

# Distribution, Biology, and Potential Horticultural Uses of Big Bend Bluebonnet (*Lupinus havardii* Wats.) – A Showy Winter Annual from the Chihuahuan Desert

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**Abstract.** *Lupinus havardii* is a winter annual native to a rather narrow geographical range in the Big Bend region of southwestern Texas. Plant populations and morphology vary greatly depending upon rainfall. Flowers are showy and generally violet-blue in color, although pink and white flowers are occasionally found in the plant's native range. This paper summarizes our observations regarding the distribution, biology, and potential horticultural uses of this desert legume.

## Introduction

The genus *Lupinus* (family *Leguminosae*, subfamily *Papilionoideae*) is composed of a wide range of herbaceous annuals to shrubby perennials. Commonly referred to as lupins (sometimes spelled "lupines", particularly in North American horticultural literature), this group of plants occupies a wide climatic range throughout the world. About 500 New World taxa have been recognized (Dunn 1984) whereas only 12 species are from the Old World (Gladstones 1998). Several *Lupinus* species, most notably low-alkaloid-containing *albus* and *angustifolius*, have considerable agricultural significance as agronomic crops produced for animal and human consumption.

Six species of *Lupinus* are native to the state of Texas (*concinus*, *havardii*, *perennis*, *plattensis*, *subcarnosus*, *texensis*). Collectively these species are commonly referred to as "bluebonnets" which, as a group, were formerly designated by the Texas legislature in 1971 to be the official state flower. The best-known and most widely distributed species in Texas is *Lupinus texensis* Hook. (simply known as the "Texas bluebonnet"). The subject of this paper, *Lupinus havardii* (Big Bend bluebonnet), is much less known due to at least two factors: 1) the species has rather narrow geographical distribution in a very remote area of the state; 2) several years may pass before there is sufficient rainfall to support significant plant populations. We have been work-

ing with *L. havardii* for the past 10 years and have found virtually no information in the literature on this species. The purpose of this article is to share our observations regarding the distribution, biology, and potential horticultural uses of this plant.

## Geographical Distribution

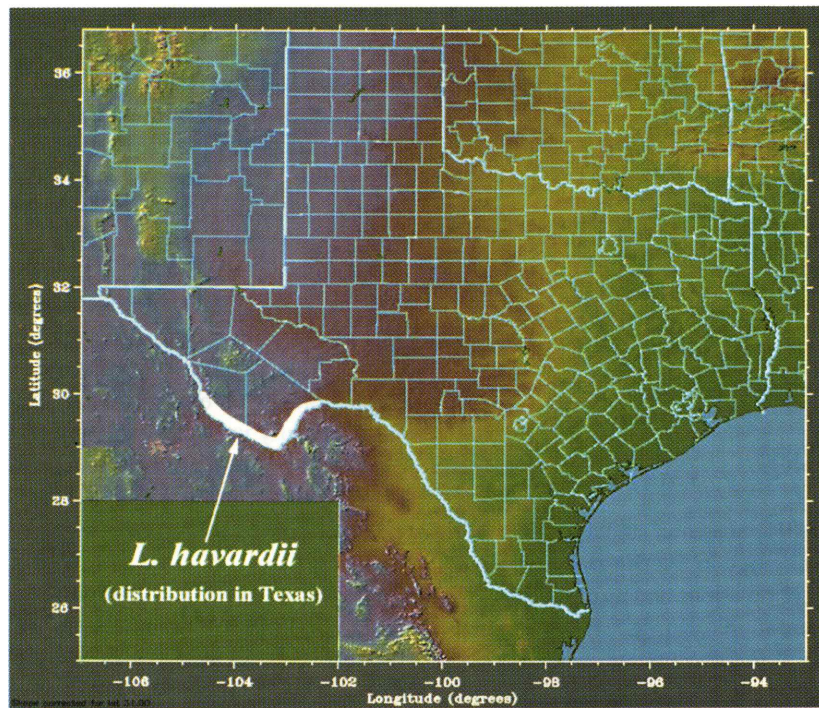
As indicated by the common name "Big Bend bluebonnet", *L. havardii* is native to the Big Bend region of southwestern Texas (Fig. 1). The species was first collected in May 1881 near Presidio, Texas by Dr. Valery Havard, a French-born surgeon who served in the U.S. Army (Andrews 1986). Populations occur sporadically in a rather narrow range along both the Texas and Mexico sides of the Rio Grande River. Depending upon the quantity and distribution of rainfall, plants can be observed from the desert floor to mountain slopes generally at elevations of 3500-4500 feet. In fact, the less frequently used common name "Chisos bluebonnet" is derived from the Chisos Mountain Range in the Big Bend National Park. Soils in this region are typically rocky or gravelly with a pH of around 8.0.

In dry years, which are common in this region, plants are sparsely distributed along creek beds and adjacent to paved roadways (Fig. 2) where runoff supplements meager precipitation. In such years, the desert floor is devoid of plants. In rare years, when rainfall is more plentiful and better distributed, populations can be observed on the desert floor and on slopes. Because rainfall is so sparse and the native habitat is so remote, it is difficult to be certain as to how widely the species is actually distributed.

## Morphological Description

The dimensions of this plant can obviously vary widely depending upon the amount of available soil moisture. The morphological description we provide herein is for plants that receive adequate moisture. Foliage is light-green and is composed of alternate, palmately compound leaves generally with seven (occasionally six or eight) leaflets. Leaflets are oblanceolate and 2-4 cm long. The upper surface of the leaflets is glabrous whereas the lower side is pubescent. Petiole length is 5-8 cm.

Flowers are generally blue to violet-blue in color. Occasionally, white or pink flowers occur. Although the vast majority of populations we have encountered are entirely blue-flowered, we have observed small, isolated populations with as many as 25% of the plants being pink- or white-flowered. Flowers are borne alternately on racemes that are generally 60-90 cm in length. The number of open flowers per raceme at any given time varies greatly from plant to plant, but generally exceeds 25. Likewise, the number of racemes per plant varies considerably. Under ample moisture conditions, we have observed plants with as many as 70-75 racemes. Each flower is 1.5-2 cm long and has a 3-6 mm wide white to yellow banner spot on the banner petal. The banner spot turns to reddish-purple due to pollination or aging, but the flowers



**Figure 1.** Geographical distribution of *Lupinus havardii* in Texas



**Figure 2.** Dr. Tim Davis examining *Lupinus havardii* growing along roadway at Big Bend National Park entrance.

sometimes shrivel before the color changes takes place. Each flower has a total of eight stamens, four of which mature prior to stigma receptivity. Pedicels are green and 4-7 mm long.

Seed pods become visible to the naked eye within about three days after pollination. At the mature green stage (Fig. 3), the pods are 30-50 mm long, 4-7 mm wide, and 4-7 mm thick. When mature dry, pod thickness is reduced to 3-4 mm. Each pod contains 4-8 seeds. Mass per 100 seeds is 1.5-2.0 g. Seeds are quadrangular, 2 mm wide X 2 mm long X 1 mm thick in dimension, are gray to tan, often speckled with black. Correll and Johnston (1970) described the seed as "pebblelike." In one of the rare scientific journal publications that mentions *L. havardii*, ultrastructural characteristics of the seed are described in detail by Bragg (1983).



**Figure 3.** Mature-green pod stage of *Lupinus havardii*.

### Biology

In a desert environment, with erratic and uncertain rainfall, efficient seed germination-regulating mechanisms play a crucial role in seedling establishment and survival. For instance, in many desert plants, hard seedcoats are often differentially permeable to water. Accordingly, all seeds do not germinate simultaneously. Additionally, splitting of the pod wall in legumes often results in the dispersal of seeds away from the mother plant. Such mechanisms act in concert to ensure gradual germination in both time and space for survival of

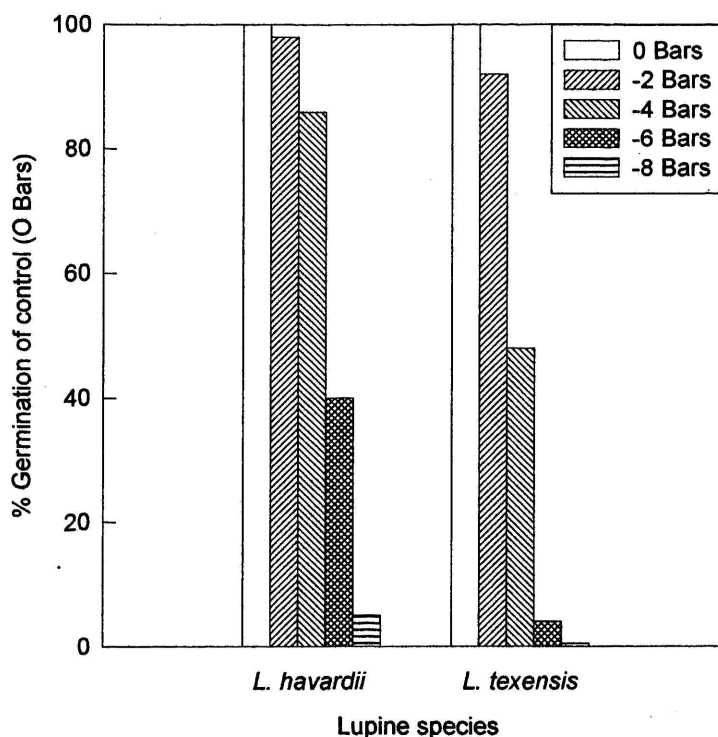
the species during long and recurrent dry periods. Seed germination in *L. havardii* is dependent upon two key factors: 1) availability of water; 2) permeability of the seed coat. In the native range of this species, seed germination occurs following rains, which typically occur in September. However, we have observed germination in native habitats as late as March following rains. The amount of moisture needed for germination has not been quantified, but studies simulating low water availability indicate that *L. havardii* can germinate under much lower water potential than *L. texensis* (Fig. 4), the most widely distributed lupin species in Texas. At -4 bars (-0.4 MPa), 86% of *L. havardii* seed germinate compared to 48% in *L. texensis*. Likewise, at -6 bars (-0.6 MPa), 40% of *L. havardii* seed germinate compared to only 4% with *L. texensis*. Even at -8 bars (-0.8 MPa), 5% of *L. havardii* seed still germinate whereas virtually no germination occurs with *L. texensis*.

As with many desert legumes, *L. havardii* has a hard seed coat that is impermeable to water. This presumably is an adaptive mechanism for species survival during the long periods between moist years. Only 10-20% of non-scarified seeds germinate (Mackay et al. 1995). Virtually nothing is known about how much time is required for the seedcoat to become permeable in the native environment of the species. We have determined, however, that germination percentages increase sigmoidally as scarification time in concentrated sulfuric acid increases (Mackay et al. 1995). A scarification time of 120 minutes results in nearly 100% germination. These results have been helpful in obtaining high numbers of plants for our greenhouse studies. Soaking the seed in water for 24 h failed to enhance germination.

Scarified seed of *L. havardii* can germinate over a fairly wide temperature range (Mackay et al. 1995). The most rapid germination occurs between 24 and 29°C. At temperatures approaching 35°C, however, seed germination begins to decline. This may be a survival mechanism to ensure that seeds do not germinate following brief heavy rains that sometimes accompany the summer monsoonal season in the Big Bend region. Light is not required for germination (Mackay et al. 1995).

Seedling establishment is highly dependent upon adequate soil moisture. We have observed large numbers of desiccated seedlings in the Big Bend region that obviously did not receive sufficient rainfall to become well-established. The precise amount and distribution of rainfall required for successful establishment is unknown. We have observed, however, that the primary root of seedlings grows rapidly downward which presumably increases the chances of remaining in contact with retreating soil moisture.

When sufficient soil moisture exists, vegetative growth continues during the fall. During this period, above-ground growth consists primarily of the production of new leaves and the development of a rosette (i.e. very little vertical elon-



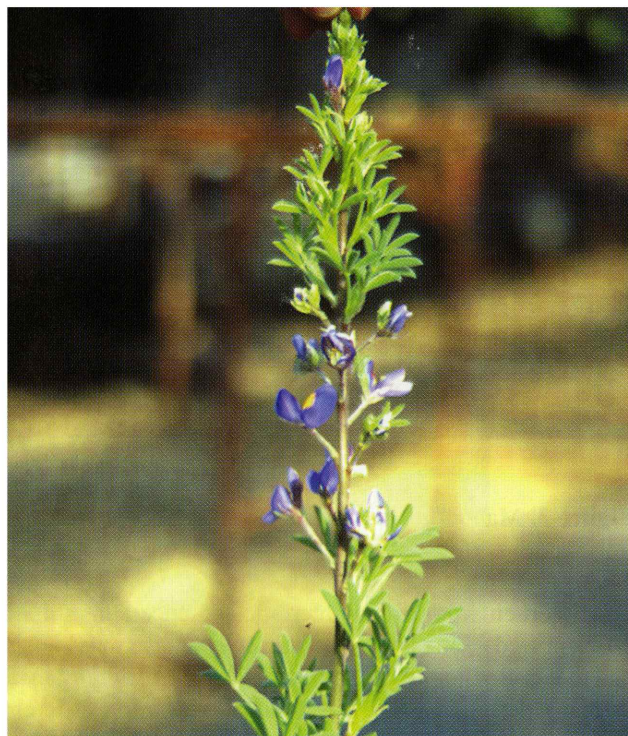
**Figure 4.** Seed germination of *Lupinus havardii* and *Lupinus texensis* as influenced by water potential

gation occurs). At some point during vegetative growth, *Bradyrhizobium* infection of roots occurs, resulting in nodulation typical of many leguminous species. However, little else is known about the symbiotic relationship between *Bradyrhizobium* and *L. havardii*.

Depending upon weather conditions and elevation, plants typically begin flowering in February and March. We have heard of instances where flowering has begun as early as November, but this appears to be rather rare. Very little is known regarding the floral biology of *L. havardii*. Preliminary results (unpublished) from the Southeastern Environmental Laboratory in Raleigh, North Carolina, suggest that flowering can occur at most daylengths. Timing and the number of racemes produced, however, may vary with photoperiod. Vernalization is not required to induce flowering, but with other *Lupinus* species, it dramatically reduces variability in flowering (Putnam et al. 1993). Along these lines, we have observed that when plants of *L. havardii* are grown in a greenhouse at relatively high temperatures, a significant number of plants undergo the rapid stem elongation that typically accompanies flowering, but exhibit vegetative budbreak at nodes that normally bear flowers (Fig. 5). Although not clearly documented, we suspect that this occurs when night temperatures are consistently above about 16C (60F). We have occasionally observed isolated plants in the wild that exhibit this response. These observations were made following a relatively mild winter.

In its native habitat, *L. havardii* requires insects for pollination. When an insect (primarily honey bees and bumble bees)

lands on a flower, it forces the interlocking wings and keel downward, so that the style and stigma protrude from between the wings. During this tripping process, the stigma



**Figure 5.** "Christmas tree" response of *Lupinus havardii*, presumably due to high night temperatures during plant development. Note that plants exhibit vegetative budbreak at nodes that normally bear flowers.

may be self-pollinated or pollinated with pollen carried on the insect from another plant. As indicated earlier, there are two sets of stamens, with one set having longer filaments so that they are arranged one above the other. The longer set matures about one week earlier than the shorter set. Thus, pollen shed can occur for a period of about two weeks (greenhouse observations). Observations from hand pollination trials indicate that the stigma is receptive about 4-7 days after anthesis and remains receptive for several days. As mentioned previously, banner color changes as the flower ages, but also changes when pollination has occurred and indicates a cessation of receptivity. The banner spot color changes from yellow to red upon pollination of a flower. Visible changes in color occur within 8 hours and the color change is complete 16 hours after pollination. Insect behavior is also affected by the change in banner spot color. When the banner spot is red, the insects no longer forage for pollen whereas they continue foraging on flowers which have a yellow banner spot.

Hand pollination of *L. havardii* is readily accomplished with camel hair artist paint brushes. The plants can be easily selfed and rapid progress can be made in isolating recessive genes. Although we know little about the outcrossing and selfing rates in the wild, it appears that most flowers are cross-pollinated because recessive flower colors (i.e. pink, white) occur rarely, and when those colors are present in larger proportions, they are in isolated populations.

Seed pod formation can be observed within three days of pollination, with flower petals shriveling and the ovaries swelling. Seed maturation takes about 8-10 weeks depending upon weather conditions. The number of seed per pod from hand pollination is usually 4-6 whereas the number from bee pollination is usually 6-8 under optimal growing conditions. In native habitats, the number of seed is usually lower, sometimes being as low as one per pod. The maximum number of seed produced per plant under optimal growing conditions is about 5,000. The final stages of seed maturation occur within a few days. During this time, the seed undergo a rapid dehydration with the seed coat changing from a translucent state to a hard opaque covering. As the seed undergoes final maturation, the seed pod also changes dramatically. The pod dehydrates and turns from green to tan and, upon final maturation, springs apart, twisting as it splits, and forcefully scattering the seed. Although little is known about the details of seed dispersal, we have observed that seeds can be propelled distances of about 6 meters in the lab.

#### Potential Horticultural Uses

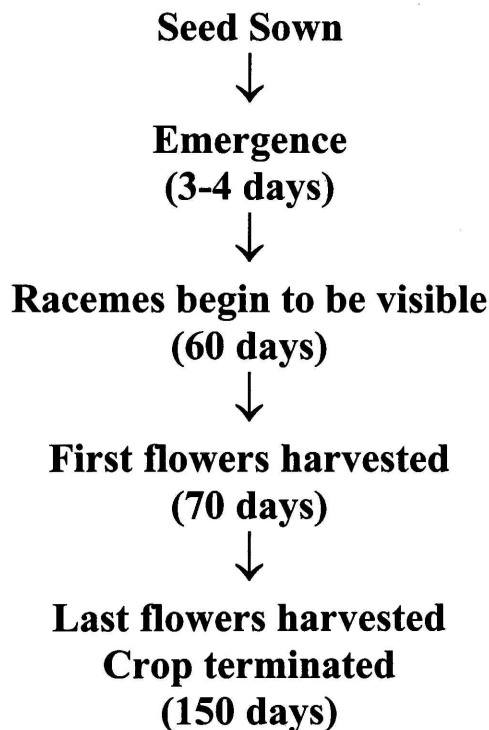
**Cut flower crop.** Because there is a critical need for high-quality, durable, spike-type flowers in the floral industry, the raceme of *L. havardii* has considerable market potential (Fig. 6). Blue flowers are particularly rare and *L. havardii* could help fill this important color niche in the industry. Accordingly, a research project was initiated in 1990 (with partial



**Figure 6.** Floral arrangements using cut racemes of *Lupinus havardii*

funding provided by the Fred C. Gloeckner Foundation, Harrison, N.Y.) with the goal of evaluating the potential of *L. havardii* as cut flower crop.

Initial trials indicated that field production of *L. havardii* was not feasible due to at least two key factors: 1) the plants are highly susceptible to root rots in most soils; 2) pollination by bees results in heavy seed production which limits flower yield. Subsequent work, therefore, focused on the possibility of greenhouse production. In contrast to what was found in the field, our research indicated that *L. havardii* performs quite well under greenhouse conditions (Davis et al. 1994). Individual plants produced an average of 10-20 harvestable racemes within 4-5 months from sowing of the seed. A generalized schedule for greenhouse production is presented in Fig. 7. Because the cut racemes command a rather high wholesale price, the crop has the potential to be profitable for commercial growers. Further work is needed, however, to better define the conditions needed to maximize profit.



**Figure 7.** Flowchart summarizing a typical greenhouse production schedule for cut flowers of *Lupinus havardii*. (Number of days indicates total time elapsed from the time the seed is sown.)

Cut flowers must be able to withstand the rigors of shipping and handling. In this regard, cut racemes of *L. havardii* perform quite well. Provided the flowers are protected from the potential deleterious effects of ethylene, they commonly exhibit a vase life of 8-10 days (Davis et al. 1995; Sankhla et al. 1998). Preconditioning the cut racemes with silver thio-sulfate (STS), an ethylene inhibitor, has been a particularly

efficacious treatment for preventing premature flower abscission induced by ethylene. Cut racemes pretreated with STS have been successfully shipped via overnight air freight. Although racemes were wilted upon arrival, they rehydrated rapidly when recut and placed in water. More recently, we have observed that 1-methylcyclopropene (1-MCP) is also quite effective in preventing flower abscission and increasing vase life (Sankhla et al. 1999).

Because of the potential of *L. havardii* as a cut flower crop, we initiated a breeding project in 1991 aimed primarily at improving plant/flower uniformity and developing novel color lines. This project moved forward rapidly because several crops can be grown and evaluated in the greenhouse each year. Furthermore, recurrent phenotypic selection rapidly results in relatively pure lines. Our breeding efforts have resulted in several separate color lines (dark blue, pink, white, light blue, coral pink, and bi-color flowers of blue/white and pink/white). Some of the more advanced color lines are shown in Fig. 8. The first formal cultivar releases from the program were made in 1998 (Mackay and Davis, 1998): 'Texas Sapphire' (blue flowers); 'Texas Ice' (white flowers). Current breeding efforts are aimed at improving the pink-flowered lines so that they flower earlier (currently, all pink-flowered lines bloom 4-6 weeks later than the blue- or white-flowered lines) and have acceptable levels of insect and disease resistance. A long-term breeding goal for all lines is the development of ethylene insensitivity in cut racemes to improve vase life and response to shipping.

*Use as a flowering pot plant.* Although not studied in detail, *L. havardii* has some potential as a potted plant for use on patios and in landscapes. If old racemes are removed regularly, plants can bloom in containers for 4-5 months. More work is needed, however, to fully evaluate the potential of *L. havardii* for this use.

*Use in landscapes.* Many gardeners in Texas have expressed an interest in growing *L. havardii* in their landscapes. Unfortunately, the plant performs poorly on most soil types and use in landscapes appears to be restricted to areas that have well-drained, coarse-textured soils. We have observed excellent wildflower plantings at the Barton C. Warnock Environmental Center in Lajitas, Texas and at a Texas Department of Transportation facility near Study Butte. Both of these plantings are well within the native range of *L. havardii*.

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**Figure 8.** Flower color lines developed in breeding program for *Lupinus havardii*