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DONALD LEE SUTTNER for the degree of DOCTOR OF PHILOSOPHY

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W. S. McGuire

Field studies to determine appropriate cutting management regimes consistent with yield, quality, and persistence of stand were conducted on several alfalfa varieties in the Columbia Basin region of Oregon.

Two groups of treatments, including consecutive cuts at the same stage of maturity and cuts made at varying maturities, were imposed on Anchor, Apex, and Washoe. The first group consisted of tenth bloom with and without fall cutting and full bud all season. The next group contained early or pre-bud followed by tenth bloom, full bud followed by tenth bloom, and tenth bloom followed by full bud.

The varieties, N-102, Saranac, and Vernal, were subjected to three and four cuts per season which corresponded to intervals of 44 and 35 days, respectively.

Results with Anchor over a two year period indicated consistently high yields of dry matter and protein using a full bud followed by tenth bloom schedule. Full bud all season or early bud followed by tenth bloom offered increased protein concentration at some sacrifice in dry

matter yield. Treatments effected only small differences in stand density.

The variety Apex underwent rapid stand decline during the course of the studies. When persistence is not an overriding consideration, full bud all season afforded increased protein content without appreciable loss in dry matter yield in comparison with most other treatments. Treatments displayed little differential effect on stand density.

Dry matter yield of Washoe was unaffected by treatments imposed. Full bud all season and immature followed by tenth bloom resulted in increased protein concentration. Differential effects evoked by treatments on stand density early in the experiment had essentially dissipated at its conclusion.

The varieties, N-102, Saranac, and Vernal, gave increased protein content with more frequent cutting without significant change in dry matter yield.

Alfalfa Cutting Management in the Columbia Basin

by

Donald Lee Suttner

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Professor of Agronomic Crop Science
in charge of major

Redacted for Privacy

Head of Department of Agronomic Crop Science

Redacted for Privacy

Dean of Graduate School

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INTRODUCTION

Alfalfa is the most important forage legume in the United States. It has shown itself to be remarkably adaptable to regions of diverse climates and soils. Alfalfa is traditionally regarded as suitable for use as pasture, hay, silage, and green chop with ruminants. In ground, dehydrated form, it has been used extensively as a protein and vitamin-rich supplement to rations of non-ruminant animals. More recently alfalfa leaf-protein preparations have been promoted as high protein supplements/alternatives to animal protein sources for human consumption.

The extraordinary utility of alfalfa has led to considerable interest in the selection of appropriate cutting management systems for maximizing both yield and nutritive value. Since these two criteria of productivity are most often found to vary inversely, in practice, management systems have usually involved optimization of the two parameters. As we approach the era of serious consideration of alfalfa as a human food source, however, it may be necessary to re-evaluate the relationship between these two important variables.

Alfalfa was probably introduced into North America in the late eighteenth or early nineteenth century. Acreage expanded rapidly between 1850 and 1900 to about two million acres. Since then alfalfa acreage has increased to 27-30 million acres (1).

The most successful early culture of alfalfa was in the Southwest, mainly with cultivars introduced from South America. Early attempts at cultivation in the Northeast met only limited success since the crop did not thrive on the acid hill soils of this region. The development of strains with increased winterhardiness as well as improved soil management practices such as use of agricultural limestone has contributed greatly to the expansion of acreage of alfalfa (1).

In Oregon alfalfa accounts for the main part of a $70 million dollar hay crop. It occupies roughly 400,000 acres, about ten percent of the tillable acreage. It is well suited to both the humid climate of Western Oregon and the arid conditions of Eastern Oregon (25).

The Columbia Basin region of Northeastern Oregon, rapidly developing into one of the most important areas of intensive irrigated agriculture in the state, is a major alfalfa producing district. Umatilla County alone, ranks fourth in alfalfa acreage, and third in production (27). The combined effects of altitude and proximity to the Columbia River gorge render this area unique climatically within the state. The influences of marine air movement up the gorge result in relatively mild winters compared to the interior. Continental influences in terms of aridity render incident light values comparatively higher than Western Oregon.

Abundant supplies of high quality water from underground sources as well as the Columbia and Umatilla Rivers assure a stable future for irrigation in the area. As a high consumptive-use crop, alfalfa requires an adequate, relatively inexpensive water source.

The rather coarse textured soils are especially well suited to perennial crops such as alfalfa since this leaves them unprotected only infrequently. This is doubly important since wind velocities in the area are often excessive.

The need to develop management systems suitable to this particular area for optimizing alfalfa productivity is obvious. Systems developed for relatively shorter seasons in Central Oregon or the Willamette Valley may not fully utilize the resources of temperature, light, and water which exist in the Columbia Basin.

This effort endeavors to define management criteria consistent with both productivity, quality, and persistence of stand for the Columbia Basin.

LITERATURE REVIEW

Cutting management regimes are basically of two general types: those based on calendar date or interval and those based on stage of maturity. Stage of maturity schedules are usually based on some combination of bud/flower criteria. Management investigations often include autumn harvest variables. These variables are included in an effort to identify critical dates in the fall after which alfalfa should not be cut to assure accumulation of adequate nutrient reserves for winter survival.

Calendar Date

Studies by Jackobs (14, 15) in the Yakima Valley of Washington, using 25, 29, 33, 37, and 41 day intervals demonstrated that maximum yields were obtained when harvested every 37-41 days. Jackobs observed that frequent cutting had little effect on stand vigor in contrast to observations commonly made in the Midwest. Seasonal yield of nitrogen was also maximized at the 37-41 day intervals. Later work (16) using 25, 30, and 40 day intervals showed similar results with respect to yield. Again, frequency of cut did not affect stand vigor.

Work in California (33) with alfalfa mixtures using 14, 21, 28, and 35 day intervals showed maximum yields at the 35 day sequence. An inverse relationship between percent crude protein and percent crude fiber was found as the length of interval increased. Later studies in California (46) with 21, 28, 35, and 42 day schedules concluded that maximum yield of crude protein was obtained at 35 days while maximum yield of dry matter occurred at 42 days. Apparent digestibility declined with increasing maturity of the forage. TDN was maximized at the 35 day interval.

Growth chamber studies by Jensen, et al. (18) using non-hardy, intermediate, and hardy cultivars with 16, 21, 28, 35, and 42 day cutting regimes demonstrated highest dry matter yields at 42 days with all three strains. No dry matter increase was observed with the non-hardy type between 21 and 35 days and the increase at 42 days was attributed to regrowth from crown buds. Percent leaves declined in all strains with less frequent cutting. Percent protein declined more sharply in leaves than in stems as cutting interval increased. Percent fiber in stems increased rapidly until 28 days and remained constant thereafter while leaf content did not change. Lignin was maximum in both leaves and stems at 35 days.

Smith, et al. (38) in an extensive study in the North Central states examined 45 and 56 day regimes. Their results indicate increasing yield with shorter interval in Wisconsin, Minnesota, and Missouri. Contrasting results in Iowa were attributed to low fertility. Stand decline with less hardy varieties at increasing harvest frequency was significant even at more southerly locations. Hardy varieties showed no appreciable decline in stand except in Iowa. Third-year residual yield data (first cutting) showed no consistent trends with increased frequency for either hardy or less hardy strains. In a companion paper, Matches and coworkers (23) reported the effects of interval cutting on composition and quality under the same interval regime. Protein concentration increased as frequency of harvest increased. Total protein and dry matter digestibility showed similar trends.

Washko and Price (45) studied the influence of 25, 30, 35, and 40 day cutting intervals on several varieties of alfalfa in Pennsylvania. Their results indicate maximum dry matter yield with a 40 day harvest regime. The 25 day interval resulted in complete stand loss the first year. Appreciable stand loss occurred with all treatments during the first season and subsequent winter period. Little stand decline was observed during the second season. Maximum persistence resulted with a 40 day interval. In terms of quality, only minor differences were detected in crude protein and percent TDN between 30 and 35 days while a marked decline in both components was observed at the 40 day interval. A 35 day schedule was selected for optimizing yield, quality, and persistence.

Offut (30) observed the effects of 14 and 21 day intervals on alfalfa yield and persistence in Arkansas. The

21 day interval led to significant yield improvement over 14 days, although both treatments were inferior to tenth bloom schedules for yield. Decline of stand appeared less pronounced for these abbreviated intervals than is observed in colder areas.

Parsons and Davis (32) compared 35 and 45 day intervals in Ohio and found highest yields of dry matter and crude protein at 45 days. Stand decline was also minimal at the longer interval. Concentration of protein, however, was highest at 35 days.

Reynolds (34) studied the effects of 21, 28, 35, 42, 56, and 84 day regimes on Tennessee alfalfa production. His data indicate that maximum yields were obtained at 42 days, however, stand persistence was similar if intervals longer than 35 days were employed. Recovery year yields were maximum with frequencies of 35 days or more.

Gasser and Lachance (8) observed the effect of 40 and 55 day intervals on yield and persistence in Quebec. Yield was unaffected by the shorter interval during the first season, however, during subsequent seasons it resulted in reduced yield from a declining stand. Concentration of protein was maximum with the 40 day interval. Their work suggests that manipulating fall cutting date can eliminate yield depression in subsequent seasons.

Judd and Radcliffe (19) compared 3, 4, 5, and 6 week cutting intervals with respect to effects on yield, protein, and persistence. Yield of both dry matter and crude protein was highest at six weeks as was stand persistence. Mean crude protein declined as length of interval increased.

Smith (37) concludes that the major advantages of calendar date schedules are ease of allocation of labor and equipment and simplicity due to elimination of the need to identify morphologically distinct stages. Its principal deficiency is the failure to accommodate variations in growth and development due to climatic factors.

Stage of Maturity

Early studies in Wisconsin (10) demonstrated that, using varieties available at the time, harvest at full bloom gave maximum dry matter yields over bud, tenth bloom, or seed stage. Serious loss of stand was also incurred with bud or tenth bloom harvests. In Alabama, Sturkie and Wilson (41) found a similar relationship when comparing the same stages of maturity.

Work by Sandal and Jacks (36) revealed that tenth bloom was superior to prebloom in terms of dry matter and crude protein yield and stand survival. Concentration of protein was higher, however, with the prebloom regime.

Graumann, et al. (11) concluded that full bloom harvests maximized dry matter yields and stand maintenance but for high quality forage cutting at tenth bloom or earlier offered significant improvement under Oklahoma conditions.

They observed that a "rest" period in preparation for overwintering or delay of subsequent spring harvest until winter-damaged plants had recovered could materially reduce stand loss. The rate of subsequent top growth was greater with increasing delay of harvest until full bloom.

Studies in the Northeast by Decker and coworkers (4) showed that removal of spring growth at full bud vs. tenth bloom followed by subsequent harvest at half bloom had no effect on alfalfa yield during four years. In contrast, early spring cutting at tenth bud stage significantly decreased dry matter yield. The latter treatment resulted in significantly greater stand loss in Maryland than more conservative management. This decline was not observed in West Virginia or Rhode Island.

Work by Smith and associates (38) in the North-central states revealed that a tenth bloom schedule was superior to a full bloom schedule in Missouri, Wisconsin, and Minnesota for dry matter yield. More pronounced stand loss occurred with tenth bloom harvest than full bloom harvest with the cultivar 'Dupuit' at all locations, while with 'Vernal' this relationship did not apply. In a later report, Matches, et al. (23) described the effects of these treatments on crude protein in alfalfa. Yield of crude protein as well as percent crude protein declined with delay of harvest from tenth bloom to full bloom. The average percent decline in crude protein from tenth bloom to full bloom was 4.6 for first growth and 2.2 for second growth.

Weir, et al. (46) examined the effects of harvest at pre-bud, bud, tenth bloom, and half bloom on yield and quality of alfalfa. Their results indicate highest seasonal yield of dry matter over a three-year period using the half bloom criterion. Highest yields of protein were obtained with either the bud or tenth bloom criterion. No significant effect on residual yield was observed after three years under these management regimes. Differences in stand density also failed to develop. Reduced yield of dry matter in more frequently cut plots was attributed to fewer culms per plant and slower regrowth after cutting. Digestibility of protein declined with maturity.

Studies by Feltner and Massengale (6) in the Southwest indicated highest dry matter yields over three years using a tenth bloom as opposed to a half bud or full bloom criterion. Stand density and forage yield decreased under all treatments with time; however, decline was greatest with half bud harvest. Seasonally, stand loss was greatest during July and August. Subsequent studies (35) revealed that quarter bloom was superior to half bloom with respect to dry matter yield.

Ogden and Kehr (31) found that making all cuttings at tenth or full bloom led to similar yields. These regimes provided higher yields than bud stage harvest or ten inch spring cutting followed by tenth bloom. Concentration of protein was highest with ten inch/tenth bloom and bud stage regimes. Protein yield was highest with tenth bloom all season. In a subsequent report, Luckett and Klopfenstein (21) observed that the weighted mean percent crude protein of all cuttings declined steadily with more conservative management. It was further concluded that bud stage harvest led to consistently higher percent leaves, protein content, and IVDMD than either tenth or full bloom.

Investigations in Western Oregon by Contreras (3) using several stages of growth criteria showed that seasonal and varietal differences can have considerable effect on relative performance of harvest systems. The hardy cultivar 'Vernal' performed best for dry matter yield with initial harvest as crown buds were beginning to elongate, followed by tenth bloom for remaining harvests. Yields with this regime were consistently higher than with other schedules including tenth bloom continuously. The same harvest criterion provided consistently high yields with the Flemish cultivar 'Dupuits'; however, other schedules performed equally well certain seasons. Crown bud followed by tenth bloom also led to high protein yields irrespective of season or variety.

Janson (17) in New Zealand demonstrated that treatments harvested at early, half bud, tenth bloom, and half bloom all yielded similarly the first year. After four years, however, early bud and half bud produced considerably less than tenth bloom. The half bloom treatment yielded only slightly less than tenth bloom. Invasion by grass and weeds was likewise minimized with tenth bloom.

In recent years, the harvesting of alfalfa according to stage of maturity schedules has received comparatively greater attention than calendar date regimes. Arguments for use of stage of maturity criterion often include enhanced uniformity of herbage quality over a range of climates and improved relationship between accumulated root reserves and time of harvest. Frequently mentioned disadvantages of these schedules are difficulty in identification of discreet maturity groupings and problems in execution when large acreages of alfalfa are involved (37).

Fall Cutting Effects

Studies by Brown (2) in Connecticut showed that cutting during mid or late September reduced yields the following year. Delaying fall harvest until after October 15 eliminated yield depression the next year. The depression was found to be associated with serious stand decline in plots harvested during September.

Smith (38) noted that third-year residual yield declined when plants were cut in mid-October in comparison with plants not cut after early September. Yields for the preceding year were, however, slightly higher with the later harvest date. The depression in residual yield was more pronounced with a non-hardy than a hardy variety. Stand decline was closely associated with residual yield.

The results of Sandal and Jacks (36) in Arkansas suggest that fall cutting may reduce the yield and persistence of alfalfa even in more southerly latitudes. Their results also indicate, however, that management during the entire season may be more critical than autumn cutting for persistence in these climates. Later work by Feltner and Massengale (6) and Robinson and Massengale (35) tends to confirm this.

Extensive efforts in the Northeast by Decker, et al. (4) revealed that early, mid, or late fall cutting had no effect on yield or persistence on a regional basis. The effects of early and mid-fall harvests were significant in some individual states such as West Virginia and Rhode Island.

Jackobs (14) examined the effects of fall cuts taken after September 1 on alfalfa in Washington. His evidence suggests that cutting after September 1 caused reduced yield the following year over uncut plots. The decline was attributed mainly to reduced spring growth since later cuttings yielded similarly. A later report (15) described the effects as being consistent across several varieties; however, in this case the depression was not observed until the third year.

Fulkerson (7) noted the effects of fall cutting on alfalfa in the Canadian winter. The results indicated general decline in residual yield and stand with mid-fall harvest compared with early or late fall cutting. Root density measurements in November declined with increasingly more northerly latitudes under mid-fall harvests.

From studies in southern Michigan, Tesar (42) observed no significant reduction in residual yield from autumn cutting on September 1, 15 or October 1 when using wilt-resistant varieties. Root numbers and size were similar for all three dates. Residual yield depression was, however, demonstrated for wilt-susceptible varieties.

Jung, et al. (20) through recent work in West Virginia found that the most pronounced decline in spring yield occurred when alfalfa was cut between September 21 and October 7 in that area. Spring growth was considered the most precise measure of autumn cutting effects since differences tended to disappear later. Delay of harvest until after October 7 had only a slight depressing effect on yield. Stand density followed yield trends closely.

Mays and Evans (24) observed autumn cutting effects in the relatively mild climate of northern Alabama. Both third and fourth cutting dates were varied. If a third harvest occurred on August 1, residual yield was reduced if fourth cutting was removed after October 1 unless delayed until after frost. In contrast, if third cutting was taken on

August 15, any removal of fourth cutting reduced residual yield. Seasonal yield was much less affected than first cutting yield during the recovery year. Stand densities for Dupuits followed the effects on yield; however, stand with the 'Williamsburg' cultivar was unaffected by autumn management.

Work by MacLeod, et al. (22) in Nova Scotia on the effects of fall cutting revealed that previous management during the season was of considerable importance. Conservative management usually rendered the effects of fall cutting less severe regardless of date of harvest. Management at tenth bloom during the season and removal of frosted herbage in the fall led to maximum dry matter.

Douglas (5) working in New Zealand demonstrated that autumn cutting was highly detrimental to spring growth yields irrespective of the date removed. Fertilization ameliorated the above effects and eliminated them when autumn growth was removed after frost.

The detrimental effects of autumn cutting are considered to arise from combinations of the following: (a) reduced carbohydrate stored in the roots and crown; (b) reduced winter hardiness and survival; (c) reduced numbers of crown buds and rhizomes for spring growth; and (d) less stubble to retain snow cover for winter protection (38).

MATERIALS AND METHODS

The study involved imposition of management schedules on the cultivars 'Anchor', 'Apex', 'Washoe', 'N-102', 'Saranac', and 'Vernal'. Anchor was located on the Stone-Hereford Ranch about six miles west of Umatilla, Oregon. The climate is typical of the lower Columbia Basin region. Rainfall is less than 11 cm annually. The mean monthly maximum temperature for July is 32.9C. The mean monthly minimum temperature for January is -5.3C. Elevation is approximately 82m. The average length of frost-free season is 190 days (40).

Apex and Washoe were situated on the property of Mr. M. Skinner, west of Hermiston, Oregon. N-102, Saranac, and Vernal stands occurred on the Umatilla Branch Experiment Station, south of Hermiston. The climate at these locations is quite similar to the first, although the elevation is about 183m and the average frost-free season is 160 days (40).

The Anchor location was situated on the second terrace above the Columbia River on soils of the Rupert series. These soils consist mainly of a loose non-calcareous sand surface underlain by coarse sand and find gravel. The series is excessively drained and difficult to manage in terms of wind erosion. Both surface and subsurface are very low in organic matter (12).

Apex and Washoe were located on the coarser soils of the Ephrata series. The surface layer is of a non-calcareous fine sandy nature derived from alluvial sediments. Underlain by gravel of gravelly sand, the soils are regarded as excessively drained and of relatively poor water-holding capacity. The series is characteristic of the upper terraces of the Columbia River in northwest Umatilla county (12).

The Umatilla Branch Station is situated primarily on a finer textured, loamy sand member of the Ephrata series. This soil arises principally from old alluvium although the upper few inches may be wind laid. The profile is comprised of loamy sands underlain by coarser material. It is rather low in organic matter and excessively drained. Erosion hazard is moderate (12).

Anchor was seeded at 22.4 kg/ha during the fall of 1972. Treatments were imposed during the 1973 and 1974 seasons. Anchor is a synthetic of the Flemish type which was selected for resistance to bacterial wilt, other leaf and stem diseases, pea aphid, and potato leafhopper. Winter-hardiness purportedly approaches that of Vernal while it retains regrowth and fall production characters of Flemish strains (43).

The Apex stand was established in the fall of 1970 with a seeding rate of 17.9 kg/ha. Treatments were again imposed during 1973 and 1974. Apex is a Flemish synthetic developed for wilt resistance and winter-hardiness. Spring growth and regrowth vigor are improved over non-Flemish cultivars (44).

Washoe was seeded at a rate of 17.9 kg/ha in fall of 1968 with management schedules effected during the fifth (1973) and sixth (1974) years of production. As a non-Flemish synthetic, Washoe was developed for resistance to pea aphids, stem menatodes and bacterial wilt. Susceptibility to leaf and stem diseases renders it unsuitable to humid areas. Regrowth and fall growth vigor may be inferior to Flemish lines (13).

N-102, Saranac, and Vernal were established in the fall of 1971 at 22.4 kg/ha. Treatments were imposed during 1974. N-102 and Saranac are Flemish types with characteristics related to Apex and Anchor. Vernal is a standard, non-Flemish type, developed in Wisconsin with exceptional winter-hardiness and bacterial wilt resistance (9, 28).

The Anchor location was serviced by a "center-pivot", sprinkler type irrigation system. Approximately 114 cm of water were applied annually per hectare at a rate of 2.5 cm per irrigation. The area was fertilized with 56, 190, 34, 3, 8 kg/ha of N, P_2O_5, S, B, and Zn respectively during the fall of 1973. An 11-48-0 mix was applied at 224 kg/ha during fall, 1974.

The Apex-Washoe site was irrigated using a "side-roll", sprinkler type unit. Roughly 102 cm of water was applied yearly per hectare in 12 irrigation cycles. A preplant application of 134 kg/ha of P_2O_5 was plowed down. Gypsum was applied at 392 kg/ha during fall, 1973 and 1974. Applications of the herbicide IPC at 9.3 l/ha were made in the early spring of 1974 and 1975 for grass and broadleaf control.

The N-102, Saranac, Vernal area was irrigated with a "hand-moved", sprinkler system. About 110 cm of water was applied per hectare using a 12 hour set on a two week cycle.

The following management schedules were applied to Anchor, Apex, and Washoe:

1. Early bud first cutting, followed by tenth bloom subsequent cuttings (EB, 1/10 blm).
2. Full bud first cutting, followed by tenth bloom subsequent cuttings (FB, 1/10 blm).
3. Full bud cuttings all season (FB).
4. Tenth bloom first cutting, followed by full bud subsequent cuttings until late September (1/10 blm, FB).
5. Tenth bloom all season until early September (1/10 blm, NFC).
6. Tenth bloom all season until late September (1/10 blm, FC).

The initial cutting in the first treatment was taken at an immature-pre-bud (IM) stage with Washoe. Determination of harvest criteria was made according to the method of Meyer and Jones (26). Treatments were assembled in a randomized complete block design with three replications.

Treatments were imposed on N-102, Saranac, and Vernal as follows:

1. Four cuttings prior to September 1.

2. Three cuttings prior to September 1.

Treatments were arranged in a randomized complete block design with four replications. Schedules corresponded to intervals of 35 and 44 days. Harvests with the three cutting regimes coincided with the regularly scheduled harvest of the surrounding area by station personnel.

Individual plot size for all varieties was 1.8 by 6.1 m. Dry matter yield was determined in all cases by harvesting a 0.9 by 6.1 m area from the center of each plot using a "Jari" sickle-bar type mower. Green weight was recorded and subsamples of approximately 1000g were dried in a forced air oven at 75C for percent dry matter.

Crude protein samples were obtained by random selection of thirty stems from each plot at harvest. Protein samples were dried at 75C and ground to 40 mesh in a "Wiley" mill. Percent nitrogen for Anchor, Apex, and Washoe was determined using the micro-Kjeldahl procedure (AOAC) as modified by Nelson and Sommers (29). Standard macro-Kjeldahl procedures (AOAC) were used for nitrogen analysis with N-102, Saranac, and Vernal. Crude protein was calculated by percent N x 6.25.

Stand densities were measured by counting the total number of crowns in two randomly selected $0.2m^2$ areas per plot. Counts were taken during September 1973, June 1974, and May 1975. Measurements were taken for two-year studies only. With Anchor, Apex, and Washoe, recovery year yields were harvested on May 28, 1975.

Statistical analysis was according to Steel and Torrie (39). Analyses of variance are included in the Appendix.

RESULTS

The various management systems imposed resulted in different numbers of cuts per season. Variation in climatic conditions and age of stand caused different numbers of cuts from season to season in some instances. The relatively later harvest dates during 1973 as compared with 1974 with Anchor were attributed to the relatively immature condition of the plants during the first season of production. All treatments not specifically designated for fall cutting were harvested in early September in 1974 due to possible termination of irrigation water supply during September. Stage of maturity at final harvest varied according to autumn management criteria. Cuttings taken prior to stipulated maturity were designated as "aftermath". From a practical standpoint this production might be more economically removed by grazing than by harvest as hay.

Dry Matter Yield

A. Anchor

Dry matter production per cutting and harvest dates for 1973 are shown in Table 1. First cutting yields were not reduced by cutting in the bud stage, indeed, apparent decline in yield occurred when harvest was delayed until tenth bloom. Yields of second cutting alfalfa were similar for all treatments except early bud first cut where a

Table 1. Mean dry matter production per cutting and harvest date for Anchor alfalfa during 1973.

	First cutting	Second cutting	Third cutting	Fourth cutting
		yield, mt/ha		
1. EB, 1/10 blm	6.72 (5/22)	2.89 (7/3)	3.76 (8/13)	2.60 (9/30)
2. FB, 1/10 blm	6.07 (6/2)	4.10 (7/10)	3.83 (8/13)	2.42 (9/30)
3. FB	6.65 (6/2)	4.26 (7/10)	3.56 (8/13)	1.79 (9/5)*
4. 1/10 blm, FB	5.67 (6/12)	3.94 (7/10)	3.36 (8/13)	2.53 (9/30)
5. 1/10 blm, NFC	5.58 (6/12)	4.19 (7/17)	2.98 (9/4)	-
6. 1/10 blm, FC	5.24 (6/12)	4.14 (7/17)	3.27 (9/4)	1.52 (9/30)*
LSD - Managements				
.05	1.02	0.37	NS	-
.01	NS	0.53	NS	-
$S_{\bar{x}}$	0.32	0.12	0.21	-

Table 2. Mean dry matter production per cutting and harvest date for Anchor alfalfa during 1974.

	First cutting	Second cutting	Third cutting	Fourth cutting
		yield, mt/ha		
1. EB, 1/10 blm	6.94 (5/13)	6.81 (6/25)	4.23 (7/31)	2.96 (9/2)*
2. FB, 1/10 blm	8.11 (5/28)	7.48 (7/2)	5.29 (8/8)	3.25 (9/2)*
3. FB	9.21 (5/28)	5.26 (6/25)	3.36 (7/24)	3.23 (9/2)
4. 1/10 blm, FB	8.96 (6/4)	6.02 (7/2)	4.32 (7/31)	3.02 (9/30)
5. 1/10 blm, NFC	9.07 (6/4)	7.10 (7/8)	5.02 (8/8)	2.64 (9/2)*
6. 1/10 blm, FC	8.24 (6/4)	6.43 (7/8)	4.54 (8/8)	3.02 (9/30)
LSD - Managements				
.05	NS	0.60	0.56	NS
.01	NS	0.85	0.81	NS
$S_{\bar{x}}$	0.48	0.19	0.18	0.22

* Aftermath

reduction in regrowth occurred. Differences in third cutting production were not significant. The failure of certain treatments to produce a fourth cutting rendered analysis of these data inappropriate.

Dry matter yields per cutting and harvest dates during 1974 are given in Table 2. Again, harvesting at early stages of maturity gave no significant reduction in first cutting yield. No decline in yield, when harvest was delayed until tenth bloom, was observed. Second growth yields revealed reduced production with full bud all season management. The tenth bloom not fall cut treatment gave higher second cut yields than tenth bloom with fall cutting. Removal of first cutting at early bud led to reduced yield of tenth bloom alfalfa at second harvest compared to full bud first cutting. Essentially the same trends were observed with third cutting yields. No significant differences were detected among fourth cutting yields.

Accumulated dry matter production for 1973 is presented in Table 3. Accumulated yield is the summation of production for a specific cutting and production for all previous cuttings. No differences in seasonal production were observed at second cutting. Seasonal production at third harvest was improved when harvested initially at full bud rather than tenth bloom. Total seasonal yield indicated similar effects.

Accumulated dry matter production for 1974 also appears in Table 3. Cumulative yield at second cutting showed reduced production from fall cutting with treatments harvested continuously at tenth bloom. Early bud initial harvest led to similar yield reductions compared with full bud initial harvest. Accumulated production at third harvest showed enhanced yield when first cutting was removed at either full bud or tenth bloom if subsequently managed at tenth bloom without fall cutting. Total yield for 1974 was also maximized by these same management combinations. Harvesting initially at early bud or at full bud all season led to significantly lower dry matter production than other treatments during the second year.

Average total yield over two seasons is presented in Table 3. Several treatments did not respond the same relative to other schedules across both seasons. Early bud followed by tenth bloom and full bud all season were among the more noticeable of these. Harvesting at full bud followed by tenth bloom provided consistently high yields during both seasons. Fall cutting had no significant effect on a two-year basis.

B. Apex

Dry matter yields and harvest dates for 1973 appear in Table 4. Harvest at early bud stage reduced first growth production in comparison with delay of harvest until full

Table 3. Accumulated dry matter production for Anchor alfalfa during the 1973 and 1974 seasons.

	1973			1974			
	Second cutting	Third cutting	Total	Second cutting	Third cutting	Total	2 year average
				yield, mt/ha			
1. EB, 1/10 blm	9.63	13.40	15.97	13.78	18.01	20.94	18.46
2. FB, 1/10 blm	10.17	14.00	16.42	15.59	20.88	24.12	20.27
3. FB	10.91	14.47	16.26	14.47	17.83	21.06	18.66
4. 1/10 blm, FB	9.61	12.97	15.50	15.01	19.33	22.36	18.93
5. 1/10 blm, NFC	9.77	12.75	12.75	16.17	21.19	23.86	18.30
6. 1/10 blm, FC	9.36	12.66	14.18	14.56	19.20	22.24	18.19
LSD - Managements							
.05	NS	1.12	0.53	1.39	1.32	0.69	0.41
.01	NS	1.59	0.76	NS	1.88	0.98	0.55
$S_{\bar{x}}$	0.31	0.35	0.17	0.44	0.42	0.22	0.14
LSD - Managements X Years							
.05	1.30						
.01	1.75						
$S_{\bar{x}}$	0.44						

Table 4. Mean dry matter production per cutting and harvest date for Apex alfalfa during 1973.

	First cutting	Second cutting	Third cutting	Fourth cutting
	yield, mt/ha			
1. EB, 1/10 blm	5.73 (5/10)	2.44 (6/25)	3.98 (7/24)	3.25 (9/29)
2. FB, 1/10 blm	6.97 (5/22)	3.38 (7/2)	4.84 (8/13)	2.40 (9/29)
3. FB	6.51 (5/22)	2.64 (6/25)	4.14 (7/17)	3.76 (9/4)
4. 1/10 blm, FB	5.71 (5/28)	3.47 (7/2)	4.08 (8/2)	2.44 (9/29)
5. 1/10 blm, NFC	5.94 (5/28)	3.58 (7/2)	4.37 (8/13)	1.86 (9/5)*
6. 1/10 blm, FC	5.98 (5/28)	3.96 (7/2)	4.75 (8/13)	2.20 (9/30)
LSD - Managements				
.05	0.72	0.83	NS	0.40
.01	NS	NS	NS	0.58
$S_{\bar{x}}$	0.23	0.27	0.21	0.13

Table 5. Mean dry matter production per cutting and harvest date for Apex alfalfa during 1974.

	First cutting	Second cutting	Third cutting	Fourth cutting
	yield, mt/ha			
1. EB, 1/10 blm	3.11 (5/13)	2.40 (6/24)	3.27 (7/24)	2.91 (9/3)
2. FB, 1/10 blm	6.34 (5/28)	3.00 (7/2)	4.39 (8/8)	1.70 (9/3)*
3. FB	6.16 (5/28)	2.04 (6/24)	2.91 (7/24)	2.51 (9/3)
4. 1/10 blm, FB	5.80 (6/3)	2.64 (7/2)	2.89 (7/31)	2.06 (9/30)
5. 1/10 blm, NFC	5.85 (6/3)	2.64 (7/2)	4.19 (8/8)	1.68 (9/3)*
6. 1/10 blm, FC	5.82 (6/3)	2.64 (7/2)	3.96 (8/8)	2.17 (9/30)
LSD - Managements				
.05	0.78	NS	0.65	0.49
.01	1.10	NS	0.92	0.69
$S_{\bar{x}}$	0.25	0.21	0.20	0.16

* Aftermath

bud. Trend toward reduced production at tenth bloom was similar to that observed with Anchor. Early bud followed by tenth bloom and full bud all season treatments depressed second cutting yield of alfalfa. Treatments displayed no significant differences for third cutting production. Relatively higher fourth cutting yields were obtained with early bud followed by tenth bloom and full bud all season treatments.

Dry matter production per cutting and dates of harvest during 1974 are shown in Table 5. First cutting yields were similar for all treatments except for lower yields encountered with early bud harvest. Delay of harvest until tenth bloom did not lead to increased yield. No significant differences were observed among treatments for second growth. Third cutting yields with more intensive schedules, including early bud followed by tenth bloom, full bud all season, and tenth bloom followed by full bud, declined relative to other treatments. Trends in fourth cutting production were similar to those observed in 1973.

Accumulated production of dry alfalfa during 1973 is presented in Table 6. Seasonal production at second harvest revealed that cutting at early bud followed by tenth bloom produced substantially less than full bud with tenth bloom or tenth bloom continuously. Accumulated dry forage at third harvest showed, essentially, a magnification of differences at second harvest. Total dry matter production

Table 6. Accumulated dry matter production for Apex alfalfa during the 1973 and 1974 seasons.

	1973			1974			
	Second cutting	Third cutting	Total	Second cutting	Third cutting	Total	2 year average
	yield, mt/ha						
1. EB, 1/10 blm	8.18	12.19	16.91	5.51	8.78	11.69	14.31
2. FB, 1/10 blm	10.35	15.16	17.56	9.34	13.73	15.46	16.51
3. FB	9.16	13.33	17.38	8.20	11.11	13.64	15.50
4. 1/10 blm, FB	9.18	13.26	15.70	8.44	11.31	13.40	14.56
5. 1/10 blm, NFC	9.52	13.89	15.74	8.49	12.69	14.36	15.05
6. 1/10 blm, FC	9.95	14.69	16.89	8.47	12.43	14.58	15.75
LSD - Managements							
.05	1.16	1.03	1.32	1.28	1.59	1.81	1.05
.01	1.66	1.46	NS	1.81	2.28	NS	1.43
$S_{\bar{x}}$	0.37	0.33	0.42	0.40	0.51	0.58	0.36
LSD - Managements x Years							
.05	1.50						
.01	NS						
$S_{\bar{x}}$	0.50						

for 1973 showed improved performance of early bud followed by tenth bloom and full bud all season relative to other treatments. Tenth bloom followed by bud cuttings and tenth bloom all season without fall cutting produced markedly less total dry matter than treatments involving full bud initial cut.

Accumulated forage during 1974 also occurs in Table 6. Seasonal production including second harvest showed similar production by all treatments excluding sharply reduced yield with early bud first cutting. Accumulated yield at the third harvest showed a relatively high plane of production by full bud followed by tenth bloom and tenth bloom all season treatments. Early bud harvested treatment continued to exhibit pronounced yield depression. At the end of the second season fall cutting showed no appreciable effect on alfalfa harvested at tenth bloom all season. Delay of initial harvest from early bud to full bud stage with subsequent tenth bloom management led to pronounced enhancement of dry matter yield.

Average dry alfalfa production for the two-year period is also presented in Table 6. Treatments differed in relative response from season to season. As with Anchor, a management system including full bud first cutting provided consistently high yields of dry matter, however harvest at continuous tenth bloom provided similar yield response.

C. Washoe

Dry matter yields per cutting and respective harvest dates for 1973 are given in Table 7. Removal at pre-bud stage led to significantly lower first cutting production than delay of harvest to full bud. An apparent depression resulted from delay of harvest until tenth bloom during 1973. Yields of second growth forage were markedly lower with two consecutive full bud harvest or immature followed by tenth bloom cuts than with full bud followed by tenth bloom management. Third cutting yields were significantly higher for immature followed by tenth bloom than for full bud continuously, tenth bloom continuously with fall cutting, or tenth bloom followed by full bud. With respect to the fourth harvest, significantly more forage was produced by immature with tenth bloom or continuous full bud management than tenth bloom all season systems.

Yields of dry matter per cutting and harvest dates during 1974 are presented in Table 8. No statistically significant differences were detected among first or second cutting yields. Third cutting dry matter production for full bud all season was markedly reduced in comparison to most other schedules. Fourth cutting yields were low in all instances, often failing to reflect substantial differences in growth interval.

Accumulated dry matter yield for 1973 appears in Table 9. Seasonal production at second cutting showed yield for

Table 7. Mean dry matter production per cutting and harvest date for Washoe alfalfa during 1973.

	First cutting	Second cutting	Third cutting	Fourth cutting
		yield, mt/ha		
1. IM, 1/10 blm	4.77 (5/10)	2.89 (6/25)	4.50 (8/2)	2.46 (9/29)
2. FB, 1/10 blm	6.14 (5/22)	4.68 (7/2)	4.19 (8/13)	2.08 (9/29)
3. FB	6.41 (5/22)	2.80 (6/25)	3.52 (7/24)	2.78 (8/23)
4. 1/10 blm, FB	5.22 (6/2)	3.58 (7/2)	3.36 (8/2)	2.20 (9/29)
5. 1/10 blm, NFC	5.56 (6/2)	3.85 (7/10)	3.76 (8/13)	1.77 (9/4)*
6. 1/10 blm, FC	5.71 (6/2)	4.01 (7/10)	3.27 (8/13)	1.86 (9/30)
LSD - Managements				
.05	0.63	1.14	0.78	0.49
.01	0.90	NS	NS	0.72
$S_{\bar{x}}$	0.20	0.37	0.25	0.16

Table 8. Mean dry matter production per cutting and harvest date for Washoe alfalfa during 1974.

	First cutting	Second cutting	Third cutting	Fourth cutting
		yield, mt/ha		
1. IM, 1/10 blm	3.70 (5/13)	3.38 (7/2)	3.70 (8/8)	1.64 (9/3)*
2. FB, 1/10 blm	5.26 (5/28)	3.09 (7/9)	3.00 (8/15)	1.08 (9/3)*
3. FB	5.06 (5/28)	2.80 (7/2)	2.44 (7/31)	1.88 (9/3)
4. 1/10 blm, FB	5.20 (6/3)	2.84 (7/2)	3.90 (8/8)	1.88 (9/30)
5. 1/10 blm, NFC	5.76 (6/3)	3.25 (7/9)	3.61 (8/15)	1.41 (9/3)*
6. 1/10 blm, FC	5.02 (6/3)	3.14 (7/9)	3.29 (8/15)	1.95 (9/30)
LSD - Managements				
.05	NS	NS	0.63	0.27
.01	NS	NS	0.90	0.38
$S_{\bar{x}}$	0.38	0.31	0.20	0.08

* Aftermath

immature followed by tenth bloom managed alfalfa lagging relative to most other treatments. No differences were observed among treatments for cumulative yield during the remainder of the season.

Accumulated dry matter production for 1974 and mean production over two seasons are also found in Table 9. No differences were detected in accumulated yield during 1974 or in two-year average production.

D. Umatilla Station Varieties

Dry matter production per cutting and total yield for N-102, Saranac, and Vernal alfalfa during 1974 is contained in Table 10. First and third cutting yields of N-102 were significantly higher under a three-cutting scheme than with four harvests. Three harvests per year did not result in significantly greater seasonal production. An identical yield pattern was observed with Saranac. First and second cutting yields of Vernal were higher under three harvest managements but, again, no differences in total yield were obtained.

Crude Protein Content

A. Anchor

Percent crude protein values for individual cuttings in 1973 appear in Table 11. Crude protein content of first cutting indicates progressive decline with increasing maturity.

Table 9. Accumulated dry matter production for Washoe alfalfa during the 1973 and 1974 seasons.

	1973			1974			
	Second cutting	Third cutting	Total	Second cutting	Third cutting	Total	2 year average
				yield mt/ha			
1. IM, 1/10 blm	7.66	12.16	14.60	7.08	10.77	12.41	13.51
2. FB, 1/10 blm	10.82	15.01	17.09	8.36	11.38	12.45	14.77
3. FB	9.21	12.72	15.50	7.86	10.28	12.19	13.84
4. 1/10 blm, FB	8.78	12.16	14.36	8.04	11.96	13.80	14.07
5. 1/10 blm, NFC	9.41	13.17	14.94	9.00	12.61	14.02	14.48
6. 1/10 blm, FC	9.72	13.01	14.85	8.13	11.45	13.37	14.12
LSD - Managements							
.05	1.64	NS	NS	NS	NS	NS	NS
.01	NS	NS	NS	NS	NS	NS	NS
$S_{\bar{x}}$	0.52	0.69	0.80	0.51	0.57	0.60	0.50
LSD - Managements x Years							
.05	NS						
.01	NS						
$S_{\bar{x}}$	0.71						

Table 10. Mean dry matter production per cutting, harvest date, and total production for N-102, Saranac, and Vernal alfalfa during 1974.

	First cutting	Second cutting	Third cutting	Fourth cutting	Total
			yield, mt/ha		
N-102					
1. 4 cuttings	5.24 (5/21)	4.12 (6/24)	2.58 (7/31)	2.13 (9/2)	14.07
2. 3 cuttings	6.79 (5/27)	4.97 (7/9)	3.10 (8/22)	-	14.86
LSD - Managements					
.05	1.46	NS	0.22	-	NS
.01	NS	NS	0.43	-	NS
$S_{\bar{x}}$	0.32	0.30	0.50	-	0.53
Saranac					
1. 4 cuttings	4.94 (5/20)	3.66 (6/24)	2.65 (7/31)	2.66 (9/2)	13.91
2. 3 cuttings	6.64 (5/27)	4.56 (7/9)	3.68 (8/22)	-	14.88
LSD - Managements					
.05	0.94	NS	0.45	-	NS
.01	NS	NS	0.81	-	NS
$S_{\bar{x}}$	0.21	0.21	0.10	-	0.27
Vernal					
1. 4 cuttings	5.27 (5/21)	3.77 (6/24)	2.95 (7/31)	1.43 (9/2)	13.42
2. 3 cuttings	6.99 (5/27)	4.17 (7/9)	3.21 (8/22)	-	14.37
LSD - Managements					
.05	1.10	0.22	NS	-	NS
.01	NS	NS	NS	-	NS
$S_{\bar{x}}$	0.24	0.05	0.11	-	0.28

Second cutting values indicate lower protein content with continuous tenth bloom harvest than with other schedules. Early bud followed by tenth bloom and tenth bloom followed by full bud resulted in higher protein concentrations in second growth forage than all other treatments. Response of tenth bloom all season treatments at third cutting was similar to earlier harvests relative to other treatments. No significant differences occurred at third cutting for percent crude protein among treatments harvested initially at the bud stage. As discussed previously, statistical analysis was not performed on fourth cutting data.

Mean crude protein percentage data for each harvest during 1974 occurs in Table 12. Removal of first cutting at full bud or tenth bloom led to no significant change in crude protein content. Harvest at early bud resulted in marked improvement in percent crude protein over later harvest. Alfalfa harvested at bud stage for second cutting was higher in protein content than second harvest forage from tenth bloom all season schedules. No significant differences were apparent among treatments harvested at tenth bloom for second cutting, regardless of maturity at first cutting. Percent crude protein at third harvest was greater for full bud all season than all other treatments whether harvested at tenth bloom or bud stage. Aftermath harvest resulted in relatively high protein concentrations in fourth cutting forage.

Table 11. Mean crude protein concentration per cutting for Anchor alfalfa during 1973.

	First cutting	Second cutting	Third cutting	Fourth cutting
		Percent		
1. EB, 1/10 blm	16.94	20.36	19.20	17.54
2. FB, 1/10 blm	14.54	18.13	18.44	17.23
3. FB	14.72	18.05	19.37	24.72
4. 1/10 blm, FB	11.44	19.29	19.75	17.40
5. 1/10 blm, NFC	11.37	14.83	16.37	-
6. 1/10 blm, FC	12.62	14.90	16.59	24.06
LSD - Managements				
.05	1.06	0.83	1.04	-
.01	1.51	1.18	1.47	-
$S_{\bar{x}}$	0.34	0.26	0.29	-

Table 12. Mean crude protein concentration per cutting for Anchor alfalfa during 1974.

	First cutting	Second cutting	Third cutting	Fourth cutting
		Percent		
1. EB, 1/10 blm	19.35	17.41	18.67	20.91
2. FB, 1/10 blm	16.17	16.88	15.46	22.45
3. FB	16.75	19.40	21.89	19.58
4. 1/10 blm, FB	15.02	18.30	17.45	16.97
5. 1/10 blm, NFC	13.65	15.80	17.13	22.43
6. 1/10 blm, FC	15.57	15.75	16.99	16.27
LSD - Managements				
.05	2.34	1.91	2.63	2.19
.01	3.33	2.71	3.74	3.11
$S_{\bar{x}}$	0.74	0.60	0.83	0.69

Weighted mean percent crude protein for 1973 is presented in Table 13. Weighted means were calculated since they provide a measure of both quality and quantity of forage. They also minimize bias arising from inclusion of small quantities of high protein aftermath. Early bud followed by tenth bloom and full bud continuously produced alfalfa significantly higher in mean crude protein than all other treatments. While the yearly production was lower in protein than the above treatments, full bud followed by tenth bloom yielded forage higher in percent protein than the remaining schedules. The three regimes lowest in protein content in 1973 were all harvested initially at tenth bloom.

Weighted mean percent crude protein values for alfalfa harvested in 1974 are also given in Table 13. Early bud initial harvest with subsequent tenth bloom management and full bud all season produced higher protein forage than other harvest schedules. Full bud followed by tenth bloom was significantly higher in protein content than tenth bloom all season without fall cutting.

Response in terms of mean percent crude protein to management schedules was essentially the same from year to year. Average crude protein across both seasons, seen in Table 13, indicated that full bud all season and early bud with tenth bloom treatments led to significantly higher protein alfalfa. Full bud followed by tenth bloom also led to higher protein forage than continuous tenth bloom management.

Table 13. Weighted mean crude protein concentration and two year average for Anchor alfalfa during 1973 and 1974.

	1973	1974	2 year average
		Percent	
1. EB, 1/10 blm	18.21	18.79	18.50
2. FB, 1/10 blm	16.73	17.11	16.92
3. FB	17.71	18.67	18.19
4. 1/10 blm, FB	15.82	16.64	16.23
5. 1/10 blm, NFC	13.69	15.86	14.77
6. 1/10 blm, FC	15.44	16.01	15.72
LSD - Managements			
.05	0.86	1.25	0.71
.01	1.22	1.78	0.97
$S_{\bar{x}}$	0.27	0.40	0.24
LSD - Managements x Year			
.05	NS		
.01	NS		
$S_{\bar{x}}$	0.34		

B. Apex

Percent crude protein values for individual cuttings in 1973 are listed in Table 14. Trends toward decreasing crude protein content with increasing maturity were observed at first cutting. A highly significant difference of approximately three percent crude protein was observed between early bud and full bud stage. Protein levels at second cutting indicate continuous full bud schedule resulted in highest protein for that harvest. No significant differences were observed among other schedules for second growth forage. The same pattern of response persisted with third cutting alfalfa. Aftermath harvest resulted in very high crude protein content at fourth cutting.

Weighted mean percent crude protein for 1973 is given in Table 14. These data showed that significantly higher levels of crude protein are obtainable by cutting at early bud initially followed by tenth bloom or at full bud all season. Other treatments did not differ except as a result of aftermath forage.

Second year protein samples for Apex were destroyed in a drying oven malfunction.

C. Washoe

Crude protein percentages by individual cutting for 1973 are contained in Table 15. Protein content of first cutting suggested that highly significant increases of four

Table 14. Mean crude protein concentration per cutting and weighted mean for Apex alfalfa during 1973.

	First cutting	Second cutting	Third cutting	Fourth cutting	Weighted mean
			percent		
1. EB, 1/10 blm	19.38	15.78	18.84	17.74	19.04
2. FB, 1/10 blm	16.04	15.60	17.26	18.96	16.67
3. FB	16.32	18.68	23.02	18.26	18.45
4. 1/10 blm, FB	14.91	16.76	18.18	18.54	16.76
5. 1/10 blm, NFC	15.73	16.24	17.98	25.02	17.61
6. 1/10 blm, FC	15.15	16.53	17.63	19.84	16.80
LSD - Managements					
.05	0.42	1.41	2.42	1.35	0.77
.01	0.60	2.01	3.44	1.92	1.09
$S_{\bar{x}}$	0.13	0.45	0.77	0.43	0.24

Table 15. Mean crude protein concentration per cutting for Washoe alfalfa during 1973.

	First cutting	Second cutting	Third cutting	Fourth cutting
	Percent			
1. IM, 1/10 blm	20.55	19.28	17.67	17.60
2. FB, 1/10 blm	18.24	17.20	17.23	19.96
3. FB	16.20	18.50	18.44	19.32
4. 1/10 blm, FB	15.82	19.53	18.12	16.94
5. 1/10 blm, NFC	16.07	16.67	18.17	26.27
6. 1/10 blm, FC	14.96	16.49	19.44	19.29
LSD - Managements				
.05	2.18	NS	NS	2.05
.01	3.10	NS	NS	2.92
$S_{\bar{x}}$	0.69	0.75	0.63	0.65

Table 16. Mean crude protein concentrations per cutting for Washoe alfalfa during 1974.

	First cutting	Second cutting	Third cutting	Fourth cutting
	Percent			
1. IM, 1/10 blm	20.80	16.95	17.45	23.91
2. FB, 1/10 blm	16.71	17.78	16.50	26.55
3. FB	17.22	19.57	20.87	24.25
4. 1/10 blm, FB	15.68	19.83	17.64	17.17
5. 1/10 blm, NFC	16.50	18.26	16.90	26.66
6. 1/10 blm, FC	15.90	17.55	16.14	19.42
LSD - Managements				
.05	1.30	1.98	2.48	2.28
.01	1.85	2.81	3.56	3.24
$S_{\bar{x}}$	0.41	0.63	0.79	0.72

or five percent can be obtained by harvesting at an immature-prebud stage as opposed to tenth bloom. No significant differences were detected among percent crude protein values for second and third harvests. Aftermath effects were quite apparent in protein content of fourth cutting forage.

Individual cutting crude protein values for 1974 are listed in Table 16. The crude protein content of alfalfa harvested at pre-bud stage was sharply higher than other treatments at first harvest. First cutting results further indicate that full bud harvest as opposed to tenth bloom provided only a marginal increase in crude protein. Stage of maturity at initial harvest had no apparent effect on crude protein level of forage harvested at tenth bloom for second harvest. Removal of second harvest at full bud led to significant increases in crude protein over tenth bloom in several instances. Increased crude protein percentage at third cutting was observed with the full bud all season schedule. All other regimes were similar in protein content for the above cutting. Since only tenth bloom followed by full bud and tenth bloom all season with fall cutting reached stipulated maturity, most differences at fourth harvest reflected aftermath effects.

Weighted mean crude protein percentages for 1973 are shown in Table 17. Harvest at prebud followed by tenth bloom provided significantly higher protein alfalfa than other management schedules excluding tenth bloom all season

Table 17. Weighted mean crude protein concentration and two year average for Washoe alfalfa during 1973 and 1974.

	1973	1974	2 year average
		Percent	
1. IM, 1/10 blm	18.95	19.16	19.06
2. FB, 1/10 blm	17.87	17.76	17.82
3. FB	17.67	19.58	18.63
4. 1/10 blm, FB	17.42	17.34	17.38
5. 1/10 blm, NFC	17.95	18.05	18.00
6. 1/10 blm, FC	16.92	16.90	16.91
LSD - Managements			
.05	1.01	0.89	0.63
.01	1.44	1.27	0.86
$S_{\bar{x}}$	0.32	0.28	0.21
LSD - Managements and Years			
.05	0.89		
.01	NS		
$S_{\bar{x}}$	0.30		

without fall cutting. The latter was higher in mean percent crude protein than similar management with fall cutting chiefly as a result of fourth cutting differences.

Weighted mean crude protein levels for alfalfa from the 1974 season, Table 17, indicated that either immature with tenth bloom or full bud all season led to significant increases in protein content. Tenth bloom harvest without fall cutting provided higher protein alfalfa than like management with fall cutting, again, largely as a result of fourth cutting differences.

Continuous full bud harvesting produced markedly higher protein alfalfa in relation to other regimes in 1974 than in 1973. Other treatments responded similarly relative to each other across both seasons. Average crude protein for both seasons, Table 17, showed that prebud followed by tenth bloom and full bud all season were higher in protein than the remaining treatments. Aftermath effects continued to cause increased protein with tenth bloom without fall cutting.

D. Umatilla Station Varieties

Individual cutting and weighted mean seasonal percent crude protein for N-102 during 1974 appears in Table 18. Four cuttings per season provided significant and highly significant increases in protein content for first and second harvests, respectively. Four cuttings per season

Table 18. Mean crude protein concentration per cutting and weighted mean total for N-102, Saranac, and Vernal alfalfa during 1974.

	First cutting	Second cutting	Third cutting	Fourth cutting	Weighted mean
			Percent		
N-102					
1. 4 cuttings	17.73	17.74	17.71	19.23	17.96
2. 3 cuttings	16.10	16.16	17.40	-	16.44
LSD - Managements					
.05	1.03	0.50	NS	-	1.23
.01	NS	0.91	NS	-	NS
$S_{\bar{x}}$	0.23	0.11	0.84	-	0.27
Saranac					
1. 4 cuttings	20.09	18.34	18.90	20.57	19.51
2. 3 cuttings	17.22	17.45	18.44	-	17.59
LSD - Managements					
.05	0.69	NS	NS	-	0.13
.01	1.27	NS	NS	-	0.24
$S_{\bar{x}}$	0.33	0.50	0.40	-	0.03
Vernal					
1. 4 cuttings	18.88	19.44	19.82	19.55	19.30
2. 3 cuttings	17.83	18.30	18.11	-	18.05
LSD - Managements					
.05	0.54	NS	NS	-	0.58
.01	0.99	NS	NS	-	1.02
$S_{\bar{x}}$	0.12	0.51	0.44	-	0.13

failed to produce a significant improvement in protein level in third cutting alfalfa. Weighted mean protein percentage was significantly enhanced by four cutting management.

Protein data for Saranac, Table 18, indicated highly significant rise in percent crude protein at first cutting with a four harvests regime. Protein levels of second and third growth alfalfa was unchanged by more frequent cutting. A highly significant improvement in seasonal protein level was obtained with a four cutting schedule.

With Vernal alfalfa, Table 18, a highly significant increase in protein was again obtained for first cutting with four harvests per season. Data for later cuttings show no significant increase due to harvest management. Seasonal protein levels were positively effected by increasing harvest frequency.

Yield of Crude Protein

A. Anchor

Production of crude protein per cutting for 1973 is shown in Table 19. First cutting protein yields suggested significant decline in protein production with advancing maturity at harvest. Reduced protein yield at second cutting resulted from early bud followed by tenth bloom and continuous tenth bloom management. Harvesting at tenth bloom all season led to significantly less protein for

Table 19. Mean yield of crude protein per cutting for Anchor alfalfa during 1973.

	First cutting	Second cutting	Third cutting	Fourth cutting
	Yield, kg/ha			
1. EB, 1/10 blm	1141	590	725	456
2. FB, 1/10 blm	881	744	708	419
3. FB	975	768	693	444
4. 1/10 blm, FB	648	762	663	442
5. 1/10 blm, NFC	637	622	486	-
6. 1/10 blm, FC	660	616	544	369
LSD - Managements				
.05	146	67	134	-
.01	207	96	NS	-
$S_{\bar{x}}$	46	21	42	-

Table 20. Mean yield of crude protein per cutting for Anchor alfalfa during 1974.

	First cutting	Second cutting	Third cutting	Fourth cutting
	Yield, kg/ha			
1. EB, 1/10 blm	1342	1191	789	612
2. FB, 1/10 blm	1312	1263	816	734
3. FB	1539	1023	739	633
4. 1/10 blm, FB	1347	1103	753	515
5. 1/10 blm, NFC	1214	1111	862	575
6. 1/10 blm, FC	1272	1016	772	496
LSD - Managements				
.05	NS	NS	NS	NS
.01	NS	NS	NS	NS
$S_{\bar{x}}$	84	54	40	58

third harvest than most other treatments. Fourth cutting data were incomplete and hence unanalyzed.

Individual cutting protein yields for 1974 are found in Table 20. No detectable differences were observed among treatments for any harvest in 1974.

Accumulated protein yields for 1973 are presented in Table 21. Significantly greater accumulated protein was observed at second harvest with early bud followed by tenth bloom and full bud first cut followed by either full bud or tenth bloom in comparison to other schedules. This pattern persisted for accumulated protein at third and also final harvests. Fall cutting caused improved protein production in tenth bloom managed alfalfa.

Accumulated crude protein in 1974, Table 21, shows no substantive differences at second or third cutting. For total protein no differences were observed among early bud with tenth bloom, full bud with tenth bloom, and full bud all season treatments. Full bud followed by tenth bloom produced more protein than any schedule which included tenth bloom first cutting. Fall cutting had no significant effect on the crude protein yield of tenth bloom managed alfalfa during 1974.

Average crude protein yield across both seasons, Table 21, was quite similar for management systems requiring removal of first growth prior to tenth bloom. Two-year mean protein yields revealed essentially no difference due to

Table 21. Accumulated crude protein production for Anchor alfalfa for 1973 and 1974.

	1973			1974			
	Second cutting	Third cutting	Total	Second cutting	Third cutting	Total	2 year average
	yield, kg/ha						
1. EB, 1/10 blm	1731	2455	2911	2532	3321	3934	3422
2. FB, 1/10 blm	1625	2335	2751	2575	3391	4125	3438
3. FB	1744	2436	2880	2562	3300	3933	3407
4. 1/10 blm, FB	1410	2073	2452	2450	3202	3717	3085
5. 1/10 blm, NFC	1258	1744	1744	2351	3187	3782	1763
6. 1/10 blm, FC	1276	1820	2188	2288	3061	3557	2873
LSD - Managements							
.05	141	202	249	NS	NS	284	177
.01	200	287	354	NS	NS	NS	241
$S_{\bar{x}}$	45	64	71	85	84	156	60
LSD - Managements x Years							
.05	223						
.01	304						
$S_{\bar{x}}$	85						

fall cutting on alfalfa harvested continuously at tenth bloom.

B. Apex

Crude protein production by cutting for 1973 is presented in Table 22. Data for first harvest showed no significant change in protein yield from early bud to full bud stage. Delay of first harvest until tenth bloom resulted in significant decline in yield of protein at first cutting. No differences in protein production were observed among treatments for second and third harvests. Early bud followed by tenth bloom and full bud all season harvest schedules led to significantly higher fourth cutting protein yields.

Accumulated crude protein yields for 1973 are given in Table 23. No significant differences in accumulated protein were detected at second, third or final cutting.

C. Washoe

Yield of crude protein by cutting for 1973 appears in Table 24. Increases in crude protein production for first cutting, although irregular, tended to indicate greater production at full bud than at tenth bloom. No differences were observed among treatments for protein yield of second or third growth forage. Data for fourth cutting alfalfa show full bud all season produced more protein than other treatments excepting tenth bloom without fall cutting.

Table 22. Mean yield of crude protein per cutting for Apex alfalfa during 1973.

	First cutting	Second cutting	Third cutting	Fourth cutting
	yield, kg/ha			
1. EB, 1/10 blm	1113	389	753	575
2. FB, 1/10 blm	1117	528	830	454
3. FB	1065	495	959	690
4. 1/10 blm, FB	852	584	742	454
5. 1/10 blm, NFC	933	584	787	465
6. 1/10 blm, FC	907	657	842	433
LSD - Managements				
.05	131	NS	NS	73
.01	186	NS	NS	104
$S_{\bar{x}}$	42	67	58	23

Table 23. Accumulated crude protein production for Apex alfalfa for 1973.

	Second cutting	Third cutting	Fourth cutting
	yield, kg/ha		
1. EB, 1/10 blm	1502	2255	3223
2. FB, 1/10 blm	1645	2474	2929
3. FB	1560	2519	3209
4. 1/10 blm, FB	1436	2178	2632
5. 1/10 blm, NFC	1517	2304	2769
6. 1/10 blm, FC	1563	2405	2466
LSD - Managements			
.05	NS	NS	NS
.01	NS	NS	NS
$S_{\bar{x}}$	64	73	203

Table 24. Mean yield of crude protein per cutting for Washoe alfalfa during 1973.

	First cutting	Second cutting	Third cutting	Fourth cutting
	yield, kg/ha			
1. IM, 1/10 blm	981	560	796	430
2. FM, 1/10 blm	1126	792	730	416
3. FB	1035	518	647	538
4. 1/10 blm, FB	824	693	610	372
5. 1/10 blm, NFC	891	641	684	464
6. 1/10 blm, FC	853	662	640	357
LSD - Managements				
.05	184	NS	NS	101
.01	NS	NS	NS	NS
$S_{\bar{x}}$	58	55	55	32

Table 25. Mean yield of crude protein per cutting for Washoe alfalfa during 1974.

	First cutting	Second cutting	Third cutting	Fourth cutting
	yield, kg/ha			
1. IM, 1/10 blm	766	572	644	391
2. FB, 1/10 blm	881	546	498	287
3. FB	872	548	509	459
4. 1/10 blm, FB	812	510	689	323
5. 1/10 blm, NFC	954	593	610	378
6. 1/10 blm, FC	800	551	536	378
LSD - Managements				
.05	NS	NS	NS	82
.01	NS	NS	NS	NS
$S_{\bar{x}}$	70	60	49	26

Protein production per harvest during 1974 is shown in Table 25. Treatments failed to exact substantive differential effects on protein production in the first, second, and third harvests. Differences in fourth cutting yield of protein suggest immature followed by tenth bloom and full bud all season treatments produced appreciably more protein than full bud followed by tenth bloom.

Accumulated crude protein production during 1973 and 1974 appears in Table 26. Cumulative seasonal yield of protein showed no response to treatments imposed during either year. Treatment means considered across both years were likewise similar.

D. Umatilla Station Varieties

Individual cutting and total seasonal yield of crude protein for N-102, Saranac, and Vernal alfalfa during 1974 is contained in Table 27. While occasional differences from individual cuttings were observed, treatments failed to effect significant change in seasonal protein yield.

<u>Stand Density</u>

A. Anchor

Mean yearly stand counts for 1973, 1974, and 1975 are shown in Table 28. Since densities in 1973 were measured in the fall, the observed differences for that year may have resulted from inherent variation within the experimental

Table 26. Accumulated crude protein production for Washoe alfalfa for 1973 and 1974.

	1973			1974			
	Second cutting	Third cutting	Total	Second cutting	Third cutting	Total	2 year average
				yield, kg/ha			
1. IM, 1/10 blm	1542	2338	2768	1338	1983	2374	2571
2. FB, 1/10 blm	1919	2648	3065	1427	1925	2212	2638
3. FB	1553	2200	2739	1419	1929	2387	2563
4. 1/10 blm, FB	1577	2127	2496	1382	2071	2394	2445
5. 1/10 blm, NFC	1532	2216	2680	1546	2156	2534	2607
6. 1/10 blm, FC	1576	2155	2513	1350	1886	2264	2389
LSD - Managements							
.05	NS	NS	NS	NS	NS	NS	NS
.01	NS	NS	NS	NS	NS	NS	NS
$S_{\bar{x}}$	93	120	146	86	110	125	96
LSD - Managements x Years (total)							
.05	NS						
.01	NS						
$S_{\bar{x}}$	123						

Table 27. Mean yield of crude protein per cutting and total for N-102, Saranac, and Vernal alfalfa during 1974.

	First cutting	Second cutting	Third cutting	Fourth cutting	Total
			yield, kg/ha		
N-102					
1. 4 cuttings	929	731	459	411	2530
2. 3 cuttings	1094	804	537	-	2435
LSD - Managements					
.05	NS	NS	NS	-	NS
.01	NS	NS	NS	-	NS
$S_{\bar{x}}$	44	52	33	-	85
Saranac					
1. 4 cuttings	993	675	502	547	2717
2. 3 cuttings	1142	799	677	-	2618
LSD - Managements					
.05	NS	NS	99	-	NS
.01	NS	NS	NS	-	NS
$S_{\bar{x}}$	41	49	22	-	53
Vernal					
1. 4 cuttings	994	734	583	280	2591
2. 3 cuttings	1247	764	582	-	2593
LSD - Managements					
.05	241	NS	NS	-	NS
.01	NS	NS	NS	-	NS
$S_{\bar{x}}$	53	20	21	-	71

Table 28. Mean stand density for Anchor alfalfa during 1973, 1974, and 1975.

	1973	1974	1975	Mean
		crowns/m^2		
1. EB, 1/10 blm	189	96	89	125
2. FB, 1/10 blm	215	121	106	147
3. FB	226	117	106	150
4. 1/10 blm, FB	194	119	118	144
5. 1/10 blm, NFC	138	83	72	98
6. 1/10 blm, FC	155	81	99	112
Mean	186	103	98	-
LSD - Managements				
.05	42	18	17	15
.01	60	25	24	20
$S_{\bar{x}}$	13	6	5	5
LSD - Years		LSD - Man x Years		
.05	16	.05		26
.01	26	.01		NS
$S_{\bar{x}}$	10	$S_{\bar{x}}$		9

Table 29. Mean stand density for Apex alfalfa during 1973, 1974, and 1975.

	1973	1974	1975	Mean
		crowns/m^2		
1. EB, 1/10 blm	125	90	55	90
2. FB, 1/10 blm	152	90	33	92
3. FB	132	76	45	84
4. 1/10 blm, FB	147	95	52	98
5. 1/10 blm, NFC	157	93	31	93
6. 1/10 blm, FC	153	86	47	96
Mean	144	88	44	-
LSD - Managements				
.05	NS	NS	NS	NS
$S_{\bar{x}}$	8	8	6	4
LSD - Years		LSD - Man x Years		
.05	23	.05		NS
.01	38	.01		NS
$S_{\bar{x}}$	6	$S_{\bar{x}}$		7

area. This possibility is, however, unlikely due to the magnitude and regularity of the differences and since the stand was relatively new. Concepts of randomness in experimental design were rigorously applied. Observed differences more likely resulted from treatment-induced stand decline during the first season of the experiment. Reduction was significantly greater for continuous tenth bloom harvest than for treatments involving full bud stage first cutting.

Data for 1974 indicated significantly greater thinning occurred with early bud followed by tenth bloom and tenth bloom all season than with other schedules. Highly significant stand loss was measured with all treatments during the winter of 1973-1974.

Stand densities in the spring of 1975 suggested that full bud with tenth bloom, full bud all season, and tenth bloom followed by full bud schedules led to similar stand densities after two years. Significantly lower densities were obtained with tenth bloom all season without fall cutting and early bud followed by tenth bloom. No harvest schedule induced substantive decline in stand during the 1974 season and subsequent winter.

B. Apex

Mean stand counts for 1973, 1974, and 1975 are presented in Table 29. Management systems failed to cause differential decline in stand density for any year. All treatments resulted in highly significant stand losses during intervals between counts.

C. Washoe

Stand density data for 1973, 1974, and 1975 occurs in Table 30. Counts taken in the fall of 1973 indicated significant differences among treatments. Considering the age of the stand it may not be possible to conclude that these differences, in fact, arose from treatment influences. Differences among treatments in 1974 suggested greater decline as a result of full bud followed by tenth bloom and tenth bloom continuously than full bud all season and tenth bloom followed by full bud. The winter of 1973-1974 effected significant decline on all treatments except tenth bloom followed by full bud. Stand densities in 1975 indicated no differences among treatments. Full bud followed by tenth bloom and tenth bloom all season without fall cutting were the only treatments not inducing substantive stand reductions during the 1974-1975 period.

Recovery Year Dry Matter Yield

First cutting yields of dry matter for Anchor, Apex, and Washoe are presented in Table 31. No differences in herbage yield were observed among treatments with any variety.

Table 30. Mean stand density for Washoe alfalfa during 1973, 1974 and 1975.

	1973	1974	1975	Mean
		crowns/m^2		
1. IM, 1/10 blm	112	79	57	82
2. FB, 1/10 blm	132	63	51	82
3. FB	122	93	54	89
4. 1/10 blm FB	98	90	51	80
5. 1/10 blm, NFC	153	69	42	88
6. 1/10 blm, FC	149	58	54	87
Mean	127	75	52	-
LSD - Managements				
.05	23	21	NS	NS
.01	33	NS	NS	NS
$S_{\bar{x}}$	7	7	7	4
LSD - Years				
.05	13			
.01	21			
$S_{\bar{x}}$	3			
LSD - Managements x Years				
.05	20			
.01	27			
$S_{\bar{x}}$	7			

Table 31. Recovery year yields at first cutting for Anchor, Apex, and Washoe on March 28, 1975.

	Anchor	Apex	Washoe
		yield, mt/ha	
1. EB (IM), 1/10 blm	5.31	3.07	3.56
2. FB, 1/10 blm	5.71	3.52	3.54
3. FB	5.78	3.52	3.49
4. 1/10 blm, FB	6.38	3.27	3.56
5. 1/10 blm, NFC	5.08	3.58	3.96
6. 1/10 blm, FC	5.82	3.72	4.21
LSD - Managements			
.05	NS	NS	NS
.01	NS	NS	NS
$S_{\bar{x}}$	0.28	0.42	0.33

Considerable invasion by weedy species, chiefly members of the Brassica, Bromus, and Capsella genera, occurred in the Apex stand by the spring of 1975. Visual weed ratings were taken with approximately 75 percent weeds in all plots. There was no apparent relationship between weed population and treatments. Invasion by weeds was judged to be zero in the case of Anchor and less than ten percent with Washoe.

DISCUSSION

Dry Matter Yield

A. Anchor

The decline in yield per cutting as the season progressed was expected. This phenomenon is observed over a broad range of climatic conditions and probably reflects a response to temperature and photoperiod. The lack of increase in dry matter production from early bud stage to tenth bloom at first cutting is unexplained. Effects of this type are not normally observed until alfalfa approaches full bloom. Such response is not readily attributable to leaf drop or high temperature early in the season. Soil moisture was adequate at harvest. A period of low night temperatures normally occurring in late May could be implicated.

The relatively better performance of more intensively managed treatments during the first season represents established trends for this period. Effects on longevity are often unexpressed during the first year. Second season production suggests consequences of such management: reduced vigor and lower production. The effects of removing fall growth appear to follow a similar pattern. The tenth bloom followed by full bud schedule, based on the observation that delayed first harvest can compensate for more liberal management the previous season, demonstrates that this effect is of marginal advantage for dry matter production.

B. Apex

The increase in dry matter through delay of first harvest from early bud to full bud was expected. This generally represents continued increase in production of stem tissue after the increase in leaf material observed in early phases of regrowth has subsided. The peaking of dry matter accumulation at full bud stage as also observed with Anchor is perplexing. Its occurrence across a broad range of production conditions including fertility, soil type, and irrigation suggests pervasive influences of considerable interest.

Variation in relative yield of bud and tenth bloom cuttings later in the season reflects both differences in previous management and differences in the time frame during which growth occurred. Changes in climatic conditions, chiefly temperature, can profoundly affect the onset of maturity. The precise cause of the depression in yield observed at second harvest is unknown. Such response is often measured later in the season in the Southwest (6) and is attributed to high temperatures.

Accumulated dry matter during the first season suggests the usual pattern of increased production with moderate increases in cutting management intensity. Second year yields display an expected inclination toward higher yields with less intensive management. Relatively lower yields with early bud initial harvest during second year indicates serious impairment of vigor generally associated with exhaustion of carbohydrate reserves. Apparently more conservative subsequent management was unable to compensate. The absence of fall cutting effects with this variety may arise from greater tolerance to winter temperatures and/or superior efficiency of reserve accumulation. It is also possible that the rather rapid general deterioration of stand with this variety has concealed potential autumn management effects.

C. Washoe

The general lack of yield response observed with this variety to cutting management variables may indicate selection keyed to persistence. Variability within the experimental area, likely arising from the age of the stand, may have prevented statistical detection of less dramatic effects.

D. Umatilla Station Varieties

Increased dry matter with later first harvest date did not coincide with observations for other locations and varieties. Much of this effect may be attributed to soil and irrigation variables. Later stages of maturity with the three cut regime than any involved at other locations may also be involved. The lack of significant total dry matter yield differences does not correspond with other locations, where significant yield increases were often obtained with more intensive management during the first year. Again, a host of soil, irrigation, varietal, and maturity variables may be involved.

Percent and Yield of Crude Protein

A. Anchor

Delay of first harvest had the anticipated effect of decreasing the percent crude protein of the herbage. These effects purportedly arise from continued production of fibrous stem tissue with little net increase in leaf material after an optimum leaf area is achieved. First cutting decline in yield of protein during the initial season can probably be ascribed to similar effects. Protein content was generally observed to increase while yield of protein declined as the season progressed, provided forage was removed at a consistent stage of maturity. Effects on percent protein issue from an increased leaf/stem ratio in later cuttings, whereas, protein production reflects typical seasonal pattern of declining dry matter production.

Seasonal average protein content suggests, as expected, that more intensive management involving earlier stages of maturity result in higher protein forage. Data further suggest that early removal of heavy first cutting growth at high protein content can allow delay of subsequent harvests to tenth bloom without significant decline in seasonal percent or yield of crude protein compared with continuous full bud management.

B. Apex

First year protein data show general trends quite similar to Anchor. The decline in percent and yield of protein with maturity is attributed to declining leaf/stem ratio and to the decline in yield of dry matter after full bud stage. The general increase in protein content at constant stage of maturity as the season progresses, again, would be largely a temperature induced phenomenon. Since total yield of protein was unchanged by treatment, percent protein data render more intensive management schedules attractive.

Considerable risk surrounds any attempt at projection concerning the effects of treatments on protein during the second year. The temptation to compare with Anchor is resisted given location variables. Although both Flemish varieties reacted similarly the first season, trends for the succeeding year were widely divergent with respect to dry matter production.

C. Washoe

The marginal decline in percent protein at increased maturity observed with this variety may reflect the effects of a thinning stand on leaf/stem ratios and/or a less stemmy habit of growth. These factors, however, did not preclude typical increases in protein in later cuttings.

The significant increase in percent protein without fall cutting seems to have resulted chiefly from a relatively immature aftermath harvest. The absence of increase or even decrease in protein yield with an additional month's growth until fall cutting indicates little late season productivity with this variety. In fact, the utility of four harvests per season in a continuous tenth bloom schedule is questionable with Washoe. Three harvest management, however, would likely incur further reduction in protein content along with possible decline in protein yield. The significant increase in weighted seasonal percent protein with continuous full bud management during the second season is unexplained. It was apparent throughout the season although somewhat more pronounced later. Seasonal climatic differences would presumably have affected all treatments uniformly.

D. Umatilla Station Varieties

Data suggest that the fourth cutting increment in protein yield is insufficient to result in increased seasonal yield of protein over a three cut schedule. The significant increase in crude protein production at first harvest from three cutting management of Vernal may result from its relatively later development in the spring, hence earlier harvest with interval schedules. Increased percent crude protein with four cuts per season was expected when forage is removed at earlier stages of development. Relatively large changes in first cutting protein content with differential management for Saranac and N-102 is of interest in terms of potential for intensive management using stage of maturity criteria.

Stand Density

A. Anchor

The considerable loss of stand during the first season and over the subsequent winter resulted largely from natural thinning which usually occurs during the early years of a stand's production. The precise cause of the greater reduction associated with tenth bloom management is unclear. Others (6) have observed similar trends at more advanced maturity and attributed it to respiratory loss of root reserves at high summer temperatures. The phenomenon may be linked to the decline in yield observed at first cutting with tenth bloom harvest. The absence of significant stand losses between 1974 and 1975 counts is encouraging. It indicates that, at least with relatively young stands, this variety is compatible with a wide variety of management systems. Recovery yields suggest that, while differences in stand density did develop, the threshold of yield limitation was not yet attained. In the absence of more extended studies it is difficult to speculate regarding estimated stand life.

B. Apex

It seems clear that extended stand life with this variety would be impossible using any of the selected management schedules. Three to four years of production would appear to be the maximum longevity possible with these regimes. The observed stand decline likely arose from an interaction of management, winterhardiness, and disease factors. It is uncertain whether further reduction of harvest frequency would prolong stand life since no trends in this regard were observed among treatments.

C. Washoe

Data indicates little differential effect by treatments at termination of the study. The proportionately greater winter loss during the 1973-1974 period due to continuous tenth bloom management does not conform to usual patterns of winterhardiness observed with this variety. Its occurrence irrespective of autumn management would appear to rule out the influence of fall carbohydrate accumulation. Final stand measurements indicate relatively low crown densities can still maintain satisfactory competition with weeds. Residual yields are characterized by relatively low levels of productivity. Such results may be attributed at least in part to the more advanced age of the stand. Although it is difficult to predict effects on younger stands, it seems reasonable to suggest that this variety is relatively tolerant of more intensive management.

Practical Considerations

The selection of an appropriate cutting management system for any specific farm operation necessitates the selection of an adequate balance among dry matter, protein, and longevity factors to best suit a producer's needs. This balance often heavily favors the dry matter component in areas, such as Oregon, where the development of effective forage grading and marketing guidelines has been only recently initiated. Dairy, dehydration, and protein extraction interests, however, have the potential for markedly altering the complexion of alfalfa marketing procedures in terms of quality factors. Areas of surplus alfalfa production such as the Columbia Basin counties should be keenly aware of these developments.

An intelligent choice between various harvest schedules requires consideration of several relevant economic factors. Of prime importance among these are fixed costs per hectare per cutting. These costs, including labor, fuel, and deterioration of equipment, must be evaluated when comparing schedules involving an increased number of cuttings per season.

A marketing system based on quality, alluded to earlier, can also have considerable impact. Premium prices for a higher quality product tend to offset its increased cost of production. A voluntary program, currently under development in Oregon, involves 30 cent increase or decrease in price per unit for each tenth percent deviation from a base protein level.

The intended use for the harvested forage is also of importance. The demands of the dairy and dehydration markets are more in keeping with intensive cutting schedules whereas those of feedlot interests often correspond with less intensive regimes.

Longevity requirements may also influence the selection of harvest schedule. Alfalfa in relatively short term rotations with other crops is most compatible with rigorous cutting schedules, however, more permanent stands often indicate more conservative management. Establishment costs must also be considered.

While it is not within the scope of these studies to evaluate the data in terms of the above factors, it is suggested that such considerations be thoroughly investigated before engaging in practical application of the results.

SUMMARY AND CONCLUSIONS

Studies were conducted to identify superior cutting management schedules for irrigated alfalfa in the Columbia Basin Region of northeastern Oregon. Studies were restricted to the coarse textured soils of the Columbia River terraces. Efforts were made to select locations which sampled the several sprinkler irrigation systems in use in the area.

There were six treatments imposed on the varieties Anchor (center-pivot), Apex (side-roll), and Washoe (side-roll). Two groups of treatments, including consecutive cuts at the same stage of maturity and cuts made at varying maturities were selected. The first group consisted of tenth bloom all season with and without fall cutting and full bud all season. The next group contained early or prebud followed by tenth bloom, full bud followed by tenth bloom, and tenth bloom followed by full bud until late September.

The varieties, N-102, Saranac, and Vernal, were subjected to three and four cuts per season under hand-moved irrigation at the Umatilla Branch Experiment Station. These frequencies corresponded to intervals of approximately 44 and 35 days, respectively.

Using one (Anchor), three (Apex), and five (Washoe) year old stands, treatments were imposed during two complete growing seasons. Data were collected for yield of oven dry matter, protein concentration, and stand density. Recovery yields and additional stand data were obtained during the spring of the third season. Umatilla Station varieties were exposed to treatments during their third season. Data on dry matter yield and percent protein were recorded.

Based on the results obtained, the following conclusions concerning cutting management are drawn:

1. Under center-pivot irrigation with the variety Anchor cutting at full bud followed by tenth bloom offers advantages over continuous tenth bloom. These include increased percent and yield of protein at no sacrifice in dry matter Stand maintenance with the earlier first cutting was quite competitive with more conservative schedules. Harvest at full bud all season or early bud followed by tenth bloom compared favorably with full bud followed by tenth bloom with respect to protein yield. The former treatments offer increased protein content while the latter offers increased dry matter. Any decision concerning the merits of these treatments, then would be based on the relative value placed on each of these components. In view of the small differences involved, stand density would probably not be an important consideration.

2. The variety Apex with side-roll irrigation would not be selected where long term productivity was a major objective. In the event that a relatively short stand life is acceptable, cutting at full bud followed by tenth bloom appears to result in no particular advantage over continuous tenth bloom with fall cutting. A slight increase in protein content accompanied by a slight decrease in dry matter was observed without fall cutting as compared to full bud with tenth bloom. In relation to the latter treatment, full bud all season offered statistically similar yields of dry matter while percent protein was considerably increased the first year. Further data as regards protein would provide a firmer basis for statements concerning this component.

3. The absence of dry matter response to treatments with Washoe under side-roll irrigation permits selection on the basis of protein alone. Either early bud followed by tenth bloom or full bud all season offers the best in terms of protein. Treatments resulted in stand density differences early in the experiment but these had essentially disappeared at its conclusion. At that time, the stand had thinned appreciably, although the

remaining crowns proved adequate to discourage invasion by weeds.

4. All varieties on the Umatilla Experiment Station failed to show significant dry matter response to cutting frequency. Increases in protein content were obtained with each variety under a four cutting schedule. The efficacy of four cutting management in terms of increasing protein content must necessarily be critically evaluated against the added expense of an additional harvest.

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APPENDIX

Appendix Table 1. Analyses of variance for dry matter yields per cutting of Anchor during 1973 and 1974.

	1973			1974		
	DF	MS	F	DF	MS	F
Replications	2	0.0230		2	0.0554	
Management	5	0.1078	2.91*	5	0.2691	5.34**
Harvest	2	6.4642	174.71**	3	20.0400	397.62**
Man x Har	10	0.1663	4.49**	15	0.2820	5.60
Man/H_1	5	0.2193	3.50*	5	0.4316	3.13NS
Man/H_2	5	0.1576	18.99**	5	0.3806	17.70**
Man/H_3	5	0.0633	2.42NS	5	0.2742	14.13**
Man/H_4				5	0.0278	0.96NS
Error	34	0.0370		46	0.0504	
Rep x Man	4	0.0251		10	0.0358	
Rep x Man	10	0.0721		6	0.0404	
Rep x Man x Har	20	0.0359		30	0.0573	
R x M/H_1	10	0.0626		10	0.1379	
R x M/H_2	10	0.0083		10	0.0215	
R x M/H_3	10	0.0262		10	0.0194	
R x M/H_4				10	0.0290	
Total	53					

Appendix Table 2. Analyses of variance for accumulated dry matter at second and third cutting of Anchor during 1973 and 1974.

	DF	SS	MS	F
1973				
Second Cutting				
Replications	2	0.0517	0.0259	
Management	5	0.9168	0.1834	3.29NS
Error	10	0.5567	0.0557	
Total	17	1.5252		
Third Cutting				
Replications	2	0.1386	0.0693	
Management	5	1.6166	0.3233	4.30*
Error	10	0.7511	0.0751	
Total	17	2.5063		
1974				
Second Cutting				
Replications	2	0.1047	0.0523	
Management	5	2.1593	0.4319	3.72*
Error	10	1.1617	0.1162	
Total	17	3.4257		
Third Cutting				
Replications	2	0.2690	0.1345	
Management	5	5.9173	1.1835	11.23**
Error	10	1.0537	0.1054	
Total	17	7.2400		

Appendix Table 3. Analysis of variance for total dry matter yields of Anchor during 1973 and 1974.

	DF	SS	MS	F
Replications	2	0.6593	0.3296	
Years	1	94.1870	94.1870	4905.57**
Rep x Years	2	0.0192	0.0192	
Management	5	3.5070	0.714	6.14**
Man x Years	5	8.1214	1.6243	14.12**
Man/Y_1	5	6.2460	1.2492	14.63**
Man/Y_2	5	5.3820	1.0760	7.52**
Error	20	2.2864	0.1143	
Rep x Man	10	1.8703	0.1870	
Rep x Man x Yrs	10	0.4161	0.0416	
Rep x Man/Y_1	10	0.8544	0.0854	
Rep x Man/Y_2	10	1.4320	0.1430	
Total	35	108.7995		

Appendix Table 4. Analyses of variance for dry matter yields per cutting of Apex during 1973 and 1974.

	DF	1973 MS	1973 F	1974 MS	1974 F
Replications	2	0.0624		0.1648	
Management	5	0.1182	2.48	0.2473	8.56**
Harvest	3	8.4559	177.65**	8.0083	277.10**
Man x Har	15	0.2053	4.31	0.3571	12.36**
Man/H_1	5	0.1483	4.80**	0.8602	23.57**
Man/H_2	5	0.2051	4.88**	0.0619	2.32NS
Man/H_3	5	0.0750	2.96NS	0.2607	10.55**
Man/H_4	5	0.3058	30.89**	0.1358	9.24**
Error	46	0.0476		0.0289	
Rep x Man	10	0.0125		0.0497	
Rep x Har	6	0.1847		0.0508	
Rep x Man x Har	30	0.0011		0.0177	
R x M/H_1	10	0.0309		0.0365	
R x M/H_2	10	0.0420		0.0267	
R x M/H_3	10	0.0253		0.0247	
R x M/H_4	10	0.0099		0.0147	
Total	71				

Appendix Table 5. Analyses of variance for accumulated dry matter at second and third cutting of Apex during 1973 and 1974.

	DF	SS	MS	F
1973				
Second Cutting				
Replications	2	1.3761	0.6881	
Management	5	1.6646	0.3329	4.09*
Error	10	0.8138	0.0814	
Total	17	3.8545		
Third Cutting				
Replications	2	0.6760	0.3380	
Management	5	3.4871	0.6974	10.97**
Error	10	0.6357	0.0636	
Total	17	4.7988		
1974				
Second Cutting				
Replications	2	0.5932	0.2966	
Management	5	5.1597	1.0319	10.65**
Error	10	0.9687	0.0969	
Total	17	6.7216		
Third Cutting				
Replications	2	0.9814	0.4907	
Management	5	8.7434	1.7487	11.318**
Error	10	1.5452	0.1545	
Total	17	11.2700		

Appendix Table 6. Analysis of variance for total dry matter yields of Apex during 1973 and 1974.

	DF	SS	MS	F
Replications	2	0.0332	0.0166	
Years	1	14.5797	14.4797	15.53NS
Rep x Years	2	1.8774	0.9387	
Management	5	3.9532	0.7906	5.22**
Man x Years	5	2.9077	0.5815	3.84*
Man/Y_1	5	1.9192	0.3838	3.67*
Man/Y_2	5	4.9500	0.9900	5.00*
Error	20	3.0287	0.1514	
Rep x Man	10	2.1681	0.2168	
Rep x Man x Yrs	10	0.8606	0.0861	
Rep x Man/Y_1	10	1.0450	0.1045	
Rep x Man/Y_2	10	1.9800	0.1980	
Total	35	26.3799		

Appendix Table 7. Analyses of variance for dry matter yields per cutting of Washoe during 1973 and 1974.

		1973		1974	
	DF	MS	F	MS	F
Replications	2	0.3031		0.0523	
Management	5	0.1464	3.97**	0.0956	2.30NS
Harvest	3	7.1582	193.99**	6.7862	163.13**
Man x Har	15	0.1984	5.38**	0.1539	3.70**
Man/H_1	5	0.2104	8.69**	0.2858	3.31NS
Man/H_2	5	0.3034	3.81*	0.0303	0.70NS
Man/H_3	5	0.1419	3.75*	0.1731	7.24**
Man/H_4	5	0.0860	5.73**	0.0683	15.88**
Error	46	0.0369		0.0416	
Rep x Man	10	0.0967		0.0540	
Rep x Har	6	0.0216		0.0328	
Rep x Man x Har	30	0.0200		0.0392	
R x M/H_1	10	0.0242		0.0862	
R x M/H_2	10	0.0797		0.0572	
R x M/H_3	10	0.0378		0.0239	
R x M/H_4	10	0.0150		0.0043	
Total	71				

Appendix Table 8. Analyses of variance for accumulated dry matter at second and third cutting of Washoe during 1973 and 1974.

	DF	SS	MS	F
1973				
Second Cutting				
Replications	2	0.9716	0.4858	
Management	5	3.2485	0.6497	4.03*
Error	10	1.6117	0.1612	
Total	17	5.8318		
Third Cutting				
Replications	2	1.9052	0.9526	
Management	5	3.3178	0.6636	2.31NS
Error	10	2.8767	0.2877	
Total	17	8.0997		
1974				
Second Cutting				
Replications	2	0.4743	0.2372	
Management	5	1.1937	0.2367	1.51NS
Error	10	1.5724	0.1572	
Total	17	3.2304		
Third Cutting				
Replications	2	0.4801	0.2401	
Management	5	2.0231	0.4046	2.12NS
Error	10	1.9132	0.1913	
Total	17	4.4164		

Appendix Table 9. Analysis of variance for total dry matter yields of Washoe during 1973 and 1974.

	DF	SS	MS	F
Replications	2	2.1222	1.0611	
Years	1	8.6044	8.6044	24.38*
Rep x Years	2	0.7058	0.3529	
Management	5	1.2004	0.2401	0.80NS
Man x Years	5	3.6019	0.7204	2.40NS
Man/Y_1	5	2.9320	0.5864	1.52NS
Man/Y_2	5	1.8700	0.3740	0.76NS
Error	20	5.9957	0.2998	
Rep x Man	10	3.9634	0.3963	
Rep x Man x Yrs	10	2.0323	0.2032	
Rep x Man/Y_1	10	3.8698	0.3870	
Rep x Man/Y_2	10	2.1260	0.2130	
Total	35	22.2304		

Appendix Table 10. Analyses of variance for dry matter yields per cutting of N-102, Saranac, and Vernal during 1974.

		N-102		Saranac		Vernal	
	DF	MS	F	MS	F	MS	F
Replications	3	0.1281		0.0563		0.0324	
Management	1	1.1224	23.58**	1.7388	85.34**	0.7526	52.26**
Harvest	2	4.026	84.58**	2.8146	137.97**	3.9238	272.48**
Man x Har	2	0.1103	2.32NS	0.0720	3.53NS	0.2581	17.92**
Man/H_1	1	0.9522	11.53*	1.1401	32.57*	1.1781	25.17*
Man/H_2	1	0.2850	3.94NS	0.3240	9.47NS	0.0630	33.51*
Man/H_3	1	0.1058	50.38**	0.4186	53.67**	0.0276	3.13NS
Error	15	0.0476		0.0204		0.0144	
Rep x Man	3	0.0636		0.0116		0.0183	
Rep x Har	6	0.0407		0.0119		0.0072	
Rep x Man x Har	6	0.0467		0.0334		0.0197	
R x M/H_1	3	0.0826		0.0350		0.0468	
R x M/H_2	3	0.0724		0.0342		0.0019	
R x M/H_3	3	0.0021		0.0078		0.0088	
Total	23						

Appendix Table 11. Analyses of variance for total dry matter yield of N-102, Saranac, and Vernal during 1974.

	DF	SS	MS	F
N-102				
Replications	3	1.1360	0.3790	
Management	1	0.2390	0.2390	1.09NS
Error	3	0.6600	0.2200	
Total	7	2.0350		
Saranac				
Replications	3	0.5860	0.1950	
Management	1	0.3650	0.3650	6.29NS
Error	3	0.1740	0.0580	
Total	7	1.1250		
Vernal				
Replications	3	0.3600	0.1200	
Management	1	0.3570	0.3570	5.85NS
Error	3	0.1840	0.0610	
Total	7	0.9010		

Appendix Table 12. Analyses of variance for crude protein concentration per cutting of Anchor during 1973 and 1974.

	1973			1974		
	DF	MS	F	DF	MS	F
Replications	2	0.8908		2	0.9193	
Management	5	27.4016	132.95**	5	19.3601	10.60**
Harvest	2	115.3908	559.88**	3	43.8012	23.99**
Man x Har	10	4.5213	21.94**	15	11.5596	6.33**
Man/H_1	5	14.3537	41.97**	5	12.1149	7.31**
Man/H_2	5	15.5258	74.50**	5	6.0703	5.53*
Man/H_3	5	6.5648	25.23**	5	14.4235	6.92**
Man/H_4				5	21.4303	14.81**
Error	34	0.2061		46	1.8266	
Rep x Man	4	0.4053		10	1.4872	
Rep x Har	10	0.1377		6	2.0303	
Rep x Man x Har	20	0.3242		30	1.8990	
R x M/H_1	10	0.3420		10	1.6762	
R x M/H_2	10	0.2084		10	1.0968	
R x M/H_3	10	012602		10	2.0844	
R x M/H_4				10	1.4469	
Total	53			71		

Appendix Table 13. Analyses of variance for weighted mean crude protein concentration of Anchor during 1973 and 1974.

	DF	SS	MS	F
Replications	2	0.1768	0.0884	
Years	1	7.5076	7.5076	24.76*
Rep x Years	2	0.6065	0.3033	
Management	5	62.3962	12.4792	35.92**
Man x Years	5	3.1408	0.6282	1.81NS
Man/Y_1	5	40.8454	8.1691	36.53**
Man/Y_2	5	24.6915	4.9383	10.48**
Error	20	6.9478	0.3474	
Rep x Man	10	4.1239	0.4124	
Rep x Man x Yrs	10	2.8239	0.2824	
Rep x Man/Y_1	10	2.2364	0.2236	
Rep x Man/Y_2	10	4.7115	0.4712	
Total	35	80.7757		

Appendix Table 14. Analyses of variance for crude protein concentration per cutting and weighted mean of Apex during 1973.

	DF	SS	MS	F
Per Cutting				
Replications	2	0.4240	0.2120	
Management	5	47.6431	9.5286	12.33**
Harvest	3	154.5228	51.5076	66.63**
Man x Har	15	186.4091	12.4272	16.08**
Man/H_1	5	39.3256	7.8651	146.74**
Man/H_2	5	18.5047	3.7009	6.14**
Man/H_3	5	67.9124	13.5825	7.68**
Man/H_4	5	108.3096	21.6619	39.40**
Error	46	35.5594	0.7730	
Rep x Man	10	7.6031	0.7603	
Rep x Har	6	5.8184	0.9697	
Rep x Man x Har	30	22.1379	0.7379	
$R \times M/H_1$	10	0.5361	0.0536	
$R \times M/H_2$	10	6.0291	0.6029	
$R \times M/H_3$	10	17.6780	1.7678	
$R \times M/H_4$	10	5.4978	0.5498	
Total	71	424.5584		
Weighted Mean				
Replications	1	0.3290	0.1645	
Management	5	15.0642	3.0128	16.90**
Error	10	1.7831	0.1783	
Total	17	17.1763		

Appendix Table 15. Analyses of variance for crude protein concentration per cutting of Washoe during 1973 and 1974.

	DF	1973 MS	1973 F	1974 MS	1974 F
Replications	2	1.2199		0.8736	
Management	5	5.5384	4.12**	19.9485	16.96**
Harvest	3	26.6148	19.77**	131.1683	111.51**
Man x Har	15	15.8089	11.75**	16.1276	13.71**
Man/H_1	5	12.7043	8.86**	10.5272	20.57**
Man/H_2	5	5.3246	3.12NS	3.9811	3.38*
Man/H_3	5	1.6900	1.43NS	8.7495	28.81**
Man/H_4	5	33.1782	26.14**	45.0736	28.81**
Error	46	1.3459		1.1763	
Rep x Man	10	1.1928		1.0591	
Rep x Har	6	1.0562		0.4886	
Rep x Man x Har	30	1.4549		1.3529	
R x M/H_1	10	1.4344		0.5118	
R x M/H_2	10	1.7056		1.1789	
R x M/H_3	10	1.1824		0.8625	
R x M/H_4	10	1.2692		1.5646	
Total	71				

Appendix Table 16. Analyses of variance for weighted mean crude protein concentration of Washoe during 1973 and 1974.

	DF	SS	MS	F
Replications	2	1.2630	0.6315	
Years	1	0.9967	0.9967	1328.93**
Rep x Years	2	0.0015	0.0008	
Management	5	18.6059	3.7212	13.57**
Man x Years	5	4.5606	0.9121	3.33*
Man/Y_1	5	6.8718	1.3744	4.46*
Man/Y_2	5	16.2948	3.2590	13.55**
Error	20	5.4850	0.2742	
Rep x Man	10	2.8320	0.2832	
Rep x Man x Yrs	10	2.6530	0.2658	
Rep x Man/Y_1	10	3.0803	0.3080	
Rep x Man/Y_2	10	2.4046	0.2405	
Total	35	30.9127		

Appendix Table 17. Analyses of variance for crude protein concentration per cutting of N-102, Saranac, and Vernal during 1974.

	DF	N-102		Saranac		Vernal	
		MS	F	MS	F	MS	F
Replications	3	0.2577		0.5226		0.4448	
Management	1	8.2368	6.26	11.3575	10.42**	10.1790	9.66**
Harvest	2	1.0272	0.78NS	1.3973	1.32NS	0.8590	0.82NS
Man X Har	2	1.1150	0.85NS	3.4266	3.24NS	0.2563	0.24NS
Man/H_1	1	5.2975	25.47*	16.5313	37.96**	2.2155	38.73**
Man/H_2	1	4.9770	102.16**	1.2561	1.28NS	2.6160	2.55NS
Man/H_3	1	0.1922	0.07NS	0.4232	0.65NS	5.8653	7.52NS
Error	15	1.3154		1.0589		1.0539	
Rep x Man	3	1.2491		0.0749		0.0710	
Rep x Har	6	1.7438		1.6124		1.7033	
Rep x Man x Har	6	0.9201		0.9975		0.8958	
R x M/H_1	3	0.2080		0.4355		0.0572	
R x M/H_2	3	0.0487		0.9832		1.0257	
R x M/H_3	3	2.8417		0.6513		0.7798	
Total	23						

Appendix Table 18. Analyses of variance for weighted mean crude protein concentration of N-102, Saranac, and Vernal during 1974.

	DF	SS	MS	F
N-102				
Replications	3	0.470	0.157	
Management	1	4.620	4.620	15.40**
Error	3	0.900	0.300	
Total	7	5.990		
Saranac				
Replications	3	0.410	0.047	
Management	1	7.360	7.360	2230.30**
Error	3	0.010	0.003	
Total	7	7.280		
Vernal				
Replications	3	0.110	0.037	
Management	1	3.140	3.140	47.08**
Error	3	0.200	0.067	
Total	7	3.450		

Appendix Table 19. Analyses of variance for yield of crude protein per cutting of Anchor during 1973 and 1974.

	1973			1974		
	DF	MS	F	DF	MS	F
Replications	2	4,600		2	1,023	
Management	5	97,795	16.81**	5	23,607	2.42NS
Harvest	2	136,080	29.41**	3	1,570,359	161.01**
Man x Har	10	33,232	7.18**	15	16,806	1.72NS
Man/H_1	5	104,964	20.49**	5	29,207	1.73NS
Man/H_2	5	16,349	15.03**	5	22,039	3.14NS
Man/H_3	5	22,947	5.34*	5	4,892	1.25NS
Man/H_4				5	17,888	2.25NS
Error	34	4,627		46	9,753	
Rep x Man	4	8,184		10	4,870	
Rep x Har	10	5,224		6	15,158	
Rep x Man x Har	20	3,617		30	10,300	
R x M/H_1	10	5,122		10	16,878	
R x M/H_2	10	1,087		10	7,011	
R x M/H_3	10	4,298		10	3,920	
R x M/H_4				10	7,960	
Total				71		

Appendix Table 20. Analyses of variance for accumulated yield of crude protein at second and third cutting of Anchor during 1973 and 1974.

	DF	SS	MS	F
1973				
Second Cutting				
Replications	2	33,010	16,505	
Management	5	530,861	106,172	22.27**
Error	10	47,672	4,767	
Total	17	611,543		
Third Cutting				
Replications	2	27,597	13,798	
Management	5	1,166,925	233,385	23.76**
Error	10	98,213	9,821	
Total	17	1,292,734		
1974				
Second Cutting				
Replications	2	24,210	12,105	
Management	5	167,735	33,547	1.95NS
Error	10	172,306	17,231	
Total	17	364,251		
Third Cutting				
Replications	2	10,184	5,092	
Management	5	165,478	33,096	1.98NS
Error	10	167,485	16,748	
Total	17	343,147		

Appendix Table 21. Analysis of variance for total yield of crude protein of Anchor during 1973 and 1974.

	DF	SS	MS	F
Replications	2	52,854	26,427	
Years	1	13,142,643	13,142,643	1.774.03**
Rep x Years	2	14,817	7,408	
Management	5	2,165,257	433,051	25.16**
Man x Years	5	809,500	161,900	9.41**
Man/Y_1	5	2,502,616	500,523	35.50**
Man/Y_2	5	472,141	94,428	4.85*
Error	20	344,204	17,210	
Rep x Man	10	234,914	23,491	
Rep x Man x Yrs	10	109,291	10,929	
Rep x Man/Y_1	10	149,397	14,940	
Rep x Man/Y_2	10	194,807	19,481	
Total	35	16,529,274		

Appendix Table 22. Analysis of variance for yield of crude protein per cutting of Apex during 1973.

	DF	SS	MS	F
Replications	2	14,648	7,324	
Management	5	112,020	22,404	2.99*
Harvest	3	2,336,087	778,696	103.86**
Man x Har	15	342,840	22,856	3.05**
Man/H_1	5	157,190	31,439	7.62**
Man/H_2	5	101,325	20,265	1.91NS
Man/H_3	5	75,243	15,049	1.84NS
Man/H_4	5	121,102	24,221	18.85**
Error	46	344,890	7,498	
Rep x Man	10	41,246	4,125	
Rep x Har	6	163,074	27,179	
Rep x Man x Har	30	140,571	4,686	
R X M/H_1	10	41,246	4,125	
R x M/H_2	10	106,116	10,612	
R x M/H_3	10	81,682	8,168	
R x M/H_4	10	12,852	1,285	
Total	71	3,150,484		

Appendix Table 23. Analyses of variance for accumulated yield of crude protein at second and third cutting and total of Apex during 1973.

	DF	SS	MS	F
Second Cutting				
Replications	2	171,849	85,924	
Management	5	58,932	11,786	1.19NS
Error	10	99,460	9,946	
Total	17	330,241		
Third Cutting				
Replications	2	89,901	44,950	
Management	5	209,397	41,879	3.25NS
Error	10	128,788	12,879	
Total	17	428,086		
Total				
Replications	2	309,499	154,750	
Management	5	1,131,556	226,311	2.31NS
Error	10	981,800	98,180	
Total	17	2,422,855		

Appendix Table 24. Analyses of variance for yield of crude protein per cutting of Washoe during 1973 and 1974.

		1973		1974	
	DF	MS	F	MS	F
Replications	2	41,913		10,537	
Management	5	25,614	4.28**	7,618	1.11NS
Harvest	3	659,294	110.11**	553,742	80.73**
Man x Har	15	17,104	2.86**	9,091	1.33NS
Man/H_1	5	32,564	3.98**	11,039	0.94NS
Man/H_2	5	22,820	3.13NS	802	0.09NS
Man/H_3	5	11,196	1.55NS	14,647	2.55NS
Man/H_4	5	10,346	4.24*	8,404	5.18*
Error	46	5,982		6,859	
Rep x Man	10	12,771		9,345	
Rep x Har	6	3,954		6,636	
Rep x Man x Har	30	4,124		6,076	
R x M/H_1	10	8,176		11,722	
R x M/H_2	10	7,292		8,493	
R x M/H_3	10	7,237		5,734	
R x M/H_4	10	2,439		1,623	
Total	71				

Appendix Table 25. Analyses of variance for accumulated yield of crude protein at second and third cutting of Washoe during 1973 and 1974.

	DF	SS	MS	F
1973				
Second Cutting				
Replications	2	116,025	58,013	
Management	5	301,155	60,231	2.40NS
Error	10	250,087		
Total	17	668,047		
Third Cutting				
Replications	2	248,444	124,222	
Management	5	451,334	90,267	2.12NS
Error	10	425,769	42,557	
Total	17	1,125,547		
1974				
Second Cutting				
Replications	2	85,056	42,528	
Management	5	67,926	13,585	0.18NS
Error	10	175,150	17,515	
Total	17	328,132		
Third Cutting				
Replications	2	88,810	44,405	
Management	5	127,200	25,440	0.88NS
Error	10	287,797	28,780	
Total	17	503,807		

Appendix Table 26. Analysis of variance for total yield of crude protein of Washoe during 1973 and 1974.

	DF	SS	MS	F
Replications	2	328,805	164,403	
Years	1	873,848	873,848	18.89*
Rep x Years	2	92,529	46,264	
Management	5	227,092	45,418	1.03NS
Man x Years	5	440,431	88,086	1.99NS
Man/Y_1	5	515,695	103,139	2.02NS
Man/Y_2	5	151,828	30,366	0.81NS
Error	20	884,909	44,245	
Rep x Man	10	480,693	48,069	
Rep x Man x Yrs	10	404,216	40,422	
Rep x Man/Y_1	10	511,625	51,163	
Rep x Man/Y_2	10	373,284	37,328	
Total	35	2,847,614		

Appendix Table 27. Analysis of variance for yield of crude protein per cutting of N-102, Saranac, and Vernal during 1974.

		N-102		Saranac		Vernal	
	DF	MS	F	MS	F	MS	F
Replications	3	23,151		9,626		3,431	
Management	1	52,684	8.18*	106,892	25.73**	42,332	10.31**
Harvest	2	421,464	65.44**	382,229	91.99**	483,079	117.70**
Man x Har	2	4,294	0.67NS	920	0.22NS	30,725	7.49**
Man/H_1	1	43,312	6.97NS	35,375	6.74NS	102,385	11.23*
Man/H_2	1	8,444	0.97NS	24,453	3.22NS	1,396	1.14NS
Man/H_3	1	9,516	2.81NS	49,207	31.67*	1	0.00NS
Error	15	6,440		4,155		4,104	
Rep x Man	3	5,090		1,808		3,712	
Rep x Har	6	6,933		3,136		4,385	
Rep x Man x Har	6	6,622		6,347		4,019	
R x M/H_1	3	6,217		5,247		9,120	
R x M/H_2	3	8,744		7,600		1,230	
R x M/H_3	3	3,392		1,554		1,402	
Total	23						

Appendix Table 28. Analyses of variance for total yield of crude protein of N-102, Saranac, and Vernal during 1974.

	DF	SS	MS	F
N-102				
Replications	3	192,913	64,304	
Management	1	12,695	12,695	0.55NS
Error	3	68,846	22,949	
Total	7	274,454		
Saranac				
Replications	3	99,668	33,223	
Management	1	15,565	15,565	1.76NS
Error	3	26,540	8,847	
Total	7	141,773		
Vernal				
Replications	3	39,105	13,035	
Management	1	5	5	0.00NS
Error	3	48,463	16,152	
Total	7	87,572		

Appendix Table 29. Analysis of variance for stand density of Anchor, Apex, and Washoe during 1973, 1974, and 1975.

	DF	Anchor		Apex		Washoe	
		MS	F	MS	F	MS	F
Replications	2	7,574		20,193		5,285	
Years	2	1,520,310	152.38**	1,576,837	74.91**	943,316	149.07**
Rep x Years	4	9,977		21,050		6,328	
Management	5	143,641	17.19**	7,194	1.26NS	8,057	1.65NS
Man X Years	10	19,944	2.39**	11,987	2.10NS	31.886	6.53**
Man/Y_1	5	119,847	6.38**	16,767	2.60NS	47,374	8.68**
Man/Y_2	5	35,881	10.88**	4,558	0.63NS	21,300	4.74**
Man/Y_3	5	27,800	9.30**	9,462	2.90NS	2,556	0.51NS
Error	30	8,354		5,710		4,878	
Rep x Man	10	11,557		7,245		5,562	
Rep x Man x Yrs	20	6,752		4,943		4,535	
Rep x Man/Y_1	10	18,772		6,458		5,461	
Rep x Man/Y_2	10	3,297		7,275		4,492	
Rep x Man/Y_3	10	2,992		3,397		4,980	
Total	53						

Appendix Table 30. Analyses of variance for recovery year yields of Anchor, Apex, and Washoe on May 28, 1975.

	DF	SS	MS	F
Anchor				
Replications	2	0.1728	0.0864	
Management	5	0.6081	0.1216	2.66NS
Error	10	0.4578	0.0458	
Total	17	1.2387		
Apex				
Replications	2	0.7216	0.3608	
Management	5	0.1662	0.0324	0.31NS
Error	10	1.0573	0.1057	
Total	17	1.9451		
Washoe				
Replications	2	0.3118	0.1559	
Management	5	0.2587	0.0517	0.79NS
Error	10	0.6152	0.0617	
Total	17	1.1857		