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Forage legumes for Texas and the US southern region

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Abstract. The combinations of infertile soil, fungal and virus diseases, nematode infestations, drought conditions, warm-season grass competition and temperature extremes often cause forage legumes to be unreliable in Texas and across the US southern region. Classical plant breeding and germplasm introduction has been used in concert to address these problems over the past 25 years. Apache arrowleaf clover (*Trifolium vesiculosum*) was developed through six cycles of recurrent selection for tolerance to bean yellow mosaic virus (BYMV). Concurrent selection in arrowleaf clover for resistance to fungal seedling diseases and tolerance to BYMV is in progress. Overton R18 rose clover (*T. hirtum*) is a cold tolerant, late flowering cultivar developed from a Spanish plant introduction. Crosses between rose clover lines with diverse origins (Turkey and Spain) have generated segregating families with variable permutations of cold tolerance, winter dormancy and date of flowering. A breeding program is in progress to develop cultivars of annual white-flowered sweetclover (*Melilotus alba*) with low coumarin, multi-stemmed crowns and rust (*Uromyces striatus*) resistance. Other breeding programs in progress include white clover (*T. repens*), crimson clover (*T. incarnatum*), red clover (*T. pretense*), ball clover (*T. nigrescens*), lablab (*Lablab purpureus*) and cowpea (*Vigna unguiculata*).

Forage legumes offer great potential to improve grassland agriculture but are often unreliable in adverse environments. The Texas Agricultural Experiment Station (TAES) Forage Legume Breeding Program is directed at development of improved cultivars for Texas and the US southern region. The primary objective is the improvement of annual clovers and other annual forage legumes for overseeding on warm season perennial grass pastures, including soils ranging from acidic sandy loams to alkaline clays.

Arrowleaf clover. 'Apache' arrowleaf clover was developed through six cycles of selection for tolerance to bean yellow mosaic virus (BYMV) disease and was released by TAES in 2001 (Smith et al. 2004). The base population for the development of Apache had 78 half-sib arrowleaf families from a field selection program that used the arrowleaf cultivars 'Yuchi', 'Meechee' and 'Amclo' as initial germplasm (Pemberton et al., 1989). Four cycles of restricted recurrent phenotypic selection for tolerance to BYMV were conducted under greenhouse conditions using mechanical inoculation with BYMV-KY204-1. Two additional cycles of selection were made in the field, also using mechanical inoculation with BYMV-KY204-1. Twenty-one plants were identified in cycle 6 that survived field BYMV infection in combination with severe root rot disease. These selections were evaluated for seed production, which ranged from none to 81 g/plant. Based on seed production, the best eight half-sib families were bulked and breeder seed was produced in Oregon in 1999.

The most striking response of arrowleaf clover to infection with BYMV is a rapid, systemic wilting beginning on the youngest growth 8-13 d post-inoculation and resulting in plant death. The inheritance of resistance to BYMV-induced lethal wilt is conferred by the recessive allele of the lethal wilt gene in arrowleaf clover (Pemberton et al., 1991). The dominant allele, *L*, imparting the systemic wilting response to BYMV, is present in 15-23% of the Yuchi arrowleaf clover population. One cycle of selection, using mechanical inoculation with BYMV-KY204-1, eliminated the susceptible (*LL* and *Ll*) genotypes (Pemberton et al., 1994).

The development of BYMV tolerance was demonstrated with arrowleaf families from 4 cycles of selection where four BYMV disease symptoms (dwarfing, rugosity, chlorosis and mosaic) and dry matter production were evaluated. Level of improvement per cycle varied by component but selection clearly improved the ability of arrowleaf clover to tolerate BYMV infection (Pemberton et al., 1994).

Apache flowers 10-14 d earlier than Yuchi and has slightly larger (18%) seed than Yuchi. Seed color of Apache ranges from yellow to red to black, and is generally darker than Yuchi seed. Apache has the same seed colors as Yuchi but with a higher percent black seed. Black seed occurrence in Apache is about 25% compared to about 2% in Yuchi. Flower color is white with older florets turning light pink and is identical to Yuchi. In five trials from 2000 – 2001, Apache forage production was equal to Yuchi or higher (3 locations; P=0.05). Apache was generally more (3 locations; P=0.05) productive in early spring harvests (March – mid April) than Yuchi with forage yield increases ranging from 100% to 38%.

Research in progress with arrowleaf clover includes evaluation of calf gains on Apache pastures, selection for resistance to *Pythium ultimum* and selection for tolerance to acid soils and high aluminum.

Rose clover. Rose clover is a self-pollinated winter annual forage legume. Commercial cultivars of rose clover include 'Hykon', 'Kondinin', 'Monte Frio' and 'Overton R18'. Hykon and Kondinin are Australian cultivars (Bailey 1967) with origins that trace back to ‘Wilton’ rose clover (Love, 1952) and both have very little winter dormancy or cold tolerance. Monte Frio is a cold-tolerant cultivar developed in California. Overton R18 rose clover was released in 1991 by TAES, and was selected for a high level of cold tolerance and improved forage production (Smith et al., 1992). This cultivar is a single plant selection from a mixed PI line introduced from Spain.

Overton R18 has survived winters and been productive in central Oklahoma and in some years southern Kansas and southern Missouri. However, Overton R18 is probably more cold tolerant (Nunes and Smith 2003) and more winter dormant than is needed for northeast Texas climatic conditions. Overton R18 reseeds well and is cold tolerant in Old World bluestem (*Bothriochloa* spp.) pastures in the Southern Great Plains (Volesky et al., 1995). In this study, two-month-old seedlings of Overton R18 survived record Oklahoma low temperatures in December with minimum temperatures reaching -27 C. In the same study, plant counts 3 and 4 years after the initial seeding averaged 22 plants/m^2 for rose clover, compared to 3 plants/m^2 for vetch.

A rose clover with less winter dormancy and better cool-season forage production than Overton R18 is needed. This reduction in winter dormancy must be balanced with enough cold tolerance to survive the winter season in the U. S. southern region. Crosses were made between Hykon or Kondinin and Overton R18. The F_2 and F_3 generations from these crosses were evaluated in northeast Texas for winter growth, cold damage and date of flowering (Smith and Rouquette 2001). Minimum temperatures dropped below –8 C on 3 days in Jan. 1996 and below -

6.5 C on 3 days in Feb. 1996. These low temperatures caused severe damage to Hykon and Kondinin rose clover and resulted in stand losses of 69 and 46%, respectively. Cold damage to Overton R18 was moderate and stand loss was 28%. Four rose clover F_3 lines were identified with minor winter damage, less than 20% stand loss and winter growth equal to Hykon. There is genetic potential in rose clover for improved combinations of late maturity, full season forage production and tolerance to northeast Texas winter temperatures.

Current research with rose clover is directed toward evaluation of Rhizobium strain effectiveness. Rose clover inoculants available in the US do not allow this clover to achieve full nitrogen fixation and forage production potential.

Sweetclover. Annual sweetclover is a forage legume that is very well adapted to the blackland and prairie soils of the US Southern Great Plains. A breeding program was initiated to produce improved cultivars of annual sweetclover with both low coumarin and reduced stem size. Denta is a low coumarin biennial and Emerald is a multi-stemmed annual sweetclover. Hand crosses and bee cage crosses were made in 2001 between Denta and Emerald. A concurrent seedling screen was successful in the intermediate stage of this sweetclover breeding program to develop F_3 families with both low coumarin and multi-stemmed crowns (Smith and Evers 2005). Forage evaluations trials, including two experimental sweetclovers from this program, were planted in central Texas in Oct. 2005.

Rust has been reported on sweetclover in Kansas (Stuteville 2002) and sweetclover rust in Texas has been tentatively identified as *Uromyces striatus.* Twenty-five sweetclover plant introduction (PI) lines were evaluated for rust reaction at Beeville, Texas in 2004 and 5 PI lines were re-evaluated in 2005 and compared to the check cultivar Hubam. Four biennial lines and one annual line were noted as variable in reaction to sweetclover rust, but Hubam was highly susceptible. Percent resistant plants ranged from 24 to 78 for the five PI lines. Breeding is in progress to combine rust resistance, low coumarin and multi-stem traits into new cultivars of annual sweetclover.

Other cool-season forage legumes. Cultivar development programs are in place with crimson, ball, white and red clover. The general objective is improvement of reliability for these forages in Texas pasture systems. This involves various selection programs to manipulate of date of flowering, hard seed content, seed production, perennial survival and annual reseeding.

Tropical forage legumes. Cowpea and lablab are useful annual forage plants for fast-growing summer pastures that can be used to supplement cattle grazing warm season perennial grasses. These summer legumes are also useful as browse for native white-tailed deer. Breeding programs are in progress to develop improved cultivars of both lablab and cowpea with improved forage and seed production traits and root-knot nematode resistance. 'Rio Verde' lablab was developed through selection for tolerance to defoliation, forage production potential and Texas seed production (Smith, 2007). This new cultivar was developed at Overton, Texas and released by TAES in 2006. Rio Verde is the first lablab cultivar developed in the US and also has the value-added trait of Texas seed production.

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