cm long and corolla are orange-yellow, tubular. Stamens, exerted, filaments 2 – 2.5 cm long; Ovary ovoid, 3 - 2 mm; Capsules ovoid, 1.5 – 2X0.6 – 0.8 cm, compressed, 2-seeded. Seeds ovoid, 7.4 – 8.5 6 – 6.8 mm. (Shetty and Singh, 1991)

It contains two fairly large, flat seeds, typically 8 mm long by 5 mm wide, covered with matted hair. *Barleria* has a central tap root, with lateral roots branching off in all directions. these shrubs flower from September to December and fruit from January to April (Parrotta, 2001). The flowers are sessile, yellow or pale orange in colour, tubular in shape (3-4 cm long) with protruding stamens. Each flower has five corolla lobes and four spine-tipped sepals (about 15 mm long). Flowering occurs mainly during autumn (April and May). The fruit are normally present during winter. The fruit is a capsule (13-20 mm long) with a sharply-pointed 'beak' (about 6 mm long) and contains two seeds. Seeds are reasonably large (about 8 mm long and 5 mm wide), flattened, and densely covered with matted hair (Howard 1989, Liogier 1997).

Chemical Constituents: Whole plant extract of Vajradanti contain iridoid glycosides, barlerin and varbascoside. Two iridoid glycosides, barlerin and acetyl barlerin are reported in Vajradanti which are classified barlerinoside, shanzhiside methyl ester, 6-*O-trans-p*-coumaroyl-8- *O*-acetylshanzhiside methyl ester, barlerin, acetylbarlerin, 7 methoxydiderroside and lupulinoside (Ata *et al.*, 2009). Barlerinoside has shown antioxidant activity. Flavonoids extracted from callus showed maximum antibacterial activity against *S. aureus*. (Chetan *et al.*, 2010). Phytochemical analysis of leaves yielded alkaloids, flavonoids, steroids, saponins, tannin, and phenolic compounds (Aneja *et al.*, 2010).

Cultivation:

Vajradanti is a popular garden ornamental and reproduces by seed; one plant producing hundreds of seeds in a season. Seeds require moist conditions to germinate. Although most seeds germinate within a few meters of the parent plant, infestations can move relatively quickly downhill, where seed transport may be aided by water. Vajradanti can also reproduce vegetatively. *Barleria* grows on a wide variety of soil types

Review Article

and seems to prefer well-drained soils. On the Australian mainland it grows well in tropical savanna country and along riverbanks.

Usage: Vajradanti possesses undoubtedly numerous medicinal properties and widely used in treatment of gastro-intestinal disorders, digestive troubles, constipation, intestinal worms, liver disorders, whooping cough, fever, toothache (Burkill, 1985), respiratory syncytial, joint pain (Parrotta, 2001). It shows hepatoprotective, anti-stress, immuno-restorative, diuretic, anti-inflammatory, antioxidant properties. It is a good nervine tonic and used in nervine disorders. Crude extract of Vajradanti is also beneficial in graying of hair arthritis and goiter curing (Khare, 2004). Vajradanti reportedly has antimicrobial activity against a wide range of micro-organisms that cause infectious disease (Aneja *et al.*, 2010). It has antiseptic properties, extracts of the plant are incorporated into herbal cosmetics and hair products to promote skin and scalp health (Prakruti, 2002).

As medicine in the Ayurvedic System:

In ancient Indian systems of medicine (Ayurvedic, Siddha) stem, leaves and flowers of *Barleria* are used for toothaches, inflammation, gastrointestinal disorders, whooping cough (Chopra, 1996). Whole plant is used for urinary and paralytic affections, rheumatism, jaundice, hepatic obstruction and dropsy. Paste of roots is applied to boils and glandular swelling, dried bark is given in whooping cough. Juice of the leaves is used in ulcer and fever (Ambasta, 1986)

Leaf juice is given in stomach disorders, urinary affections; mixed with honey and given to children with fever and catarrh. Leaf juice is also applied to lacerated soles of feet in the rainy season and after mixing with coconut oil, it is applied for pimples. Roots paste is applied over boils and glandular swellings. Ash, obtained from the whole plant, mixed with honey, is given in bronchial asthma.

Vajradanti contains a variety of active compound classes like alkaloids, flavonoids, glycosides, phenolics, saponins etc. It has been used in the medicines for their wide therapeutic activities (Saadabi *et al.*, 2006). In modern era of medicine the demand of herbal medicines is increasing rapidly because of their higher safety margin and low cost. Scientific researchers have shown it to be beneficial in different disease.

Antibacterial Activity:

Several reports demonstrated that the extract of *B. prionitis* leaves and callus possesses antibacterial activity against a number of Gram positive bacteria. Ethanolic extract of *B. prionitis* showed antibacterial activity against *Bacillus cereus* and *Pseudomonas aeruginosa* (Kosmulalage *et al.*, 2007). The extracts of barks, leaves and stems showed potent antibacterial activity against oral pathogens *Streptococcus mutans*, *Staphylococcus aureus*, *Pseudomonas aeruginosa* and *Bacillus cereus* causing dental caries (Aneja *et al.*, 2010). The antimicrobial activity of *B. prionitis* may be due to the presence of acetylbarlerin, barlerin, shanzhiside methyl ester, verbascoside, balarenone, pipataline, 13, 14-seco-stigmasta-5, 14-diene-3-*a*-ol and 6-O-acetyl shanzhiside methyl ester (Kosmulalage *et al.*, 2007; Aneja *et al.*, 2010).

Antifungal Activity:

Methanol, ethanol and acetone extract of Vajradanti bark showed more potent antifungal activity against *Saccharomyces cerevisiae* and two strains of *Candida albicans*. (Aneja *et al.*, 2010). It is investigated that ethanol extracts of stem and root showed fungistatic and fungicidal activities against *Candida albicans* (Amoo *et al.*, 2011).

Antioxidant Activity:

It is found that the whole plant extract of vajradanti possesses potent antioxidant activity. Study evaluated that the ethanolic extract possess more potent antioxidant activity then aqueous (Chetan *et al.*, 2011). Another study revealed that the methanolic extract of roots, leaves and stem possesses significant antioxidant activity (Amoo *et al.*, 2011). It was observed that the leaves showed higher degree of antioxidant potential and high phenolic content in comparison to flower and stem (Jaiswal *et al.*, 2010).

Anti-Inflammatory Activity:

Several studies evaluate the use of Vajradanti in the treatment of inflammations. Anti-inflammatory activity of ethanolic extracts of leaves, stems and roots was documented through *in-vitro* inhibition of enzyme dichloromethane (COX-1 and COX-2) with subsequent inhibition of prostaglandin synthesis (Amoo *et al.*, 2009). Another study revealed that the whole plant extract is very effective against

Review Article

carrageenin- induced paw edema in rats (singh, *et al.*, 2003). Moreover, the ethanolic extract of flowers was investigated for significant anti-inflammatory activity in rats (Jaiswal *et al.*, 2010)

Antifertility Activity:

The antifertility activity of *B. prionitis* roots was observed (Gupta *et al.*, 2000). Oral administration of methanolic root extract reduced the spermatogenesis in male albino rats (Gupta *et al.*, 2000; Verma *et al.*, 2005). Decreased number of production of round spermatids, sperm motility, spermatogonia, preleptotene spermatocytes population and mature leydig cells was revealed by Gupta *et al.*(2000). Biochemical investigation reported that the root extract was also reduced the total protein, glycogen, sialic acid contents of the testes, testicular glycogen contents, epididymides, ventral prostate and seminal vesicle (Gupta *et al.*, 2000; Verma *et al.*, 2005). The antifertility effect of root extract may be due to the presence of barlerin and acetyl barlerin via affecting the functions of testicular somatic cells (Gupta *et al.*, 2000).

In Vitro Conservation Studies in Barleria:

Medicinal plants are very useful but due to over-utilization and continuous depletion have affected their supply and loss of genetic. The immediate rising demand of plant-based drugs is unfortunately creating heavy pressure on some important medicinal plant populations in the wild due to their over-harvesting. Most of the study is based on conservation strategies for threatened medicinal plants with special reference to *Barleria prionitis* using *in vitro* and *ex vitro* propagation techniques. Due to over-exploitation of this species, there is a danger of becoming extinct because medicinal plant species are mostly threatened by over-exploitation, land conversion and habitat destruction. More than 95% of almost 400 plant species used in preparing medicine by various industries are harvested from wild populations in India. We have developed here a protocol for plant regeneration of *Barleria prionitis*. The International Union for Conservation of Nature (IUCN) Species survival commission report ‘‘Extinction crisis continues apace’’ for the year 2009 revealed that 70% of plants are under threat. The continuous exploitation of several medicinal plant species from the wild (Kala, 2003 Planning Commission Report 2000) and substantial loss of their habitats during past 15 years have resulted in population decline of many high value medicinal plant species over the years. The primary threats to medicinal plants are those that affect any kind of biodiversity used by humans (Sundriyal and Sharma, 1995; Rao *et al.*, 2004). Use of Plant growth regulators in *in vitro* techniques have found increasing use in the conservation of threatened plants in recent years. Some researchers develop a protocol for callus induction in *Barleria prionitis* (Premjet *et al.*, 2010; Shukla *et al.*, 2011).

Shoot regeneration and multiplication of *Barleria* could be traced in the literature search. There are many reports showing that the application of thidiazuron (TDZ) results in a better shoot regeneration capacity in comparison with other cytokinins (Babaoglu, 2000; Zhang *et al.*, 2001). Much work has been done for conservation of medicinal plants, but only a few studies are reported for *B. prionitis* in the field of conservation management, and there is no report of systematic cultivation of this important plant. However, no successful protocol has been developed yet for plant regeneration of this important medicinal plant (Shukla *et al.*, 2011). Therefore, attention has been focused on develop a best protocol for *in vitro* regeneration of *Barleria* species using different explants and different hormones combinations. Future conservation biotechnology research and its applications must be aimed at conserving threatened, mainly endemic plants from conservation hotspots.

CONCLUSION

From the ancient time Vajradanti occupy a significant place in the Ayurvedic medicine in India. The detailed information as provided in this review on conservation strategies and traditional uses, phytochemistry and pharmacology of the extracts of different parts might be added value in the scientific evaluation of medicinal use of this plant. Literature survey revealed the promising pharmacological activity includes antimicrobial, anthelmintic, antifertility, antioxidant, antidiabetic, anti-inflammatory, anti-arthritis, cytoprotective, hepatoprotective, anti-diarrhoeal, enzyme inhibitory, diuretic and anti-nociceptive activities of the extract and isolated chemical compounds of this plant without any toxic effects. In future study, the conversion of these pharmacological activities in to the modern drugs, proper

Review Article

scientific evaluation includes isolation of responsible phytochemicals, their mechanism of actions, toxicity of these molecules and proper standardization need to be explored.

REFERENCES

- Agrawal B, Das S and Pandey A (2011).** Boerhaavia Diffusa Linn.: A review On Its Phytochemical and Pharmacological profile. *Asian Journal of Applied Science* **4** 663-684.
- Ambasta SP (1986).** *The Useful Plants of India* (CSIR, New Delhi).
- Amoo SO, Finnie JF and Van Staden J (2009).** *In vitro* pharmacological evaluation of three *Barleria* species. *Journal of Ethnopharmacology* **121** 274-277.
- Amoo SO, Ndhlala AR, Finnie JF and Van Staden J (2011).** Antifungal, acetylcholinesterase inhibition, antioxidant and phytochemical properties of three *Barleria* species. *South African Journal of Botany* **77** 435-445.
- Aneja KR, Joshi R and Sharma C (2010).** Potency of *Barleria prionitis* L. bark extracts against oral diseases causing strains of bacteria and fungi of clinical origin. *New York Science Journal* **3**(11) 5–12.
- Ata A, Kalhari KS and Samarasekera R (2009).** Chemical constituents of *Barleria prionitis* and their enzyme inhibitory and free radical scavenging activities. *Phytochemistry Letters* **2**(1) 37-40.
- Babaoglu M and Yorgancilar M (2000).** TDZ-specific plant regeneration in salad burnet. *Plant Cell, Tissue and Organ Culture* **440** 31–34.
- Balkwill MJ and Balkwill K (1997).** Delimitation and infrageneric classification of *Barleria* (Acanthaceae). *Kew Bulletin* **52**(3) 535-573.
- Balkwill MJ and Balkwill K (1998).** A preliminary analysis of distribution pattern in a large, pantropical genus, *Barleria* L. (Acanthaceae). *Journal of Biogeography* **25** 95 – 110.
- Burkill HM (1985).** *The Useful Plants of West Tropical Africa* (Royal Botanic Garden, Kew, UK) **1** 960.
- Chetan B Chavan, Ulka V Shinde, Maheshwar Hogade and Somnath Bhinge (2010).** Screening Of In-Vitro Antibacterial Assay Of *Barleria Prionitis* Linn. *Journal of Herbal Medicine and Toxicology* **4**(2) 197-200.
- Chetan C, Suraj M, Maheshwari C, Rahul A and Priyanka P (2011).** Screening of antioxidant activity and phenolic content of whole plant of *barleria prionitis* linn. *International Journal of Research in Ayurveda and Pharmacy* **2** 1313-1319.
- Chopra RN, Nayar SL and Chopra IC (1996 Rpr.).** *Glossary of Indian Medicinal Plants* (National Institute of Science Communication, New Delhi) 110 012.
- Gantait A, Maji A, Barman T, Banerji P, Venkatesh P and Mukherjee PK (2011).** Estimation of Capsaicin Through Scanning Densitometry and Evaluation of Different Varieties of Capsicum In India. *Natural Product Research* **26** 216-222.
- Gupta RS, Kumar P, Dixit VP and Dobhal MP (2000).** Antifertility studies of the root extract of the *Barleria prionitis* Linn in male albino rats with special reference to testicular cell population dynamics. *Journal of Ethnopharmacology* **70** 111-117.
- Howard RA (1989).** *Flora of the Lesser Antilles, Leeward and Windward Islands* (Arnold Arboretum, Harvard University, Jamaica Plain, MA) **6** 658.
- Jaiswal SK, Dubey MK, Das S, Verma AR and Rao CV (2010).** A comparative study on total phenolic content, reducing power and free radical scavenging activity of aerial parts of *Barleria prionitis*. *International Journal of Phytomedicine* **2** 155-159.
- Kala CP (2003).** Commercial exploitation and conservation status of high value medicinal plants across the borderline of India and Nepal in Pithoragarh. *The Indian Forester* **129** 80–84.
- Karthikeyan S, Sanjappa M and Moorthy S (2009).** Acanthaceae. In: *Flowering Plants of India – Dicotyledons: Volume I (Acanthaceae – Avicenniaceae)* (Botanical Survey of India, Kolkata) 1 – 62.
- Khare CP (2004).** *Indian Herbal Remedies: Rational Western Therapy, Ayurvedic and Other Traditional Usage, Botany*, 1st edition (Springer, New York) 93-94.
- Khare CP (Rpr.) (2007).** *Indian Medicinal Plants An Illustrated Dictionary* (Springer–Verlag).

Review Article

- Kosmulalage KS, Zahid S, Udenigwe CC, Akhtar S, Ata A and Samarasekera R (2007).** Glutathione S-transferase, acetylcholinesterase inhibitory and antibacterial activities of chemical constituents of *Barleria prionitis*. *Zeitschrift für Naturforschung B* **62** 580-586.
- Liogier HA (1997).** *Descriptive Flora of Puerto Rico and Adjacent Islands* (Editorial de la Universidad de Puerto Rico, San Juan, PR) **5** 436.
- Mabberley DI (1987).** *The Plant Book* (University Press, Cambridge, New York).
- Mabberley DJ (2008).** *Mabberley's Plant-Book: A Portable Dictionary of Plants, Their Classification and Uses*, third edition (Cambridge University Press, Cambridge).
- Mukherjee PK, Mukherjee A, Maji K, Rai S and Heinrich (2009).** The Sacred Lotus (*Nelumbo nucifera*)- Phytochemical And Therapeutic Profile. *Journal of Pharmacy and Pharmacology* **61** 407-422.
- Panwar HS, Nauriyal MM and Joshi HC (1979).** *In vitro* screening of certain indigenous plants for their antimycotic activity. *Veterinary Research Bulletin* **2**(2) 164-167.
- Parrotta JA (2001).** *Healing Plants of Peninsular India* (CABI Publishing, Wellington, UK & New York) 917.
- Prakruti (2002).** Suddh Bhangra (maka) oil. Available: <http://www.prakrutiherbals.com/hairoil.htm> 2.
- Premjet D, Premjet S, Arthur R, Lelono A and Tachibana S (2010).** Callus induction and determination of iridoid glycosides from *Barleria prionitis* Linn. leaf explants. *Australian Journal of Basic and Applied Sciences* **4** 4461–4467.
- Probiotics New Zealand (2002).** Probiotics for life—improving your health and quality of life through good bacteria. Available: http://www.probiotics.co.nz/prdcts_efml.asp?ProductID=5. 3 p. Vaipani.
- Rao MR, Palada MC and Becker BN (2004).** Medicinal and aromatic plants in agro-forestry systems. *Agroforestry Systems* **61** 107-122.
- Saadabi AMA, Sehemí AG and AL-Zailaie KA (2006).** In Vitro Antimicrobial Activity of Some Saudi Arabian Plants used in Folkloric Medicine. *International Journal of Botany* **2** 201-204.
- Shetty BV and Singh V (1991).** *Flora of Rajasthan* (Botanical Survey of India, Calcutta) **2**.
- Shukla P, Singh A, Gawri S, Alexander A and Sonwane S (2011).** In vitro propagation of *Barleria prionitis* L. and its antibacterial activity. *International Journal of Pharma Professional's Research* **2**(1) 198–200.
- Singh B, Bani S, Gupta DK, Chandan BK and Kaul A (2003).** Anti-inflammatory activity of 'TFA' an active fraction from the plant *Barleria prionitis* Linn. *Journal of Ethenopharmacology* **85**(2-3) 187-193.
- Singh B, Chandan BK, Prabhakar A, Taneja SC, Singh J and Qazi GN (2005).** Chemistry and hepatoprotective activity of an active fraction from *Barleria prionitis* Linn. In experimental animals. *Phytotherapy Research* **19**(5) 391– 404.
- Sundriyal RC and Sharma E (1995).** *Cultivation of Medicinal Plants and Orchids in Sikkim Himalaya* (Almora: G.B. Pant Institute of Himalayan Environment and Development).
- Vaipani Herbal Ayurvedic Partisthan (No Date).** A herbal ayurvedic cosmetics company. Available: <http://www.vaipani.com/skincare/skin%20Care-Page3.html> 2.
- Verma PK, Sharma A, Joshi SC, Gupta RS and Dixit VP (2005).** Effect of Isolated fractions of *Barleria prionitis* root methanolic extract on reproductive function of male rats: preliminary study. *Fitoterapia* **76**(5) 428–432.
- Zhang CL, Chen DF, Elliott MC and Slater A (2001).** Thidiazuron-induced organogenesis and somatic embryogenesis in sugar beet (*Beta vulgaris* L.). *In Vitro Cellular & Developmental Biology – Plant* **37** 305–310.