

YIELD, QUALITY AND BOTANICAL COMPOSITION OF AUTUMN-ACCUMULATED
GRASS-LEGUME MIXTURES AND DIGESTIBILITY OF ENSILED AUTUMN-
ACCUMULATED ORCHARDGRASS AND ALFALFA

by

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ABSTRACT

Beef cattle producers in the southeastern US often stockpile forage in late summer to extend the grazing season and reduce feeding costs. Three stockpiled grass-legume mixtures were evaluated for winter grazing. In addition, stockpiled forages were ensiled and evaluated as livestock feed. Four accumulation dates and seven harvest dates were randomized to small plots of tall fescue (*Festuca arundinacea* Schreb.) -red clover (*Trifolium pratense* L.), orchardgrass (*Dactylis glomerata* L.) -red clover, and orchardgrass-alfalfa (*Medicago sativa* L.). The amount of grass and legume in the fescue-red clover mixture shifted from less than 30% grass and more than 60% legume in October to over 60% grass and less than 10% legume in April. All forage mixtures contained at least 15% CP from November to March. Fescue-red clover was higher in TNC and lower in NDF, ADF and cellulose in January and March than the orchardgrass-legume mixtures. Fescue-red clover was higher in yield than the orchardgrass-legume mixtures from November to February. Delaying stockpiling until September 1 or 15 increased ($P < .05$) legume content and decreased dead grass content in orchardgrass-clover and orchardgrass-alfalfa. Accumulating growth from September 15 increased percent CP in fescue-red

clover and orchardgrass-clover, compared to August 15, and decreased percent NDF in all forage mixtures. Percent IVDMD increased in orchardgrass-clover when stockpiling was delayed until September 15. May yields decreased only in orchardgrass-alfalfa when stockpiling was delayed until September. Orchardgrass stockpiled on August 3 and September 3, and alfalfa stockpiled on September 3 were ensiled alone. Chemical composition of silages was determined after 90 d of fermentation. Silages averaged 16.0% CP and 44.7% NDF. Digestibility of the ensiled stockpiled forages was estimated using acid insoluble ash as a marker with 18 wether lambs. No differences were observed in DM or CP digestibility, but NDF digestibility was lower for alfalfa silage than for orchardgrass silages. All stockpiled grass-legume mixtures provided high quality winter grazing, and all silages were of good quality and digestibility. Fescue-red clover maintained both good quality and higher yield than the other mixtures. Ensiling stockpiled alfalfa and orchard grass provided a method of maintaining CP and digestibility for subsequent feeding.

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INTRODUCTION

Beef cattle production in the southeastern U.S. has traditionally consisted of cow-calf enterprises based primarily on forages. As costs associated with animal agriculture increase, so does interest in grazing as a low cost feed source. Stockpiling is a forage management technique employed by livestock producers to extend the grazing season into winter, when hay or silage would normally be fed. It is a low-cost alternative to systems that rely on machinery and labor to harvest forage in order to carry livestock through the winter until pasture is again available. Cool-season grasses have been used successfully for stockpiling, but require N fertilization for optimum yields. Combining legumes with grasses could reduce or eliminate the need for costly N fertilizer. However, prior to the time this study was initiated, information was limited about how stockpiling and winter harvesting affect yield, chemical composition, and botanical composition of different combinations of grasses and legumes. These parameters were monitored over 1 yr of a long-term experiment developing all-forage systems for beef cattle production. If it can be demonstrated that stockpiling grass-legume combinations provide nutrition of a quality and quantity that is at least equivalent to what preserved forages provide to wintering cattle, then stockpiling can be considered a desirable method of extending the grazing season and a cost-effective management tool for livestock producers.

Ensiling of stockpiled forages is a practice about which little is known. While it may not be cost effective compared to grazing, it can offer the livestock producer an alternative management tool by preserving excess forage when it is at peak quality and yield for future use. An experiment was designed to investigate the potential for

ensiling stockpiled grasses and legumes. Silages were evaluated for chemical composition and digestibility.

LITERATURE REVIEW

Basis for Stockpiling

Some of the earliest work on winter grazing of forages was reported by British researchers in the late 1930's. These studies indicated that grazing of forages in winter was possible under certain conditions, and that at least part of the nutritional requirements of livestock could be met by grass (Griffith and Hutton, 1936; Davies and Fagan, 1938). A few decades later production and utilization of winter grasses were tested by Baker et al. (1961) using existing fields in England and Wales. They demonstrated that forage for winter grazing could be produced, not only in a research setting but also on commercial farms under widely varying environmental conditions. Cowling (1962) concluded that winter forage yield is largely dependent on summer and autumn weather, and therefore can vary considerably from year to year. He also noted that while there is some loss of DM in autumn-accumulated forage due to weathering, it is not high when compared with losses occurring in other methods of conservation such as ensiling. Baker et al. (1965) reported there was a greater amount of forage wasted by livestock when grazing autumn-produced pasture than when grazing at other times. They concluded that grain supplements would be needed to maintain livestock performance if animals were forced to utilize winter forage more efficiently. In contrast, it was demonstrated in Virginia that animals grazing stockpiled forage performed as well as those on conventional hay feeding programs (Hammes, 1976).

Forage Species Suitable for Stockpiling

The bulk of early investigations on autumn accumulation of forages focused on several cool-season perennial grasses, including tall fescue (*Festuca arundinacea*), orchardgrass (*Dactylis glomerata*), perennial ryegrass (*Lolium perenne*) and Kentucky bluegrass (*Poa pratensis*). Baker and coworkers (1961) found that perennial ryegrass deteriorated more rapidly than orchardgrass in autumn and should be grazed before the end of November, while orchardgrass provided high quality grazing in December and January. Tall fescue was found to be superior to orchardgrass in yield, digestibility and for cattle weight gains in November and December (Baker et al.,1965; Archer and Decker,1977a). Both bluegrass and tall fescue contained more than enough CP to meet the requirements of non-lactating beef cows (Van Soest, 1994), but tall fescue had consistently greater yields than bluegrass (Taylor and Templeton, 1976).

One of the primary reasons for the increase in nutritional quality of some cool-season perennials in autumn is the accumulation of total non-structural carbohydrates (TNC). This occurs when plant growth slows with cooling temperatures (Brown et al.,1963). Respiration and synthesis of new tissue decrease faster than the rate of photosynthesis, resulting in an increase of stored carbohydrates. Tall fescue is especially noted for its ability to store TNC when compared with orchardgrass and bluegrass (Taylor and Templeton, 1976; Sheehan et al.,1985).

The problem often encountered with some grasses in autumn and winter is senescence, also known as “winter burn”. It is defined as that part of the plant

material which has turned brown and appears dead. Certain species of grasses are more susceptible to winter burn than others, orchardgrass and perennial ryegrass among them (Baker et al.,1961; Miles et al.,1964). The more winter burned tissue there is, the lower the quality and palatability of the forage. In Montana, Houseal and Olson (1996) found a greater proportion of live to dead material in Idaho fescue compared to bluebunch wheatgrass. The CP content of the dead component of these grasses was less than 5%, lower than what is needed to meet requirements of mature beef cows. Rates of DM disappearance of the dead components in both Idaho fescue and bluebunch wheatgrass were lower than rates for live components. Grasses with a high TNC content exhibit less tendency toward winter burn (Miles et al.,1964). In West Virginia, Collins and Balasko (1981b) reported that tall fescue, a grass which characteristically stores large amounts of carbohydrates and does not deteriorate in quality until after January, seems to be an ideal grass for stockpiling. Bagley et al. (1983) related increasing TNC values to high voluntary intake and digestibility of tall fescue. Autumn stockpiling of fescue is a recommended management scheme for extending the grazing season across the southern states from Missouri to Virginia, although certain considerations apply now that the effects of endophyte infection in tall fescue on grazing animals are well documented (Schmidt et al., 1982; Hemken et al., 1984; Read and Camp, 1986; Stuedemann and Hoveland, 1988).

Little information was available before the late 1970's regarding the use of perennial forage legumes after frost in autumn and through winter. At that time interest increased and data began to be collected on fall production of alfalfa (*Medicago sativa*) and red clover (*Trifolium pratense*), among other legumes. In

Kentucky, Collins and Taylor (1980) reported that alfalfa accumulated from early August was higher in yield but decreased more rapidly in quality during early autumn than did alfalfa grown from early September. They then compared quality changes in autumn-accumulated alfalfa and red clover and found that substantial declines in IVDMD occurred following a combination of subfreezing temperatures and precipitation (Collins and Taylor, 1984). However, both legumes maintained CP concentrations in excess of requirements of most classes of livestock. In Wisconsin, Collins (1982) studied birdsfoot trefoil (*Lotus corniculatus*) stockpiled for summer utilization, but included data from autumn. He reported that birdsfoot trefoil harvested during October was high in CP and IVDMD after regrowth periods of as much as 3 mo. He also observed increases in TNC and decreases in NDF in the October harvested-legume, relative to the summer-harvested legume. Sheehan and co-workers (1985) studied the effects of winter on red clover and two cool-season grasses in Virginia. Red clover tended to be as high or higher in nutritive value than orchardgrass and tall fescue in September and October, but then deteriorated rapidly in November, and had completely senesced by early December.

Data from stockpiled grass-legume combinations are limited. In Great Britain, Cowling (1962) reported that an orchardgrass-alfalfa row crop combination accumulated from early August provided a valuable crop for winter grazing. Using the combination of a grass and a legume offered a buffer against drastic yield reductions when adverse weather conditions prevailed. More recently, Belesky and Fedders (1995) studied stockpiled orchardgrass-white clover swards in West Virginia. They observed changes in botanical composition and morphology of the forage due to management practices during autumn. Turner et al. (1998) reported on the animal

performance data from the above-mentioned swards. They concluded that market weight lambs can be produced from mixed species autumn pasture, although it takes more time, compared to fattening lambs in a feedlot on orchardgrass hay and pelleted concentrate. Hitz and Russell (1998) studied stockpiled forages for winter grazing in Iowa. They reported that cows grazing endophyte-free fescue in combination with alfalfa gained comparably to cows fed hay in drylot. Still, more information is needed to understand the complexities of using grass-legume combinations for autumn and winter grazing.

Effect of Length of Accumulation Period on Yield and Quality of Stockpiled Forages

After comparing results of accumulation dates ranging from mid-July to mid-September in Wales, Baker et al. (1961) recommended resting orchardgrass pastures from mid-August for the best combination of yield and quality. Orchardgrass accumulated from various dates in July was over-mature and had an excessive amount of winter burn. In Virginia, Rayburn et al. (1979) reported that as the stockpiling period was shortened from June to September, yield of tall fescue decreased over four-and-a-half fold. At the same time, total TNC increased from 15.6 to 23.0% and CP increased from 9.4 to 11.3%. Similar trends in yield and quality of stockpiled tall fescue were reported by Fribourg and Bell (1984) in Tennessee. Losses of accumulated DM were small through December but much larger when the harvest was delayed until January. Rayburn and coworkers (1980) concluded that the best time to begin accumulating tall fescue depends on a variety of management considerations, such as the area of tall fescue, the amount of other available forages,

and the nutritional needs of the livestock. As in other phases of forage management, stockpiling involves a compromise between yield and quality of the crop.

When dealing with a combination of alfalfa and orchardgrass, Cowling (1962) warns that if the accumulation period is too long, the alfalfa will drop its leaves and the quality will rapidly decline. Collins and Taylor (1980) in Kentucky demonstrated that yields of alfalfa-orchardgrass accumulated from early August were higher than yields accumulated from early September. However, DM losses began earlier for the August stockpiled forage than the September stockpiled forage. Alfalfa accumulated from early August was lower in percent leaf, N and IVDMD than alfalfa accumulated from early September, which agrees with Cowling's findings.

Effect of Nitrogen Fertilization on Yield and Quality of Stockpiled Forages

Fertilizer N has been used to stimulate growth of forages for autumn stockpiling. Studies have been conducted to determine the effect of different rates of fertilizer application on yield and quality of autumn-saved pasture. Archer and Decker (1977a) reported a 50% increase in average DM yield of orchardgrass and tall fescue after 100 days of growth following an application of 100 kg N/ha. Crude protein tended to increase but IVDMD was not affected by N fertilization. Rayburn et al. (1979) compared different dates of fertilizer application and found that DM yields of tall fescue in December were highest for the June and lowest for the September application dates. Collins and Balasko (1981a) also reported that N fertilization increased winter tall fescue yield. In addition, they found that yield response to N fertilization is influenced by the date of initiation of stockpiling. Quality of stockpiled

tall fescue was improved by N fertilization due to increases in IVDMD, CP and WSC, but supplementation of energy, P and Mg to grazing livestock may be necessary, beginning in January (Collins and Balasko, 1981b). Cowling (1962) demonstrated that to a certain extent N fertilization will compensate for a delay in the date of stockpiling. He also reported that 78.5 kg N·ha⁻¹ applied to an orchardgrass-alfalfa mixture did not greatly reduce alfalfa productivity.

Effect of Winter Harvest on Spring Yields.

While information is available supporting the use of stockpiled forages to provide quality autumn and winter grazing, it is also important to know how such management practices will affect yields in the following spring. Cowling (1962) reported the spring yield of orchardgrass was reduced when the grass was harvested twice in the winter (November and February) but not when a single harvest was made. In the case of alfalfa-orchardgrass, fertilizer treatment and winter harvest had little effect on the yield of alfalfa. Taylor and Templeton (1976) tested the effect of harvesting stockpiled tall fescue and bluegrass in autumn and winter on spring yields by first applying 50 kg/ha N in early March. The spring growth was then harvested in mid-May. Results showed small but significant reductions in yield of the spring crop due to harvesting in November or December. Collins and Taylor (1980) found that in general, harvests after the beginning of November did not reduce spring yields of alfalfa-orchardgrass, compared with unharvested forage. These experiments gave some indication that winter harvest of stockpiled forages does not have a detrimental

effect on the stand of forage, but care should be taken not to harvest alfalfa before the first killing frost. Hall et al. (1998) compared three fall-grazing management systems in Pennsylvania. They found that while fall stockpiling and grazing of tall fescue or perennial ryegrass extended the grazing season, there was a 15% decrease in forage production the following spring.

Animal Performance on Stockpiled Forages

In 1976, Hammes reported that animals grazing stockpiled tall fescue during the winter performed similarly to those in conventional hay feeding programs. Stocker calves grazing stockpiled fescue-alfalfa gained as much as calves that were barn-fed alfalfa-orchardgrass hay (Allen et al., 1992). Both of these studies were conducted in northern Virginia. Hitz and Russell (1998) found that pregnant beef cows grazing stockpiled fescue-alfalfa or smooth bromegrass-red clover maintained equal or greater body weights and condition scores, compared to those fed hay in a drylot in southern Iowa.

There is renewed interest in the use of grass-legume combinations for grazing and hay production. This is due in part to problems inherent in the use of N fertilizer: high cost and the potential for groundwater pollution. Rayburn et al. (1980) suggested that there may be a legume-grass synergism that accounts for small but biologically important improvements in beef production efficiency. In an experiment conducted with cows and calves grazing fescue-ladino clover at different levels of nitrogen fertilization, both cows and calves gained more on the zero-N treatment than on the two N application treatments (Stricker et al., 1979). It was pointed out that

there was a higher proportion of clover in the zero-N treatment than in the other treatments. Burns and co-workers (1973) reported higher gains per calf on tall fescue-ladino clover compared to calves grazing tall fescue alone or fescue plus 'Coastal' bermudagrass. Steer daily gains, overall gains and feed efficiency were highest on orchardgrass-clover pastures compared to steers grazing bermudagrass-clover, fescue-clover and bermudagrass + N or bermudagrass + N + fescue pasture (McLaren et al., 1983). On the other hand, more beef was produced per hectare on bermudagrass + fescue due to greater forage production and a longer grazing season.

Ensiling of Grasses and Legumes

Grasses and legumes have been ensiled successfully for centuries by northern Europeans, but it was not a generally accepted practice in the U.S. until the 1930's (Noller, 1980). Forage producers have often found that first-cutting hay is difficult to cure because of cool, rainy weather. For this reason the spring growth is frequently conserved as silage to prevent loss of the harvest. Another advantage of making silage as compared to field-cured hay is that a greater amount of nutrients is preserved for feeding, and in turn there is less need for supplements.

The practice of ensiling stockpiled forages is a relatively recent one, primarily confined to research farms (Torres, 1983). Stockpiled forages are normally intended for grazing, but will deteriorate in yield and quality as winter progresses (Miles et al., 1964; Collins and Taylor, 1984; Sheehan et al., 1985). The advantage of ensiling stockpiled forages over grazing them is that well-made silage can be preserved for a

long period of time with minimal loss of nutrients while no such guarantee can be made for the forages in situ.

The process of ensiling is governed primarily by the interactions of the composition of the plant material, the amount of air in the silage mass, and the bacteria present on the plant material (Noller, 1980). During the initial phase of ensiling, plant enzymes and aerobic bacteria utilize readily-available carbohydrates until the oxygen supply is exhausted. The next phase of ensiling is anaerobic, and lactic acid bacteria act on the soluble carbohydrates to produce lactic acid and other short-chain fatty acids. Ideally, the acid reduces the pH of the silage to 4.2 or lower in direct cut forage, and acts to preserve it from further bacterial growth and enzyme action.

The forage mass must be packed tightly in the silo for proper fermentation to occur (Noller, 1980). If substantial air is left in the silage, aerobic bacteria will consume the soluble carbohydrates. As a result, the carbohydrate sources may be insufficient to support the lactic acid bacteria population long enough to lower the pH, leading to spoilage.

A high water soluble carbohydrate (WSC) content of the forage is important for desired fermentation, particularly if it will be ensiled alone (Noller, 1980). The WSC content of a forage is affected by a variety of factors such as stage of maturity, species and management practices, including stockpiling. Forages that are high in protein may be difficult to ensile because they require more lactic acid to lower the pH. Immature forages are lower in WSC than mature crops, and legumes tend to be lower in WSC than grasses (Wilson and Wilkins, 1973).

The moisture content of ensiled crops also plays an important role in the

fermentation process. Direct cut silages are usually high in moisture. Wilting of the crop in the field reduces the moisture level by about 10 to 20% (Noller, 1980). The purpose of wilting herbage prior to ensiling is to improve the fermentation of crops which are normally low in WSC and high in moisture content. In a study with alfalfa ensiled at several DM contents, there was an increase in lactic acid production and reduced DM losses with increasing dryness of the forage up to the level of 34.4% (Murdoch, 1960).

Intake and Digestibility of Grass and Legume Silage

The digestibility of cut herbage is similar to the digestibility of the resulting silage (Harris and Raymond, 1963). Hammes et al. (1966) reported that silage made from early-cut alfalfa-orchardgrass was higher in digestibility than that made from late-cut forage. Hirodiglou et al. (1965) studied the effects of wilting and various chemical additives on legume silages. They found that wilting resulted in a reduction in digestibility due to overheating of the silage. In addition, they found no advantage to adding salts, lime or organic acids to high-moisture silages.

Although there may be a close relationship between digestibility and voluntary intake for dry feeds, this relationship does not apply to silages. Harris and Raymond (1963) reported intake of silage was much lower than that of the same crop fed fresh to sheep, while the digestibilities of both were high. Wilkins et al. (1971) measured the voluntary intake by sheep of many different silages. When all the silages were considered, they found no correlation between intake and apparent DM digestibility. However, when the legume silages were considered separately, this correlation was

significant and positive, and for grasses other than ryegrass the correlation was significant and negative. They suggested that the higher intake of legume silages was related to a lower cell wall content as compared to the grass silages.

Intakes of wilted silages are reported to be higher than intakes of unwilted crops (Murdoch, 1960; Harris and Raymond, 1963). Wilkins et al. (1971) suggested that this is due to better fermentation in silages of high DM content and that the DM content was related indirectly to intake through its effect on the fermentation process.

MATERIALS AND METHODS

Experiment 1: Small Plots

A small plot experiment was conducted from August 1, 1982 to May 11, 1983 at the Middleburg Agricultural Research and Extension Center in Middleburg, VA (77°43'30 west longitude, 38°57'30 north latitude, elevation 155.5 m) to evaluate three grass-legume combinations for stockpiling. The plots, measuring approximately 10 m by 6 m, were fenced off within paddocks that were part of a grazing experiment. Forages used were tall fescue (*Festuca arundinacea*)-red clover (*Trifolium pratense*), orchardgrass (*Dactylis glomerata*)-alfalfa (*Medicago sativa*), and orchardgrass-red clover. Each grass-legume combination was replicated four times in a completely randomized design. Cultivars used were 'Kentucky-31' tall fescue, 'Kenstar' red clover, 'Arc' alfalfa and 'Hallmark' orchardgrass. The tall fescue was less than 5% infected with *Acremonium coenophialum* (Allen et al., 1992a).

Small plots were divided into four strips 1 m wide and 7 m long with the treatments randomized in each plot. Accumulation began on August 1, August 15, September 1 and September 15, and harvest dates were Oct. 1, November 3, December 8, January 3, February 1, March 1, and April 5. Stockpiling was initiated on each accumulation date by clipping the forages with a sicklebar mower at 5 cm, then fertilizing with ammonium nitrate at the rate of 80 kg N/ha. Lime, P and K were applied according to soil test recommendations. Boron was applied to the alfalfa-containing plots. Spring re-growth was measured on May 11, 1983 by obtaining yield measurements on all combinations of accumulation and harvest dates.

On a given harvest date the appropriate plots were clipped with a sicklebar

mower at 5 cm to measure yield. Grab samples were taken from each harvested plot and hand-separated into grass, legume and weed components prior to drying. The weight of the grab sample was added back to the total weight of the mowed plot for yield measurement. Any species other than the expected grass and legume were classified as weeds, and they consisted primarily of broadleaf weed species. The grass and legume components were further divided into live (green) and dead (brown) fractions. After botanical composition was determined from the grab sample fractions they were recombined for chemical analysis. Forage samples for yield and quality were dried in a forced draft oven at 60°C. Samples used for quality were ground in a Wiley mill through a 2 mm screen. Crude protein and DM were determined by AOAC methods (1990), NDF by the method of Van Soest and Wine (1967), ADF by the method of Van Soest (1963), lignin and cellulose by Van Soest and Wine (1968), total non-structural carbohydrates (TNC) as described by Wolf and Ellmore (1975), and IVDMD by the method of Tilley and Terry (1963).

Experiment 2: Ensiling Stockpiled Forages

An experiment was conducted to evaluate the digestibility by sheep of stockpiled orchardgrass and alfalfa ensiled alone. Silage was made from these forages on Oct. 28, 1982 at the Shenandoah Valley Agricultural Research and Extension Center, Steeles Tavern, VA. Existing stands of forages were used for making the silage. Two treatments were used for orchardgrass: stockpiling began August 3 and September 3 after clipping and fertilizing with 90 kg N/ha; and two for alfalfa, also stockpiled on August 3 and September 3 after being clipped and fertilized with 220 kg K₂O/ha. Other nutrients were supplied according to soil test

recommendations. The treatment of alfalfa stockpiled on August 3 was discarded after it became apparent that it would be overmature by the time it was to be ensiled in October.

On the day of ensiling, stockpiled forages were mowed to a 5 cm stubble, raked into windrows and wilted. After wilting, the forages were chopped in a hammermill. The chopped forages were packed into 210 L metal drums double-lined with polyethylene bags. The drums were packed by trampling and when full (approximately 90 kg) the bags were sealed individually after expelling as much air as possible. The forages were allowed to ferment for a minimum of 90 d. When a silo was opened for the first time, observations were made regarding the appearance and odor of the silage. The top 5 cm of forage material were discarded from each silo due to spoilage.

Digestion Trial. A digestion trial was conducted with 12 Dorset-cross and 6 Suffolk-cross wether lambs (32.5 kg) fed the ensiled forages. The lambs were blocked according to breeding and weight and randomized within blocks to the three treatments. They were placed in false-bottom stalls, similar to those of Briggs and Gallup (1949), to allow separate collection of feces and urine. One silo from each treatment group was opened 2 d before feeding to allow for DM determination. During a 5 d transition period, experimental silages were introduced to the diets in increments of 10% per feeding on a DM basis. The digestion trial consisted of a 10 day preliminary period and a 7 day collection period. Silages were fed at approximately 2% of body weight, DM basis, plus 10 g salt daily in equal portions during 2-h feeding periods at 12-h intervals. Feed refusals, if any, were collected

prior to each feeding. Water was available at all times, except during the feeding periods.

Grab samples of the silages were taken as each drum was opened. Extracts were prepared from these samples for pH and WSC (Dubois et al., 1956 as modified by Johnson et al., 1966) determination. Silage samples were also taken at each feeding and composited at the end of the trial for determination of nutrient composition. Feces were dried daily in a forced draft oven at 60°C and stored in large metal cans. At the end of the trial a composite sample for each wether was taken. Dry matter, CP, NDF, ADF, lignin and cellulose of feed and fecal samples were determined using the same methods as in Experiment 1. Acid insoluble ash (AIA) was used as a marker to determine apparent digestibility of the silages. The method of Van Keulen and Young (1977) was used to measure AIA. This method was used successfully to measure digestibility of rations fed to sheep. Thonney et al. (1979) also used the method successfully to determine digestibility of cattle rations. Apparent digestibility was calculated as follows using DM as an example:

$$100 - [100 * (\%AIA \text{ in feed} / \%AIA \text{ in feces}) * (\%DM \text{ in feces} / \%DM \text{ in feed})].$$

Ruminal fluid samples were collected 2 h after feeding on the final day of the trial via stomach tube, filtered through four layers of cheesecloth, and subsamples were placed in tubes containing metaphosphoric acid for VFA analysis. The VFA analysis was performed by gas chromatography (Varian Vista 3700 Gas Chromatograph, column packed with 10% SP-1200/10% H₃PO₄ on 80/100 Chromasorb WAW). The concentrations of the VFAs were determined by integration based on a standard

containing 51.7 $\mu\text{mol/ml}$ acetic acid, 30.6 $\mu\text{mol/ml}$ propionic acid, 10.4 $\mu\text{mol/ml}$ butyric acid, 5.2 $\mu\text{mol/ml}$ valeric acid, 5.0 $\mu\text{mol/ml}$ isobutyric acid, and 5.0 $\mu\text{mol/ml}$ isovaleric acid. The internal standard was 4-methyl valeric acid. The remaining ruminal fluid was used for pH determination. Blood samples were obtained 6 h post-feeding on the last day of the trial by jugular puncture, collected in heparin-containing tubes, and analyzed for urea by the method of Coulombe and Favreau (1963).

Statistical Analyses

Experiment 1 data were analyzed as a nested block design, where forage systems were blocks and reps nested within blocks. Accumulation dates were treatments repeated over harvest dates (or time). Analysis of variance was performed using the mixed procedure of SAS (SAS, 1996). Experiment 2 data were analyzed as a randomized complete block design. Analysis of variance was performed using the general linear models procedure of SAS (SAS, 1996). Mean separations were achieved using the Tukey-Kramer method for both experiments.

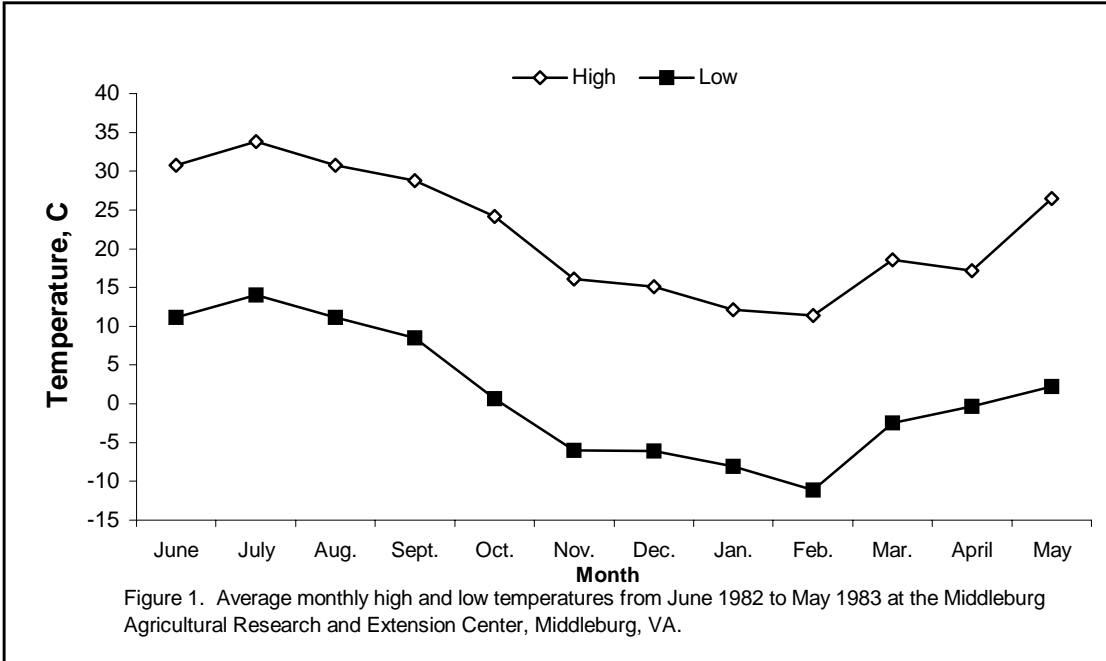
RESULTS AND DISCUSSION

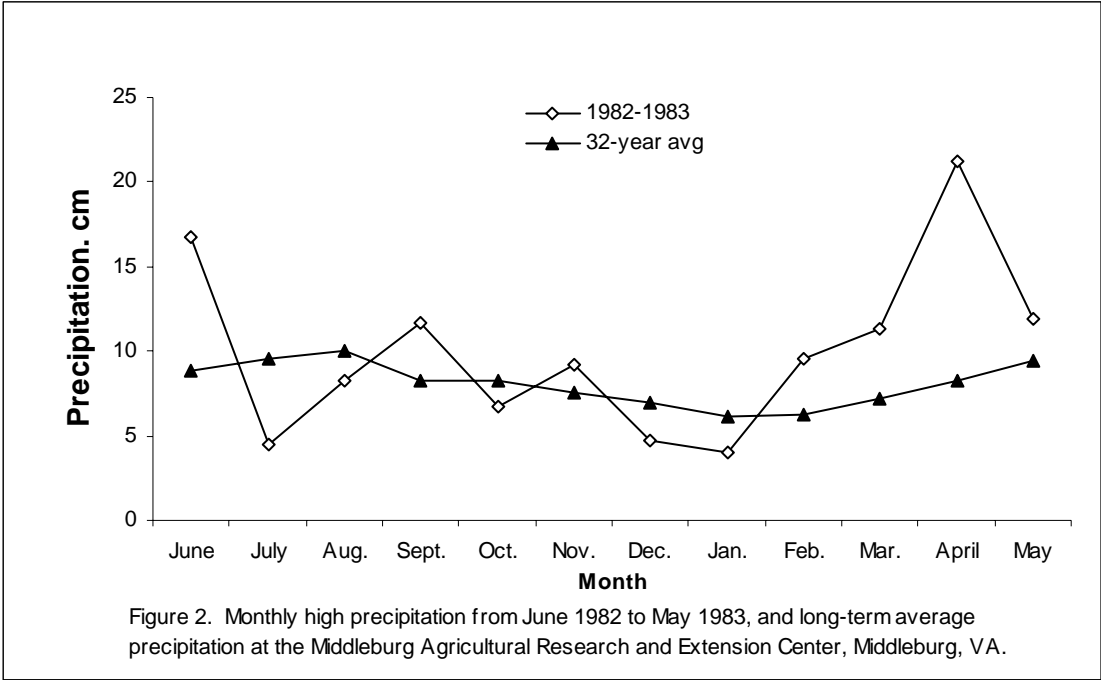
Experiment 1

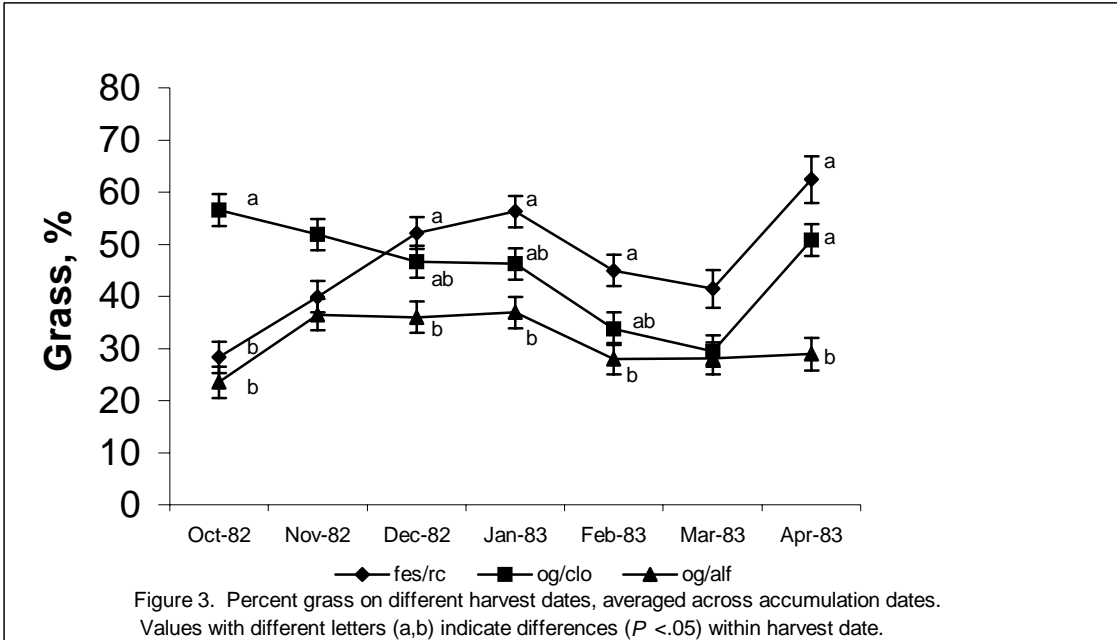
Weather. Average monthly temperatures for the period of June 1982 to May 1983 are presented in Figure 1, indicating the winter months were relatively mild. Monthly precipitation from June 1982 through February 1983 was similar to the long-term average (Figure 2), but above average from March to May.

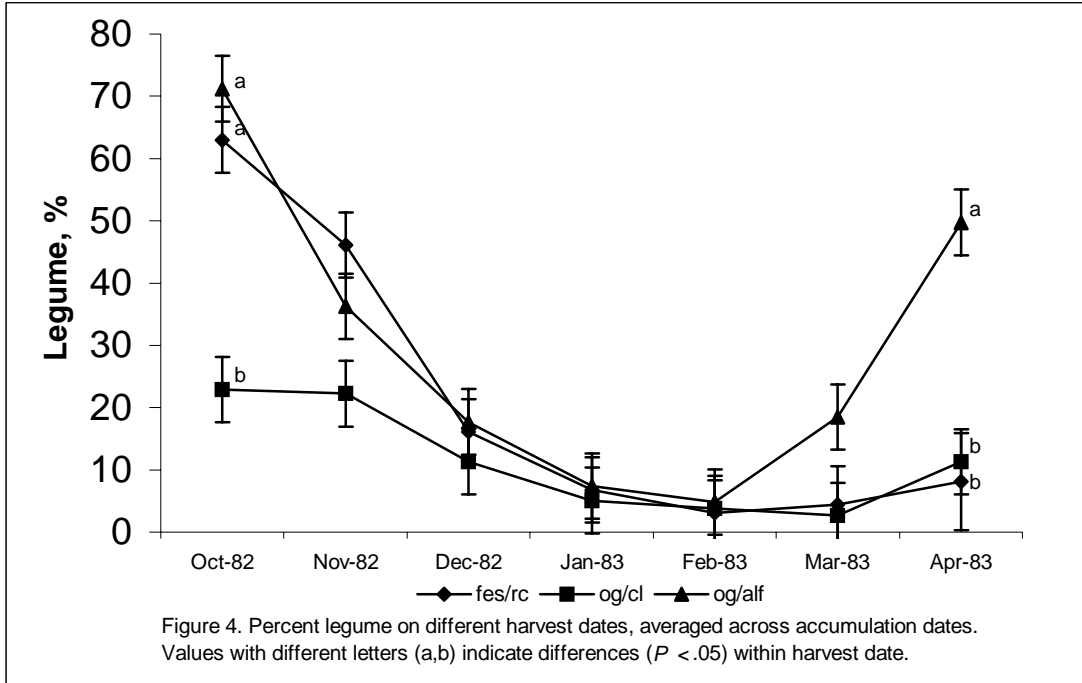
Effects of Harvest Dates on Botanical Composition. In October, the beginning of the sampling period, the orchardgrass-red clover mixture contained more grass ($P < .05$) than the orchardgrass-alfalfa and fescue-red clover mixtures (Figure 3). The grass component in orchardgrass-red clover decreased from October to the lowest levels in March, whereas percent grass in fescue-red clover increased (harvest date x forage system interaction, $P < .05$). The decrease in orchardgrass is similar to what Taylor and Templeton (1976) observed with stockpiled fescue and bluegrass. By December, fescue-red clover was higher in percent grass ($P < .05$) than the orchardgrass-alfalfa, while percent grass in orchardgrass-red clover was intermediate ($P > .05$). This trend was maintained until April. In April, percent grass was lowest ($P < .05$) for orchardgrass-alfalfa, due to new growth of alfalfa.

The legume in the orchardgrass-red clover mixture contained more volunteer white clover and ladino clover than red clover, thus this mixture will be referred to as orchardgrass-clover for the remainder of this document. Percent legume was lower ($P < .05$) than for the other forage mixtures in October (Figure 4), a reflection of the differences in percent grass. After October, the amount of legume decreased in all three mixtures until it reached the lowest levels in February (less than 10%), and





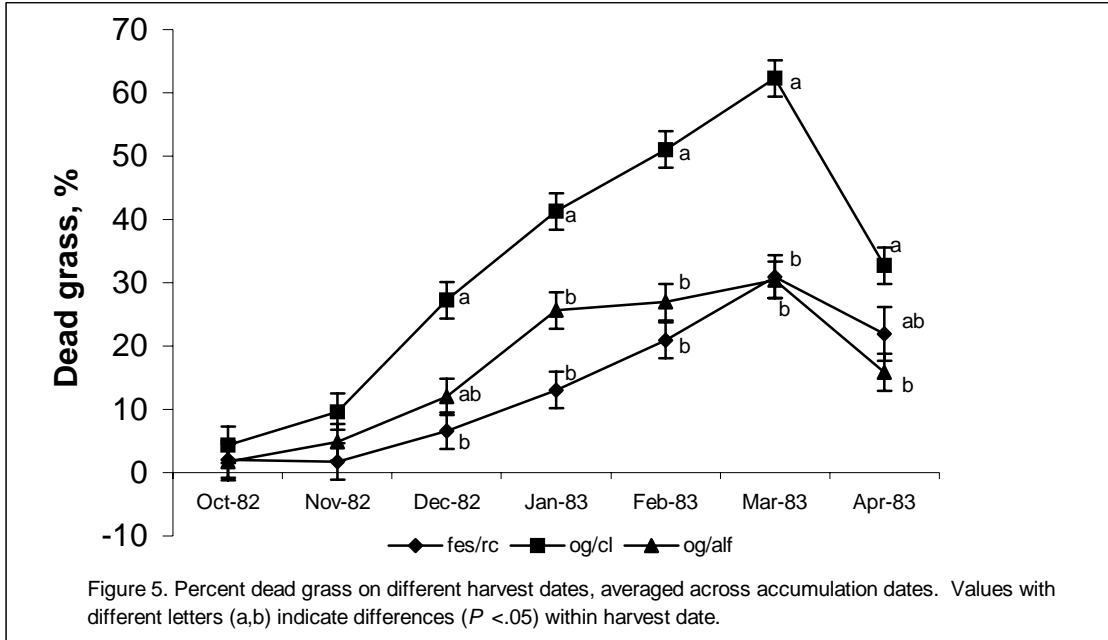


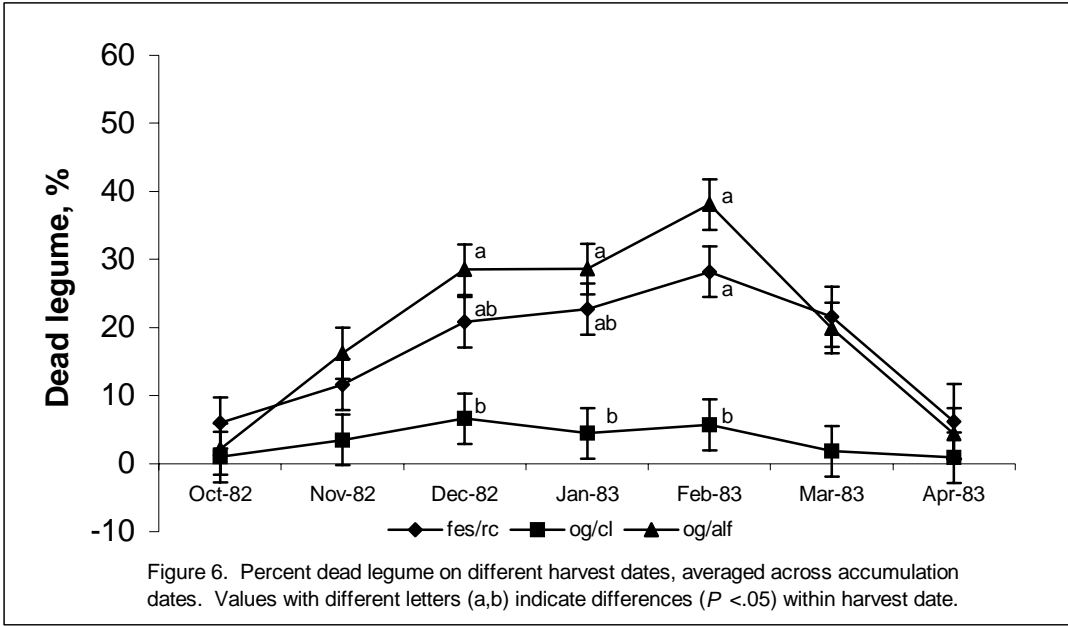


there were no differences between the forage mixtures. After February, percent alfalfa increased rapidly compared to the clovers in the other two mixtures, especially in April (harvest date x forage system interaction, $P < .05$).

Percent dead grass was similar among the three forage mixtures in October and November (Figure 5). By December, percent dead grass in orchardgrass-clover was greater than for fescue-red clover ($P < .05$), and intermediate ($P > .05$) for orchardgrass-alfalfa. Thereafter, percent dead grass remained highest ($P < .05$) for orchardgrass-clover (harvest date x forage system interaction, $P < .01$). The proportion of dead grass in December in orchardgrass-clover approached 25%, and was about 60% in April. Archer and Decker (1977b) reported the proportion of dead leaves in stockpiled orchardgrass and tall fescue increased by 25 percentage units between October and December. In contrast, in the present study the proportion of dead grass increased in fescue-red clover and orchardgrass-alfalfa by 4.6 and 10.3 percentage units, respectively, during the same period. Gerrish et al. (1994) reported that N fertilization reduced the proportion of dead grass in stockpiled tall fescue swards from 19 to 13%. From January to March the orchardgrass-clover mixture was higher in percent dead grass ($P < .05$) than the other forage mixtures. In April, percent dead grass decreased sharply in orchardgrass-clover, but was greater than for orchardgrass-alfalfa ($P < .05$), and intermediate for fescue red-clover ($P > .05$). All forage mixtures peaked in dead grass content in March, a reflection that forages started spring growth after that sampling date.

The forage mixtures were similar in dead legume content in October and November (Figure 6). By December there was a sharp increase ($P < .05$) in the

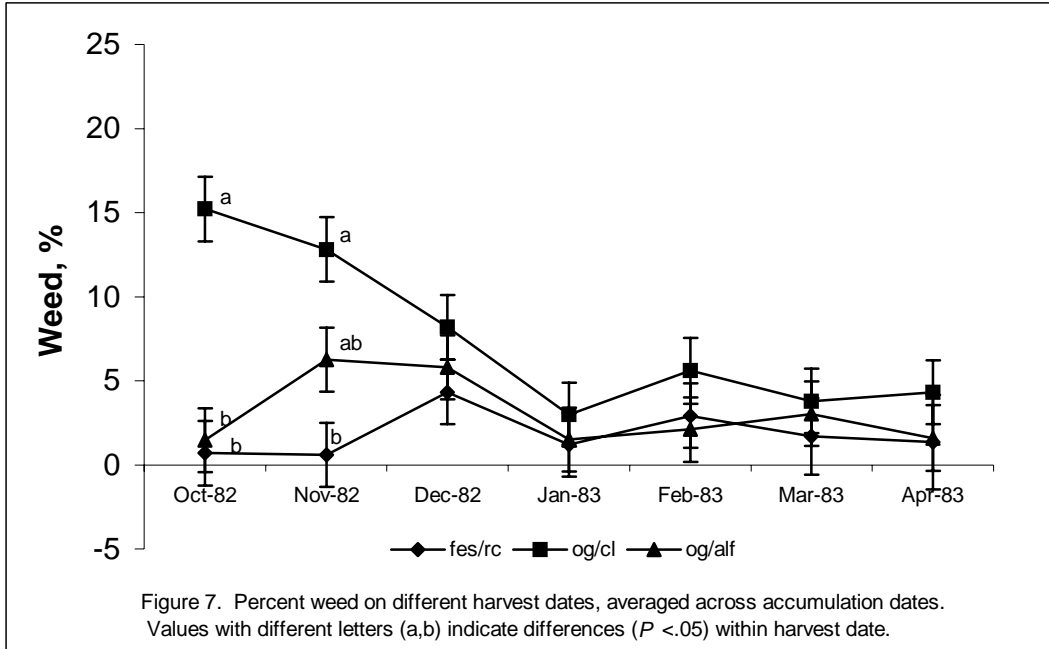


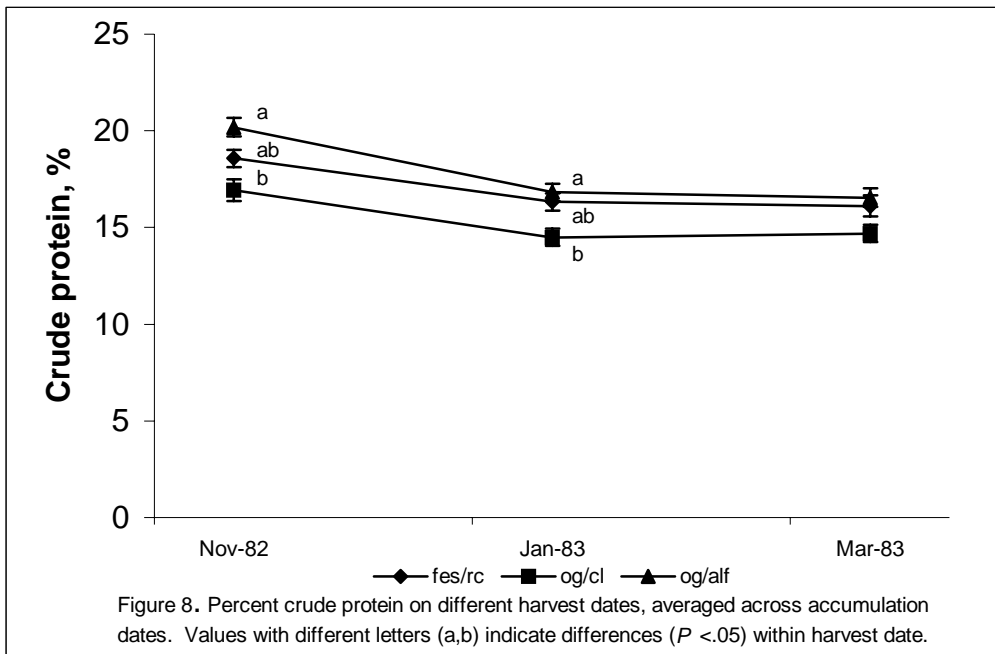


amount of dead legume in the orchardgrass-alfalfa mixture, compared to the orchardgrass-clover mixture (harvest date x forage system interaction, $P < .05$). This difference ($P < .05$) continued until February, after which the amount of dead legume declined and was not different among the three forage mixtures.

Weed contamination, shown in Figure 7, was greater in orchardgrass-clover than in the other forage mixtures in October (harvest date x forage system interaction, $P < .05$). By November, percent weed was greater in orchardgrass-clover than in fescue-red clover ($P < .05$) but not different from that in orchardgrass-alfalfa. From December through April there were no differences in weed content between the forage mixtures, which remained below 6% of the botanical composition.

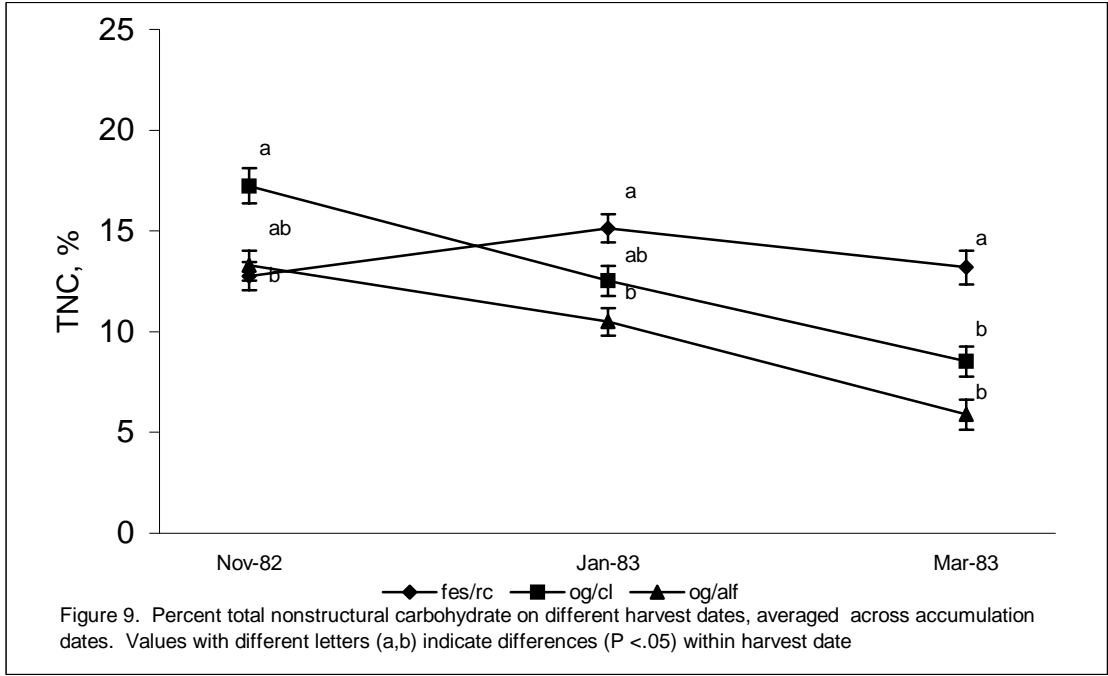
Effects of Harvest Dates on Forage Quality. Crude protein in these stockpiled forages averaged 15 to 20% through the sampling period (Figure 8), more than adequate for wintering beef cattle (NRC, 2000). The orchardgrass-alfalfa mixture was higher ($P < .05$) in CP than orchardgrass-clover, but not different from fescue-red clover, in November and January. This could be due to the presence of alfalfa as well as the tendency for orchardgrass to be higher in CP than fescue in stockpiling situations (Archer and Decker, 1977a). In March there was no difference in CP levels between the forage mixtures. Average CP values during the winter for orchardgrass-clover (~ 15%) and fescue-red clover (~ 17%) in this study compare favorably to those obtained by McLaren et al. (1983) for spring and summer grazed fescue-clover (14.4%) and orchardgrass-clover (14.9%).

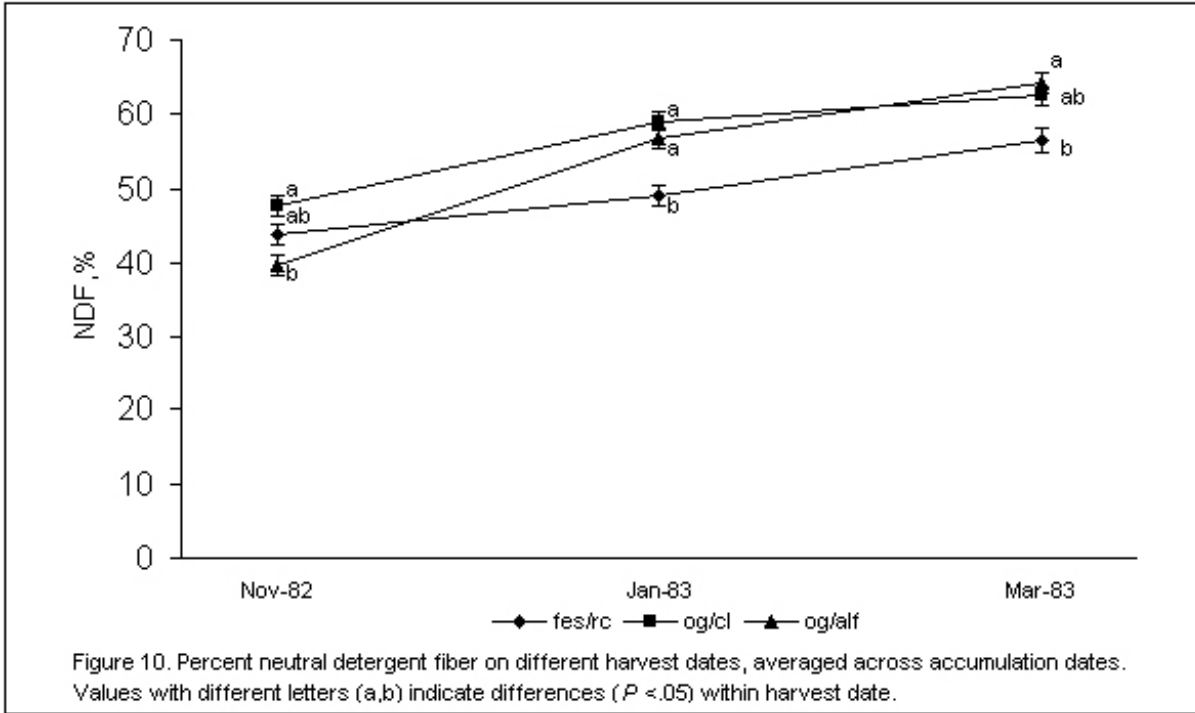


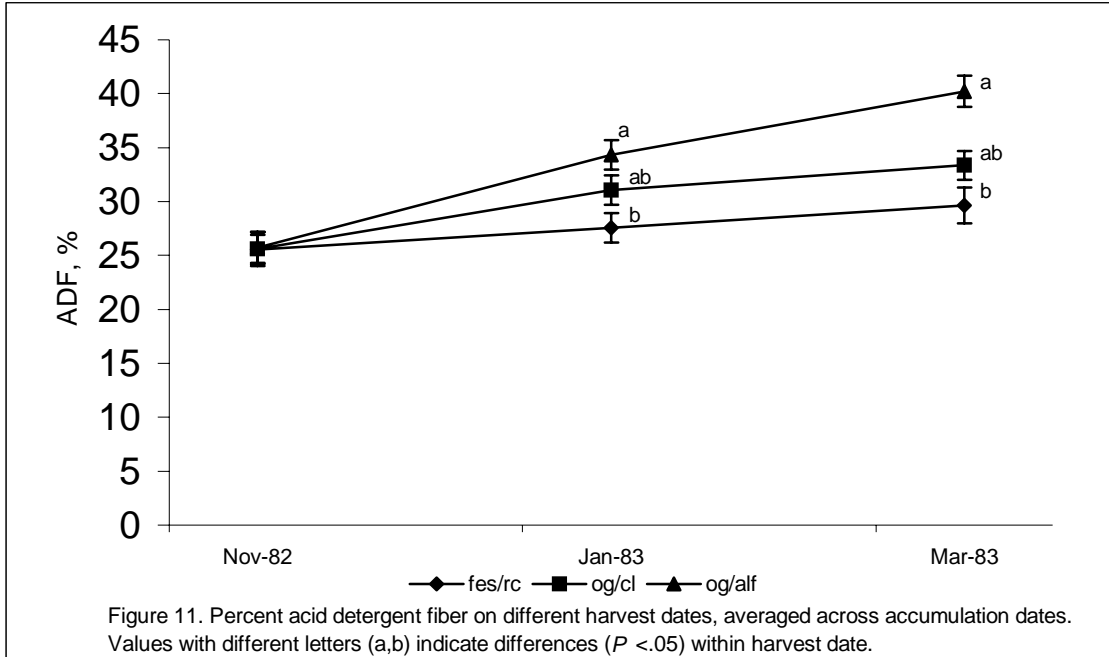


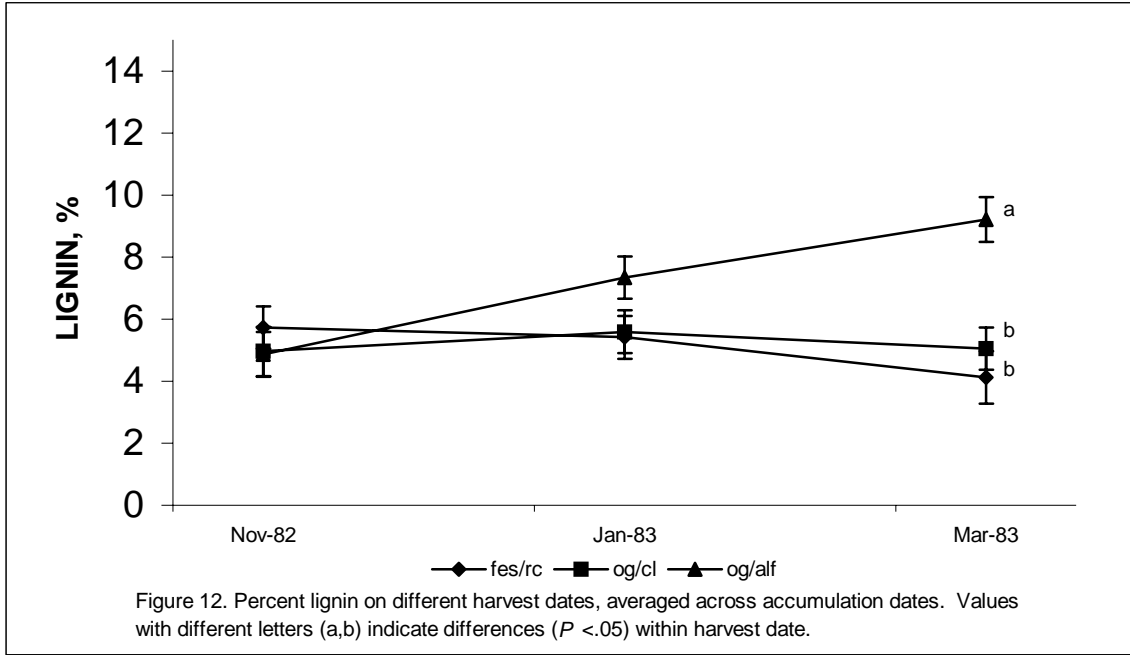
Orchardgrass-clover was higher in TNC content ($P < .05$) than fescue-red clover in November, but not different from that in orchardgrass-alfalfa (Figure 9). While the orchardgrass-containing mixtures exhibited a steady decline in TNC through the sampling period, the fescue-red clover TNC increased in January. In March, the TNC level was higher ($P < .05$) for fescue-red clover than that in the other mixtures (harvest date x forage system interaction, $P < .01$).

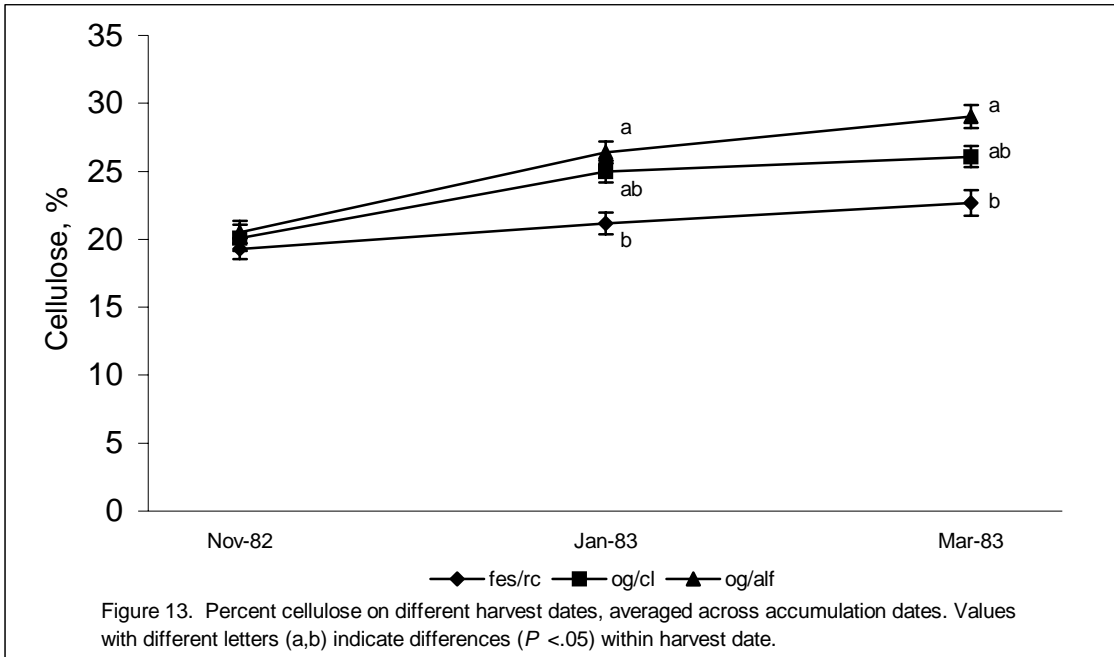
Neutral detergent fiber generally increased in all forage mixtures from November to March (Figure 10). In November, NDF was higher ($P < .05$) in the orchardgrass-clover mixture than the orchardgrass-alfalfa mixture. In January NDF was higher ($P < .05$) for orchardgrass-clover and orchardgrass-alfalfa than for fescue-red clover (harvest date x forage system interaction, $P < .01$), and this trend continued in March. In March, orchardgrass-alfalfa was higher ($P < .05$) in NDF than fescue-red clover, while orchardgrass-clover was intermediate. The three forage mixtures were similar in ADF in November (Figure 11). In January and March orchardgrass-alfalfa contained more ADF ($P < .05$) than fescue-red clover, while orchardgrass-clover was intermediate (harvest date x forage system interaction, $P < .05$). Orchardgrass-alfalfa nearly doubled in percent lignin (Figure 12) from November to March, and was higher ($P < .05$) than orchardgrass-clover and fescue-red clover in March (harvest date x forage system interaction, $P < .05$). Orchardgrass-clover and fescue-red clover remained fairly constant in lignin content across the sampling dates. However, the slight trend for a decrease in lignin and slight increase in TNC of the fescue-red clover from November to March contrasts with the findings of Bagley et al. (1983). They reported a large decrease in TNC for tall fescue during that period. The cellulose content (Figure 13) of the three forage mixtures paralleled







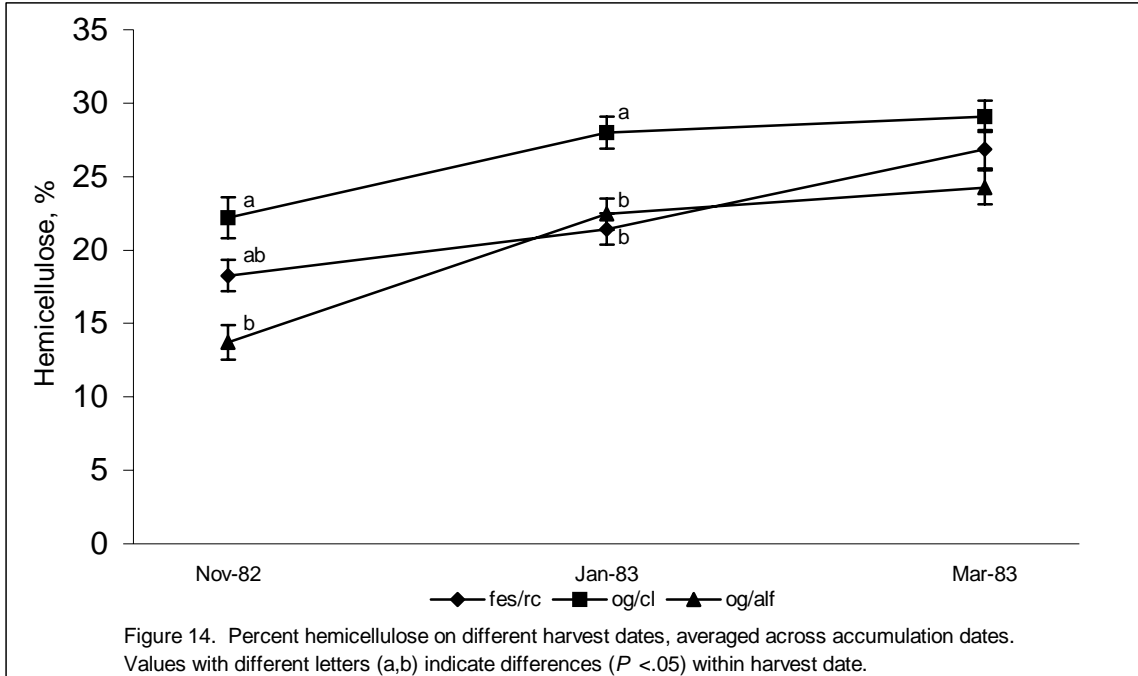


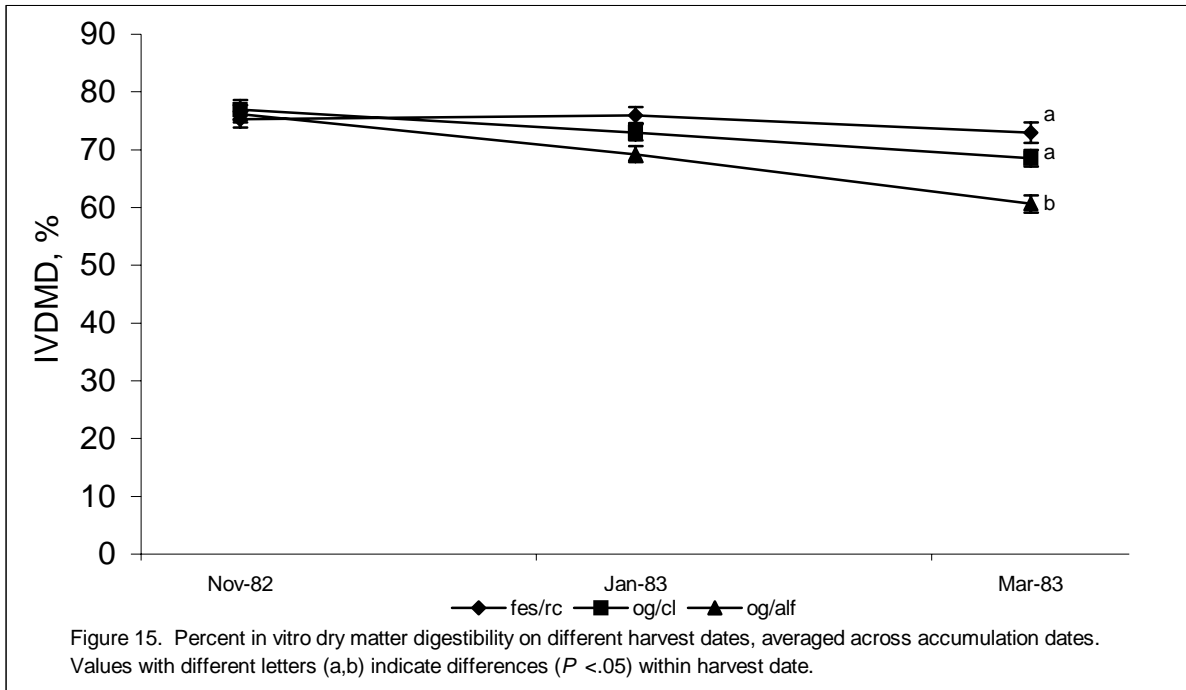


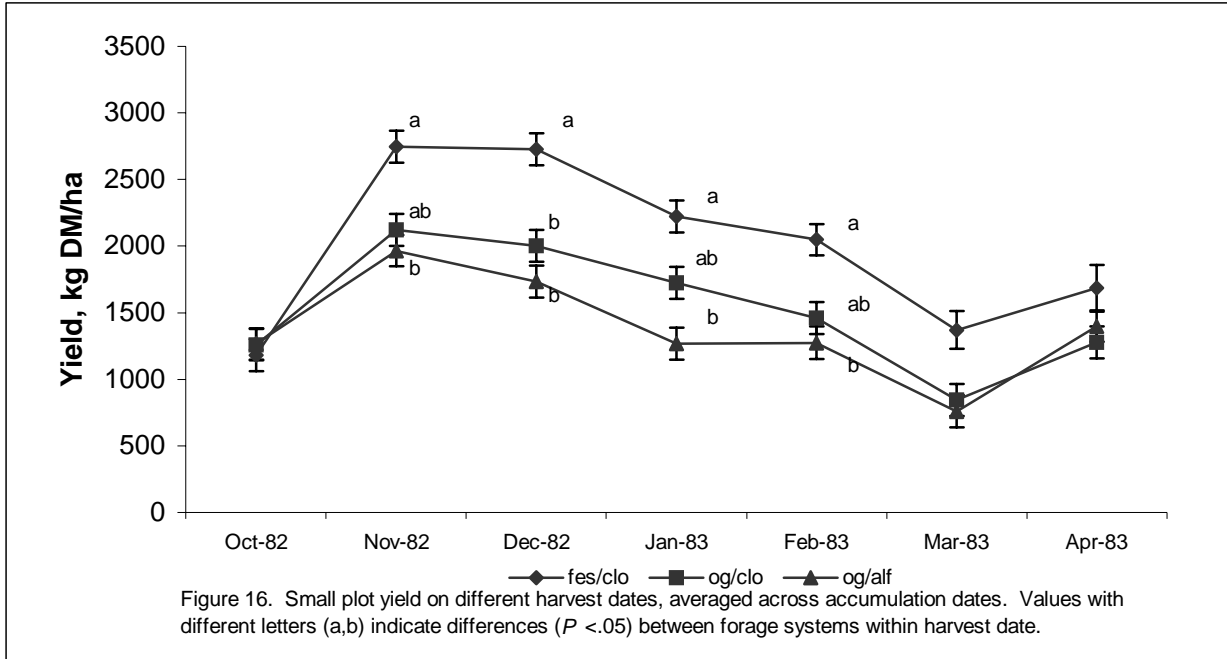
the percent ADF (Figure 11). Hemicellulose content (Figure 14) was higher ($P < .05$) in the orchardgrass-clover than orchardgrass-alfalfa in November and higher than the other mixtures in January, but not different in March.

The three forage mixtures were similar in IVDMD in November and January (Figure 15). It should be noted that the percent legume in the orchardgrass-clover mixture was only 22% at this time compared to 46% in the fescue-red clover and 36% in the orchardgrass-alfalfa, so the orchardgrass was the major contributor to the IVDMD value of 77%. This agrees with an average IVDMD of 79% in stockpiled orchardgrass sampled in November by Archer and Decker (1977a). By March, IVDMD was lower in orchardgrass-alfalfa ($P < .05$), but remained constant in the other mixtures (harvest date x forage system interaction, $P < .01$). The high IVDMD in the fescue-red clover mixture in March (72.9%) can be attributed to the grass component, since there was less than 5% legume at this sampling date. These trends agree with the comparison between autumn-accumulated tall fescue and orchardgrass made by Sheehan et al. (1985), except for November in this experiment, when the legume content in all forage mixtures was much higher than in January and March. Also, in the present experiment red clover persisted into January, as compared to only December, reported by Sheehan et al. (1985).

Effects of Harvest Dates on Yield. Yield data of the small plots are presented in Figure 16. The three forage mixtures did not differ in yield in October ($P > .05$), all approximately 1200 kg DM/ha. This is considerably less than tall fescue yields of 3153 kg OM/ha and orchardgrass yields of 2907 kg OM/ha harvested in October in Wisconsin, averaged over four N treatments and three locations (Riesterer et al.,





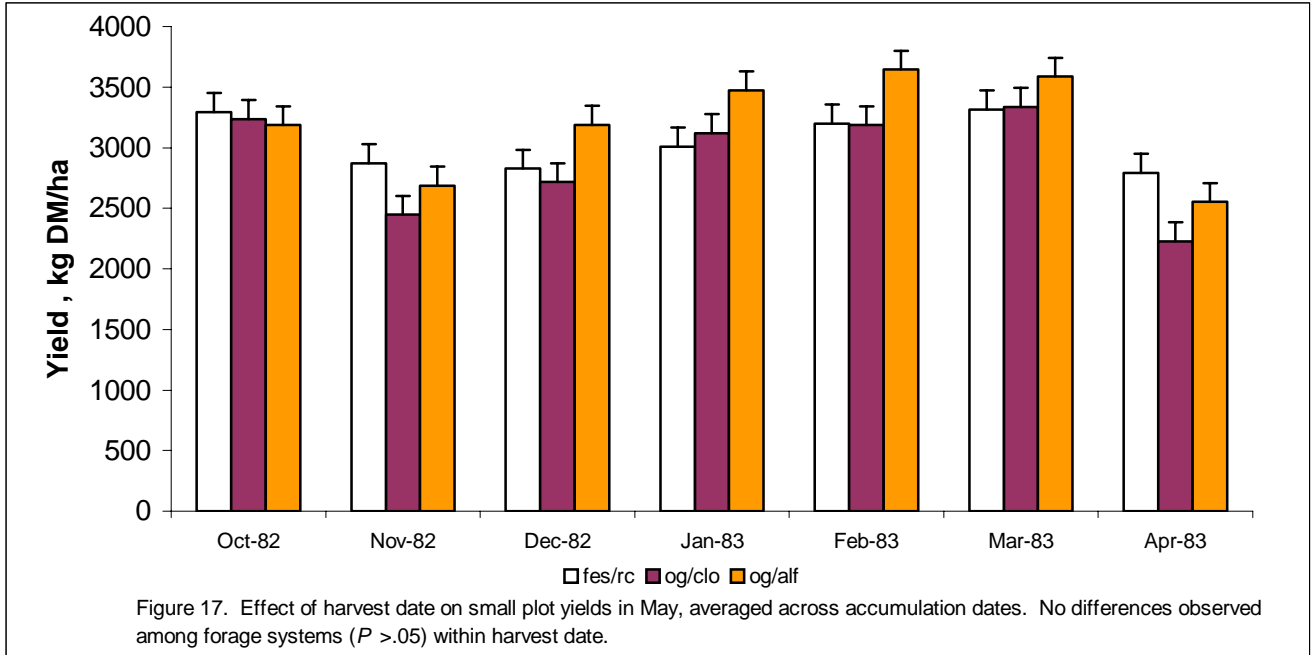


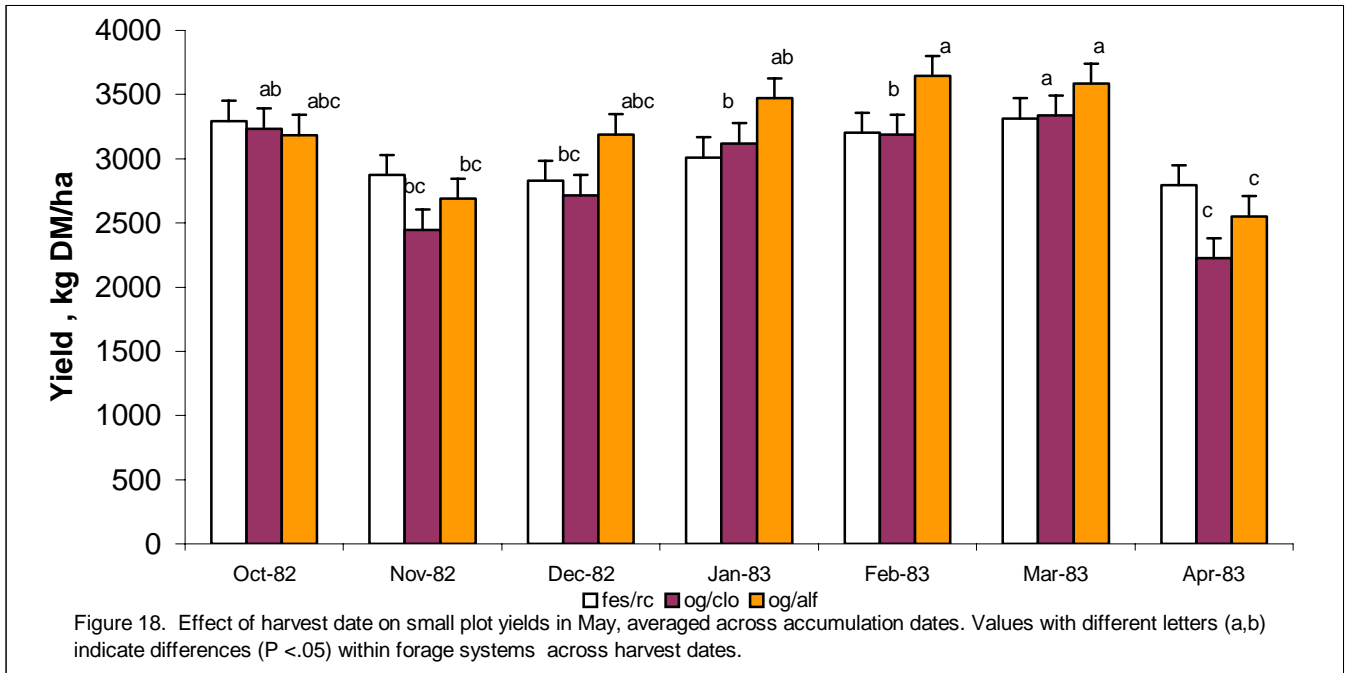
2000). In November, all forage mixtures reached maximum yields, consistent with the study by Archer and Decker (1981a) in Maryland, in which they reported yields of stockpiled orchardgrass and tall fescue harvested in November were higher than yields in October and December. Gerrish et al. (1994) in Missouri also measured maximum yields of stockpiled tall fescue in November, averaging 3258 kg DM/ha compared to 2747 kg DM/ha for fescue-red clover in the present study. Fescue-red clover yield increased sharply compared to the orchardgrass-containing mixtures, with fescue-red clover yielding more ($P < .05$) than orchardgrass-alfalfa while orchardgrass-clover was intermediate (harvest date x forage system interaction, $P < .01$). Yields of fescue-red clover accumulated on August 15 and harvested in November, December, January, and February (3177, 3157, 2651, 2384 kg DM/ha) were intermediate to those reported by Taylor and Templeton (1976) for fescue alone at higher (100 kg/ha) and lower (50 kg/ha) rates of N fertilization. The yield of fescue-red clover stayed constant in December and continued to be higher ($P < .05$) than orchardgrass-alfalfa through February, while yield of orchardgrass-clover was intermediate during this period except for December, when it was lower ($P < .05$) than fescue-red clover. Average December yield of tall fescue reported by Riesterer (2000) of 2783 kg OM/ha was similar to that observed for fescue-red clover (2728 kg DM/ha) in the present experiment, while the average December yield of orchardgrass of 2567 kg OM/ha (Reisterer et al., 2000) was greater than what was observed in the present experiment for orchardgrass-clover (2002 kg DM/ha) and orchardgrass-alfalfa (1732 kg DM/ha). Yields in March and April were not different ($P > .05$) among the forage mixtures in the present experiment. Fescue-red clover yields in March averaged 1370 kg DM/ha, considerably less than March tall fescue yields averaging

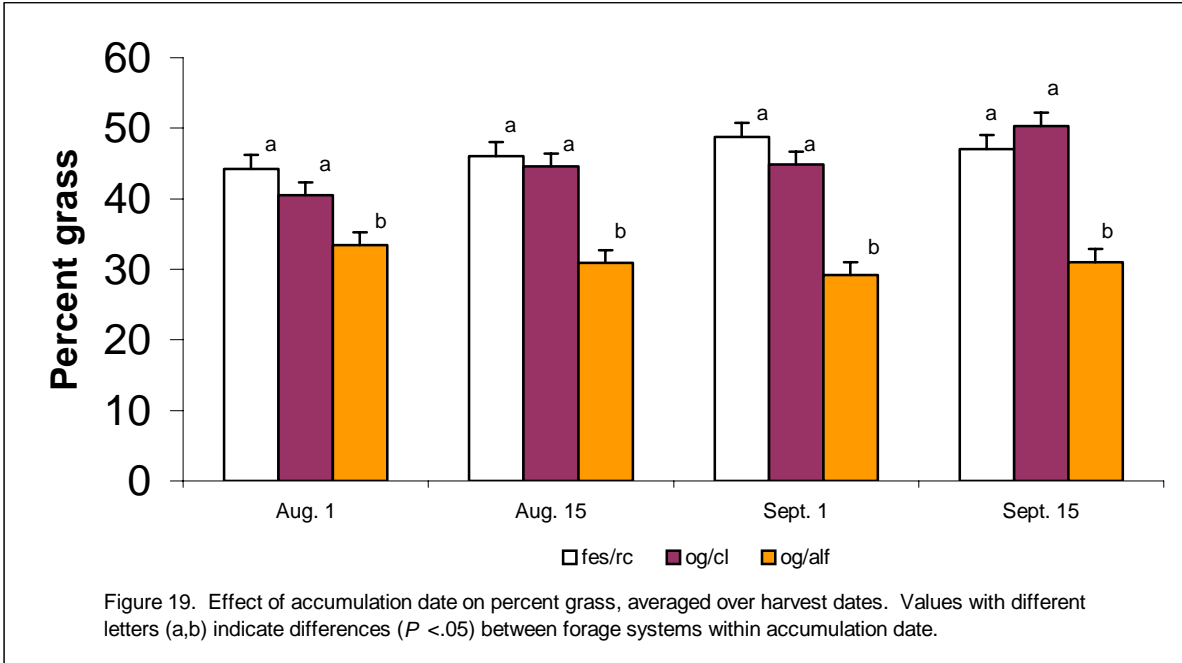
2430 kg OM/ha as reported by Riesterer et al. (2000). March yields of orchardgrass-legume mixtures in the present study averaged 803 kg DM/ha, while in Wisconsin yields of stockpiled orchardgrass averaged 2040 kg OM/ha (Riesterer et al., 2000). From December to March, yields of stockpiled forages generally decreased in the present study, coinciding with an increase in amounts of dead grass and dead legume.

Effects of Harvest Dates on Spring Yield. Yield data of forage mixtures from all harvest dates on May 11, 1983 are presented in Figure 17. Forage mixtures harvested on the same date during autumn or winter did not differ in yield when harvested in May ($P > .05$). However, Figure 18 illustrates differences observed ($P < .05$) when comparing the influence of different harvest dates on May yield of a particular forage mixture. Orchardgrass-alfalfa yields were higher in May after being clipped in February and March, compared to November and April, and lower but not different ($P > .05$) when clipped in Oct., December, and January. Yields of orchardgrass-clover were higher ($P < .05$) in May after being clipped in Mar. than when clipped in November, December, January, February or April. Interestingly, yields of fescue-red clover in May were not affected by date of harvest in autumn or winter ($P > .05$), averaging 3045 kg DM/ha.

Effects of Accumulation Date on Botanical Composition. For each of the four accumulation dates, fescue-red clover and orchardgrass-clover had higher ($P < .05$) percentages of grass than orchardgrass-alfalfa (Figure 19, accumulation date x forage system interaction, $P < .01$). Within forage system, delaying stockpiling until



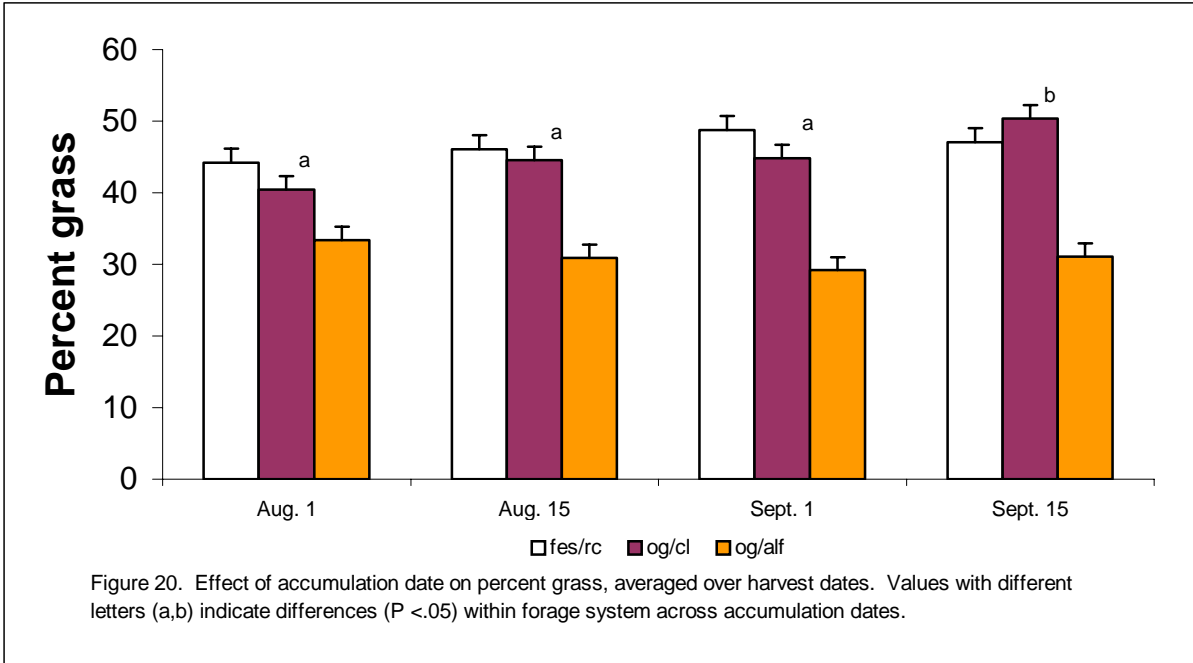


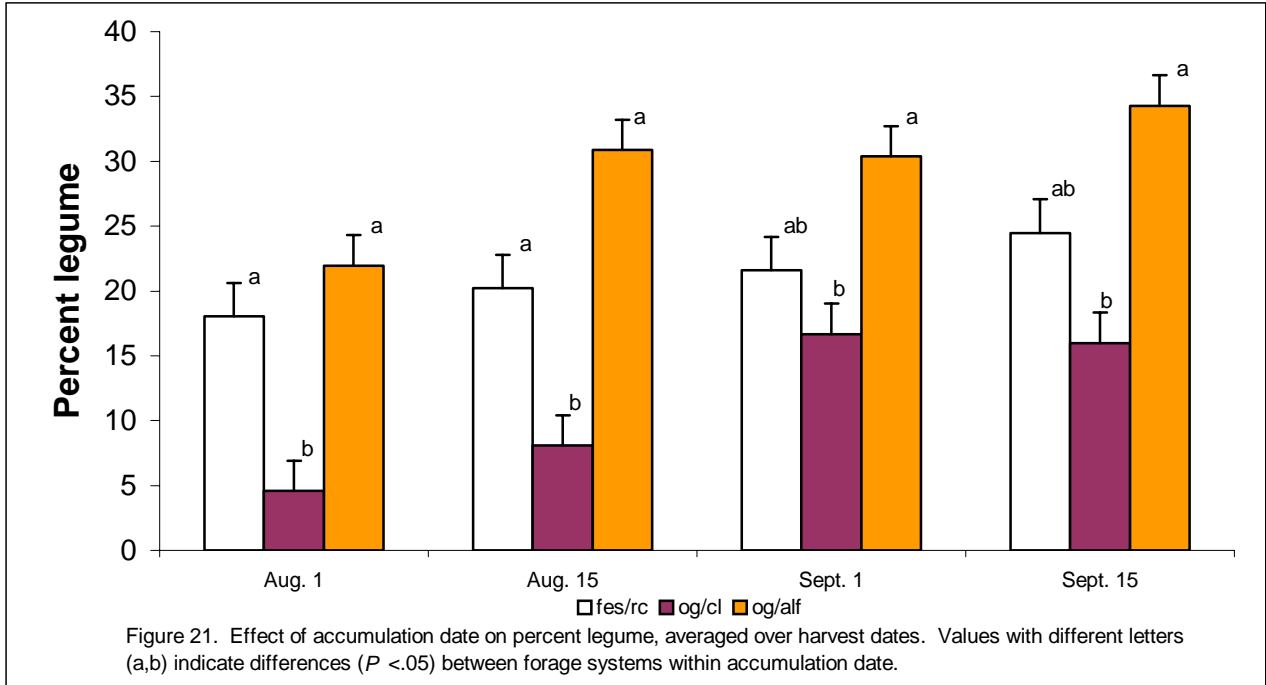


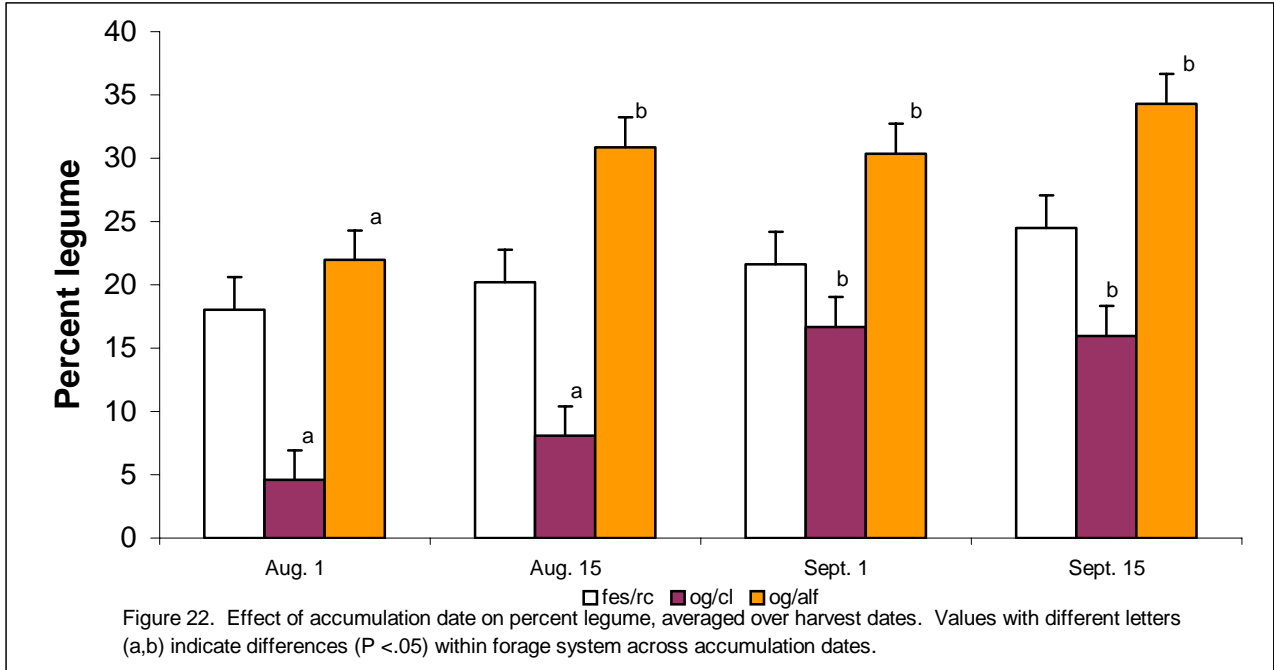
September 15 resulted in an increase ($P < .05$) in the grass component of orchardgrass-clover (Figure 20), but had no effect ($P > .05$) on the amount of grass in fescue-red clover or orchardgrass-alfalfa.

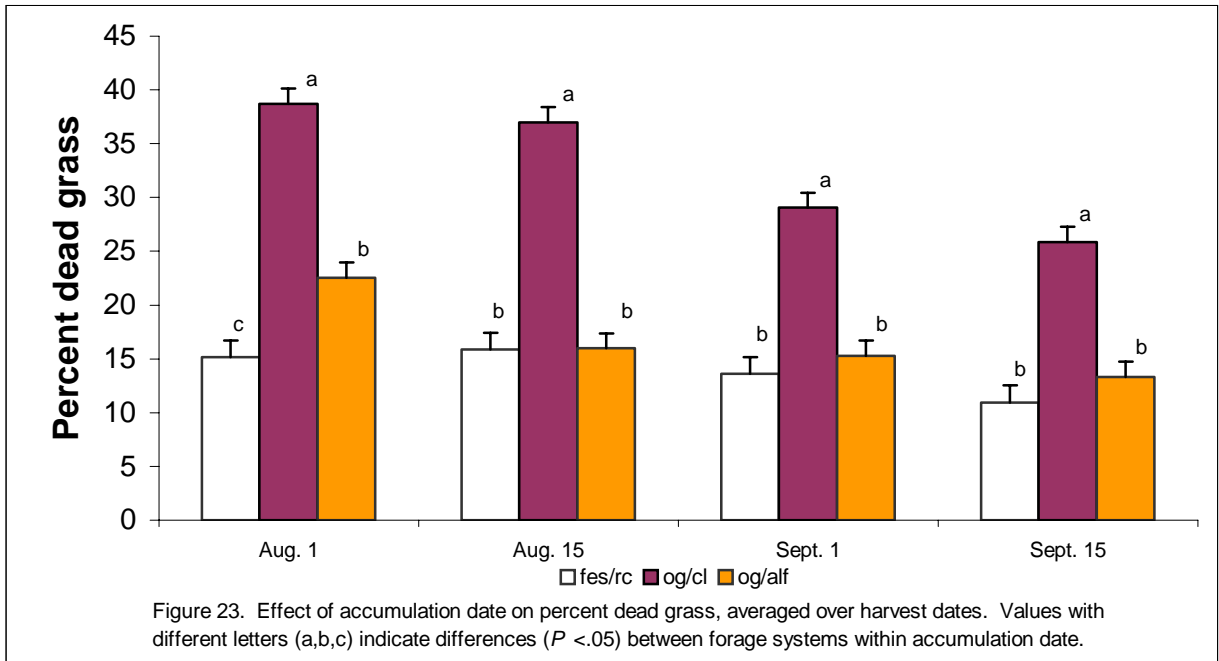
Orchardgrass-clover was lower ($P < .05$) in percent legume compared to orchardgrass-alfalfa for all four accumulation dates (Figure 21). Orchardgrass-clover was also lower ($P < .05$) in percent legume than fescue-red clover for the August 1 and 15 accumulation dates (accumulation date x forage system interaction, $P < .01$). Fescue-red clover was intermediate in percent legume for the September 1 and 15 accumulation dates. Within forage system, percent legume was higher ($P < .05$) in orchardgrass-alfalfa when accumulated on August 15, September 1 and September 15 than on August 1 (Figure 22). Percent legume increased ($P < .05$) in orchardgrass-clover when stockpiled on September 1 and 15 compared to August 1 and 15. On the other hand, accumulation date had no ($P > .05$) effect on percent legume in fescue-red clover.

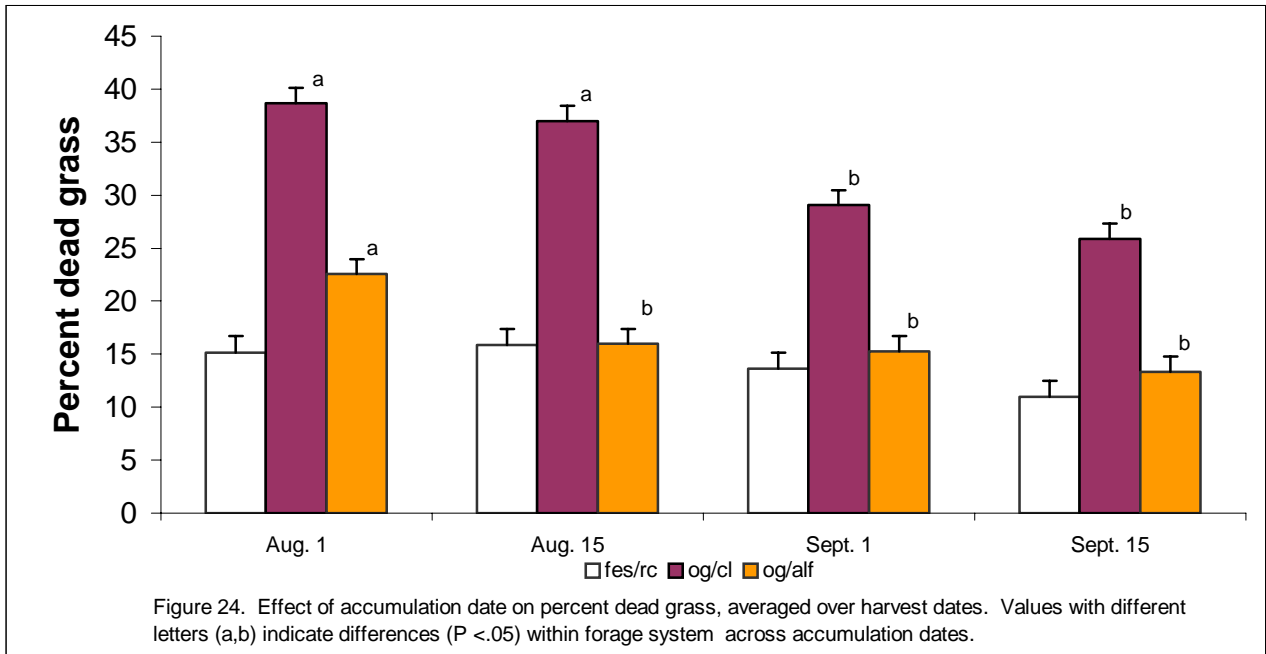
The highest percent dead grass was measured in orchardgrass-clover for all accumulation dates (Figure 23, $P < .05$). Except for August 1, when fescue-red clover was lowest ($P < .05$), fescue-red clover and orchardgrass-alfalfa contained similar amounts of dead grass for the August 15, September 1 and September 15 accumulation dates (accumulation date x forage system interaction, $P < .001$). Within forage system, orchardgrass-clover had more ($P < .05$) dead grass when stockpiled on both August dates than when stockpiled on both September dates (Figure 24). Orchardgrass-alfalfa contained more dead grass when stockpiled on August 1 compared to the other 3 accumulation dates. Percent dead grass was not affected by accumulation date in fescue-red clover ($P > .05$).







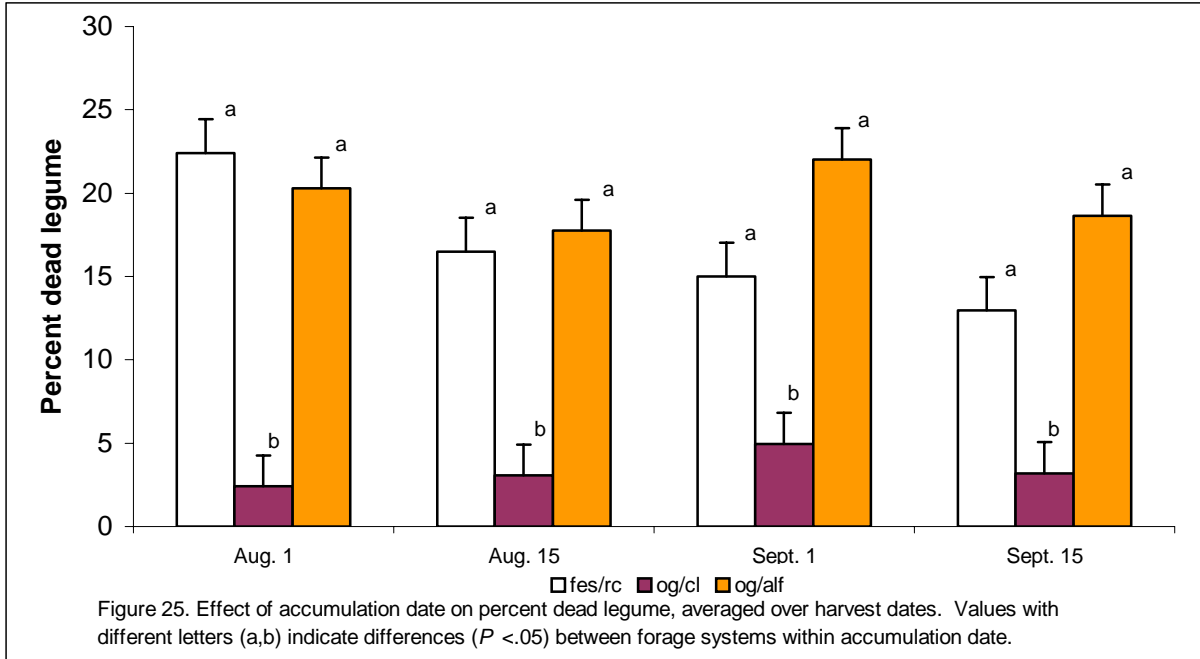


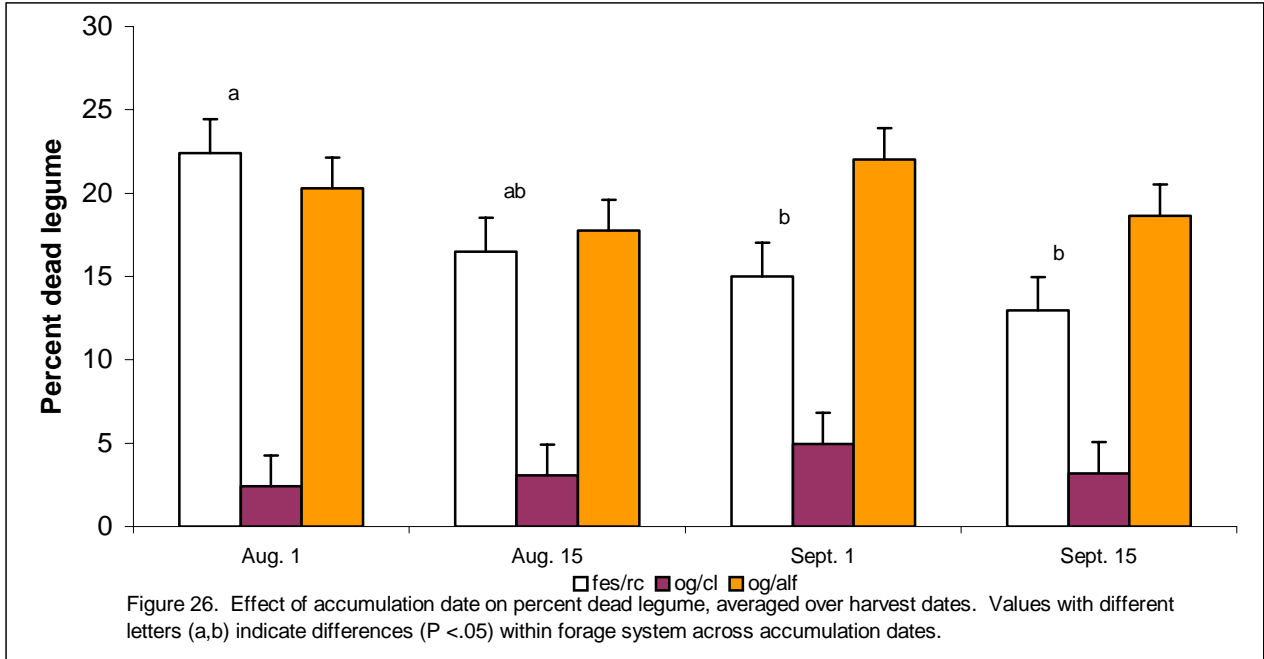


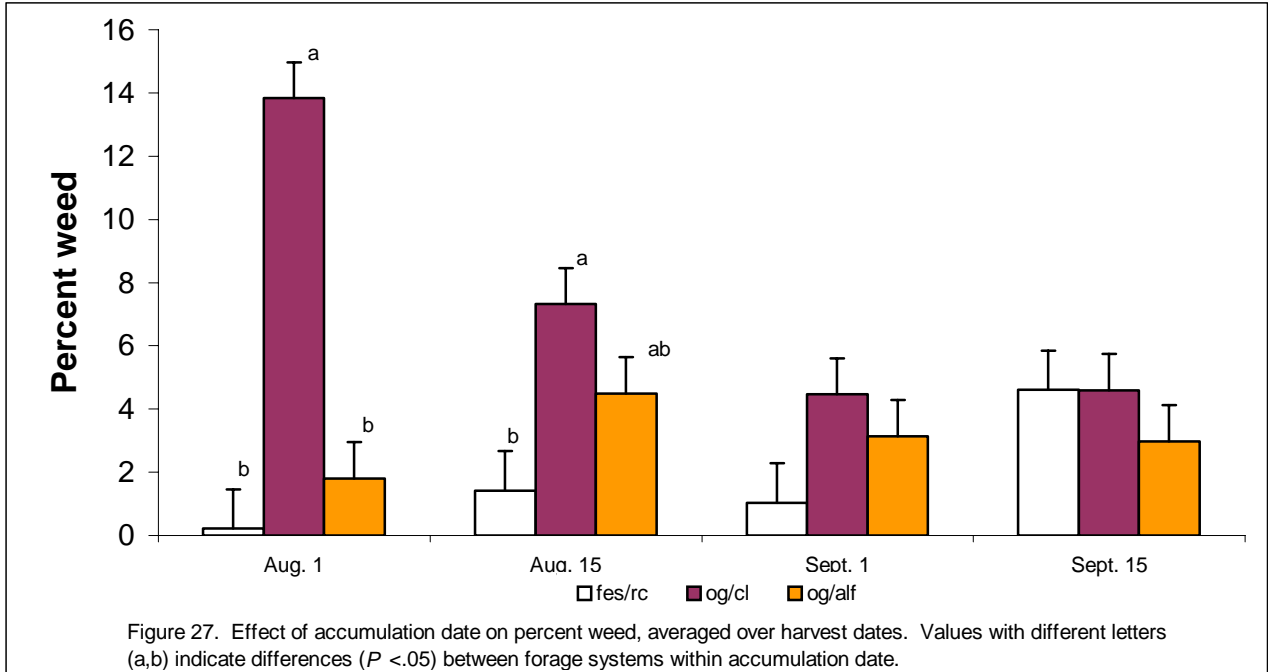
Orchardgrass-clover contained the lowest ($P < .05$) percent dead legume (Figure 25) compared to orchardgrass-alfalfa and fescue-red clover for all accumulation dates (accumulation date x forage system interaction, $P < .01$). Within forage system, percent dead legume was higher ($P < .05$) in fescue-red clover stockpiled on August 1 (Figure 26), compared to September 1 and 15. Accumulation date did not affect the amount of dead legume in orchardgrass-clover or orchardgrass-alfalfa.

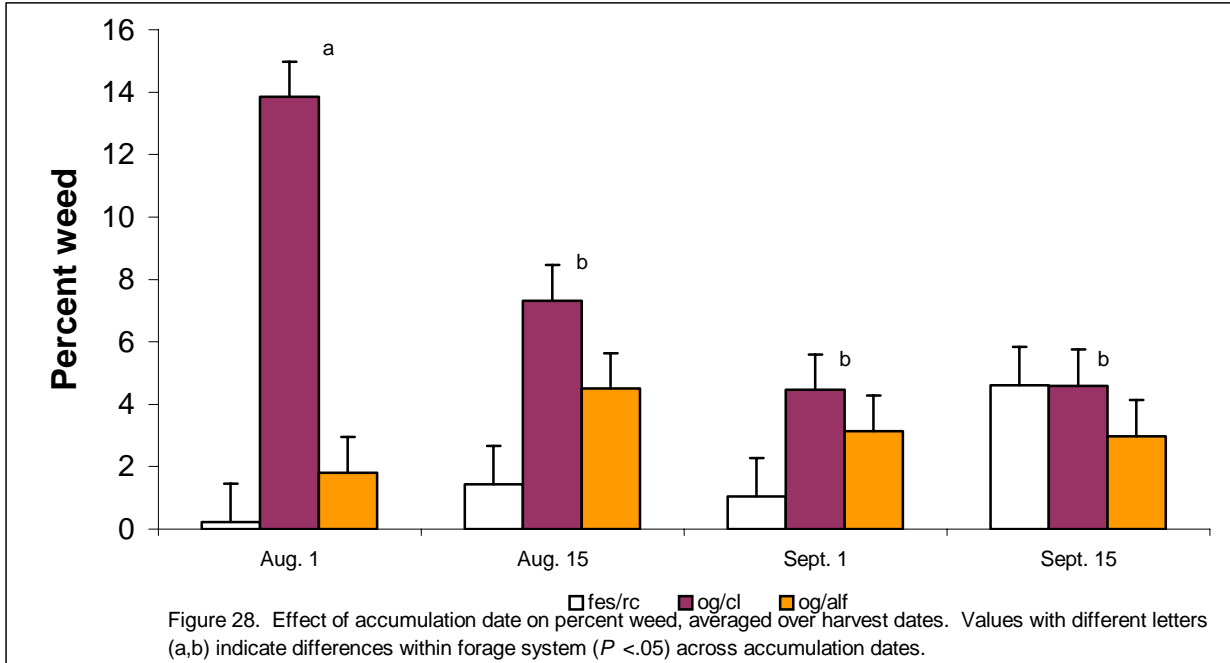
The percent weed was much higher ($P < .05$, Figure 27) in orchardgrass-clover than in the other forage mixtures for the August 1 accumulation date (accumulation date x forage system interaction, $P < .001$). When stockpiled on August 15 orchardgrass-clover contained more ($P < .05$) weeds than fescue-red clover, while orchardgrass-alfalfa was intermediate. There were no differences in weed content ($P > .05$) among the forage mixtures for the September 1 and 15 accumulation dates. Within forage system, orchardgrass-clover was highest ($P < .05$) in percent weed when stockpiled on August 1 (Figure 28) compared to the other accumulation dates. Percent weed was not affected by accumulation date in fescue-red clover or orchardgrass-alfalfa ($P > .05$).

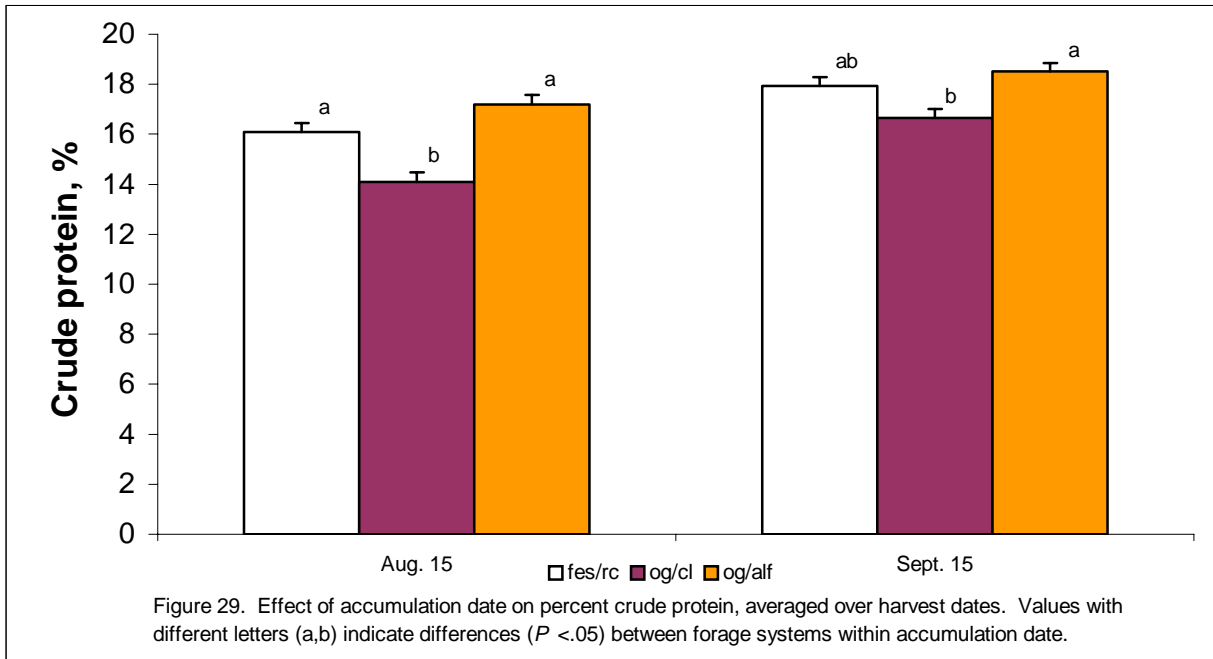
Effects of Accumulation Date on Forage Quality. Crude protein was higher ($P < .05$) in fescue-red clover and orchardgrass-alfalfa than orchardgrass-clover for the August 15 accumulation date (Figure 29). Orchardgrass-alfalfa was higher ($P < .05$) in CP content than orchardgrass-clover for the September 15 accumulation date, while fescue red-clover was intermediate in CP content. Rayburn et al. (1979)









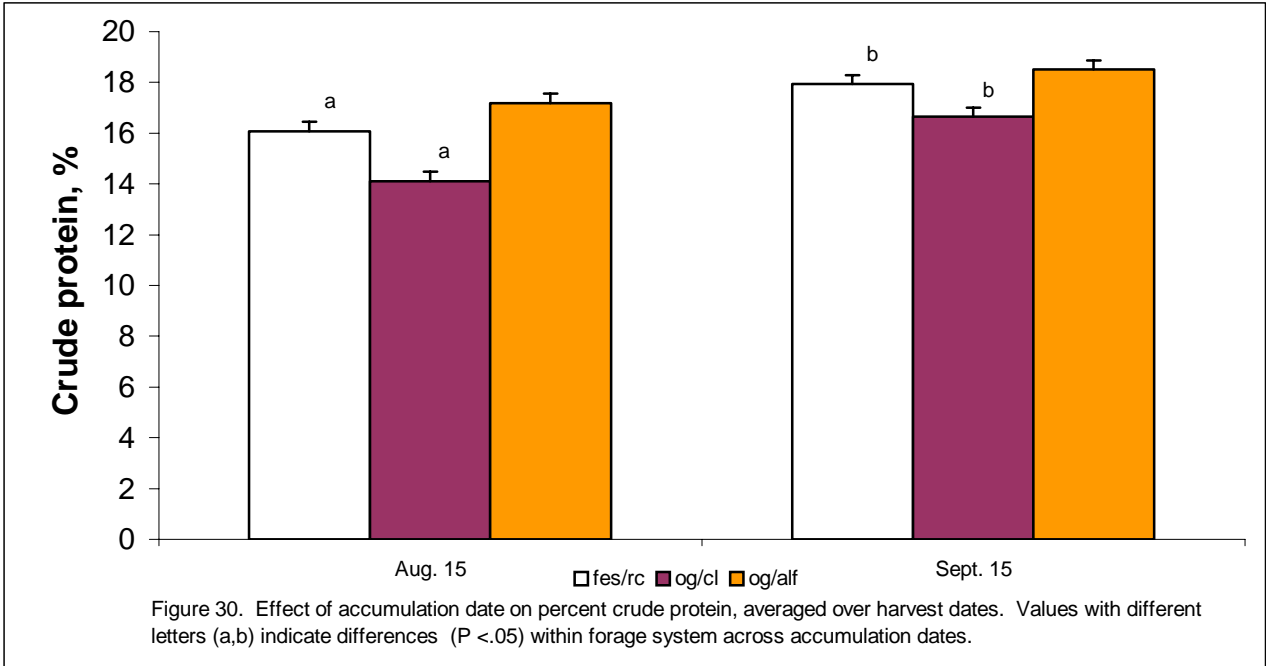


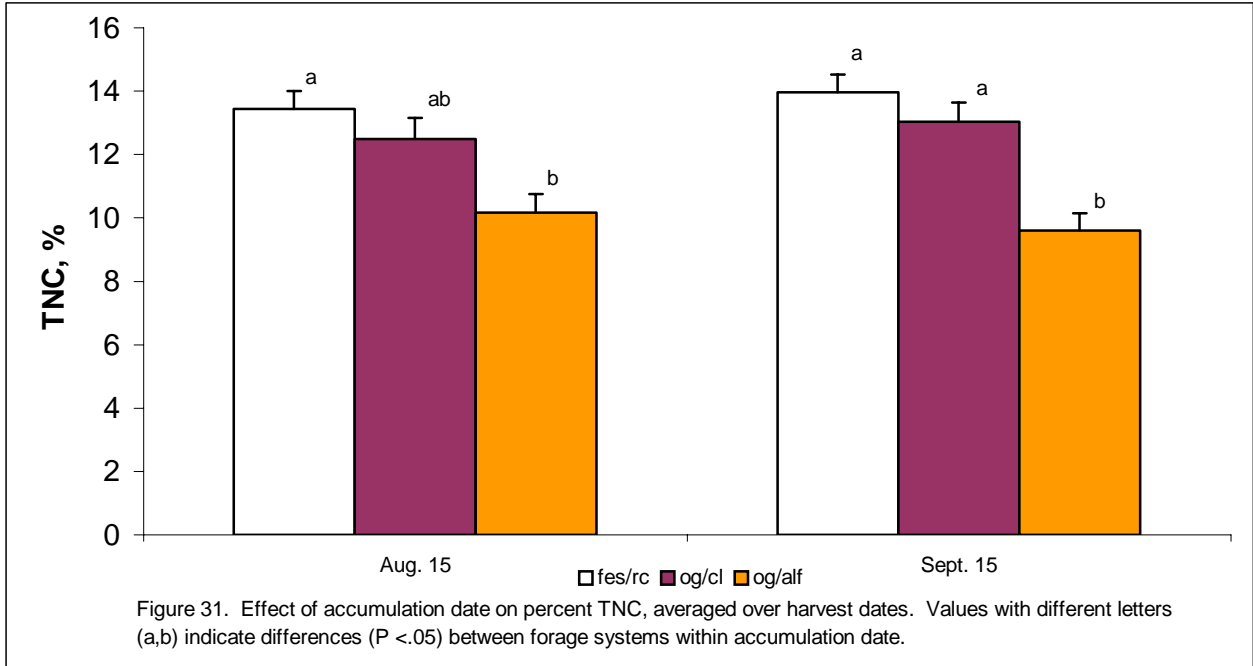
reported increases in CP of stockpiled tall fescue with later date of N fertilization and initiation of stockpiling. Within forage system, increases ($P < .05$) in CP were observed in the present experiment for fescue-red clover (17.9% vs. 16.1%) and orchardgrass-clover (16.6% vs. 14.1%) stockpiled on September 15 as compared to August 15 (Figure 30). The CP content of orchardgrass-alfalfa did not change with the delay in stockpiling date.

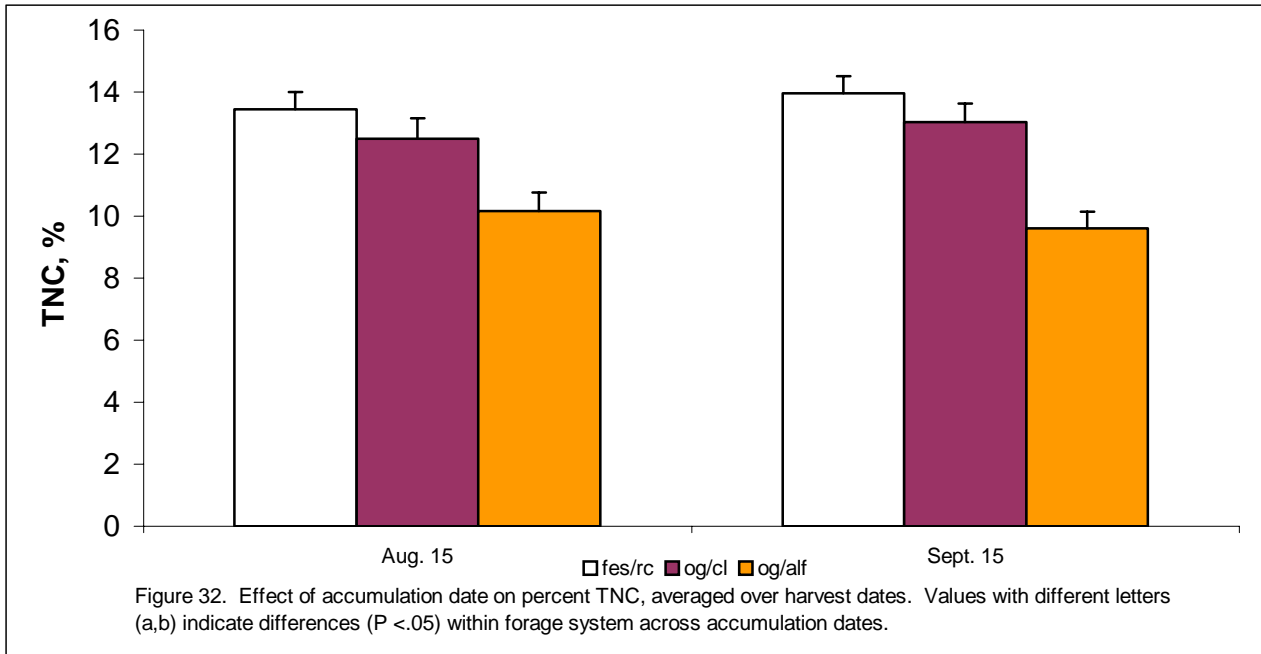
Fescue red-clover was higher ($P < .05$) in TNC than orchardgrass-alfalfa for both the August 15 and the September 15 accumulation dates (Figure 31). Orchardgrass-clover was intermediate in TNC content for August 15, and was higher than orchardgrass-alfalfa for the September 15 accumulation date. Increases in TNC content of December harvested tall fescue were observed by Rayburn et al. (1979) as stockpiling was delayed from June to September. Within forage system, TNC content of the forage mixtures in this study did not differ ($P > .05$) due to accumulation date (Figure 32).

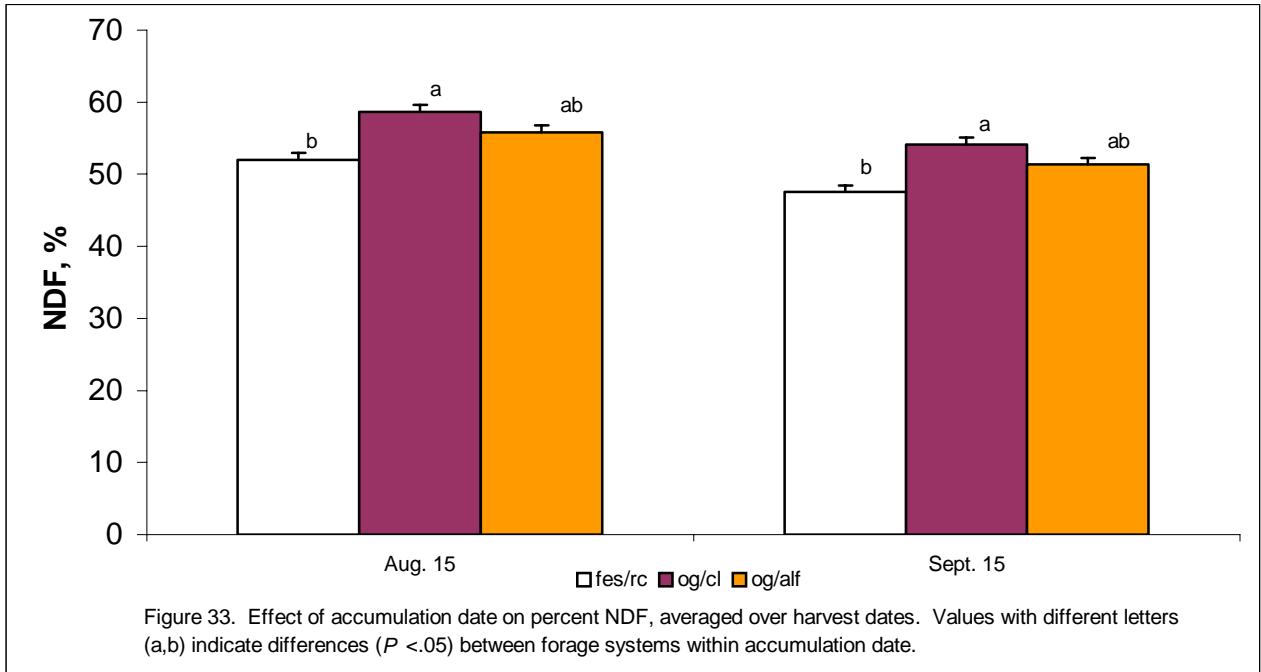
Neutral detergent fiber was higher ($P < .05$) in orchardgrass-clover than in fescue red-clover for the August 15 and September 15 accumulation dates (Figure 33). Orchardgrass-alfalfa was intermediate in NDF content for both accumulation dates. Within forage system, NDF in all three forage mixtures decreased ($P < .05$) by an average of four percentage units with the delay in stockpiling date from August 15 to September 15 (Figure 34). Gerrish and coworkers (1994) reported a similar decrease in NDF in stockpiled tall fescue when N fertilization was delayed from August 1 to August 29. They termed it a small and possibly negligible effect.

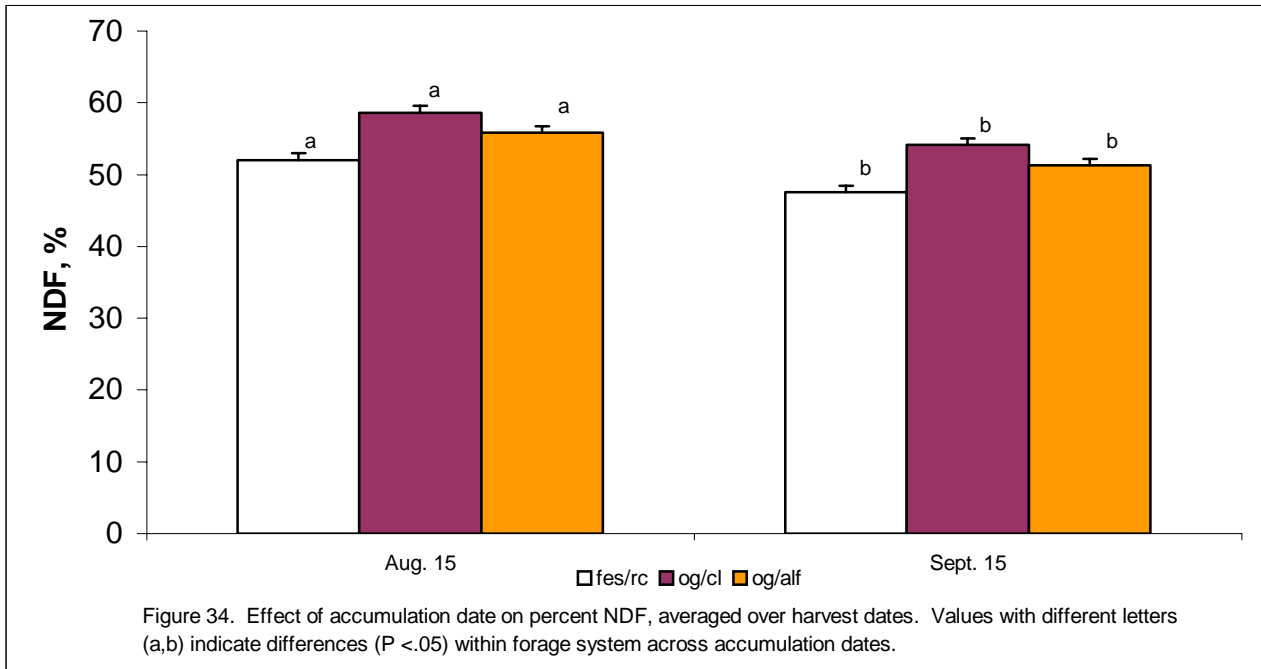
There were no differences ($P > .05$) in ADF among the forage









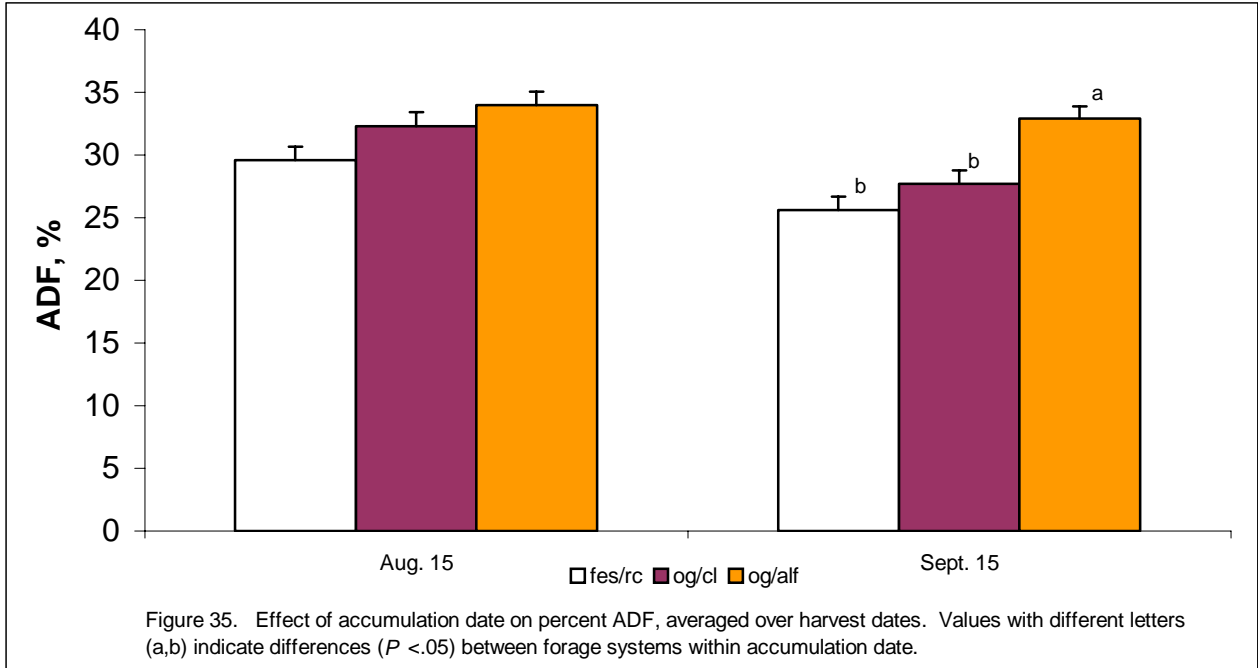


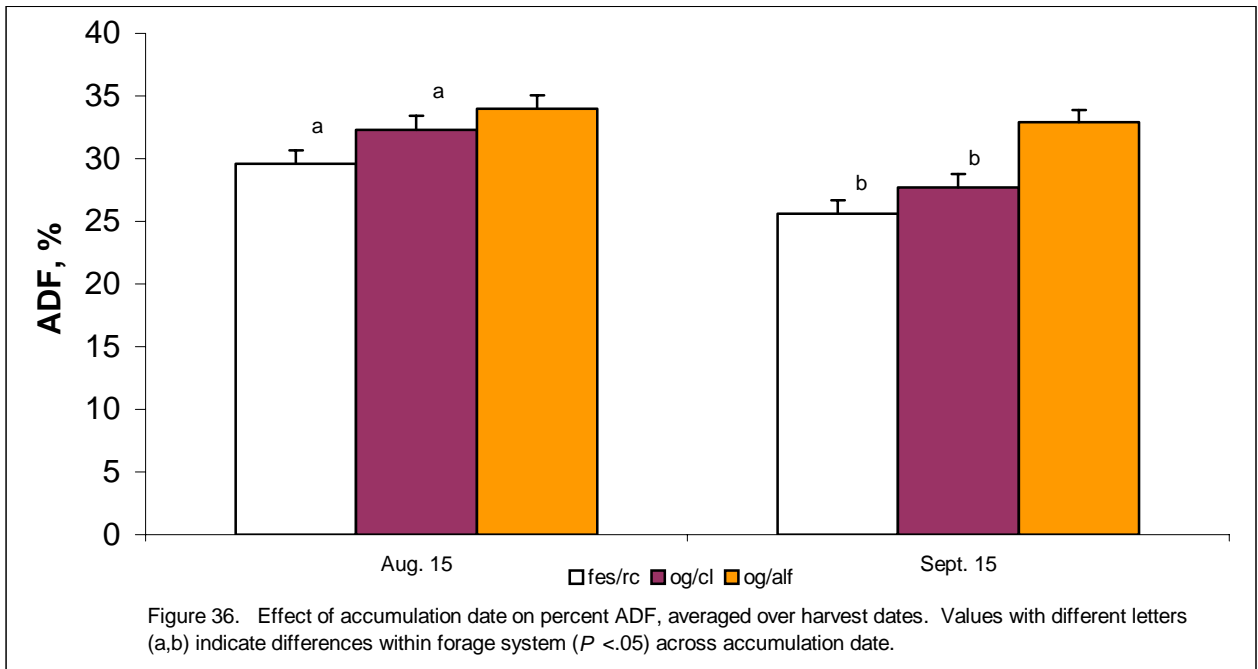
mixtures stockpiled on August 15 (Figure 35). However, when stockpiled on September 15, orchardgrass-alfalfa was higher ($P <.05$) in ADF than fescue red-clover and orchardgrass-clover. Within forage system, fescue-red clover and orchardgrass-clover stockpiled on August 15 contained more ($P <.05$) ADF than when stockpiled on September 15 (Figure 36). Accumulation date did not affect ADF content in orchardgrass-alfalfa ($P >.05$).

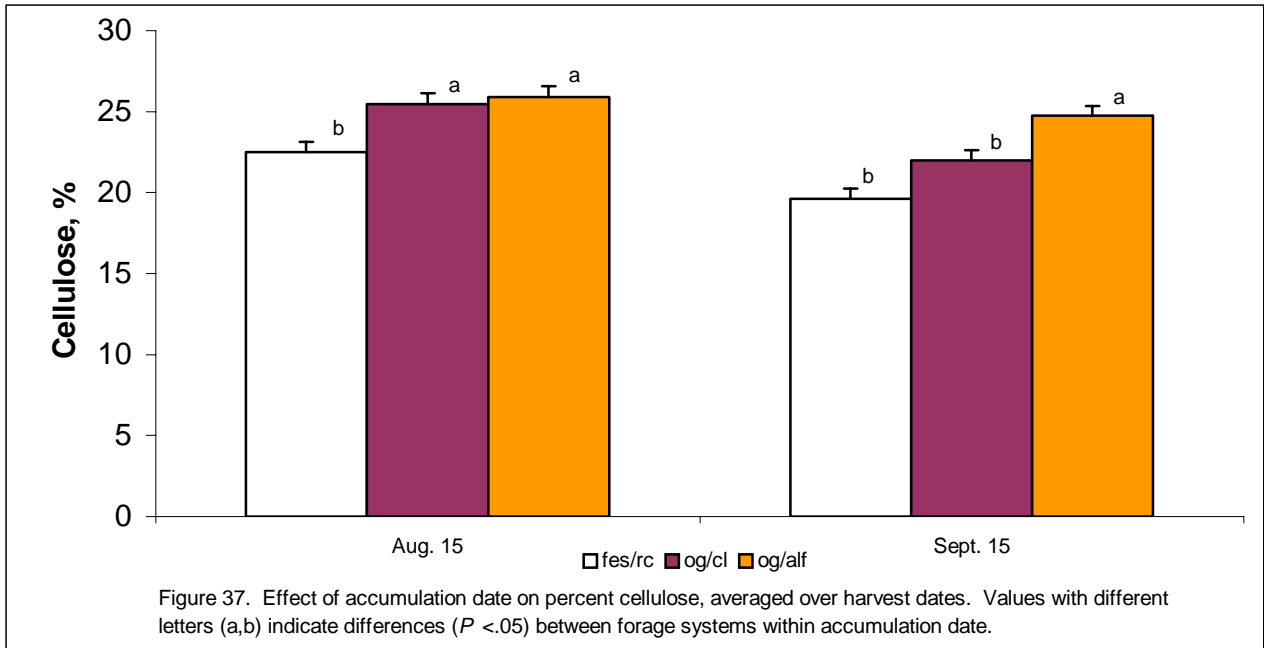
Fescue red-clover was lower ($P <.05$) in cellulose than orchardgrass-clover and orchardgrass-alfalfa (Figure 37), for the August 15 accumulation date. Both fescue red-clover and orchardgrass-clover contained less ($P <.05$) cellulose than orchardgrass-alfalfa when stockpiled on September 15. Within forage system, cellulose content decreased ($P <.05$) in fescue-red clover and orchardgrass-clover when stockpiling was delayed from August 15 to September 15 (Figure 38). Cellulose content was not affected by accumulation date in orchardgrass-alfalfa ($P >.05$).

For both accumulation dates orchardgrass-clover contained more ($P <.05$) hemicellulose than orchardgrass-alfalfa (Figure 39). Fescue-red clover was intermediate in hemicellulose content for August 15, and lower ($P <.05$) than orchardgrass-clover for September 15. Within forage system, accumulation date did not affect ($P >.05$) hemicellulose content (Figure 40).

The three forage mixtures were not different ($P >.05$) in percent lignin for the August 15 accumulation date (Figure 41). For September 15, orchardgrass-alfalfa contained more ($P <.05$) lignin than fescue-red clover and orchardgrass-clover. Within forage system, accumulation date had no effect ($P >.05$) on lignin content (Figure 42).







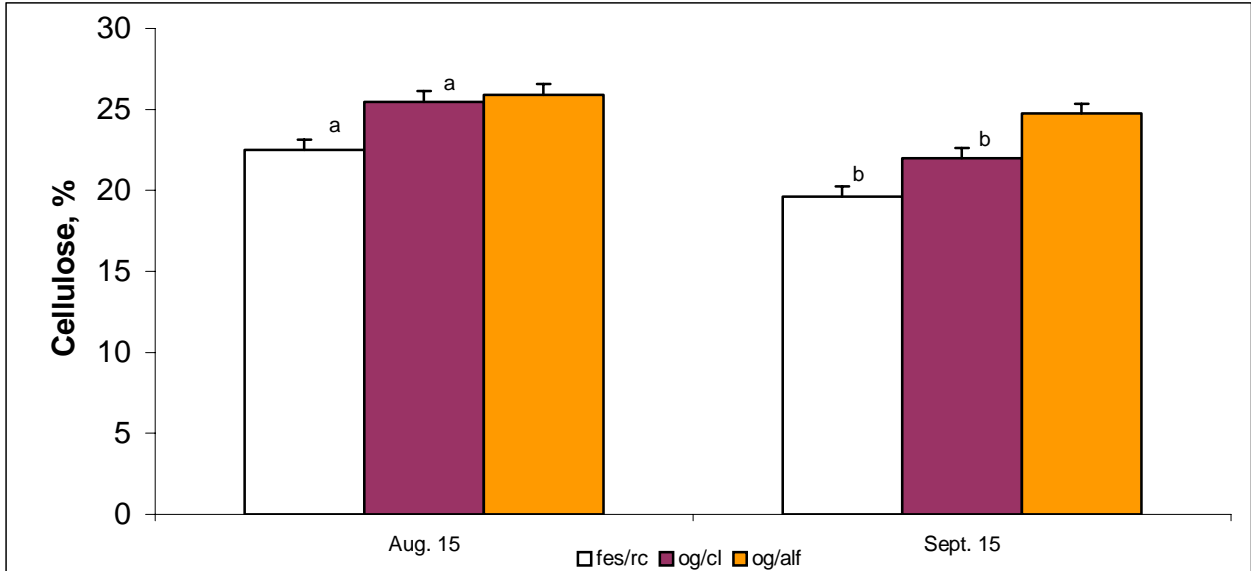
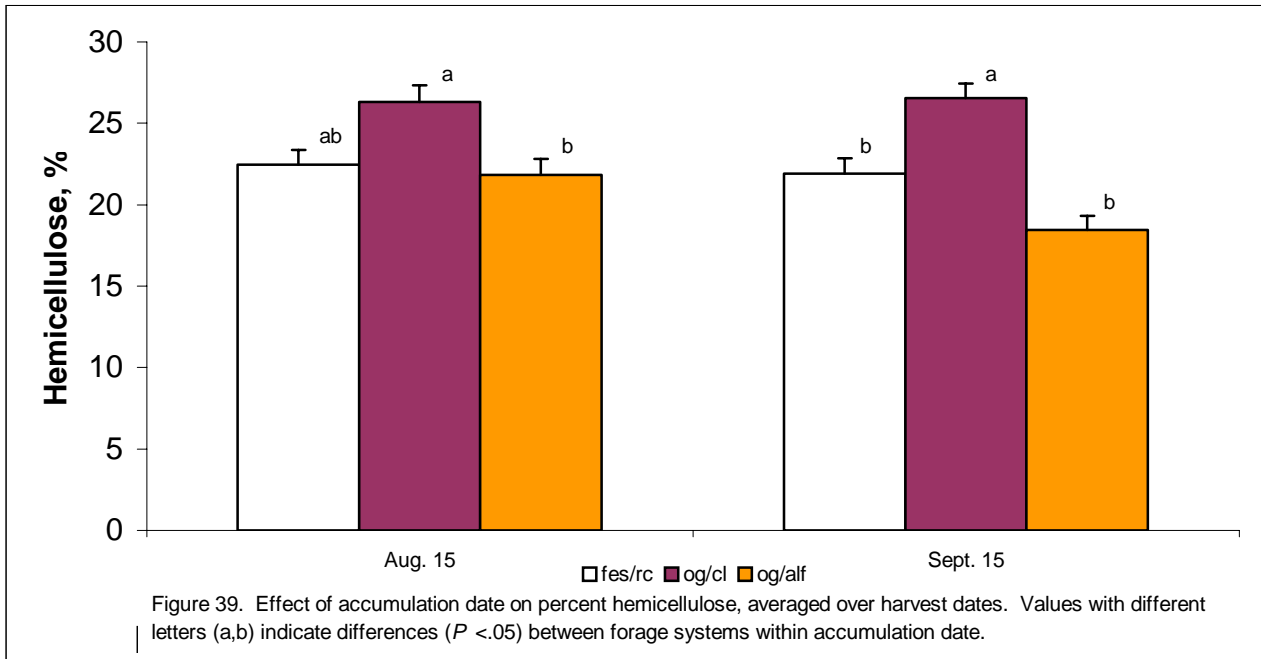
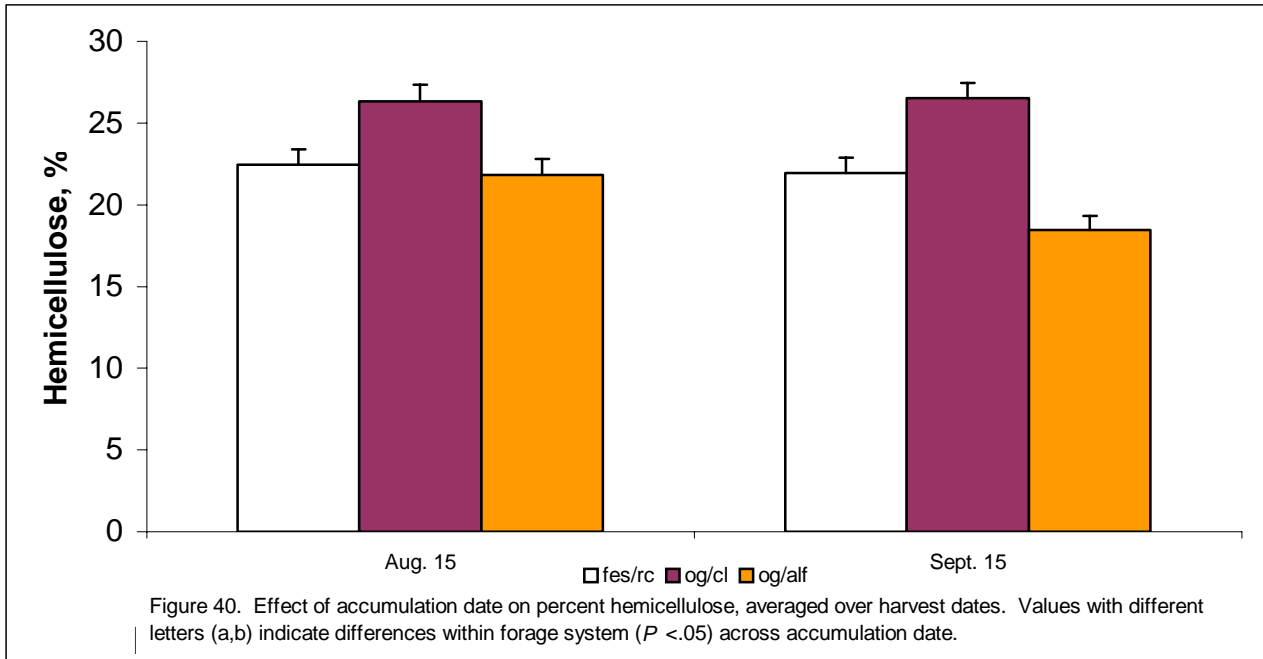
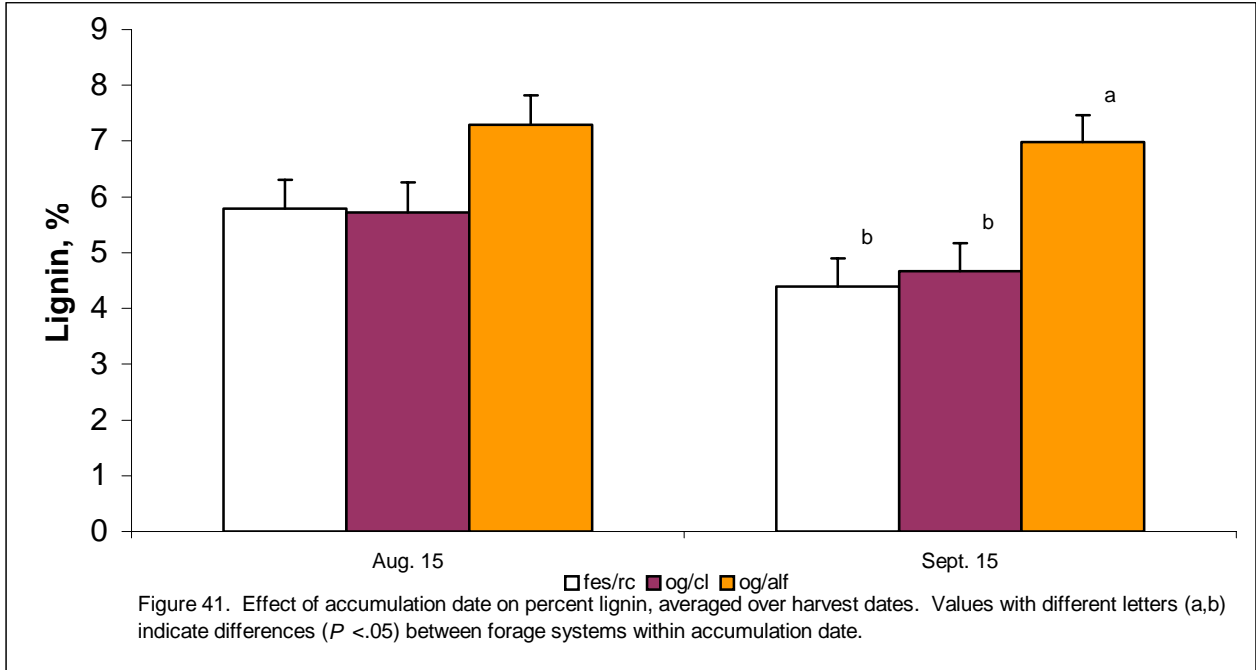
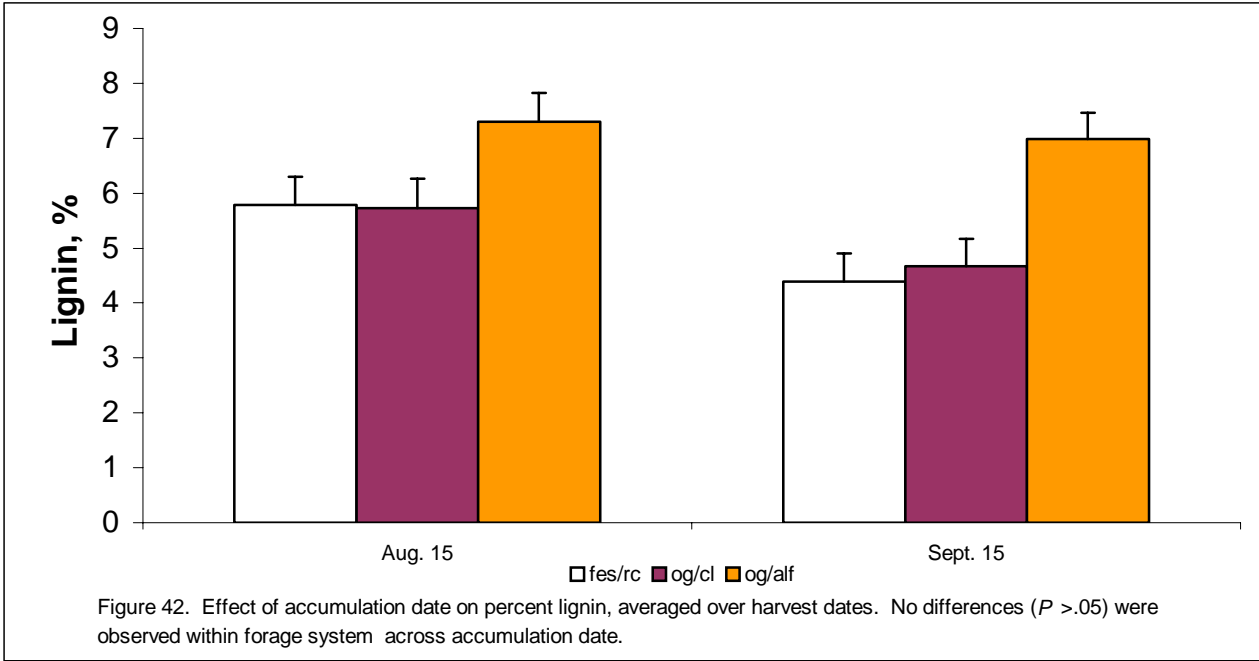


Figure 38. Effect of accumulation date on percent cellulose, averaged over harvest dates. Values with different letters (a,b) indicate differences within forage system ($P < .05$) across accumulation date.



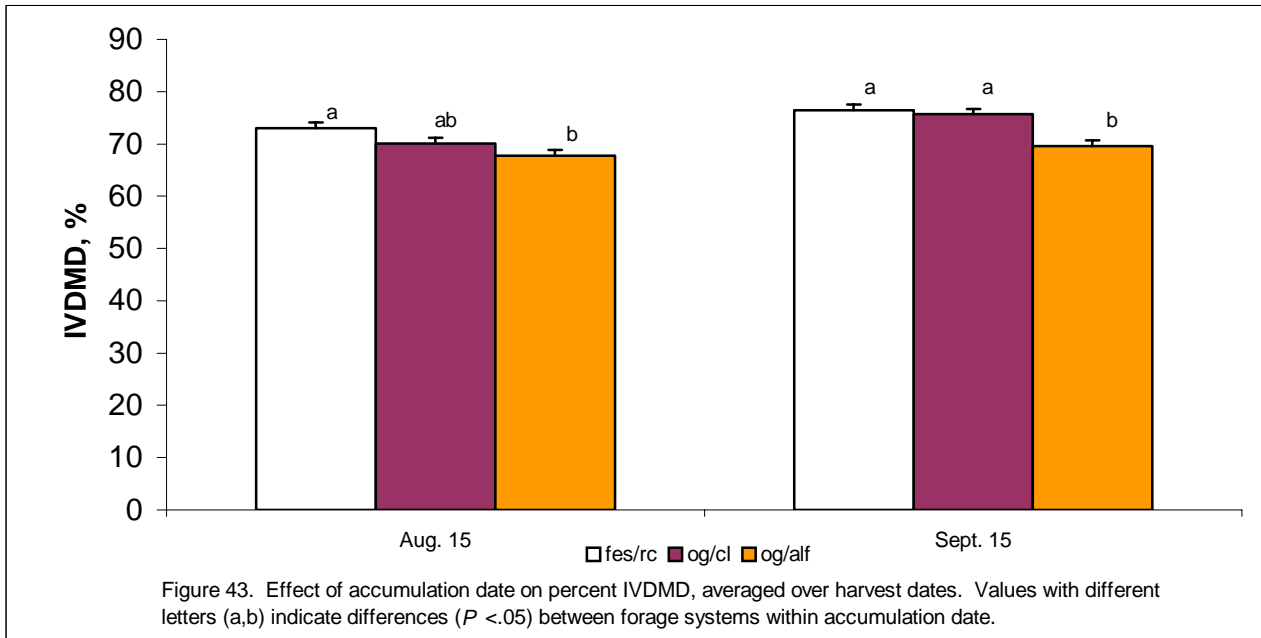


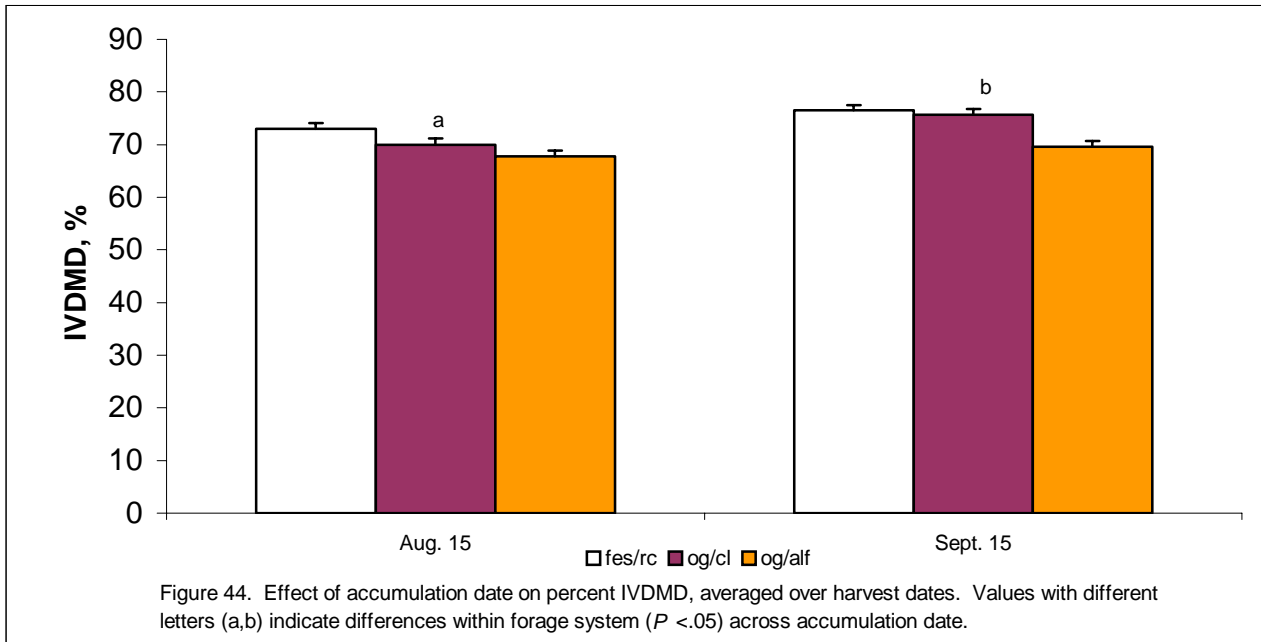


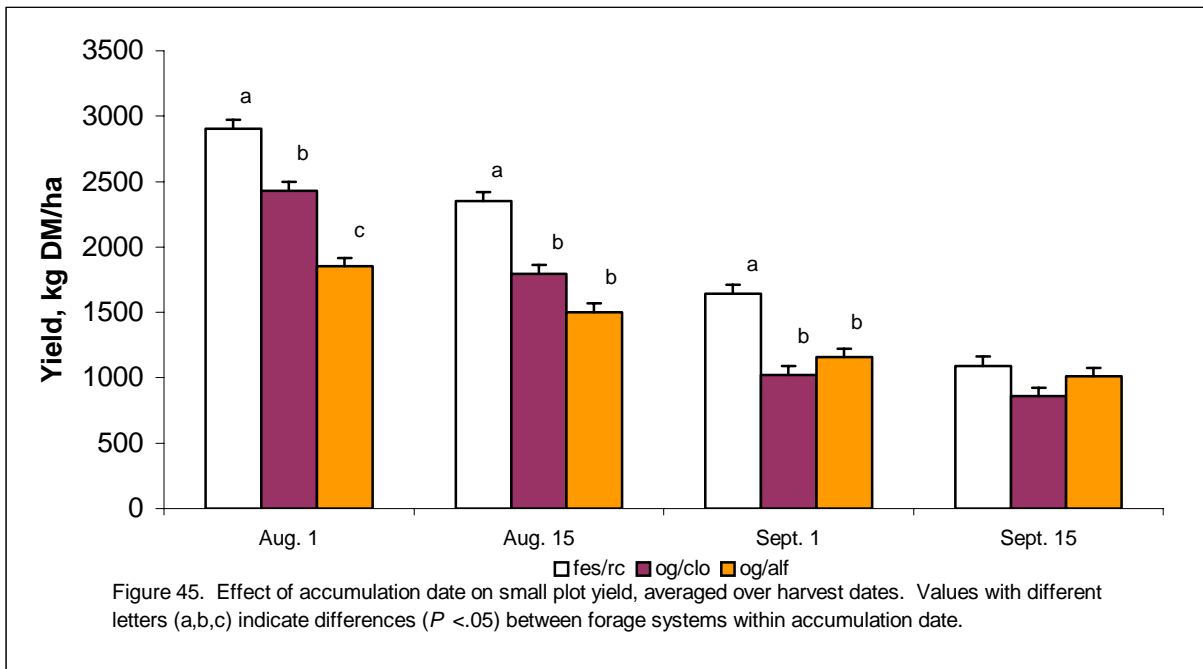


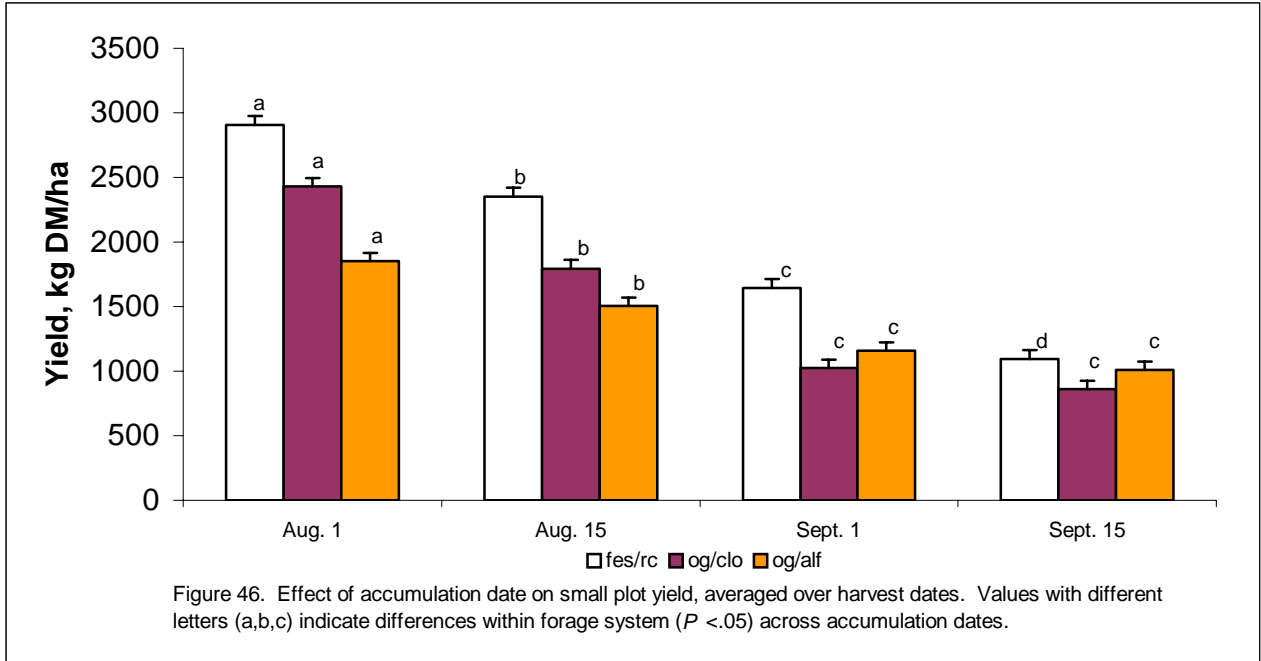
Percent IVDMD was higher ($P < .05$) in fescue-red clover than orchardgrass-alfalfa for both accumulation dates (Figure 43). Orchardgrass-clover was intermediate in IVDMD for August 15, but higher ($P < .05$) than orchardgrass-alfalfa for September 15. Within forage system, IVDMD increased ($P < .05$) in orchardgrass-clover when stockpiling was delayed from August 15 to September 15 (Figure 44). Percent IVDMD was not affected by accumulation date in fescue-red clover and orchardgrass-alfalfa ($P > .05$).

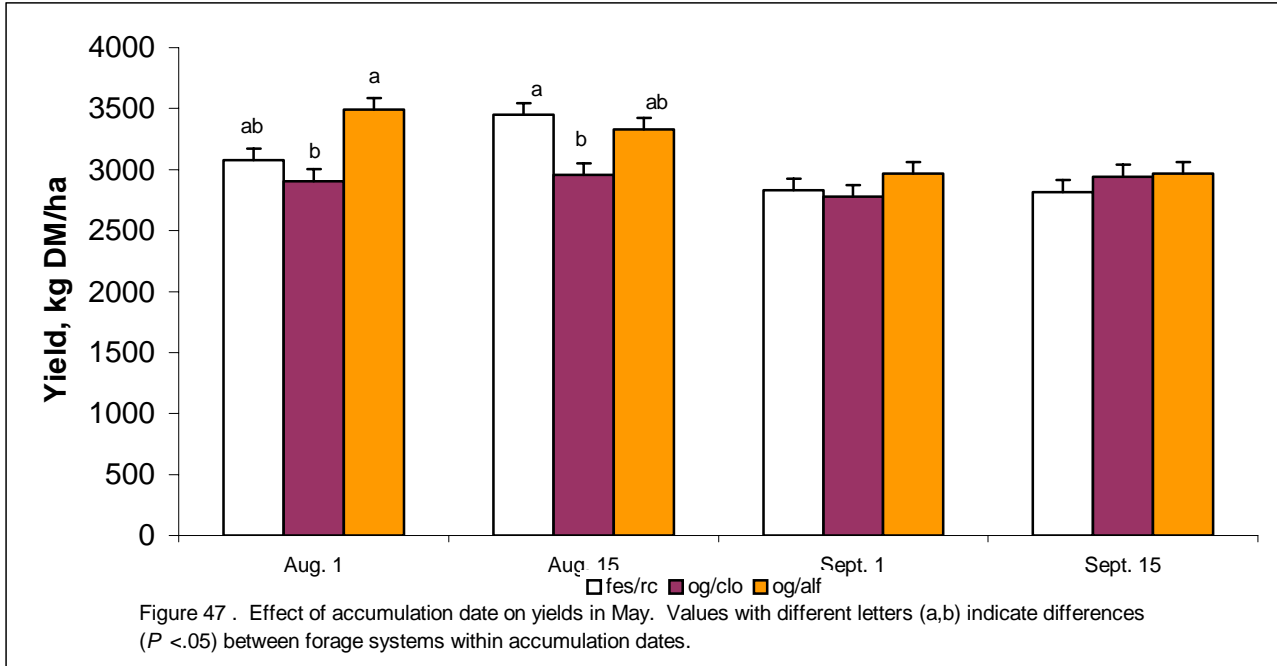
Effects of Accumulation Date on Yield. Fescue-red clover was higher in yield ($P < .05$) than the orchardgrass-legume mixtures for the August 1, August 15 and September 1 accumulation dates (Figure 45). For the August 1 accumulation date, orchardgrass-clover yielded more forage than orchardgrass-alfalfa ($P < .05$), but the two mixtures were similar in yield ($P > .05$) for the August 15 and September 1 accumulation dates. However, the yields of grass-legume mixtures in the present experiment (2339 kg DM/ha for fescue-red clover; 1645 kg DM/ha for orchardgrass-clover and orchardgrass-alfalfa) were less than those of tall fescue (3170 kg DM/ha) and orchardgrass (2133 kg DM/ha) alone as reported by Archer and Decker (1981a) for a similar growth period and no N fertilizer. There were no differences in yield among the three forage mixtures for the September 15 accumulation date. Within forage system, yield of fescue-red clover decreased ($P < .05$) with each delay of stockpiling date (Figure 46). Collins and Balasko (1981a) also saw declines in yield of tall fescue with delay of initiation of stockpiling. Yield of the two orchardgrass mixtures decreased ($P < .05$) with delay of stockpiling until September 1. No further decrease in yield was observed ($P > .05$) in orchardgrass-clover or orchardgrass-









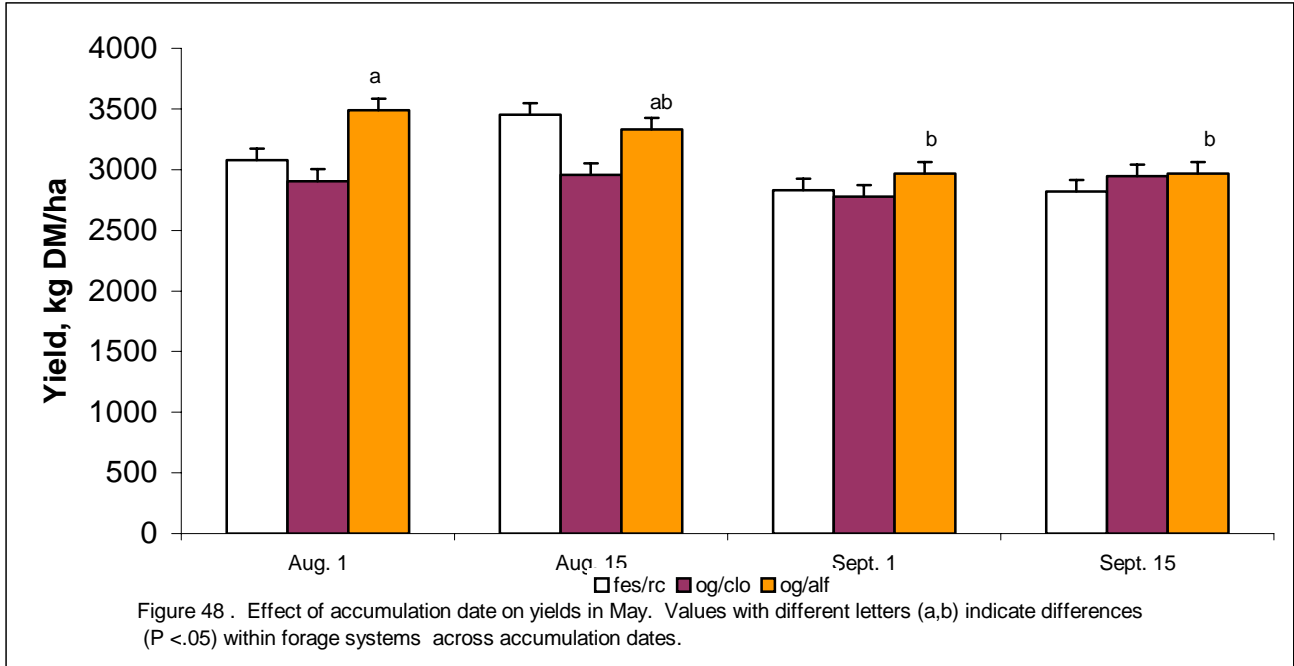


alfalfa when stockpiling was initiated on September 15.

Effects of Accumulation Dates on Spring Yield. May yields of stockpiled forages averaged across harvest dates are presented in Figure 47. Orchardgrass-alfalfa was higher ($P < .05$) than orchardgrass-clover for the August 1 accumulation date, while fescue-red clover was intermediate ($P > .05$). For the August 15 accumulation date, fescue-red clover was higher in yield ($P < .05$) than orchardgrass-clover, while orchardgrass-alfalfa was intermediate ($P > .05$). No differences were observed among the forage mixtures for either of the September accumulation dates. Within forage system, spring yield of orchardgrass-alfalfa was highest in plots accumulated from August 1 ($P < .05$), intermediate for plots accumulated from August 15, and lowest for plots accumulated from September 1 and 15 (Figure 48). In the fescue-red clover and orchardgrass-clover systems, date of accumulation had no effect ($P > .05$) on yield in May.

General Discussion. The results of the present study with regard to botanical composition indicate that when stockpiling orchardgrass-clover in early August weed encroachment may be a problem. Other than that, the botanical composition of the orchardgrass-legume mixtures changed little, suggesting these forages are suitable in mixtures. On the other hand, the legume component in fescue-red clover decreased dramatically over time. This is likely due to the competitiveness of tall fescue, and suggests that fescue should be managed carefully to maintain the legume component.

The quality of the stockpiled forages was generally quite good, suggesting



they would provide high quality grazing through the winter months with little need for supplementation. The CP content remained at or above 15% until March. However, according to the work of Bagley et al. (1983), the digestibility of CP in tall fescue decreased in March. Thus, supplemental protein may be needed after February. Fescue-red clover retained a higher content of TNC in January and March than the other forage mixtures. This suggests fescue-red clover would be better suited for stocker cattle after March than the orchardgrass-legume mixtures. The IVDMD did not decrease through the winter in fescue-red clover, a surprising result considering the decrease in digestibility observed by Bagley et al. (1983) in March. The yields of the stockpiled forages in winter were lower for the September accumulation dates than the August dates, but the quality was better. These factors should be considered when incorporating stockpiling and winter grazing into a management scheme. In addition, it is better to accumulate alfalfa in September as opposed to August so the growth will be vegetative when the first killing frost occurs. The August stockpiled alfalfa bloomed before frost and lost some of its nutritional value.

Based on the results of this experiment the tall fescue-red clover was the most suitable forage mixture to stockpile.

Experiment 2

Chemical Composition and pH of Ensiled Stockpiled Forages. The chemical composition and pH of ensiled stockpiled alfalfa and orchardgrass are presented in Table 1. The pH of the alfalfa silage was 4.8, comparable to 4.77 reported by Fraser et al. (2000) for alfalfa cut at the late bud stage in early September and ensiled after

Table 1. Chemical composition of stockpiled orchardgrass and alfalfa silage

Component	Orchardgrass		
	Alfalfa	August stockpiled	September stockpiled
pH	4.80	4.74	4.71
 %		
Dry matter	37.35	38.90	32.74
Crude protein ^a	17.50	15.84	14.53
Cell solubles ^a	60.68	52.18	50.08
Neutral detergent fiber ^a	37.79	46.97	49.24
Acid detergent fiber ^a	30.19	29.39	30.04
Cellulose ^a	20.75	22.37	23.03
Lignin ^a	7.66	5.96	5.92
Feed AIA ^{ab}	1.53	0.85	0.68
Water soluble carbohydrates ^a	3.87	6.23	4.66

^aDM basis

^bAcid insoluble ash

2 days of wilting in Wales. Fraser and coworkers (2000) also measured a pH of 5.05 in silage made from alfalfa harvested at the early flower stage in late September. In Ontario, silage composed of 85% legumes (alfalfa and red clover) and 15% grass and harvested in October had a pH of 4.9 for wilted compared to 4.6 for direct cut (Hirodiglou et al., 1965). Owens et al. (2002) obtained an average pH of 4.48 for unwilted alfalfa silage harvested in late June in Wisconsin. Silage in the present study made from August stockpiled orchardgrass had a pH of 4.74, and for September stockpiled orchardgrass, pH was 4.71. These values are higher than pH 3.9 and pH 4.0 reported by Dawson et al. (2002) for wilted perennial ryegrass silages in Northern Ireland. The ryegrass silages had growth periods corresponding in length to the stockpiled orchardgrass treatments in the present study, but in summer rather than autumn. Wilting of grass or legume forage can improve silage quality by reducing organic acid formation and stabilizing the silage at a higher pH (Van Soest, 1994). Wilting also increases DM of silage, and well-prepared silages of greater than 30% DM are generally more palatable and have better intakes. In the present study, all silages contained more than 30% DM.

Crude protein of the alfalfa silage was 17.5%, comparable to 18.2% CP for early cut and 18.3% for late cut alfalfa silage in the study by Fraser et al. (2000). Hirodiglou et al. (1965) reported CP values of 16.0% for wilted and 15.4% for direct-cut legume silages harvested in October. June-harvested unwilted alfalfa silage in Wisconsin, inoculated with lactic acid bacteria and fermented in 100 mL tubes, averaged 21.1% CP (Owens et al., 2002). Orchardgrass silage in the present study stockpiled in August and September contained 15.8% and 14.3% CP, respectively. Dawson et al. (1999) reported CP values for wilted perennial ryegrass averaging

18.0%. In well-preserved silage, proteins are less completely fermented and more likely to survive to the finished product fed to the animal, increasing palatability (Van Soest, 1994).

Neutral detergent fiber (37.8%) and ADF (30.2%) in the stockpiled alfalfa silage were lower than values reported by Fraser et al. (2000) for early and late cut alfalfa silage (47.8% and 48.1% NDF, 44.2% and 47.0% ADF respectively). The orchardgrass silage contained 47.0% and 49.2% NDF when stockpiled in August and September, respectively. Dawson et al. (2002), in northern Ireland, reported NDF of 71.4% for perennial ryegrass silage with the same number of days of growth as the August stockpiled orchardgrass, but in summer. Perennial ryegrass silage, with the same number of days of growth as the September stockpiled orchardgrass, contained 60.9% NDF (Dawson et al., 2002); again this was summer growth. August and September stockpiled orchardgrass silages were lower in ADF (29.4% and 30.0%, respectively) than perennial ryegrass silages with the same length of growth periods (43.3% and 39.2%, respectively; Dawson et al., 2002).

The stockpiled alfalfa silage contained 3.87% WSC. Owens et al. (2002) reported a mean of 4.06% TNC in unwilted alfalfa silage harvested in June, while Fraser et al. (2000) found 0.49% WSC in early cut and 0.67% WSC in late cut alfalfa silages, and Hirodiglou et al. measured 7.33% hydrolysable sugar in wilted legume silage. The orchardgrass silages stockpiled in August and September contained 6.23% and 4.66% WSC, respectively. These values are considerably higher than those reported by Dawson et al. (2002) for summer-harvested perennial ryegrass silages with a growth period similar to the August stockpiled orchardgrass (1.95% WSC) and with the same amount of growth as the September

stockpiled orchardgrass (2.29% WSC).

Digestion Trial. Acid insoluble ash was greater than 0.75% in the alfalfa and August stockpiled orchardgrass silages, but slightly below for the September orchardgrass silage (Table 1). Fecal AIA averaged 4.7%, 2.7%, and 2.3% for the alfalfa, August stockpiled orchardgrass, and September stockpiled orchardgrass, respectively. Diets containing forages are better suited to the AIA method than high concentrate diets due to the greater AIA content in forages, especially grasses (Thonney et al., 1985). Thonney et al. (1985) concluded the AIA method of measuring digestibility of ruminant diets can be used with confidence if the diet contains 0.75% or more AIA in the DM. Van Soest (1994) pointed out there are problems with the use of AIA as an internal marker, and recommends the use of ADF-AIA to overcome these problems.

Apparent digestibilities of the stockpiled alfalfa and orchardgrass silages are shown in Table 2. The silages were similar in DM digestibility ($P > .05$), ranging from 67.6% for alfalfa to 69.7% for September stockpiled orchardgrass. The IVDMD values obtained for the silages (Table 2) were within two percentage units of the apparent DM digestibility values for each silage. When Wilkins et al. (1971) compared 70 different grass and legume silages, they found DM digestibility varied from 55.3% to 80.0%, and that grass silage was generally higher in digestibility than legume silage. Crude protein digestibility was also similar among the treatments ($P > .05$), ranging from 71.7% for August stockpiled orchardgrass to 74.0% for alfalfa. Owens et al. (2002) observed large increases in NPN concentration in unwilted alfalfa and red clover silages due to proteolysis in the silo. In addition, they found

Table 2. In vitro DM digestibility and apparent digestibility of silages

Item	Orchardgrass		
	Alfalfa	August stockpiled	September stockpiled
 %		
In vivo digestibility			
Dry matter	67.59 ^a	68.44 ^a	69.70 ^a
Crude protein	74.03 ^a	71.66 ^a	72.00 ^a
Neutral detergent fiber	51.63 ^a	67.14 ^b	67.92 ^b
Acid detergent fiber	48.61 ^a	59.74 ^b	62.07 ^b
Cellulose	61.52 ^a	71.23 ^b	71.73 ^b
In vitro dry matter digestibility	66.25	68.86	68.18

Values within rows with different letters (a,b) are different ($P < .05$).

that unwilted alfalfa silage was consistently higher in NPN than unwilted red clover silage. Their data indicate about two thirds of the total N in the unwilted alfalfa silage consisted of NPN, typical of high moisture silage. Silages in the present study were wilted, a practice that generally results in better preserved protein fractions (Van Soest, 1994). Wilting inhibits respiration in dying plant tissue, which is considered the most important factor affecting quality of conserved forages. Limiting post-harvest respiration, which involves dissipation of sugar and hydrolysis of protein, is critical for obtaining a favorable sugar to protein ratio, which ensures good fermentation.

The digestibilities of NDF, ADF and cellulose in the stockpiled alfalfa silage were lower than those in the stockpiled orchardgrass silages ($P < .05$). These results may appear to be contradictory to the fact that there were no differences in DM digestibility. The higher cell soluble concentration in alfalfa silage than orchardgrass silages (Table 1) perhaps compensated for the differences in NDF and ADF digestibility. Fraser et al. (2000) reported NDF digestibilities of 50.9% and 49.3% for early and late cut alfalfa silages, respectively. These values are comparable to the NDF digestibility of 51.63% for alfalfa silage in the present study.

Treatment means for BUN and rumen pH of lambs fed ensiled forages are presented in Table 3. Lambs fed the alfalfa silage had higher BUN values ($P < .05$) than lambs eating orchardgrass silages, possibly a reflection of differences in CP in the silages. When N is abundant in the rumen relative to energy, ruminal ammonia concentration increases (Van Soest, 1994). Unused ammonia in the rumen enters the bloodstream and is converted to urea by the liver. Under controlled feeding situations it has been demonstrated in cattle that increasing dietary protein results in

higher BUN levels, when energy intake is held constant (Hammond, 1997). Ruminant pH was higher ($P < .05$) in lambs eating alfalfa silage and September stockpiled orchardgrass silage compared to those eating August stockpiled orchardgrass silage. Since the August stockpiled orchardgrass silage tended to contain more WSC than the other silages, this may account for greater acid production in the rumen and a lower pH.

Volatile fatty acids in rumen fluid of lambs fed ensiled forages are presented in Table 4. There were no differences ($P > .05$) due to treatment in the proportion of acetate, propionate and butyrate produced in the rumen, although there was a tendency for lambs fed the August stockpiled orchardgrass to produce more propionate. This may be explained by the WSC content of the August stockpiled orchardgrass silage, which tended to be higher than the other silages.

Table 3. Blood urea nitrogen (BUN) and rumen pH of lambs fed ensiled forages

	Alfalfa	Orchardgrass	
		August stockpiled	September stockpiled
BUN, mg/100 mL	21.84 ^a	16.27 ^b	17.44 ^b
Ruminal pH	6.94 ^a	6.73 ^b	6.97 ^a

Values within rows with different letters (a,b) are different ($P < .05$).

Table 4. Rumen volatile fatty acids (VFA) of lambs fed ensiled forages

	Alfalfa	Orchardgrass	
		August stockpiled	September stockpiled
Acetate, mol/100 mol	55.39 ^a	53.75 ^a	54.98 ^a
Propionate, mol/100 mol	28.47 ^a	32.13 ^a	28.24 ^a
Butyrate, mol/100 mol	2.73 ^a	2.12 ^a	2.79 ^a

Values within rows with different letters (a,b) are different ($P < .05$).

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