

TALL FESCUE AND ARROWLEAF  
CLOVER FOR RANGE  
INTERSEEDING

By

STEPHEN MICHAEL MOLLOY

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Thesis Approved:

*W E McMurphy*  
\_\_\_\_\_  
Thesis Adviser

*Billy B. Tucker*  
\_\_\_\_\_

*Ronald J. Lyle*  
\_\_\_\_\_

*Norman N. Durham*  
\_\_\_\_\_  
Dean of the Graduate College

989211

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## CHAPTER I

### INTRODUCTION

Winter pasture programs are needed to complement established warm season grazing lands. Properly managed, winter pastures could reduce supplemental feed cost and labor requirements of the cattlemen. Eastern Oklahoma has millions of acres that could be transformed into productive summer and winter pastures. These rough, rocky lands are now occupied by hardwoods of little value, mostly post oak (Quercus stellata Wang.) and blackjack oak (Q. marilandica Muench.). Different methods of increasing forage production on these landscapes have been attempted with varying success. In recent years chemical spraying by aerial application has given good control of hardwoods resulting in a release of native grasses greatly increasing forage production of these areas (Elwell, 1964; Hall and Crawford, 1965; Ray, 1958). In this region, production of these areas can also be increased by spraying, followed by seeding with tall fescue (Festuca arundinacea Schreb.) to establish a cool season pasture (Webb, 1975.)

Another means of increasing forage production is to seed a cool season species into an established warm season pasture. This process is slow and not as successful as establishing a cool season species immediately after spraying (Senter, 1975). The establishment of the cool season species was slowed by competition from the native grasses or nitrogen immobilization by organic matter with a high C/N ratio.



The objectives of these studies are to evaluate methods of establishing 'Kentucky 31' tall fescue and 'Yuchi' arrowleaf clover (Trifolium vesiculosum Savi) into existing warm season native rangeland.

## CHAPTER II

### LITERATURE REVIEW

#### Liming

Soil pH is very important in the establishment and survival of plants. Some plants grow well on acid soils while others will not. For example, tall fescue can be grown on soils with a pH as low as 4.5 (Baker and Tucker, 1973), but arrowleaf clover is acid sensitive. Hoveland et al. (1969) reported that production of arrowleaf clover forage was 62% less at pH 5.0 than at pH 6.0, which was considered the optimum pH for production. Palazzo and Duell (1974) found that legumes produced more when soil pH was near neutral while in most acid plots there was essentially no growth. Literature reports indicate that soils below pH 6.0 might require liming to raise the pH to a level which will enable clovers to obtain maximum production.

Growth response after liming is usually attributed to a change in the pH, but the change in pH is only one benefit of liming and may only be part of the reason for a response in growth. Liming of acid soils also affects the availability of certain plant nutrients. For example, soils high in Al and Fe at a low pH have less available P than soils at a high pH level. The addition of a liming material will increase the availability of P by altering the reactions of Al and Fe with the phosphates in the soil.

The Al concentration in soils affects plant growth by altering the availability of certain nutrients. The Al concentration affecting the availability of nutrients is only one reason for poor growth on soils high in this element. Even at low concentration Al itself can be toxic to certain plants. Liming of high Al soils caused by low pH reduces the Al activity and removes it from the soil solution alleviating the possibility of toxicity. With the Al removed the soil solution becomes occupied with other elements and the benefits are reaped through a growth response. The reduction of Al activity is probably the greatest single direct benefit of liming (Tisdale and Nelson, 1975). Helyar and Anderson (1970) also attributed the response of plants after liming to the alleviation of excess Al.

Liming also increases the availability of Mo which is involved with symbiotic nitrogen fixation of legumes (Mulder and VanVeen, 1960; Tisdale and Nelson, 1975; Troug, 1948). It has been clearly established that Mo affects the functioning of the symbiosis within the nodule, not the formation of nodules, and Mo availability is pH dependent. Yield increases from lime have been attributed to the release of available Mo (Anderson and Moye, 1952; Anderson and Oertel, 1946; Anderson and Thomas, 1946).

An increase in Ca concentration has been described as the reason for a growth response after liming. An adequate supply of Ca is needed for growth and is essential for nodulation of legumes (Healy, 1965; White, 1967). If a response in growth was due to Ca increases then there must be some evidence of a Ca deficiency restricting growth. Albrecht and Smith (1953) stated that a Ca deficiency of crops grown on acid soils might result from a low Ca supply combined with a high

proportion of other exchangeable cations. They also commented that a Ca deficiency existed under conditions of a low Ca supply combined with a high crop requirement. In such situations a growth response could be attributed to an increase in Ca concentration due to liming. Bray (1971) has attributed alfalfa yield increases to a Ca response rather than a change in pH after liming. Literature reports indicate that for legumes the growth response to Ca is indirect, not a direct response to an increase in plant uptake. Lowther and Loneragan (1970) reported that increases in Ca improved nodulation of legumes in percent plants nodulated as well as the number of nodules per plant. Nodulation was also found to be improved in the presence of lime by Roughley and Walker (1973). Liming has been reported to increase the survival and multiplication of the rhizobia in the soil needed for nodulation (Healy, 1965; White, 1967). Not only is Ca important for nodulation of legumes, but it is also needed by the organisms responsible for nitrification. Therefore liming would also enhance nitrification and other soil processes. If acid soils are limed to pH values of 5.5 or 6.5 then decomposition of plant residue and breakdown of soil organic matter will be enhanced (Tisdale and Nelson, 1975).

Caution should be taken not to over lime which would result in a decrease of phosphate availability because of calcium and magnesium phosphate precipitates (Tisdale and Nelson, 1975).

#### Pelleting

Liming is usually by broadcast applications, however coating the seed with a lime pellet may give similar results around the seedling. Lime pelleting began when Snieszko (1941) coated field peas with lime

after inoculation and observed improved nodulation. Lime pelleting as a practical field technique for establishing certain legumes on acid soils was developed by Loneragan et al. (1955) in Australia. A study conducted by Lobb (1958) revealed that lime used as a seed coating at 2-3 lb/acre resulted in similar effects on legume nodulation as 1-3 tons of lime/acre broadcast. He concluded that the localized lime was sufficient to alter the acidity of the soil immediately around the germinating seedling, thus resulting in satisfactory nodulation. He also noted that pelleted seed had nodules whether inoculated or not, and that initial growth and vigour was better than unpelleted seed. Research conducted by Iswaran et al. (1972) and Norris (1971b) verify that pelleting improves nodulation. If pelleting improves nodulation then it must do something to benefit the rhizobia inside the pellet. Hastings and Drake (1960) stated that pelleting offered protection to the rhizobia from the outside environment; with this protection possibly allowing more rhizobia to participate in the nodulation of the host. Pelleting is also reported to increase nutrient uptake and dry matter production (Iswaran et al., 1972; Wade et al., 1972).

Like other techniques the pelleting process may not be 100 percent efficient. Norris (1971b) in Australia evaluated the effect of lime pelleting at two locations. At one, there was a large soil population of rhizobia necessary for nodulation; a very small population existed at the other location. Where the rhizobia were abundant there was little benefit from lime pelleting in comparison to the controls. In contrast the location with the small population of rhizobia exhibited improvement in nodulation as a result of lime pelleting. Legumes grown in soils having an adequate supply of the specific rhizobia may not respond to

lime pelleting, while plants in a newly established field might respond to the added supply of rhizobia in the pellet.

In contrast Bergersen et al. (1958) thought that establishment failure of legumes on newly broken soils was caused by an antibiotic producing agent; incorporating the inoculant into pellets overcame the problem. Other reasons for pelleting failure were given by Hastings and Drake (1960). They thought that failure might result if the inoculated seed was held too long after inoculation or sown into a very dry soil under dry, warm conditions. Failures could also result from inoculated seed being planted without adequate covering or planted in the winter months before germination could take place. Data obtained by these workers indicated that better results can be obtained by planting immediately after inoculation or pelleting and planting early in the winter to allow rapid germination and some plant growth.

Storage time affects the performance of inoculated seed. Brockwell (1962) reported that lime pelleted seed could be stored for up to four weeks and the inoculum still be viable at sowing time. This 4-week storage time was verified by Norris (1971a), who also observed a progressive loss of rhizobia up to four weeks in all of his experiments. After three weeks the resulting percentage of nodulation was below an economic level for field planting. In addition he noted a significant difference in pelleting material on survival of rhizobia. Calcium silicate was lethal to the rhizobia while a malt extract showed a definite protective action. Lime pelleting did not produce any adverse effects on rhizobia survival. To further evaluate the effect of pelleting on inoculum survival, Norris (1971c) conducted another experiment using lime and rock phosphate as pelleting materials. He observed a difference in the

survival of rhizobia strains pelleted with the same material. Rhizobia strain CB159 survived under pelleting equally as well as the peat culture and sticker only up to four weeks, but both lime and phosphate pelleting improved survival to six weeks and phosphate pelleting to eight weeks. However, the survival of strain CB756 was not improved by lime or phosphate pelleting. He concluded that for a 4-week storage period there was no advantage of pelleting over simply sticking the inoculum.

Lime pelleting has been reported to affect germination. While conducting several parallel experiments Norris (1971a) observed that lime pelleting decreased or stimulated germination depending on the rhizobia strain and legume species. Norris (1967) also stated that lime pelleting might be harmful to some legumes, particularly those possessing the slow growing "cowpea" type of rhizobia. If the lime pelleting effects on germination are rhizobia and species dependent, then its effect on nodulation might also be rhizobia and species dependent. This might help explain the results observed by Norris (1971b) in which lime pelleting increased nodulation for one legume but decreased nodulation on another species requiring the same rhizobia strain.

To further enhance germination to increase the chances of success scarified seed should be used. Southwick and Wood, (1958) using scarified seed, improved the germination percentage of birdsfoot trefoil (Lotus corniculatus L.) by approximately 35%. Unscarified shrunken seed germinated 43% while the scarified seed had a germination percentage of 80. The unscarified plump seed germinated 63% which was much lower than the 97% germination for scarified plump seed. In addition, Wood (1969) reported scarified seed to have one-third more seedlings than unscarified

seed in a greenhouse study. These studies indicate that scarification definitely increases the chance of obtaining a better stand.

By permitting faster absorption of water and air, scarification reduces the time of emergence. Sims et al. (1974) reported that 95% of the final emergence was reached 10 days after planting scarified seed compared to 50% for unscarified seed. They also noted a tendency for lower emergence for lime pelleted nonscarified seed.

### Burning

Excessive litter accumulations result in a decline of productivity in grassland areas receiving precipitation in excess of 25-30 inches annually (Anderson, 1972; Curtis and Partch, 1948; Hadley and Keickhefer, 1963; Old, 1969; Vogl, 1974). The removal of excess litter and standing vegetation was the reason for including burning in this study as the removal of litter allows better seed to soil contact. McClure (1958) obtained successful establishment of grass by broadcasting seed immediately after a fire. Kucera et al. (1967) suggested that beneficial effects of fire on prairie could be expected only where there was dependable precipitation in excess of 18 inches annually.

The response of grasslands to burning is varied, depending upon several factors, including (1) climatic patterns (primarily precipitation) preceeding and following the burn, (2) site conditions, such as exposure, soil texture, and depth, (3) composition of the grassland, and (4) the quality of the grassland as influenced by management practices such as grazing (Anderson 1976).

Burning studies can be found extensively in the literature with contrasting results. Experiments in Kansas have revealed detrimental



effects on forage yields (Aldous, 1934; Anderson, 1964; Anderson, 1965; Anderson et al., 1970; Hopkins et al., 1948; Launchbaugh, 1964; McMurphy and Anderson, 1963; McMurphy and Anderson, 1965; Owensby and Anderson, 1965; Smith et al., 1964). In contrast to these, other research has shown beneficial results in terms of increased forage production resulting from burning (Anderson, 1972; Curtis and Partch, 1948; Ehrenreich and Hikman, 1963; Hadley and Keickhefer, 1963; Kucera and Ehrenreich, 1962; Old, 1969; Owensby, 1970; Vogl, 1974).

Burning has been reported to reduce soil moisture and increase soil temperature. Anderson (1965), Ehrenreich and Hikman (1963), Hopkins (1948), Kelting (1957), Launchbaugh (1964), and McMurphy and Anderson (1963) found soil moisture to be lower on burned than unburned sites. McMurphy and Anderson (1963) concluded that winter burns depleted soil moisture more than late spring burns. It seems logical that burning could reduce forage production if soil moisture was limiting in an area of inadequate rainfall. Decreased infiltration rates also contribute to reduce soil moisture (Hanks and Anderson, 1957). Soil moisture reduction is also influenced by higher soil temperatures on burned areas (Aldous, 1934; Ehrenreich and Hikman, 1963; Kucera and Ehrenreich, 1962; Morris, 1968).

Observations on burned and unburned grasslands have given rise to contrasting results, with respect to soil nutrients. Morris (1968) noted that burning did not affect the soil organic matter or N content over a three year period. Old (1969) found that N levels were higher in the soil of burned plots. Work by Valmis and Gowans (1961) and Mayland (1967) also revealed that N availability was higher on soils from burned areas than from unburned areas.

Ehrenreich and Hikman (1963) concluded that burning had no apparent effect on the amount of exchangeable K, but increased available P. The top 0.75 inches of soil on recently burned areas had more available P than the unburned areas. Valmis and Gowans (1961) reported that burning increased P, N, S, and pH. The increase in soil pH was also noted by Mayland (1967), Ehrenreich and Hikman (1963), and Marshall and Averill (1928).

Christensen (1976) found that burning increased the amount of N, K, Ca, and Mg in the soil, but that P was unaffected. Vogl (1974) stated that the actual effects of burning on soil nutrients at any given site may be quite variable depending on the condition of the vegetation, character of the soil, and topography.

#### Fertilization

As the first step in establishing a pasture a soil test will aid in determining the proper amounts of P, K, and lime that should be applied before seeding. Application of a starter fertilizer has been suggested to insure success of stand establishment of areas being converted to grass from rough rocky land in Oklahoma and Missouri (Crawford et al., 1967; Rommann et al., 1974).

Webb (1975) reported that a starter fertilizer of 12-12-12 at 100 lb/acre had the consistent effect of increasing tall fescue production by 22% over that with no starter fertilizer. It was also reported that forage production was increased with each increased level of nitrogen. Webb also found that fescue could be established in a healthy stand of native grass released by spraying for brush control, but that the process is slow. The first year may appear to be a failure but with proper

management and fertility the second year growth was more encouraging.

Seedling vigor and thus initial stand establishment may be affected by fertilizer (Gomm 1962). Seedling vigor was not affected before the second leaf stage by fertilizer, but by the third leaf stage seedlings in the fertilized treatments average 2.7 inches taller than those in unfertilized treatments. The effect of fertilizer on seedling vigor may vary depending on the grass species (Gullakson et al., 1964; Welch et al., 1962). Senter (1975) reported no difference in seedling establishment due to N and P treatments.

Fertilizer effect on forage yield and quality of different cool season species has been well established. Vogel and Peters (1961) found that areas seeded to tall fescue and lespedeza (Lespedeza spp.) resulted in a three fold increase in total yield of fescue and other desirable forage plants and a marked decrease in herbage production from the less desirable forage plants.

Fuller et al. (1971) reported that tall fescue was a productive grass if properly fertilized with N, P, and K. Crude protein content was much higher in N fertilized tall fescue than unfertilized. Rommann, Armbruster, and Jobes (1976) along with Rommann and McMurphy (1973) confirm that crude protein and forage production increased with increasing levels of N fertilization. Taylor and Templeton (1976) observed increased crude protein content and forage production of cool season grasses with N fertilization. They also found that tall fescue production from August 15 to December 1 on plots receiving 0, 44, and 88 lb N was 1672, 2728, and 3872 lb/acre, respectively.

Rommann et al. (1974) suggested application of 50 lb of actual N/acre during February following seeding of tall fescue in rough rocky

land in Eastern Oklahoma. They contended that this would encourage more vigorous development of the fescue plants and also allow them to fully mature. In addition, seed from these mature plants helped to fill in any thin stands.

Senter (1975) observed slow growth and apparent absence of plants the first fall and spring following seeding. But only after aerially applying 300 pounds of 23-11-11 fertilizer/acre could an evaluation of the seeded grass species be made.

Fertilization alone may not be the reason for increased forage production in rough timbered land seeded to tall fescue. Defoliated tree trunks left after spraying may produce some shading on seedlings and mature plants. A study conducted by Stritzke et al. (1976) evaluated the effect of shade and fertility on dry matter production of tall fescue. The amount of shade required for maximum fall forage growth appeared to depend on the fertility level. Production was greatest under 30 and 40 percent shade with high and low fertility respectively. Early spring forage production was not influenced by fertility and maximum yields occurred under 47% shade.

Although N fertilization is not needed for legumes, P fertilization is important. Hoveland et al. (1969) found that 'Yuchi' arrowleaf clover made poorer growth than crimson clover (Trifolium incarnatum L.) at low soil P levels and when no P was added in the seedling stage, the arrowleaf clover died. Stiegler and Rommann (1975) also stressed the importance of P fertility in 'Yuchi' arrowleaf clover production.

## Herbicides

Chemical herbicides have been used for many years to suppress brush and release native grass vegetation for grazing. This release of the native grass species after spraying has provided increased forage production from previously low forage producing areas (Davis, 1967; Eaton et al., 1970; Elwell, 1964; Elwell, 1968; Elwell et al., 1970; Ray, 1958; Rommann et al., 1974; McMurphy et al., 1976; Webb, 1975). Following the release of the native grass it may be desirable to lengthen the grazing season by introducing cool-season species into the grass stands. Jung (1975) suggested that the establishment of cool season species into established stands might require reducing the competition from the existing species, with this reduction accomplished by heaving grazing, close clipping, some type of minimum tillage, or chemical treatment.

Paraquat (1, 1-dimethyl-4, 4-bipyridinium) has excellent contact activity, rapid action on grasses, no residual activity, and seeding can be done soon after application. The rate of application will be influenced by the species present and the time of application. One application of paraquat usually will not kill established perennials (Triplett et al., 1975).

Dudley and Wise (1953) in Mississippi, and Decker et al. (1969) in Maryland have shown that cool season species can be successfully seeded into warm season grass pastures to extend the grazing season. Wilkinson et al. (1975) succeeded in establishing a cool season grass species into a bermudagrass sward by using paraquat as a desiccant before seeding. Other successful seeding trials with the aid of herbicides have been reported by Campbell (1974), Douglas (1965), Douglas

et al. (1965), and Hoffman (1975).

Applying a herbicide before seeding does more than help in reducing competition. Prior treatment of the seeding site with a herbicide retains dead vegetation which provides wind protection for seedlings and a more favorable moisture environment (Dowling et al., 1971).

Triplett et al. (1975) pointed out that while herbicides are helpful in grassland improvement, they represent only one factor in a successful renovation program. They also stated that attention must be given to fertility, grazing management, seeding date, and other relative factors to insure the most benefit from grassland improvement efforts.

## CHAPTER III

### MATERIALS AND METHODS

Four different experiments are discussed in this report. Two were field studies attempting to establish tall fescue and arrowleaf clover. The third experiment was conducted in a greenhouse to determine the effect of storage time and pelleting adhesive on clover inoculation. The fourth study, conducted in a germinator, was to evaluate clover germination as affected by storage time and pelleting adhesive.

#### Field Studies

##### Description of Field Study Areas

The studies were conducted in areas A and L on the Sarkeys Foundation Research and Demonstration Area near Lamar in Hughes County (Webb 1975). Soils of area A, a wooded area, are mostly of the Hector Complex (Lithic Dystrichrepts). The Hector Complex is a shallow, stony and somewhat excessively drained soil forming from an acid sandstone and shale material with slopes of 5 to 30%. Area L, a grassland, is comprised of predominately Hartsells fine, sandy loam (Typic Hapludults) soils. The Hartsells is a moderately deep, well-drained soil formed from acid sandstone with slopes of 3 to 5% (Long 1968). A soil test revealed that these soils were low in nitrogen and available phosphorous and slightly low in potassium and acid (Table 1).

The native vegetation as described by Long (1968) is the same for

Table 1. Soil test results from the study sites before fertilizer treatments were applied.

Study and Location	NO <sub>3</sub> -N	P	K	pH
	<u>Lb/acre</u>			
Tall fescue				
Wooded area	<5	10	120	5.2
Grassland area	<5	5	115	5.2
Clover				
Wooded area	<5	8	75	5.1
Grassland area	<5	5	110	5.3



both soils. The dominant woody species include blackjack oak, post oak, and hickory (Carya spp.). The important herbaceous species are big bluestem (Andropogon gerardi Vitman.), little bluestem [Schizachyrium scoparium (Michx.) Nash = Andropogon scoparium Michx.], indiagrass [Sorghastrum nutans (L) Nash], and switchgrass (Panicum virgatum L.). Currently the vegetation of the wooded area is dominated by little bluestem and threeawn (Aristida spp.), while threeawn, panicum (Panicum), splitbeard bluestem (Andropogon ternarius Michx.), and broomsedge (A. virginicus L.) dominate the grassland area (Table 2,3). Botanical composition of the two areas was determined by the point method (Levy and Madden, 1933). The apparatus used in this method was a small frame containing 10 sliding pins. The pins were pushed down until a basal plant contact was made and the hit recorded.

Prior to this study the wooded area had received 1.6 lb/acre of 2, 4, 5-T (2, 4, 5-trichlorophenoxy acetic acid) low volatile ester on June 15, 1971 for brush control and burned on February 22, 1972.

#### Tall Fescue Field Study

The tall fescue study was a split-plot experimental design with three replications with subplots in a 3 X 3 factorial of seedbed preparation methods X N fertility treatments. The three seedbed preparation methods were a check, paraquat application, and fire treatment. The three fertility treatments consisted of 0, 40, and 320 lb of N/acre in the form of ammonium nitrate. The plot size was seven ft X seven Ft.

The paraquat treatment was  $\frac{1}{4}$  lb of active ingredient/acre applied on September 27, 1975. The herbicide was calculated to be applied with 30 gallon of water per acre. The herbicide was applied using a CO<sub>2</sub> sprayer at a low pressure (psi=20). At the time of spraying the wind

Table 2. Botanical composition of tall fescue study plots in two study areas before treatments were initiated, August 13, 1975, reported as percent of total vegetation.

Common Name	Scientific Name	Percent
Grassland Area		
Threeawn	<u>Aristida</u> spp.	46.9
Sedge	<u>Carex</u> spp.	12.3
Panicum	<u>Panicum</u> spp.	12.2
Splitbeard Bluestem	<u>Andropogon ternarius</u>	10.2
Broomsedge	<u>Andropogon virginicus</u>	4.1
Lespedeza	<u>Lespedeza</u> spp.	4.1
Buttonweed	<u>Diodia teres</u>	2.0
Trailing Wildpea	<u>Strophostyles</u> spp.	2.0
Rattail Grass	<u>Manisuris cylindrica</u>	2.0
Bottlebrush	<u>Plantago aristata</u>	2.0
Pussytoes	<u>Antennaria neglecta</u>	2.0
Wooded Area		
Little Bluestem	<u>Schizachyrium scoparium</u>	43.9
Threeawn	<u>Aristida</u> spp.	19.5
Panicum	<u>Panicum</u> spp.	12.2
Broomsedge	<u>Andropogon virginicus</u>	9.8
Dropseed	<u>Sporobolus</u> spp.	4.9
Paspalum	<u>Paspalum</u> spp.	4.9
Sedge	<u>Carex</u> spp.	2.4
Miscellaneous		2.4

Table 3. Botanical composition of clover plots in two study areas before treatments were initiated, August 13, 1975, reported as percent of total vegetation.

Common Name	Scientific Name	Percent
Grassland Area		
Panicum	<u>Panicum spp.</u>	25.0
Threeawn	<u>Aristida spp.</u>	20.5
Broomsedge	<u>Andropogon virginicus</u>	18.2
Splitbeard	<u>Andropogon ternarius</u>	13.6
Paspalum	<u>Paspalum spp.</u>	13.6
Sedge	<u>Carex spp.</u>	6.8
Buttonweed	<u>Diodia teres</u>	3.2
Wooded Area		
Little Bluestem	<u>Schizachyrium scoparium</u>	42.1
Threeawn	<u>Aristida spp.</u>	18.4
Broomsedge	<u>Andropogon virginicus</u>	15.8
Dropseed	<u>Sporobolus spp.</u>	5.3
Sedge	<u>Carex spp.</u>	5.3
Panicum	<u>Panicum spp.</u>	5.3
Big Bluestem	<u>Andropogon gerardi</u>	2.6
Paspalum	<u>Paspalum spp.</u>	2.6
Sideoats Grama	<u>Bouteloua curtipendula</u>	2.6

was relatively calm and there was some soil moisture present. The designated plots for this experiment were burned on September 27, 1975 with a light wind (<5MPH) and adequate soil moisture for seed germination. The dry grass in the areas was totally consumed by the flames from the fire.

Phosphorous and potassium were hand broadcast to all plots on October 11, 1975, both at the rate of 50 lb/acre. Concentrated superphosphate, 0-46-0, was used as the P source and murate of potash, 0-0-60, was used as the source of K.

The 40 lb/acre of N was applied at seeding as well as one of the three application of the 320 lb/acre. The first split application was at a rate of 160 lb of N/acre. The second and third applications were each 80 lb of N/acre, the second being applied on February 26, 1976 and the third on April 1, 1976. The tall fescue seed was broadcast on October 25, 1975 at a rate of 15 lb/acre.

Stand success was evaluated by obtaining a fescue plant count and forage production for each plot. On June 17, 1976 a plant count was recorded for the whole plot areas. Forage production was estimated by harvesting a  $19\frac{1}{2}$  X  $19\frac{1}{2}$  inch quadrat from the center of each plot. The forage samples were oven dried, weighed and production was reported as lb/acre.

#### Clover Field Study

The clover study was a split-plot experimental design with main plots being locations, grassland and wooded areas, while sub plots were a factorial arrangement of two seedbed preparation methods X two lime treatments X two seed treatments. The two seedbed preparation methods were check and fire. Burning was accomplished on September 27,

1975 under the same conditions as described in the fescue field study.

The two lime treatments were no lime and lime broadcast at 1.5 T of effective calcium carbonate equivalent/acre. Lime was applied on October 11, 1975.

The two seed treatments were non-pelleted and pelleted seed. Pelleting was accomplished by taking approximately 5 grams of arrowleaf clover seed which was scarified for 10 seconds in a Forsberg scarifier and mixing with 0.4 ml of molasses until wet. Next the Rhizobia inoculum was added at triple the recommended rate and mixed thoroughly with the seed. Then, 2.5 grams of finely, ground limestone was stirred with the seed until all seeds were evenly coated with lime and formed single pellets. The pellets were then allowed to air dry at room temperature. The seed receiving the pellet treatment was pelleted two days before seedings. All seed treatments were mixed with inoculum, and those not pelleted received inoculum treatment just prior to seeding. At the time of seeding, soil moisture was good. Seeding was accomplished on October 25, 1975 at a 5 lb/acre seeding rate.

Subplot size was an area seven ft X seven ft.

On October 11, 1975  $P_2O_5$  and  $K_2O$  were applied to all plots each at 120 lb/acre. The P source was 0-46-0 and 0-0-60 was used for K.

Stand success was evaluated by determining the number of clover plants for the complete plot area on June 10, 1976. Forage production was not recorded due to excessive grazing by wildlife.

In the second year of the study it was virtually impossible to count the number of plants in certain plots because of the plant density and basal sprouting. A percentage clover canopy coverage was estimated therefore, from a 3 X 4 ft quadrat before clipping the plot

to determine forage yield. The samples were oven dried and the results reported in lb/acre.

#### Greenhouse Study

The experimental design employed was a factorial of five pelleting dates X five pelleting adhesives with five replications. The five dates were 4 weeks, 3 weeks, 2 weeks, 1 week before seeding and pelleting on the seeding date.

The five pelleting adhesives were (1) molasses neutralized, (2) natural molasses, (3) vegetable cooking oil, (4) karo syrup (glucose), and (5) methyl cellulose.

All pelleted seed was prepared using scarified 'Yuchi' arrowleaf clover seed. Pelleting was accomplished by adding the adhesive to the seed, stirring well, then adding the rhizobia at triple the recommended rate and adding the proper amounts of lime. Five grams of seed were prepared for each treatment.

Not all the adhesives required the same volume to wet the seed adequately. Treatments 1, 2, and 4 required 0.4 ml of each to wet the seeds. After the addition of the rhizobia and stirring well, 2.5 grams of finely, ground limestone was mixed in until all the seeds were evenly coated and formed single pellets. Treatment number 3 required 0.6 ml of oil to wet the seeds and 6 grams of the lime material to form the pellets. Not all of the seeds fell out in single pellets when using methyl cellulose.

The substances used in treatments 1 and 5 had to be prepared prior to the pelleting procedure. Adhesive number 1 (molasses neutralized) was obtained by adding 7.5 ml of 4M KOH to 250 ml of natural molasses

with an initial pH of about 5. The final pH of the solution was near 6.6. Adhesive number 5 was the most difficult to prepare. Methyl cellulose at 1.25 grams was added to 50 ml of water near boiling and stirred vigorously until the powder was dispersed.

All the prepared pellets were air dried for 48 hours before being packaged and stored at room temperature until seeding date, except the pellets prepared on the seeding date.

The soil used in this study was the Hartsells five sandy loam from the Sarkeys Foundation demonstration area. The soil was autoclaved for four hours to sterilize. After autoclaving the soil was placed in 5 3/4 X 4 1/4 inch containers to a level one inch from the top.

Since this particular soil was low in phosphorous and potassium a nutrient solution of  $\text{KH}_2\text{PO}_4$  was used to supply these needed nutrients. The solution was mixed by adding 1 ml of stock solution of  $\text{KH}_2\text{PO}_4$  into 1 liter of distilled water. Each pot received 30 ml of the solution on April 26, May 10 and May 25.

The pots were seeded on April 12, 1976 at the rate of 50 pellets per pot. At seeding time the greenhouse bench containing the pots was subirrigated with one and a half inch of water and remained flooded until the soil surface of the pots became wet. The plants were allowed to grow for 66 days and on June 18 the study was concluded. A Wiley-Mill micro grinder was used to grind the plant material fine enough to pass through a 40 mesh screen. Nitrogen concentrations were determined on the ground plant material to help determine treatment differences.

### Germinator Study

The experimental design was a factorial of 5 pelleting treatments X 5 pelleting dates with five replications. The pelleting treatments and dates were the same as those of the greenhouse study. Pelleting was accomplished at the same time and in the same manner of that for the greenhouse study.

Plastic boxes, 2 7/8 by 2 7/8 by 1 1/8 inch, with lids were used as germinating containers. The substrate for all boxes was 2 thicknesses of Kimpac germination tissue cut to equal size. Eight ml of distilled water was used as the moistening agent. Each box contained 50 seeds.

A Stults single chamber germinator was used. The germination environment temperature was set a constant 20°C. All treatments entered the germinator on April 13, 1976.

A plant count was recorded for each treatment on April 27, 1976 approximately two weeks after the study began. Only seedlings which possessed both cotyledoms were considered successfully germinated.

### Data Analysis

The data collected in each study were subjected to an Analysis of Variance as an aid in evaluating treatment differences (Steele and Torrie, 1960).



## CHAPTER IV

### RESULTS AND DISCUSSION

#### Field Studies

Seeding was accomplished one month after seedbed preparation was completed. Good seed to soil contact was possible in the burned plots, but may have been partially inhibited in the other treatments due to standing litter. Surface soil moisture was adequate at the time of seeding.

##### Tall Fescue Field Study

The tall fescue seeding was not a renowned success. So few tall fescue seedlings were present in many plots that seedlings in the entire 7 X 7 ft plot were counted. The very best results were still less than one tall fescue plant / ft<sup>2</sup> (Table 4).

An accidental fire on March 23, 1976 swept through the grassland area. The seedbed preparation of burning had no fuel, but the paraquat and checks did burn. The effect of this fire is not known.

No significant difference in fescue establishment was detected due to seedbed preparation in either area, grassland or wooded (Figures 1, 2, 3, and 4).

The level of N fertility had a significant effect on number of fescue plants established on grassland area (Figure 1) with best results from the 320 lb of N treatment.

Table 4. Mean plant number and production for tall fescue as affected by seedbed preparation and nitrogen fertility.

Seedbed Preparation	Fertilizer N lb/acre	Number Plants/ 49 ft <sup>2</sup>	Production lb/acre
Grassland Area			
Check	0	4 b *	605 c
Check	40	8 b	1259 c
Check	320	8 b	5002 a
Chemical	0	4 b	702 c
Chemical	40	10 b	1490 c
Chemical	320	23 a	3645 ab
Fire	0	5 b	848 c
Fire	40	5 b	1017 c
Fire	320	10 b	2240 bc
Wooded Area			
Check	0	40 a	1635 c
Check	40	42 a	2374 bc
Check	320	22 a	4602 a
Chemical	0	40 a	2204 bc
Chemical	40	34 a	2192 bc
Chemical	320	29 a	3452 ab
Fire	0	32 a	2277 bc
Fire	40	11 a	1017 c
Fire	320	26 a	3597 ab

\*Means within areas followed by the same letter are not significantly different at P=.05.

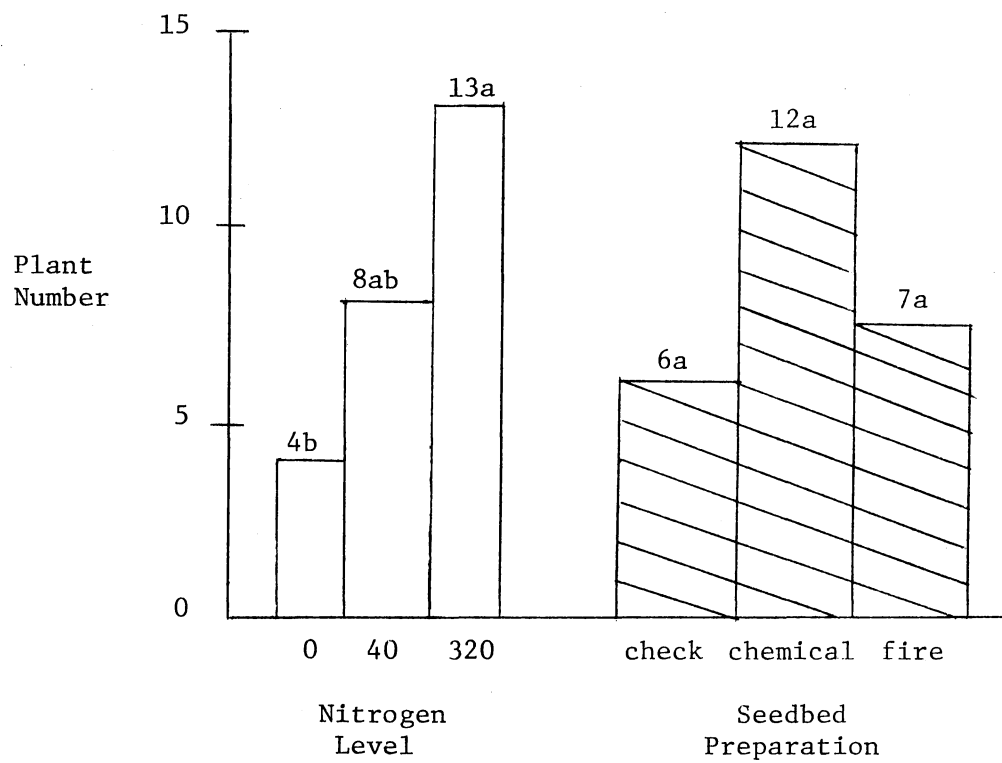


Figure 1. Tall fescue plant number per 49 ft.<sup>2</sup> in a grassland area as influenced by nitrogen fertility and seedbed preparation.

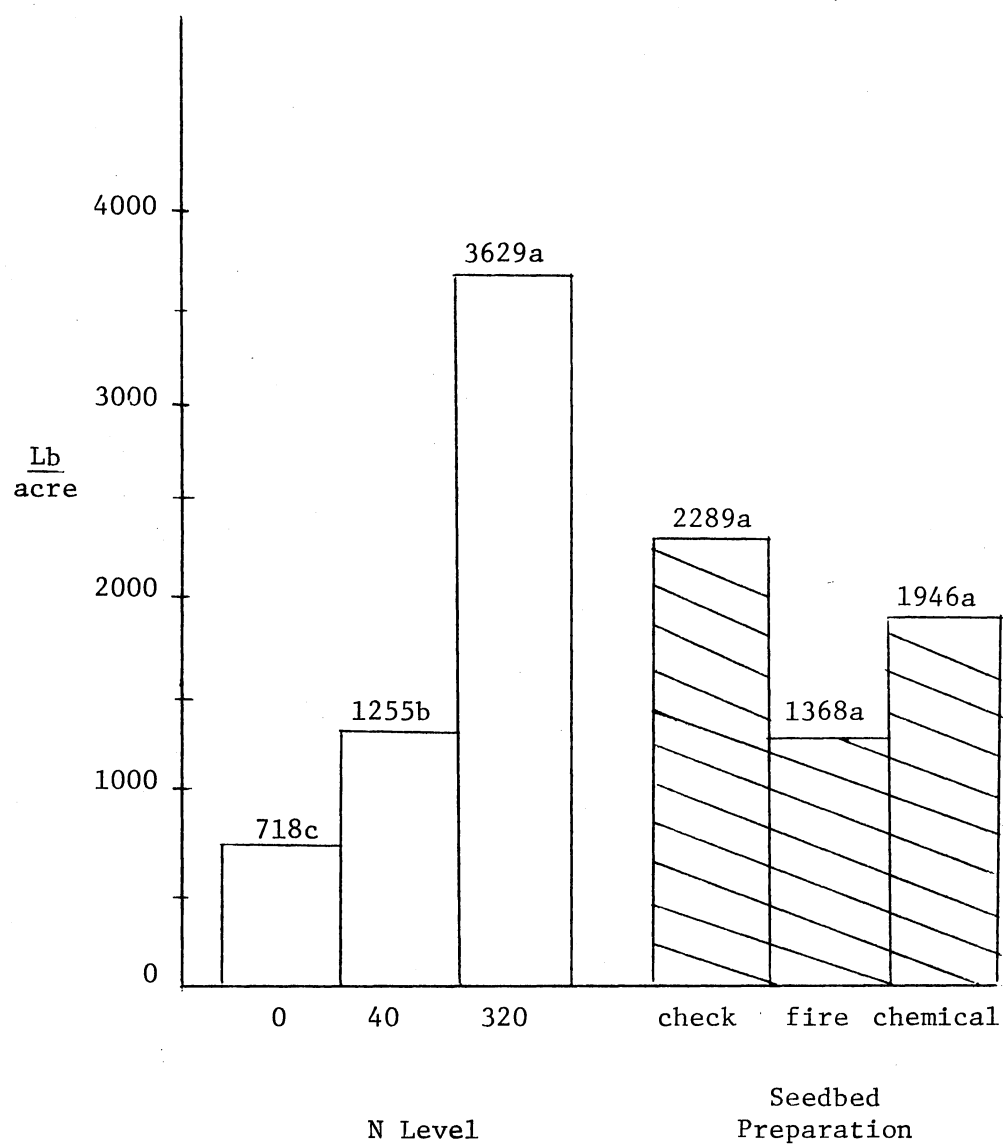


Figure 2. Tall fescue production as influenced by nitrogen fertility level and seedbed preparation in a grassland area.

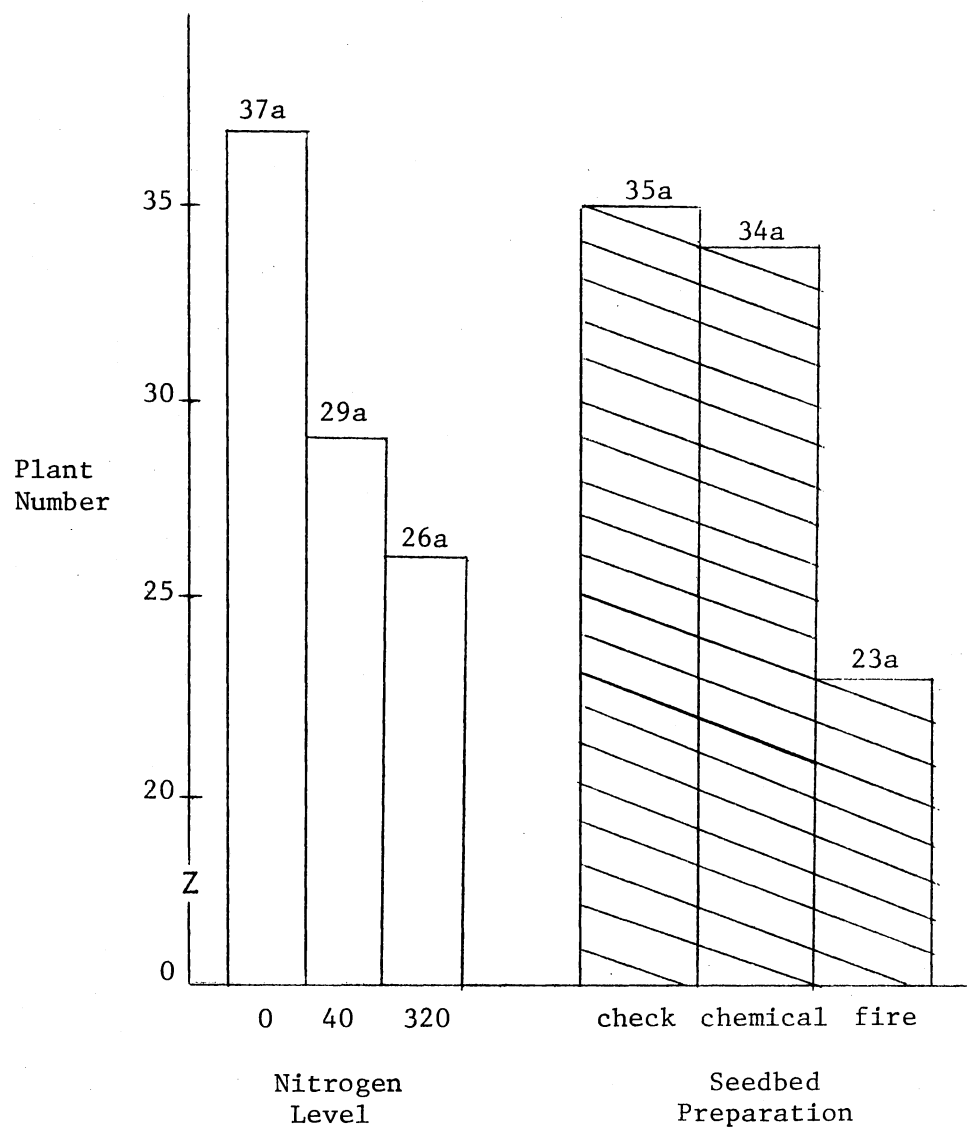


Figure 3. Plant numbers of tall fescue per 49 ft.<sup>2</sup> as affected by seedbed preparation and nitrogen fertility level in a wooded area.

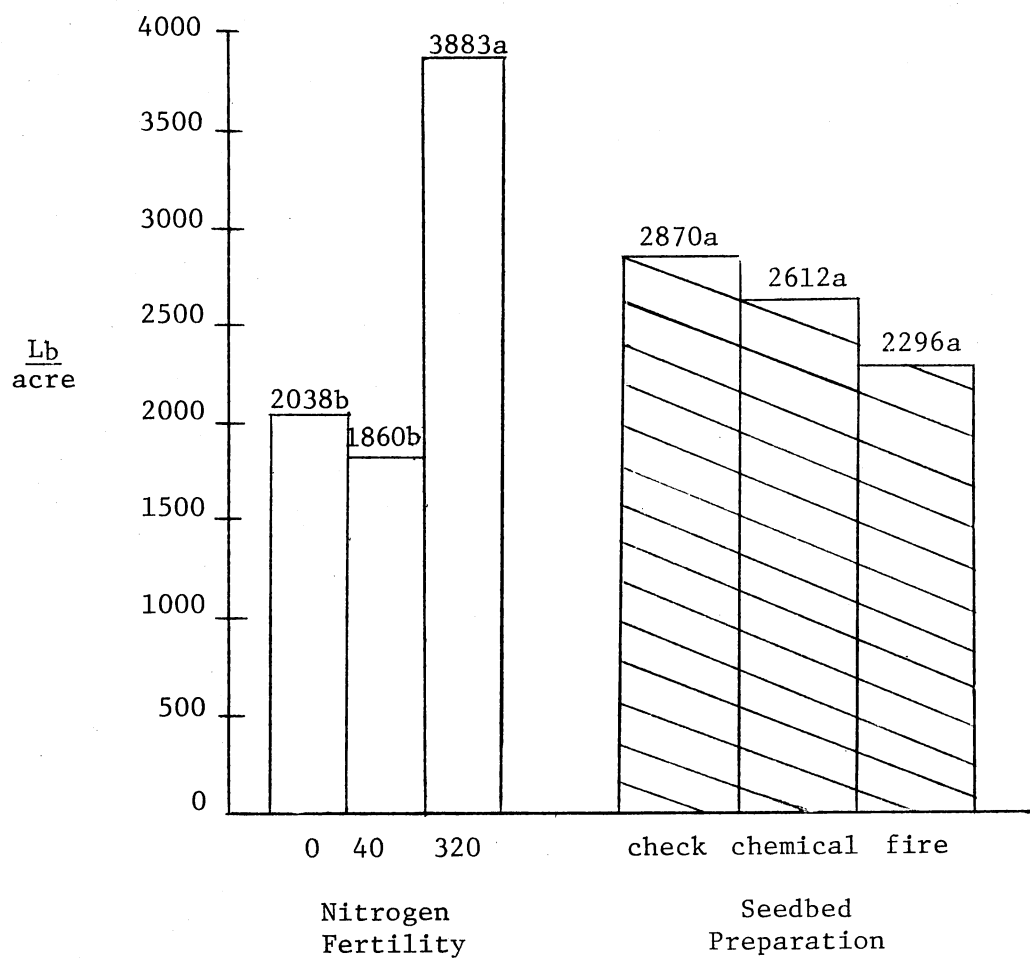


Figure 4. Tall fescue production as affected by nitrogen fertility level and seedbed preparation in a wooded area.

Greater success in plant number was noted in the wooded area than the grassland area. However, neither seedbed preparation nor N fertility had any significant effect on stand establishment in the wooded area (Figure 3).

Seedbed preparation had no significant effect on forage production in either area (Figures 2 and 4).

Grass production was significantly increased by the 320 lb N application in both areas (Figures 2 and 4). However, the 40 lb N did not increase production above the non fertilized treatment.

This lack of response from the 40 lb N treatment lends support to the conclusions of Senter (1975) that establishment was affected by the process of N immobilization by organic matter.

In the second year no evaluation was made of the tall fescue field study. For some unknown reason no plants were found in any of the plots in the grassland or wooded area. As previously mentioned, the wooded area was accidentally burned in late March. However, fescue plants from another older study in that area recovered after the burn. No explanation for the death of the fescue in both areas is available, but the hot, summer drought undoubtedly contributed to this loss (Appendix Table 9).

#### Clover Field Study

The number of arrowleaf clover seedlings established was not great and generally less than one clover plant / ft<sup>2</sup> (Table 5). However, the plant does branch profusely with some lower branches becoming semi-prostrate. Thus, a low density of healthy plants can make a striking appearance.

Table 5. Mean plant number for arrowleaf clover as affected by seedbed preparation and seed treatment.

Seedbed Preparation	Seed Treatment	Plant number / 49 ft <sup>2</sup>
Grassland Area		
Check	Inoculated seed only	3c*
Check	Inoculated seed & Lime	3c
Check	Pelleted seed	25ab
Check	Pelleted seed & Lime	5c
Fire	Inoculated seed only	2c
Fire	Inoculated seed & Lime	10bc
Fire	Pelleted seed	14bc
Fire	Pelleted seed & Lime	36a
Wooded Area		
Check	Inoculated seed only	5c
Check	Inoculated seed & Lime	9c
Check	Pelleted seed	54ab
Check	Pelleted seed & Lime	30abc
Fire	Inoculated seed only	28abc
Fire	Inoculated seed & Lime	24bc
Fire	Pelleted seed	36abc
Fire	Pelleted seed & Lime	57a

\*Means within area followed by same letter are not significantly different at  $P=.05$ .



Plant numbers were not affected by seedbed preparation of burning or the broadcast application of lime (Figures 5 and 6) in either area. However, the pelleting treatment significantly increased clover plant numbers in both areas.

No forage yield data were possible the first year because of considerable grazing by wildlife. Numerous tracks and droppings from deer were observed in both areas. However, the plants did produce seed which reseeded the plot areas.

The extreme density of the clover stand the second year made a plant count impractical, therefore evaluation was based on a percent clover canopy and forage production. The percent clover canopy was made only for the grassland area because the plots in the wooded area were accidentally burned in late March and few clover plants survived. No significant improvements in percent clover canopy were observed due to seedbed preparation (fire), lime treatment, or pelleting (Table 6). Neither was clover production affected by fire, lime, or pelleting. Total forage production was significantly increased by pelleting and liming but not by burning (Table 6). The method of establishment produced variable results in the amount of clover. However, those plots with the greatest clover canopy were the highest total forage producers (Figure 7), the regression of the relationship of percent clover canopy to total yield was  $y = 18.336 X + 757$  where  $y$  = yield in lb/acre and  $X$  = clover canopy (as decimal of percent). Correlation of this line to actual yield was 0.88 which was significant at .01 level (Figure 7). The improvement in clover forage production is evident, but there is still a need to develop more reliable establishment procedures.

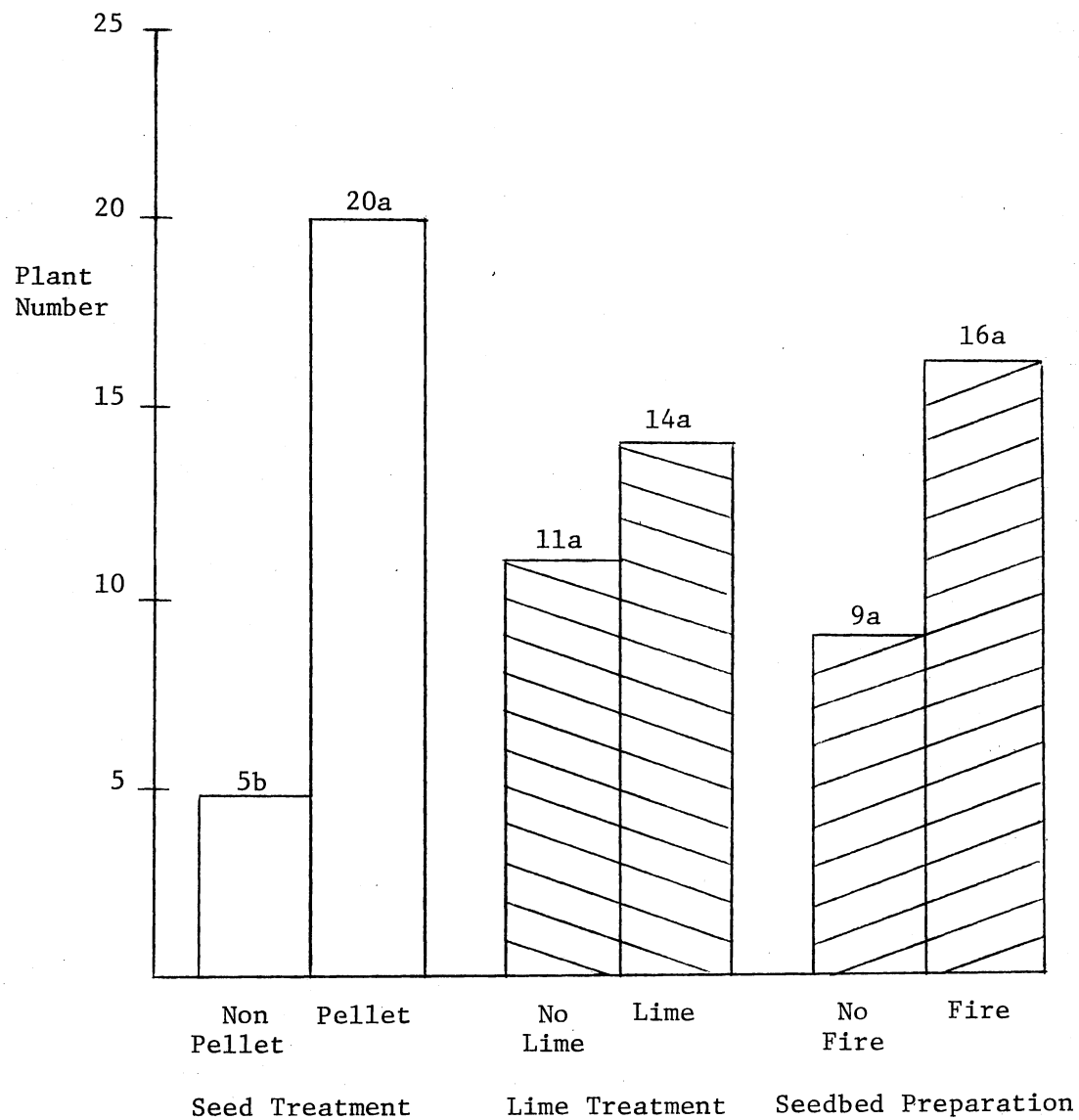


Figure 5. Arrowleaf clover plant number per 49 ft<sup>2</sup> in a grassland area as influenced by seed treatment, lime treatment, and seedbed preparation in 1976.

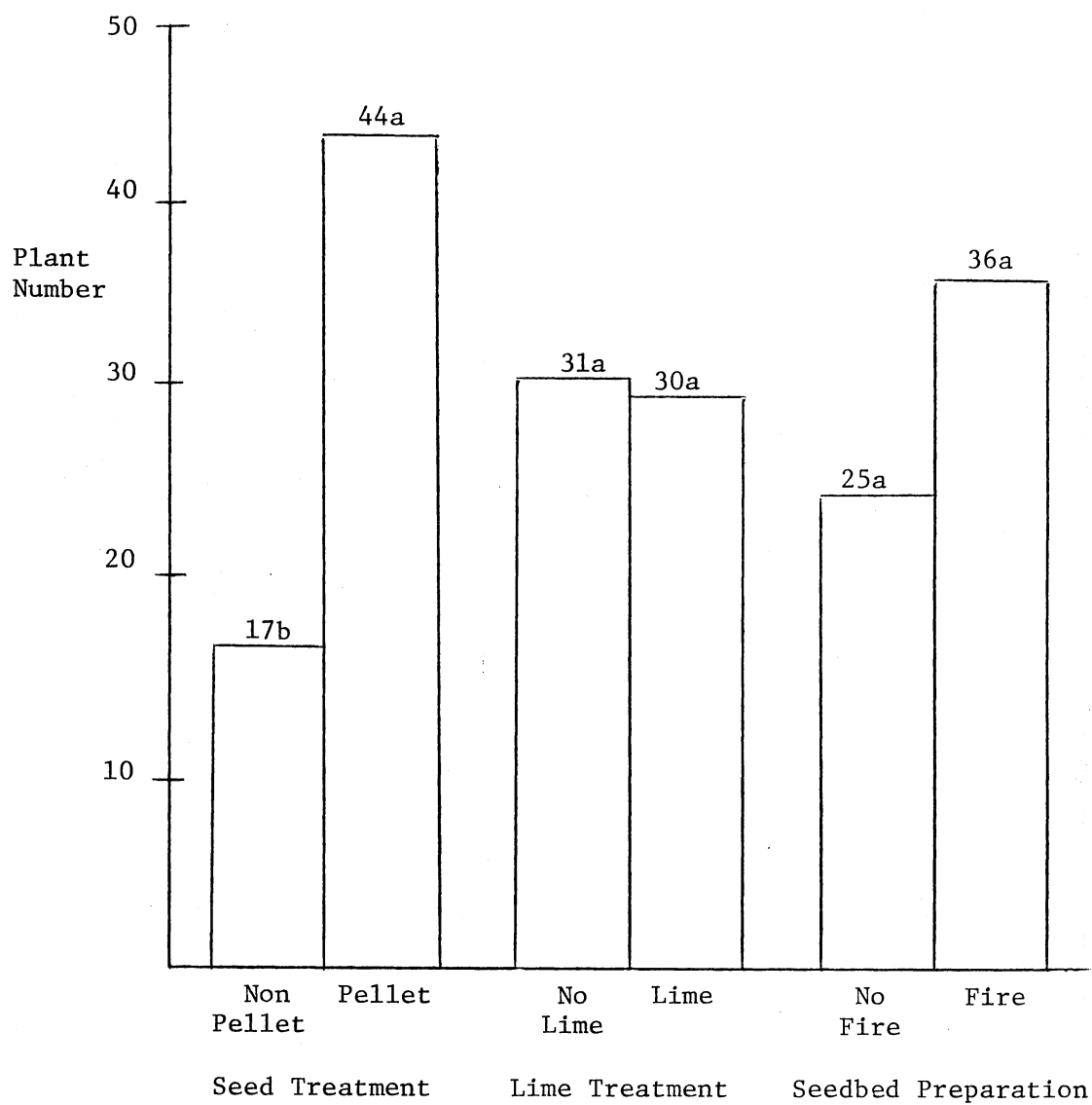


Figure 6. Plant number of arrowleaf clover per 49 ft<sup>2</sup> as affected by seed treatment, lime treatment, and seedbed preparation in a wooded area in 1976.

Table 6. Mean percent clover canopy, clover yield, and total yield for grassland area as affected by seed treatments, lime treatment, and seedbed treatments in 1977.

Treatment	% Clover Canopy *	lb/acre	
		Clover Yield	Total Yield
Pellet	58 ns	1495 ns	1919 *
No Pellet	31	714	1240
Lime	59 ns	1427 ns	1866 *
No Lime	30	783	1240
Fire	50 ns	1347 ns	1732 ns
No Fire	40	862	1427

\* Means were significantly increased by that treatment; ns indicates no significant effect associated with the treatment.

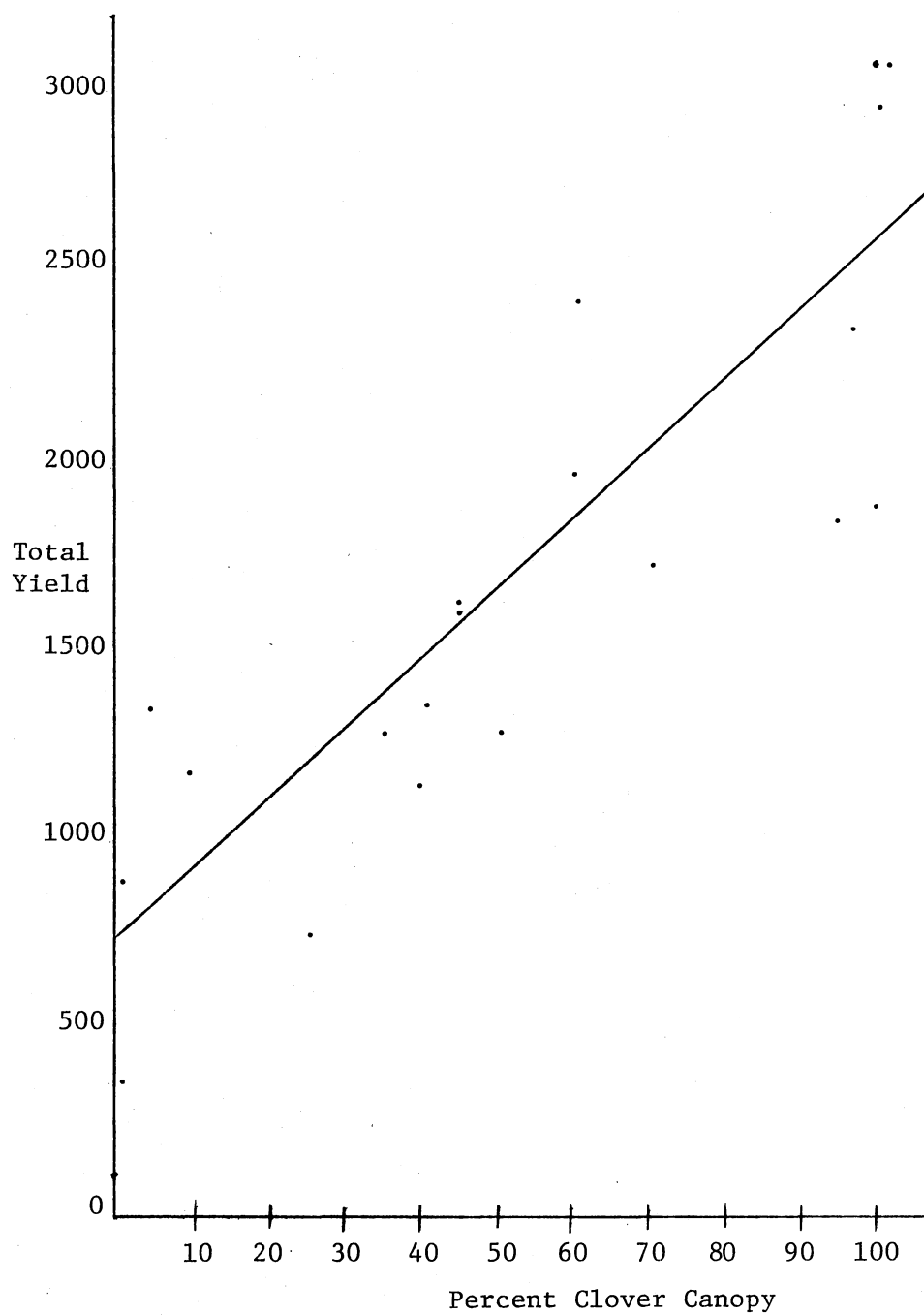


Figure 7. Regression of percent clover canopy upon yield.

### Greenhouse Study

The objective of the greenhouse study was to evaluate different adhesives for pelleting and the effect of a time delay between pelleting and planting.

Plant N percentage was used to express the results (Table 7). Significant differences in percent N were attributed to the time delay with the lowest N content associated with the longest time delay (Figure 8). No significant differences were observed when seeding was delayed two weeks or less.

The pelleting adhesive did not have a significant difference in N percent (Figure 9). These results would indicate that several possible adhesives are available for the purpose of pelleting.

However, ease of pelleting should be considered before an adhesive is chosen to be used. For example, it would not be practical for a farmer to neutralize molasses because a pH meter is needed, and 4M KOH may not be readily available as a neutralizing agent and it is extremely caustic. Methyl cellulose had to be dissolved which caused problems determining how much powdered material was necessary to form the binding adhesive. Too much powder made a very gummy substance and too little would not make the adhesive sticky enough.

Not all adhesives required the same amount of lime. Too much lime made a soft pellet and too little did not coat all the seeds, and thus might have exposed the inoculum to the environment.

### Germinator Study

This study was conducted to determine the effects of pelleting adhesive and time delay before seeding on germination. The mean ger-

Table 7. Mean nitrogen percent of arrowleaf clover forage as affected by pelleting date and pelleting adhesive and storage time after pelleting.

Storage Time	Pelleting Treatment				
	Molasses Neutralized	Molasses	Oil	Glucose	Methyl Cellulose
4 weeks	2.56a*	2.30b	1.98b	2.42ab	2.52a
3 weeks	2.64a	2.42a	2.14b	2.16b	2.47a
2 weeks	2.42a	2.56a	2.46ab	2.50ab	2.50a
1 week	2.61a	2.51a	2.57a	2.45ab	2.40a
0 week	2.32a	2.76a	2.61a	2.67a	2.64a

\*Means of dates from the same pelleting treatment followed by the same letter are not significantly different at  $P=.05$ .

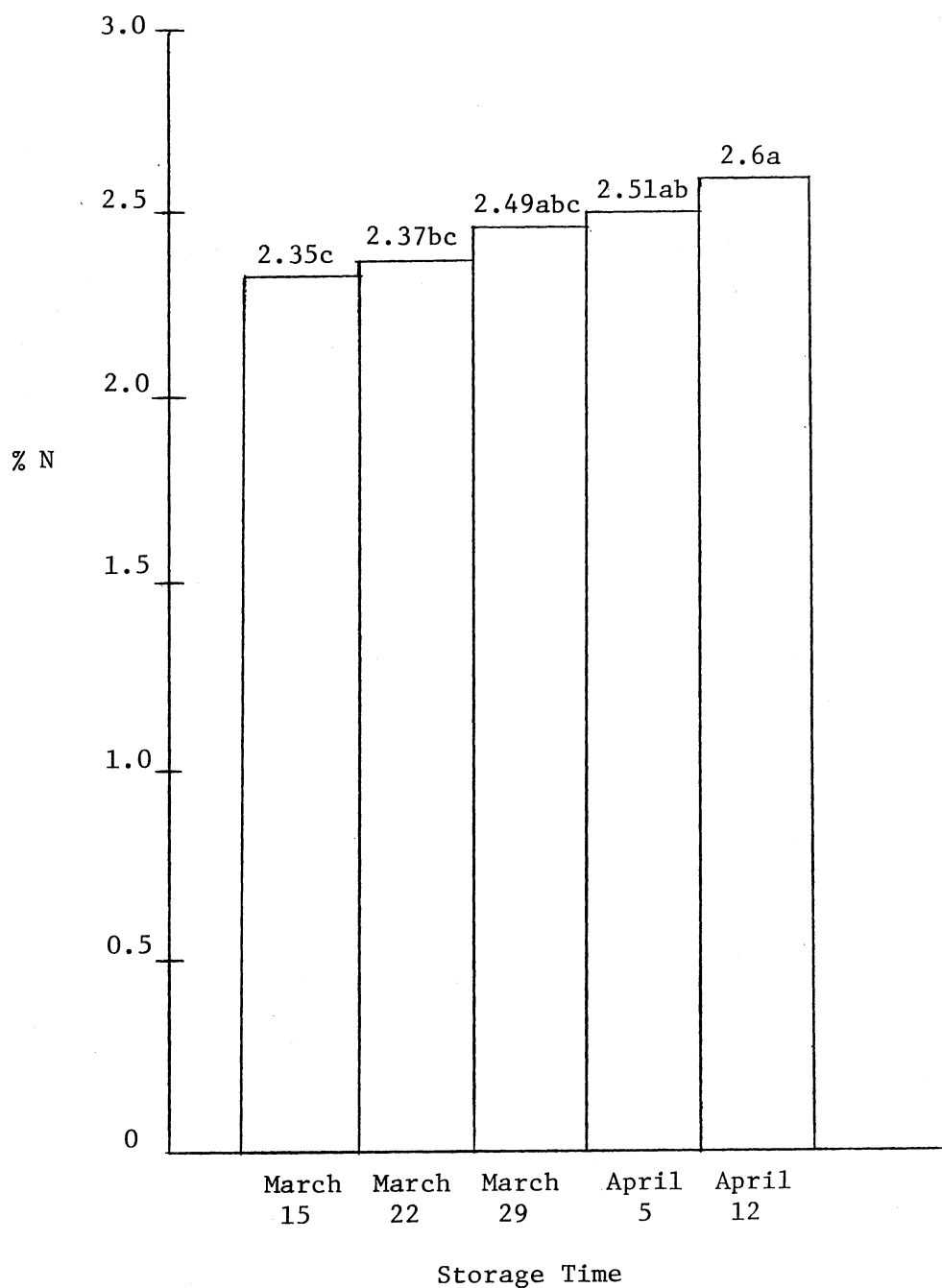


Figure 8. Percent nitrogen of arrowleaf clover in a greenhouse as affected by storage time after pelleting.



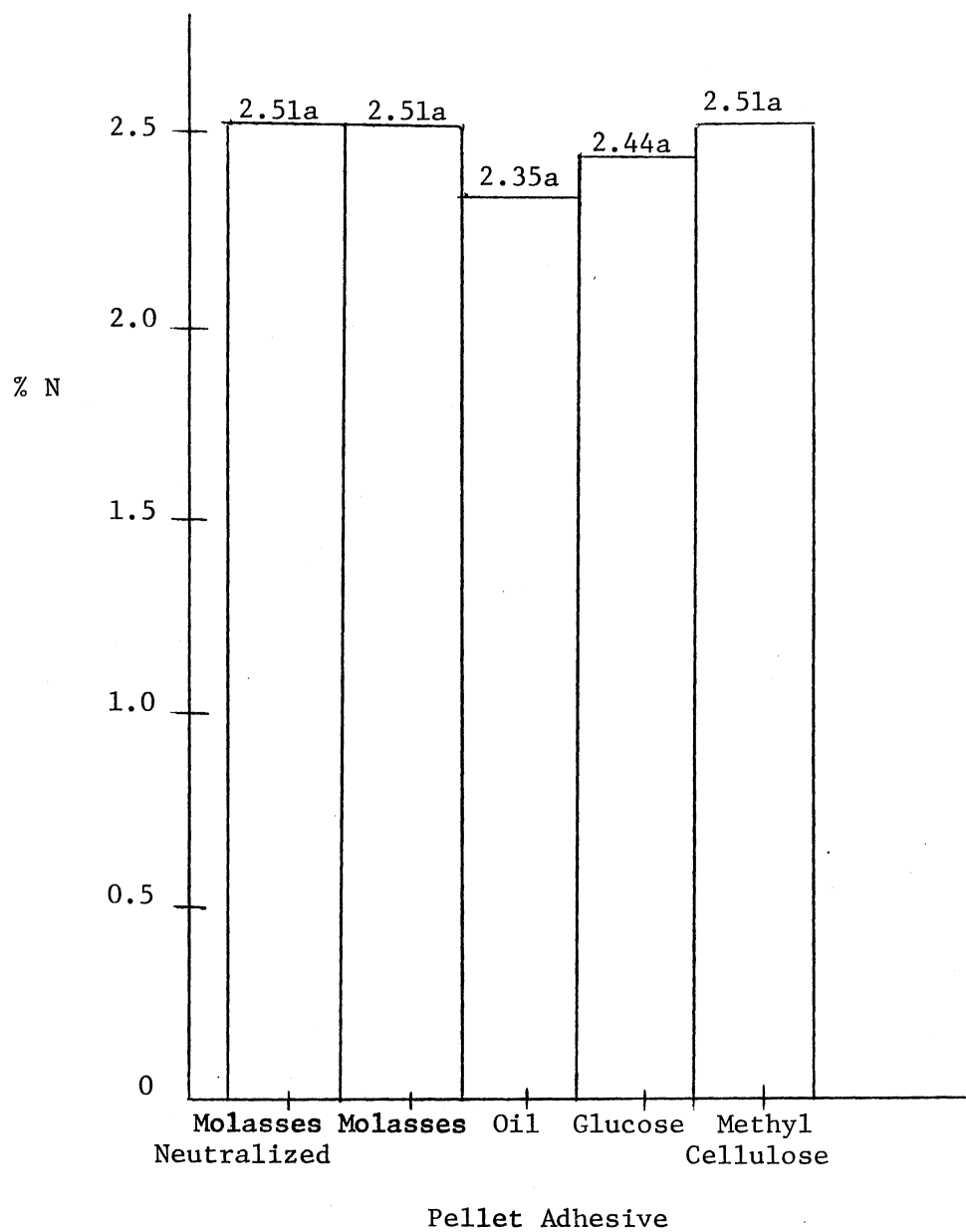


Figure 9. Nitrogen percent of arrowleaf clover in a greenhouse as influenced by pellet adhesive treatment.

mination percent of each treatment as affected by pelleting adhesive and time delay before seeding is given in Table 8.

The length of time between pelleting and seeding did not affect germination (Figure 10), but the pelleting adhesive did. Lowest germination occurred with the oil adhesive treatment which had 68% germination while all other treatments had 72% germination (Figure 11).

Table 8. Mean germination percent of arrowleaf clover as affected by pelleting date and pelleting adhesive treatment.

Storage Time	Pelleting Treatment				
	Molasses Neutralized	Molasses	Oil	Glucose	Methyl Cellulose
4 weeks	70b*	76a	72a	68ab	74a
3 weeks	68b	72a	66b	72ab	74a
2 weeks	72ab	64b	70a	74a	70ab
1 week	74a	72a	70a	72ab	68b
0 week	74a	72a	64b	76a	70ab

\*Means of pelleting treatments at the same date followed by the same letter are not significantly different at  $P=.05$ .

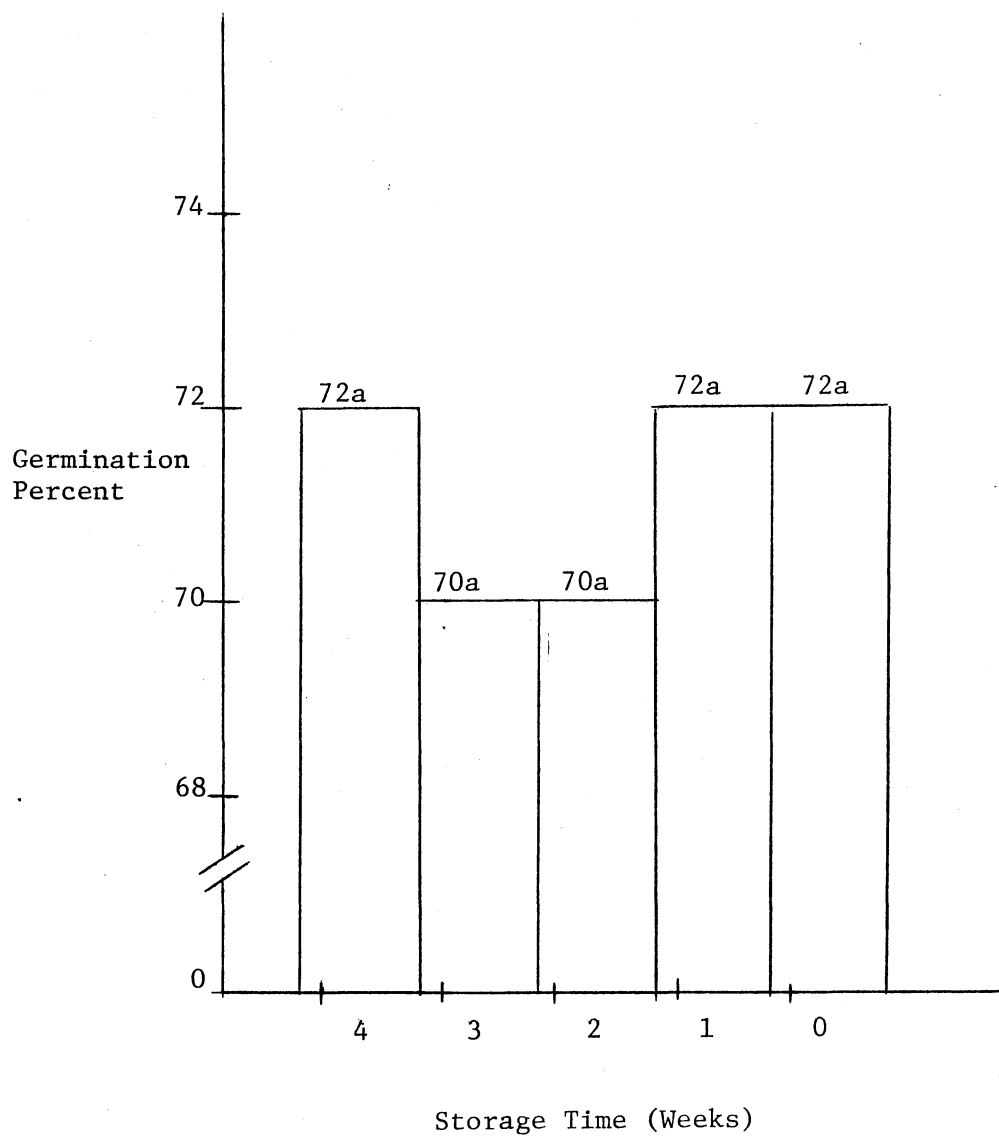


Figure 10. Germination of arrowleaf clover as influenced by storage time after pelleting.

## CHAPTER V

### SUMMARY AND CONCLUSIONS

Methods of establishing arrowleaf clover and tall fescue in existing warm season native rangeland were investigated on a study area within the Ouachita Highlands Resource area of Eastern Oklahoma. Evaluation of these field studies was based on plant density and forage production from small quadrats. Also, studies were conducted to determine the effect of pelleting date and pelleting adhesive on percent nitrogen in arrowleaf clover in a greenhouse and on germination in a germinator.

Only in the grassland area was plant number influenced by a treatment while total production was influenced in both areas. Plant number in the grassland area was increased by the N fertilization, but significant differences were obtained for only the 320 lb rate. The 320 lb rate produced significant increases in production in both areas while the 40 lb rate did not increase production over the no fertility treatment. There were no significant differences in plant number or total production due to seedbed preparation method, therefore, no advantage was gained by using any particular one.

Plant number of arrowleaf clover was not affected by burning or the application of 1.5 T/acre of lime, but pelleting consistently had more plants than non pelleting in both areas the first year.

The extreme density of the clover stand the second year made a

plant count impractical, therefore, evaluation was based on clover canopy, and total forage production.

No significant increases in clover canopy or clover production were observed, however, total forage production was increased by pelleting and liming but not by burning.

The greenhouse study revealed that N percent in arrowleaf clover is not affected by pelleting adhesive, but that the shorter storage time before planting assured higher N percent in plants.

Germination was unchanged for molasses, molasses neutralized, glucose, and methyl cellulose, but was significantly lowered by the oil treatment.

The value of arrowleaf clover for improving forage production was quite apparent. The use of pelleted seed improved seeding success, and the adhesive may be chosen on the basis of availability and ease of handling. More reliable methods of obtaining successful stands of clover are still needed.

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## APPENDIXES

Table 9. Monthly precipitation received at Holdenville,  
Oklahoma (20 miles west of the study area). Source:  
U.S. Dept. of Commerce. 1976. Climatological Data.

Month	Precipitation Received		Departure From Normal	
	1975	1976	1975	1976
Inches				
January	2.33	Trace	+0.75	-1.58
February	4.84	0.10	+2.77	-1.97
March	5.92	4.57	+3.29	+1.84
April	3.75	4.08	-0.73	-0.40
May	9.90	3.80	+3.49	-2.61
June	6.47	2.55	+1.70	-2.22
July	4.20	1.70	+0.03	-2.47
August	1.75	1.05	-1.14	-1.84
September	2.53	1.15	-1.67	-3.05
October	0.60	3.72	-3.11	+0.01
November	2.93	0.50	+0.82	-1.61
December	2.15	1.60	-0.03	-0.58
Total	47.37	24.82	+6.07	-16.48

VITA<sup>1</sup>

Stephen Michael Molloy

Candidate for the Degree of

Master of Science

Thesis: TALL FESCUE AND ARROWLEAF CLOVER FOR RANGE INTERSEEDING

Major Field: Agronomy

Biographical:

Personal Data: Born on July 31, 1953, in Cherokee County, Oklahoma, the son of Robert Henry and Ruby Mae Molloy.

Education: Graduated from Tahlequah High School, Tahlequah, Oklahoma in May 1971; received the Bachelor of Science degree in Agronomy, Range Management option, from Oklahoma State University, Stillwater, Oklahoma in May 1975; attended graduate school at Oklahoma State University, May 1975, to June 1977.

Professional Experience: Reared and worked on a dairy farm near Tahlequah, Oklahoma. Employed by the Department of Agronomy, Oklahoma State University, as a graduate research assistant, May 1975, to June 1977.

Professional Organization: Society for Range Management, and National Geographic Society.