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Comparison of Protein, Forage, and Root Yield Data of Five Pasture Mixtures as Influenced by Clipping, Irrigation, and Nitrogen Fertilization

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COMPARISON OF PROTEIN, FORAGE, AND ROOT YIELD DATA OF FIVE PASTURE MIXTURES AS INFLUENCED BY CLIPPING, IRRIGATION, AND NITROGEN FERTILIZATION

by

Clair E. Blaser

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To my beloved wife, Rosemary

and our ten lovely children

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ABSTRACT

Comparison of Protein, Forage, and Root Yield Data of
Five Pasture Mixtures as Influenced by Clipping,
Irrigation, and Nitrogen Fertilization

by

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A study was made to compare the protein and forage yield and root dry weight data of five pasture mixtures as influenced by two clipping frequencies (28 and 35 day clipping intervals), three irrigation intervals (1 inch every 5 days, 2 inches every 10 days and 4 inches every 20 days) and four levels of nitrogen fertilization (0, 50, 100, and 200 pounds per acre). The study was conducted at the Greenville Farm, Logan, Utah. The farm has about 1 percent surface slope and is a well-drained Millville silt loam that occurs on an alluvial fan. It is high in potash and phosphorous and is alkaline, having a pH of 7.9 to 8.2.

Only mixtures gave significant percent forage protein results. Clipping, irrigation and fertilization treatments did not significantly affect the percent of forage protein but did affect the forage yield and thus the total protein production per acre. The total forage protein yield increases were nearly lineal with the nitrogen treatment increases.

The yield of forage from the 35 day clipping frequency was greater than from the 28 day clipping frequency for all five mixtures. The

mixtures containing alfalfa showed greater response to the harvest frequency in increased forage yield than the other mixtures.

All nitrogen applications gave forage yield increases. The first 50 pound increment gave the greatest and the second 50 pound increment gave the least forage yield response.

The different irrigation intervals, with the same total seasonal water applied, resulted in no significant forage yield differences.

Ladino clover had the greatest root dry weight per acre with the 28 day harvests and 50 pounds of nitrogen. The alfalfa and grass root dry weights per acre were largest with the 35 day harvests, the first 50 pound increment of nitrogen application and the longest irrigation interval. A mixture of alfalfa and intermediate wheatgrass had the high alfalfa root dry weight and the low grass root dry weight yield per acre.

Ladino clover roots were high in both the percent and pounds of total available carbohydrates (TAC) per acre with the 20 day irrigation interval and with five harvests. Grass roots percent and total pounds of TAC per acre were high with five harvests. Alfalfa root TAC per acre was nearly double with four harvests over five harvests and showed the greatest response to the first 50 pounds of nitrogen and the 20 day irrigation interval.

Five harvests gave higher root to forage (R/F) ratios for all mixtures except the ladino clover-grass mixture.

Zero pounds of nitrogen gave the highest R/F ratio for the grass-only mixture. Fifty pounds of nitrogen gave the highest R/F ratios for the other four mixtures.

INTRODUCTION

The root represents one of the main organs of the plant body. It is comparable to the submerged part of an iceberg in that the part beneath the surface is virtually disregarded until some problem arises. It has been suggested that the below ground part of the plant environment could be under the control of the agriculturist to a greater extent than the aboveground micro and macroclimate. While little can be done in changing the composition, humidity, or temperature of the air or the quantity of light available, much can be done by proper fertilization, irrigation, drainage, and cultivation to influence the structure, fertility, aeration, and temperature of the soil and hence its suitability for root growth (Mitchell, 1970, page 73).

In the abundant literature dealing with the effects of various management factors on plant growth and forage production, data showing the effects of these conditions on root growth are lacking. This is probably in part due to the labor involved in separating them from the soil for determining their mass or extent. The behavior of the tops that we observe are dependent on conditions influencing root growth, distribution, and activity and therefore on the ability of the roots to absorb various minerals and water from the soil and, in the case of grasses and legumes, to store sufficient nonstructural carbohydrates as available food reserves to initiate and maintain new foliage growth until the photosynthetic compensation level is reached.

An understanding of the effects of various management factors on relative root growth as contrasted with shoot growth should be of more

than merely academic interest and may be of considerable practical importance to anyone interested in the growing of plants (pasture). For example, management practices which tend to increase carbohydrate reserve storage in the roots or favor root growth more than shoot growth, will almost invariably put a plant in a condition to more likely survive severe winter conditions, drought or high temperatures or both. Management practices which tend to deplete root reserves or favor shoot growth over root growth tend to make the plant more susceptible to these adverse conditions. Individual species differ in their response to different management practices.

Troughton (1957) could find no report of any worker that the maximum growth of both roots and shoots coincide when measurements were taken at frequent intervals.

The aim of good crop (pasture) management should be to maintain an adequate level of reserves in the desirable species of the sward, achieved by using suitable management practices that are available.

The long range pasture experiment of which this study is a part, has been carefully examined and many of the results reported. Jethmalani (1962) considered the different management practices on the production and forage quality of the six pasture mixtures. Gawai (1967) analyzed the forage yield and chemical composition of the all grass mixture as influenced by the different management practices. Johanson (1967) reported on the root chemical composition and production of five pasture mixtures under the different management practices. Allred (1965a,b,c,1966) analyzed some of the results in a series of articles "Up-grading Irrigated Pastures". Hill (1972) determined the effects of commercial and legume nitrogen on dry matter and nitrogen

production and sward changes of three pasture mixtures as affected by different management factors.

Considering the importance of the plant roots and their role in forage production, additional research became desirable on the well established pasture plantings to investigate the influence of different management practices on both root and forage production.

The basic objectives in planning and performing this study were to determine the influence of two clipping frequencies, three irrigation intervals, and four nitrogen fertilization levels on grass and legume root yields, root to forage ratios, protein production, and root carbohydrate reserves of five pasture mixtures after four years of forage production under the different management practices.

REVIEW OF LITERATURE

Influence of Management Factors on Protein, Forage, and Root Yields of Pasture Mixtures.

Clipping frequency

The time of season and frequency of removal of top growth of pastures has been shown by several investigators (Granfield, 1935; Graber and Sprague, 1938; Nelson, 1925) to influence the vigor and future productivity of the stand.

Jackobs (1950) suggested, in his article concerning Yakima Valley, that, because most reports on alfalfa management have come from the midwestern states, where alfalfa is not as well adapted as it is in the irrigated regions of the west, some management practices not suited to areas where alfalfa is not well adapted may be safe to use where alfalfa is well adapted.

Yager and Tesar (1968), working in Michigan, partially agreed that the strict recommendation of not cutting alfalfa in September or early October now in effect in many states should be re-examined. Liberalizing such recommendations would permit occasional "fall cutting" of alfalfa stands for greater flexibility of management.

Graber and Sprague (1938) have shown the deleterious effect of cutting alfalfa at an immature stage in the fall and more especially on low fertility soils. Sprague and Cowett (1961) indicated that cutting managements did not influence persistence of ladino clover when grown with orchardgrass. Growth of ladino clover with bromegrass was hampered only when the first and second cuttings were at the hay stage.

Bromegrass and orchardgrass were little influenced by different cuttings when grown with ladino clover. Jackobs (1950) concluded that spring clipping had little or no effect on seasonal yields during the current or subsequent years. Although late cutting in the fall had a pronounced effect on early growth, this effect diminished as the season progressed.

Mueggler (1967) found that the removal of herbage either during early growth or after the foliage began to dry did not appreciably affect the vegetative production until the third year of clipping.

Kust and Smith (1960) found no marked differences in the protein yields from alfalfa regardless of the clipping frequency in 1956. In 1957 they found that the protein yields varied widely among the treatments and were of the same approximate ranking as the yields of the hay.

In Ohio, Parsons and Davis (1960) found that a 35 day cutting schedule gave the lowest alfalfa yield but had the highest protein percentage. Cutting every 45 days produced the maximum alfalfa yield and the lowest protein percentage.

Jackobs (1952) showed that with alfalfa the nitrogen percentage was negatively correlated with the amount of growth, advance of the growing season and interval between cuttings. He obtained the maximal seasonal yield of nitrogen when the interval between cuttings was 37 days and no early spring clipping practiced.

In Illinois, Burger, Jackobs, and Hittle (1962) used alfalfa and ladino clover as legumes, and orchardgrass and bromegrass. The yields of the various mixtures were greater with three clippings, less with four clippings, and least with five clippings. Allred (1965a) found

that with less frequent clipping the seasonal production was higher. Nevertheless, the amount of dry matter produced by the mixtures decreased in each of four harvest years regardless of the other management factors involved. After four years all harvest frequencies sapped the vigor of the alfalfa.

Biswell and Weaver (1933) working with prairie grasses found that overgrazing of pastures and frequent cutting of hay crops reduced the dry weight of roots from 2.6 to 20.6 percent of the control plants with an average 10.1 percent and reduced the average root volume to 11.7 percent of the control plants.

The effect of clipping on root production was reviewed by Weaver and Darland (1949) who noted that, with one exception, studies indicated that clipping may ultimately decrease production.

Nelson's (1925) experiments indicate that frequent cutting of alfalfa in premature stages depleted root reserves and retarded root growth.

Dotzenko and Ahlgren (1950) working with alfalfa found a positive correlation of 0.84 between the dry weight of roots and the total polysaccharides in the roots. Frequent and early cutting treatments reduced the dry weight of alfalfa roots and the percentage of total polysaccharides found in the roots. There was also a positive correlation of 0.86 for the yields of top growth obtained on June 7 and the amount of total polysaccharides stored in the roots. Cutting alfalfa earlier than one-tenth bloom reduced the forage yields and this reduction was related to the weight of the roots and the percentage of polysaccharides in the roots. Alfalfa reacted exactly the same in mixture with bromegrass as it did when grown alone.

Schuster (1964), working in Colorado with native plants, found grass root weights were significantly greater under no use than under moderate and heavy use, but nongrass root weights did not vary significantly.

Harrison (1931) clipped grasses at different heights and concluded that the amount of roots increased with the height to which the grasses were clipped.

Robertson (1933) observed that, in general, root penetration of seedling grasses was retarded 35 to 62 percent as a result of frequent clipping, the dry weight of the roots was reduced from 68 to 98 percent; and the dry weight of the tops was reduced from 80 to 96 percent.

Graber et al. (1927), in summarizing their work and other research to date, stated that alfalfa harvested at full bloom or in the seed stage of growth yielded roots highest in dry matter weights and total available carbohydrates (TAC). Earlier cuttings decreased both the root dry matter weights and TAC with increases in the frequency of the cutting of the top growth. This marked retardation of root growth decreased the top growth and intensified the quantitative relationship of the root reserves. They suggested that the storage of food reserves in the roots of alfalfa does not exceed a certain concentration and when this point is reached root extension occurs and/or the reserves are converted into non-recoverable organic substances. The manifestations of the grasses observed, from the depletion of the food reserve of the roots, were very similar to alfalfa with one important exception. No mortality could be readily observed in the grasses cut ten or more times per season but death occurred in all the Grimm alfalfa plants cut nine times at the rosette stage of growth. On a dry weight basis the

roots (with crowns) of plants cut at the succulent stages averaged 7.35 grams while those cut at more mature stages averaged 12.65 grams, or nearly twice as much. Bluegrass established for thirty years (with the past ten years of heavy grazing) gave root yields of 75 grams per square foot as compared to 147 grams per square foot when lightly grazed.

McCarty and Price (1942) concluded that the concentration of reserve carbohydrates stored in the roots and stem bases at the end of the growing season was related to the amount of herbage present during the normal storage period (following the final season clipping). The concentration became less as the interval between the time of clipping and the normal storage period decreased. All of the clipping treatments reduced the concentration of the reserve carbohydrates.

Working in Tennessee where some green leaves were present through the winter, Reynolds (1971) compared the nonstructural available carbohydrates (TAC) in alfalfa roots under six harvest frequencies of eight, six, five, four, three, or two cuttings per year. The two, three, and four cutting treatments had the most vigorous and productive stands. The yields in the third year did not have a significant positive correlation with carbohydrate concentrations at the end of the second harvest year.

Investigators generally agreed that the more frequent and drastic the clipping treatment the less the yields of tops, rhizomes, and roots. Severe defoliation affected root growth adversely and resulted in lower amounts of carbohydrates stored in the underground portion of grasses and legumes. The greater the intensity and/or frequency of clipping,

the greater was the reduction in herbage, flower stalks, and root production (Mueggler, 1967).

Low carbohydrate percentages were associated with losses in stand as well as reduced yields (Graber et al., 1927 and Bryant and Blaser, 1964).

Tesar and Ahlgren (1950) working with ladino clover, found that frequent clipping reduced both the weight and TAC in the stolons by the time of the last cutting and that the TAC varied according to the severity of the cutting treatments. By November the percentages of TAC were about the same on all plots regardless of cutting treatment. The higher fall stolon weights gave the higher spring stolon weights and the weights of live stolons in the spring and yields that summer were positively correlated.

Weinmann (1952) determined that the effects of repeated defoliation were cumulative and the progressive depletion of root reserves will bring about a reduction in the weight of the storage organs. Certain clipping treatments may not result in a decreased percentage of TAC but merely a reduction in storage organ weights. His conclusion was that both percentages and actual amounts of TAC must be calculated in order to assess full effects of management practices or root reserves.

After reviewing McCarty and Price and others, Troughton (1957) summarized that a decrease in the concentration of reserve carbohydrates in the underground organs at the end of the herbage growth season was in proportion to the number of defoliations during the growing season or in inverse proportion to the length of the interval between defoliations.

Cooper and Watson (1967) found that cutting treatments of four, three, two, and none had little effect on the final TAC level in roots of alfalfa at the end of the growing season. Frequent cutting apparently was not detrimental when the last cutting was early enough to provide time for carbohydrate storage before a killing frost. The initial carbohydrate level was reached more quickly following a late rather than an early summer cutting.

Kust and Smith (1960) found that the level of TAC in the storage organs of alfalfa as of mid-November was reduced by fall cutting and by cutting more frequently than three times per year. There was a close relationship between the amount of carbohydrates present in the storage organs of alfalfa in the fall and the yield of hay obtained from the plants in the subsequent year.

Reynolds and Smith (1962) concluded that higher levels of carbohydrates were attained under two cuttings than under three cuttings in alfalfa, smooth bromegrass and timothy.

Removal of the leaf-bearing parts of a plant will almost certainly result in a check or cessation of further root growth and sometimes death and decay of the existing roots. Defoliation directly removes actual or potential food making tissues, thus diminishing the food supply to the roots; and it increases the relative supply of water and minerals, especially nitrogen, to the shoots. Thus root development is checked and shoot development favored. The degree of reduction in root growth will vary with the degree of defoliation and the season at which it is carried out (Curtis and Clark, 1950, page 680).

Irrigation

Van Horn et al. (1956), Tesar (1958), and McKibben, Gard, and Webb (1959) in pasture irrigation studies all found favorable response to irrigation of pastures by increased production.

In Delaware, Mitchell (1962) decided that supplemental irrigation improved seasonal distribution of growth but didn't significantly change the seasonal dry matter.

Under California conditions, Hagan and Peterson (1953) found very little difference between pasture mixtures on the consumptive use of water.

Hansen (1924) reporting on pasture irrigation at the Huntley Branch Station, Montana recommended irrigation intervals of two to four weeks during the grazing season as needed to keep the surface soil well supplied with water. Welch (1941), considering Idaho conditions, recommended light frequent irrigations for better grass yields than heavier, less frequent, irrigations. Robertson et al. (1952) found that ten to fourteen day intervals were best for irrigation in their Colorado pasture studies.

An alfalfa-bromegrass mixture gave an increase of 14.4 percent in dry matter when irrigated in New York as reported by Levine, Kennedy, and Gray (1955). Results were the same from three different levels of water application.

Lorenz, Rogler, and Holman (1959), in a North Dakota study, found that irrigation significantly increased yields but the yields at two irrigation levels seldom differed to a significant degree.

Allred (1965c) concluded, in his Utah pasture study, that the frequency of irrigation and not the amount per season was the main

factor in the yield of all grass and ladino clover-grass mixtures. He further concluded (Allred, 1966) that the frequency of irrigation did not affect the production of forage over the four year averages with an alfalfa-intermediate wheatgrass mixture.

Myers and Shockley (1955), in their Idaho studies of forage crops under irrigation, found plants extracted about forty percent of their moisture from the upper quarter and seventy percent from the upper half of the root zone.

Bloodworth, Burleson, and Cowley (1958) studied root distribution and found that in irrigated areas where a "plowsole" layer existed, a large percentage of plant roots were found to occupy the first foot of soil and especially the first six inches of soil.

Mitchell (1962) found that irrigation increased root growth as measured by both methylene blue adsorption and root weight although in the latter case significant irrigation x species interactions were noticed. The heavier root systems were always associated with supplemental irrigation.

Upchurch and Lovvorn (1951), in their North Carolina study, found that the maximum depth of taproot penetration of alfalfa was attained by the end of the first year. The greatest changes noted from the age of one to six years were increases in the number of laterals per plant and increases in the diameter of the laterals and the tap root at all depths.

Bray (1963) stated that there was a clear tendency for root production within species to decrease from irrigated to non-irrigated fields with irrigated fields showing the highest production. Among the non-irrigated fields, there was a production decline from the

moist climate of Germany to the drier climate of the western U. S. S. R. This trend was supported by information from three species (Triticum sp., Trifolium sp. and Medicago sativa) for which data was available from all three regions.

Brown and Blaser (1970) found that moisture stress which retards growth of grasses caused an increase in percentage of soluble reserve carbohydrates. An inverse relationship between the rate of growth and soluble carbohydrates might be expected. Drought appears to depress carbohydrate utilization to a greater extend than photosynthesis. There was an increase in reserve carbohydrates under moisture stress or during drought.

Mitchell (1970) stated that a limited water supply decreased root growth slightly but caused an even more striking reduction in shoot growth. Under certain management conditions, this response was used to favor the development of a more extensive root system, thus providing a better root system to support increased shoot growth later.

An increase in the amount of water in the soil results, in most environments, in an increase in shoot-relative-to-root-growth i.e. the percentage of the plants weight in the roots decreases. The roots adapt themselves to the available water supply by their distribution in the soil (Troughton, 1957).

There have been more studies on the effect of soil moisture on root growth than any other factor. The results of investigators appear to be in conflict because some claim an increase in water increases root growth while others claim a decrease in root growth with moisture increases. By using a root to shoot ratio (R/S) on the investigation

results, an increase in water decreases relative root growth and increases relative shoot growth.

Water is supplied almost entirely through the roots for most land plants so the shoots are dependent upon the roots for their water. Most of the plant water loss is from the shoots.

An increase of water to the shoots increases their growth and activity and their use of more of the manufactured sugars. This diminishes the carbohydrate supply to the roots, reducing root growth, and gives a decrease in roots when expressed as part of the total plant weight.

Water is more commonly limiting and limiting to a greater degree for shoots than for roots. Any treatment that will improve the available water supply to the plant is likely to favor the shoots more than roots (Curtis and Clark, 1950, pages 669, 670).

Clipping frequency and irrigation

Peterson and Hagan (1953) studied four irrigated pasture mixtures harvested at two, three, four, and five week intervals over a three year period. All mixtures increased in yields as growth intervals were extended from two weeks to five weeks. The average increase of all mixtures was 92 percent. The ladino clover-grass mixtures showed the least increase (43 percent) and the alfalfa-grass mixtures showed the most increase (177 percent) by lengthening the cutting intervals.

Hagan and Peterson (1953) found that there was very little difference in the consumptive-use rates of water during the hot dry months of July and August in California under different clipping, irrigation, or mixture regimes. Consumptive-use rates averaged approximately 0.3

inch of water per day. Cutting more frequently than two weeks or less frequently than five weeks may affect rooting depths. The large differences in yield obtained under the several clipping frequencies with those pasture mixtures, for which the consumptive-use rates were nearly equal, led to correspondingly large differences in forage production per unit of water consumed.

Brown and Blaser (1970) stated that although frequent cutting or heavy grazing during dry weather conditions were generally thought to be harmful to forage stands, it had been shown to the contrary that cutting alfalfa six times per year reduced stands to a much greater degree under irrigation than with no irrigation (Ward et al. 1966).

May (1960) concluded that studies on soil water content and temperature had given consistent results as illustrated by the experiments of Barnes (1936) showing the pattern of induced fluctuations. Plants were grown at three different moisture levels combined with three temperatures. At any one temperature the root carbohydrate percentages varied inversely with the moisture, and at any one moisture level the percentage again varied inversely, this time with the temperature.

Lorenz, Rogler, and Holman (1959) found that the pasture yields averaged somewhat lower than hay yields at all moisture levels.

Nitrogen fertilization

Studies conducted on nitrogen added to pastures have given many contradictory results.

Watkins (1940) worked with Bromus inermis in the field and found no conclusive results or consistent effect due to the application of a nitrogeneous fertilizer.

Jackobs (1952), in a Yakima Valley study, found only a slight response to nitrogen in a legume dominated pasture mixture but a marked response to nitrogen in a predominately grass or grass alone mixture.

Austensen, Chapin, and Law (1955) obtained increased yields from applications of 90 and 180 pounds of nitrogen per acre to a ladino clover-orchardgrass mixture of only 0.47 and 0.64 tons per acre, respectively. They suggested that 60 to 90 pounds of nitrogen per acre as about optimum rates under their conditions in northwestern Washington.

Under North Carolina conditions, Woodhouse and Chamblee (1953) determined the response of a ladino clover-grass mixture to nitrogen applications of 50 to 400 pounds per acre. The increase in dry matter production ranged from 300 to 3000 pounds per acre. They recommended up to 400 pounds of nitrogen per acre for all grass pastures for maximum yields but cautioned that the high rates may reduce or eliminate the legume from the sod.

In Wyoming, Lewis (1955) obtained increased forage production with nitrogen on two grass-legume mixtures. The grass portion increased and the legume portion of the mixture decreased.

At two locations in Kentucky, Doll, Hatfield, and Todd (1961) determined that the use of nitrogen fertilizer was not practical on grass-legume pastures but was necessary to obtain high yields on grass pastures.

From grazing trials in Virginia, both Blaser et al. (1956) and Compling, Maclusky, and Holmes (1958) reported increased carrying capacity and more production from grass pastures heavily fertilized with nitrogen than from grass-legume mixtures with no nitrogen applied

but lower quality forage as evidenced by the lower daily gains obtained per animal.

Sullivan et al. (1959) found no difference in forage quality between the herbage of grass-legume and nitrogen fertilized grass pastures in a Pennsylvania study. The application of 140 to 160 pounds of nitrogen per acre in 30 to 40 pound increments to the grass mixture evidenced more stable and higher forage production than grass-legume mixtures without nitrogen fertilization.

Brown and Munsell (1943) and Wagner (1954) reported more uniform seasonal production with a grass-legume mixture than nitrogen fertilized grass. Robinson and Sprague (1952) reported more uniform production with nitrogen fertilized grass than with grass-legume mixtures.

Allred (1965a,b), in his Utah study, found that in alfalfa-grass mixtures more forage was produced with the high rate of nitrogen fertilization at all irrigation frequencies, however, the decrease in the legume component that was associated with heavy nitrogen fertilization resulted in a decrease in percent protein at the frequent irrigation interval. With the grass mixture there was an increased response with each increment applied with successive harvests indicating very little, if any, nitrogen carry over from one clipping to the next.

Parvis (1955) studied the effect of nitrogen on the yield and protein content of alfalfa in New Jersey and found that 25 and 50 pounds of nitrogen per acre reduced the yield, 100 pounds gave the same yield as no fertilizer, and 200 pounds of nitrogen increased both the alfalfa yields and protein content significantly provided that four cuttings instead of three cuttings were made.

Parsons (1958) studied the response of three alfalfa-grass mixtures to nitrogen fertilization in Ohio. He found no effect of nitrogen treatments on the dry matter yield on the second or third cutting and a first cutting response only with the alfalfa-orchardgrass mixture. The added nitrogen increased the orchardgrass component and decreased the alfalfa component. In each mixture the total protein production of the first cutting increased as the nitrogen rates were increased to 100 pounds per acre because of the increase of percent nitrogen in the grass. However, the alfalfa-orchardgrass mixture showed a decrease in protein production with 25 and 50 pounds of nitrogen per acre because of the drastic change in sward components.

Using several species of grasses in Pennsylvania, Harrington and Washko (1956) found that the application of 100 pounds of nitrogen per acre after each harvest produced the greatest amount of forage and the largest yield of protein per acre with better seasonal distribution of the production. Dotzenko (1961) also used several species of grasses in an experiment conducted in Colorado and found that annual nitrogen rates to 640 pounds per acre increased both the forage production and percent nitrogen content. The different species responded differently.

Reynolds and Smith (1950), working with hairy vetch, determined that fertilization increased the total pounds of nitrogen per acre in both the tops and roots. The increase was greater in the roots.

Sullivan and Sprague (1953) found that the application of nitrogen, whether applied on the day of cutting or seven or fourteen days later, resulted in an immediate decline in the percent of fructose and sucrose in both the roots and stubble as compared with unfertilized plants and increased the total and especially the soluble nitrogen in all plant

parts. The difference tended to decrease as time advanced. Bell and DeFrance (1944), reported that with added nitrogen, increased carbohydrate accumulation occurred in the roots. May (1960), cited Weinmann's work of 1943 and 1948 and concluded that with fertilizer applications (NPK) to natural pastures no change in carbohydrate accumulation occurred although the herbage yield was increased. Benedict and Brown (1944) and Sprague and Sullivan (1950) have both reported that added nitrogen gave a decreased percentage of carbohydrates.

Knoblauch et al. (1955), working in New Jersey, stated that an application of nitrogen fertilizer to a Phleum pratense pasture during the growing season resulted in an increased weight and increased nitrogen and carbohydrate content of the corms.

According to Benedict and Brown (1944), one of the principal effects of lowering the concentration of nitrogen in the growth medium was to increase the concentration and quantity of starch and/or sucrose in both the roots and shoots of plants.

Macleod (1965) found that the yield of roots was significantly increased by addition of nitrogen fertilizer for all grass species studied. The grass roots showed greater response to nitrogen than the alfalfa roots. Fertilization showed no significant change in the TAC of the underground portions of bromegrass, significant TAC increases in the underground portions of orchardgrass, and significant decreases in TAC in alfalfa roots. The TAC in alfalfa roots was lower in alfalfa-grass mixtures than when the alfalfa was grown alone.

Auda, Blaser, and Brown (1966) decided that nitrogen stimulated tillering and growth, which lowered the carbohydrate reserves. They

cited Colby, Drake, Sprague, and Waite to substantiate their conclusion that root weights decreased with added nitrogen.

Harrison (1931) found that the addition of nitrogen increased top growth but the weight of the roots did not increase over the roots of unfertilized grasses.

Mitchell (1962) stated that nitrogen fertilization was generally associated with smaller root systems as measured by methylene blue adsorption and to a lesser extent by dry weight measurements. He quoted the work of Kennedy in comparing 0 to 200 pounds of nitrogen on orchardgrass and concluded that nitrogen increased root development which resulted in better production during a dry season.

Oswalt, Bertrand, and Teel (1959) used root weights and P32 uptake to follow the growth of bromegrass and orchardgrass roots and concluded that, since dry matter production is increased and root yields decreased, nitrogen must have increased the efficiency of the root system.

Troughton (1957) wrote that, in general, it appeared that plants grown in conditions where available nitrogen was a factor limiting growth had a well-developed root system, but a poorly developed shoot system. Plants grown with an excess of nitrogen exhibited the opposite relative development.

Mitchell (1970, pages 181, 182) concluded that an increased supply of nitrogen, within limits of practical interest, caused more top growth in relation to root growth (i.e. it decreased the root-shoot ratio). Thus an adequate supply of nitrogen favored the use of available carbohydrates for growth of the top. In addition, a greater nitrogen supply tended to increase the quantity of growth hormone

present in the plant. This favored top growth and inhibited root growth. However, nitrogen fertilizer increased the total dry weight of roots.

Nitrogen is directly necessary for protein formation and growth. It is more likely to be deficient in the shoots because of the distance from the supply. A deficiency of nitrogen checks the shoot growth and restricts carbohydrate utilization by the shoots. This increases the carbohydrate supply available to the roots which increases root reserve storage or root growth if carbohydrates are the limiting factor. The nitrogen is absorbed from the soil by the roots and a deficiency is more likely to limit shoot growth, but increase root growth and/or enlargement. An increase in the available nitrogen supply will increase the protein and relative shoot growth and decrease the relative root growth (Curtis and Clark, 1950, pages 671-673).

Nitrogen fertilization and clipping frequency

Harrison (1931) decided that mineral fertilization did not compensate for the lack of top growth in the production of roots.

Weinmann (1952) concluded that an abundance of nitrogen may, under severe defoliation, produce an actual reduction in root weight.

Oswalt, Bertrand, and Teel (1959) found that clipping stopped root growth within 24 hours and induced root decomposition in 24 to 48 hours after clipping. The roots reached a greater depth when no nitrogen was applied. Nitrogen increased the root diameter and decreased the rate of elongation.

Higher protein percentages in the forage were usually obtained with both nitrogen fertilization and more frequent clipping. Because

of lower dry matter yields, too frequent clipping decreased the total protein production regardless of the higher protein percentages found in the younger, more succulent forage.

Nitrogen fertilization and irrigation

Using a ladino clover-orchardgrass mixture, Robinson and Sprague (1952) found that nitrogen fertilization greatly increased yields on both irrigated and non-irrigated plots. Both actual and percentage increases in yield from the nitrogen were greater on non-irrigated plots than on irrigated plots. There was an increase in yield due to irrigation with both high nitrogen and no nitrogen fertilization. The annual yields on plots receiving both irrigation and nitrogen averaged 8050 pounds per acre when clipped to simulate rotational grazing as compared to an averaged yield of 2950 pounds per acre on plots receiving neither irrigation or nitrogen fertilization. Herbage on the high nitrogen fertilized plots was nearly all orchardgrass at the end of the experiment.

Levine, Kennedy, and Gray (1955) studied a bromegrass-alfalfa mixture in New York using four irrigation levels. Yields were the same for the three irrigation levels applying water, all of which were higher than the yields of the plots receiving no water. Nitrogen fertilization increased the yields at all four moisture levels.

Bennett, Stanford, and Bumenil (1953) showed that the percent uptake of nitrogen into plants decreased with increasing soil moisture, but since irrigation increased yields, the total uptake was usually higher with irrigation.

Kmoch et al. (1957), studying root development of winter wheat in central Nebraska, found that nitrogen fertilizer increased root weights at all moisture levels and at nearly all soil depths.

Cooper, Klages, and Schulz-Schaeffer (1962), working with six grass species in Montana, found orchardgrass responded relatively less to high nitrogen applications than the other grass species, particularly when grown under low irrigation. They also found that the percentages of applied nitrogen recovered by the plants increased with increased frequency of irrigation and were greater on plots fertilized with 100 pounds of nitrogen per acre than on plots fertilized with 400 pounds of nitrogen per acre.

Allred (1966) found that the frequency of irrigation did not affect the production of forage from an alfalfa-intermediate wheatgrass mixture over four year averages. There were insignificant yield increases to nitrogen fertilization of 0.1 ton with 50 pounds of nitrogen, 0.27 ton with 100 pounds of nitrogen, and 0.57 ton with 200 pounds of nitrogen per acre.

Nitrogen fertilization, clipping frequency, and irrigation

Nelson and Robins (1956) considered the results of different moisture and nitrogen fertilization levels and two clipping heights on the production of a ladino clover-orchardgrass mixture in western Washington. An irrigation frequency of 7 to 11 days and a clipping height of twelve inches gave the highest forage yield. Both longer irrigation frequencies of 15 to 20 and 20 to 30 days and a six-inch clipping height gave lower yields. Applying 50 pounds of nitrogen in April produced more forage than the same amount applied in June.

The application of 100 pounds of nitrogen at one time gave a lower yield than a split application of two 50 pound increments which was lower than three 33.3 pound increments applied in April, May, and June. Application rates of nitrogen greater than 100 pounds produced approximately the same forage yield but did reduce the percentage of ladino clover in the sward. Decreased frequency of irrigation also decreased the ladino clover content.

Lorenz et al. (1961) studied the influence of nitrogen fertilization, harvest frequency and moisture on the production of bromegrass and an alfalfa-bromegrass mixture in North Dakota. The low-moisture level (non-irrigated) gave the lowest yield. The yields at the medium and high-moisture levels were similar and significantly higher than the low-moisture level. Yields were doubled by the application of 40 pounds and tripled by the application of 80 pounds of nitrogen at the low moisture level. An application of 200 pounds of nitrogen increased the yields fourfold at both the medium- and high-moisture levels. Frequent clipping reduced the average yield of all treatments by 18, 33, and 29 percent at the low-, medium-, and high-moisture levels, respectively. At the low-moisture level, yields of the mixture were equivalent to those of bromegrass receiving 40 pounds of nitrogen, but when irrigated they were equivalent to those receiving 120 and 160 pounds of nitrogen for the pasture and hay treatments, respectively. The percentage of alfalfa in the mixture increased with time at the higher moisture levels but decreased at the low-moisture level. Frequent clipping also held the percentage of alfalfa in the mixture at a lower level than cutting at the hay stage.

Mixtures

From California, Warren (1957) reported that the most successful pastures have been those that included just one type of legume and one or two types of grass. The ease of management of the legume determined the success of these stands. Peterson et al. (1959) agreed in principle and recommended that the pasture mixture be kept relatively simple.

Blaser, Skrdla, and Taylor (1952ab) working in humid non-irrigated eastern United States also advocated the use of simple mixtures because, as they point out, complex mixtures revert to simple ones in response to competition and environmental adaptation.

However, Kopland, Post, and Stitt (1954) reported that the rather complex Huntley mixture was superior to several simple grass-legume mixtures for dairy cattle, under Montana conditions. Bateman and Keller (1956) in their Utah studies, obtained the highest yield from a complex mixture and with Jackobs (1952) indicate that the high yields of mixed pastures are the results of including a highly productive legume. These studies indicated alfalfa-grass mixtures as superior in yield to those using either ladino clover or birdsfoot trefoil as the legume.

In Montana, Cooper, Eslick, and Stitt (1960) confirmed the alfalfa-grass mixtures as highest yielding followed in decreasing order by mixtures containing ladino clover and red clover, ladino clover, alsike clover, and birdsfoot trefoil.

Fuelleman, Burlison, and Kammlade (1944) determined that both bromegrass and orchardgrass gave larger yields of forage as well as larger gains by grazing animals when associated with a legume such as alfalfa. Protein and calcium content were materially increased both

in percentages and in pounds per acre production by including alfalfa in the mixture.

Mitchell (1962) decided that the inclusion of orchardgrass with legumes as a forage crop generally resulted in significant dry matter increases. Orchardgrass responded significantly to all three levels of nitrogen used over no nitrogen.

Tesar and Ahlgren (1950) found that mixtures of ladino clover with smooth bromegrass, timothy or orchardgrass were more productive than ladino clover alone.

Washko and Pennington (1956) concluded that bromegrass, orchardgrass, reed canarygrass or tall oatgrass yielded more forage in association with ladino clover than with alfalfa.

In direct contrast, Burger, Jackobs, and Hittle (1962) found that alfalfa-grass combinations consistently outyielded ladino clover-grass mixtures regardless of the cutting management used. They also found bromegrass mixtures produced more dry matter than orchardgrass mixtures, regardless of frequency or height of cutting or legume association.

In Pullman, Washington, Woods et al. (1953) found no significant difference in the yield of hay between alfalfa-grass mixtures and alfalfa grown alone. More roots were produced by mixtures than alfalfa alone--4.34 tons per acre as compared to 2.59 tons per acre. In the mixture, the grasses produced more roots than the alfalfa--2.81 tons and 1.53 tons per acre, respectively. The yield of roots by mixtures was determined by the grass and not by the alfalfa and was dependent on the kind of grass grown with the alfalfa. The root yield average

was similar for both the bunch and sod grasses--3.68 tons and 3.64 tons per acre, respectively.

Aberg, Johnson, and Wilsie (1943) decided that all grasses had a significantly higher yield of roots when grown in association with alfalfa and sweet clover. In no case in either the field or greenhouse study was there a significant gain or loss in forage or root yields for both members of an association. Significant gains or losses in yield for one crop usually resulted in significant losses or gains, respectively, for the other crop in association. Response of crops in mixtures was of the compensating type rather than mutually beneficial or antagonistic. Alfalfa yields were reduced in competition with orchardgrass.

Root reserves

The most important reserve substances of grasses were considered by Weinmann (1948) to be sugars, fructosans, dextrins, and starch. He considered all others to be structural materials which could not be further utilized by the plant. Similar opinions were held by Brown (1943) and Sullivan and Sprague (1953).

These nonstructural carbohydrates stored in the crowns and underground plant organs have an important role in perennial plants growth and longevity. These carbohydrates are frequently referred to as root reserves total nonstructural carbohydrates (TNC), or total available carbohydrates (TAC). The latter designation will be used in this paper because true carbohydrate analysis of root reserves has to restrict itself to those carbohydrates available for relocation from the storage organs for use by other parts of the plant. Roots can

manufacture none of their own sugar but are dependent on the tops for this essential. The distance separating the roots and shoots makes carbohydrates more limiting to root growth. Any treatment that is likely to increase the carbohydrate content of the plant is likely to favor the roots more than the tops.

EXPERIMENTAL DESIGN AND METHODS

This experiment was conducted at the Greenville Experimental Farm, Logan, Utah, from 1960 to 1965.

The soil was Millville silt loam that occurs on an alluvial fan, well-drained and has a surface slope of about one percent. It is high in potash and phosphorous and is alkaline, having a pH of 7.9 - 8.2.

Experimental Design

The experiment was set up in a factorial arrangement (modified split plot design) with irrigation as the main plot consisting of four moisture intervals with four replications arranged in a Latin-square design. The sub-plots were two frequencies of clipping, four levels of nitrogen fertilization, and six pasture mixtures. The plan of the layout is given in Figure 1. The size of the smallest experimental unit was 6 feet x 23 feet in size. The overall experiment involved a total of 768 plots. Forage, protein, and root yield data for this study was obtained from 480 plots.

Pasture Establishment

Plots were seeded in the spring of 1960. During the establishment year, the plots were uniformly irrigated by sprinkler with approximately one and one-half inches of water at eight- to ten-day intervals. The irrigation was done replication-wise. All the plots were mowed twice to control weeds. No treatment was started the first year.

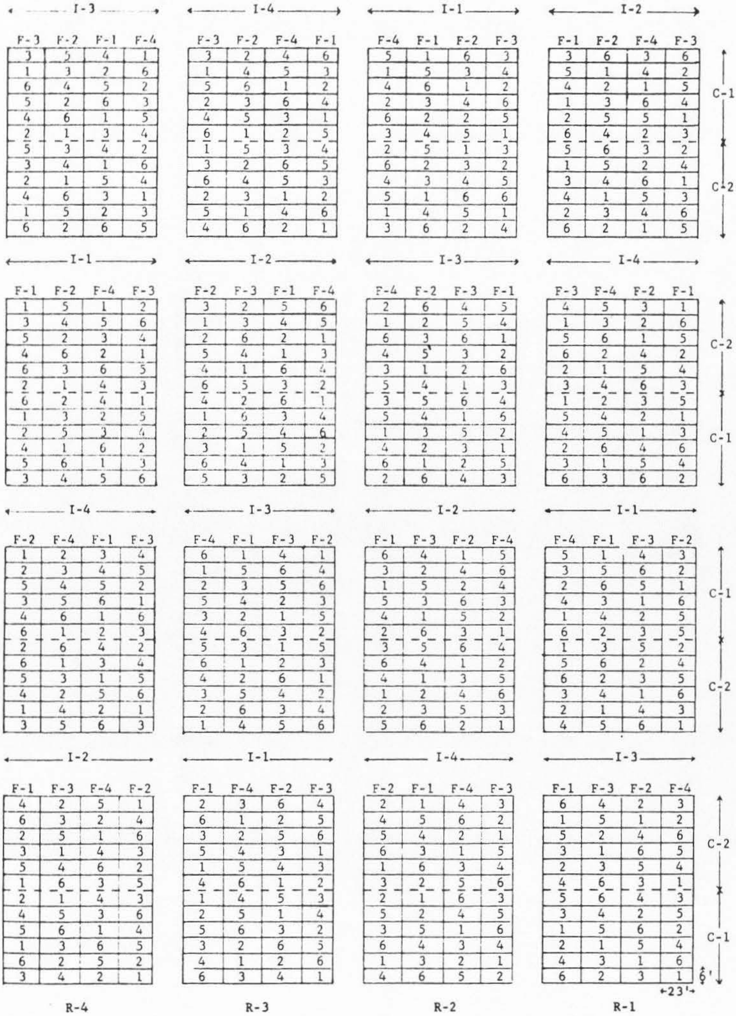

Figure 1. Map of the field plan showing the arrangement of plots and the treatment received

Treatments

The treatments were applied during the year 1961. For convenience, letters will be used to designate different treatments, viz. "I" for irrigation, "F" for fertilization, "C" for clipping, and "M" for pasture mixtures. These symbols are consistent in designation with all previous publications relating to this pasture study. These letters will be referred to frequently throughout this paper when discussing the various treatments. These treatments were as follows:

Clipping frequency

Two clipping frequencies were included in the study.

Symbol	Treatment
C-1	One-half the plots harvested four times a season at 35 day intervals.
C-2	One-half the plots harvested five times a season at 28 day intervals.

The state of forage development was used to determine the initial clipping date for both clipping treatments.

In 1965 all plots were clipped the same. The initial spring growth was removed by close mowing with a rotary lawn mower. A second mowing down to the plant crowns took place just prior to the undercutting of the plots. The clipped forage was blown away from the mowed area (Figure 2).

Irrigation

Irrigation water was applied to the plots using a perforated pipe sprinkler system designed to fit the plot design. The application rate was approximately one inch of water per hour.

The four irrigation treatments provided equivalent total amounts of water of approximately 23 inches each growing season, but the amount and frequency of the individual treatments varied.

Symbol	Interval
I-1	Long - 4 inches of water every 20 days.
I-2	Medium - 3 inches of water every 15 days.
I-3	Medium Short - 2 inches of water every 10 days
I-4	Short - 1 inch of water every 5 days.

No irrigation water was applied in 1965, the year the roots were removed for this study. The winter water supply from natural precipitation did stimulate some forage growth in the early spring. After the initial spring growth, the soil moisture was depleted to a level below plant utilization.

No root samples were taken or other data compiled from the I-2 irrigation plots.

Nitrogen fertilization

Four levels of actual nitrogen per acre were used on the plots.

Symbol	Treatment
F-1	0 pounds of nitrogen per acre
F-2	50 pounds of nitrogen per acre
F-3	100 pounds of nitrogen per acre
F-4	200 pounds of nitrogen per acre

The fertilizer was applied as ammonium nitrate. Fifty pounds of nitrogen were applied in April to the F-2, F-3 and F-4 plots. Addi-

tional 50 pound applications were made after successive harvests for the F-3 and F-4 plots each year.

The soil was high in potash. One hundred pounds per acre of phosphate were broadcast over the entire experimental area in the springs of 1961 and 1963 as P_2O_5.

Pasture mixtures

The planted mixtures were composed of legumes plus grasses or grasses alone. Certified seed was used in the mixtures if available. To obtain uniform distribution the seed was mixed with sawdust and broadcast over the plot by hand. The soil was smoothed with a garden rake to provide coverage of the seed.

No companion crop was planted with the forage mixtures. The land had either been in a row crop or fallow the previous two years. Nevertheless a good crop of annual weeds grew and were removed by clipping the entire experimental area June 16 and again August 4, 1960.

The varieties of legumes and grasses used in the mixtures were:

Ranger Alfalfa	(*Medicago sativa*)
Ladino Clover	(*Trifolium repens*)
Kenland Red Clover	(*Trifolium pratense*)
Granger Birdsfoot Trefoil	(*Lotus corniculatus*)
Orchardgrass	(*Dactylis glomerata*, commercial)
Manchar Bromegrass	(*Bromus inermis*, commercial)
Tualatin Tall Oatgrass	(*Arrhenatherum elatius*)
Greenar Intermediate Wheatgrass	(*Agropyron intermedium*)
Reed Canarygrass	(*Phalaris arundinacea*, commercial)

The components and the seeding rates for the six mixtures were as follows:

Symbol	Legume	Seeding rate lbs./acre	Grass	Seeding rate lbs./acre
			Bromegrass	4
M-1	Alfalfa	3	Orchardgrass	3
	Ladino Clover	2	Tall Oatgrass	3
	Red Clover	3	Reed Canarygrass	3
	sub-totals	8		13
			TOTAL 21 pounds	
M-2	Ladino Clover	3	Orchardgrass	8
			Bromegrass	12
	sub-totals	3		20
			TOTAL 23 pounds	
M-3	Alfalfa	3	Orchardgrass	8
			Bromegrass	12
	sub-totals	3		20
			TOTAL 23 pounds	
M-4	Birdsfoot Trefoil	6	Orchardgrass	6
			Bromegrass	10
	sub-totals	6		16
			TOTAL 22 pounds	
M-5	Alfalfa	3	Intermediate wheatgrass	15
	sub-totals	3		15
			TOTAL 18 pounds	
M-6	None		Orchardgrass	8
			Bromegrass	12
	sub-totals	0		20
			TOTAL 20 pounds	

M-1 was the most complex mixture consisting of three legumes and four grasses. The other mixtures were relatively simple. M-6 was composed of grasses only.

No root samples were taken or other data compiled from the M-4 plots. The birdsfoot trefoil component had nearly disappeared from the stand by the 1964 harvest season basically leaving only an orchardgrass-bromegrass pasture similar to M-6.

One problem did develop with the alfalfa-intermediate wheatgrass mixture (M-5). There was an invasion of the plots by dandelions beginning the second harvest season and increasing each year thereafter. This was the only mixture that had any significant weed invasion during the experiment.

Forage Yield Data

The forage was cut to a height of two inches with a Milbradt plot mower having a three-foot sickle bar. Just prior to each harvest the alley-ways were blocked out. Then a swath the width of the mower and 20 feet long was harvested through the middle of each plot for an area of 60 square feet. The total herbage harvested from each strip was weighed green. A sample of 1000 grams of the freshly cut material was taken in a bag for dry weight and protein analysis. The 1000 gram green samples were dried in a forced hot-air oven and then reweighed. Resulting data were used to compute the percentage dry weight.

Root Yield Data

The root samples were obtained during the summer of 1965. A 1 foot level of root undercutting was determined for this experiment because of power available, the mass of soil involved, and the apparently small percentage of roots extending below the 1 foot depth. Undercutting to the 12 inch depth was performed with a modified Noble-sweep, 42 inches wide, attached to a tool bar of a wheel tractor

(Figures 3, 4, 5). The direction of cutting was at right angles to the long side of the plots. Two trips were made through each plot giving two areas for the root samples. All plots were undercut, even though no root samples were to be taken, to insure uniformity of depth (Figure 6). The forage growth had been clipped and blown from the sample areas prior to undercutting (Figure 2).

As the soil was extremely dry, there was a tendency for large clumps of dirt and sod to rise. Two riders on the tool bar insured that there was no sod displacement away from the sample areas (Figure 7).

A 3-foot square welded metal frame was used to outline the individual sample areas (Figure 8).

The soil and roots from the framed area were removed and placed on canvasses and the larger clods broken with a large wooden mallet (Figure 9). The canvasses were emptied into a portable tractor-mounted cement mixer. Water was added and the mixer was run long enough to loosen the soil from the roots. The material was poured onto framed one-fourth and one-eighth inch screens and washed with fresh water (Figures 10, 11).

The washed roots were placed into a smaller cement mixer for final cleanup, rinsed on one-eighth inch screens (Figure 12) and sorted into three categories (a) all grass roots, (b) ladino clover roots, and (c) alfalfa roots, including all other legume roots (Figure 13). The weed roots were sorted out and discarded. Dandelions were the prevalent weeds and were only serious in the M-5 samples.

The sorted roots were put into clean cotton bags and dried by forced hot air to ten percent moisture or less.

Figure 2. Clipping and removing the spring forage growth.

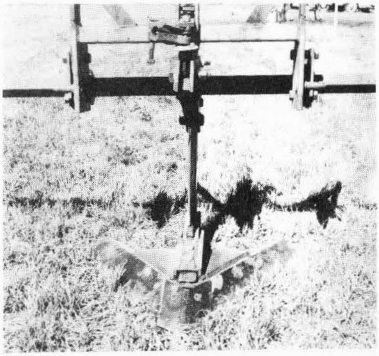

Figure 3. View showing the construction and attachment of the modified sweep.

Figure 4. Undercutting operation showing the sweep in the ground.

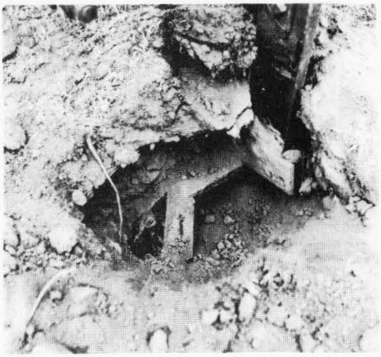

Figure 5. The soil removed. Note the relation of the roots and the sweep.

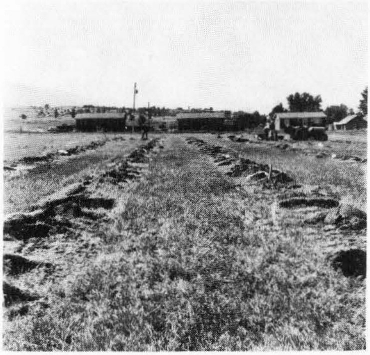

Figure 6. A field view showing the uniformity and layout after mowing and undercutting.

Figure 7. Riders on tool bar keeping sod displacement minimal.

Figure 8. Three foot square metal frame and sod cutting tool.

Figure 9. Removing the sod from the plots onto a canvas and breaking up the clods.

Figure 10. Washing the soil from the roots in a tractor mounted cement mixer.

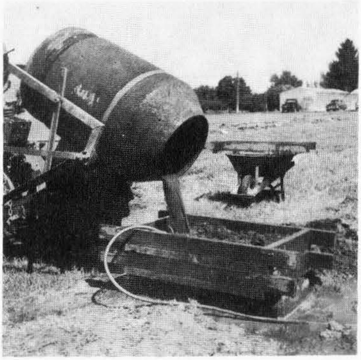

Figure 11. Dumping onto a stack of screens.

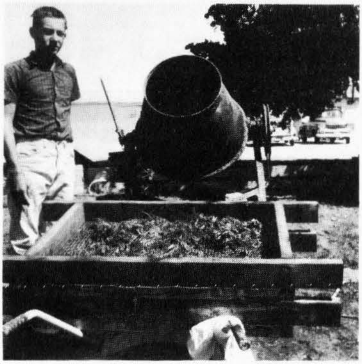

Figure 12. Final washing and clean-up in a small cement mixer.

Figure 13. The roots sorted and ready to bag and dry.

The dried roots were weighed and a sample ground in a Wiley grinder for chemical analysis. The ground root samples were stored in sealed plastic vials until testing.

Root yields per acre were determined.

Protein Analysis

For the forage protein analysis, all of the plots of two replications were sampled for each harvest.

The dried samples were finely ground in a Wiley mill. A one gram sample was used to determine the total nitrogen percent. The percent protein was calculated by multiplying the percent total nitrogen with the factor 6.25 as outlined in Appendix A.

Nitrogen was determined by a modified Kjeldahl method. Reagents included concentrated sulfuric acid, sodium hydroxide solution (40 to 45 percent NaOH by weight), standard 0.0715N H_2SO_4 and 20 mesh granular zinc. Other reagents used are listed in the following paragraphs.

The digestion mixture used was prepared by mixing copper sulfate, anhydrous powder; sodium sulfate, anhydrous powder; and powdered selenium in a 5:10:0.5 ratio.

The indicator solution was a mixture of brome cresol green, aqueous one percent solutions of new coccine, and p-nitrophenol.

The ammonia was distilled in two percent boric acid solution and the contents then titrated with 0.0715N H_2SO_4. The procedure followed was essentially the same as given by Jackson (1958, pages 183-203) and is given in Appendix A.

Total Available Carbohydrate (TAC) Analysis

The root samples were forced air-dried to 10 percent moisture. The dried tissue was sampled, ground and stored in capped plastic vials until analysis was made. Analysis was made on samples from two of the replications.

The TAC in the root samples were extracted and hydrolyzed by the acid method outlined by Smith (1962). Changes from the procedure outlined by Smith were (1) 0.2N H_2SO_4 was used in place of 2 percent v./v. (approximately 0.8N) H_2SO_4; (2) a reflux condensor was not used; (3) the concentrations of NaOH and HCL were decreased; (4) the hydrolyzate was diluted to 125 ml. with distilled water; and (5) an aliquot analyzed by a modified Nelson-Somogyi test (Nelson, 1944; Somogyi, 1952).

The absorption of each sample was read at 520 millimicrons against a treatment blank on a Perkin-Elmer Double Beam Spectrophotometer, Coleman 124.

The results were calculated against a known standard of a 10 percent sucrose solution and reported as percent TAC.

Complete extraction and analysis procedures are given in Appendix A.

Statistical Analysis

A statistical analysis was made at the Utah State University Computer Center. An analysis of variance was made for the dry matter yield of the total roots, total legume roots and the roots of the alfalfa, ladino clover and grass; forage yield; percent forage protein; forage protein production; root/forage ratio as a percent;

percent available carbohydrates and total available carbohydrates (TAC) of total roots and of the roots of the alfalfa, ladino clover, and grass.

F tests were made for the main effects and interactions at the .05 and .01 probability levels. LSD tests at the .05 and .01 levels were made for the main effects which had significant F values.

The term significant refers to the .05 level and highly (or very) significant refers to the .01 level of probability.

EXPERIMENTAL RESULTS

The experimental results of this pasture mixture study as influenced by clipping frequency (C), irrigation (I), and nitrogen fertilization (F) are presented in the following order: dry matter yield per acre, percent protein and protein yield per acre for the forage harvested in 1964; dry matter yield per acre, percent total available carbohydrates (TAC) and TAC per acre for ladino clover, alfalfa, total legume, grass and total grass and legume roots harvested in 1965; and the root-dry-matter-yield to forage-dry-matter-yield ratio (R/F) as a percent. All average yields are in pounds per acre.

Forage

Dry matter yield

The analysis of variance for the total seasonal dry matter yield is given in Table 111 (Appendix C) and shows highly significant F values for the main effects of clipping, nitrogen fertilization, and mixtures and interactions between mixtures x clipping, mixtures x irrigation, and mixtures x nitrogen fertilization and a significant F value for mixtures x clipping x nitrogen fertilization. The average dry matter yields as influenced by the different management practices are given in Table 94 (Appendix B).

Effect of clipping frequency. The response of forage production to clipping frequency appears in Table 1. Treatment C-1 (four harvests per season) gave a highly significant greater yield than C-2 (five harvests per season). The difference was 1068 pounds of dry matter per acre.

Table 1. Effect of clipping frequency on forage dry matter production, 1964

Clipping	Harvests per year	Average yield
		lbs/A
C-1	4	6919
C-2	5	5851
		LSD 0.01 = 158

<u>Effect of nitrogen fertilization</u>. Table 2 and Figure 14 show the forage production response to the four different levels of nitrogen fertilization. There was no significant yield difference between the F-2 (50 pounds) and F-3 (100 pounds) treatments. All other differences were highly significant.

<u>Effect of mixture</u>. Forage production as affected by mixtures is shown in Table 3 and Figure 15. The alfalfa containing mixtures M-1, M-3, and M-5 were high in production but indicated no significance in yield differences. There were highly significant yield differences between each of the alfalfa mixtures and both the M-2 (ladino clover-grass) and M-6 (grass-only) mixtures.

<u>Interaction of irrigation interval x mixture</u>. The average dry matter yields as influenced by irrigation x mixture are shown in Table 4 and Figure 16. This first order interaction was highly significant. The I-1 (20 day interval) gave the lowest yield with all mixtures except M-3. Little difference was recorded in yield between the I-3 (10 day interval) and I-4 (5 day interval) irrigation intervals except with M-3.

<u>Interaction of clipping frequency x mixture</u>. The average dry matter yields as influenced by clipping x mixture are shown in Table 5

Table 2. Effect of nitrogen fertilization on forage dry matter production, 1964

Fertilization	Nitrogen	Average yield
	lbs/A	
F-1	0	4994
F-2	50	6074
F-3	100	6414
F-4	200	8059

LSD 0.05 = 429
0.01 = 572

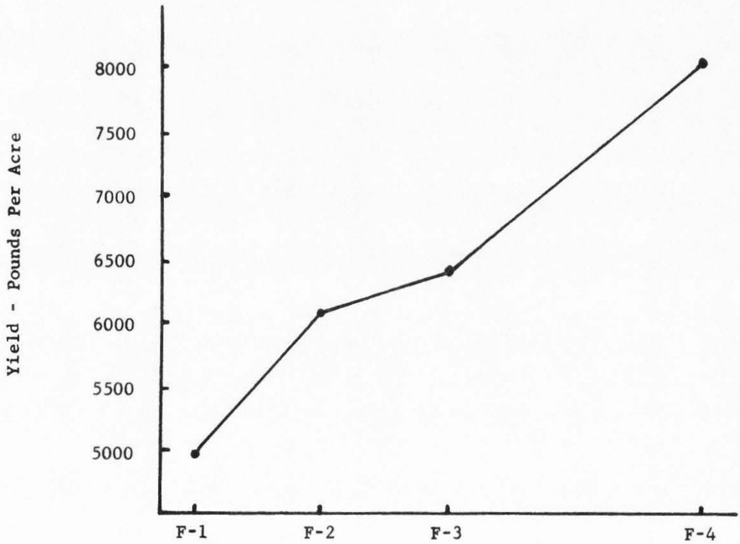

Figure 14. Average forage dry matter yield as influenced by nitrogen fertilization

Table 3. Effect of mixtures on dry matter production, 1964

Mixture	Species	Average yield
		lbs/A
M-1	A-RC-LC-OG-BG-RCG-TOG	7009
M-2	LC-OG-BG	6069
M-3	A-OG-BG	7060
M-5	A-IWG	6868
M-6	OG-BG	4920

LSD 0.05 = 198
0.01 = 260

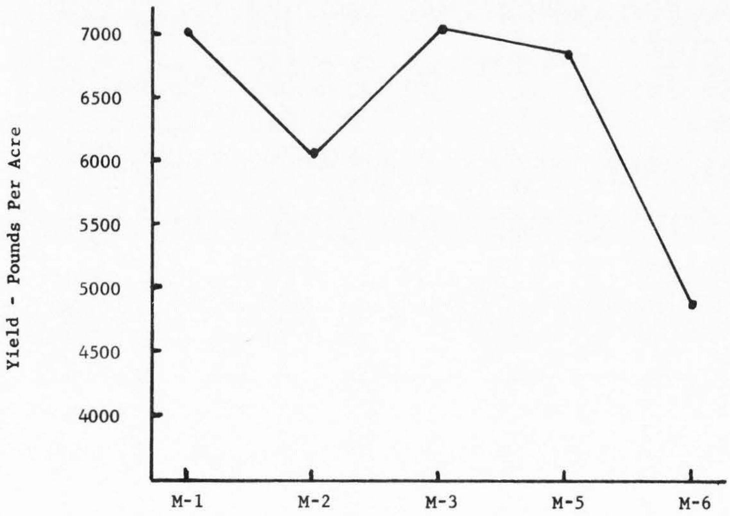

Figure 15. Average forage dry matter yield as influenced by mixtures

Table 4. Average forage dry matter yield as influenced by irrigation and mixture, 1964

Irrigation	Mixture M-1	M-2	M-3	M-5	M-6	Average
				165/A		
I-1	6900	5274	7130	6766	4438	6102
I-3	7111	6452	7230	6931	5098	6564
I-4	7015	6481	6821	6908	5224	6490
Average	7009	6069	7060	6868	4920	

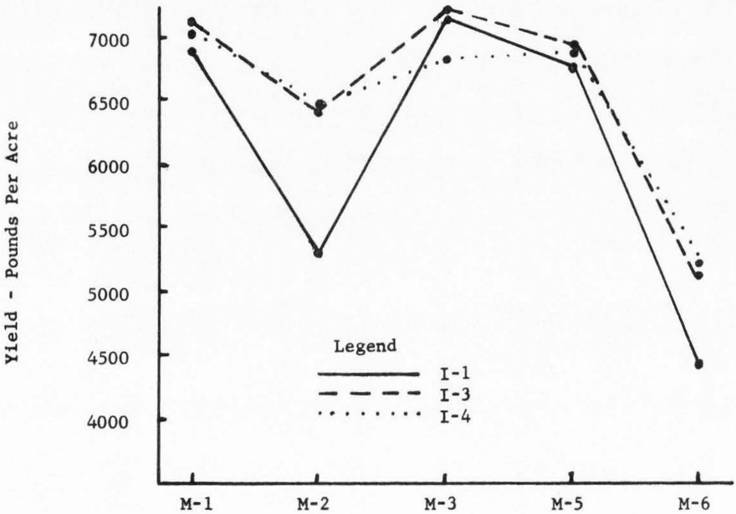

Figure 16. Average forage dry matter yields of pasture mixtures as influenced by irrigation interval

and Figure 17. This interaction was highly significant. The C-1 treatment gave the highest average yield with all mixtures. The overall average yield difference between the two clipping frequencies was 1068 pounds. M-2 and M-6, the non-alfalfa containing mixtures, averaged less than half this difference with 374 and 456 pounds, respectively.

Interaction of nitrogen fertilization x mixture. The interaction of fertilization x mixture gave highly significant results. The average dry matter yields are shown in Table 6. Figure 18 graphically indicates that each succeeding increase of nitrogen fertilization gave increased forage production by all mixtures. The additional 50 pounds of nitrogen added as the F-3 treatment did not give as large an increase in production as the first 50 pounds of nitrogen (F-2), except with M-5. The F-4 (200 pounds of nitrogen) treatment showed the least variation between mixtures. M-2 and M-6 showed the greatest deviation by lower forage production with F-1, F-2, and F-3. M-6 (grass-only) gave the lowest production at all nitrogen levels.

Interaction of clipping frequency x nitrogen fertilization x mixture. The second order interaction of clipping x fertilization x mixture was significant at the 0.05 level. The average yields are given in Table 7 and graphed in Figure 19. Only M-2 showed an increase of production with C-2, and this was with F-1 (no nitrogen). Only M-1 did not have an increase in production with each additional nitrogen treatment. The F-3 treatment yielded slightly less (38 pounds) than the F-2 treatment. These are the only two exceptions to general production trends in this second order interaction of a yield increase with an increase of nitrogen and a higher yield with fewer clippings.

Table 5. Average forage dry matter yield as influenced by clipping frequency and mixture, 1964

Clipping	Mixture M-1	M-2	M-3	M-5	M-6	Average
	lbs/A					
C-1	7876	6256	7826	7491	5148	6919
C-2	6142	5882	6294	6246	4692	5851

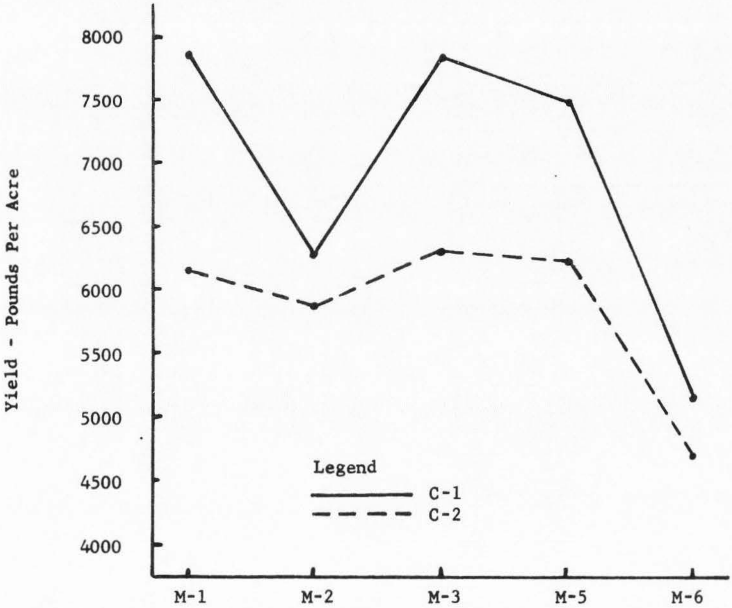

Figure 17. Average forage dry matter yields of pasture mixtures as influenced by clipping frequency

Table 6. Average forage dry matter yield as influenced by nitrogen fertilization and mixture, 1964

Fertilization	Mixtures M-1	M-2	M-3	M-5	M-6	Average
	lbs/A					
F-1	5929	4489	5694	6040	2820	4994
F-2	6883	5685	6913	6598	4288	6074
F-3	6973	6000	7219	7026	4855	6414
F-4	8251	8102	8415	7808	7720	8059

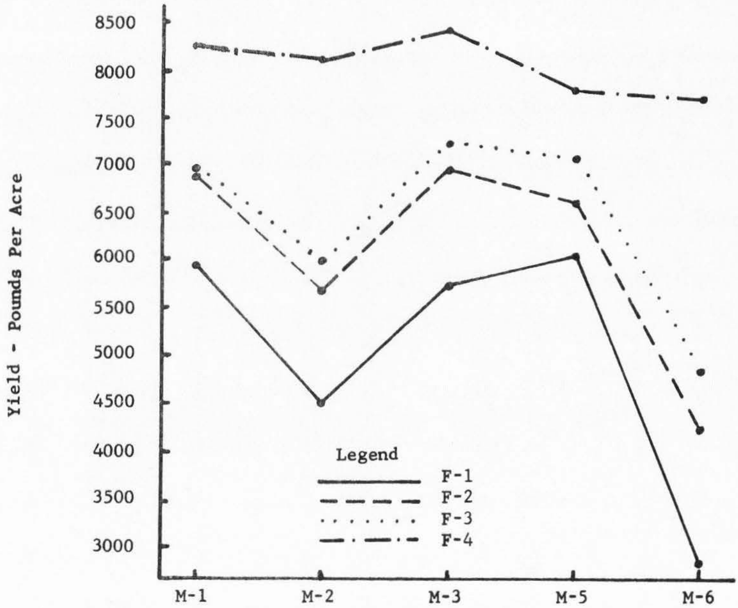

Figure 18. Average forage dry matter yields of pasture mixtures as influenced by nitrogen fertilization.

Table 7. Effect of clipping frequency and nitrogen fertilization on average yield of pasture mixtures, 1964

		M-1	M-2	M-3	M-5	M-6	Average
		lbs/A					
C-1	F-1	7039	4427	6494	6746	2858	5513
	F-2	7670	5951	7772	7280	4597	6654
	F-3	7888	6152	8150	7827	4966	6995
	F-4	8907	8491	8891	8112	8170	8514
C-2	F-1	4819	4552	4894	5335	2782	4476
	F-2	6096	5419	6055	5916	3979	5494
	F-3	6058	5847	6289	6223	4743	5832
	F-4	7595	7713	7938	7503	7269	7604

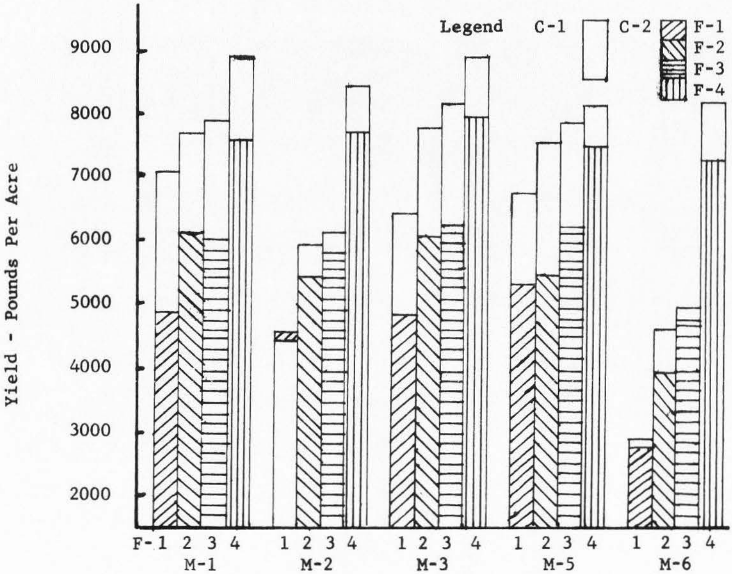

Figure 19. Average forage dry matter yield of pasture mixtures as influenced by clipping frequency and nitrogen fertilization

Percent protein

The analysis of variance for percent protein content of the forage is given in Table 112 (Appendix C). Mixtures alone indicated a significant F value and this was at the 0.01 level. Complete data on percent protein of the forage as influenced by the various management practices are compiled in Table 95 (Appendix B).

Effect of mixture. The effect of mixture on percent protein of the forage is given in Table 8 and graphically shown in Figure 20. The percent protein in M-2 was significantly lower than M-5 and M-6 was significantly lower than M-1. Both M-3 and M-5 had highly significant protein percentages above M-6.

M-1, M-3, and M-5, the three mixtures containing alfalfa, were highest in percent protein followed by M-2, the ladino clover-grass mixture. M-6, the all grass mixture, was lowest in percent protein.

Protein yield

The protein yield is the product of dry matter yield and percent protein. The analysis of variance is given in Table 113 (Appendix C). Average protein yield data are given in Table 96 (Appendix B). The analysis of variance shows highly significant F values for clipping frequency, nitrogen fertilization, mixture, irrigation interval x mixture and clipping frequency x mixture. These were also indicated as highly significant F values in the dry matter yield analysis of variance.

Effect of clipping frequency. The effect of clipping frequency on the protein yield appears in Table 9. Treatment C-1 was highly significant over C-2.

Table 8. Effect of mixtures on percent protein content of forage, 1964

Mixture	Species	Average percent
M-1	A-RC-LC-OG-BG-RCG-TOG	15.89
M-2	LC-OG-BG	15.50
M-3	A-OG-BG	16.56
M-5	A-IWG	17.29
M-6	OG-BG	14.09

LSD 0.05 = 1.44
0.01 = 1.91

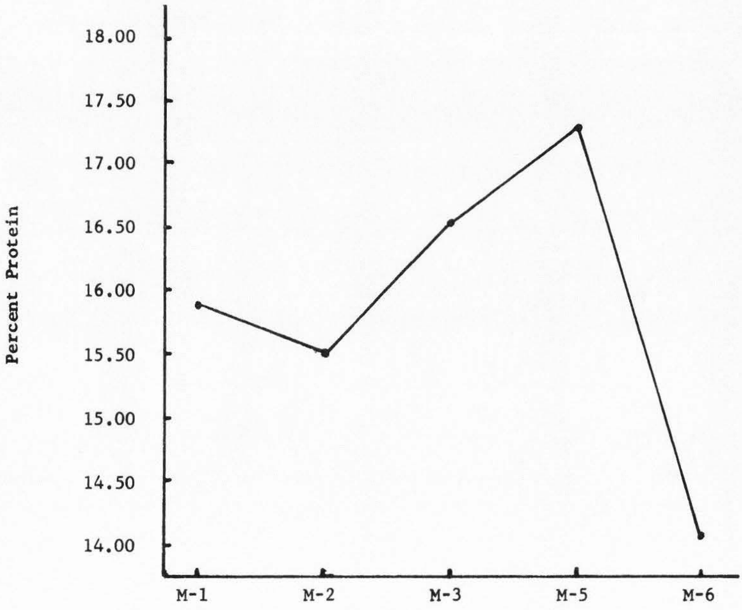

Figure 20. Average percent protein content of forages as influenced by mixtures

Table 9. Effect of clipping frequency on forage protein yield, 1964

Clipping	Harvests per year	Protein yield
		lbs/A
C-1	4	1067
C-2	5	968
		LSD 0.01 = 97

Effect of nitrogen fertilization. Table 10 and Figure 21 show the effect of nitrogen fertilization on the protein yield. The graph design is very similar to the forage dry matter graph (Figure 14). All differences were highly significant except between F-2 and F-3.

Effect of mixture. Protein production as affected by mixtures is shown in Table 11 and Figure 22. The graph has a great similarity to Figure 15 with the protein yield highest in the alfalfa containing mixtures, M-1, M-3 and M-5 but there was no significance in the protein yield differences of these three mixtures. There were highly significant differences between each of the alfalfa mixtures and M-2 and M-6. M-6 was low in protein production with 246 pounds less protein than M-2 and 413 pounds less than M-1, the lowest of the three alfalfa containing mixtures.

Interaction of irrigation interval x mixture. The average forage protein yields as influenced by irrigation x mixture are shown in Table 12 and Figure 23. This first order interaction was highly significant. Little difference was noted in protein yield between I-3 and I-4 except I-3 was the higher for all mixtures. I-1 was highest in protein production with M-1, M-3, and M-5, the alfalfa containing mixtures, and lowest with M-3 and M-6. M-2 and M-3 showed

Table 10. Effect of nitrogen fertilization on forage protein yield, 1964

Fertilization	Nitrogen	Protein yield
	lbs/A	
F-1	0	801
F-2	50	959
F-3	100	1004
F-4	200	1304

LSD 0.05 = 98
0.01 = 131

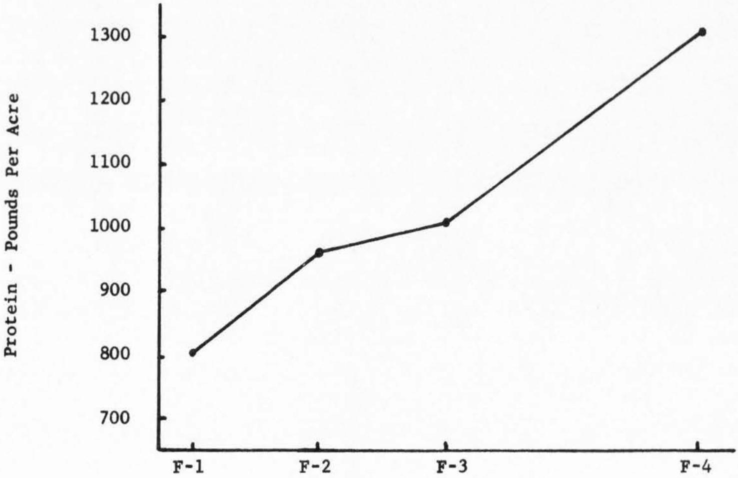

Figure 21. Average forage protein yield as influenced by nitrogen fertilization

Table 11. Effect of mixture on forage protein yield, 1964

Mixture	Species	Protein yield
		lbs/A
M-1	A-RC-LC-OG-BG-RCG-TOG	1110
M-2	LC-OG-BG	943
M-3	A-OG-BG	1149
M-5	A-IWG	1188
M-6	OG-BG	697
	LSD 0.05 =	84
	0.01 =	110

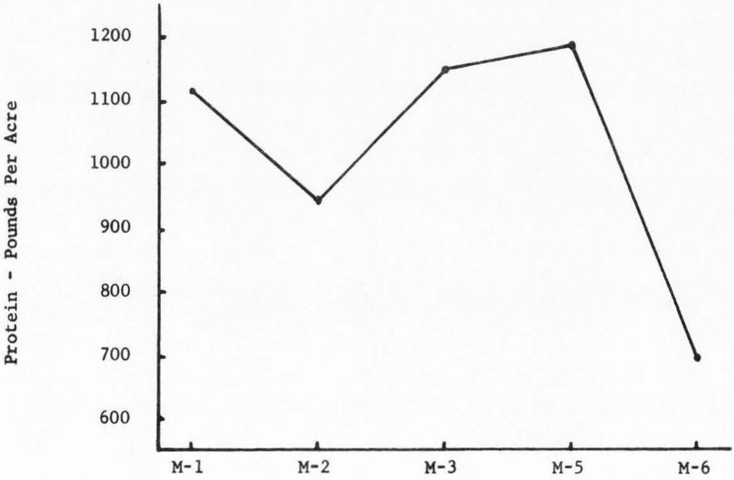

Figure 22. Average forage protein yield as influenced by mixture

Table 12. Average forage protein yield as influenced by irrigation and mixture, 1964

Irrigation	Mixture M-1	M-2	M-3	M-5	M-6	Average
	lbs/A					
I-1	1158	838	1249	1215	647	1021
I-3	1113	1000	1119	1210	729	1034
I-4	1058	990	1078	1138	716	996
Average	1110	943	1149	1188	697	

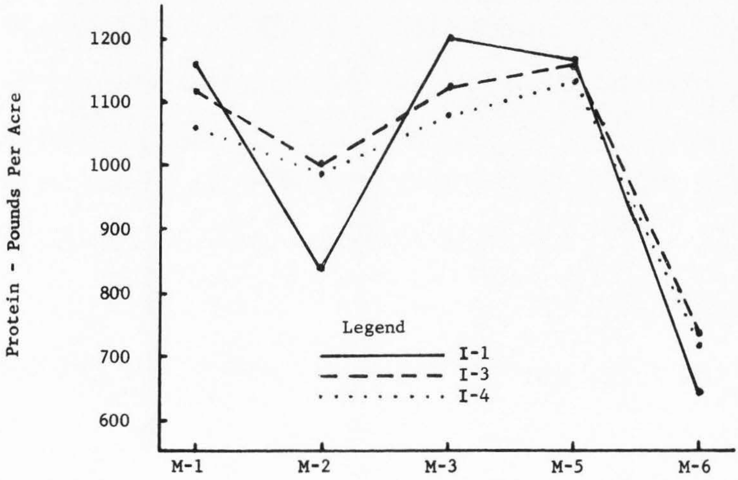

Figure 23. Average forage protein yield of pasture mixtures as influenced by irrigation interval

the largest deviation in protein production as influenced by irrigation interval.

Interaction of clipping frequency x mixture. The average forage protein yields as influenced by clipping x mixture are shown in Table 13 and Figure 24. This interaction was highly significant. The C-1 treatment gave the highest protein yield with the alfalfa containing mixture but less than C-2 with the ladino clover-grass and grass-only mixture. The mixtures ranked in order of protein production with the C-1 treatment and the deviation from the C-2 treatment protein production are M-5, M-3, M-1, M-2, and M-6 (212, 208, 199, -98 and -26 pounds, respectively).

Root Dry Matter Yield

The root dry matter yields were all figured in pounds per acre. The experimental results will be discussed for ladino clover, alfalfa, total legume, grass, and total grass and legume roots, respectively,

Ladino clover root yield

The analysis of variance for the ladino clover root dry matter yields is given in Table 114 (Appendix C). The yield data are compiled in Table 97 (Appendix B). The main effects of clipping frequency and mixtures; and the interactions of irrigation x nitrogen fertilization and mixtures x irrigation interval showed significant F values. The main effect of nitrogen fertilization showed a highly significant F value. The irrigation interval was nonsignificant but the root yield increased with the increased frequency of irrigation.

Effect of clipping frequency. The effect of clipping frequency on ladino clover root production is shown in Table 14. The ladino

Table 13. Average forage protein yield as influenced by clipping frequency and mixture, 1964

Clipping	Mixture M-1	M-2	M-3	M-5	M-6	Average
	lbs/A					
C-1	1209	894	1252	1294	684	1067
C-2	1010	992	1044	1082	710	968

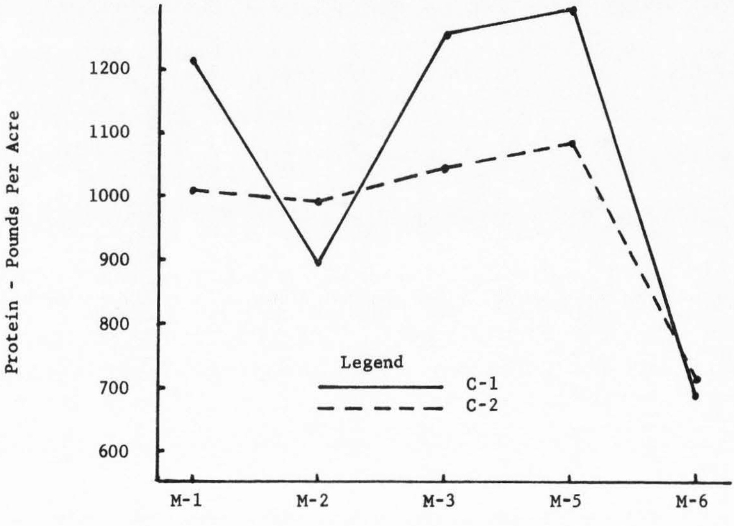

Figure 24. Average forage protein yield of pasture mixtures as influenced by clipping frequency

clover under C-2 gave a significantly higher root yield than under C-1. There was a difference of 133 pounds of roots per acre.

Table 14. Effect of clipping frequency on ladino clover root production, 1965

Clipping	Harvests per year	Root dry weight
		lbs/A
C-1	4	203
C-2	5	336
	LSD 0.05	= 98
	0.01	=141 N.S.

Effect of nitrogen fertilization. Table 15 and Figure 25 show the effect of nitrogen fertilization on ladino clover root yield. The differences were highly significant. Fifty pounds of nitrogen (F-2) gave the highest yield, followed by no nitrogen (F-1), 100 pounds of nitrogen (F-3) and 200 pounds of nitrogen (F-4).

Effect of mixture. The effect of mixtures on ladino clover root yield is shown in Table 16. The difference was significant. Only two mixtures contained ladino clover. The simple mixture (M-2) gave a higher ladino clover root yield than the more complex mixture (M-1).

Interaction of irrigation interval x mixture. The results of the interaction between irrigation x mixture on ladino clover root production appear in Table 17 and Figure 26. M-2 gave higher yields than M-1 at the two longer irrigation intervals (I-1 and I-3) but dropped in yield with the shortest irrigation interval (I-4) while M-1 made a sharp increase under the I-4 treatment.

Table 15. **Effect of nitrogen fertilization on ladino clover root production, 1965**

Fertilization	Nitrogen	Root dry weight
	lbs/A	
F-1	0	318
F-2	50	454
F-3	100	253
F-4	200	52

LSD 0.05 = 108
0.01 = 144

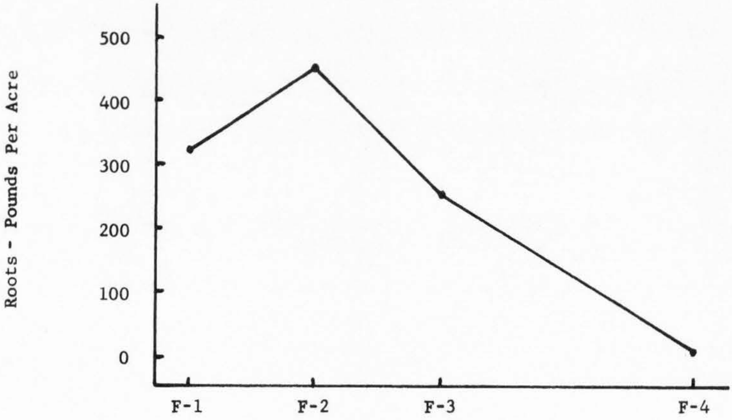

Figure 25. Average ladino clover root production as influenced by nitrogen fertilization

Table 16. Effect of mixture on ladino clover root production, 1965

Mixture	Species	Average yield
		lbs/A
M-1	A-RC-LC-OG-BG-RCG-TOG	238
M-2	LC-OG-BG	302
		LSD 0.05 = 51
		0.01 = 68

Table 17. Average ladino clover root production as influenced by irrigation interval and mixture, 1965

Irrigation	Mixture M-1	Mixture M-2	Average
	lbs/A		
I-1	149	257	203
I-3	205	326	266
I-4	359	320	340
Average	238	302	

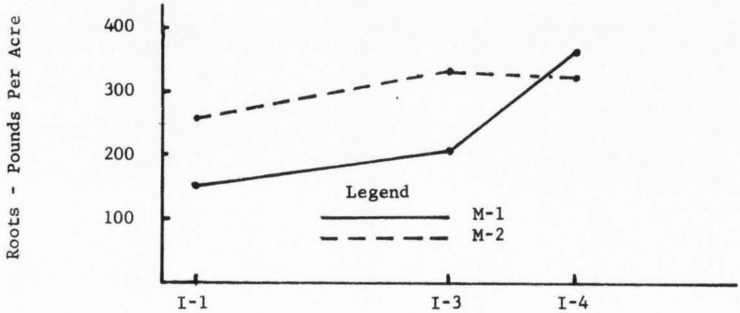

Figure 26. Average ladino root production of pasture mixtures as influenced by irrigation interval

Interaction of irrigation interval x nitrogen fertilization. The results of the interaction between irrigation x fertilization on ladino clover root production appear in Table 18 and Figure 27. The results were significant. The production of I-1 and I-3 was similar at F-2, dropped to less than fifty percent at F-3 and a similar drop at F-4. The root production at F-4 was low for all three irrigation intervals. I-4 was high in production at F-2 and F-3 treatment levels, intermediate at F-1 and low at F-4.

Alfalfa root yield

The analysis of variance for the alfalfa root dry matter yields is given in Table 115 (Appendix C). The yield data are compiled in Table 98 (Appendix B). All of the legume roots in M-1 except the ladino clover roots were considered in the alfalfa root category. The main effects of clipping frequency, irrigation interval,mixture and nitrogen fertilization were all highly significant. The first order interaction of irrigation x fertilization was significant and the second order interaction of clipping x fertilization x mixture was significant.

Effect of clipping frequency. The response of alfalfa root production to clipping frequency is shown in Table 19. Plants cut four times a season (C-1) gave a highly significant increase in root production of 1024 pounds over plants cut five times a season (C-2).

Table 18. Average ladino clover root production as influenced by irrigation interval and nitrogen fertilization, 1965

Irrigation	Fertilization F-1	F-2	F-3	F-4	Average
	lbs/A				
I-1	231	366	164	52	203
I-3	432	407	154	69	266
I-4	293	590	440	34	340
Average	318	454	253	52	

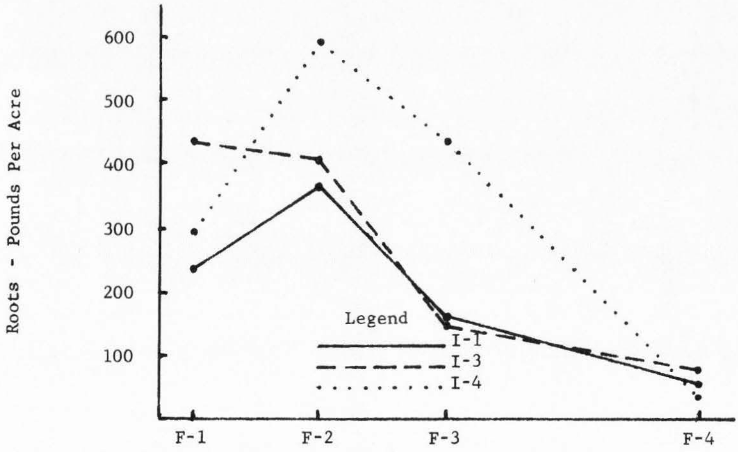

Figure 27. Average ladino clover root production at nitrogen fertilization levels as influenced by irrigation interval

Table 19. Effect of clipping frequency on alfalfa root production, 1965

Clipping	Harvests per year	Root dry weight
		lbs/A
C-1	4	2169
C-2	5	1145

LSD 0.01 = 345

Effect of mixture. The effect of mixture on alfalfa root production is shown in Table 20 and was highly significant between all three mixtures containing alfalfa. The simplest mixture of alfalfa and intermediate wheatgrass (M-5) gave the highest alfalfa root yield followed by M-3 and then the most complex mixture (M-1) giving the lowest yield.

Table 20. Effect of mixture on alfalfa root production, 1965

Mixture	Species	Root dry weight
		lbs/A
M-1	A-RC-LC-OG-BG-RCG-TOG-	1172
M-3	A-OG-BG	1704
M-5	A-IWG	2096

LSD 0.01 = 138

Effect of irrigation interval. The effect of irrigation interval on alfalfa root production is shown in connection with legume root production in Table 21 and Figure 28 and was highly significant. The longest irrigation interval (I-1) gave the highest alfalfa root yield followed by lower yields in the order of the shortening interval (I-3 and I-4)

Table 21. Effect of irrigation interval on alfalfa and total legume root production, 1965

Irrigation	Interval	Root dry weight	
		Alfalfa	Total legume
	days	lbs/A	
I-1	20	2098	1675
I-3	10	1514	1268
I-4	5	1358	1188
	LSD 0.05 =	306	323
	0.01 =	464	490 N.S.

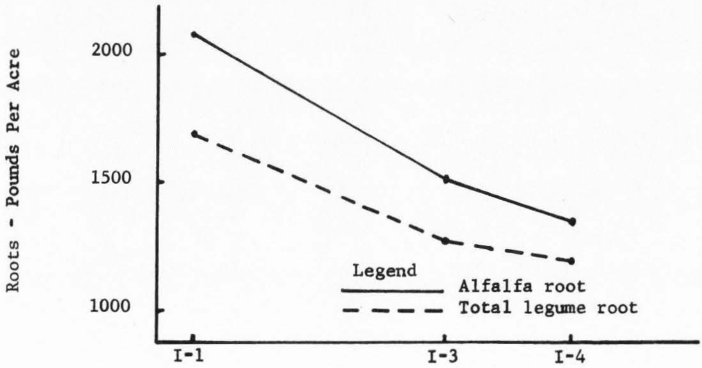

Figure 28. Average alfalfa and total legume root production as influenced by irrigation interval

Effect of nitrogen fertilization. The highly significant effect of nitrogen fertilization on alfalfa root production is shown with the legume root production in Table 22 and Figure 29. The F-2 treatment gave the highest root yield followed by F-1, F-3 and F-4. The differences between the F-1 and F-2 and F-1 and F-3 treatments were not significant.

Interaction of irrigation interval x nitrogen fertilization. The significant results of the interaction of irrigation x fertilization on alfalfa root production are shown in Table 23 and Figure 30. At all fertilization rates I-1 gave the highest yield. I-3 gave the lowest yield at F-3 but was second highest at all other fertilization rates. The alfalfa root production dropped with the I-4 treatment as the nitrogen increased except a slight increase with the F-3 treatment. The F-2 treatment produced the highest root yield for both I-1 and I-3.

Interaction of clipping frequency x mixture x nitrogen fertilization. The results of the significant second order interaction of clipping x mixture x fertilization on alfalfa root production are given in Table 98 (Appendix B). The alfalfa root production averaged over clipping was highest with the F-2 and lowest with the F-4 treatment for all three mixtures containing alfalfa. The alfalfa root production averaged over fertilization was highest with the C-1 and lowest with the C-2 frequency for all three alfalfa mixtures.

Legume root yield

The analysis of variance for the legume-root-dry-matter yields is given in Table 116 (Appendix C). The yield data are compiled in Table 99 (Appendix B).

Table 22. Effect of nitrogen fertilizer on alfalfa and total legume root production, 1965

Fertilizer	Nitrogen	Root dry weight Alfalfa	Root dry weight Legume
	lbs/A		
F-1	0	1913	1594
F-2	50	2032	1750
F-3	100	1800	1476
F-4	200	888	688
		LSD 0.05 = 172	128
		0.01 = 229	171

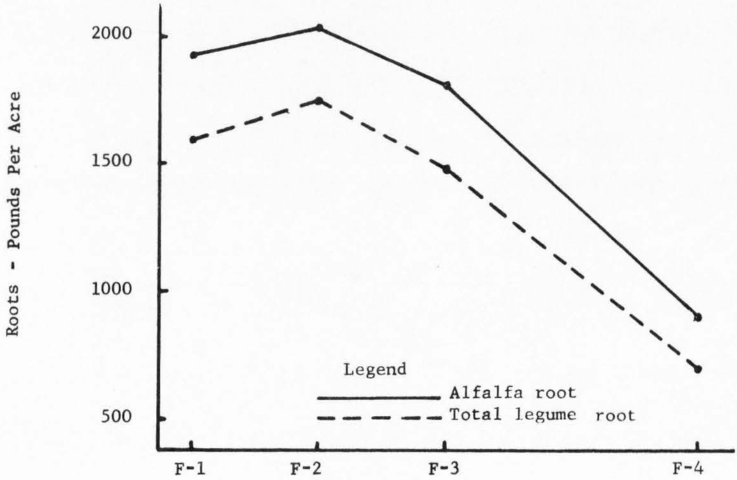

Figure 29. Average alfalfa and total legume root production as influenced by nitrogen fertilizer

Table 23. Average alfalfa root production as influenced by irrigation interval and nitrogen fertilization, 1965

Irrigation	Fertilization F-1	F-2	F-3	F-4	Average
	lbs/A				
I-1	2388	2464	2242	1298	2098
I-3	1762	2092	1446	757	1514
I-4	1588	1539	1712	592	1358
Average	1913	2032	1800	888	1657

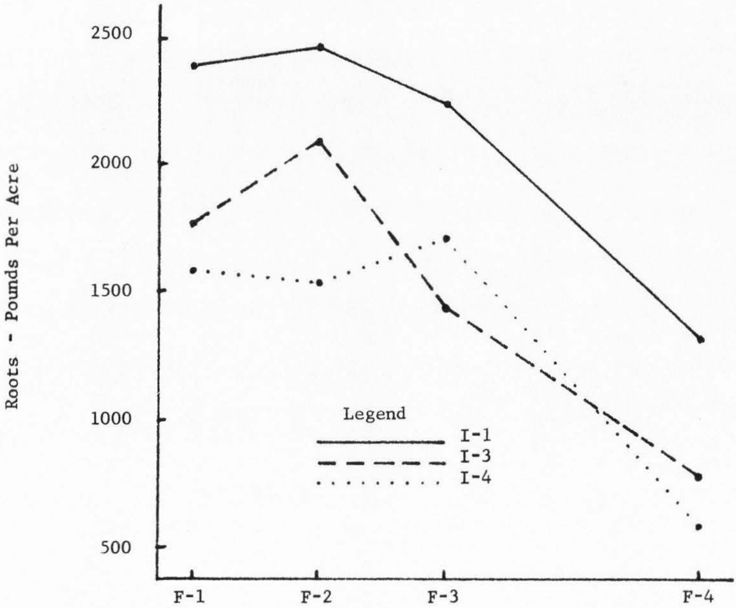

Figure 30. Average alfalfa root production at nitrogen fertilization levels as influenced by irrigation interval

This information is a compilation of ladino clover and alfalfa root production data. M-1 was the only mixture containing both alfalfa and ladino clover so these two were combined. M-2 contained only ladino cloverand M-3 and M-5 contained only alfalfa as legumes; M-6 was grass-only and not included in the data.

The analysis of variance gave a significant F value for irrigation interval, highly significant F values for clipping frequency, mixtures, nitrogen fertilization, irrigation x fertilization, irrigation x mixture, clipping x mixture and fertilization x mixture.

As the graphs for irrigation, fertilization and irrigation x fertilization for legume root production were very similar to those of the alfalfa root production, these data were combined in the tables and graphs.

Effect of clipping frequency. The effect of clipping frequency on legume root production is shown in Table 24. Four clippings per season (C-1) outyielded five clippings per season (C-2) by 702 pounds.

Table 24. Effect of clipping frequency on legume root production, 1965

Clipping	Harvests per year	Root dry weight
		lbs/A
C-1	4	1728
C-2	5	1026
		LSD 0.01 = 229

Effect of irrigation interval. The effect of irrigation interval on legume root production is shown in Table 21 and Figure 28. The legume root production was lower than the alfalfa root production

after averaging in the ladino root production. The curves were similar except closer in production with the more frequent irrigation treatments. I-1 was significant in increased production over I-3 and I-4 but the difference between I-3 and I-4 was nonsignificant.

Effect of mixture. The effect of mixtures on legume root production is shown in Table 25 and Figure 31. All root yield differences for the four mixtures were highly significant. M-2 was lowest and M-5 highest in legume root production.

Effect of nitrogen fertilization. The effect of nitrogen fertilization on legume root production is shown in Table 22 and Figure 25. The yield difference between F-1 and F-3 was nonsignificant, between F-1 and F-2 significant and between all other treatments high significant. The legume root yield with F-2, F-1, F-3 and F-4 was 1750, 1594, 1476 and 688 pounds per acre, respectively.

Interaction of irrigation interval x nitrogen fertilization. The highly significant results of the interaction of irrigation x fertilization on legume root production are shown in Table 26 and Figure 32. Figure 32 is similar to the alfalfa root yield graph (Figure 30) for the same interaction. I-1 gave the highest yield at all fertilization rates. I-3 was the lowest of the irrigation levels in production at F-3 but was second highest at all other fertilization rates. Both I-1 and I-3 increased in production with the first 50 pounds of nitrogen (F-2) but dropped off sharply as higher rates of nitrogen were applied. Legume root production increased with the short irrigation interval (I-4) through the 100 pound (F-3) nitrogen application and then decreased sharply with the highest increment of fertilization (F-4). F-4 produced the lowest root yield with all three irrigation intervals.

Table 25. Effect of mixtures on legume root production, 1965

Mixture	Species	Root dry weight
		lbs/A
M-1	A-RC-LC-OG-BG-RCG-TOG	1408
M-2	LC-OG-BG	302
M-3	A-OG-BG	1704
M-5	A-IWG	2906

LSD 0.01 = 136

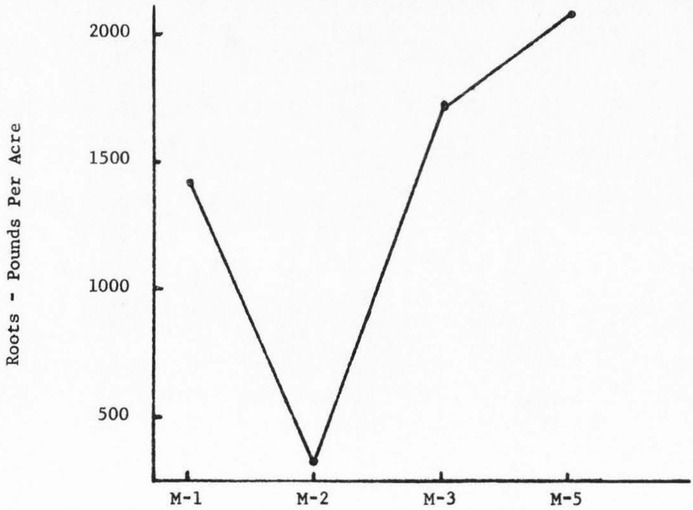

Figure 31. Average legume root production as influenced by mixture

Table 26. Average legume root production as influenced by irrigation interval and nitrogen fertilization, 1965

Irrigation	Fertilization F-1	F-2	F-3	F-4	Average
	lbs/A				
I-1	1906	2030	1764	1000	1675
I-3	1538	1772	1162	602	1268
I-4	1337	1449	1504	461	1188
Average	1594	1750	1476	688	

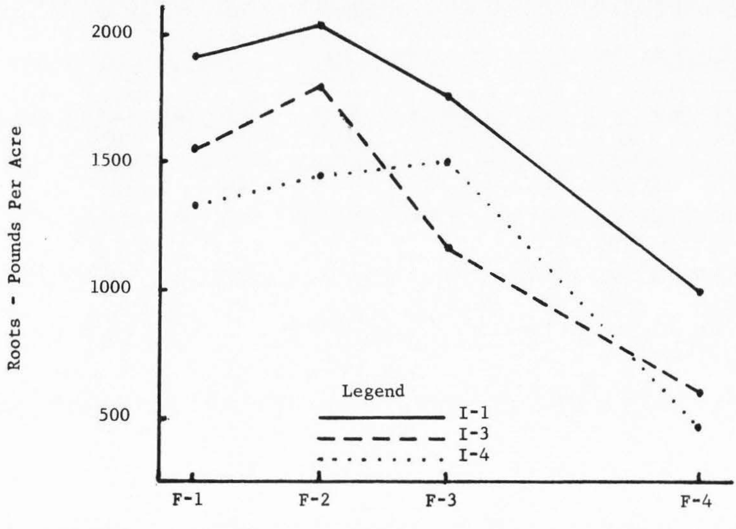

Figure 32. Average legume root production at nitrogen fertilization levels as influenced by irrigation interval

Interaction of irrigation interval x mixture. The interaction of irrigation x mixture on legume root production was highly significant and is shown in Table 27 and Figure 33. The long irrigation interval (I-1) had the highest root production with all mixtures except M-2 where it was lower than the other irrigation intervals. I-3 had a slightly larger root production than I-4 with all mixtures. Figure 33 indicates M-2 being very low in comparison with the other mixtures in legume root production.

Interaction of clipping frequency x mixture. Table 28 and Figure 34 give the highly significant clipping x mixture legume root production data. C-1 gave a substantially higher yield than C-2 for all mixtures except M-2 where the root production dropped slightly lower than C-2.

Interaction of nitrogen fertilization x mixture. Table 29 and Figure 35 give the highly significant nitrogen fertilization x mixture legume root production data. The 50 pound nitrogen (F-2) treatment yielded highest with all mixtures followed by 0 pounds (F-1), 100 pounds (F-3) and 200 pounds (F-4) except M-1 yielded 41 pounds more legume roots with F-3 than F-1. M-2 yielded least for all fertilization levels. Less mixture variation in legume root yield was noted with F-4 than any of the other fertilization treatments.

Grass root yield

The analysis of variance for the grass-root-dry-matter yields is given in Table 117 (Appendix C). The yield data are compiled in Table 100 (Appendix B). The effects of irrigation interval and the clipping frequency x nitrogen fertilization x mixture interaction were signif-

Table 27. Average legume root production of pasture mixtures as influenced by irrigation interval, 1965

Irrigation	Mixtures M-1	M-2	M-3	M-5	Average
	lbs/A				
I-1	1753	259	2172	2519	1675
I-3	1260	326	1575	1913	1268
I-4	1212	320	1366	1855	1188
Average	1408	302	1704	2096	

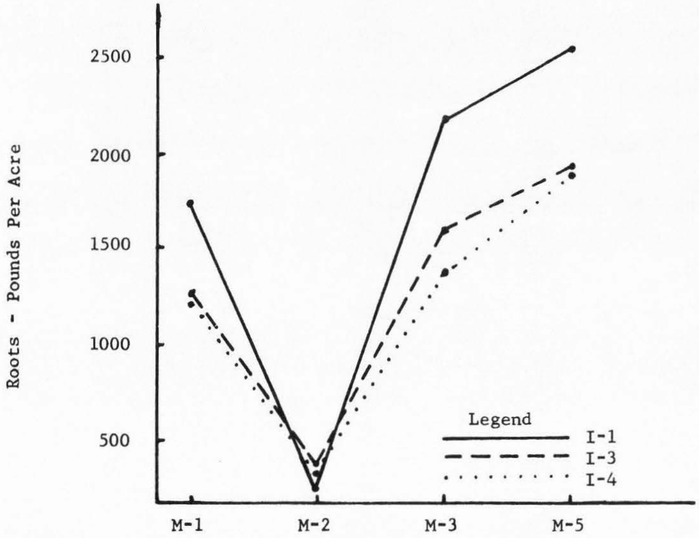

Figure 33. Average legume root production of pasture mixtures as influenced by irrigation interval

Table 28. Average legume root production of pasture mixtures as influenced by clipping frequency, 1965

Clipping	Mixture M-1	M-2	M-3	M-5	Average
	lbs/A				
C-1	1914	247	2126	2626	1728
C-2	902	356	1283	1565	1026
Average	1408	302	1704	2096	

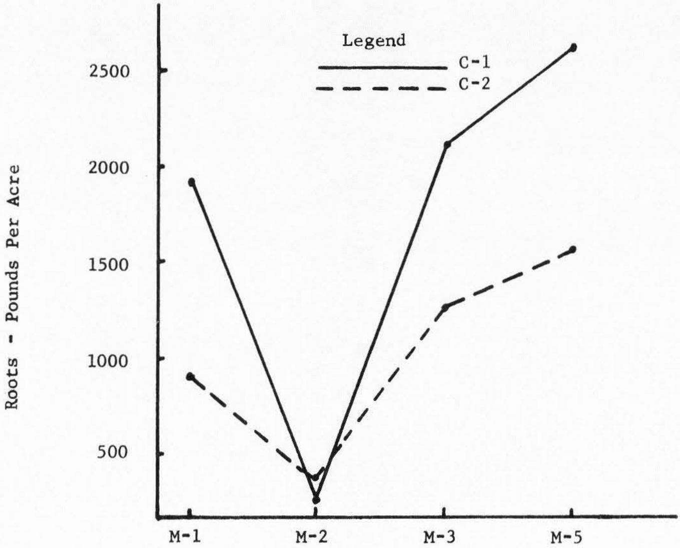

Figure 34. Average legume root production of pasture mixtures as influenced by nitrogen fertilization

Table 29. Average legume root production of pasture mixtures as influenced by nitrogen fertilization, 1965

Fertilizer	Mixture M-1	M-2	M-3	M-5	Average
	lbs/A				
F-1	1515	368	2150	2340	1594
F-2	1860	519	2252	2371	1750
F-3	1556	261	1769	2320	1476
F-4	698	56	645	1352	688
Average	1408	302	1704	2096	

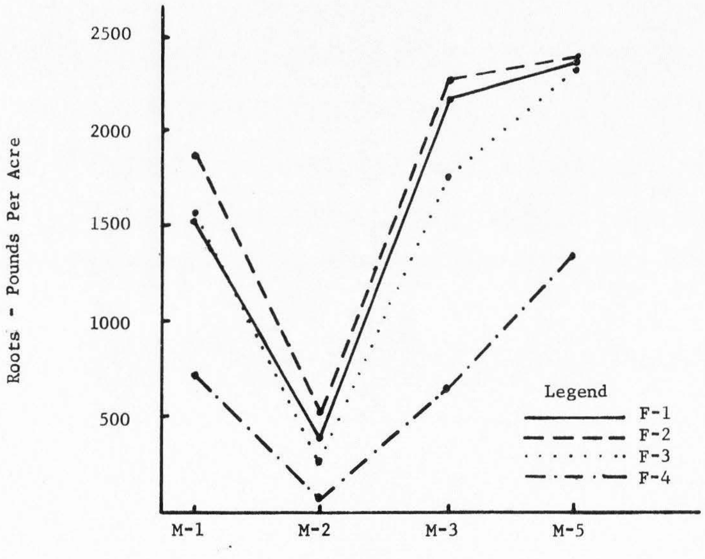

Figure 35. Average legume root production of pasture mixtures as influenced by nitrogen fertilization

icant. Nitrogen fertilization, mixture, clipping frequency x mixture, and nitrogen fertilization x mixture all gave highly significant results.

Effect of irrigation interval. The effect of irrigation on grass root production is shown with the total root production data in Table 30 and Figure 36. The 20 day interval (I-1) gave the highest root production followed by the 5 day interval (I-4). The difference was nonsignificant. The 10 day interval (I-3) was the lowest in production. Yield differences between the I-3 and the other two irrigation intervals were significant.

Effect of mixture. The effect of mixture on grass root production is shown with the data for total root production in Table 31 and Figure 37. The differences between M-1 and M-5 and M-2 and M-3 were nonsignificant. All other differences were highly significant. M-6 (grass-only) was highest in grass root production followed by M-2 (grass-ladino clover).

Effect of nitrogen fertilization. The effect of nitrogen fertilization on grass root production is shown in Table 32 and Figure 38 with the total root production data. The difference between F-2 and F-4 was nonsignificant; between F-1 and F-3, significant; and between all others, highly significant. Highest root production came from 50 pounds of nitrogen (F-2) followed by 200 pounds (F-4), 100 pounds (F-3), and 0 pounds (F-1).

Interaction of clipping frequency x mixture. The clipping x mixture interaction on grass root production was highly significant. The results are given in Table 33 and Figure 39. M-1 and M-3 each had 3 pounds difference in grass root yield under the two clipping treatments. M-6 showed a 145 pound difference and M-2 a 557 pound

Table 30. Effect of irrigation interval on grass and total root production, 1965

Irrigation	Interval	Root dry weight: Grass	Root dry weight: Total root
	days	lbs/A	
I-1	20	5398	6734
I-3	10	4823	5837
I-4	5	5249	6200
	LSD 0.05 =	417	435
	0.01 =	632 N.S.	659

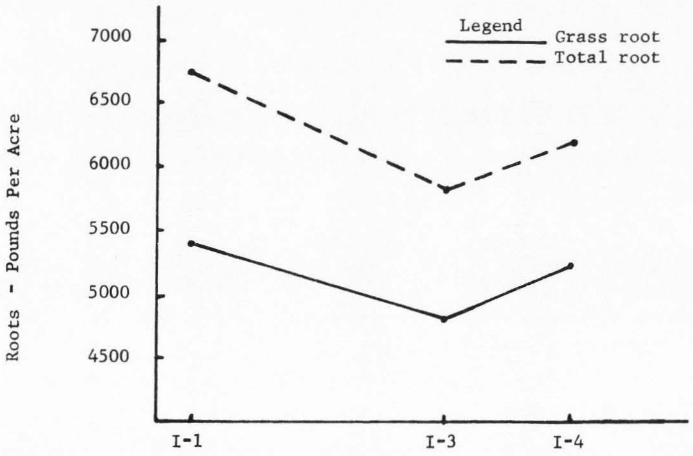

Figure 36. Average grass and total root production as influenced by irrigation interval

Table 31. Effect of mixture on grass and total root production, 1965

Mixture	(Species)	Root dry weight Grass	Total root
		lbs/A	
M-1	A-RC-LC-OG-BG-RCG-TOG	4798	6199
M-2	LC-OG-BG	5345	5647
M-3	A-OG-BG	5148	6852
M-5	A-IWG	4733	6829
M-6	OG-BG	5759	5759
	LSD 0.05 =	248	248
	0.01 =	327	327

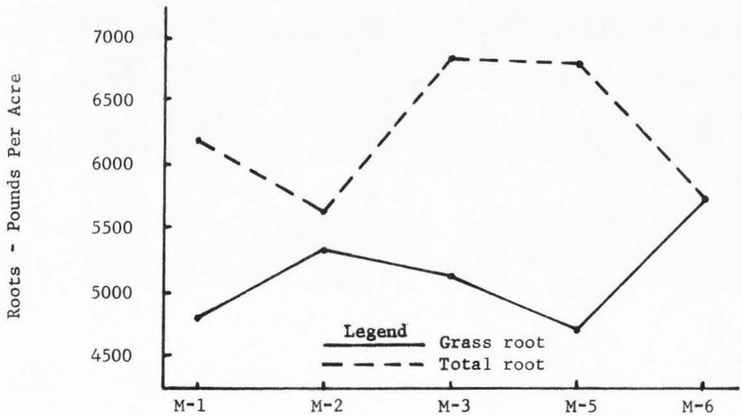

Figure 37. Average grass and total root production as influenced by mixture

Table 32. Effect of nitrogen fertilization on grass and total root production, 1965

Fertilization	Nitrogen	Root dry weight Grass	Total root
	lbs/A		
F-1	0	4275	5549
F-2	50	6020	7416
F-3	100	4679	5861
F-4	200	5652	6202
	LSD 0.05 =	386	396
	0.01 =	514	528

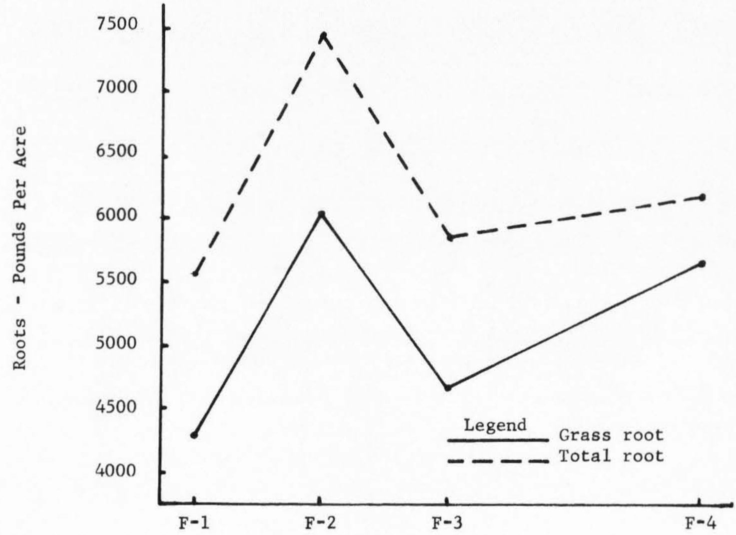

Figure 38. Average grass and total root production as influenced by nitrogen fertilization

Table 33. Average grass root production of mixtures as influenced by clipping frequency, 1965

Clipping	Mixture M-1	M-2	M-3	M-5	M-6	Average
	lbs/A					
C-1	4799	5624	5146	4113	5831	5103
C-2	4796	5067	5149	5353	5686	5210
Average	4798	5345	5148	4733	5759	

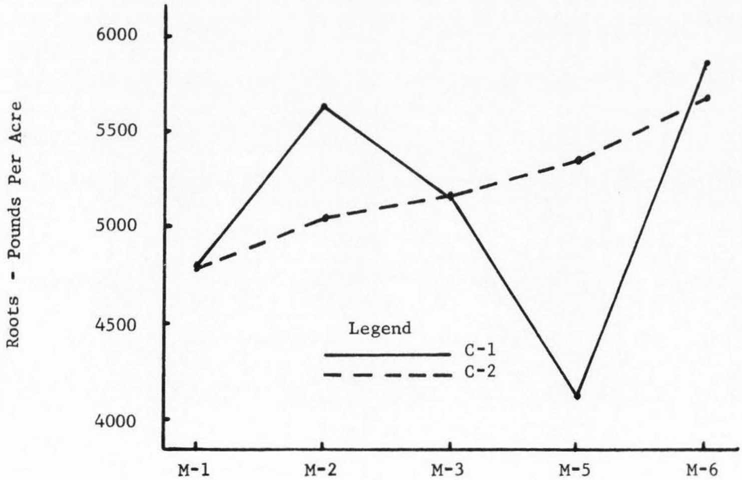

Figure 39. Average grass root production of mixtures as influenced by clipping frequency

difference in favor of 4 harvests (C-4). M-5 (alfalfa and intermediate wheatgrass) had 1240 pounds higher grass root yield in favor of 5 harvests (C-2).

Interaction of nitrogen fertilization x mixture. The results of grass root production from the highly significant fertilization x mixture interaction are shown in Table 34 and Figure 40. F-2 yielded highest for all mixtures except second for M-5. F-4 was second in production for all mixtures except was first for M-5. F-3 was third and F-1 was lowest in grass root production for all mixtures.

Interaction of clipping frequency x nitrogen fertilization x mixture. Significant grass root production results were obtained with the interaction of clipping x fertilization x mixture and are shown in Table 35 and Figure 41. The mixtures varied in response to the different clipping and fertilization treatments.

Total root yield

The analysis of variance for the total-root-dry-matter yields is given in Table 118 (Appendix C). The yield data are compiled in Table 101 (Appendix B). All of the main effects clipping frequency, irrigation interval, mixture, and nitrogen fertilization were highly significant. The clipping frequency x mixture and nitrogen fertilization x mixture interactions were highly significant. The irrigation interval x mixture and clipping frequency x nitrogen fertilization x mixture interactions were significant. This data was obtained by combining the legume and the grass root data. M-6 was the grass-only mixture so did not change nor was it affected by the presence of legumes in this compilation. The grass roots were dominant in yield in all other mixtures.

Table 34. Average grass root production of mixtures as influenced by nitrogen fertilization, 1965

Fertilization	M-1	M-2	M-3	M-5	M-6	Average
	Mixtures					
	lbs/A					
F-1	4037	4260	4072	4034	4970	4275
F-2	5516	6512	5929	5054	7089	6020
F-3	4460	4833	4844	4044	5216	4679
F-4	5178	5777	5748	5800	5758	5652
Average	4798	5345	5148	4733	5759	

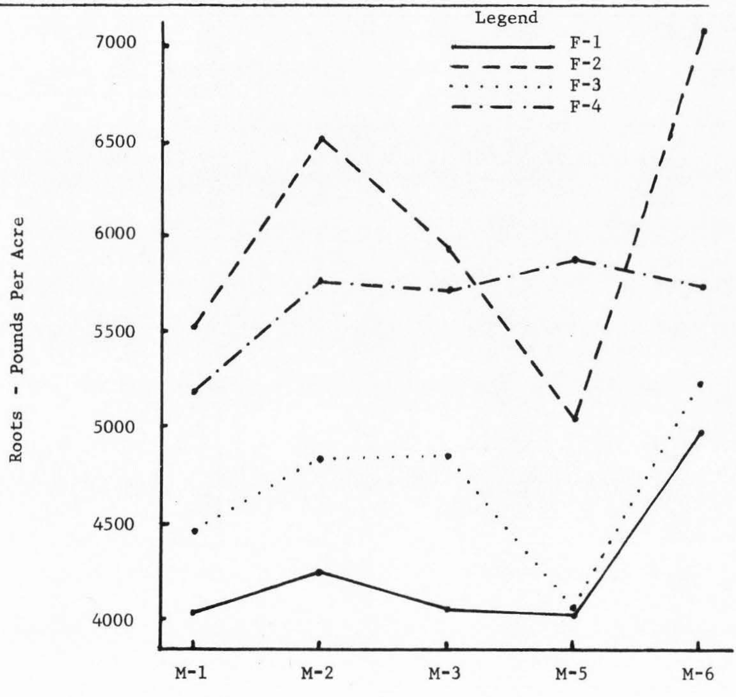

Figure 40. Average grass root production of mixtures as influenced by nitrogen fertilization

Table 35. Effect of clipping frequency and nitrogen fertilization on average grass root yield of pasture mixtures, 1965

		M-1	M-2	M-3	M-5	M-6	Average
		lbs/A					
C-1	F-1	4074	4455	4101	3556	5040	4245
	F-2	5122	6684	5867	4443	6541	5732
	F-3	4436	5277	4608	3509	5702	4706
	F-4	5566	6080	6010	4920	6040	5728
C-2	F-1	4000	4065	4042	4513	4901	4304
	F-2	5911	6341	5991	5665	7637	6309
	F-3	4485	4388	5079	4579	4731	4652
	F-4	4789	5474	5485	6657	5476	5577

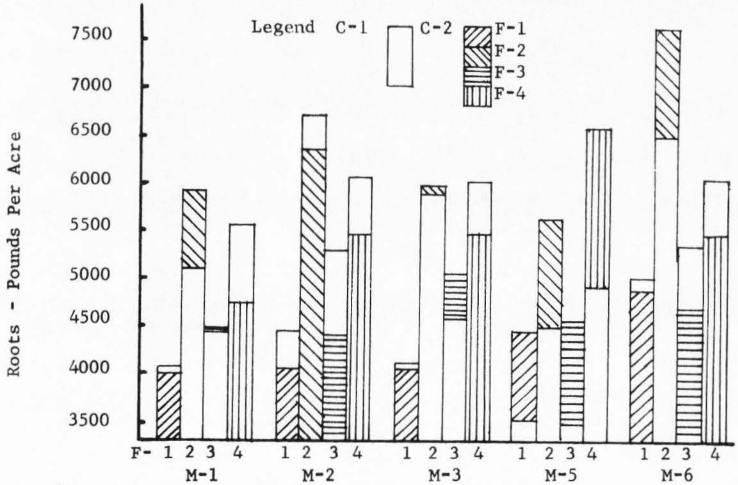

Figure 41. Average grass root dry matter yield of pasture mixtures as influenced by clipping frequency and nitrogen fertilization

Effect of clipping frequency. The effect of clipping frequency on the total root production is shown in Table 36 . The results were highly significant with the four harvests per season (C-1) outyielding the five harvests per season (C-2) by 450 pounds of roots.

Table 36. Effect of clipping frequency on total root production, 1965

Clipping	Harvests per year	Average yield
		lbs/A
C-1	4	6482
C-2	5	6032
		LSD 0.01 = 414

Effect of irrigation interval. The effect of irrigation on total root production is shown with the affect on grass root production in Table 30 and Figure 36 . The long interval irrigation (I-1) was highest in total root production and significantly higher than the short interval irrigation (I-4) which was second in root production. I-3 was lowest in production but the yield difference was only 363 pounds less than I-4 and was nonsignificant. I-1 produced 897 pounds more roots than I-3, a highly significant difference. The graph is very similar to the grass root graph.

Effect of mixture. The effect of mixture on total root production is shown in Table 31 and Figure 37 . Root yield differences between M-3 and M-5 and M-2 and M-6 were nonsignificant. All other differences were highly significant.

Effect of nitrogen fertilization. The effect of fertilization on total root production is shown in Table 32 and Figure 38 . Root yield

differences between F-1 and F-3 and F-3 and F-4 were nonsignificant. All other differences were highly significant. The highest root yield was obtained with the 50 pounds of nitrogen (F-2) treatment.

Interaction of clipping frequency x mixture. The clipping x mixture interaction on total root production was highly significant. The results are given in Table 37 and Figure 42. C-1 gave better root yields for all mixtures but M-5, ranging from 145 pounds more for M-6 to 1001 pounds more for M-1.

Interaction of irrigation interval x mixture. The irrigation x mixture interaction on total root yield was significant. The results are given in Table 38 and Figure 43. I-1 had a higher root yield for all mixtures although there was only a 7 pound difference with M-2 over the second highest irrigation interval (I-4). The I-3 treatment was lowest in root yield for all mixtures.

Interaction of nitrogen fertilization x mixture. The fertilization x mixture interaction on total root yield was highly significant. The results are given in Table 39 and Figure 44. F-2 was highest in root production for all mixtures. F-1 was lowest for all but M-5. F-4 was second high for M-2, M-5 and M-6.

Interaction of clipping frequency x nitrogen fertilization x mixture. The results of the significant interaction of clipping x fertilization x mixture on total root yield are given in Table 40 and Figure 45. C-2 produced more root yield only with M-5 (F-2 and F-4) and M-6 (F-2). F-2 was highest in total root yield followed by F-4, F-3 and F-1 in all mixtures except in M-3. F-1 had a slightly higher production than F-3. C-2 was more variable in production but F-2 was still highest for all mixtures.

Table 37. Average root production of mixtures as influenced by clipping frequency, 1965

Clipping	Mixture M-1	M-2	M-3	M-5	M-6	Average
	lbs/A					
C-1	6700	5870	7272	6739	5831	6482
C-2	5699	5423	6432	6919	5686	6032
Average	6199	5647	6852	6829	5759	

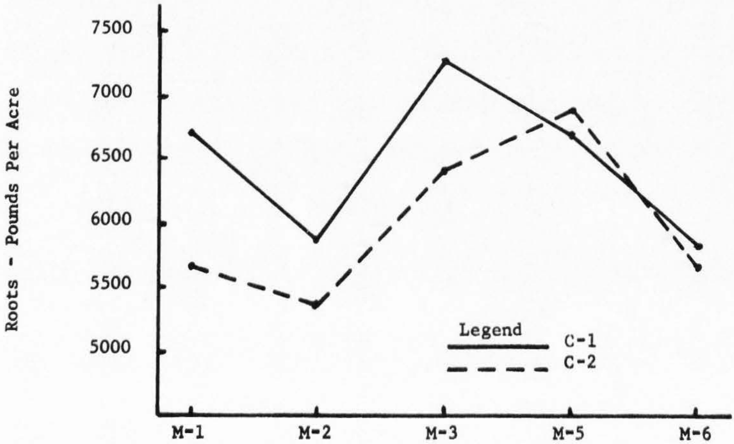

Figure 42. Average root production of mixtures as influenced by clipping frequency

Table 38. Average root production of mixtures as influenced by irrigation interval, 1965

Irrigation	Mixture M-1	M-2	M-3	M-5	M-6	Average
	lbs/A					
I-1	6622	5900	7532	7618	6000	6734
I-3	5852	5146	6456	6283	5449	5837
I-4	6125	5893	6568	6584	5828	6200
Average	6199	5647	6852	6829	5759	

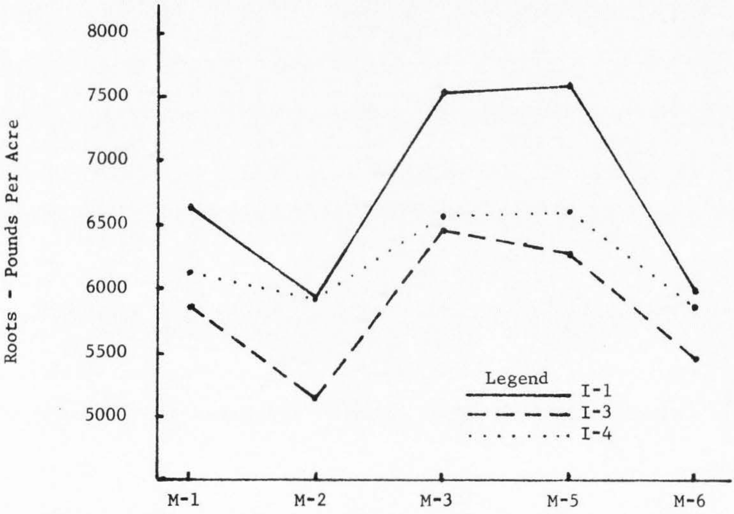

Figure 43. Average root production of mixtures as influenced by irrigation interval

Table 39. Average root production of mixtures as influenced by nitrogen fertilization, 1965

	Mixture					
Fertilization	M-1	M-2	M-3	M-5	M-6	Average
	lbs/A					
F-1	5552	4628	6222	6373	4971	5549
F-2	7352	7032	8181	7425	7089	7416
F-3	6017	5093	6613	6365	5216	5861
F-4	5876	5833	6393	7151	5758	6202
Average	6199	5647	6852	6829	5759	

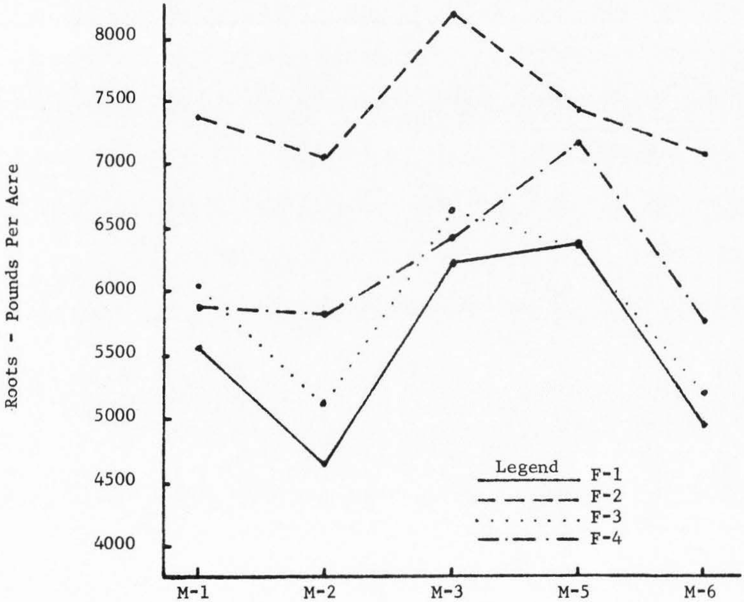

Figure 44. Average root production of mixtures as influenced by nitrogen fertilization

Table 40. Effect of clipping frequency and nitrogen fertilization on average total root yield of pasture mixtures, 1965

		M-1	M-2	M-3	M-5	M-6	Average
		lbs/A					
C-1	F-1	6103	4758	6764	6382	5040	5810
	F-2	7568	7163	8581	7279	6541	7427
	F-3	6481	5456	6747	6434	5702	6164
	F-4	6649	6103	6995	6860	6040	6530
C-2	F-1	5001	4498	5680	6366	4901	5289
	F-2	7136	6901	7780	7571	7637	7405
	F-3	5553	4730	6478	6296	4731	5557
	F-4	5104	5564	5790	7442	5476	5875

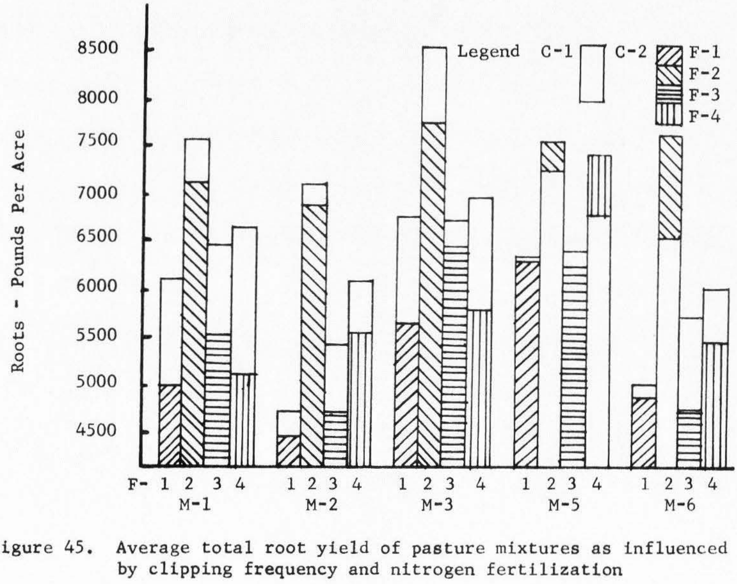

Figure 45. Average total root yield of pasture mixtures as influenced by clipping frequency and nitrogen fertilization

Root Reserves-Percent Total Available Carbohydrates (TAC)

Root reserves as a percent were calculated by dividing the sum of the legume and grass TAC in pounds per acre by the total root weight per acre. The percent TAC will be discussed for ladino clover, alfalfa, grass, and total roots (grass and legumes combined).

Ladino clover root percent TAC

The analysis of variance for the ladino clover root percent TAC is given in Table 119 (Appendix C). The data are compiled in Table 102 (Appendix B). Only the main effect of mixture was highly significant. The main effect of nitrogen fertilization and the irrigation interval x clipping frequency interaction were significant. All other results were nonsignificant.

Effect of mixture. The effect of mixture on ladino clover root percent TAC is given in Table 41. The difference of percent TAC of the ladino clover in M-1 as compared to M-2 was 5.64 and highly significant.

Table 41. Effect of mixture on ladino clover root percent TAC

Mixture	Species	TAC
		%
M-1	A-RC-LC-OG-BG-RCG-TOG	19.75
M-2	LC-OG-BG	14.11
		LSD 0.01 = 2.88

Effect of nitrogen fertilization. The effect of fertilization on ladino clover root percent TAC is given in Table 42. The percent

TAC was highest with the F-4 treatment followed by F-1, F-3 and F-2. F-4 was significantly higher than F-1 and F-3 in percent TAC and highly significant over F-2. All other differences were nonsignificant.

Table 42. Effect of nitrogen fertilization on ladino clover root percent TAC

Fertilization	Nitrogen	TAC
	lbs/A	%
F-1	0	16.85
F-2	50	14.94
F-3	100	15.95
F-4	200	19.99

LSD 0.05 = 2.69
0.01 = 4.07

Interaction of clipping frequency x irrigation interval. The clipping x irrigation interaction gave a significant F value for ladino clover root percent TAC. The results are given in Table 43 and Figure 46. Both clipping frequencies increased in percent TAC as the irrigation interval changed from I-1 to I-3 and C-2 showed a sharp increase from I-3 to I-4 while C-1 dropped over 4 percent from I-3 to I-4.

Alfalfa root percent TAC

The analysis of variance for the alfalfa root percent TAC is given in Table 120 (Appendix C). The data are compiled in Table 103 (Appendix B). The main effect of mixture and the nitrogen fertilization x mixture interaction were significant. All other results were nonsignificant.

Table 43. Average ladino clover percent TAC as influenced by clipping frequency and irrigation interval

Clipping	Irrigation I-1	Irrigation I-3	Irrigation I-4	Average
	%			
C-1	16.64	19.62	15.42	17.23
C-2	15.49	16.22	18.20	16.63
Average	16.06	17.92	16.81	

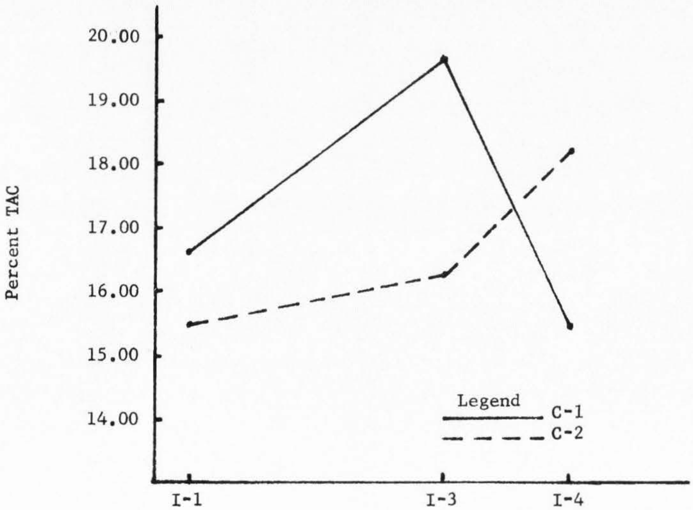

Figure 46. Average ladino clover percent TAC at irrigation intervals as influenced by clipping frequency

<u>Effect of mixture</u>. The effect of mixture on alfalfa root percent TAC is given in Table 44. M-3 had the highest percent TAC, M-1 was second and M-5 was lowest in percent TAC. The difference between M-3 and M-5 was significant.

Table 44. Effect of mixture on alfalfa root percent TAC

Mixture	Species	TAC
		%
M-1	A-RC-LC-OG-BG-RCG-TOG	16.58
M-3	A-OG-BG	16.98
M-5	A-IWG	15.70

LSD 0.05 = 0.96
0.01 = 1.35 N.S.

<u>Interaction of nitrogen fertilization x mixture</u>. The fertilization x mixture interaction gave a significant F value for alfalfa root percent TAC. The results are given in Table 45 and Figure 47. F-1 produced the highest percent TAC for M-3, F-2 for M-1 and F-3 for M-5. No pattern was apparent.

<u>Grass root percent TAC</u>

The analysis of variance for the grass root percent TAC is given in Table 121 (Appendix C). The data are compiled in Table 104 (Appendix B). The main effects of irrigation interval, nitrogen fertilization, and mixture and the irrigation interval x mixture interaction were all highly significant. Clipping frequency and the interactions of clipping frequency x nitrogen fertilization and clipping frequency x mixture were significant. The data of the highly significant main

Table 45. Average alfalfa percent TAC of mixtures as influenced by nitrogen fertilization

Fertilization	Mixture M-1	M-3	M-5	Average
	%			
F-1	16.05	18.56	15.23	16.61
F-2	17.36	16.94	14.47	16.25
F-3	16.72	15.61	17.08	16.47
F-4	16.22	16.79	16.00	16.34
Average	16.58	16.98	15.70	

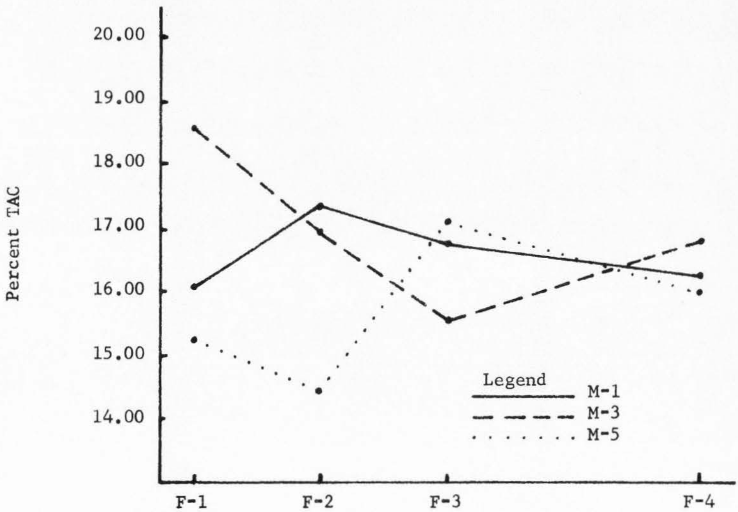

Figure 47. Average alfalfa percent TAC of mixtures as influenced by nitrogen fertilization

effects are compiled and graphed with the total root data to show the effect of the grass component on the total root percent TAC.

Effect of clipping frequency. The effect of clipping on grass root percent TAC is given in Table 46. C-2 had a significantly higher percent TAC than C-1.

Table 46. Effect of clipping frequency on grass root percent TAC

Clipping	Harvests per year	TAC
		%
C-1	4	15.63
C-2	5	16.61

LSD 0.05 = 0.77
0.01 = 1.04 N.S.

Effect of irrigation interval. The effect of irrigation on grass root percent TAC is shown in Table 47 and Figure 48. I-3 produced the highest percent followed by I-4 and then I-1. The higher percent TAC of I-3 and I-4 were both highly significant over I-1 but were nonsignificant between themselves.

Effect of mixture. The effect of mixture on grass root percent TAC is shown in Table 48 and Figure 49. There was considerable variation between mixtures. There were nonsignificant differences between M-2 and M-3, M-1 and M-5 and M-5 and M-6. There was a significant difference between M-1 and M-6. All other differences were highly significant.

Effect of nitrogen fertilization. The effect of fertilization on grass root percent TAC is shown in Table 49 and Figure 50. The fertilization treatments listed in order of decreasing percent TAC were

Table 47. Effect of irrigation interval on grass and total roots percent TAC

Irrigation	Interval	TAC	
		Grass	Total root
	days	%	
I-1	20	14.86	15.08
I-3	10	16.98	16.88
I-4	5	16.53	16.56
	LSD 0.05 =	0.94	0.81
	0.01 =	1.27	1.10

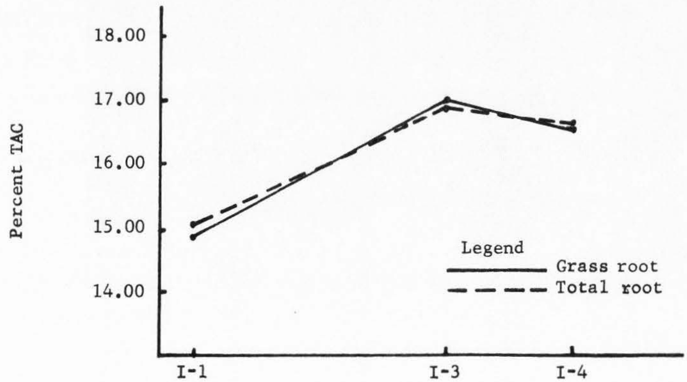

Figure 48. Average grass and total roots percent TAC as influenced by irrigation interval

Table 48. Effect of mixture on grass and total roots percent TAC

Mixture	Species	TAC Grass	TAC Total root
		%	%
M-1	A-RC-LC-OG-BG-RCG-TOG	18.15	18.04
M-2	LC-OG-BG	13.69	13.71
M-3	A-OG-BG	14.86	15.56
M-5	A-IWG	17.20	16.82
M-6	OG-BG	16.71	16.71
	LSD 0.05 =	1.21	1.05
	0.01 =	1.64	1.42

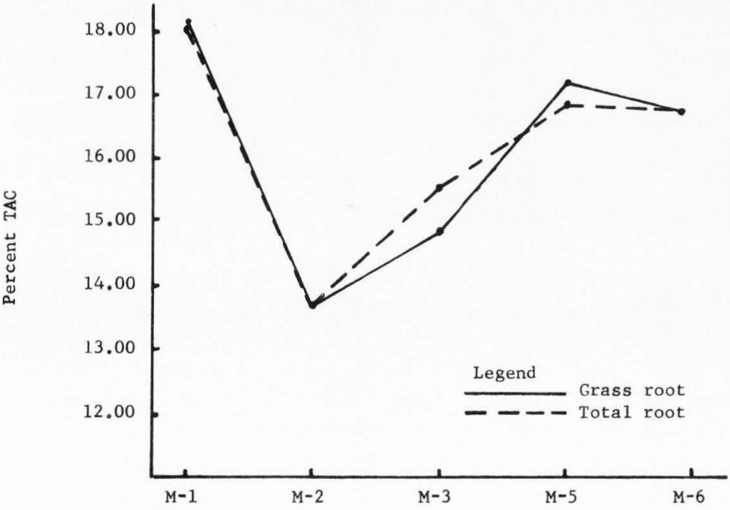

Figure 49. Average grass and total roots percent TAC as influenced by mixture

Table 49. Effect of nitrogen fertilization on grass and total roots percent TAC

Fertilization	Nitrogen lbs/A	TAC Grass	TAC Total root
		%	%
F-1	0	16.13	16.15
F-2	50	14.55	14.73
F-3	100	16.48	16.54
F-4	200	17.34	17.27
	LSD 0.05 =	1.08	0.94
	0.01 =	1.47	1.27

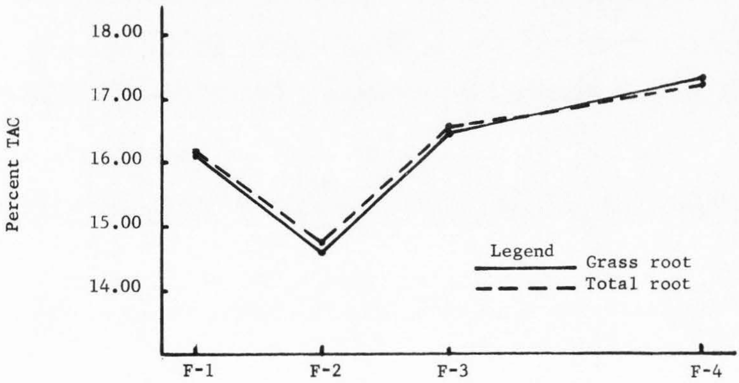

Figure 50. Average grass and total roots percent TAC as influenced by nitrogen fertilization

F-4, F-3, F-1 and F-2. F-4 was significantly higher than F-1; and F-4, F-3 and F-1 each produced a percent TAC that was highly significant over the F-2 percent TAC.

Interaction of irrigation interval x mixture. The irrigation x mixture interaction was highly significant for grass root percent TAC. The results are given in Table 50 and Figure 51. I-3 produced higher percent TAC than I-1 in all mixtures, was highest in M-1 and M-5 and second highest in M-2, M-3 and M-6. I-4 produced highest percent TAC in M-2, M-3 and M-6, second highest in M-5, and lowest in M-1.

Interaction of clipping frequency x nitrogen fertilization. The clipping x fertilization interaction was significant for grass root percent TAC. The results are given in Table 51 and Figure 52. The more frequent clipping (C-2) gave a higher percent TAC for all fertilization levels except 50 pounds (F-2). The greatest difference between the two clippings occurred with F-4 with a 3.21 percent difference.

Interaction of clipping frequency x mixture. The clipping x mixture interaction was significant for grass root percent TAC. The results are given in Table 52 and Figure 53. The more frequent clipping (C-2) gave a higher percent TAC for all mixtures except M-2 than C-1. M-1 and M-6 had differences of over 2 percent TAC in favor of C-2.

Total roots percent TAC

Total roots percent TAC is a computation of the ladino clover, alfalfa and grass root percent TAC. The analysis of variance for the total roots percent TAC is given in Table 122 (Appendix C). The data

Table 50. Average grass root percent TAC of mixtures as influenced by irrigation interval

Irrigation	Mixture M-1	M-2	M-3	M-5	M-6	Average
	%					
I-1	16.94	13.14	12.12	15.56	16.55	14.86
I-3	21.98	13.28	14.52	18.35	16.77	16.98
I-4	15.54	14.66	17.95	17.68	16.82	16.53
Average	18.15	13.69	14.86	17.20	16.71	

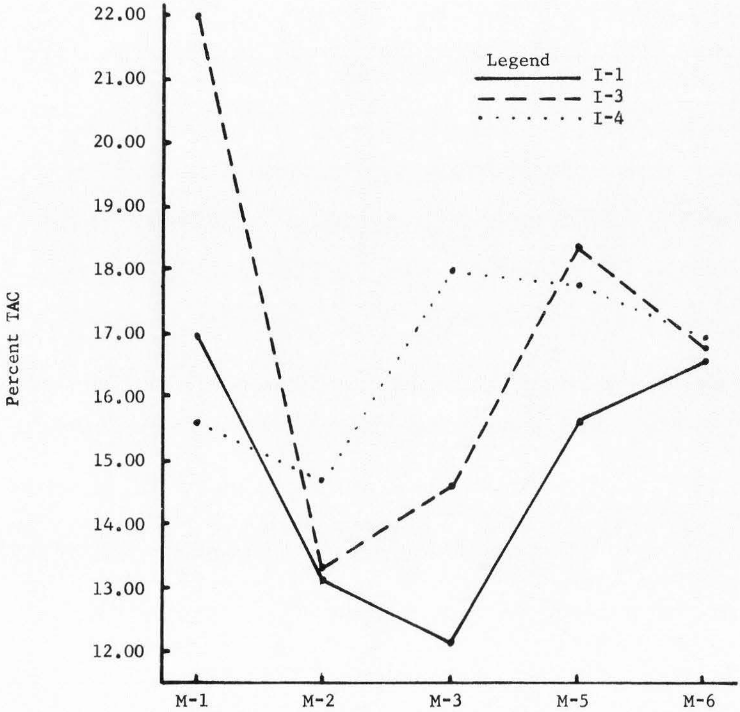

Figure 51. Average grass root percent TAC of mixtures as influenced by irrigation interval

Table 51. Average grass root percent TAC as influenced by clipping frequency and nitrogen fertilization

Clipping	Fertilization F-1	F-2	F-3	F-4	Average
	%				
C-1	15.90	14.80	16.10	15.74	15.63
C-2	16.35	14.29	16.86	18.95	16.61
Average	16.13	14.55	16.48	17.34	

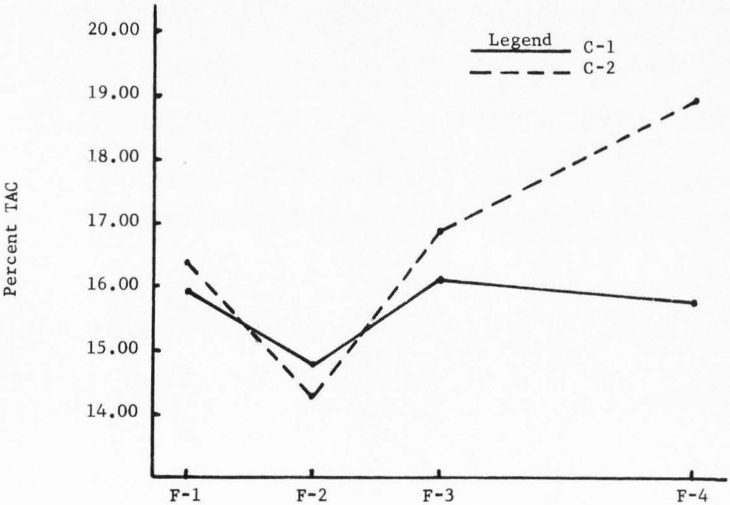

Figure 52. Average grass root percent TAC of nitrogen fertilization levels as influenced by clipping frequency

Table 52. Average grass root percent TAC of mixtures as influenced by clipping frequency

Clipping	Mixture M-1	M-2	M-3	M-5	M-6	Average
	%					
C-1	16.72	14.06	14.68	17.05	15.65	15.63
C-2	19.58	13.32	15.05	17.34	17.77	16.61
Average	18.15	13.69	14.86	17.20	16.71	

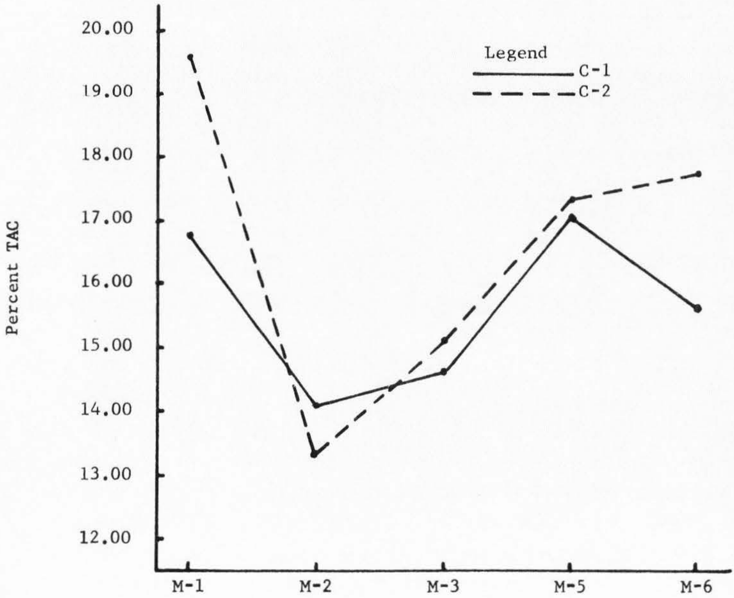

Figure 53. Average grass root percent TAC of mixtures as influenced by clipping frequency

are compiled in Table 105 (Appendix B). All four main effects, clipping frequency, irrigation interval, nitrogen fertilization and mixture were highly significant. The clipping frequency x nitrogen fertilization and irrigation interval x mixture interactions were highly significant. The irrigation interval x nitrogen fertilization and clipping frequency x mixture interactions were significant.

Effect of clipping frequency. The effect of clipping on total roots percent TAC is given in Table 53. The C-2 percent TAC results were highly significant over C-1.

Table 53. Effect of clipping frequency on total roots percent TAC

Clipping	Harvests per year	TAC
		%
C-1	4	15.71
C-2	5	16.64
		LSD 0.01 = 0.90

Effect of irrigation interval. The effect of irrigation interval on total roots percent TAC is shown in Table 47 and Figure 48. I-3 produced the highest percent followed by I-4 and then I-1. The I-3 and I-4 percents were both highly significant over the I-1 percent but were nonsignificant between themselves.

Effect of mixture. The effect of mixture on total roots percent TAC is shown in Table 48 and Figure 49. The difference between M-5 and M-6 was nonsignificant; between M-3 and M-5, M-3 and M-6, M-5 and M-1, and M-6 and M-1 significant; and between all others highly significant.

Effect of nitrogen fertilization. The effect of fertilization on total roots percent TAC is shown in Table 49 and Figure 50. F-4 produced the highest percent TAC followed by F-3, F-1 and F-2. F-4 was significantly higher than F-1; and F-4, F-3 and F-1 each produced a percent TAC that was highly significant over the F-2 percent TAC.

Interaction of clipping frequency x nitrogen fertilization. The clipping x fertilization interaction for total roots percent TAC was highly significant. The results are given in Table 54 and Figure 54. The more frequent clipping (C-2) produced higher percent TAC at all fertilization levels except F-2 where the percent dropped below that of the C-1 treatment. F-2 produced the lowest percent TAC for both clipping frequencies. F-4 had the largest difference between the two clipping treatments, 3.24 percent.

Interaction of irrigation interval x mixture. The irrigation x mixture interaction for total roots percent TAC was highly significant. The results are given in Table 55 and Figure 55. M-2 was lowest for all irrigations. M-6 had least differences between irrigation treatments. I-4 gave the lowest percent for all mixtures except it was second low with M-1.

Interaction of irrigation interval x nitrogen fertilization. The irrigation x fertilization interaction for total roots percent TAC was significant. The results are given in Table 56 and Figure 56. I-1 was lowest for all fertilization levels. I-3 and I-4 were similar in results with a drop from F-1 to F-2 and then an increase through F-3 and F-4. I-1 dropped from F-1 to F-2, increased with F-3 and dropped with F-4.

Table 54. Average total roots percent TAC as influenced by clipping frequency and nitrogen fertilization

Clipping	Fertilization F-1	F-2	F-3	F-4	Average
	%				
C-1	15.89	15.03	16.23	15.65	15.71
C-2	16.41	14.42	16.84	18.89	16.64
Average	16.15	14.73	16.54	17.27	

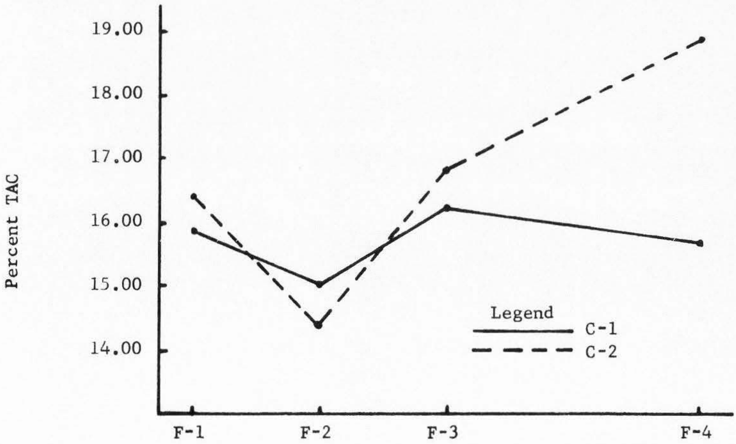

Figure 54. Average total roots percent TAC of nitrogen fertilization levels as influenced by clipping frequency

Table 55. Average total roots percent TAC of mixtures as influenced by irrigation interval

Irrigation	Mixture M-1	M-2	M-3	M-5	M-6	Average
	%					
I-1	16.92	13.20	13.45	15.23	16.55	15.08
I-3	21.11	13.34	15.52	17.64	16.77	16.88
I-4	16.10	14.58	17.72	17.58	16.82	16.56
Average	18.04	13.71	15.56	16.82	16.71	

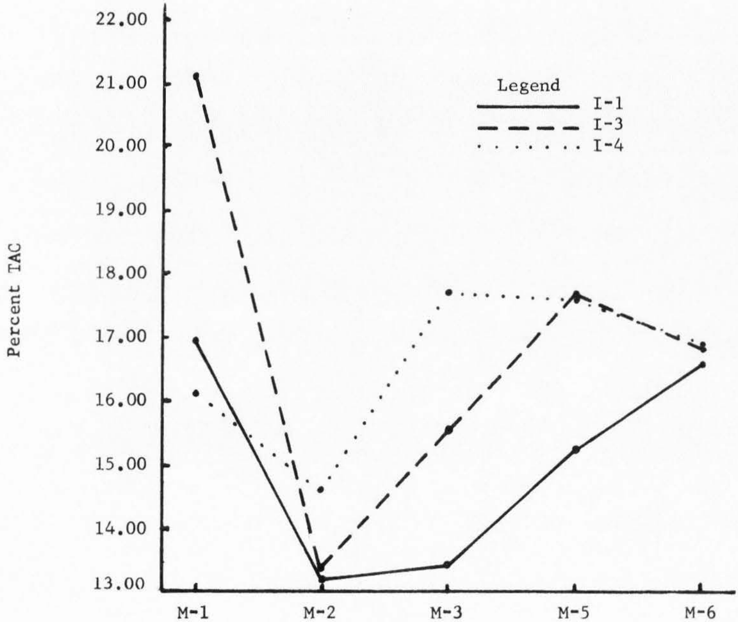

Figure 55. Average total roots percent TAC of mixtures as influenced by irrigation interval

Table 56. Average total roots percent TAC as influenced by irrigation interval and nitrogen fertilization

Irrigation	Fertilization F-1	F-2	F-3	F-4	Average
	%				
I-1	15.35	14.14	16.07	14.73	15.08
I-3	17.06	14.97	16.94	18.53	16.88
I-4	16.03	15.07	16.59	18.56	16.56
Average	16.15	14.73	16.54	17.27	

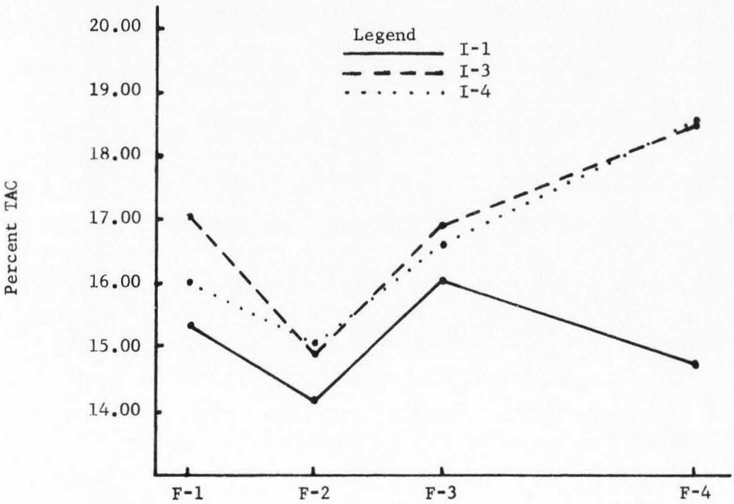

Figure 56. Average total roots percent TAC of nitrogen fertilization as influenced by irrigation interval

Interaction of clipping frequency x mixture. The clipping x mixture interaction for total roots percent TAC was significant. The results are given in Table 57 and Figure 57. C-2 was high in percent TAC for all but M-2. Both clippings took a sharp drop from M-1 to M-2, were nearly the same for M-3 and M-5 but separated for M-6 when the C-1 percent TAC dropped nearly one percent. M-1 had the highest and M-2 had the lowest percent TAC for both clippings.

Root Reserves--Pounds Total Available Carbohydrates (TAC)

The root reserves in pounds of TAC per acre is the sum of the legume and grass TAC in pounds per acre. The pounds TAC will be discussed for ladino clover, alfalfa, grass, and total roots (grasses and legumes).

Ladino clover root TAC

The analysis of variance for pounds of TAC in ladino clover roots is given in Table 123 (Appendix C). The data are compiled in Table 106 (Appendix B). The nitrogen fertilization treatment and irrigation interval x mixture interaction were highly significant. Clipping frequency and the irrigation interval x nitrogen fertilization interaction were significant. All other results were nonsignificant.

Effect of clipping frequency. The effect of clipping on pounds of TAC for ladino clover roots is given in Table 58. C-2 produced more pounds TAC than C-1 (51 to 32 pounds). The difference was significant.

Table 57. Average total roots percent TAC of mixtures as influenced by clipping frequency

Clipping	M-1	M-2	M-3	M-5	M-6	Average
	Mixture					
	%					
C-1	16.77	14.06	15.48	16.53	15.65	15.71
C-2	19.31	13.36	15.64	17.10	17.77	16.64
Average	18.04	13.71	15.56	16.82	16.71	

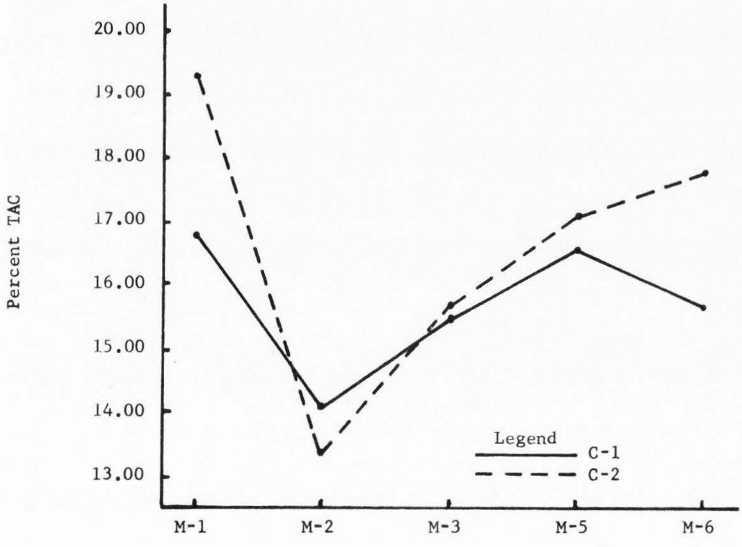

Figure 57. Average total roots percent TAC of mixtures as influenced by clipping frequency

Table 58. Effect of clipping frequency on ladino clover root TAC

Clipping	Harvests per year	TAC
		lbs/A
C-1	4	32
C-2	5	51
	LSD 0.05 =	15
	0.01 =	22 N.S.

Effect of nitrogen fertilization. The effect of fertilization on pounds of TAC for ladino clover roots is given in Table 59 and was highly significant. F-2 was highest in pounds of TAC, not significantly higher than F-1, but highly significant in pounds over F-3 and F-4. The F-1 yield was nonsignificant compared to F-3 but there was a highly significant yield difference over F-4.

Table 59. Effect of nitrogen fertilization on ladino clover root TAC

Fertilization	Nitrogen	TAC
	lbs/A	
F-1	0	52
F-2	50	64
F-3	100	39
F-4	200	10
	LSD 0.05 =	16
	0.01 =	21

Interaction of irrigation interval x mixture. The irrigation x mixture interaction on ladino clover root TAC production was highly significant. The results are shown in Table 60. M-2 had slightly

higher production than M-1 with I-1 and I-3 but the M-2 TAC dropped 6 pounds with I-4 while M-1 increased 24 pounds.

Table 60. Average Pounds of ladino clover root TAC of mixtures as influenced by irrigation interval

Mixture	Irrigation			Average
	I-1	I-3	I-4	
	lbs/A			
M-1	26	38	62	42
M-2	36	46	40	41
Average	31	42	51	

Interaction of irrigation interval x nitrogen fertilization. The irrigation x fertilization interaction on ladino clover root TAC production was significant. The results are shown in Table 61 and Figure 58. I-3 gave the highest yield with no nitrogen (F-1) and then decreased with each increase of nitrogen. I-1 and I-4 increased from F-1 to their highest production at F-2 and then decreased with each increase in fertilization. The low yield for all irrigations was F-4.

Alfalfa root TAC

The analysis of variance for pounds of TAC in alfalfa roots is given in Table 124 (Appendix C). The data are compiled in Table 107 (Appendix B). All four main effects--clipping frequency, irrigation interval, mixture, and nitrogen fertilization were highly significant. The first order interactions--irrigation interval x nitrogen fertilization, clipping frequency x mixture and nitrogen fertilization x mixture and second order interactions--irrigation interval x nitrogen

Table 61. Average pounds of ladino clover root TAC as influenced by irrigation interval and nitrogen fertilization

Irrigation	Fertilization F-1	F-2	F-3	F-4	Average
	lbs/A				
I-1	35	53	28	8	31
I-3	71	58	24	15	42
I-4	50	80	66	8	51
Average	52	64	39	10	

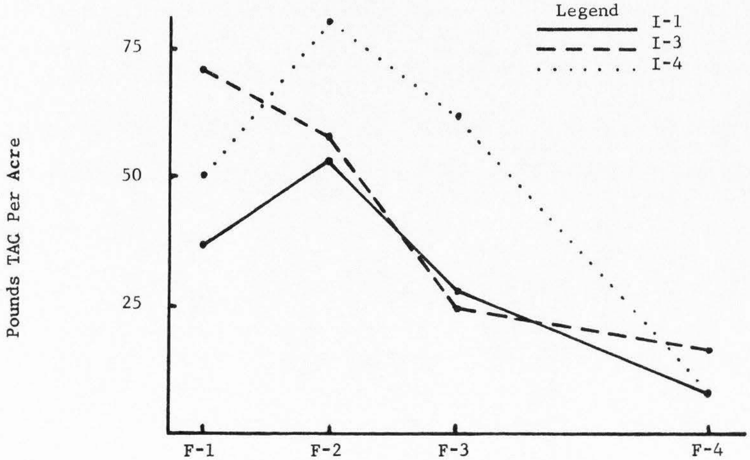

Figure 58. Average pounds of ladino clover root TAC at nitrogen fertilization levels as influenced by irrigation interval

fertilization x mixture, and clipping frequency x nitrogen fertilization x mixture were all highly significant. The clipping frequency x irrigation interval x nitrogen fertilization x mixture interaction was significant.

Effect of clipping frequency. The effect of clipping on pounds of TAC for alfalfa roots is given in Table 62. C-1 produced 353 pounds compared to 189 pounds for C-2. The results were highly significant.

Table 62. Effect of clipping frequency on alfalfa root TAC

Clipping	Harvests per year	TAC
		lbs/A
C-1	4	353
C-2	5	189
		LSD 0.05 = 37
		0.01 = 53

Effect of irrigation interval. The effect of irrigation on pounds of TAC for alfalfa roots was highly significant and is given in Table 63. I-1 had the highest production and there was a highly significant decrease through I-3 and I-4.

Table 63. Effect of irrigation interval on alfalfa root TAC

Irrigation	Interval	TAC
	days	lbs/A
I-1	20	335
I-3	10	253
I-4	5	225
		LSD 0.05 = 48
		0.01 = 73

Effect of mixture. The effect of mixture on pounds of TAC for alfalfa roots is given in Table 64. All differences were highly significant. Production increased from the low with M-1 through M-3 to a high with M-5.

Table 64. Effect of mixture on alfalfa root TAC

Mixture	Species	TAC
		lbs/A
M-1	A-RC-LC-OG-BG-RCG-TOG	195
M-3	A-OG-BG	291
M-5	A-IWG	327
		LSD 0.05 = 18
		0.01 = 23

Effect of nitrogen fertilization. The effect of fertilization on pounds of TAC for alfalfa roots is given in Table 65. The difference between F-1 and F-2 was nonsignificant, between F-2 and F-3 significant and between F-1, F-2 and F-3 and F-4 highly significant.

Table 65. Effect of nitrogen fertilization on alfalfa root TAC

Fertilization	Nitrogen	TAC
	lbs/A	lbs/A
F-1	0	318
F-2	50	328
F-3	100	299
F-4	200	140
		LSD 0.05 = 29
		0.01 = 39

Interaction of irrigation interval x nitrogen fertilization. The irrigation x fertilization interaction on alfalfa root TAC production was highly significant. The results are shown in Table 66 and Figure 59. I-1 was highest in production at all fertilization levels with the highest being at the F-1 level and dropping with each increase in nitrogen. I-3 produced its highest at the F-2 level of nitrogen. I-4 hit its peak at the F-3 level of nitrogen. The F-4 treatment recorded the lowest amount of TAC for all three irrigation intervals.

Interaction of irrigation interval x mixture. The irrigation x mixture interaction on alfalfa root TAC production was highly significant. The results are shown in Table 67 and Figure 60. I-1 was highest, I-3 second, and I-4 lowest in pounds TAC for all three mixtures. M-1 was lowest in pounds TAC for all three irrigations.

Interaction of clipping frequency x mixture. The clipping x mixture interaction on alfalfa root TAC production was highly significant. The results are shown in Table 68 and Figure 61. Four harvests (C-1) was more favorable than five harvests (C-2) for all three alfalfa containing mixtures.

Interaction of nitrogen fertilization x mixture. The fertilization x mixture interaction on alfalfa root TAC production was highly significant. The results are shown in Table 69 and Figure 62. M-1 increased in TAC production from F-1 to F-2 then dropped with each increase of nitrogen. M-3 decreased from its high at F-1 with each nitrogen increment increase. M-5 dropped from F-1 to F-2, increased with F-3 and dropped with F-4. All three mixtures produced the lowest TAC with the highest level of nitrogen (F-4).

Table 66. Average pounds of alfalfa root TAC at nitrogen fertilization levels as influenced by irrigation interval

Irrigation	Fertilization F-1	F-2	F-3	F-4	Average
	lbs/A				
I-1	396	391	348	204	335
I-3	289	349	254	122	253
I-4	267	243	295	96	225
Average	318	328	299	140	

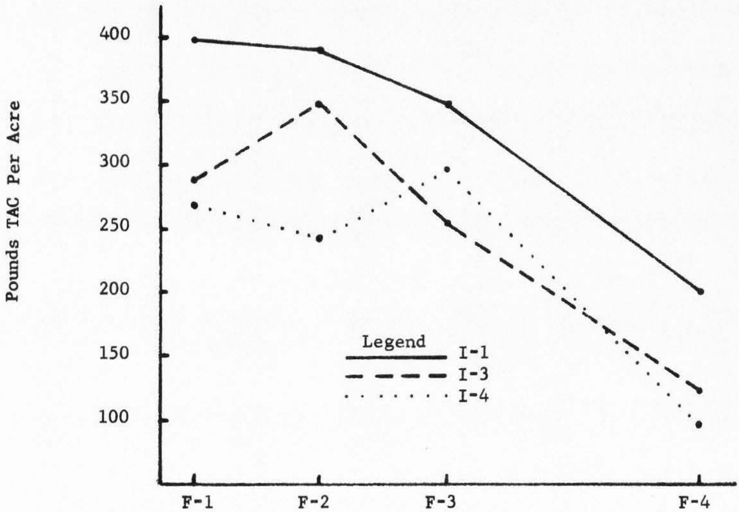

Figure 59. Average pounds of alfalfa root TAC at nitrogen fertilization levels as influenced by irrigation interval

Table 67. Average pounds of alfalfa root TAC of mixtures as influenced by irrigation interval

Mixture	Irrigation M-1	M-3	M-5	Average
	lbs/A			
I-1	263	369	372	335
I-3	178	282	301	253
I-4	146	221	209	225
Average	195	291	327	

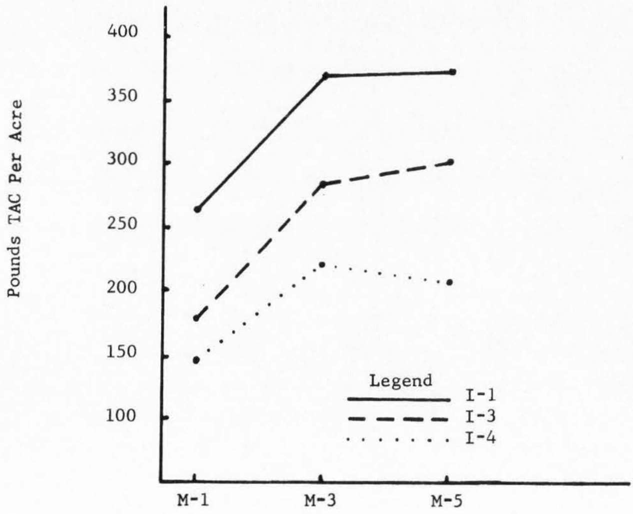

Figure 60. Average pounds of alfalfa root TAC of mixtures as influenced by irrigation interval

Table 68. Average pounds of alfalfa root TAC of mixtures as influenced by clipping frequency

Clipping	M-1	M-3	M-5	Average
	Mixture			
	lbs/A			
C-1	293	360	407	353
C-2	97	222	248	189
Average	195	291	327	

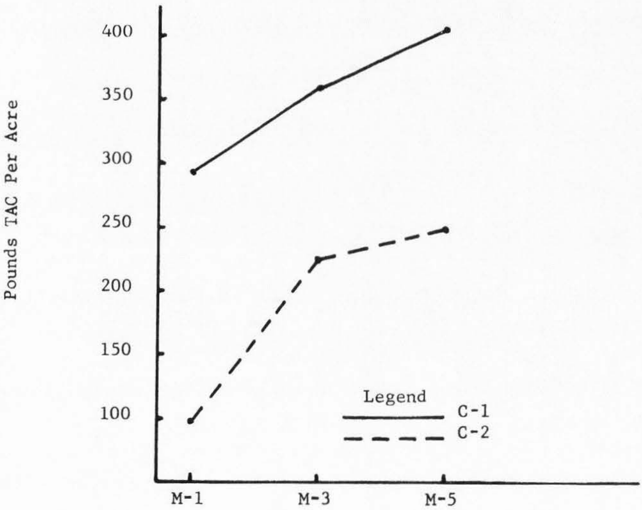

Figure 61. Average pounds of alfalfa root TAC of mixtures as influenced by clipping frequency

Table 69. Average pounds of alfalfa root TAC of mixtures as influenced by nitrogen fertilization

Fertilization	Mixtures M-1	M-3	M-5	Average
		lbs/A		
F-1	200	403	350	318
F-2	260	382	340	328
F-3	218	274	405	299
F-4	103	104	214	140
Average	195	291	327	

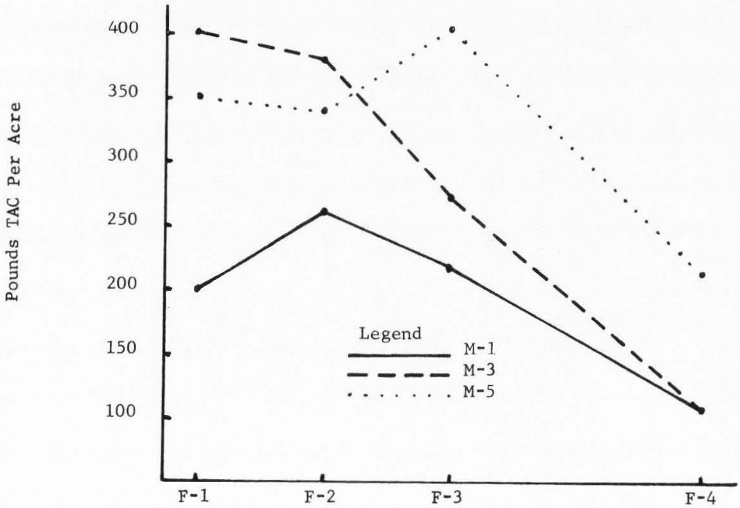

Figure 62. Average pounds of alfalfa root TAC of mixtures as influenced by nitrogen fertilization

Interaction of irrigation interval x nitrogen fertilization x mixture. The irrigation x fertilization x mixture interaction on alfalfa root TAC, production was highly significant. The results are shown in Table 70. F-4 produced the least alfalfa root TAC in all interactions. The M-3 production was highest with I-1 and I-4 with no nitrogen (F-1). Under I-3, all three mixtures produced highest with 50 pounds nitrogen (F-2).

Interaction of clipping frequency x nitrogen fertilization x mixture. The clipping x fertilization x mixture interaction on alfalfa root TAC production was highly significant. The results are shown in Table 71. F-4 produced the least alfalfa root TAC in all interactions. F-1 was highest for M-2 with C-1 and M-2 and M-3 with C-2. M-1 was highest with F-2 with C-1 and highest with F-3 with C-2. The C-1 TAC production was higher than the C-2 for all mixtures and fertilizations.

Interaction of clipping frequency x irrigation interval x nitrogen fertilization x mixture. The clipping x irrigation x fertilization x mixture interaction on alfalfa root TAC production was significant. The results are shown in Table 107 (Appendix B).

Grass root TAC

The analysis of variance for pounds of TAC in grass roots is given in Table 125 (Appendix C). The data are compiled in Table 108 (Appendix B). Three main effects, clipping frequency, mixture, and nitrogen fertilization, and the following interactions were highly significant: clipping frequency x mixture, irrigation interval x mixture, nitrogen fertilization x mixture, clipping frequency x

Table 70. Average pounds of alfalfa root TAC of mixtures as influenced by irrigation interval and nitrogen fertilization

	I-1			I-3			I-4			
Fertilization	M-1	M-3	M-5	M-1	M-3	M-5	M-1	M-3	M-5	Average
	lbs/A									
F-1	262	520	406	201	353	313	138	335	330	318
F-2	325	463	386	262	408	376	194	277	260	328
F-3	308	306	429	148	291	323	196	226	464	299
F-4	157	188	266	98	75	192	54	48	185	140
Average	263	369	372	178	282	301	146	221	309	

Table 71. Average pounds of alfalfa root TAC of mixtures as influenced by clipping frequency and nitrogen fertilization

	C-1			C-2			
Fertilization	M-1	M-3	M-5	M-1	M-3	M-5	Average
	lbs/A						
F-1	287	497	405	113	309	295	318
F-2	407	457	403	114	308	278	328
F-3	313	328	516	122	220	294	299
F-4	165	156	303	41	51	126	140
Average	293	360	407	97	222	248	

irrigation interval x mixture, irrigation interval x nitrogen fertilization x mixture and clipping frequency x irrigation interval x nitrogen fertilization x mixture. The clipping frequency x nitrogen fertilization x mixture interaction was significant.

The tables and figures for nitrogen fertilization and mixture are included with the all root TAC and shows the effect of the grass root TAC on the total root TAC.

Effect of clipping frequency. The effect of clipping on pounds of TAC for grass roots is given in Table 72. C-2 had the highest TAC production. The difference between the two clippings was highly significant.

Table 72. Effect of clipping frequency on grass root TAC

Clipping	Harvests per season	TAC
		lbs/A
C-1	4	790
C-2	5	857
		LSD 0.01 = 48

Effect of mixture. The effect of mixture on pounds of TAC for grass roots is given in Table 73 and Figure 63 with the total root TAC. The difference in TAC yield of M-2 and M-3 was nonsignificant, of M-1 and M-5 was significant, and of all others was highly significant.

Effect of nitrogen fertilization. The effect of fertilization on pounds of TAC for grass roots is given in Table 74 and Figure 64 with the total roots TAC. F-1 had the lowest production. F-3 was second

Table 73. Effect of mixture on grass and total root TAC

Mixture	Species	TAC Grass	TAC Total root
		lbs/A	
M-1	A-RC-LC-OG-BG-RCG-TOG	864	1101
M-2	LC-OG-BG	729	770
M-3	A-OG-BG	754	1048
M-5	A-IWG	818	1146
M-6	OG-BG	951	951
	LSD 0.05 =	42	42
	0.01 =	55	55

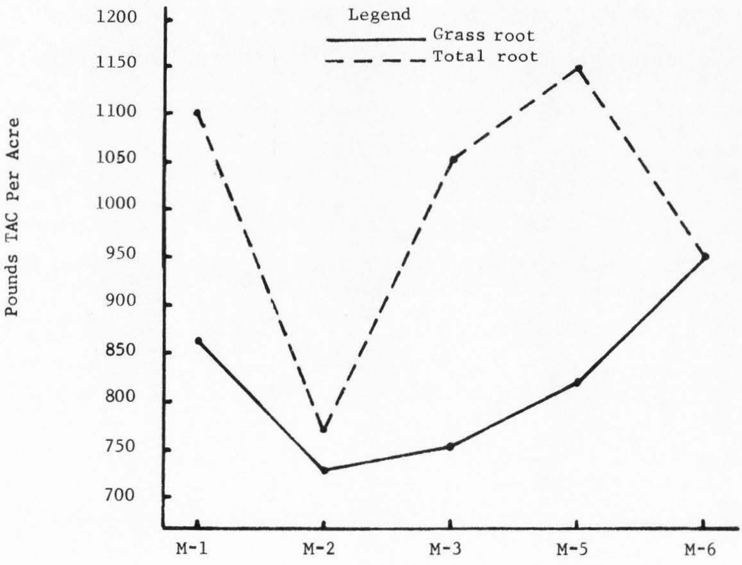

Figure 63. Average grass and total root TAC as influenced by mixture

Table 74. Effect of nitrogen fertilization on grass and total root TAC

Fertilization	Nitrogen	TAC Grass	TAC Total root
	lbs/A		
F-1	0	691	902
F-2	50	864	1088
F-3	100	770	966
F-4	200	968	1056
	LSD 0.05 =	60	62
	0.01 =	81	83

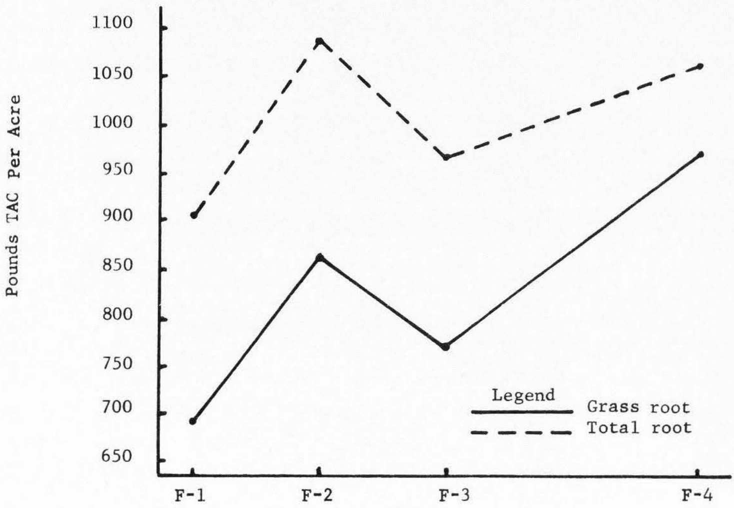

Figure 64. Average grass and total root TAC as influenced by nitrogen fertilization

low and the difference was significant. All other differences were highly significant. F-4 had the highest TAC production followed by F-2.

Interaction of clipping frequency x mixture. The clipping x mixture interaction on grass root TAC production was highly significant. The results are shown in Table 75 and Figure 65. C-2 was highest for all mixtures except M-2. There was only a 10 pound difference with M-3.

Interaction of irrigation interval x mixture. The irrigation x mixture interaction on grass root TAC production was highly significant. The results are shown in Table 76 and Figure 66. Only the M-3 and M-5 interaction with irrigation produced the same order of TAC production with I-4 highest, I-3 second, and I-1 lowest.

Interaction of nitrogen fertilization x mixture. The fertilization x mixture interaction on grass root TAC production was highly significant. The results are shown in Table 77 and Figure 67. F-1 was low for all mixtures except with M-5 where it produced slightly higher than F-3. F-4 was highest in production with M-1, M-3, and M-5, the alfalfa containing mixtures; and second with M-2 and M-6. F-2 was highest with M-2 and M-6, second with M-3 and M-5 and third with M-1.

Interaction of clipping frequency x irrigation interval x mixture. The clipping x irrigation x mixture interaction on grass root TAC production was highly significant. The results are shown in Table 78. M-1, M-5 and M-6 all had higher production at all three irrigation intervals under the C-2 treatment. M-2 had higher production under the C-1 treatment.

Table 75. Average pounds of grass root TAC of mixtures as influenced by clipping frequency

Clipping	Mixture M-1	M-2	M-3	M-5	M-6	Average
	lbs/A					
C-1	797	786	749	703	912	790
C-2	931	671	759	933	989	823
Average	864	729	754	818	951	

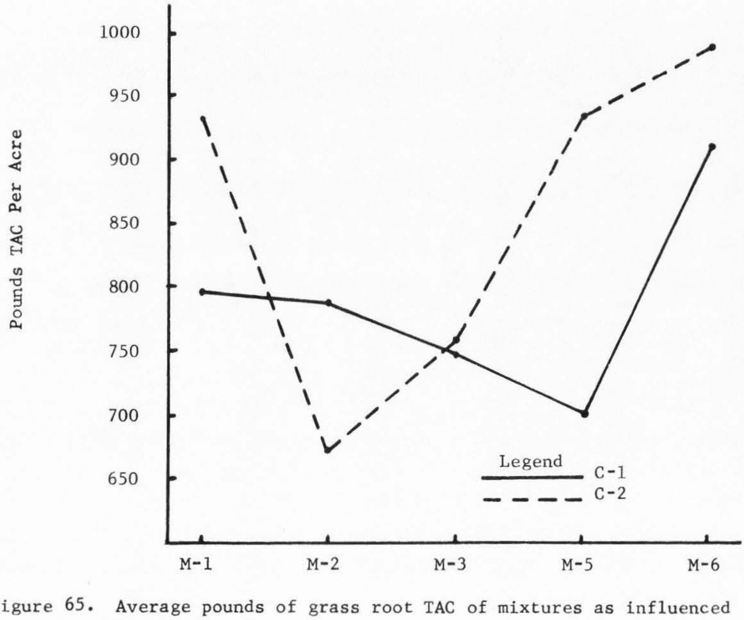

Figure 65. Average pounds of grass root TAC of mixtures as influenced by clipping frequency

Table 76. Average pounds of grass root TAC of mixtures as influenced by irrigation interval

Irrigation	Mixture M-1	M-2	M-3	M-5	M-6	Average
	lbs/A					
I-1	827	744	624	789	985	794
I-3	993	630	707	810	897	808
I-4	771	811	931	856	968	867
Average	864	729	754	818	951	

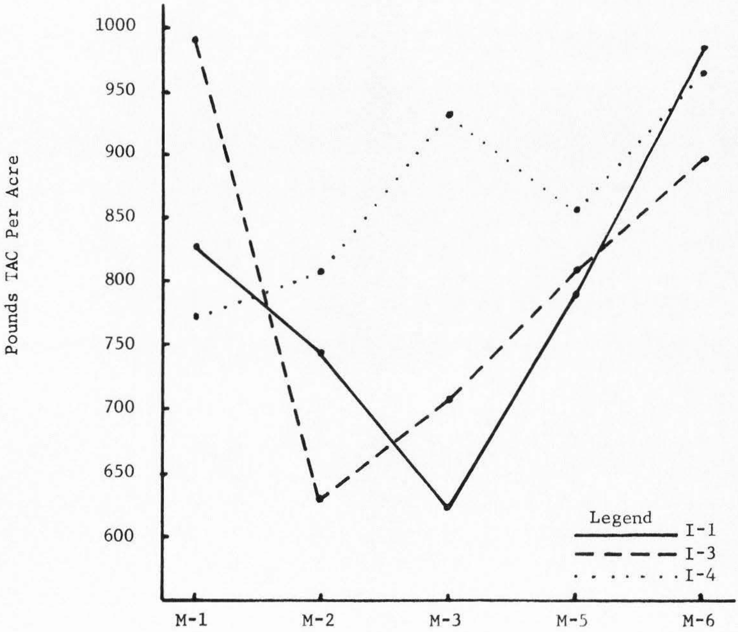

Figure 66. Average pounds of grass root TAC of mixtures as influenced by irrigation interval

Table 77. Average pounds of grass root TAC of mixtures as influenced by nitrogen fertilization

Fertilization	Mixture M-1	M-2	M-3	M-5	M-6	Average
	lbs/A					
F-1	710	574	647	691	813	691
F-2	834	820	772	863	1030	864
F-3	888	711	679	658	916	770
F-4	1024	810	918	1060	1026	968
Average	864	729	754	818	951	

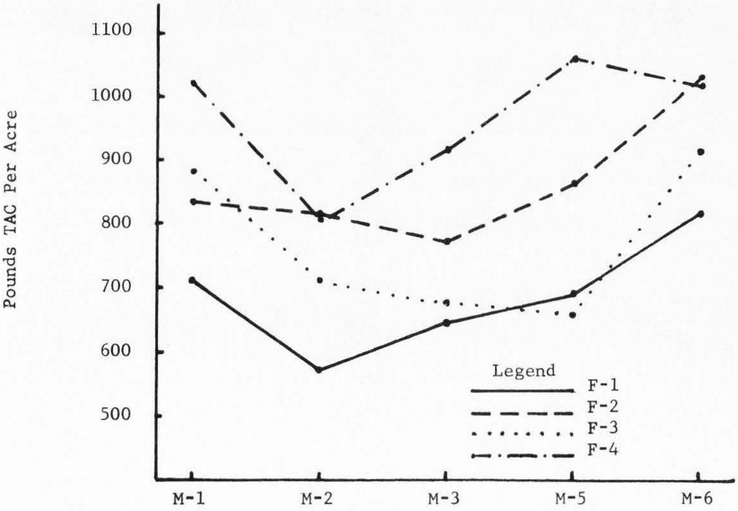

Figure 67. Average pounds of grass root TAC of mixtures as influenced by nitrogen fertilization

Table 78. Average pounds of grass root TAC of mixtures as influenced by clipping frequency and irrigation interval

Irrigation	C-1 M-1	C-1 M-2	C-1 M-3	C-1 M-5	C-1 M-6	C-2 M-1	C-2 M-2	C-2 M-3	C-2 M-5	C-2 M-6
	lbs/A									
I-1	741	834	633	752	962	914	655	616	827	1008
I-3	928	708	678	766	798	1058	552	735	853	1000
I-4	723	817	937	592	977	820	806	926	1120	958
Average	797	786	749	703	912	913	671	759	933	989

Interaction of clipping frequency x nitrogen fertilization x mixture. The clipping x fertilization x mixture interaction on grass root TAC production was significant. The results are shown in Table 79.

Table 79. Average pounds of grass root TAC of mixtures as influenced by clipping frequency and nitrogen fertilization

Fertilization	C-1 M-1	C-1 M-2	C-1 M-3	C-1 M-5	C-1 M-6	C-2 M-1	C-2 M-2	C-2 M-3	C-2 M-5	C-2 M-6
	lbs/A									
F-1	738	651	643	578	760	682	496	652	804	902
F-2	758	909	806	749	970	910	731	739	977	1090
F-3	812	772	654	591	963	963	650	704	726	869
F-4	881	814	894	895	958	1168	806	942	1226	1093
Average	797	781	749	703	912	931	671	759	933	989

Interaction of irrigation interval x nitrogen fertilization x mixture. The irrigation x fertilization x mixture interaction on grass root TAC production was highly significant. The results are shown in Table 80.

Interaction of clipping frequency x irrigation interval x nitrogen fertilization x mixture. The clipping x irrigation x fertilization x mixture interaction was highly significant. The results are shown in Table 108 (Appendix B).

Total roots TAC

The analysis of variance for pounds of TAC in the total roots is given in Table 126 (Appendix C). The data are compiled in Table 109 (Appendix B). The main effects of mixture and nitrogen fertilization and the following interactions were highly significant: clipping frequency x mixture, irrigation interval x mixture, nitrogen fertilization x mixture, clipping frequency x irrigation interval x mixture, clipping frequency x nitrogen fertilization x mixture, irrigation interval x nitrogen fertilization x mixture, and clipping frequency x irrigation interval x nitrogen fertilization x mixture. The clipping frequency x irrigation interval x nitrogen fertilization interaction was significant.

Effect of mixture. The effect of mixture on pounds of TAC for total roots is given in Table 73 and Figure 63 with the grass root TAC. The difference in TAC yield of M-2 and M-3 was nonsignificant, of M-1 and M-5 was significant, and of all others was highly significant.

Table 80. Average pounds of grass root TAC of mixtures as influenced by irrigation interval and nitrogen fertilization

Irrigation	Fertilization	Mixture M-1	M-2	M-3	M-5	M-6
		lbs/A				
I-1	F-1	706	523	571	700	826
	F-2	840	883	592	832	1075
	F-3	928	761	652	629	988
	F-4	835	810	682	995	1052
I-3	F-1	911	513	588	552	899
	F-2	957	688	717	872	1033
	F-3	1018	612	520	706	762
	F-4	1087	707	1002	1108	902
I-4	F-1	513	684	783	821	768
	F-2	704	888	1008	884	982
	F-3	717	760	866	640	998
	F-4	1151	914	1069	1078	1122
Average		864	729	754	818	951

Effect of nitrogen fertilization. The effect of fertilization on pounds of TAC for total roots is given in Table 76 and Figure 64 with the grass root TAC. F-1 had the lowest production, F-3 was second low and the difference was significant. F-2 had the highest production but the difference over second place F-4 was non-significant. All other differences were highly significant.

Interaction of clipping frequency x mixture. The clipping x mixture interaction on total root TAC production was highly significant. The results are shown in Table 81 and Figure 68. C-1 was highest for M-1, M-2 and M-3. C-2 was highest for M-5 and M-6. There was only a 36 pound difference with M-1, a 103 and 120 pound difference for M-2 and M-3, respectively, and a 71 and 72 pound difference for M-5 and M-6, respectively.

Interaction of irrigation interval x mixture. The irrigation x mixture interaction on total root TAC production was highly significant. The results are shown in Table 82 and Figure 69. The M-2, M-3 and M-5 interaction with irrigation produced the same order of TAC production with I-4 highest, I-1 second and I-3 lowest. I-3 was highest of all irrigations with M-1 but lowest with all other mixtures.

Interaction of nitrogen fertilization x mixture. The fertilization x mixture interaction on total root TAC production was highly significant. The results are shown in Table 83 and Figure 70. F-1 was low for all mixtures except with M-3 where it showed a higher production than F-3 or F-4. F-2 was highest in production with all mixtures except with M-5 where F-4 has a 72 pound higher production.

Table 81. Average pounds of total root TAC of mixtures as influenced by clipping frequency

Clipping	Mixture M-1	M-2	M-3	M-5	M-6	Average
	lbs/A					
C-1	1119	821	1109	1110	912	1014
C-2	1083	718	989	1181	989	992
Average	1101	770	1049	1146	950	

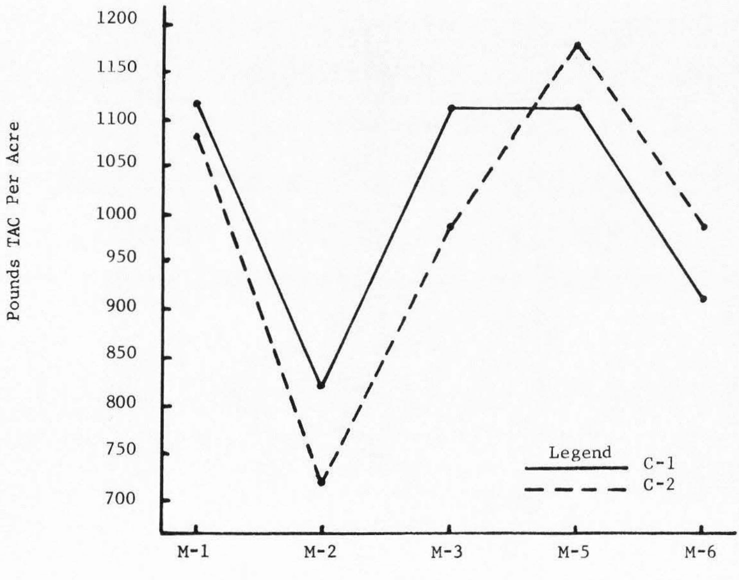

Figure 68. Average pounds of total root TAC of mixtures as influenced by clipping frequency

Table 82. Average pounds of total root TAC of mixtures as influenced by irrigation interval

Irrigation	Mixture M-1	M-2	M-3	M-5	M-6	Average
	lbs/A					
I-1	1114	781	1003	1161	985	1009
I-3	1209	676	988	1111	899	977
I-4	979	852	1153	1165	968	1023
Average	1101	770	1048	1146	951	

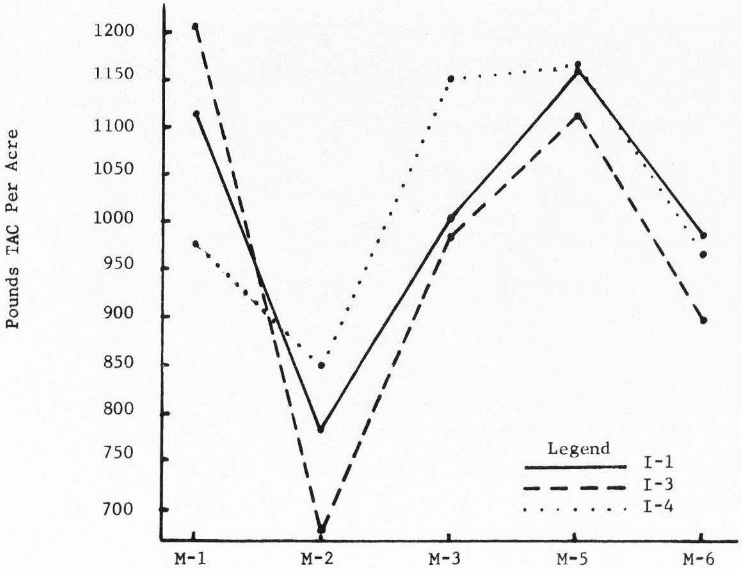

Figure 69. Average pounds of total root TAC of mixtures as influenced by irrigation interval

Table 83. Average pounds of total root TAC of mixtures as influenced by nitrogen fertilization

Fertilization	Mixture M-1	M-2	M-3	M-5	M-6	Average
			lbs/A			
F-1	964	624	1050	1041	831	902
F-2	1153	887	1167	1203	1030	1088
F-3	1148	747	954	1064	916	966
F-4	1138	820	1022	1275	1026	1056
Average	1101	770	1048	1146	951	

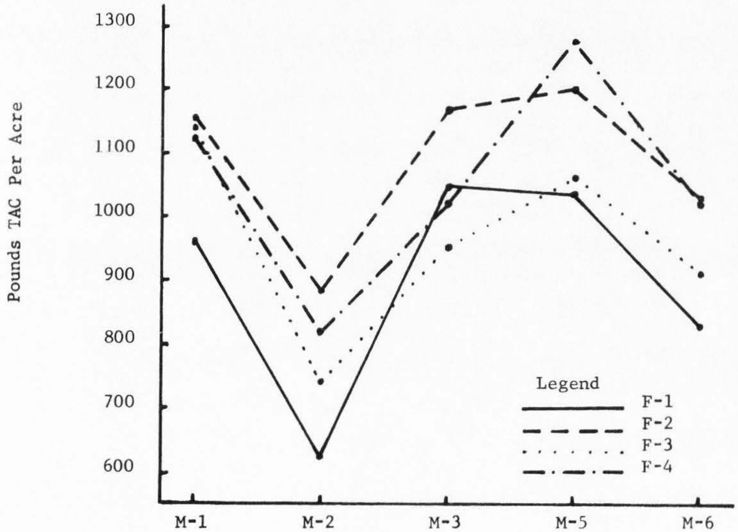

Figure 70. Average pounds of total root TAC of mixtures as influenced by nitrogen fertilization

F-2 had only a 5 and 15 pound higher production than F-3 and F-4, respectively, with M-1 and only a 4 pound higher production than F-4 with M-6.

Interaction of clipping frequency x irrigation interval x mixture. The clipping x irrigation x mixture interaction on total root TAC production was highly significant. The results are shown in Table 84. M-2 and M-3 both had higher root TAC production at all three irrigation intervals under the C-1 treatment. C-1 also had higher production with the other mixtures except under C-2, M-1 produced more pounds of root TAC with I-1, M-5 produced more with I-4, and M-6 produced more with I-1 and I-3 than under C-1.

Interaction of clipping frequency x nitrogen fertilization x mixture. The clipping x fertilization x mixture interaction on total root TAC production was highly significant. The results are shown in Table 85. Under C-2 all mixtures except M-3 had higher root TAC production with F-4 and M-6 had higher production with F-1, F-2, and F-4 than under C-1. The production was less under C-2 for all other mixture x fertilization interaction treatments.

Interaction of clipping frequency x irrigation interval x nitrogen fertilization. The clipping x irrigation x fertilization interaction on total root TAC production was significant. The results are shown in Table 86.

Interaction of irrigation interval x nitrogen fertilization x mixture. The irrigation x fertilization x mixture interaction on total root TAC production was highly significant. The results are shown in Table 87.

Table 84. Average pounds of total root TAC of mixtures as influenced by clipping frequency and irrigation interval

	C-1					C-2				
Irrigation	M-1	M-2	M-3	M-5	M-6	M-1	M-2	M-3	M-5	M-6
	lbs/A									
I-1	1099	858	1056	1199	962	1129	704	950	1123	1008
I-3	1242	750	1032	1160	798	1176	602	945	1062	1000
I-4	1014	854	1238	971	977	943	849	1068	1359	958
Average	1119	821	1109	1110	912	1083	718	987	1181	989

Table 85. Average pounds of total root TAC of mixtures as influenced by clipping frequency and nitrogen fertilization

	C-1					C-2				
Fertilization	M-1	M-2	M-3	M-5	M-6	M-1	M-2	M-3	M-5	M-6
	lbs/A									
F-1	1070	698	1139	983	760	857	550	960	1099	902
F-2	1199	971	1263	1152	970	1106	803	1072	1255	1091
F-3	1154	795	982	1107	963	1143	698	925	1020	869
F-4	1052	818	1050	1198	958	1224	821	993	1352	1093
Average	1119	821	1109	1110	912	1083	718	987	1181	989

Table 86. Average pounds of total root TAC as influenced by clipping frequency, irrigation interval and nitrogen fertilization

	C-1				C-2			
Irrigation	F-1	F-2	F-3	F-4	F-1	F-2	F-3	F-4
	lbs/A							
I-1	994	1095	1008	1043	840	1119	1015	958
I-3	897	1111	990	988	892	1061	782	1093
I-4	898	1127	1002	1016	890	1016	997	1239
Average	930	1111	1000	1015	874	1065	931	1096

Table 87. Average pounds of total root TAC of mixtures as influenced by irrigation interval and nitrogen fertilization

		Mixture				
Irrigation	Fertilization	M-1	M-2	M-3	M-5	M-6
		lbs/A				
I-1	F-1	1001	560	1091	1107	826
	F-2	1198	950	1092	1218	1075
	F-3	1258	796	958	1058	988
	F-4	999	818	871	1261	1052
I-3	F-1	1174	592	941	865	899
	F-2	1264	760	1125	1249	1033
	F-3	1194	633	811	1029	762
	F-4	1204	718	1077	1300	902
I-4	F-1	715	720	1118	1151	768
	F-2	995	951	1284	1143	982
	F-3	993	812	1092	1104	998
	F-4	1211	923	1117	1263	1122
Average		1101	770	1048	1146	951

Interaction of clipping frequency x irrigation interval x nitrogen fertilization x mixture. The clipping x irrigation x fertilization x mixture interaction was highly significant. The results are shown in Table 109 (Appendix B).

Root To Forage Ratio

The root to forage (R/F) ratios were figured by dividing the total root weight by the forage dry matter weight.

Total root to forage ratio

The analysis of variance for the total root/forage ratio (R/F) is given in Table 127 (Appendix C). The data are compiled in Table 110 (Appendix B). All four main effects--clipping frequency, irrigation interval, mixture, and nitrogen fertilization were highly significant. The first order interaction of nitrogen fertilization x mixture was highly significant and clipping frequency x mixture was significant.

Effect of clipping frequency. The effect of clipping frequency on the R/F ratio was highly significant and is given in Table 88. C-2 had a larger R/F ratio than C-1--1.14 to 1.04, respectively, but the difference was nonsignificant.

Table 88. Effect of clipping frequency on R/F ratio

Clipping	Harvests per year	R/F ratio
C-1	4	1.04
C-2	5	1.14

LSD 0.05 = 0.18 N.S.

Effect of irrigation interval. The effect of irrigation on the R/F ratio was highly significant and is given in Table 89 and Figure 71. The difference between the I-1 and I-4 R/F ratio was significant and between the I-1 and I-3 R/F ratio was highly significant. The I-3 and I-4 R/F ratios were nearly similar. I-1 produced the highest R/F ratio and I-3 the lowest.

Effect of mixture. The effect of mixture on the R/F ratio is given in Table 90 and Figure 72. M-6 had the highest and M-1 had the lowest R/F ratio. M-2, M-3 and M-5 were nearly identical. The differences between M-6 and the other four mixtures were highly significant. All other differences were nonsignificant.

Effect of nitrogen fertilization. The effect of fertilization on the R/F ratio is given in Table 91 and Figure 73. F-1 and F-2 had identical and the highest R/F ratio. F-3 was next and F-4 was lowest. All differences except between F-1 and F-2 were highly significant.

Interaction of clipping frequency x mixture. The clipping x mixture interaction on the R/F ratio was significant. The results are shown in Table 92 and Figure 74. C-2 was highest for all mixtures except M-2. M-1 was lowest and M-6 was highest for both clipping treatments.

Interaction of nitrogen fertilization x mixture. The fertilization x mixture interaction on the R/F ratio was highly significant. The results are shown in Table 93 and Figure 75. F-2, F-1, F-3, and F-4 was the order from the highest to the lowest R/F ratio for M-1, M-2, M-3 and M-5. For M-6, the fertilizer treatments were in order of increasing nitrogen; F-1, F-2, F-3 and F-4 for decreasing R/F ratios.

Table 89. Effect of irrigation interval on R/F ratio

Irrigation	Interval	R/F ratio
	days	
I-1	20	1.24
I-3	10	0.99
I-4	5	1.04

LSD 0.05 = 0.14
0.01 = 0.21

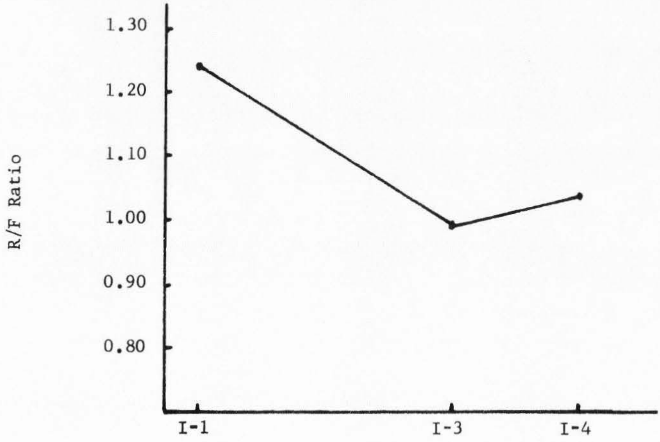

Figure 71. Average R/F ratio as influenced by irrigation interval

Table 90. Effect of mixture on R/F ratio

Mixture	Species	R/F ratio
M-1	A-RC-LC-OG-BG-RCG-TOG	0.93
M-2	LC-OG-BG	1.03
M-3	A-OG-BG	1.02
M-5	A-IWG	1.04
M-6	OG-BG	1.44

LSD 0.05 = 0.26
0.01 = 0.34

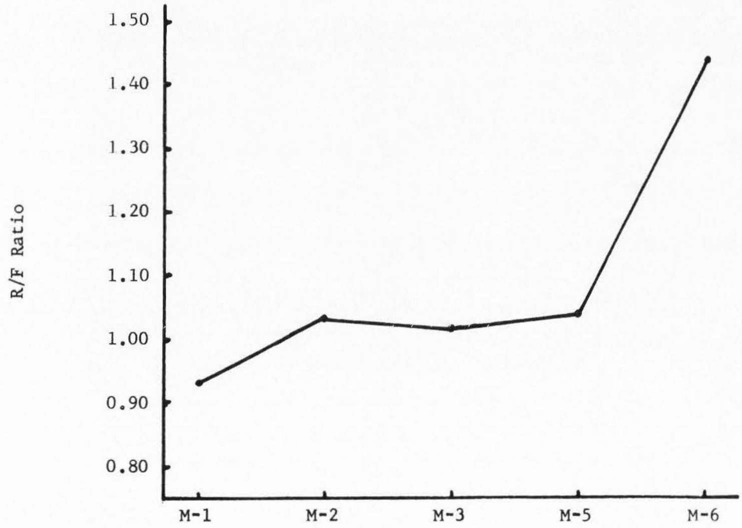

Figure 72. Average R/F ratio as influenced by mixture

Table 91. Effect of nitrogen fertilization on R/F ratio

Fertilization	Nitrogen	R/F ratio
	lbs/A	
F-1	0	1.32
F-2	50	1.32
F-3	100	0.96
F-4	200	0.78

LSD 0.05 = 0.13
0.01 = 0.17

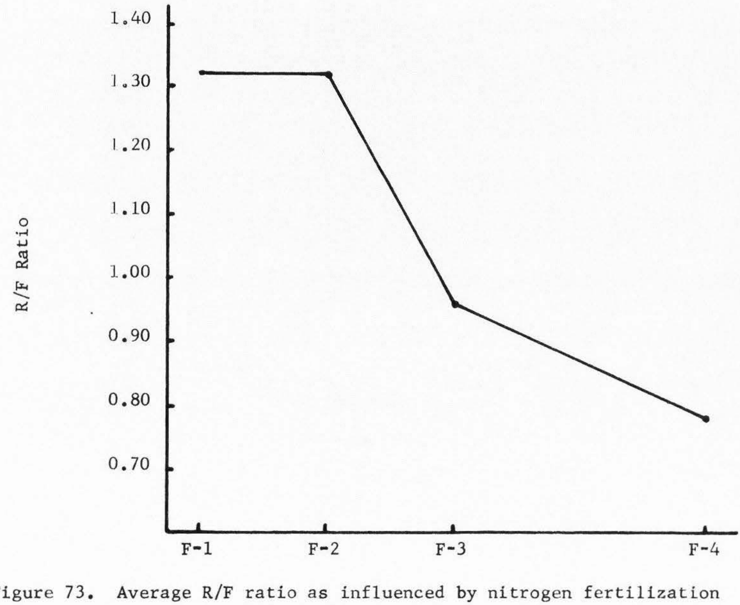

Figure 73. Average R/F ratio as influenced by nitrogen fertilization

Table 92. Average R/F ratio of mixtures as influenced by clipping frequency

Clipping	M-1	M-2	M-3	M-5	M-6	Average
	Mixture					
	R/F ratio					
C-1	0.88	1.05	0.95	0.92	1.41	1.04
C-2	0.98	1.01	1.10	1.16	1.47	1.14
Average	0.93	1.03	1.02	1.04	1.44	

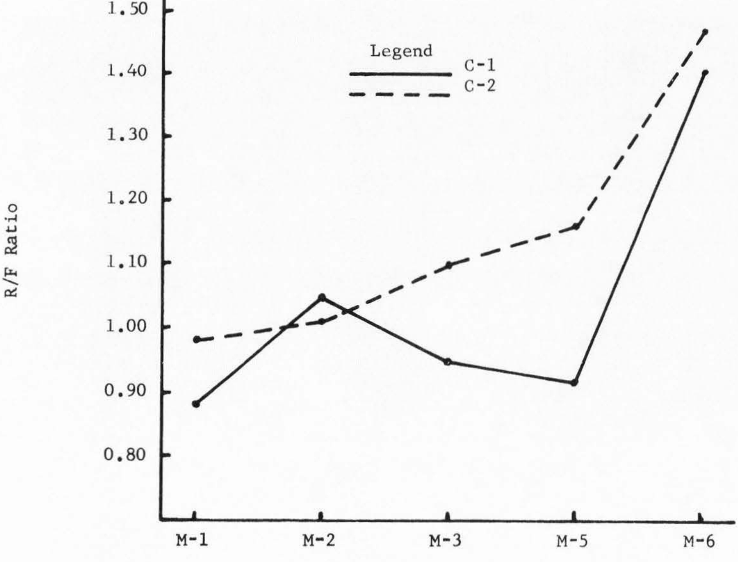

Figure 74. Average R/F ratio of mixtures as influenced by clipping frequency

Table 93. Average R/F ratio of mixtures as influenced by nitrogen fertilization

Fertilization	Mixture M-1	M-2	M-3	M-5	M-6	Average
	R/F ratio					
F-1	0.99	1.21	1.15	1.10	2.14	1.32
F-2	1.12	1.31	1.24	1.18	1.74	1.32
F-3	0.89	0.89	0.95	0.94	1.11	0.96
F-4	0.72	0.73	0.76	0.94	0.75	0.78
Average	0.93	1.03	1.02	1.04	1.44	

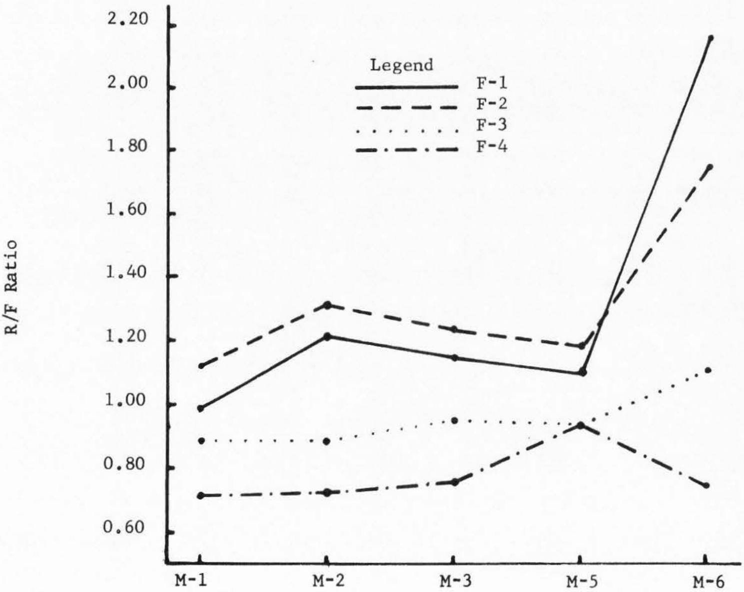

Figure 75. Average R/F ratio of mixtures as influenced by nitrogen fertilization

DISCUSSION

Forage

Response of forage dry matter yield to various management factors

This study found and agrees with Burger, Jackobs, and Hittle (1962) in Illinois that the less frequent and thus fewer harvests treatment (C-1) gave the highest forage yield. The difference was highly significant over the C-2 treatment.

Each nitrogen increment gave a yield increase. The initial 50 pounds of nitrogen affected the greatest yield change resulting in a yield increase of 1080 pounds over no nitrogen. The second 50 pound increment gave a 340 pound yield increase and the last 100 pound increment gave a 1645 pound yield increase.

Cooper, Eslick, and Stitt (1960) in Montana and Jackobs (1952) in Yakima Valley found that alfalfa-grass mixtures were superior in yield to mixtures containing other legumes. There were no significant yield differences between any of the three mixtures containing alfalfa (M-1, M-3, M-5) but the difference in yields from these mixtures were highly significant and greater than the grass-only (M-6) and ladino clover-grass (M-2) mixtures. The lower ladino clover-grass (M-2) yield is in contradiction to Washko and Pennington's (1956) findings that bromegrass and orchardgrass yielded more forage in association with ladino clover than with alfalfa.

Previous work by Lorenz, Rogler and Holman (1959) determined that irrigation increased yields but the yields at two irrigation

levels seldom differed significantly. Irrigation as a main factor gave no significant yield difference; as a first order interaction with mixtures gave highly significant results. The twenty day irrigation interval (I-1) gave the lowest average yield followed by the five day interval (I-4) and then the ten day interval (I-3) with average yields of 6102, 6490 and 6564 pounds respectively. The grass-only (M-6) and the ladino clover-grass (M-2) mixtures gave a slightly higher yield response to the five day (I-4) than the ten day (I-3) and least yield response to the twenty day (I-1) irrigation interval. The yield of the alfalfa mixture showed least variation with change in irrigation interval.

The clipping x mixture interaction was highly significant. The five harvests per season (C-2) decreased the yield for all mixtures from the yield of the four harvests per season (C-1). The ladino clover-grass (M-2) and grass-only (M-6) mixtures were affected less by the more frequent harvest than the three mixtures containing alfalfa (M-1, M-3 and M-5).

The fertilization x mixture interaction indicated that all mixtures had an increase of forage production with each succeeding increase of applied nitrogen. The first 50 pound nitrogen treatment (F-2) gave greater yield increases than the second 50 pound increment (F-3). The second 50 pound increment gave the smallest increase for all five mixtures. The 200 pound treatment (F-4) showed the least yield differences between mixtures. The grass-only mixture (M-6) had the lowest forage production at all nitrogen levels but gave the greatest response to each fertilization treatment. The ladino clover-grass mixture (M-2) was second in total response.

The clipping frequency x nitrogen fertilization x mixture interaction showed general trends of yield increases with each increase of nitrogen and fewer clippings.

Forage Percent Protein

Effect of various management factors on percent protein

Mixtures had highly significant differences in percent protein. All other management factors and all interactions were nonsignificant.

The mixtures containing alfalfa (M-1, M-3, and M-5) had the highest percent forage protein. There was a decrease in protein with an increase in the number of grass species in the alfalfa mixture. The ladino clover-grass mixture (M-2) had a lower percent protein than the three mixtures containing alfalfa. The grass-only mixture (M-6) had the lowest percent protein for all five mixtures.

Forage Protein Yield

Effect of various management factors on protein yield

The forage protein yield basically followed the forage yield as it was the product of forage dry matter and percent protein. Only mixtures as a treatment gave significant results in percent protein. These differences were in harmony with the forage yield differences attributed to the main effect of mixtures and thus the forage protein yields as affected by mixtures showed more deviation from the affect of mixtures on forage dry matter production than other treatments or interactions.

Protein yields from four harvests per season (C-1) were highly significant over the protein yields from five harvests per season (C-2). The protein yield of mixtures as influenced by the four harvests per

season (C-1) was higher for the mixtures containing alfalfa (M-1, M-3 and M-5) and lower for the ladino clover-grass (M-2) and grass-only (M-6) mixtures. Clipping frequency had little effect on protein production of the grass-only mixture (M-6).

Nitrogen treatment effects on protein yields were similar to the effects on forage yields with all yield differences being highly significant except between the 50 pounds per acre (F-2) and the 100 pounds per acre (F-3) treatments which difference was nonsignificant.

There was agreement with Kust and Smith's (1960) findings on protein yields from alfalfa as the protein yields from the mixtures containing alfalfa (M-1, M-3 and M-5) showed little variation and the differences were nonsignificant but were all highly significant over the ladino clover-grass (M-2) and grass only (M-6) mixtures. The grass-only mixture (M-6) had the lowest protein yield of 697 pounds per acre--246 pounds less than the ladino clover-grass mixture (M-2) with 943 pounds of protein, and 413 pounds less than M-1 the lowest of the mixtures containing alfalfa with 1110 pounds of protein.

The irrigation interval x mixture interaction gave little yield differences between irrigation treatments with the ten day interval (I-3) being higher than the five day interval (I-4) for all mixtures and resulting in an average production difference of only 38 pounds. The twenty day irrigation interval (I-1) gave slightly higher protein yields for the three mixtures containing alfalfa (M-1, M-3 and M-5) but lower protein yields for the ladino clover-grass (M-2) and grass-only (M-6) mixtures than the shorter irrigation intervals. The ladino clover-grass mixture (M-2) showed the most deviation in protein yield as influenced by the different irrigation intervals.

Roots

Effect of various management factors on root dry matter yield

The specie(s) in the mixture seemed to be a major determining factor in the affect of various management factors on root dry matter yield.

Ladino clover roots. Five harvests per season (C-2) gave significantly higher ladino clover root yields than four harvests per season (C-1).

Fifty pounds of nitrogen per acre gave the highest ladino clover root yield of 454 pounds with a lower root yield of 318 pounds with no nitrogen, 253 pounds with 100 pounds of nitrogen and 52 pounds with 200 pounds of nitrogen per acre.

The simple ladino clover-grass mixture (M-2) gave higher root yields than the more complex mixture (M-1) and gave higher root yields at the two longer irrigation intervals (I-1 and I-3) but M-1 responded to the shortest irrigation interval (I-4) with a sharp increase to outyield M-2 in ladino clover roots.

The short irrigation interval (I-4) gave the highest root yield with 50 pounds (F-2) and 100 pounds (F-3) of nitrogen. Ladino clover root production varied little between the twenty day (I-1) and the ten day (I-3) irrigation intervals for the 50 pounds (F-2), 100 pounds (F-3) and 200 pounds (F-4) nitrogen treatments.

Alfalfa and total legume roots. Four harvests per season (C-1) gave highly significant alfalfa and total legume root yields over five harvests per season (C-2).

Four harvests per season (C-1) gave higher total legume root production for the three alfalfa-grass mixtures (M-1, M-3 and M-5)

but slightly lower root production for the ladino clover-grass mixture (M-2) than the five harvests per season (C-2).

Alfalfa root yield dropped as the mixture became more complex going from a high of 2096 pounds of roots with the alfalfa-one grass mixture (M-5), to 1704 pounds with alfalfa-two grass mixture (M-3), to the low of 1172 pounds with the complex mixture (M-1). Total legume roots followed the same pattern except the ladino clover-grass mixture (M-2), although not as complex as M-1, had the lowest total legume root yield of 302 pounds but contained no alfalfa.

The 50 pound nitrogen treatment (F-2) gave the highest, 0 pounds (F-1) slightly less, but both gave highly significant root yields over 100 pounds (F-3) and 200 pounds (F-4) of nitrogen with one minor exception--F-3 produced 41 pounds more legume roots than F-2 with M-1.

Fifty pounds of nitrogen (F-2) produced the highest alfalfa and total legume root yield for both the twenty day (I-1) and ten (I-3) irrigation interval. The twenty day interval (I-1) gave the highest root yield at all fertilization rates.

Two hundred pounds of nitrogen (F-4) and the five harvests per season (C-2) gave the lowest alfalfa root yield for all three of the mixtures containing alfalfa.

The longest irrigation interval of twenty days (I-1) gave the highest root yield followed by lower yields in the order of the shortened irrigation intervals. Except for the non-alfalfa mixture (M-2), the twenty day irrigation interval (I-1) had the highest total legume root production for all the legume containing mixtures. The ten day irrigation interval (I-3) had slightly higher total legume

root production than the five day irrigation interval (I-4) for all mixtures.

Grass roots. The four harvests per season (C-1) gave higher grass root production for the ladino clover-grass (M-2) and grass-only mixtures (M-6) and lower grass root production for the alfalfa-one grass mixture (M-5) than the five harvests per season (C-2).

Grass root production was highest with the 50 pound nitrogen (F-2) treatment followed by the 200 pound (F-4), 100 pound (F-3), and 0 pound (F-1) nitrogen treatments in the order of decreasing root production.

No nitrogen (F-1) gave the lowest grass root production for all mixtures with 100 pounds of nitrogen (F-3) just slightly higher for M-5 and M-6 but second lowest for all mixtures. The 50 pound nitrogen application (F-2) yielded highest in grass roots for all mixtures except second high for M-5. 200 pounds of nitrogen (F-4) was second for all mixtures except was highest for M-5 and showed the least deviation between mixtures for the various fertilization treatments.

The grass-only mixture (M-6) had the highest grass root yield followed by the ladino clover-grass mixture (M-2).

The twenty day irrigation interval (I-1) gave the highest grass root yield with a slight decrease for the five day interval (I-4) and a significant decrease for the ten day irrigation interval (I-3).

Total roots. Four harvests per season (C-1) produced a yield of 6482 pounds of total roots which was highly significant over the lower total root yield of 6032 pounds of total roots for the five harvests per season (C-2). Four harvests per season (C-1) gave the highest total root yields for all mixtures except M-5 over five harvests per

season (C-2). Boswell and Weaver (1933) and Weaver and Darland (1949) pointed out that frequent harvesting and/or overgrazing reduced root volume and weight.

The twenty day irrigation interval (I-1) gave the highest total root production with the five day interval (I-4) second and the ten day interval (I-3) lowest in total root production. This order was true for all mixtures and followed the results of the grass root yield as influenced by irrigation interval.

The three mixtures containing alfalfa (M-1, M-3 and M-5) had the highest total root yield followed by the grass-only mixture (M-6) and then the ladino clover-grass mixture (M-2) with the lowest total root yield.

Fifty pounds of nitrogen (F-2) produced the highest total root yield for all mixtures, 0 pounds of nitrogen produced the lowest total root yield and for all mixtures except M-5. These total root yields nearly paralleled the grass root yields for all four fertilization treatments.

Effect of various management factors on percent root reserves--total available carbohydrates (TAC)

Ladino clover root percent TAC. The most complex ladino clover mixture (M-1) resulted in a much higher percent total available carbohydrates (TAC) than the other mixture containing ladino clover (M-2) i.e. 19.75 and 14.11, respectively.

The highest level of nitrogen, 200 pounds (F-4), resulted in the highest percent TAC of 19.00 and was significantly higher than the results of 0 pounds (F-1) with 16.85, 100 pounds (F-3) with 15.95,

and highly significant over the 14.94 percent TAC resulting from 50 pounds of nitrogen (F-2).

The percent TAC increased for the five clippings per season treatment (C-2) as the irrigation interval shortened; however, the five clippings per season treatment (C-1) showed an increase in percent TAC with the irrigation interval change from twenty to ten days but showed a sharp percent decrease as the irrigation interval shortened from ten to five days.

Alfalfa root percent TAC. The mixtures showed little variation in percent TAC with only one difference being significant.

The 0 pounds of nitrogen (F-1) treatment showed the largest variation among the mixtures. This variation narrowed with each increase of nitrogen. No other pattern was apparent.

Grass root percent TAC. The five harvests (C-2) resulted in a significantly higher grass root percent TAC than the four harvests (C-1). The more frequent clipping (C-2) showed higher grass root percent TAC for all nitrogen applications except the 50 pound treatment (F-2). The higher the level of applied nitrogen the larger the difference in percent TAC between the two clipping treatments.

Only the ladino clover-grass mixture (M-2) had a lower grass root percent TAC with the five harvests per season (C-2) than with the four harvests per season (C-1).

Considerable variation in grass root percent TAC between mixtures existed. Some differences were nonsignificant, some significant, and others highly significant.

Fertilization effect on grass root percent TAC indicated that 200 pounds of nitrogen (F-4) resulted in the highest, 100 pounds (F-3)

second high, 0 pounds (F-1) third high, and 50 pounds (F-2) of nitrogen the lowest percent TAC.

There was only a small nonsignificant difference in grass root percent TAC between the highest for the ten day (I-3) and the next high for the five day irrigation interval (I-4) but both were highly significant over the lowest percent TAC for the twenty day irrigation interval (I-1). The different irrigation intervals had least effect on the grass-only mixture (M-6) and most effect on the complex mixture (M-1).

Total root percent TAC. Total root percent TAC was derived by computation using ladino clover, alfalfa, and grass root percent TAC figures. All four main effects were highly significant. The grass roots constituted a major portion of the total roots for several of the mixtures and thus there are many similarities in the effects of treatments on total root percent TAC to the effects of the same treatments on grass root percent TAC. The preceding discussion under grass root percent TAC is applicable here for total root percent TAC.

The ladino clover-grass mixture (M-2) had the lowest total root percent TAC for all irrigations. The all grass mixture (M-6) showed the least differences between the different irrigation intervals. The twenty day irrigation interval (I-1) gave the lowest total root percent TAC for all fertilization levels and for all mixtures except second low with the complex mixture (M-1). The two shorter irrigation intervals (I-3) and (I-4) were similar in trend to I-1 for the lower three nitrogen levels but showed an increase in percent TAC from the 100 pound (F-3) to the 200 pound nitrogen (F-4) treatment. The longest

irrigation interval (I-1) showed a decrease for the highest nitrogen treatment (F-4).

Effect of various management factors on pounds of total available carbohydrates (TAC)

The pounds of total available carbohydrates (TAC) is the product of the percent TAC and pounds of total root dry matter.

Ladino clover root TAC. The more frequent clipping (C-2) and the lower nitrogen levels, 0 and 50 pounds (F-1 and F-2) resulted in substantially higher pounds of TAC than the less frequent clipping (C-1) and higher levels of nitrogen, 100 and 200 pounds (F-3 and F-4). For all irrigation intervals the TAC production dropped with increased nitrogen above the 50 pound level (F-2) reaching the lowest yield with the 200 pounds of nitrogen (F-4) application.

Alfalfa root TAC. Whereas, only mixture and the nitrogen fertilization x mixture interaction were significant for alfalfa root percent TAC; all main effects and most interactions were highly significant for alfalfa root pounds of TAC.

Results similar to Graber, et al. (1927) were obtained wherein the four harvests per season (C-1) resulted in nearly twice the pounds of alfalfa root TAC as the five harvests per season (C-2). This was true for each mixture as well as the clipping average.

Fifty pounds of nitrogen (F-2) resulted in the highest alfalfa root TAC production of 328 pounds, just 10 pounds greater than 0 pounds of nitrogen (F-1) at 318 pounds, 29 pounds higher than the 100 pounds of nitrogen (F-3) at 299 pounds and over twice the production of 200 pounds of nitrogen (F-4) at 140 pounds of TAC per acre which was low

for all mixtures. Except for the F-4 results, the different nitrogen levels showed various results with the different mixtures.

The simplest mixture (M-5) gave the greatest TAC production with a decrease through each of the other mixtures (M-3 and M-1) related to the increasing complexity of the mixtures with 327, 291 and 195 pounds of TAC, respectively.

The twenty day irrigation interval was highest in TAC production at all fertilization levels, decreasing from the high of 396 pounds with 0 pounds of nitrogen (F-1) through each increase of nitrogen applied.

Grass root TAC. Five harvests per season (C-2) yielded significantly higher grass root TAC than four harvests (C-1). This held true for all mixtures except the ladino clover-grass mixture (M-2).

No nitrogen (F-1) gave the lowest production of grass root TAC; 100 pounds of nitrogen per acre (F-3) had significantly higher production; 50 pounds of nitrogen (F-2) and then 200 pounds of nitrogen (F-4), respectively, each gave highly significant increased grass root TAC production. In interaction with mixture, these trends were basically the same.

Total root TAC. Total root TAC is the sum of legume and grass root TAC. All differences in total root TAC production between mixtures were significant or highly significant. The mixtures containing alfalfa were all substantially higher in total root TAC over the grass root TAC production.

Fifty pounds of nitrogen (F-2) gave the highest total root TAC production; just slightly, but not significantly higher than the 200 pounds of nitrogen (F-4). Zero pounds of nitrogen (F-1) gave the

lowest production of total root TAC. The interactions of other treatments with mixture produced several variations from the general trends.

Root to Forage Ratio

The total root/forage ratio (R/F) was a calculation being the quotient of total root weight (dividend) and forage dry matter weight (divisor). A figure of one or larger indicates as many or more pounds of roots as pounds of harvested forage.

The five harvests per season (C-2) gave a relatively higher R/F ratio than the four harvests per season (C-1). This was true for all mixtures except the ladino clover-grass mixture (M-2).

The 0 pounds (F-1) and 50 pounds (F-2) of nitrogen had the largest and identical R/F ratios of 1.32 followed by the ratios of 0.96 for 100 pounds of nitrogen (F-3) and 0.78 for 200 pounds of nitrogen.

In interaction with mixtures, the 200 pounds of nitrogen (F-4) gave the smallest R/F ratios for all mixtures except an identical R/F ratios for the alfalfa-intermediate wheatgrass mixture (M-5) with the second low R/F ratio for the nitrogen treatment of 100 pounds (F-3). 50 pounds of nitrogen (F-2) had the largest R/F ratio for all mixtures except the grass-only (M-6) where the 0 pounds of nitrogen (F-1) changed from the second largest to the largest R/F ratio.

The grass-only mixture (M-6) had the largest R/F ratio of 1.44 and the complex mixture (M-1) had the lowest R/F ratio of 0.93. The other three mixtures--(M-2, M-3 and M-5) had almost identical R/F ratios of 1.03, 1.02 and 1.04, respectively.

The twenty day irrigation interval (I-1) produced the largest R/F ratio, significantly larger than the five day interval (I-4) and highly

significant over the ten day interval (I-3) which was the lowest with R/F ratios of 1.24, 1.04 and 0.99, respectively.

The 0 pounds of nitrogen (F-1) and grass-only mixture (M-6) interaction had the largest R/F ratio. It was 2.14.

SUMMARY AND CONCLUSIONS

The field experiment was conducted at the Greenville Farm at North Logan, Utah, on a Millville silt loam soil that occurs on a well-drained alluvial loam, high in potash and phosphorus with a pH of 7.9 to 8.2.

A study was made during 1964 to evaluate the forage and protein yield and in 1965 to evaluate the root yield, total available carbohydrates (TAC), and root/forage R/F ratio of ladino clover, alfalfa, and grass in five pasture mixtures as influenced by two clipping frequencies, three irrigation intervals and four nitrogen fertilization levels.

The results are summarized and conclusions drawn as follows:

Four harvests a season gave a greater forage yield than five harvests. The alfalfa mixtures were affected greater by the clipping frequencies than the ladino clover-grass and grass-only mixtures.

All nitrogen applications gave a yield increase. The first 50 pounds had the most response. The second 50 pound increment gave the least response of the nitrogen treatments. All mixtures responded about the same. All mixtures responded to each nitrogen application with increased yields for each increase in nitrogen but the mixtures containing alfalfa had less response than the ladino clover-grass and grass only mixtures. The grass-only mixture had less yield with 0 pounds of nitrogen and showed the greatest response at all nitrogen application levels.

The three mixtures containing alfalfa gave substantially greater yields than the mixtures with no alfalfa. The yield responses were equal in the simple and more complex mixtures.

With equal amounts of water applied, the irrigation interval gave no significant yield results. There was little forage yield difference between the ten and twendy day irrigation intervals, but the ten day interval was slightly better for the conditions of this project. The twenty day irrigation interval was too long for good forage production from the non-alfalfa mixtures.

Only the mixtures treatment showed significant percent protein results. The grass-only mixture had the lowest percent protein and the alfalfa-one grass mixture had the highest percent protein.

Clipping frequency, irrigation interval, and nitrogen fertilization did not affect the percent of forage protein but did affect the forage yield. Their affect on forage protein yield was closely related to their affect on the forage yield.

Four harvests gave higher protein production than five harvests from the mixtures containing alfalfa but less from the mixtures containing no alfalfa.

No nitrogen gave the low forage protein yield. Protein yield registered a gradual increase with each increase in nitrogen. Increases were nearly lineal and didn't follow the forage yield increases.

The mixtures containing alfalfa gave the highest protein yield. The protein yield decreased with the increase of the number of species in the mixture. The lowest protein yield was from the grass-only mixture. The twenty day irrigation interval gave highest protein yields

when the mixtures contained alfalfa. The ten day irrigation interval gave higher protein yield than the five day interval for all mixtures.

Ladino clover grown as the only legume in a mixture with bromegrass and orchardgrass gave a higher ladino clover root yield per acre than ladino clover grown with a mixture of red clover, alfalfa, bromegrass, orchardgrass, tall oatgrass and Reed canary grass.

Ladino clover plants harvested five times a season gave a higher root yield than those harvested four times a season.

Fifty pounds of nitrogen per acre gave the highest ladino clover root yield followed by 0 pounds, 100 pounds and 200 pounds of nitrogen per acre. The irrigation interval interaction caused variation to the above.

Alfalfa plants harvested four times a season gave a higher root yield than those harvested five times a season.

Fifty pounds of nitrogen per acre gave the highest alfalfa root yield followed by 0 pounds, 100 pounds and 200 pounds of nitrogen per acre.

Alfalfa grown in a mixture with intermediate wheatgrass gave the highest root yield followed by that grown in a mixture with bromegrass and orchardgrass; and a mixture with ladino clover, red clover, bromegrass, orchardgrass, tall oatgrass and Reed canarygrass. The alfalfa root yield was less as the mixture became more complex.

The longest irrigation interval of twendy days gave the highest alfalfa root yield followed by lower yields in the order of the shortened irrigation intervals--ten days and five days.

Grass plants in the grass-only; alfalfa, intermediate wheatgrass; and ladino clover, bromegrass and orchardgrass mixtures harvested four

times a season gave a higher root yield than those harvested five times a season.

Fifty pounds of nitrogen per acre gave the highest grass root yield followed by 200 pounds, 100 pounds and 0 pounds of nitrogen per acre.

Grass grown alone gave the highest root yield followed by the ladino clover-grass mixture.

The longest irrigation interval of twenty days gave the highest grass root yield followed by a slight root yield decrease for the five day interval and a larger root yield decrease for the ten day interval.

Pasture plants harvested four times a season gave a larger total root yield than plants harvested five times a season.

Fifty pounds of nitrogen per acre gave the highest total root yield followed by 200 pounds, 100 pounds, and 0 pounds of nitrogen per acre.

The three mixtures containing alfalfa gave the highest total root yield followed by the grass-only and then the ladino clover-grass mixtures.

The longest irrigation interval of twenty days gave the highest total root yield followed by the five day interval and then the ten day interval.

Although the ladino clover root percent TAC was highest in the complex mixture and with 200 pounds of nitrogen the actual pounds of TAC were nearly identical from both mixtures containing ladino clover, and lowest from 200 pounds of nitrogen. Both percent and pounds of TAC were high with five harvests per season and with the twenty day

irrigation interval. The pounds of TAC decreased as the irrigation interval decreased from twenty to ten to five days.

Alfalfa plants harvested four times a season gave nearly twice the pounds of alfalfa root TAC as those harvested five times a season. This was true for each alfalfa mixture.

Fifty pounds of nitrogen per acre gave the highest alfalfa root TAC production followed by 0 pounds, 100 pounds and 200 pounds of nitrogen per acre.

Alfalfa grown in a mixture with intermediate wheatgrass gave the highest alfalfa root TAC production followed by that grown in a mixture with bromegrass and orchardgrass; and a mixture with ladino clover, red clover, bromegrass, orchardgrass, tall oatgrass and reed canarygrass. The alfalfa root TAC production was less as the mixture became more complex.

The twenty day irrigation interval gave the highest alfalfa root TAC production followed by the ten day and then five day irrigation interval as a treatment and for each alfalfa mixture.

Grass plants harvested five times a season gave both a higher grass root percent and production of TAC than those harvested four times a season.

Two hundred pounds of nitrogen per acre gave the highest grass root percent TAC followed by 100 pounds, 0 pounds and 50 pounds of nitrogen per acre.

Two hundred pounds of nitrogen per acre gave the highest grass root TAC production followed by 50 pounds, 100 pounds and 0 pounds of nitrogen per acre.

Pasture plants harvested four times a season gave a lower total root percent TAC but a higher TAC production than those harvested five times a season.

Two hundred pounds of nitrogen per acre gave the highest total root percent TAC followed by 100 pounds, 0 pounds and 50 pounds of nitrogen per acre.

Fifty pounds of nitrogen per acre gave the highest total root TAC production followed by 200 pounds, 100 pounds and 0 pounds per acre.

The twenty day irrigation interval gave the highest total root TAC production followed by the ten day and then five day irrigation interval.

Pasture plants harvested five times a season gave a higher R/F ratio than those harvested four times a season. Only the ladino clover-grass mixture was otherwise.

Fifty pounds of nitrogen per acre gave the highest R/F ratio for all mixtures except the grass-only mixture. Zero pounds of nitrogen gave the highest R/F ratio for the grass-only mixture. When averaged over mixtures, 0 and 50 pounds of nitrogen per acre gave identical and the highest R/F ratio followed by 100 pounds and 200 pounds of nitrogen per acre.

The grass-only mixture had the highest R/F ratio and the most complex mixture had the lowest R/F ratio. The three mixtures containing alfalfa had nearly identical R/F ratios.

The twenty day irrigation interval gave the highest R/F ratio followed by the five day and then ten day irrigation interval.

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APPENDIXES

Appendix A

Method of Chemical Analysis to Determine Total Available Carbohydrate (TAC) Content

Reagents

Somogyi reagent. Dissolve 24 grams of anhydrous Na_2CO_3 and 12 grams of Rochelle salt in about 250 ml of water. Dissolve 4 grams of $CuSO_4 \cdot 5H_2O$ in 40 ml of water. Add the dissolved copper sulfate to the dissolved carbonate and Rochelle salt without stirring. Add 16 grams of $NaHCO_3$. Dissolve 18 grams of anhydrous Na_2SO_4 in about 500 ml of hot water and boil to expel the air. After cooling, the solutions are united and diluted to a volume of 1000 ml.

During the first few days, or a week, a slight amount of cuprous oxide may settle, together with impurities of the ingredients used. Remove these by filtration. No more self reduction takes place at ordinary room temperature, except, perhaps under prolonged exposure to sunlight (Somogyi, 1952).

Nelson reagent. Dissolve 25 grams ammonium molybdate in 450 ml of distilled water. Add 25 ml of concentrated H_2SO_4 and mix. Dissolve 3 grams $Na_2HAsO_4 \cdot 7H_2O$ in 25 ml of water. Add to the above 475 ml and mix. Place in a 38 C incubator for 24-48 hours. Filter and store in a brown glass, stoppered bottle. Prevent exposure to sunlight or prolonged exposure to artificial light.

TAC extraction and analysis

1. Place one-half gram of the uniformly dried, ground root samples into a 100 ml flask.

2. Add 50 ml of 0.2N H_2SO_4. Stopper with large glass marbles or glass bulbs blown from thick wall tubing.

3. Heat in a boiling water bath for 1 hour.

4. Filter the hot solution through Whatman's #42 filter paper into a 125 ml flask.

5. Wash the filtrate with approximately 50 ml of distilled water.

6. Add phenophthalein indicator.

7. Add 6 F. NaOH until indicator end point is reached.

8. Remove indicator color by making slightly acid with 1 percent HCL.

9. Fill to the 125 ml mark with distilled water.

10. Make a 10:1 dilution by extracting 5 ml and diluting to 50 ml.

11. Place 5 ml into a test tube calibrated to 25 ml.

12. Add 5 ml Somogyi solution. Stopper with a large glass marble or a glass bulb blow n from thick wall tubing.

13. Heat in a rapidly boiling water bath for 10 minutes. Avoid undue agitation of the test tubes while boiling.

14. Remove and cool to room temperature with running tap water for about three minutes or in a 20 C water bath for 5 minutes.

15. Add 2 ml Nelson reagent.

16. Cap and rotate or gently shake to allow completion of the interaction between the acid and the carbonates. Release the pressure by uncapping as necessary.

17. Dilute to the 25 ml mark with distilled water.

18. Cap and mix by inverting the test tube several times.

19. Analyze at 520 millimicrons against a reagent blank that is treated identical in the procedure outlined above except step #1 (no root tissue used).

20. Prepare a known standard solution of glucose that does not exceed 0.6 mg glucose per 5 ml. For ease of computation use a 10 percent (0.5 mg per 5 ml) glucose standard. Start the sugar standard preparation with step #11 and continue through step #19.

21. A straight Beer's law plot line should be obtained from the readings of a series of dilutions of the glucose standard.

22. Calculations for the above dilutions with a 10 percent glucose standard were made by dividing the reading of the unknown by the reading of the glucose standard and multiplying by 25 to obtain the percent glucose in the unknown (or by dividing the glucose standard reading by 25 and dividing the reading of the unknown by this answer to obtain the percent glucose).

Preparation of racks to hold 20 flasks and 20 test tubes allowed for the testing of 18 unknowns with each batch. It took about six hours to complete the entire run of each batch.

The analytical procedure with the Somogyi reagent is much the same as with other copper reagents used in colorimetry. A measured volume of the solution to be analyzed is mixed with an identical volume of the copper reagent and heated in a boiling water bath. For glucose and fructose a 10 minute heating period is adequate. After cooling, Nelson's chromogenic reagent is added and care is taken to dissolve the cuprous oxide completely. The blue solution is then diluted to a volume selected in accordance with the quantities of sugar involved.

Rather than a sterotyped recipe, the above allows for technique elasticity and adaptability to a great variety of experimental conditions. From 1 to 5 ml of sugar solution per analysis with equal volumes of the copper reagent can be used. The amount of chromogenic reagent to be added need not exceed 2 ml. The final volume of the colored solution can be adapted to the prevalent color densities. In microanalysis, when the amount of sugar is low, the final volume can be kept to 6 ml which is the combined volume of 2 ml portions each of the sugar solution, the copper reagent, and the chromogenic reagent. At the other extreme, a dilution to 25 ml is in order when the solution contains up to 0.6 mg per 5 ml of glucose or other sugar of

comparable reducing power. Color density being the limiting factor, the above technique is limited to a range of 0.2 to 12 percent sugar (Somogyi 1952).

Using a concentration of acid greater than 0.2N may result in the breakdown of structural carbohydrates and destroy some of the glucose.

Grueb and Wedin (1969) and Smith (1969) investigated different methods of removing TAC from plant tissue. They determined that the plant species and stage of growth are two variables to be considered in obtaining accurate results when considering the type of enzyme and/or concentration of sulfuric acid to use.

When alfalfa TAC values were at their lowest levels, the acid values were always 2 to 4 percentage units higher than the enzyme values. At all other times when alfalfa TAC levels were high, the enzyme treatment resulted in values up to 20 percentage units higher than the acid values. In those species, or during the season in other species when starch is an important constituent of stored carbohydrates, the enzymatic extraction and saccharification if di- and polysaccharides to reducing sugars is a more accurate method for estimating TAC than simultaneous extraction and hydrolysis using 0.2N H_2SO_4 (Greub and Wedin, 1969).

The acid method is apt to over-estimate the TAC where little starch is present and under-estimate where large amounts of starch are present.

The time of root harvest and preliminary chemical analysis both indicated a low to medium level of starch content in the alfalfa, grass, and ladino roots and so the dilute acid method was used.

Kjeldahl Method of Chemical Analysis to Determine Nitrogen Content

Reagents

Digestion mixture. Thoroughly mix 500 grams sodium sulfate, anhydrous powder; 50 grams copper sulfate, anhydrous powder; and 5 grams powdered selenium metal. All ingredients should be finely ground.

Boric acid. Mix 100 ml of standard indicator solution with 18 liters of 2 percent boric acid solution.

Standard indicator solution. This was a standard mixture of brome cresol green, aqueous percent solution of new coccine, and p-nitrophenol.

Procedure

1. Place 1 gram of the uniformly dried, ground forage into an 800 ml Kjeldahl flask.

2. Add 1 teaspoonful (approximately 10 grams) of the digestion mixture.

3. Wash with enough distilled water (15-20 ml) down the neck of each flask to thoroughly soak all the contents.

4. Add 20 ml of concentrated sulfuric acid.

5. Place the flask on the digestion heater of the standard Kjedahl apparatus and boil until the conversion of the nitrogen is complete (about 30 minutes).

6. Allow the flask and contents to cool.

7. Add about 300 ml of distilled water and mix thoroughly.

8. Add 1 gram of 20 mesh granular zinc.

9. Using a dispensing burette, add 75 ml of concentrated sodium hydroxide allowing it to run down and under the solution in the flask.

10. Connect each flask to a distilling tube under which has been placed a 500 ml Erlenmeyer receiving flask containing 50 ml of a boric acid solution.

11. After connecting to the distilling tube, swirl the flask gently to mix the contents.

12. Place on a hot digestion heater and distill until about 150 ml has distilled into the receiving flask.

13. Titrate the distillate with 0.0715 N sulfuric acid until the green color has changed to a grey color or colorless as was established for the indicator.

14. A blank containing no forage should be run through the Kjedahl process. Titrate the blank and subtract the blank titration reading from the titration reading of the sample.

15. One mg of the titration acid is equivalent to 1 mg of nitrogen in the ammonia form. Using a 1 gram sample, the percentage of nitrogen is calculated by multiplying the difference of ml of acid used in titration between the blank and the sample of 0.10.

16. About 16 percent of proteins is nitrogen on the average and $100 \div 16 = 6.25$. The percent protein was determined by percent nitrogen times 6.25 (NX6.25).

Appendix B

Interaction Tables

Table 94. Average dry matter yields in pounds per acre of forage as influenced by the interaction of clipping frequency, nitrogen fertilization, irrigation interval, and mixture

		C1					C2					Average
		F1	F2	F3	F4	Ave	F1	F2	F3	F4	Ave	C1 & C2
M1	I1	7390	7685	7910	8470	7866	4789	5820	5905	7276	5934	6900
	I3	6905	7890	8125	9248	8041	4981	5839	6091	7815	6181	7111
	I4	6824	7436	7621	9002	7721	4737	6630	6178	7695	6310	7015
M2	I1	3951	5178	5367	8017	5629	3650	4403	4990	6641	4921	5274
	I3	4955	6475	6890	8347	6667	4993	5628	6180	8136	6235	6452
	I4	4374	6198	6200	9110	6470	5011	6226	6371	8360	6492	6481
M3	I1	6920	8022	8120	8875	7935	5156	6322	6030	7598	6276	7130
	I3	6710	8084	8607	9251	8163	5202	5355	6464	8164	6295	7230
	I4	5853	7208	7721	8548	7334	4324	6490	6375	8055	6310	6821
M5	I1	6703	7480	7735	8467	7596	5104	6146	6006	6480	5934	6766
	I3	6665	7336	7588	8146	7434	5068	6033	6766	7842	6427	6931
	I4	6870	7020	8157	7722	7442	5832	5570	5898	8195	6373	6908
M6	I1	2520	4062	4416	7482	4620	2303	3755	4346	6620	4255	4438
	I3	2980	5082	5240	8350	5413	2578	3957	5024	7576	4784	5098
	I4	3073	4646	5243	8680	5410	3463	4227	4860	7608	5040	5224
						Averages of the above						
	M1	7039	7670	7888	8907	7876	4819	6096	6058	7595	6142	7009
	M2	4427	5951	6152	8491	6256	4552	5419	5847	7713	5882	6069
	M3	6595	7772	8150	8891	7826	4894	6055	6289	7938	6294	6061
	M5	6746	7280	7827	8112	7491	5335	5916	6223	7505	6246	5858
	M6	2848	4597	4966	8171	5148	2782	3979	4743	7269	4692	4920
	I1	5497	6485	6711	8262	6739	4190	5289	5456	6923	5464	6102
	I3	5643	6974	6290	8668	7144	4564	5362	6105	7907	5984	6564
	I4	5399	6502	6989	8612	6875	4673	5829	5936	7982	6105	6490
M or I		5513	6654	6995	8514	6919	4476	5494	5832	7604	5851	6385
						Averages over clippings						
	M1	5929	6883	6973	8251	7009						
	M2	4489	5685	6000	8102	6069						
	M3	5694	6913	7219	8415	7061						
	M5	6040	6598	7026	7808	6868						
	M6	2820	4288	4855	7720	4920						
	I1	4844	5877	6083	7592	6101						
	I3	5104	6168	6697	8288	6564						
	I4	5036	6165	6462	8297	6490						
M or I		4994	6074	6414	8059	6385						

Note: Explanation of abbreviations and treatments on pages 31-35

Table 95. Average percent forage protein (N x 6.25) as influenced by the interaction of clipping frequency, nitrogen fertilization, irrigation interval, and mixture

		C1					C2					Ave
		F1	F2	F3	F4	Ave	F1	F2	F3	F4	Ave	C1 & C2
M1	I1	16.97	15.35	17.07	17.23	16.68	16.39	17.39	16.19	17.44	16.85	16.76
	I3	15.47	13.79	14.10	16.15	14.88	16.85	16.21	15.01	18.12	16.55	15.71
	I4	12.99	15.82	15.57	13.52	14.48	16.35	15.52	17.15	14.75	15.94	15.21
M2	I1	15.46	12.66	13.80	15.74	14.42	16.58	16.70	16.19	19.35	17.20	15.81
	I3	13.82	13.30	14.62	15.03	14.19	16.63	17.17	16.07	17.19	16.76	15.48
	I4	12.65	14.29	15.39	13.79	14.03	14.65	17.80	15.59	16.48	16.38	15.21
M3	I1	17.43	17.68	16.92	17.31	17.34	18.37	17.12	17.46	18.07	17.76	17.55
	I3	16.05	14.59	14.27	15.26	15.04	17.77	15.67	15.02	16.22	16.17	15.61
	I4	17.28	16.35	15.51	14.06	15.80	21.83	15.35	16.38	15.36	17.23	16.51
M5	I1	17.94	18.29	18.16	18.71	18.28	17.14	18.05	17.35	17.41	17.49	17.88
	I3	15.93	17.83	17.19	17.57	17.13	18.22	17.32	17.97	17.67	17.80	17.46
	I4	15.31	16.94	15.33	17.69	16.32	17.02	16.88	16.57	16.40	16.71	16.51
M6	I1	14.05	12.15	13.11	15.32	13.66	15.13	15.53	13.90	16.15	15.18	14.42
	I3	14.16	12.42	11.81	14.30	13.17	14.96	13.81	15.54	16.58	15.22	14.20
	I4	13.42	13.12	11.53	13.21	12.82	14.23	14.11	14.42	15.28	14.51	13.66
							Averages of the above					
M1		15.14	14.99	15.58	15.65	15.34	16.53	16.37	16.12	16.77	16.48	15.89
M2		13.98	13.42	14.60	14.85	14.21	15.95	17.22	16.28	17.67	16.78	15.50
M3		16.92	16.20	15.57	15.54	16.06	19.32	16.05	16.29	16.55	17.05	16.56
M5		16.39	17.69	16.89	17.99	17.24	17.46	17.42	17.30	17.16	17.33	17.29
M6		13.88	12.56	12.15	14.28	13.22	14.77	14.48	14.62	16.00	14.97	14.09
I1		16.38	15.23	15.81	16.87	16.07	16.72	16.96	16.22	17.68	16.90	16.49
I3		15.09	14.39	14.49	15.66	14.88	16.89	16.04	15.92	17.16	16.50	15.70
I4		14.33	15.30	14.69	14.45	14.69	16.82	15.93	16.22	15.65	16.16	15.70
M or I		15.26	14.97	14.96	15.66	15.21	16.81	16.31	16.12	16.83	16.52	15.87
							Average over clippings					
M1		15.84	15.68	15.85	16.21	15.89						
M2		14.96	15.32	15.44	16.26	15.50						
M3		18.12	16.13	15.93	16.05	16.56						
M5		16.93	17.55	17.10	17.58	17.29						
M6		14.32	13.52	13.39	15.14	14.09						
I1		16.55	16.09	16.02	17.28	16.49						
I3		15.99	15.21	16.20	16.41	15.70						
I4		15.57	15.62	15.44	15.05	15.43						
M or I		16.04	15.64	15.55	16.25	15.87						

Note: Explanation of abbreviations and treatments on pages 31-35

Table 96. Average yields in pounds per acre of forage protein (N x 6.25) as influenced by the interaction of clipping frequency, nitrogen fertilization, irrigation interval, and mixture

		C1					C2					Average
		F1	F2	F3	F4	Ave	F1	F2	F3	F4	Ave	C1 & C2
M1	I1	1254	1179	1350	1463	1312	777	1012	956	1268	1003	1158
	I3	1068	1088	1146	1492	1198	840	945	914	1414	1028	1113
	I4	886	1176	1185	1217	1116	774	1030	1060	1135	1000	1058
M2	I1	610	655	742	1262	817	606	735	808	1284	858	838
	I3	686	861	1007	1254	952	829	966	993	1401	1047	1000
	I4	553	886	954	1256	912	733	1110	1056	1378	1069	990
M3	I1	1206	1419	1374	1536	1384	946	1082	1053	1374	1114	1249
	I3	1077	1180	1228	1412	1224	924	839	970	1324	1014	1119
	I4	1011	1179	1198	1202	1158	744	997	1044	1237	1006	1078
M5	I1	1202	1368	1405	1583	1390	875	1110	1043	1128	1039	1215
	I3	1062	1309	1305	1432	1277	924	1045	1216	1386	1143	1210
	I4	1052	1189	1251	1366	1214	992	940	977	1344	1063	1138
M6	I1	354	494	578	1147	643	348	583	604	1069	651	647
	I3	422	631	619	1194	716	386	546	780	1257	742	729
	I4	412	610	604	1147	693	493	596	701	1162	738	716
						Averages of the above						
	M1	1069	1148	1227	1391	1209	797	996	977	1272	1010	1110
	M2	616	801	901	1257	894	723	937	952	1354	992	943
	M3	1098	1259	1267	1383	1252	871	973	1022	1312	1044	1149
	M5	1105	1289	1320	1460	1294	930	1032	1079	1286	1082	1188
	M6	396	578	600	1163	684	409	575	695	1163	710	697
	I1	925	1023	1090	1398	1109	710	904	893	1225	933	1021
	I3	863	1014	1061	1357	1074	781	868	975	1356	995	1034
	I4	783	1008	1038	1238	1017	747	935	968	1251	975	996
M or I		857	1015	1063	1331	1067	746	903	945	1277	968	1017
						Averages over clippings						
	M1	933	1072	1102	1332	1110						
	M2	670	869	927	1306	943						
	M3	984	1116	1144	1348	1149						
	M5	1018	1160	1200	1373	1188						
	M6	403	577	648	1163	697						
	I1	818	964	992	1312	1021						
	I3	822	941	1018	1356	1034						
	I4	765	972	1003	1244	996						
M or I		801	959	1004	1304	1017						

Note: Explanation of abbreviations and treatments on pages 31-35

Table 97. Average dry matter yields in pounds per acre of ladino clover roots as influenced by the interaction of clipping frequency, nitrogen fertilization, irrigation interval, and mixture

		C1					C2					Average
		F1	F2	F3	F4	Ave	F1	F2	F3	F4	Ave	C1 & C2
M1	I1	112	102	45	15	68	279	381	188	73	230	149
	I3	240	134	112	33	130	408	481	176	103	280	205
	I4	295	478	307	38	280	280	808	644	19	438	359
M2	I1	172	375	123	10	170	361	606	301	109	344	257
	I3	534	453	53	47	272	545	608	278	93	381	326
	I4	204	607	364	13	297	392	466	446	65	342	320
					Averages for the above							
	M1	216	238	155	29	159	322	540	336	65	316	238
	M2	303	478	180	23	247	433	560	342	89	356	302
	I1	142	238	84	12	119	320	494	244	91	287	203
	I3	387	294	82	40	201	476	520	227	98	330	266
	I4	250	542	336	26	288	336	637	545	42	390	340
M or I		260	358	167	26	203	377	550	339	77	336	270
					Averages over clippings							
	M1	269	389	246	47	238						
	M2	368	519	261	56	302						
	I1	231	366	164	52	203						
	I3	432	407	154	69	266						
	I4	293	590	440	34	340						
M or I		318	454	253	52	270						

Note: Explanation of abbreviations and treatments on pages 31-35

Table 98. Average dry matter yields in pounds per acre of alfalfa roots as influenced by the interaction of clipping frequency, nitrogen fertilization, irrigation intervals, and mixture

		C1					C2					Average
		F1	F2	F3	F4	Ave	F1	F2	F3	F4	Ave	C1 & C2
M1	I1	2195	2598	2322	1495	2152	994	1251	1445	527	1054	1603
	I3	1802	2397	1367	1142	1677	641	574	396	121	433	1055
	I4	1455	1778	1982	524	1435	400	231	356	103	272	854
M3	I1	3198	3046	2205	1750	2550	2262	2407	1898	608	1794	2172
	I3	2286	2760	2264	752	2016	1372	1899	1087	178	1134	1575
	I4	2506	2338	1948	453	1811	1279	1062	1212	128	920	1366
M5	I1	3536	3068	3339	2212	3039	2140	2411	2246	1199	1999	2519
	I3	2760	3004	2310	1772	2461	1711	1916	1254	578	1365	1913
	I4	2182	2436	3124	1769	2378	1707	1290	1651	578	1331	1855
						Averages of the above						
	M1	1817	2258	1890	1054	1755	678	685	732	250	587	1172
	M3	2663	2715	2139	985	2126	1638	1789	1399	305	1283	1704
	M5	2826	2836	2924	1918	2626	1853	1906	1717	785	1565	2096
	I1	2976	2904	2622	1819	2580	1799	2023	1863	778	1616	2098
	I3	2283	2720	1980	1222	2051	1241	1463	912	292	977	1514
	I4	2048	2184	2351	915	1875	1129	894	1073	270	841	1358
M or I		2436	2603	2318	1319	2169	1390	1460	1283	447	1145	1657
						Averages over clippings						
	M1	1248	1472	1311	652	1172						
	M3	2150	2252	1769	645	1704						
	M5	2340	2371	2320	1352	2096						
	I1	2388	2464	2242	1298	2098						
	I3	1762	2092	1446	757	1514						
	I4	1588	1539	1712	592	1358						
M or I		1913	2032	1800	888	1657						

Note: Explanation of abbreviations and treatments on pages 31-35

Table 99. Average dry matter yields in pounds per acre of legume roots as influenced by the interaction of clipping frequency, nitrogen fertilization, irrigation interval, and mixture

		C1					C2					Average
		F1	F2	F3	F4	Ave	F1	F2	F3	F4	Ave	C1 & C2
M1	I1	2307	2700	2367	1510	2221	1273	1632	1632	600	1284	1753
	I3	2030	2531	1479	1175	1806	1049	1006	572	224	713	1260
	I4	1750	2256	2289	562	1714	680	1039	1000	122	710	1212
M2	I1	172	375	123	10	170	361	606	301	109	344	257
	I3	534	453	53	47	272	545	608	278	93	381	326
	I4	204	607	364	13	297	392	466	446	65	342	320
M3	I1	3198	3046	2205	1750	2550	2267	2407	1898	608	1794	2172
	I3	2286	2760	2264	752	2016	1372	1899	1087	178	1134	1575
	I4	2506	2338	1948	453	1811	1279	1062	1212	128	920	1366
M5	I1	3536	3068	3339	2212	3039	2140	2411	2246	1199	1999	2519
	I3	2760	3004	2310	1772	2461	1711	1916	1254	578	1365	1913
	I4	2182	2436	3124	1769	2378	1707	1390	1651	578	1331	1855
						Averages of the above						
	M1	2030	2496	2045	1082	1914	1001	1226	1068	315	902	1408
	M2	303	478	180	23	247	433	560	342	89	356	302
	M3	2663	2715	2139	985	2126	1638	1789	1399	305	1283	1704
	M5	2826	2836	2924	1918	2626	1853	1906	1717	785	1565	2096
	I1	2303	2297	2008	1370	1995	1509	1764	1519	629	1355	1675
	I3	1903	2187	1526	936	1639	1169	1357	798	268	898	1268
	I4	1660	1909	1931	699	1550	1014	989	1077	223	826	1188
M or I		1955	2131	1822	1002	1728	1231	1370	1131	373	1026	1377
						Averages over clippings						
	M1	1515	1860	1556	698	1408						
	M2	368	519	261	56	302						
	M3	2150	2252	1769	645	1704						
	M5	2340	2371	2320	1352	2096						
	I1	1906	2036	1764	1000	1675						
	I3	1538	1772	1162	602	1268						
	I4	1337	1449	1504	461	1188						
M or I		1594	1750	1476	688	1377						

Note: Explanation of abbreviations and treatments on pages 31-35

Table 100. Average dry matter yields in pounds per acre of grass roots as influenced by the interaction of clipping frequency, nitrogen fertilization, irrigation interval, and mixture

		C1					C2					Average
		F1	F2	F3	F4	Ave	F1	F2	F3	F4	Ave	C1 & C2
M1	I1	4297	5005	4664	5275	4810	4119	6541	4764	4436	4965	4888
	I3	3808	4654	4620	5553	4659	4002	5637	3849	4623	4528	4594
	I4	4116	5708	4023	5871	4929	3878	5554	4841	5308	4895	4912
M2	I1	4334	7269	6092	6986	6170	3981	5990	4508	5987	5116	5643
	I3	4116	5959	4728	5342	5036	3289	6273	3754	5100	4604	4820
	I4	4916	6825	5010	5912	5666	4925	6760	4903	5446	5481	5573
M3	I1	4028	6609	4259	6568	5366	4162	6530	5359	5546	5354	5360
	I3	3924	5195	4811	5027	4739	3894	6552	4292	5358	5024	4882
	I4	4350	5796	4755	6436	5334	4069	5070	5586	5552	5069	5202
M5	I1	3846	4558	3741	6508	4663	4754	5910	4676	6800	5535	5099
	I3	2969	4716	3798	4168	3913	4245	4842	4162	6061	4827	4370
	I4	3852	4056	2989	4150	3762	4539	6244	4899	7109	5698	4730
M6	I1	5190	6510	6211	6463	6094	5046	7614	4824	6135	5905	6000
	I3	4625	6607	4960	5471	5416	4971	7886	4122	4946	5481	5449
	I4	5306	6507	5934	6187	5984	4685	7412	5246	5348	5673	5829
						Averages of the above						
	M1	4074	5122	4436	5566	4799	4000	5911	4485	4789	4796	4798
	M2	4455	6684	5277	6080	5624	4065	6341	4388	5474	5067	5345
	M3	4101	5867	4608	6010	5146	4042	5991	5079	5485	5149	5148
	M5	3556	4443	3509	4942	4113	4513	5665	4579	6657	5353	4733
	M6	5040	6541	5702	6040	5831	4901	7637	4731	5476	5686	5759
	I1	4339	5990	4993	6360	5421	4412	6481	4826	5781	5375	5398
	I3	3888	5426	4583	5112	4753	4080	6238	4086	5218	4893	4823
	I4	4508	5778	4542	5711	5135	4419	6208	5075	5731	5363	5249
M or I		4245	5732	4706	5728	5103	4304	6309	4652	5577	5210	5157
						Averages over clippings						
	M1	4037	5516	4460	5178	4798						
	M2	4260	6512	4833	5777	5345						
	M3	4072	5929	4844	5748	5148						
	M5	4034	5054	4044	5800	4733						
	M6	4970	7089	5216	5758	5759						
	I1	4376	6236	4910	6070	5398						
	I3	3984	5832	4310	5165	4823						
	I4	4464	5993	4818	5741	5249						
M or I		4275	6020	4679	5652	5157						

Note: Explanation of abbreviations and treatments on pages 31-35

Table 101. Average dry matter yields in pounds per acre of total roots (grasses and legumes) as influenced by the interaction of clipping frequency, nitrogen fertilization, irrigation interval, and mixture

		C1					C2					Average
		F1	F2	F3	F4	Ave	F1	F2	F3	F4	Ave	C1 & C2
M1	I1	6604	7555	7032	6785	6994	5392	8173	6396	5036	6249	6622
	I3	5838	7185	6099	6728	6463	5051	6643	4421	4847	5240	5852
	I4	5866	7964	6312	6432	6644	4559	6593	5841	5430	5606	6125
M2	I1	4506	7644	6215	6996	6340	4342	6596	4809	6096	5461	5900
	I3	4649	6412	4781	5388	5308	3834	6881	4032	5193	4985	5146
	I4	5120	7432	5373	5925	5963	5317	7226	5348	5402	5823	5893
M3	I1	7226	9655	6464	8317	7916	6424	8758	7257	6154	7148	7532
	I3	6210	7954	7074	5779	6755	5267	8451	5379	5535	6158	6456
	I4	6855	8134	6704	6890	7146	5348	6131	6798	5680	5989	6568
M5	I1	7382	7626	7080	8720	7702	6894	8321	6922	7999	7534	7618
	I3	5729	7720	6108	5940	6374	5956	6758	5416	6639	6192	6283
	I4	6034	6492	6112	5919	6140	6246	7634	6550	7688	7029	6584
M6	I1	5190	6510	6211	6463	6094	5046	7614	4824	6135	5905	6000
	I3	4625	6607	4960	5471	5416	4971	7886	4122	4946	5481	5449
	I4	5306	6507	5934	6187	5984	4685	7412	5246	5348	5673	5828
		Averages of the above										
	M1	6103	7568	6481	6649	6700	5001	7136	5553	5104	5699	6199
	M2	4758	7163	5456	6103	5870	4498	6901	4730	5564	5423	5647
	M3	6764	8581	6747	6995	7272	5680	7780	6478	5790	6432	6852
	M5	6382	7279	6434	6860	6739	6366	7571	6296	7442	6919	6829
	M6	5040	6541	5702	6040	5831	4901	7637	4731	5476	5686	5759
	I1	6182	7798	6600	7456	7009	5620	7892	6042	6284	6459	6734
	I3	5410	7176	5805	5861	6063	5016	7324	4674	5432	5612	5837
	I4	5836	7306	6087	6271	6375	5231	6999	5957	5909	6024	6200
M or I		5810	7427	6164	6530	6482	5289	7405	5557	5875	6032	6257
		Averages over clippings										
	M1	5552	7352	6017	5876	6199						
	M2	4628	7032	5093	5833	5647						
	M3	6222	8181	6613	6393	6852						
	M5	6373	7425	6365	7151	6829						
	M6	4971	7089	5216	5758	5759						
	I1	5901	7845	6321	6870	6734						
	I3	5213	7250	5239	5647	5837						
	I4	5534	7152	6022	6090	6200						
M or I		5549	7416	5861	6202	6257						

Note: Explanation of abbreviations and treatments on pages 31-35

Table 102. Average percent available carbohydrate on ladino roots as influenced by the interaction of clipping frequency, nitrogen fertilization, irrigation interval and mixture

	C1					C2					Ave
	F1	F2	F3	F4	Ave	F1	F2	F3	F4	Ave	C1 & C2
M1 I1	18.91	23.55	13.73	23.73	19.98	16.73	14.18	20.23	15.45	16.65	18.31
I3	22.27	19.82	21.50	30.23	23.46	17.73	14.59	17.50	27.36	19.30	21.38
I4	19.82	13.58	17.49	19.64	17.63	24.68	16.00	16.44	28.83	21.49	19.56
M2 I1	14.29	13.39	15.35	10.23	13.29	13.32	13.58	16.82	13.58	14.32	13.81
I3	16.44	14.06	14.99	17.67	15.79	12.87	13.32	11.98	14.40	13.14	14.47
I4	13.50	12.09	11.98	15.29	13.22	11.61	11.12	13.47	23.44	14.91	14.06
Averages of the above											
M1	20.33	18.98	17.57	24.53	20.36	19.71	14.92	18.06	23.88	19.14	19.75
M2	14.74	13.18	14.07	14.40	14.10	12.60	12.67	14.09	17.14	14.12	14.11
I1	16.60	18.47	14.49	16.98	16.64	15.02	13.88	18.52	14.52	15.49	16.06
I3	19.36	16.94	18.24	23.95	19.62	15.30	13.96	14.74	20.88	16.22	17.92
I4	16.66	12.84	14.74	17.46	15.42	18.14	13.56	14.96	26.14	18.20	16.81
M or I	17.54	16.08	15.82	19.46	17.23	16.16	13.80	16.07	20.51	16.63	16.93
Averages over clippings											
M1	20.02	16.95	17.82	24.21	19.75						
M2	13.67	12.93	14.08	15.77	14.11						
I1	15.81	16.18	16.51	15.75	16.06						
I3	17.33	15.45	16.49	22.42	17.92						
I4	17.40	13.20	14.84	21.80	16.81						
M or I	16.85	14.94	15.95	19.99	16.93						

Note: Explanation of abbreviations and treatments on pages 31-35

Table 103. Average percent available carbohydrate in alfalfa roots as influenced by the interaction of clipping frequency, nitrogen fertilization, irrigation interval, and mixture

		C1					C2					Ave
		F1	F2	F3	F4	Ave	F1	F2	F3	F4	Ave	C1 &C2
M1	I1	16.02	16.68	16.28	15.22	16.05	17.22	17.30	16.45	16.09	16.76	16.41
	I3	16.33	18.41	16.81	15.58	16.78	16.53	14.58	16.85	15.50	15.86	16.32
	I4	14.70	19.43	16.77	17.17	17.04	15.50	17.65	17.15	17.75	17.01	17.03
M3	I1	18.20	16.69	14.73	15.94	16.39	20.25	17.37	15.11	16.09	17.20	16.80
	I3	18.62	17.52	17.03	15.90	17.27	20.39	17.45	18.05	17.07	18.24	17.75
	I4	19.23	16.26	14.06	15.45	16.25	14.69	16.34	14.69	20.28	16.50	16.38
M5	I1	13.46	14.83	15.35	15.70	14.84	15.73	13.11	15.38	15.45	14.92	14.88
	I3	13.99	15.49	19.09	15.87	16.11	14.06	14.97	16.35	17.78	15.79	15.95
	I4	16.17	11.90	16.17	15.87	15.03	17.96	16.50	20.17	15.34	17.49	16.26
						Averages of the above						
	M1	15.68	18.20	16.62	15.99	16.62	16.42	16.51	16.82	16.45	16.55	16.58
	M3	18.68	16.82	15.27	15.76	16.64	18.44	17.05	15.95	17.81	17.32	16.98
	M5	14.54	14.07	16.87	15.81	15.32	15.92	14.86	17.30	16.19	16.07	15.70
	I1	15.89	16.07	15.45	15.62	15.76	17.73	15.93	15.65	15.88	16.30	16.03
	I3	16.31	17.14	17.64	15.78	16.72	16.99	15.67	17.08	16.78	16.63	16.67
	I4	16.70	15.89	15.67	16.16	16.11	16.05	16.83	17.34	17.79	17.00	16.55
M or I		16.30	16.37	16.25	15.86	16.20	16.93	16.14	16.69	16.82	16.64	16.42
					Averages over clippings							
	M1	16.05	17.36	16.72	16.22	16.58						
	M3	18.56	16.94	15.61	16.79	16.98						
	M5	15.23	14.47	17.08	16.00	15.70						
	I1	16.81	16.00	15.55	15.75	16.03						
	I3	16.65	16.40	17.36	16.28	16.67						
	I4	16.38	16.36	16.50	16.98	16.55						
M or I		16.61	16.25	16.47	16.34	16.42						

Note: Explanation of abbreviations and treatments on pages 31-35

Table 104. Average percent available carbohydrate in grass roots as influenced by the interaction of clipping frequency, nitrogen fertilization, irrigation interval, and mixture

		C1					C2					Ave
		F1	F2	F3	F4	Ave	F1	F2	F3	F4	Ave	C1 & C2
M1	I1	19.33	12.30	15.37	14.68	15.42	13.47	16.29	23.90	20.18	18.46	16.94
	I3	22.20	18.97	24.46	15.37	20.25	24.40	18.31	23.54	28.55	23.70	21.98
	I4	12.46	13.57	14.65	17.27	14.49	13.24	11.41	17.43	24.26	16.58	15.54
M2	I1	13.46	13.94	15.20	11.65	13.56	11.65	12.56	13.23	13.46	12.72	13.14
	I3	14.72	13.70	13.58	14.37	14.09	12.80	8.90	15.51	12.68	12.47	13.28
	I4	15.55	13.13	14.92	14.57	14.54	12.24	13.03	15.75	18.11	14.78	14.66
M3	I1	14.09	10.26	13.28	10.95	12.14	13.79	9.14	13.79	11.64	12.09	12.12
	I3	15.56	12.50	12.46	16.98	14.38	14.91	11.98	10.26	21.47	14.66	14.52
	I4	17.24	18.79	16.77	17.24	17.51	20.14	18.28	16.72	18.53	18.39	17.95
M5	I1	17.24	15.99	15.20	16.07	16.12	15.52	15.84	14.75	13.89	15.00	15.56
	I3	14.64	18.81	18.73	24.77	19.24	15.77	17.72	16.82	19.52	17.46	18.35
	I4	16.52	15.54	16.48	14.62	15.79	22.15	18.21	16.08	21.80	19.56	17.68
M6	I1	16.25	15.05	16.50	15.50	15.82	16.02	15.38	19.70	17.98	17.27	16.55
	I3	16.02	12.72	15.66	15.24	14.91	21.25	15.54	18.12	19.62	18.63	16.77
	I4	13.08	16.74	18.31	16.78	16.23	17.95	11.81	17.33	22.56	17.41	16.82
						Averages of the above						
	M1	18.00	14.95	18.16	15.77	16.72	17.04	15.34	21.62	24.33	19.58	18.15
	M2	14.64	13.59	14.57	13.53	14.06	12.23	11.50	14.83	14.75	13.32	13.69
	M3	15.63	13.85	14.17	15.06	14.68	16.25	13.13	13.59	17.21	15.05	14.86
	M5	16.13	16.78	16.80	18.49	17.05	17.81	17.26	15.88	18.40	17.34	17.20
	M6	15.12	14.84	16.82	15.84	15.65	18.41	14.24	18.38	20.05	17.77	16.71
	I1	16.07	13.51	15.11	13.77	14.67	14.09	13.84	17.07	15.43	15.11	14.86
	I3	16.67	15.34	16.98	17.35	16.57	17.83	14.49	16.85	20.37	17.38	16.98
	I4	14.97	15.55	16.23	16.10	15.71	17.12	14.55	16.66	21.05	17.34	16.53
M or I		15.90	14.80	16.10	15.74	15.63	16.35	14.29	16.86	18.95	16.61	16.12
						Averages over clippings						
	M1	17.52	15.14	19.89	20.05	18.15						
	M2	13.44	12.54	14.70	14.14	13.69						
	M3	15.94	13.48	13.88	16.14	14.86						
	M5	16.97	17.02	16.34	18.44	17.20						
	M6	16.76	14.54	17.60	17.95	16.71						
	I1	15.08	13.68	16.09	14.60	14.86						
	I3	17.25	14.92	16.91	18.86	16.98						
	I4	16.05	15.05	16.44	18.57	16.53						
M or I		16.12	14.55	16.48	17.34	16.12						

Note: Explanation of abbreviations and treatments on pages 31-35

Table 105. Average percent available carbohydrate in all roots as influenced by the interaction of clipping frequency, nitrogen fertilization, irrigation interval, and mixture

		C1					C2					Ave
		F1	F2	F3	F4	Ave	F1	F2	F3	F4	Ave	C1 &C2
M1	I1	18.63	13.76	15.66	14.81	15.72	14.34	16.35	22.11	19.70	18.12	16.92
	I3	20.41	18.79	22.69	15.47	19.34	22.87	17.75	22.71	28.18	22.88	21.11
	I4	13.38	14.90	15.46	17.27	15.25	14.13	12.19	17.29	24.16	16.94	16.10
M2	I1	13.49	13.92	15.19	11.65	13.56	11.79	12.66	13.47	13.45	12.84	13.20
	I3	14.93	13.72	13.60	14.40	14.16	12.81	9.30	15.28	12.71	12.52	13.34
	I4	15.47	13.05	14.72	14.58	14.46	12.21	12.91	15.56	18.18	14.72	14.58
M3	I1	15.91	12.28	13.77	12.00	13.49	16.06	11.40	14.14	12.07	13.42	13.45
	I3	16.68	14.24	13.92	16.85	15.42	16.06	13.21	11.84	21.34	15.61	15.52
	I4	17.97	19.06	15.98	17.13	17.54	18.75	17.94	16.36	18.57	17.90	17.72
M5	I1	15.43	15.53	15.28	15.97	15.55	15.58	15.05	14.85	14.13	14.91	15.23
	I3	14.33	17.51	18.86	22.12	18.20	15.28	16.94	16.71	19.37	17.08	17.64
	I4	16.39	14.17	17.78	15.00	15.84	21.01	17.89	17.10	21.32	19.33	17.58
M6	I1	16.25	15.05	16.50	15.50	15.82	16.02	15.38	19.70	17.98	17.27	16.55
	I3	16.02	12.72	15.66	15.24	14.91	21.25	15.54	18.12	19.62	18.63	16.77
	I4	13.08	16.74	18.31	16.78	16.23	17.95	11.81	17.33	22.56	17.41	16.82
						Averages of the above						
	M1	17.47	15.82	17.94	15.85	16.77	17.11	15.43	20.70	24.01	19.31	18.04
	M2	14.63	13.56	14.50	13.54	14.06	12.27	11.62	14.77	14.78	13.36	13.71
	M3	16.85	15.19	14.56	15.33	15.48	16.96	14.18	14.11	17.33	15.64	15.56
	M5	15.38	15.74	17.31	17.70	16.53	17.29	16.63	16.22	18.27	17.10	16.82
	M6	15.12	14.84	16.82	15.84	15.65	18.41	14.24	18.38	20.05	17.77	16.73
	I1	15.94	14.11	15.28	13.99	14.83	14.76	14.17	16.86	15.47	15.32	15.08
	I3	16.47	15.40	16.95	16.82	16.41	17.65	14.55	16.93	20.24	17.34	16.88
	I4	15.26	15.58	16.45	16.15	15.86	16.81	14.55	16.73	20.96	17.26	16.56
M or I		15.89	15.03	16.23	15.65	15.71	16.41	14.42	16.84	18.89	16.64	16.17
						Averages over clippings						
	M1	17.29	15.62	19.32	19.93	18.04						
	M2	13.45	12.59	14.64	14.16	13.71						
	M3	16.90	14.69	14.34	16.33	15.56						
	M5	16.34	16.18	16.78	17.98	16.82						
	M6	16.76	14.54	17.60	17.95	16.73						
	I1	15.35	14.14	16.07	14.73	15.08						
	I3	17.06	14.97	16.94	18.53	16.88						
	I4	16.03	15.03	16.59	18.56	16.56						
M or I		16.15	14.73	16.54	17.27	16.17						

Note: Explanation of abbreviations and treatments on pages 31-35

Table 106. Average pounds TAC per acre in ladino roots as influenced by the interaction of clipping frequency, nitrogen fertilization, irrigation interval, and mixture

		C1					C2					Average
		F1	F2	F3	F4	Ave	F1	F2	F3	F4	Ave	C1 & C2
M1	I1	21	24	65	3	14	46	54	38	12	38	26
	I3	54	26	24	10	28	72	63	31	28	48	38
	I4	58	65	54	7	46	69	130	106	6	78	62
M2	I1	24	50	18	1	24	48	83	51	15	49	36
	I3	88	64	78	8	42	70	81	34	14	50	46
	I4	28	74	44	2	37	46	52	60	15	43	40
					Averages of the above							
	M1	44	38	28	7	29	63	82	58	15	55	42
	M2	47	62	23	4	34	55	72	48	14	47	41
	I1	23	37	12	2	19	47	68	44	13	43	31
	I3	71	45	16	9	35	71	72	32	21	49	42
	I4	43	69	49	5	41	58	91	83	10	60	51
M or I		45	50	26	5	32	59	77	53	15	51	41
					Averages over clippings							
	M1	54	60	43	11	42						
	M2	51	67	38	9	41						
	I1	35	53	28	8	31						
	I3	71	58	24	15	42						
	I4	50	80	66	8	51						
M or I		52	64	39	10	41						

Note: Explanation of abbreviations and treatments on pages 31-35

Table 107. Average pounds TAC per acre in alfalfa roots as influenced by the interaction of clipping frequency, nitrogen fertilization, irrigation interval, and mixture

		C1					C2					Average
		F1	F2	F3	F4	Ave	F1	F2	F3	F4	Ave	C1 & C2
M1	I1	352	433	378	228	348	172	216	238	86	177	263
	I3	296	441	230	178	286	106	84	67	19	69	178
	I4	214	347	332	90	246	62	40	61	18	45	146
M3	I1	582	508	325	279	424	458	418	287	98	315	369
	I3	426	484	386	120	354	280	332	196	30	210	282
	I4	482	380	274	70	301	188	173	178	26	141	221
M5	I1	476	455	513	347	448	337	316	346	185	296	372
	I3	386	465	441	281	393	240	287	205	103	209	301
	I4	353	290	594	281	379	306	230	333	89	239	309
						Averages of the above						
	M1	287	407	313	165	293	113	114	122	41	97	195
	M3	497	457	328	156	360	309	308	220	51	222	291
	M5	405	403	516	303	407	295	278	294	126	248	327
	I1	470	466	405	285	406	322	317	290	123	263	335
	I3	369	463	352	193	344	209	234	156	51	162	253
	I4	350	339	400	147	309	185	148	190	44	142	225
M or I		396	423	386	208	353	239	233	212	73	189	271
						Averages over clippings						
	M1	200	260	218	103	195						
	M3	403	382	274	104	291						
	M5	350	340	405	214	327						
	I1	396	391	348	204	335						
	I3	289	349	254	122	253						
	I4	267	243	295	96	225						
M or I		318	328	299	140	271						

Note: Explanation of abbreviations and treatments on pages 31-35

Table 108. Average pounds TAC per acre in grass roots as influenced by the interaction of clipping frequency, nitrogen fertilization, irrigation interval, and mixture

		C1					C2					Average
		F1	F2	F3	F4	Ave	F1	F2	F3	F4	Ave	C1 & C2
M1	I1	857	616	717	774	741	555	1066	1139	895	914	827
	I3	845	883	1130	854	928	977	1032	906	1320	1059	993
	I4	513	774	590	1014	723	514	634	844	1288	820	771
M2	I1	583	1013	926	814	834	464	752	597	806	655	744
	I3	606	816	642	768	708	421	558	582	647	552	630
	I4	764	896	747	862	817	603	881	772	966	806	811
M3	I1	568	678	566	719	633	574	506	739	646	616	624
	I3	611	650	600	854	678	566	785	440	1150	735	707
	I4	750	1089	797	1110	937	815	927	934	1029	926	931
M5	I1	663	728	569	1046	752	738	936	690	944	827	789
	I3	435	887	712	1032	766	670	858	700	1183	853	810
	I4	636	630	492	607	592	1006	1137	788	1550	1120	856
M6	I1	844	980	1025	1002	962	808	1171	950	1103	1008	985
	I3	741	840	777	834	798	1056	1226	747	970	1000	899
	I4	694	1089	1086	1038	977	841	875	909	1206	958	968
						Averages of the above						
	M1	738	758	812	881	797	682	910	963	1168	931	864
	M2	651	909	772	814	786	496	731	650	806	671	729
	M3	643	806	654	894	749	652	739	704	942	759	754
	M5	578	749	591	895	703	804	977	726	1226	933	818
	M6	760	970	963	958	912	902	1090	869	1093	989	951
	I1	703	803	760	871	784	628	886	823	879	804	794
	I3	648	815	772	868	776	738	892	675	1054	840	808
	I4	672	896	743	926	809	756	891	849	1208	926	867
M or I		674	838	758	888	790	707	890	782	1047	857	823
						Averages over clippings						
	M1	710	834	888	1024	864						
	M2	574	820	711	810	729						
	M3	647	772	679	918	754						
	M5	691	863	658	1060	818						
	M6	831	1030	916	1026	951						
	I1	665	845	792	875	794						
	I3	693	854	724	961	808						
	I4	714	893	796	1067	867						
M or I		691	864	770	968	823						

Note: Explanation of abbreviations and treatments on pages 31-35

Table 109. Average pounds TAC per acre in all roots as influenced by the interaction of clipping frequency, nitrogen fertilization, irrigation interval, and mixture

		C1					C2					Average
		F1	F2	F3	F4	Ave	F1	F2	F3	F4	Ave	C1 & C2
M1	I1	1230	1060	1101	1005	1099	773	1336	1414	992	1129	1114
	I3	1194	1350	1384	1041	1242	1155	1179	1004	1366	1176	1209
	I4	785	1187	976	1111	1014	644	804	1010	1312	943	979
M2	I1	608	1064	944	815	858	512	835	648	820	704	781
	I3	694	880	650	776	750	491	640	616	660	602	676
	I4	792	970	791	864	854	649	933	832	982	849	852
M3	I1	1150	1186	890	998	1056	1032	998	1026	743	950	1003
	I3	1036	1133	985	974	1032	846	1116	637	1181	945	988
	I4	1232	1469	1071	1180	1238	1003	1100	1112	1055	1068	1153
M5	I1	1139	1184	1082	1393	1199	1074	1252	1035	1130	1123	1161
	I3	821	1352	1152	1314	1160	910	1145	905	1286	1062	1111
	I4	989	920	1087	888	971	1312	1366	1120	1639	1359	1165
M6	I1	844	980	1025	1002	962	808	1171	950	1103	1008	985
	I3	741	840	777	834	798	1056	1226	747	970	1000	899
	I4	694	1089	1086	1038	977	841	875	909	1206	958	968
						Averages of the above						
	M1	1070	1199	1154	1052	1119	857	1106	1143	1224	1083	1101
	M2	698	971	795	818	821	550	803	698	821	718	770
	M3	1139	1263	982	1050	1109	960	1072	925	993	987	1048
	M5	983	1152	1107	1198	1110	1099	1255	1020	1352	1181	1146
	M6	760	970	963	958	912	902	1091	869	1093	989	951
	I1	994	1095	1008	1043	1035	840	1119	1015	958	983	1009
	I3	897	1111	990	988	996	892	1061	782	1093	957	977
	I4	898	1127	1002	1016	1011	890	1016	997	1239	1035	1023
M or I		930	1111	1000	1015	1014	874	1065	931	1096	992	1003
						Averages over clippings						
	M1	964	1153	1148	1138	1101						
	M2	624	887	747	820	770						
	M3	1050	1167	954	1022	1048						
	M5	1041	1203	1064	1275	1146						
	M6	831	1030	916	1026	951						
	I1	917	1107	1012	1000	1009						
	I3	894	1086	886	1040	977						
	I4	894	1071	999	1127	1023						
M or I		902	1088	966	1056	1003						

Note: Explanation of abbreviations and treatments on pages 31-35

Table 110. Average root to forage (R/F) ratio as influenced by the interaction of clipping frequency, nitrogen fertilization, irrigation interval, and mixture

		C1					C2					Ave
		F1	F2	F3	F4	Ave	F1	F2	F3	F4	Ave	C1&C2
M1	I1	0.93	1.00	0.89	0.83	0.91	1.19	1.46	1.12	0.69	1.11	1.01
	I3	0.87	0.95	0.80	0.73	0.84	1.07	1.18	0.76	0.62	0.91	0.87
	I4	0.90	1.10	0.83	0.72	0.89	0.97	1.04	0.96	0.71	0.92	0.90
M2	I1	1.56	1.59	1.15	0.88	1.29	1.47	1.49	1.02	0.92	1.23	1.26
	I3	0.98	1.09	0.70	0.65	0.86	0.85	1.26	0.66	0.64	0.85	0.85
	I4	1.24	1.24	0.91	0.65	1.01	1.17	1.16	0.86	0.65	0.96	0.99
M3	I1	1.05	1.21	0.80	0.95	1.00	1.36	1.47	1.23	0.81	1.22	1.11
	I3	0.96	1.03	0.84	0.63	0.86	1.06	1.61	0.88	0.68	1.06	0.96
	I4	1.17	1.13	0.88	0.81	1.00	1.28	0.97	1.09	0.71	1.01	1.00
M5	I1	1.11	1.03	0.92	1.04	1.03	1.39	1.40	1.19	1.25	1.31	1.17
	I3	0.89	1.10	0.84	0.76	0.90	1.18	1.23	0.83	0.86	1.02	0.96
	I4	0.89	0.93	0.75	0.76	0.83	1.12	1.43	1.11	0.94	1.15	0.99
M6	I1	2.60	1.63	1.42	0.87	1.63	2.56	2.20	1.11	0.92	1.70	1.66
	I3	1.75	1.36	0.98	0.66	1.19	2.18	2.04	0.86	0.65	1.44	1.31
	I4	2.25	1.45	1.19	0.71	1.40	1.50	1.77	1.09	0.70	1.27	1.33
					Averages of the above							
	M1	0.90	1.02	0.84	0.76	0.88	1.08	1.23	0.94	0.67	0.98	0.93
	M2	1.26	1.31	0.92	0.73	1.05	1.16	1.30	0.85	0.74	1.01	1.03
	M3	1.06	1.12	0.84	0.80	0.95	1.23	1.35	1.06	0.73	1.10	1.02
	M5	0.97	1.02	0.84	0.85	0.92	1.23	1.35	1.04	1.02	1.16	1.04
	M6	2.20	1.48	1.19	0.75	1.41	2.08	2.00	1.02	0.76	1.47	1.44
	I1	1.45	1.29	1.04	0.91	1.17	1.59	1.60	1.13	0.92	1.31	1.24
	I3	1.09	1.10	0.83	0.69	0.93	1.27	1.46	0.80	0.69	1.06	0.99
	I4	1.29	1.17	0.91	0.73	1.03	1.21	1.27	1.02	0.74	1.06	1.04
M or I		1.28	1.19	0.93	0.78	1.04	1.36	1.45	0.98	0.78	1.14	1.09
					Averages over clippings							
	M1	0.99	1.12	0.89	0.72	0.93						
	M2	1.21	1.31	0.89	0.73	1.03						
	M3	1.15	1.24	0.95	0.76	1.02						
	M5	1.10	1.18	0.94	0.94	1.04						
	M6	2.14	1.74	1.11	0.75	1.44						
	I1	1.52	1.45	1.09	0.92	1.24						
	I3	1.18	1.28	0.81	0.69	0.99						
	I4	1.25	1.22	0.97	0.74	1.04						
M or I		1.32	1.32	0.96	0.78	1.09						

Note: Explanation of abbreviations and treatments on pages 31-35

Appendix C

Analysis of Variance Tables

Table 111. Analysis of variance of dry matter yields of total forage, 1964

Source of variation	DF	Mean square	F value
Replication	3	36325380	
Irrigation	2	9877256	
Error	6	8873079	
Clipping	1	136865300	48.15 **
Clipping x irrigation	2	2792103	
Error	9	2842304	
Fertilization	3	193369700	70.32 **
Fertilization x irrigation	6	755021	
Fertilization x clipping	3	436056	
Fertilization x irr. x clip.	6	601301	
Error	54	2749690	
Mixture	4	79748480	165.04 **
Mixture x irrigation	8	3260859	6.75 **
Mixture x clipping	4	9300156	19.25 **
Mixture x irr. x clip.	8	443594	
Mixture x fertilization	12	6806662	14.09 **
Mixture x irr. x fert.	24	376656	
Mixture x clip. x fert.	12	1077787	2.23 *
Mix. x irr. x clip. x fert.	24	428617	
Error	288	483201	

* Significant at 0.05
** Significant at 0.01
All other F values nonsignificant

Table 112. Analysis of variance of percent forage protein, 1964

Source of variation	DF	Mean square	F value
Irrigation	2	7.066	
Clipping	1	17.580	
Clipping x irrigation	2	5.316	
Fertilization	3	0.258	
Fertilization x irrigation	6	4.363	
Fertilization x clipping	3	2.574	
Fertilization x irr. x clip.	6	6.063	
Mixture	4	32.186	5.48 **
Mixture x irrigation	8	5.311	
Mixture x clipping	4	16.301	
Mixture x irr. x clip.	8	3.096	
Mixture x fertilization	12	4.076	
Mixture x irr. x fert.	24	6.500	
Mixture x clip. x fert.	12	2.312	
Mixture x irr. x clip. x fert. (Error)	24	5.875	

** Significant at 0.01
All other F values nonsignificant

Table 113. Analysis of variance of forage protein production, 1964

Source of variation	DF	Mean square	F value
Replication	3	856885	
Irrigation	2	159300	
Error	6	302253	
Clipping	1	1836327	17.35 **
Clipping x irrigation	2	499254	
Error	9	105868	
Fertilization	3	6517720	45.04 **
Fertilization x irrigation	6	122934	
Fertilization x clipping	3	12029	
Fertilization x irr. x clip.	6	138928	
Error	54	144723	
Mixture	4	4487508	51.61 **
Mixture x irrigation	8	274321	3.16 **
Mixture x clipping	4	777164	8.94 **
Mixture x irr. x clip.	8	136936	
Mixture x fertilization	12	141454	
Mixture x irr. x fert.	24	82208	
Mixture x clip. x fert.	12	101382	
Mixture x irr. x clip. x fert.	24	111369	
Error	288	86945	

** Significant at 0.01
All other F values nonsignificant

Table 114. Analysis of variance of dry matter yields of ladino clover roots, 1965

Source of variation	DF	Mean square	F value
Replication	3	382990	
Irrigation	2	296830	
Error	6	339523	
Clipping	1	942900	10.48 *
Clipping x irrigation	2	18915	
Error	9	89977	
Fertilization	3	1377317	19.76 **
Fertilization x irrigation	6	205847	2.59 *
Fertilization x clipping	3	45553	
Fertilization x irr. x clip.	6	11620	
Error	54	69702	
Mixture	1	153290	4.79 *
Mixture x irrigation	2	109740	3.43 *
Mixture x irr. x fert.	6	32685	
Mixture x clip. x fert.	3	34670	
Mix. x irr. x clip. x fert.	6	51365	
Error	72	31994	

* Significant at 0.05
** Significant at 0.01
All other F values nonsignificant

Table 115. Analysis of variance of dry matter yields of alfalfa roots, 1965

Source of variation	DF	Mean square	F value
Replication	3	1786435	
Irrigation	2	14278630	19.01 **
Error	6	751143	
Clipping	1	76219050	93.82 **
Clipping x irrigation	2	57969	
Error	9	812402	
Fertilization	3	19790710	74.92 **
Fertilization x irrigation	6	684786	2.59 *
Fertilization x clipping	3	227569	
Fertilization x irr. x clip.	6	309254	
Error	54	264166	
Mixture	2	20359620	152.33 **
Mixture x irrigation	4	78440	
Mixture x irr. x fert.	12	203132	
Mixture x clip. x fert.	6	327122	2.45 *
Mix. x irr. x clip. x fert.	12	216661	
Error	144	133655	

* Significant at 0.05
** Significant at 0.01
All other F values nonsignificant

Table 116. Analysis of variance of dry matter yields of legume roots, 1965

Source of variation	DF	Mean square	F value
Replication	3	2372766	
Irrigation	2	8735605	7.83 *
Error	6	1115996	
Clipping	1	47185010	98.83 **
Clipping x irrigation	2	93302	
Error	9	477933	
Fertilization	3	21482960	109.14 **
Fertilization x irrigation	6	686954	3.49 **
Fertilization x clipping	3	75823	
Fertilization x irr. x clip.	6	234810	
Error	54	196839	
Mixture	3	57026600	434.50 **
Mixture x irrigation	6	1371725	10.45 **
Mixture x clipping	3	7222007	55.03 **
Mixture x irr. x clip.	6	13802	
Mixture x fertilization	9	1427225	10.87 **
Mixture x irr. x fert.	18	217115	
Mixture x clip. x fert.	9	149536	
Mix. x irr. x clip. x fert.	18	153106	
Error	216	131248	

* Significant at 0.05
** Significant at 0.01
All other F values nonsignificant

Table 117. Analysis of variance of dry matter yields of grass roots, 1965

Source of variation	DF	Mean square	F value
Replication	3	33137800	14.25 **
Irrigation	2	14258390	6.13 *
Error	6	2325146	
Clipping	1	1392669	
Clipping x irrigation	2	782444	
Error	9	1440970	
Fertilization	3	79873720	35.98 **
Fertilization x irrigation	6	839938	
Fertilization x clipping	3	3160439	
Fertilization x irr. x clip.	6	1450777	
Error	54	2220237	
Mixture	4	16953120	22.17 **
Mixture x irrigation	8	527951	
Mixture x clipping	4	10876110	14.22 **
Mixture x irr. x clip.	8	1199202	
Mixture x fertilization	12	2936160	3.84 **
Mixture x irr. x fert.	24	888220	
Mixture x clip. x fert.	12	1542398	2.02 *
Mix. x irr. x clip. x fert.	24	776818	
Error	288	744653	

* Significant at 0.05
** Significant at 0.01
All other F values nonsignificant

Table 118. Analysis of variance of dry matter yields of the total roots, 1965

Source of variation	DF	Mean square	F value
Replication	3	20752400	8.21 *
Irrigation	2	32582310	12.90 **
Error	6	2526604	
Clipping	1	24372950	12.54 **
Clipping x irrigation	2	395183	
Error	9	1943029	
Fertilizer	3	80152570	34.20 **
Fertilizer x irrigation	6	1866414	
Fertilizer x clipping	3	2547974	
Fertilizer x irr. x clip.	6	1629042	
Error	54	2343861	
Mixture	4	31315670	41.07 **
Mixture x irrigation	8	1930331	2.53 *
Mixture x clipping	4	5679452	7.45 **
Mixture x irr. x clip.	8	1308535	
Mixture x fertilization	12	2324559	3.05 **
Mixture x irr. x fert.	24	942433	
Mixture x clip. x fert.	12	1373564	1.80 *
Mix. x irr. x clip. x fert.	24	988943	
Error	288	762505	

* Significant at 0.05
** Significant at 0.01
All other F values nonsignificant

Table 119. Analysis of variance of percent TAC of ladino clover roots, 1965

Source of variation	DF	Mean square	F value
Irrigation	2	14.010	
Clipping	1	4.213	
Clipping x irrigation	2	39.105	5.41 *
Fertilization	3	57.116	7.90 *
Fertilization x irrigation	6	18.937	
Fertilization x clipping	3	6.873	
Fertilization x irr. x clip.	6	11.313	
Mixture	1	381.377	2.76 **
Mixture x irrigation	2	5.831	
Mixture x clipping	1	4.613	
Mixture x irr. x clip.	2	10.708	
Mixture x fertilization	3	14.575	
Mixture x irr. x fert.	6	9.001	
Mixture x clip. x fert.	3	5.138	
Mix. x irr. x clip. x fert. (Error)	6	7.228	

* Significant at 0.05
** Significant at 0.01
All other F values nonsignificant

Table 120. Analysis of variance of percent TAC of alfalfa roots, 1965

Source of variation	DF	Mean square	F value
Irrigation	2	2.854	
Clipping	1	3.614	
Clipping x irrigation	2	1.486	
Fertilization	3	0.448	
Fertilization x irrigation	6	1.652	
Fertilization x clipping	3	1.124	
Fertilization x irr. x clip.	6	1.886	
Mixture	2	10.334	4.44 *
Mixture x irrigation	4	3.269	
Mixture x clipping	2	1.249	
Mixture x irr. x clip.	4	2.335	
Mixture x fertilization	6	8.983	3.86 *
Mixture x irr. x fert.	12	2.634	
Mixture x clip. x fert.	6	1.238	
Mix. x irr. x clip. x fert. (Error)	12	2.328	

* Significant at 0.05
All other F values nonsignificant

Table 121. Analysis of variance of percent TAC of grass roots, 1965

Source of variation	DF	Mean square	F value
Irrigation	2	49.716	12.05 **
Clipping	1	28.792	6.98 *
Clipping x irrigation	2	3.472	
Fertilization	3	41.037	9.95 **
Fertilization x irrigation	6	8.644	
Fertilization x clipping	3	18.803	4.56 *
Fertilization x irr. x clip.	6	6.464	
Mixture	4	78.532	19.04 **
Mixture x irrigation	8	33.370	8.09 **
Mixture x clipping	4	12.967	3.14 *
Mixture x irr. x clip.	8	5.495	
Mixture x fertilization	12	6.613	
Mixture x irr. x fert.	24	6.583	
Mixture x clip. x fert.	12	5.937	
Mix. x irr. x clip. x fert. (Error)	24	4.124	

* Significant at 0.05
** Significant at 0.01
All other results nonsignificant

Table 122. Analysis of variation of percent TAC of total roots, 1965

Source of variation	DF	Mean square	F value
Irrigation	2	37.091	12.02 **
Clipping	1	26.564	8.61 **
Clipping x irrigation	2	2.086	
Fertilization	3	34.314	11.12 **
Fertilization x irrigation	6	7.793	2.53 *
Fertilization x clipping	3	19.902	6.45 **
Fertilization x irr. x clip.	6	4.370	
Mixture	4	63.859	20.70 **
Mixture x irrigation	8	19.220	6.23 **
Mixture x clipping	4	11.071	3.59 *
Mixture x irr. x clip.	8	4.580	
Mixture x fertilization	12	5.263	
Mixture x irr. x fert.	24	4.381	
Mixture x clip. x fert.	12	5.117	
Mix. x irr. x clip. x fert. (Error)	24	3.085	

* Significant at 0.05

** Significant at 0.01

All other F value nonsignificant

Table 123. Analysis of variance of TAC of ladino clover roots, 1965

Source of variation	DF	Mean square	F value
Replication	3	9219.03	
Irrigation	2	6366.40	
Error	6	8709.24	
Clipping	1	1769.88	8.30 *
Clipping x irrigation	2	457.52	
Error	9	2131.10	
Fertilization	3	25701.23	16.77 **
Fertilization x irrigation	6	3617.87	2.36 *
Fertilization x clipping	3	1019.01	
Fertilization x irr. x clip.	6	209.60	
Error	54	1532.63	
Mixture	1	76.26	
Mixture x irrigation	2	5100.52	9.09 **
Mixture x clipping	1	1710.05	
Mixture x irr. x clip.	2	703.00	
Mixture x fertilization	3	428.24	
Mixture x irr. x fert.	6	1236.47	
Mixture x clip. x fert.	3	756.78	
Mix. x irr. x clip. x fert.	6	971.03	
Error	72	560.84	

* Significant at 0.05

** Significant at 0.01

All other F values nonsignificant

Table 124. Analysis of variance of TAC of alfalfa roots, 1965

Source of variation	DF	Mean square	F value
Replication	3	37616	
Irrigation	2	308750	16.74 **
Error	6	18443	
Clipping	1	1937988	100.82 **
Clipping x irrigation	2	9123	
Error	9	19222	
Fertilization	3	557473	72.85 **
Fertilization x irrigation	6	24288	3.17 **
Fertilization x clipping	3	9667	
Fertilization x irr. x clip.	6	7399	
Error	54	7653	
Mixture	2	446657	116.29 **
Mixture x irrigation	4	16823	4.38 **
Mixture x clipping	2	20939	5.45 **
Mixture x irr. x clip.	4	2700	
Mixture x fertilization	6	76893	20.02 **
Mixture x irr. x fert.	12	9696	2.52 **
Mixture x clip. x fert.	6	22728	5.92 **
Mix. x irr. x clip. x fert.	12	8715	2.27 *
Error	144	3841	

* Significant at 0.05
** Significant at 0.01
All other F values nonsignificant

Table 125. Analysis of variance of TAC of grass roots, 1965

Source of variation	DF	Mean square	F value
Replication	3	883004	16.42 **
Irrigation	2	243780	
Error	6	53764	
Clipping	1	535803	20.40 **
Clipping x irrigation	2	94958	
Error	9	26264	
Fertilization	3	1715970	31.73 **
Fertilization x irrigation	6	81050	
Fertilization x clipping	3	116066	
Fertilization x irr. x clip.	6	108397	
Error	54	54081	
Mixture	4	758708	34.70 **
Mixture x irrigation	8	341090	15.60 **
Mixture x clipping	4	406342	18.58 **
Mixture x irr. x clip.	8	158365	7.24 **
Mixture x fertilization	12	99333	4.54 **
Mixture x irr. x fert.	24	73241	3.35 **
Mixture x clip. x fert.	12	43130	1.97 *
Mix. x irr. x clip. x fert.	24	79849	3.65 **
Error	288	21867	

* Significant at 0.05
** Significant at 0.01
All other F values nonsignificant

Table 126. Analysis of variance of TAC of total roots, 1965

Source of variance	DF	Mean square	F value
Replication	3	544474	10.29 **
Irrigation	2	90786	
Error	6	52923	
Clipping	1	60480	
Clipping x irrigation	2	67307	
Error	9	39760	
Fertilization	3	866544	15.05 **
Fertilization x irrigation	6	96957	
Fertilization x clipping	3	145540	
Fertilization x irr. x clip.	6	145436	2.53 *
Error	54	57573	
Mixture	4	2142527	99.77 **
Mixture x irrigation	8	237476	11.06 **
Mixture x clipping	4	209215	9.74 **
Mixture x irr. x clip.	8	184593	8.60 **
Mixture x fertilization	12	87564	4.08 **
Mixture x irr. x fert.	24	68359	3.18 **
Mixture x clip. x fert.	12	56083	2.61 **
Mix. x irr. x clip. x fert.	24	81341	3.79 **
Error	288	21475	

* Significant at 0.05
** Significant at 0.01
All other F values nonsignificant

Table 127. Analysis of variance of the root/forage ratio as a percent, 1964 and 1965

Source of variance	DF	Mean square	F value
Replication	3	4.073	15.98 **
Irrigation	2	2.812	11.03 **
Error	6	0.255	
Clipping	1	1.227	15.73 **
Clipping x irrigation	2	0.132	
Error	9	0.078	
Fertilization	3	8.685	33.79 **
Fertilization x irrigation	6	0.121	
Fertilization x clipping	3	0.353	
Fertilization x irr. x clip.	6	0.108	
Error	54	0.257	
Mixture	4	3.740	46.33 **
Mixture x irrigation	8	0.144	
Mixture x clipping	4	0.259	3.21 *
Mixture x irr. x clip.	8	0.106	
Mixture x fertilization	12	1.122	13.90 **
Mixture x irr. x fert.	24	0.064	
Mixture x clip. x fert.	12	0.129	
Mix. x irr. x clip. x fert.	24	0.063	
Error	288	0.081	

* Significant at 0.05

** Significant at 0.01

All other F values nonsignificant

VITA

Clair E. Blaser

Candidate for the Degree of

Master of Science

Thesis: Comparison of Protein, Forage, and Root Yield Data of Five Pasture Mixtures as Influenced by Clipping, Irrigation, and Nitrogen Fertilization

Major Field: Plant Science

Biographical Information:

Personal Data: Born at Plano, Idaho, March 23, 1923, son of Ernest and Margaret Grosnick Blaser; married Rosemary Polson November 9, 1945; ten children--Gregory, Stephen, Rebecca, Scott, Barbara, Teresa, Howard, Robert, Martin, and Jason.

Education: Attended elementary school at Plano, Idaho; graduated from Edmunds High School, Plano, Idaho in 1940; received Associate Degree from Ricks College in 1942; attended University of Washington in 1944; attended Notre Dame, 1944-45; received the Bachelor of Science (agriculture) from Ricks College in 1956; did graduate work in Plant Science at Utah State University, 1964-1974.

Professional Experience: 1964 to present, instructor of Agronomy at Ricks College, Rexburg, Idaho; 1964-71, supervisor and enumerator for the Crop Reporting Service, U.S.D.A., Boise, Idaho; 1949-68, owner-operator of a 100 cow grade A dairy farm.

Military and Other Experience: 1943-46, Ensign, Minesweepers, U.S. Navy; 1946-53, Lt. (j.g.) U.S. Naval Reserve; 1951-53, missionary, Church of Jesus Christ of Latter-day Saints.