

# Leguminous trees as low-maintenance ornamentals

Wesley M. Jarrell

Peter Clark

Ross A. Virginia

Leguminous plants include both herbaceous and woody types, both shrubs and trees. Many of these shrubs and trees have been used as ornamentals; many others have the potential, in appearance and adaptation, to complement existing plantings.

Most leguminous plants are capable of growth on soils lacking nitrogen by forming symbiotic associations with bacteria (*Rhizobium*) that infect the plant root, forming specialized structures known as nodules. The bacteria in these nod-

ules convert atmospheric nitrogen gas to ammonia, which is readily used by the plant. This process is termed nitrogen fixation. Although the plant may grow most rapidly with added fertilizer nitrogen, in many cases it will grow nearly as fast with little or no nitrogen supplied from the soil. When the nodule associations are effective, plants require no fertilizer nitrogen for growth.

## Growth without N fertilizer

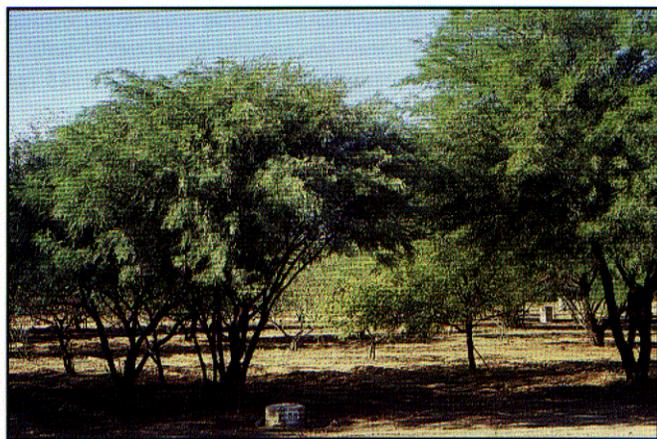
In addition to this trait, many legumes are highly tolerant of intermittent drought, and some tolerate extreme drought.

The objectives of our research were to determine the relative abilities of some established landscape ornamental legumes, and relatively unused species as well, to grow in the absence of added fertilizer nitrogen. Methods were explored to gain rapid growth in the glasshouse without inhibiting nitrogen fixation, so that seedlings or young trees would support viable, effective nodules when planted out. In addition, the relative effects of drought on plant growth and nitrogen fixation were measured for several leguminous species in comparison with nonleguminous *Nerium oleander* (oleander).

Sixteen woody legumes were tested for their ability to nodulate in the greenhouse in association with rhizobial strains thought to be specific for the genera to which the legumes belonged. Species tested were from four genera: *Acacia*, *Prosopis*, *Cassia*, and *Erythrina*. Mixtures of all rhizobial isolates were also used to determine if there were beneficial or adverse effects. (If mixed inocula were effective, it would simplify management in that a separate inoculum need not be produced for each species of tree.) *Rhizobium* cultures were obtained from the U.S. Department of Agriculture culture collection in Beltsville, Maryland.

## Rhizobial cocktail

*Acacia*, *Prosopis*, *Cassia*, and *Erythrina* species were inoculated and grown in containers in the glasshouse, in a vermicu-



Woody legumes hold promise as landscape plants that can produce their own nitrogen and prosper with relatively little or no added nitrogen fertilizer. This plantation of *Prosopis* at UC Riverside is maintained to test the nitrogen-producing capability of various species.

lite medium. Stem heights were measured and, at the final harvest, plant fresh and dry weights were determined and roots observed for nodules. Results showed that most plants responded strongly to mineral nitrogen in the nutrient solution, although some species exhibited relatively little response. Those inoculated with a mixture, or "cocktail," of rhizobial types tended to respond as well as or better than those inoculated with a single strain, but three species grew more rapidly with their specific strain. Overall, the fixing plants appeared healthy but did not grow as rapidly as the fertilized plants, and, with a few exceptions, use of the inoculum cocktail proved as effective as the single specific organism.

Because it is desirable to get plants established and growing as rapidly as possible in the greenhouse to avoid excessive residence time there, it may be advantageous to supply some fertilizer nitrogen. In the presence of soil nitrogen, however, rhizobial infection in plants may be greatly diminished. We therefore experimented with a split root system, in which the lower half of the nursery container was filled with sterile vermiculite containing 17-9-13 Osmocote micro-resin-coated fertilizer, and the remainder filled with sterile vermiculite. The seeds planted in the top half then were inoculated with rhizobia. Since the direction of water flow was maintained from top to bottom by regular leaching irrigations, fertilizer nitrogen was confined to the lower half of the container, while the upper portion was suitable for the formation of effective nodules. Two species were planted in these trials, *Prosopis alba* and *Acacia baileyana*. In other treatments, the fertilizer was mixed throughout the pot or no nitrogen was added at all, and plants were not inoculated.

The plants were largest where fertilizer was added, with *Prosopis* growing fastest when fertilizer was mixed throughout the pot, and *Acacia* fastest when it was confined to the lower half. The nodule mass on *Acacia* was equal to or greater than that on *Prosopis*, except where they were not inoculated. The *Acacia* nodule mass remained high or increased with fertilization, with a tremendous effect of deep placement (inhibition in the lower half, stimulation of nodulation in the upper half). *Prosopis* showed a much less pronounced response. From these results, it appears quite promising to separate the zones of fertilization and nodulation.

### Experimental design

A large field experiment examined the relationship between nitrogen fixation, nitrogen fertilization, and plant water requirements. A single line of irrigation pipe was set up on the UC Riverside Experiment Station with sprinkler heads spaced at 4.5-meter (15-foot) intervals. The sprinklers wetted the soil out to 12 meters from the line, resulting in a linear decrease in rate of water application with distance from the line. Seedlings of *Acacia baileyana*, *Acacia decurrens*, *Acacia saligna*, and *Prosopis alba* were planted in rows (1.5 meters apart) perpendicular to the irrigation line, with nine plants at 1.5-meter intervals on either side of the line. In addition, established cuttings of *Nerium oleander* were planted as



The relationship between nitrogen fixation, nitrogen fertilization, and plant water requirements was tested in a field experiment at UC Riverside. After harvest, analysis of the four legume species in the trial showed that all were able to produce enough nitrogen on their own to support vigorous growth.

non-nitrogen-fixing reference plants. Three fertilizer treatments were imposed: noninoculated, inoculated, and inoculated with 100 kilograms nitrogen per hectare per year applied as ammonium nitrate. Treatments were replicated three times in blocks down the irrigation line; fertilization treatment subplots were randomized within each block, and the tree row order was randomized within each fertilizer treatment plot. Trees were planted in June 1984; the field was fully irrigated for one month, at which time differential irrigation was imposed. Trees were fertilized in September by a weighed quantity of fertilizer applied around each tree.

Trees were harvested in October 1985, weighed, and separated into leaf and stem components for tissue analysis. Inoculation had little effect on tree growth; apparently sufficient effective native rhizobia existed in the soil to nodulate the plants. The oleander cuttings responded as expected to the imposed water regime, with some mortality at the edges of the wetted area, while the largest shrubs were adjacent to the irrigation line. *Prosopis* demonstrated a similar pattern, while *Acacia baileyana* growth decreased near the irrigation line and reached a peak about 4 meters from the line, suggesting that it was sensitive to excessive moisture. *Acacia saligna* and *Acacia decurrens* growth was quite erratic. Leaf morphology of the *A. decurrens* plants suggested that there was a high degree of variation, perhaps due to interspecific hybridization among plants in the UCR botanic garden, from which the seed was collected. *Acacia saligna* plants varied randomly in size with distance from the sprinkler line; large plants were even located in the outermost rows.

### Results

In summary, seedlings of all four legume species appeared to outperform oleander in growth rates and survival under experimental conditions. The responses may be due to better tap-root development or root system development in general, or to differences in physiology making the plant less sensitive to drought. *Acacia saligna* plants were especially vigorous and fast-growing, although also among the most variable in plant-to-plant sizes unrelated to treatment. In addition, *A. saligna* does not lose its phyllodes (flat, expanded petioles) to any

---

great extent, and it stays green throughout the year, while the other acacias and *Prosopis* shed many or all of their leaves.

Woody legumes hold great promise as landscape components that function extremely well on relatively little or no added fertilizer nitrogen. Requirements for phosphorus, potassium, and other fertilizer nutrients should also be minimal. Species like *A. saligna* may develop extensive root systems that effectively extract water from large volumes of soil, allowing them to survive and grow on low water inputs. Inoculation may be needed for some species, but requirements must be determined on an individual basis. Effective nodulation can be coupled with acceptably fast growth in nurseries by spatially separating the fertilizer and the zone of inoculation in the container.

Our group at UC Riverside is maintaining a *Prosopis* plantation on campus with a number of species that represent the variation in the genus. We also have a substantial collection of rhizobia from *Prosopis*, as well as from *Acacia* and *Erythrina*.

*Wesley M. Jarrell is Associate Professor of Soil Science and Peter Clark is Staff Research Associate, Dry Lands Research Institute and Department of Soil and Environmental Sciences, University of California, Riverside; and Ross A. Virginia is Associate Professor of Biology, Systems Ecology Research Group, San Diego State University, San Diego.*