INCREASED LONGEVITY OF RED CLOVER THROUGH SELECTION FOR PERSISTENCE AND DISEASE RESISTANCE

R.R. Smith
USDA-ARS, US Dairy Forage Research Center, 1925 Linden Dr., Madison, WI. USA. 53706

ABSTRACT
Red clover (*Trifolium pratense* L.), an excellent perennial forage legume, has been considered for many years to be a short-lived, two to three years, forage. Selection for resistance to foliar and root rot diseases and for longevity of stand over the past four decades has improved the persistence of the currently available cultivars. The present studies were conducted to evaluate the progress from selection for longevity and disease resistance. Selection for stand longevity and improved disease resistance has reliably extended the production of red clover into the third and fourth year. Selection for healthy plants in 3- or 4-year old stands of red clover has simultaneously selected for resistance to root rots caused by *Fusarium oxysporum*. Total 4-year forage yields of current populations of red clover are twice that produced by cultivars and germplasm available in the 1960's.

KEYWORDS
Red clover, breeding, selection, persistence, disease, yield

INTRODUCTION
Red clover is one of the leading forage legumes in the U.S., Canada, and northern and eastern Europe. In the U.S. it has long been considered to be a short-lived perennial. Environmental stress and root rot diseases contribute to the lack of persistence of the species (Taylor and Smith, 1979; Smith and Kretschmer, 1989; Venuto *et al*., 1992). Of the root rot causing pathogens of red clover, organisms of the *Fusarium* species have been isolated most consistently from diseased roots (Kilpatrick *et al*., 1954; Chi, 1965; Velde, 1980; Leath, 1985). The foliar disease, northern anthracnose, caused by *Aureobasidum caulivora* (Kirchn.) W.B. Cooke, is endemic and causes severe forage loss during the first growth of the season. Therefore, resistance to these pathogens should lead to improved persistence and yield. Selection for plant longevity in older stands of red clover and the incorporation of genes for resistance to root rot pathogens are the most practical methods of improving persistence of red clover (Smith, 1983; Venuto *et al*., 1992). The object of the this research was to evaluate red clover cultivars and improved germplasm developed over the last four decades for forage yield and persistence and for their reaction to foliar and root rot diseases.

METHODS
Over the past four decades the emphasis of the USDA-ARS and University of Wisconsin red clover breeding program has been to select 70 to 100 surviving, reasonably healthy plants from 3- or 4-year old field tests and to intercross these selected plants: thus, generating a new cycle of persistent selection. The subsequent progeny are evaluated and screened for disease reaction and subjected to further attribute evaluation. Since the 1950's this process has been repeated four times with the cultivar Lakeland being released in 1953 , Arlington in 1973 (Smith, et al., 1973) and Marathon in 1987 (Smith, 1994). These three cultivars of red clover and the population, C11, developed in the 1980's, were used in the present studies to evaluate the progress from selection for persistence and disease resistance. Seedlings of these populations were evaluated in the greenhouse to determine their reaction to root rot caused by *F. oxysporum* and to northern anthracnose. Procedures described by Venuto et al. (1995) were used to evaluate root rot and those proposed by Smith and Maxwell (1973) for northern anthracnose. Forage yield and other agronomic data were collected on replicated field tests conducted on the Arlington Research Station, Arlington, WI. Data presented on the disease responses are the means of three separate greenhouse evaluations and agronomic data are the means of two field tests.

RESULTS AND DISCUSSION
Improvement in forage yield (3 year total forage) and resistance to root rot and northern anthracnose in red clover over the four decades of selection is present in Figure 1. Resistance to the two diseases, root rot and northern anthracnose, has steadily increased with the development of new germplasm. Two to three cycles of selection for resistance to northern anthracnose was applied during each cycle of selection for persistence. On the other hand, only one cycle of selection for root rot occurred after the third cycle of selection for persistence. Earlier improvement in root rot resistance was the result of natural selection for resistance with the selection of healthy, persistent plants. Total forage yield increased over the cycles of selection due, in part, to selection for disease resistance and to increased persistence. There was no difference in forage yield (4.0 Mg ha^{-1}) among the populations developed over the four decades in the second year of production (Figure 2). The differences among the populations occurs in the third and fourth year of production with Marathon and Wis Exp producing excellent forage yields in these latter years of production. Selection in exiting 3- and 4-year old stands of yield trials has been effective in improving persistence and to some extent root rot resistance. Selection is continuing in this like manner in the current program.

REFERENCES
Chi, C.C. 1965. Pathogenicity of species from red clover. Can. Plant. Dis. Surv. **45**: 3-7.

Kilpatrick, R.A., E.W. Hanson and J.G. Dickson. 1954. Root and crown rot of red clover in Wisconsin and relative prevalence of associated fungi. Phytopath. **44**: 292-297.

Leath, K.T. 1985. General Diseases. *In* N. L. Taylor (ed.) Clover Science and Technology. Agronomy **25**: 205-233. Am. Soc. of Agron. Madison, WI.

Smith, R.R. 1983. Breeding for disease resistance in red clover. p. 110-113. *In* J.A. Smith and V.W. Hays (ed.) Proc. XIV Intnatl. Grassl. Cong. Lexington, KY. 15-24 June 1981.

Smith, R.R. 1994. Registration of 'Marathon' red clover. Crop Sci. **34**: 1125.

Smith, R.R. and D.P. Maxwell. 1973. Northern anthracnose resistance in red clover. Crop Sci. **13**: 271-273.

Smith, R.R., D.P. Maxwell, E.W. Hanson and W.K. Smith. 1973. Registration of Arlington red clover. Crop Sci. **13**: 771.

Smith, R.R. and A.E. Kretschmer, Jr. 1989. Breeding and genetics of legume persistence. p. 541-552. *In* G.C. Marten (ed.) Persistence of Forage Legumes. Am. Soc. of Agron. Madison, WI.

Taylor, N.L. and R.R. Smith. 1979. Breeding and genetics of red clover. Adv. Agron. **31**: 125-154.

Velde, M.J. 1980. Breeding for *Fusarium* Root Rot Resistance in Red Clover. Univ. Wisconsin M.S. Thesis, Madison, WI.

Venuto, Brad C. R.R. Smith and C.R. Grau. 1992. Effect of natural selection for persistence on response to *Fusarium oxysporum* in red clover. p.70-71. *In* D.S. Wofford and K.H. Quesenberry (eds.) Proc. Twelfth Trifolium Conference. 25-27 March, 1992. Gainesville, FL.

Venuto, B.C. R.R. Smith and C.R. Grau. 1995. Virulence, legume host specificity, and genetic relatedness of isolates of *Fusarium oxysporum* from red clover. Plant Dis. **79**: 406-410.

Figure 1
Progressive improvement in the performance of red clover resulting from four decades of breeding for persistence and disease resistance

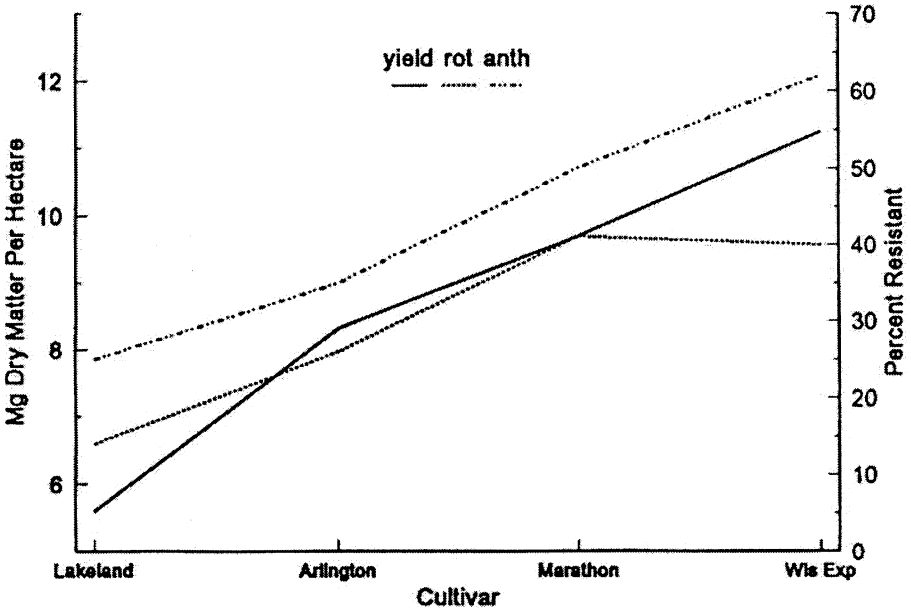

Figure 2
Three year forage production of red clover resulting from four decades of breeding for persistence and disease resistance