NITROGEN ACCUMULATION IN THE TOP GROWTH OF COOL-SEASON ANNUAL FORAGE LEGUMES

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Summary

Nitrogen accumulation in the top growth of five cool-season annual forage legume species was monitored during the growing season for 3 years at the Texas A&M University Agricultural Research and Extension Center at Overton. Hairy vetch (*Vicia villosa* Roth), 'Tibbee' crimson clover (*Trifolium incarnatum* L.), 'Overton R18' rose clover (*Trifolium hirtum* All.), 'Mt. Barker' subterranean clover (*Trifolium subterraneum* L.), and 'Yuchi' arrowleaf clover (*Trifolium vesiculosum* Savi.) were sampled every 2 weeks during the growing season beginning in October. Yuchi arrowleaf accumulated the most nitrogen (N) at 300 lb/acre in May. However, this would be too late for spring planting of a summer crop. Hairy vetch and Tibbee crimson had the best N accumulation of 80 to 120 lb/acre by late February. Overton R18 rose clover and Mt. Barker subterranean clover generally had lower N yields. Peak N yields of each species varied among years because of differences in climatic conditions.

Introduction

Early government farm programs encouraged monoculture farming and maximizing yield per acre which is dependent on large fertilizer and pesticide inputs. Recent concerns about the environment and protection of nonrenewable resources has led to the promotion of "sustainable" farming systems. Schaller (1993) described sustainable agriculture as environmentally sound, productive, economically viable, and socially desirable agriculture. Winter cover crops, particularly leguminous ones, are critical components of sustainable farming systems in the southeastern US because the sloping land is subject to erosion (Hargrove and Frye, 1987). Besides soil conservation, legume cover crops conserve water and energy, improve soil, control spring weeds, and add N to the agricultural system.

Legumes obtain N from three sources: from commercial N fertilizer or animal waste; by mineralization of indigenous organic matter; and from the atmosphere by symbiotic N_2-fixation. *Rhizobium* bacteria, which infect the root hairs of a legume plant, transform N gas from the air into ammonium (NH_4) which can be used by the plant. The amount of N_2-fixation is dependent

Keywords: Cover crop / legumes / crop rotation.

on soil N level, legume species, climate, and management factors affecting plant growth. From whatever source, the amount of N available from the legume plant is dependent on N concentration and accumulated biomass (Holderbaum et al., 1990).

Biomass production of forage legumes is dependent on adaptability to climate and soil. Legume species are soil specific in terms of soil texture, drainage, and pH. Hairy vetch, rose clover, crimson clover, subterranean clover, and annual medics (*Medicago truncatula*) were evaluated as winter cover crops on a high pH blackland soil in southeast Texas (Evers and Gabrysch, 1993). Although Overton R18 rose clover was the most productive (7950 lb dry matter/acre), hairy vetch accumulated the most N (134 lb/acre) because it maintained a high N percentage at maturity. In northeast Texas, Hairy vetch and crimson clover produced the most N/acre when harvested in mid-April (Smith et al., 1993).

Termination of the winter cover crop will vary depending on the optimum planting date of the following crop in the farming system. Accumulated N in the above ground growth of five cool-season annual legume species was determined at 2 week intervals during the growing season at the Texas A&M University Agricultural Research and Extension Center at Overton. This information will identify the best legume species for maximum N accumulation in northeast Texas and document N accumulation during the legume growing season.

Procedure

The study was planted in late September on a Keithville-Sawtown fine sandy loam in 1990 and 1991 and a Darco fine sandy loam in 1992. Hairy vetch (30 lb/acre), Yuchi arrowleaf clover (8 lb/acre), Tibbee crimson clover (16 lb/acre), Overton R18 rose clover (14 lb/acre), and Mt. Barker subterranean clover (16 lb/acre) were drilled in 7-in. rows on a prepared seedbed. Hairy vetch was only planted in 1990. Lime and fertilizer were applied according to soil test by the Texas A&M University Soil, Water, and Forage Testing Laboratory. Four by 100 ft. strips of each species were planted in a randomized complete block design with four replications. The 100 ft strip was divided into 25 4x4 ft subplots and randomized for bi-weekly harvest. Beginning in October, the above ground growth was removed from the middle 14x20.5 in. (2 ft^2) of a subplot. Harvested growth was dried in a oven at 140°F for 48 hr and weighed to estimate dry matter production.

Nitrogen concentration was determined by near infrared reflectance spectroscopy (NIRS). The calibration equation was developed from 203 subsamples and validated with 19 subsamples. The R^2 of calibration (correlation of known values on NIRS values) was 0.96 and the standard error of calibration (SEC) was 0.80. The R^2 of validation (correlation of known values on NIRS-predicted values) was 0.95 and the standard error of performance (SEP) was 0.92. Subsamples used in the equation were assayed for N by macro-Kjeldahl procedure.

Results and Discussion

Data for each year are presented separately because hairy vetch was only included the first year and there were significant differences between the last 2 years. Normal temperatures and excessive rainfall, especially in spring, characterized the 1990-91 growing season. Autumn N accumulation in hairy vetch and Tibbee crimson clover was superior to the other species (Fig. 1). However, during the winter, N accumulation decreased in crimson clover because of low January temperatures but continued to increase in Hairy vetch. Nitrogen accumulation increased with increasing temperatures during the spring for all species (Fig. 2). Hairy vetch and Mt. Barker subterranean clover peaked in late April, Overton R18 rose and Tibbee crimson clovers in early May, and Yuchi arrowleaf through May and early June. The wet April and May prolonged the growth of all species, especially the late maturing arrowleaf clover.

Normal temperatures occurred during the 1991-92 growing season but spring rainfall was low. Species ranking for N accumulation in autumn was crimson > subterranean > arrowleaf > rose (Fig. 3). Peak N accumulations occurred earlier for all species than the previous year because of the dry spring but were higher than the previous year except for arrowleaf clover (Fig. 4). The dry spring favored rose clover growth so that N accumulation of rose and crimson clovers were similar.

The 1992-93 growing season was characterized by a mild winter, cool spring, and good moisture conditions after October. Crimson clover had the highest N accumulation during the autumn and winter months (Fig. 5). There was little difference among the other three species until February. The mild winter temperatures resulted in higher N accumulations by the end of February than in the previous 2 years. Cooler than normal spring temperatures enhanced rose and subterranean clover's growth so that peak N accumulation did not occur until late May (Fig. 6). However, crimson clover peaked a month earlier than the previous 2 years. Ranking for maximum N accumulation was arrowleaf > subterranean > rose > crimson.

Nitrogen accumulation varied among years because of the effect of temperature and rainfall on plant growth and development. Hairy vetch and Tibbee crimson clover had the highest N accumulation at the end of February of approximately 80 to 120 lb/acre. Both are large seeded legumes with good seedling vigor. Crimson was the earliest maturing species evaluated. Peak

N accumulation was about 200 lb/acre but occurred from late March to early May depending on climatic conditions. Yuchi arrowleaf clover is the latest maturing species and had the highest N accumulation of 300 lb/acre which usually occurred in May. This would be too late for rotating with a spring planted crop, however, it would work well with an autumn vegetable crop. Overton R18 rose clover reached maximum N accumulation from late April to May at about 200 lb/acre in 2 out of 3 years. Under lower rainfall in central Texas and Oklahoma it would probably be superior to the other species. Mt. Barker subterranean clover usually had low N yields during the spring. Its low prostrate growth habit is ideal for developing a solid canopy quickly to suppress weeds. However, this same low growth habit prevents subterranean clover from accumulating a large biomass like the other upright species when not defoliated. Therefore, subterranean clover is a poor choice for a cover crop unless growth would be terminated in March.

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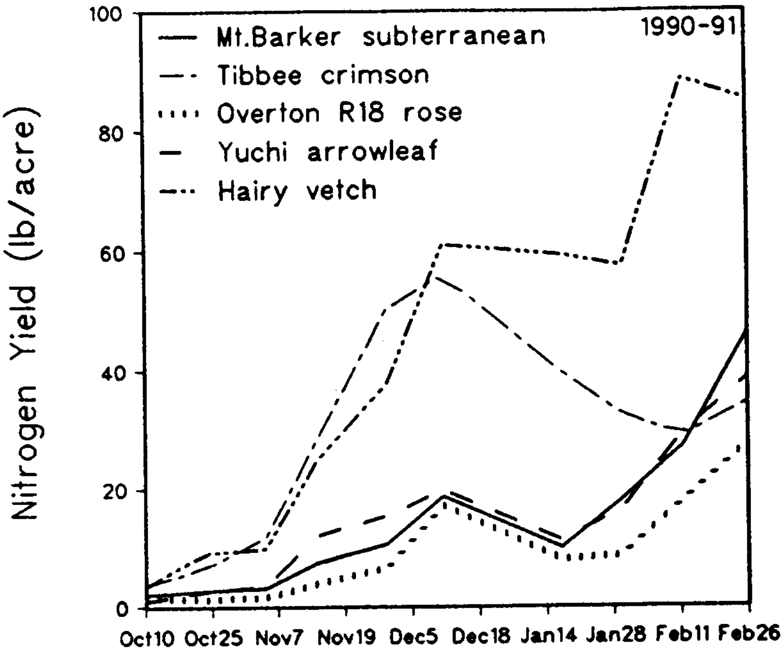

Figure 1. Nitrogen accumulation in the top growth of five cool-season annual forage legumes from October through February, 1990-91.

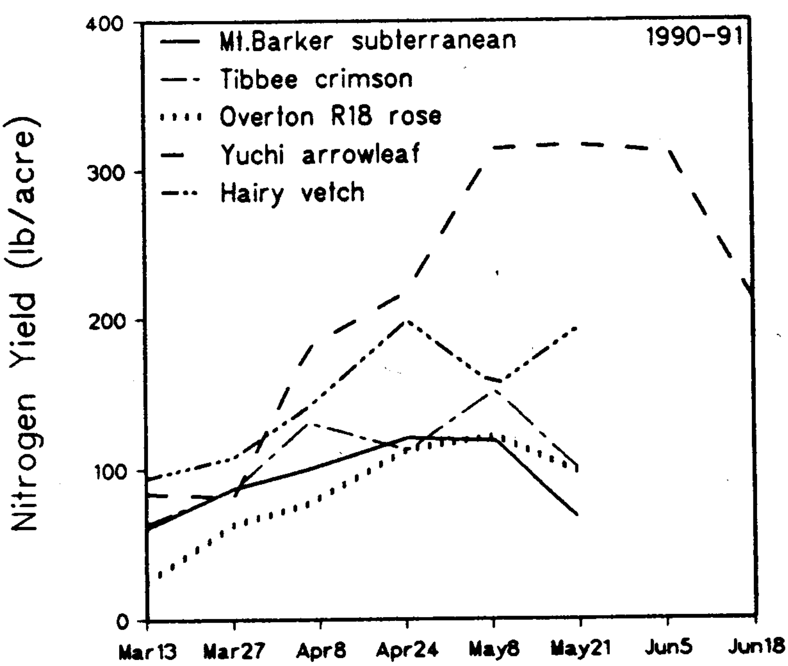

Figure 2. Nitrogen accumulation in the top growth of five cool-season annual forage legumes from March through June, 1991.

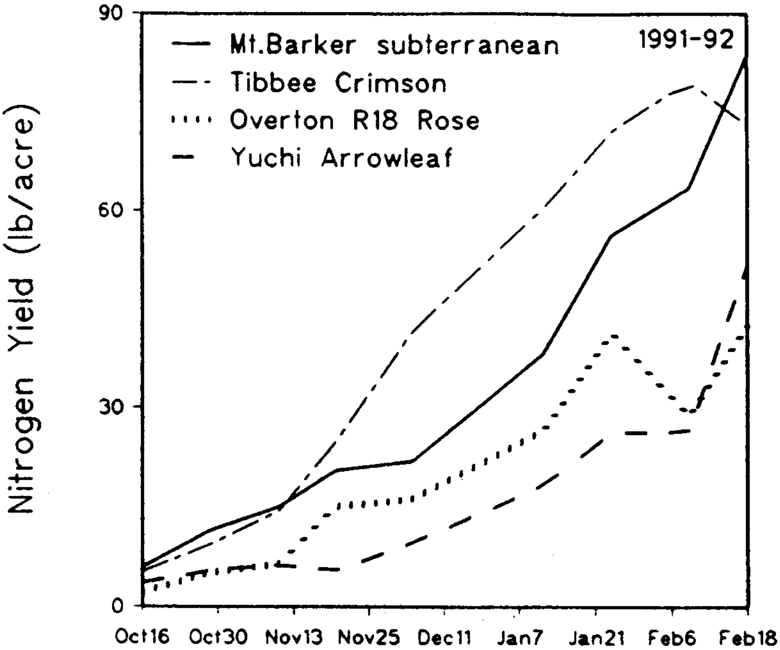

Figure 3. Nitrogen accumulation in the top growth of four cool-season annual forage legumes from October through February, 1991-92.

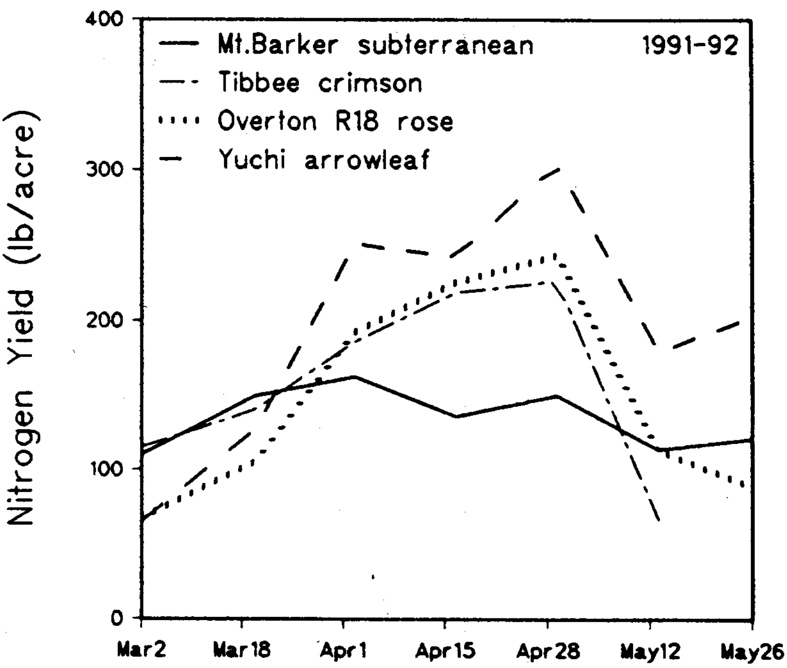

Figure 4. Nitrogen accumulation in the top growth of four cool-season annual forage legumes from March through May, 1992.

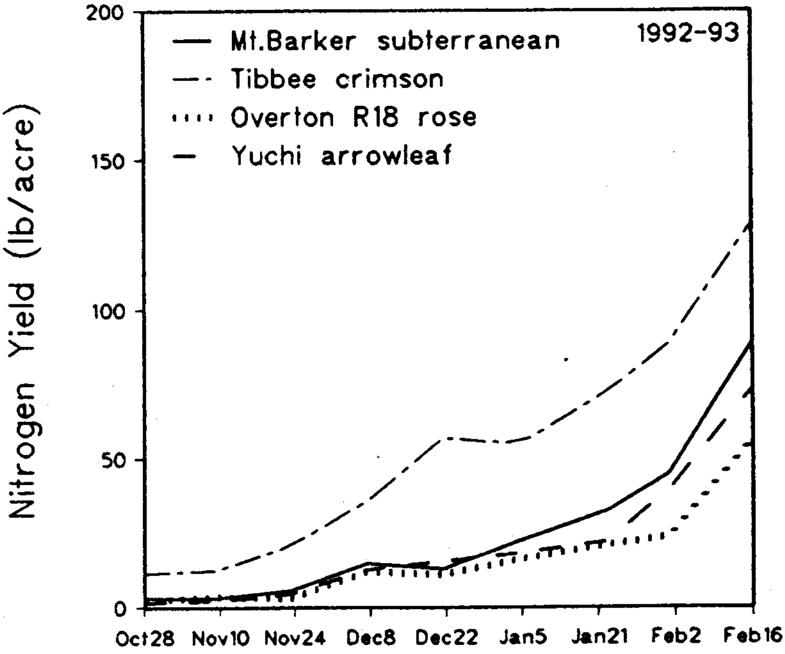

Figure 5. Nitrogen accumulation in the top growth of four cool-season annual forage legumes from October through February, 1992-93.

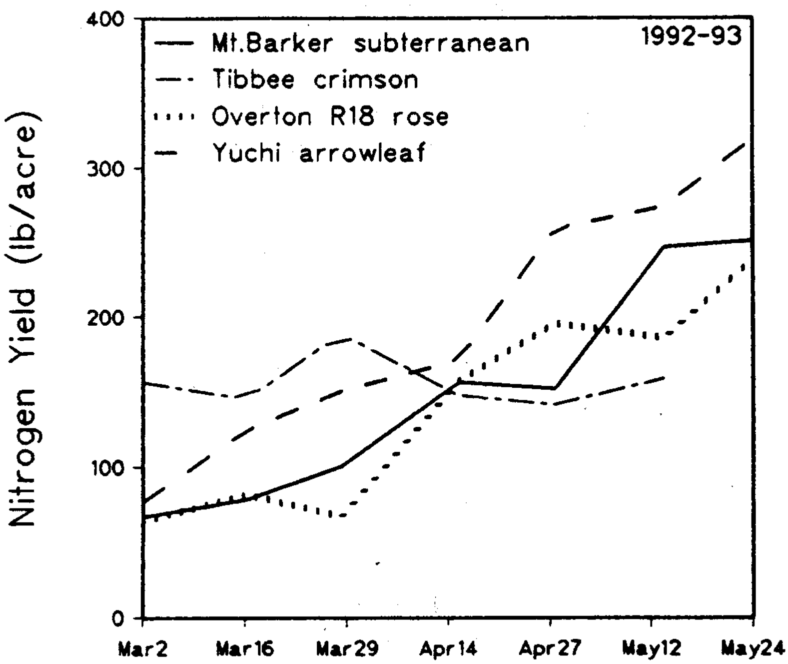

Figure 6. Nitrogen accumulation in the top growth of four cool-season annual forage legumes from March through May, 1993.