EVALUATION AND BREEDING OF *HILARIA BELANGERI* 
FOR TURFGRASS USE.

by

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Edward Daniel Ralowicz
who fostered my love for the plant kingdom, and showed me the
power of knowledge and the good things that can come from it,

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ABSTRACT

Curly mesquite (*Hilaria belangeri* (Steud.) Nash) is a palatable, nutritious range grass in the southwestern United States. A research project was initiated in 1988 on plant material collected within Arizona to determine the value of this species as a turfgrass, if sufficient genetic variation existed in vegetative, reproductive, and germination traits to allow for improvement of the turfgrass value by breeding, and if this species could be successfully established by seeding.

Curly mesquite can withstand the rigors of turfgrass cultural practices (mowing and fertilizing), while maintaining an attractive, healthy appearance. Plant material from five separate geographic origins was subjected to 5 cm and 10 cm heights of cut, and a no cut treatment, along with nitrogen applications of 0, 48, and 96 kg ha\(^{-1}\) yr\(^{-1}\) in a randomized complete block split-split plot design. Cutting at 10 cm, and application of 96 kg N ha\(^{-1}\) yr\(^{-1}\) produced the best color and highest ground cover. Control (uncut) plots exhibited low vigor and color.

Broad-sense \((h^2_b)\) and narrow-sense \((h^2_n)\) heritability estimates were computed for measured and rated characters on clones and their open-pollination progeny grown at Safford (S) and Tucson (T), AZ. Estimates of \(h^2_b\) of measured characters were: leaf length 0.29 (S) and 0.45 (T), stature 0.83 (S) and
0.71 (T), and flowers·spike"\(^{-1}\) 0.40 (S) and 0.36 (T). Significant variation was not observed in leaf width. Significant \(h^2\) estimates of 0.31, 0.51, and 0.30 were obtained for leaf length, stature, and flowers·spike"\(^{-1}\), respectively. Broad-sense heritability estimates ranged from 0.46 to 0.79 for color, and 0.47 to 0.69 for density ratings. Cumulative germination percentages had \(h^2\) estimates ranging from 0.45 to 0.61. Hard seed (%) and seed weight (mg 100 seed"\(^{-1}\)) had \(h^2\) estimates of 0.83 and 0.95, respectively.

Successful seedling establishment occurred after June, July and August sowings. Ground cover at the close of the season was greatest for the June seeding. A significant difference did not exist between the ground cover means of seeding rates (1 and 2 gm m"\(^{-2}\)).

The results of these investigations clearly warrant further efforts in the development of curly mesquite into a low maintenance turfgrass.
CHAPTER 1

INTRODUCTION AND REVIEW OF THE LITERATURE

Water and Turf in the Desert

The southwestern desert (west Texas, New Mexico, Arizona, and southern California) is characterized by extremely high temperatures and evaporation. Annual precipitation typically is 30 cm or less. Turfgrass in this region takes the forms of resorts and golf courses, public parks, cemeteries, and school yards. Limited turfgrass use occurs on home lawns. In Arizona, turfgrass facilities larger than 5 hectares are required to limit irrigation water use to 1.5 m ha\(^{-1}\) yr\(^{-1}\) (Arizona Dept. of Water Resources, 1988). These facilities must develop strategies to comply with the regulations set forth by the Arizona Department of Water Resources Groundwater Management Plan.

Several strategies are in use on a national level to reduce turfgrass irrigation requirements: increasing irrigation efficiency, improving irrigation scheduling, and developing grasses which are naturally adapted to moisture stress.

Research Objectives and Accomplishments

The focus of this research has been to investigate the potential of curly mesquite (\textit{Hilaria belangeri} (Stued.) Nash)
to become a low maintenance, low water requiring turfgrass established by seeding. Curly mesquite will be referred to hereafter as mesquitegrass in an effort to increase public acceptance of this potential turfgrass. Collections of the species were conducted in Cochise, Gila, Graham, Greenlee, Navajo, Pima, Pinal, Santa Cruz, and Yavapai Counties in Arizona. Morphological and reproductive traits were evaluated to assess germplasm diversity and genetic potentials for improvement. Concurrent experiments have examined turfgrass management practices, and factors affecting establishment by seeding. This research has a) identified genetically superior plants to begin a conventional breeding and turfgrass improvement program, and b) the practices to secure and sustain this species as turf.

**Previous Work and Present Outlook**

A major goal of current turfgrass research is to reduce water inputs while maintaining attractive, functional turf. One strategy is the development of previously underutilized grass species possessing turfgrass qualities and mechanisms permitting growth in harsh environments.

Mesquitegrass is an important range grass in the Southwest and has been recognized for its turfgrass potential (Kneebone, 1985; Humphrey, 1960; Bentley, 1898; Lamson-Scribner, 1897). Turfgrass attributes of this grass include
perennial growth, low stature, tolerance to defoliation, fine leaf texture, asexual spread by stolons, and establishment by seed. Its elevational range of adaptation in Arizona extends from approximately 600 to 1800 meters. The species grows in patches differing in density that colonize small (<10 cm³) to extensive areas (1 hectare).

Turfgrass Breeding and Improvement

Most, if not all, turfgrass breeding programs begin with the acquisition of the targeted species from natural habitats, and these ecotypes are evaluated in space planted nurseries. Discovering naturally occurring variants presents one of the most productive methods of securing the variable germplasm necessary for a successful breeding program (Funk, 1981; Burton, 1974, 1969). Masson and Bourgoin (1985) stated that prerequisite to breeding was the identification of the available diversity of germplasm. Examination of cytological, floral, morphological, and physiological variation was compulsory in assessing germplasm diversity.

Breeding and improvement strategies at the onset of turfgrass domestication programs have been outlined by Meyer and Funk (1989), Hurly and Funk (1985), Funk (1981), Berner (1977), Daniel (1970), Burton (1989, 1974, 1969), and Burton and DeVane (1953). Ecotypic selection was followed by evaluations of plant material for turfgrass traits entailing
measurements or ratings. Hurly and Funk (1985), Wofford and Baltensperger (1985), Burton (1969, 1951), Lebsock and Kalton (1954), and Burton and De Vane (1953) stated that in turfgrass breeding a survey of the nature and amount of variation in important traits could guide the breeder in determining the most effective breeding procedures to be used.

Evaluation of breeding potential is a 3-step process: a) partitioning of the observed variance in desired traits into genetic and environmental components to estimate heritability in the broad sense ($h^2_b$), b) estimating narrow-sense heritability ($h^2_n$) from progeny data, and c) calculating the expected gains from selection based on $h^2_n$ estimates (Rogers, 1989; Wofford and Baltensperger, 1985; Burton and DeVane, 1953; Burton, 1951). Broad-sense heritability estimates were calculated from analysis of variance (ANOVA) for the respective trait. The narrow-sense heritability of a trait was determined by the regression of progeny values on the values of a) maternal parents, b) paternal parents, c) the parental averages, and also by the intra-class correlation of half-siblings (Rogers, 1989; Wofford and Baltensperger, 1985; Falconer, 1981).

Heritability studies estimate genetic expression and transmission at the population level. Genes, not genotypes, link the generations. Estimates of heritability are obtained
from the degree of resemblance between relatives. The use of genetically identical plants (clones) permits estimation of the environmental effects on expression of a quantitative trait as no genetic variation exists within a clone. Any measured variation within a clone should be due to the environment (Wofford and Baltensperger, 1985; Falconer, 1981; Burton, 1969; Burton and DeVane, 1953).

Heritability studies are best performed in different environments (Falconer, 1981; Berner, 1977). Performance at one location can be considered to be a particular character (Gallais, 1984; Falconer, 1981). When this is done, the heritability values can be viewed as estimates of two different traits, for example, leaf length in environment A and leaf length in environment B. This estimates the effects of environment on gene expression and leads to the conclusions: a) the environment does not allow full expression of the genes, and b) different genes are working in different environments (a significant genotype x environment interaction).

**Selection and Environmental Ramifications**

The ultimate aim of the breeder is to develop superior plant material. Heritability information is used to predict the gain from selection. All selection is indirect in that breeders select 'genotypes' based on phenotypic measurements of individuals or groups of their progenies (Gallais, 1984).
Environmental differences in the phenotypic expression of a trait, and significant genotype x environment interactions affect decisions as to where to perform selection, or conduct the breeding program, in the 'good' or 'poor' environment. Hammond (1947) presented a two-fold argument. Firstly, an environment favoring expression of the desired character will permit more rapid progress from selection (compared to an unfavorable environment). Secondly, if the improved breed is moved to stress conditions, it will perform better than if the breed had been developed under less favorable conditions. Falconer (1952) countered with the argument that a superior genotype in one environment cannot be expected to be superior in all environments. Byth et al. (1969) in soybeans (Glycine max (L.) Merr.) and Frey (1964) in oats (Avena spp.) found no differences between selection in fertile or poor environments. Arboleda-Rivera and Compton (1974) demonstrated that selection in a favorable environment was not associated with a significant advance in poor growing conditions for maize (Zea mays L.).

There is no simple answer to the question of conditions under which selection should be conducted. Falconer (1952) acknowledged that each case must be treated individually. He proposed treating the performances in two environments as genetically correlated characters, and imposed the restriction of, specifically and only, using two
environments. James (1961) developed a selection index combining performance in both environments. Freeman and Perkins (1971) developed linear regression techniques to relate performance of genotypes to environmental conditions. These researchers admitted, however, that environmental quantification was generally difficult in practice. Gallais (1984) pointed out that selection in stress situations will favor 'adaptation', and selection in good environments will be for 'potential'.

Views on Seeding

Burton (1989), Hintzen and Van Wijk (1985), Hurly and Funk (1985), Berner (1977), and Daniel (1970) encouraged assessing genetic variation in an effort to improve seed production at the beginning of a turfgrass breeding program. Vogel et al. (1989), McKell (1972), and Rogler (1954) asserted that a major objective of a grass breeding program should be increasing seedling vigor. Factors affecting seedling vigor are seed size, seed quality, germination rate, emergence rate, and relative growth rate. Rogler (1954) concluded that selection for large or heavy seed increased seedling vigor in crested wheatgrass (*Agropyron desertorum* Fisch. ex Link). Kneebone (1972) stated that selection of individuals that partition large quantities of carbohydrate reserves into seeds, or that mature more viable seeds than the
rest of the population was equally as important as the selection of vigorous seedlings that had displayed rapid and uniform germination.

Establishment by seeding will facilitate acceptance and commercial production of a grass. Vogel et al. (1989), Masson and Bourgoin (1985), Funk (1981), and Burton (1969) emphasized ease and economy of establishment were of primary importance in developing turfgrasses. Seed propagation decreases turfgrass establishment costs. Breeding superior seed producing turfgrass varieties, however, is more difficult and time consuming than genetic improvement of vegetatively propagated species (Burton, 1969).