EFFECT OF PLANT POPULATION AND HARVEST FREQUENCY STUDIES ON DRYLAND ALFALFA

by

Manzoor H. Pirzada

A Thesis Submitted to the Faculty
of Agricultural Sciences in Partial Fulfillment of
The Requirements for the Degree of
MASTER OF SCIENCE IN AGRICULTURE

Major: Agronomy - Seed Technology
Minor: Plant Pathology

Approved:

In Charge of Major Work

Chairman, Graduate Committee

American University of Beirut

1964

Studies on Dryland Alfalfa

Pirzada

ACKNOWLEDGEMENTS

The author wishes to express his heartfelt gratitude to Dr. Donald W. Bray for his invaluable advice, constructive criticism, helpful suggestions, encouragement and correction of the manuscript.

He also feels highly indebted to the Crop Production staff at the farm for their timely co-operation through the course of this investigation.

Manzoor H. Pirzada

ABSTRACT

An experiment was conducted during the years 1963-64, at the AUB Agricultural Research and Education Center, to study the effect of harvest frequency during the seeding year, and different plant populations on the yield and quality of dryland alfalfa.

The results reveal that the greatest amount of total green forage and dry matter were obtained under the two harvest regime adopted during the seeding year. Frequent harvesting during the seeding year was found to be effective in reducing green forage yield, plant height and protein content of plots harvested the following spring. In contrast, a slight increase in yield of dry matter and a pronounced increase in the number of stems per plant were observed to result from such treatments.

The difference between the total yields of green forage and dry matter, as affected by the three harvest frequencies, were not significant statistically. However, a significantly higher protein content was obtained in these plots, and a less increase in stem number also occured.

Significant differences in total green forage yields and number of stems per plant were recorded between full and half population plots. The increase in number of stems as counted in the half population plots was twice as great as the increase in the full population plots. Although differences were not significant, the full population treatment was found effective in increasing the yield of dry matter, protein content and plant height in all harvest treatment combinations.

TABLE OF CONTENTS

LIST OF TABLES

INTRODUCTION

Alfalfa is known to be the "Queen of forages". In America and other countries of the world, alfalfa is an integral part of livestock programmes, because it provides forage rich in high quality livestock feed.

According to Morrison (34) alfalfa hay provides over three times as much digestible protein per acre as does clover and timothy hay and nearly two and a half times as much as does corn grown for silage. Moreover, cows fed on well cured alfalfa hay as part of a balanced ration, need less grain and other concentrates to produce high yields of high quality milk. Alfalfa leaf meal is of special value as a vitamin supplement for swine and poultry rations.

There is however, in the Middle East, a relative lack of integration of crops and livestock husbandry. In Lebanon, the production of vegetables and fruits is preferred to forage production. Consequently Lebanon spends much foreign exchange to import meat and dairy products (41).

The Beka'a plain is the granary of Lebanon. Annual precipitation received at the Agricultural Research and Education Center of the AUB has averaged 376.5 mm. for the eight year period 1955-63. The climate is mild and growth of winter crops is not seriously interrupted. Production of forage crops is rare. Natural grazing is supplemented by cereals and legumes, and some times with green cereal crops. The farmers face difficulties in feeding their animals during the winter and early spring months.

In Lebanon, one sixth of the cultivable area gets the benefit of irrigation facilities. The rest of the area depends upon rain to produce crops (35). Alfalfa, being unique in its adaptation, is well fitted to Lebanese environmental conditions where rainfall effectivity and temperature conditions make dry-land production of forage crops difficult.

Under dry-farming conditions, water is the overall limiting factor in crop production. The rate of seeding is one of the effective ways to influence the efficiency of water removal (32). It is also known that quality of alfalfa is affected greatly by cultural practices. Therefore the latest information available about the fundamentals and techniques in forage production needs to be applied to increase the use of alfalfa in Lebanon.

Present investigations were undertaken with alfalfa grown without irrigation at the Agricultural Research and Education Center of the AUB, located in the Beka'a. The effect of harvest frequency and different plant populations on the yield and quality of dry-land alfalfa were studied during the period of 1963-64.

REVIEW OF LITERATURE

The extent to which crop yields may be modified or stabilized through cultural practices, and the response of crops to such practices are matters of fundamental importance. Different types of alfalfa displayed wide differences in their adaptation to environmental changes, and maximum returns from a crop of alfalfa were reported to be dependent largely on various management practices.

Factors Affecting Alfalfa Forage Yield

Under dry-farming conditions, water is recognized to be the limiting factor. For alfalfa, dry areas are critical from the stand point of the production of high quality forage.

a. Plant Population: Clements *et al.* (7) stated that competition between plants became more critical as stand densities increased. Stahler (44) showed that in thick stands, water as well as light were the primary competitive factors. Willard (49) observed that in addition to precipitation, extended periods of drought were the only factors that retarded the development of crown buds in alfalfa. It was further postulated that light penetrating the canopy and reaching the crown of the plants might also be of some importance.

To maintain a good productive stand of alfalfa under dry-land conditions, Willard (48) and Bolton (4) reported that moisture problems were obviated by sowing as little as two pounds of seed per acre. This limited the number of plants per unit area of land.

Kramer and Davis (28) tested 30 varieties and strains at three cutting stages, sown in rows 7 and 18 inches apart and a 6 inch spacing within the rows. A high correlation between yield and stand of alfalfa was obtained. It was also observed that the influence of stand on the yield was greater in the first than in the second year after seeding. This was due to the ability of alfalfa to adapt to a thin stand. This view was later substantiated by the work of Blaser <u>et al.</u> (3).

Cowett and Sprague (9) studied single plants with regard to chemical as well as environmental factors affecting tillering in alfalfa. It was observed that of all the factors studied, stand density had the most pronounced effect on the number of stems produced by the alfalfa plants. Lower stand densities resulted in less yield per unit area, but a greater number of stems per plant. Whereas, by increasing the stand density of alfalfa from 1 to 8 plants per square foot, a decrease in the number of stems and dry weight per plant was recorded. When alfalfa was harvested high or in advanced stages of maturity, an increase in yield and total number of stems per plant were noted. Hence, it was concluded that carbohydrate accumulation in the roots was likely to be the most critical factor governing stem production.

Cowett and Sprague (10) considered the influence of stand density and light intensity on micro environment and stem production of alfalfa. This data showed that a decrease in stand density was usually followed by increased tillering, which partially compensated for the absence of plants.

Loomis <u>et al.</u> (31) proposed that 90-95% of the total dry matter of higher plants consists of carbon compounds derived from photosynthesis. It was argued that the amount of available light imposed an upper limit to total photosynthesis and hence to dry matter yield.

Carmer and Jackobs (6) reported the results of an experiment involving seeding rates, row spacing and fertilizer placement. In general, the size of individual plants (height) and dry weight of top growth decreased as the seeding rate, and consequently the plant population and level of competition increased. It was found that at later dates, the stands were more nearly alike for the different spacings.

Rumbaugh (39) transplanted clones of two alfalfa varieties, Ranger and Teton, at four different distances (5.25, 10.50, 21 and 42 inches), to study the effect of population density on yield of alfalfa. After two years of observation, it was concluded that yields of the two varieties were identical at close spacing but, as population density increased, dry matter per plant decreased more rapidly in the variety Teton. Stem length exhibited a curvilinear relationship to increasing inter-plant competition within varieties. Stem number per plant of the varieties tended to be more nearly equal in the second year than in the first year of harvest.

b. Root Reserves: It was long recognized that the stored organic foods of certain plants have a direct bearing on their future productive capacity. Alfalfa being a perennial has to undergo successive seasons of growth, each of which is influenced by the previous year's management practices.

According to Grandfield (23) and Graber (22) the role of root reserves is important in the successful production of alfalfa.

Aldous (1) conducted studies on the relation of organic root reserves to the growth of some pasture plants. It was observed that the organic reserves of the perennial herbacious plants decreased in the spring until the top development reached a certain stage, after which organic reserves accumulated and were stored in the roots.

Nelson (36) conducted elaborate experiments to study the behaviour of alfalfa when cut at bud, one-tenth bloom, full bloom and seed-pod stage, two to three times per season. It was observed that frequent cutting of alfalfa in premature stages resulted in depleted root reserves. This caused slow recovery after cutting, and subsequent low yields of hay. This work lent support to the hypothesis that:

1. In alfalfa the root and the crown both, were important depositories of root reserves.
2. The early stages of new top growth were initiated largely at the expense of previously deposited organic root reserves.
3. The quality and the relative availability of these storage materials to the early growth requirements, influenced the subsequent growth and ultimate production.

Several workers (23, 24, 42, 49) conducted cutting experiments on alfalfa, and found that after each cutting there was a rapid decline of total carbohydrates. Frequent cutting resulted in a lower carbohydrate content in roots.

Reynolds and Smith (38) studied carbohydrate reserves in the roots of alfalfa grown with smooth bromegrass and timothy under three and two cutting schedules per year. It was reported that the trends of total carbohydrate were similar in their cyclic nature, but the percentage of the total available carbohydrate in all the species declined during early spring growth after cutting and then increased until seed was formed.

c. Fall Cut: Alfalfa yield and quality is associated with a number of factors. Being a perennial crop, the cutting treatments given in the seeding year have a profound effect on the yield, dry matter, height and number of plants and quality of alfalfa hay in subsequent years.

Garber and Moore (20) stated that two cuts of alfalfa near the full bloom stage, yielded considerably more hay. In contrast, early cutting resulted in weak, thin stands with retarded growth and consequent low yields. It was concluded that too early or too late cutting of alfalfa was damaging to production in subsequent years.

Nelson (36) found an increase in the number of crown buds, shoots and main stems as an immediate effect of frequent and early cutting. However, the average and total yield of top growth was much less than when cuttings were made at more mature stages. Moreover, frequently cut plots during the very first season gave low yields in the following years. Grandfield (23) scheduled cutting treatments so as to give growing periods of various lengths after the last cutting in the fall, and thus provided different degrees of protection from winter killing. While summarizing 20 years of experimental work on the time and frequency of cutting, it was reported that frequent early season cutting usually resulted in injury to the stand and decreased yields. Infrequent cuttings were helpfull in maintaining good stands for a longer period, and thus resulted in higher yields. It was also intimated that the fall of the year is a critical period where cutting practices are concerned, because a fall harvest has a material bearing on the organic root reserves and future growth of the crop.

Results obtained under similar conditions showed that early cutting of the first crop not only held down the yield of the first crop, but reduced that of the second crop even more, and lower yields of alfalfa hay were obtained in the following years (2).

Graber and Sprague (21) considered such factors as two summer cuts, two summer plus one late fall cut and two summer plus one early and one late fall cut, all at the full bloom stage, as they influenced the yield of a variety of alfalfa named Variegated. It was concluded that time and frequency of cutting of alfalfa were influenced by many factors such as moisture, soil conditions, length of the growing season, severity of winter season etc. However, it was confirmed that fall cutting treatments were more effective in reducing productivity especially on a soil of moderately low fertility.

Tysdal and Kiesselbach (47) made a comparative study on the differential response of four varieties; Ladak, Grimm, Nebraska common and Hardistan, as they were influenced by early, middle and late season cuttings. It was reported that with the late cutting treatment, Ladak yielded 108 percent of Grimm. However, in the following year Ladak, in the middle season cutting treatment, yielded only 83 percent as much as Grimm. In the third year of the experiment, in all the middle and late cuttings Ladak was the highest yielding variety. It was thus claimed that the response of alfalfa varieties to different times of cutting was so great that a variety could almost be made lowest or highest yielding in a series of standard varieties through changes in the time of cutting.

Hilderband and Harrison (24) dug several hundred plants from a one year old field of Hardigan alfalfa and transplanted them into a sand medium. These plants were kept growing in a green house for one year by frequent watering and addition of a nutrient solution at regular intervals. During this period, these plants were subjected to weekly, biweekly and monthly cuts at 1, 3, 6, 9 and 12 inch heights. It was found that frequent and close to the crown cutting of alfalfa resulted in marked decreases in yield of hay and in plant vigour of alfalfa. Cutting at the highest level (12 inch) resulted in a decreased yield because of loss of leaves and maturity of the plants. However it was concluded that alfalfa when cut at the 9 inch level at weekly or biweekly intervals gave good yields of the top growth and roots.

Dotzenko and Ahlgren (18) showed that alfalfa in a mixture with bromegrass, when cut at various heights and harvest schedules reacted much the same as did alfalfa alone. It was observed that frequent and early cutting of this mixture reduced the weight of roots and the percentage of alfalfa in the following year. Forage yield of alfalfa alone was highest when plants were cut at a more mature stage.

Dennis et al. (16) tested Vernal alfalfa in association with Piper Sudan grass under different intervals of cutting. The data indicated that frequent removal of top growth of alfalfa and Sudan grass, and alfalfa alone resulted in a definite lowering of dry matter production.

Studies on the management of alfalfa pastures by Rusell (40) showed that pasturing the fall growth of the new seeding was conducive to winter killing and lower yields in the following year. No material benefit was observed as the forage gained by harvesting the fall growth was nullified by the reduced yields in the subsequent years.

Davies et al. (12) showed that in the first harvest year significantly higher yields with three cuts than with a two cut system were obtained. The difference between the third and the fourth cut was not significant. Though maximum dry matter in the first harvest year was obtained with three cuts, better results were obtained in the following years from the plots cut twice in the previous year. This showed that frequency of cutting had a marked effect on the production of the following years.

Davies and Davies (13) conducted experiments under similar conditions and reported that increased frequency of cutting had a significant effect on the mean annual yields of dry matter and crude protein over the whole period. These results were later confirmed by Davies (14).

Davies (15) compared eight varieties of lucern under three cutting schedules for two years. Yield comparisons of early and late types subjected to different cutting treatments gave significant interactions. The data indicated that their behaviour was not identical in each treatment. All varieties did not respond in the same way to frequency of cutting. In all varieties more cutting in the first year was found to be proportionately more effective in decreasing the dry matter in the subsequent years.

Jackobs (26) included time and frequency of cutting, to study the effect on alfalfa yield, under irrigated conditions. The data showed that vigour of alfalfa was not reduced seriously by frequent cuttings. A slight decline in yield was observed as the interval between cuttings was reduced. A more pronounced effect of the last fall cut was discernible on the early growth of the following spring. However this deleterious effect diminished as the season progressed.

McKenzie (33) working with Grimm alfalfa grown under irrigated condition found that in the first year, three cuttings at the bud stage of growth resulted in a higher yield of hay than did two cuttings at either early or late flowering stages. The following year, when the same cutting treatments were employed, yields from the bud and late flowering treatments were significantly lower than were those harvested at the early flowering stage. Winter injury was prevalent in the plants which had been cut three times in the bud stage and in those cut twice in the late flowering stage.

d. Spring Cut: Jackobs (26) selected a field of established Ladak alfalfa with a uniform stand to study the effect of cutting schedules under irrigated conditions. In the spring season, the plants were clipped every fourth day, starting after 25 days of growth. The plants were clipped at 4, 7, and 12 inch heights. Data from the first year's experiment indicated highly significant differences in dry matter yield between plots cut at different intervals. The differences between the plots clipped at various stages in the spring were not significant. However, after two years' observation, it was concluded that spring clipping had little or no effect on seasonal yields during the current or subsequent years. Yields of dry matter were found directly proportional to length of intervals between cuttings. Similar results were reported by Law and Patterson(29).

Dent (17) discussed the behaviour of two alfalfa varieties; Du Puits and Provence in relation to time of spring cuttings, and various stages and heights of cutting. Data revealed that the effect of consistent early spring cutting retarded the growth so much that after a third cut, growth was erratic and negligible. No material advantage was achieved from taking a spring cut before the crop reached a height of 18 inches and that for a continuous supply of forage, the crop be allowed to flower at least once per season.

Canode and Klages (5) reported a spring clipping trial where the plants were cut at various stages of growth. This study was conducted for two years under unirrigated conditions. It was observed that the yields of all plots that had produced two cuttings of forage in the first and second years were slightly lower as compared to those plots that were subjected to one cut, during the first and second years of harvest. In addition, clipping of the spring growth in immature stages usually delayed the second cut until July. Accordingly it was suggested that the most productive system of management under the conditions of the experiment was to make two cuttings each spring allowing the crop to reach the first bloom stage of growth each time.

Protein Content and Feed Quality

The most reliable measurement of forage quality in agronomic research is protein content, and leaf to stem ratio.

Canode and Klages (5) reviewed some of the early literature, where it was found from feeding trials, that the feeding value of alfalfa decreased materialy with delay in cutting.

Woodman et al. (50) worked on the nutritive value of alfalfa and analysed cuts taken at various stages of growth. It was found that the quality of the produce decreased continuously with the increase in plant height. Similar results were reported by Dent (17).

Woodman et al. (51) showed that the decrease in quality with progress toward maturity was due not only to the change in leaf to stem ratio, but also due to a decrease in the nitrogen percentage of both leaves and stems. An improvement in quality from first cut to third cut was reported. It was due to the proportion of leaf being greater in later cuts. It was suggested that at the first cut plants attained a greater height and took a longer time to reach maturity.

Comstock and Law (8) evaluated the protein content of alfalfa alone and several alfalfa-grass mixtures, cut at different stages simulating pasture conditions. It was reported that grasses endured frequent cutting much better than did alfalfa. However, early cutting resulted in a lower percentage of alfalfa in the mixture and consequently a lower quality forage product. Dotzenko and Ahlgren (19) reported similar results.

Jackobs (27) observed that under irrigated conditions only the length of the growing period influencedthe nitrogen percentage in the forage. The changes in the nitrogen percentage were due to changes in the leaf to stem ratio. Thus it was concluded that the nitrogen percentage in Ladak alfalfa was negatively correlated with the amount of growth, advance of growing season, intervals between cutting and season of the year.

Davies and Davies (13) showed that the cutting system employed in the first harvest year had a significant effect on the mean annual yield of crude protein over the whole period the stand was in production. The protein yields from the plots cut twice in the first year were significantly less than those cut three and four times in the same year.

Canode and Klages (5) observed that leaf loss from alfalfa plants, under non-irrigated conditions started early in the spring on highly fertile soils and by the time the plants reached the first bloom stage of growth, the percentage of leaves remaining on the forage standing in the field was just above forty percent.

Davies (15) compared eight varieties under three cutting schedules for two years. It was observed that in all the varieties there was twice as much protein in the leaves, as in the stems. Increased frequency of cutting was found to produce a higher percentage of leaf and better quality of hay. No significant effect of cutting on protein content was recorded in the following year.

Parsons and Davis (37) discussed the influence of differential cutting and phosphorous fertilizer on forage quality of a Vernal alfalfa stand. It was stated that the protein level was higher with frequent cuttings because the plants were cut at a more immature stage.

Crowder *et al.* (11) reported that under a 5, 7, 9, 11 and 13 week cutting schedule, most plants in the 5 and 7 week interval plots did not reach physiological maturity at harvest. At 11 and 13 week intervals production of green forage was high. The hay obtained was of low quality due to plant maturity and greater leaf loss.

Smith and Kust (42) conducted elaborate experiments to study the influence of harvest management on Vernal alfalfa. Included were four cuttings; 3, 4, 5 and 6 times each year, four intervals; 22, 28, 34 and 48 days and 1 and 3 inch cutting heights. The results indicated that the yields of protein generally were not affected by the frequency or height of cutting in the first year. However, total protein yields increased by inclusion of a fall cut. In contrast, in the second harvest year, protein yields were reduced in those plots which, in the previous year received a fall cut, or which were cut more than three times before September that is, before fall.

Willard (49) stated that protein decreased steadily with maturity. This decrease in protein was due to several factors. One of them was density of stand. More of the lower leaves were shaded off in the dense stand, and died from shading. Since the percentage of protein in alfalfa leaves is usually about double that of stems, this loss of leaves reduced the protein in hay. The exact figures in any given field vary with the vigour of growth. Tall heavy growth will contain a lower percentage of leaves. Pre-bud hay may contain 50-60 percent of leaves, or even more in some harvests late in the season.

Thus, in summary, it may be stated that the stand, productivity and quality of alfalfa, are influenced by the cultural practices. The magnitude of this influence varies according to time, type and rhythm in the cultural practices followed during the seeding year of production. Their effects were more pronounced when alfalfa was grown under unirrigated conditions.

MATERIALS AND METHODS

This experiment was conducted under non-irrigated conditions, during the year 1963-64, at the AUB Agricultural Research and Education Center, located in the north central part of the Beka'a plain. In general the farm soil is reported to be calcareous in origin, high in potash, low in organic matter and with a pH of 8 (35).

The seasonal character of rainfall is typical of a Mediterranean climate; most of the rain coming in winter (November to April). The distribution over the last three years showed that on an average of 375.5 mm. rain was received during these months. During 1963-64 rainy season, this average was exceeded by 95.0 mm. The minimum temperature recorded was minus 5°C. The winter is succeeded by a hot dry summer, where the daily temperature frequently exceeds 30°C. till early September, when regular rains set in.+

A field of alfalfa was planted on March 12th, 1963. The variety used was AUB composite, which is a synthetic hybrid evolved by the Crop Production staff by inter-planting these adapted varieties (Hairy Peruvian, Chilian and African). Natural inter-pollination was allowed in order to blend the seed into a synthetic. Sowing was done with a tractor driven seeding machine in rows 50 cm. apart. The seeding rate was two pounds of seed per acre.

After germination, when the alfalfa seedlings reached a height of 3-4 cm., a uniformly populated piece of land was selected for carrying out

---

+ Mimeo. pamphlet No. C.P. 25, Faculty of Agricultural Sciences, American University of Beirut, January - 1964.

this experiment. A split plot design with four replications was employed. The main plots consisted of three main harvest treatments:

1. Check - Harvested on May 9, 1964, (one year after planting).
2. July harvest - Harvested on July 8, 1963, (the year planted) then again on May 9, 1964, with Check.
3. December harvest - Harvested on July 8 and December 20, 1963, (the year planted), and then on May 9, 1964, with Check (one year after planting).

Each main harvest treatment plot was divided into two sub-plots. One sub-plot represented full stand and the adjacent sub-plot represented the half stand. The desired populations (full and half stand) were achieved as follows:

The full stand was the stand which existed in the field as a result of the original seeding. Considering this population as full stand, the population in the adjacent plot of the same harvest treatment was reduced to half stand by removing approximately one half of the plants within the row. A 4-inch wide hand hoe was used to remove 4-inch blocks of plants at 4-inch intervals. Each sub-plot was comprised of three rows each five meters long and 50 cms. apart.

In the early stages of growth, weed competition was suppressed with regular hand weeding. Six kgs. per dunum of P_2O_5 in the form of superphosphate were applied with a "Gandy" spreader in the month of October 1963. "Gusathione" was applied using the recommended dose to control the alfalfa weevil (Hypera species).

Eight main harvest treatment plots (July and December) were clipped first on 8th of July 1963, then four of these plots were again harvested on 20th December 1963. The Check and all other harvest treatment plots were harvested on 9th May 1964.

Observations were recorded at every harvest on number of stems, and height of plants in a one meter randomly selected part of the central row in each plot. For forage yield, four meters of the five meter long central row were harvested, leaving a half meter at either end and one row on each side as border. After air-drying the harvested material for six weeks, representative samples in duplicate were taken from each plot. These weighed samples were dried in an oven for twenty four hours at a constant temperature of 70°C. (25). Dry matter is reported on an oven dry basis.

For protein determination, the oven dried material was thoroughly mixed and representative samples (in duplicate) were taken. These samples were weighed on an analytical balance and ground in a Wiley mill with a forty mesh sieve. These samples before weighing were again kept in an oven for nearly two hours to remove moisture, and were then cooled in a desiccator. For protein content, approximately two grams of the ground material were weighed on an electrical balance to the nearest tenth of a milligram. Analyses for protein content were done according to the modified Kjeldahl method as specified in the Association of Official Agricultural Chemists' Official Methods of Analysis (25). Statistical methods appropriate to the split plot design were used to analyse the data (30, 43).

RESULTS AND DISCUSSION

A one year study was conducted to observe the effect of two plant populations and three harvest frequencies on the yield and quality of alfalfa (Medicago sativa L.), when grown under non-irrigated conditions. The agronomic data obtained included forage yield, dry matter yield (on oven dry basis), number and height of stems per meter of row and protein percent of the forage. Data were taken during the seeding year of alfalfa, and after one year the entire experiment was harvested to evaluate the residual effect of the different treatments, to which the experimental plots were subjected in the previous year.

The results are summarized in tables 1-12. Analysis of variance tables are given in the appendix. The L.S.D. figures in the tables are given only for the treatments that were statistically significant.

Green Forage Yield

The total yield figures in table 1, represent the mean green weight of each plot, clipped during the seeding year and again the following spring (May 1964). It is evident that the highest green forage yield was obtained from the plots harvested during the seeding year, in July and December of 1963 and again in May of 1964. The check represents the plots harvested only once, that is in May of 1964. This plot yielded less green forage than did the plots harvested once or twice during the seeding year. However, yields from the two cut and one cut systems were similar. All harvest treatments did not differ significantly from the check as is shown in table 8.

The extended and uninterrupted period afforded to the plots under the one cut per year system is suggested as the major factor in allowing these plots to equal in yields the plots under the other more frequent cutting systems. Similar increases in green forage yield with increased frequency of cuttings in the first year of production of alfalfa were recorded by several workers (3, 9, 28).

It is interesting to note that the full and half populations were not similar in their effects on the yield of alfalfa. The highest mean forage yield of 990.52 kgs. per dunum was obtained from full population plots. This trend is visible through the full stands of all harvest treatments. The behaviour of the half population plots was erratic. Though the differences between yields of half and full population plots under the three cutting systems were not consistent, they were significant statistically (appendix table 8).

It is also clear from the data that the forage yield in both the plant stands increased with an increase in the number of cuts. This increase in yield was more pronounced in the half stand, where it was nearly twice that of the full stand. This tendency towards similar yields from different plant populations in alfalfa was observed by other investigators (3, 6, 28).

In table 2, the relative importance of the components which make up each of the totals is presented. This presentation also allows comparisons to be made between the totals themselves. The green weight from the full stand of the "check" column is taken as base, and all the other yield components and their totals alike are assigned a percentage, based on a comparison with this base as 100 percent.

The harvest treatments adopted during the seeding year had an influence on the performance the second year of production. This can be determined by comparing the components in the "a" columns. Plots harvested

Table 1. Total yield in kgs. per dunum of green alfalfa forage, as affected by population and harvest frequency during the seeding year.

Plant stand	Harvest frequency			Means of stands
	check[a]	July[ab]	December[abc]	
Full	988.63	937.49	1045.44	990.52
Half	874.99	909.08	971.57	918.54
Means of harvest	931.80	923.28	1008.50	

a. One cut per year (May 1964).
ab. Two cuts per year (July 1963 and May 1964).
abc. Three cuts per year (July, Dec. 1963 and May 1964).

L.S.D. for population at 5% level of significance = 54.01

Table 2. Yield data, expressed as percent of the check (full stand) treatment, which is assigned a value of 100. Components of each harvest are also expressed as percent of the check.

Plant stand	Harvest frequency							
	check	July			December			
		components			components			
	1[a]	1[b]	2[a]	total	1[b]	2[c]	3[a]	total
Full	100.00	19.53	75.28	94.81	19.53	10.91	75.28	105.72
Half	87.24	17.24	75.71	91.95	17.24	9.19	71.83	98.26
Means of harvest	93.62	18.38	75.49	93.38	18.38	10.05	73.53	101.99

Column headings: 1-3 numericals in heading denote the sequence of cutting.

a. Cut on 9th May 1964.
b. " " 8th July 1963.
c. " " 20th Dec. 1963.

either once or twice during the seeding year yielded only 75% as much as did the plots that were not harvested until one year after seeding. This difference was almost exactly the same for both the full and half stands. This decrease in yield following harvest treatments applied the year of seeding was made up for by the material harvested at these times. That is, total yields per plot per year were not significant statistically.

This, then leads to the consideration of economics, and future effects of these seeding year harvest treatments. If total yields are not to be much influenced by such treatments, then the expenses of repeated harvesting cannot be justified. These plots must be evaluated in subsequent years to reveal the full effects of the seeding year harvest treatments.

Therefore, it is suggested that all the treatments be harvested in May 1965. This additional data will furnish the requisite information and will reveal any lasting deleterious effect of the harvest practices followed in the seeding year.

Dry Matter

Table 3 shows the total dry matter yield of all the plots harvested in May 1964; one year after seeding. Prior to this harvest, the July plots were clipped once and the December plots were clipped twice during 1963. It can be seen from the data that average dry matter yields in the frequently harvested plots were nearly 11% higher than the plots which were not cut during the seeding year. The dry matter yields under the one cut and two cut harvest frequency treatments were similar, whereas the dry matter yields of the check plots were somewhat lower. The differences in dry matter yields due to harvest treatments were not significant statistically (table 9).

either once or twice during the seeding year yielded only 75% as much as did the plots that were not harvested until one year after seeding. This difference was almost exactly the same for both the full and half stands. This decrease in yield following harvest treatments applied the year of seeding was made up for by the material harvested at these times. That is, total yields per plot per year were not significant statistically.

This, then leads to the consideration of economics, and future effects of these seeding year harvest treatments. If total yields are not to be much influenced by such treatments, then the expenses of repeated harvesting cannot be justified. These plots must be evaluated in subsequent years to reveal the full effects of the seeding year harvest treatments.

Therefore, it is suggested that all the treatments be harvested in May 1965. This additional data will furnish the requisite information and will reveal any lasting deleterious effect of the harvest practices followed in the seeding year.

Dry Matter

Table 3 shows the total dry matter yield of all the plots harvested in May 1964; one year after seeding. Prior to this harvest, the July plots were clipped once and the December plots were clipped twice during 1963. It can be seen from the data that average dry matter yields in the frequently harvested plots were nearly 11% higher than the plots which were not cut during the seeding year. The dry matter yields under the one cut and two cut harvest frequency treatments were similar, whereas the dry matter yields of the check plots were somewhat lower. The differences in dry matter yields due to harvest treatments were not significant statistically (table 9).

Higher dry matter yields were recorded from full population plots. This trend was prevalent in all the harvest frequency treatments. The difference in total dry matter yields between half and full population plots increased with an increase in the harvest frequency during the seeding year. This may be a result of less intra-plant competition in the half population, in the initial stages of growth. This stimulated the plants to produce many new stems after each cut. Consequently, even though there was greater production of stems per plant in the half stand (see table 7), there was less dry matter produced. In other words, even though the population density increased the dry matter per plant decreased. This view was also expressed by Rumbaugh (39).

Although there was an overall increase in total dry matter yield from the July and December sequences of clipping, these increases were not statistically significant. These results are in agreement with several investigators (12, 13, 15, 26) who observed the deleterious effect of frequent cuttings made in any one year, on the dry matter yield of the following year. Davies (15) reported that more frequent cutting in the first year was found to be proportionately more effective in decreasing the dry matter in the subsequent years.

Table 4 presents a break-down of the total dry matter yield obtained during the whole period of the experiment. The yield of dry matter from the full stand of the "check" column is taken as a base, and all the other yield components and their totals alike are expressed as percentages, based on comparisons with this base as 100 percent.

The residual effect of the seeding year harvest treatments can be judged by comparing the "a" component of each harvest treatment. All the plots harvested during the seeding year yielded 5-10% more dry matter than

Table 3. Effect of population and harvest frequency on alfalfa dry matter yield, kgs. per dunum, when harvested one year after seeding.

Plant stand	Harvest frequency			Means of stands
	check[a]	July[ab]	December[abc]	
Full	248.97	275.83	274.20	266.33
Half	239.91	262.09	252.48	251.49
Means of harvests	244.44	268.96	263.34	

a. One cut per year (May 1964).
ab. Two cuts per year (July 1963 and May 1964).
abc. Three cuts per year (July, Dec. 1963 and May 1964).

Table 4. Total dry matter yield, expressed as percent of the check (full stand) treatment, which is assigned a value of 100. Components of each harvest are also expressed as percent of the check.

Plant stand	Harvest frequency								Means of stands
	check	July			December				
	1[a]	1[b]	2[a]	total	1[b]	2[c]	3[a]	total	
Full	100.00	25.52	110.78	136.30	24.66	7.60	110.13	142.39	139.34
Half	96.36	18.67	105.26	123.93	18.32	7.39	101.40	127.11	125.52
Means of harvests	98.18	22.09	108.02	-	21.99	7.49	105.76	-	-

Column headings: 1-3. numericals in heading denote the sequence of cutting.

a. Cut on 9th May 1964.
b. Cut on 8th July 1963.
c. Cut on 20th December 1963.

did those not harvested during the seeding year, irrespective of plant populations. This increase may be the effect of the increased number of stems (table 7); a consequence of the increased number of cuts given to these plots in the previous year. Full stand plots gave higher yields than did the half stand plots. This trend is reflected in all the harvest treatment combinations.

Furthermore, it can be seen that harvest treatments adopted during the seeding year greatly influenced the total dry matter yield in all the treatment combinations. This increase in total yield, over that of the "check" ranges from 36-42% for the full population, and from 23-27% for the half population.

A detailed study of the relative components under each harvest treatment reveals that the difference in total yield of dry matter was actually due to the clippings taken in the previous seeding year. Otherwise, the residual effect exceeded the check by only 5-10%.

Earlier writers (12, 13, 15, 16, 26) conducted similar experiments over a longer period of time. It was indicated that yields of dry matter were associated directly with the length of intervals between cuttings in the year the different intervals were practiced. Nevertheless, more cuts resulted in a loss of vigour by the alfalfa plants and lower yields in post treatment years. These observations emphasize the importance of continuing the present study.

Protein Content and Total Protein

Under the semi-arid conditions prevailing in the Beka'a plain, harvest frequency was found to have an effect on the protein content in alfalfa hay. The data presented in table 5 showed a marked difference in protein percentage of the plants when harvested during the seeding year and in the spring of the following year.

The first cut was delayed until July 1963, when plants were in the pod-stage of development, and the lower leaves had started turning yellow. At the time of harvest, the plants were virtually mature and no further increase in plant height expected. This delayed cutting resulted in an average protein percentage of 15.35. Consequently, low quality produce was obtained from the alfalfa clipped in July. These results are in agreement with earlier workers (5, 17, 51, 52).

In 1963, plots of the December harvest treatments were clipped when the plants were in the pre-bud stage. Plants were succulent, and laden with lush green leaves. Though no stem to leaf ratio was determined, it was observed that plants were immature. The average plant height was 13 cm., and comparatively more leaves on the stems were found than were on the plants cut in July. Willard (49) claimed that pre-bud hay may contain 50-60 percent of the leaves, or even more in the same harvests. Thus December harvest resulted in an overall higher protein percentage (23.20) and good quality hay. These results are in keeping with the work of Jackobs (27) and Davies (15).

All plots were harvested in May 1964 to measure the residual effect of the harvest frequencies adopted in the seeding year. It is evident from table 5 that plots harvested in May 1964 displayed differences which could be ascribed to the previous management practices. The highest protein percentage of 16.07 was obtained from plots which were not subjected to any harvest treatments in the seeding year. The plots clipped once (July 1963), and twice (July and December 1963) gave an average of 13.26 and 12.64 percent protein respectively. This showed that a gradual reduction occured in the protein percentage with a corresponding increase in the harvest

Table 5. Effect of population and harvest frequency on alfalfa protein percent and total protein, determined during the seeding year and one year after seeding.

Plant stand	Harvest frequency								
	Check (May 1964)		July harvest			December harvest			
	% Prot.	kgm. prot./du.	% Protein July 1963	% Protein May 1964	kgm. prot./du.	% Protein July 1963	% Protein Dec. 1963	% Protein May 1964	kgm. prot./du.
Full	16.08	158.97	15.32	12.85	125.23	15.32	22.60	12.37	146.05
Half	16.07	140.06	15.39	13.57	126.46	15.39	22.80	12.91	138.64
Means of harvests	16.07	149.79	15.35	13.26	125.84	15.35	23.20	12.64	142.34

L.S.D. for harvest frequency at 5% level of significance = 1.70.

Table 6. Effect of population and harvest frequency on alfalfa plant height in cm., harvested one year after seeding.

Plant stand	Harvest frequency			Means of stands
	check[a]	July[ab]	December[abc]	
Full	47.6	44.3	41.4	44.4
Half	44.4	43.5	38.7	42.2
Means of harvests	46.0	43.9	40.0	

a. One cut per year (9th May 1964).
ab. Two cuts per year (8th July 1963 and 9th May 1964).
abc. Three cuts per year (8th July, December 1963 and May 1964).

L.S.D. for harvest frequency at 5% level of significance = 5.34.

frequencies of the seeding year. Plants harvested once or twice during the seeding year yielded significantly less protein than did the check plots (table 10). The lowest protein percentage was obtained from plots which were clipped the previous December. These observations are in accordance with those of Davies and Davies (13) and Smith and Kust (42), where the relationship between crude protein and nutritive value of alfalfa was studied.

It was pointed out earlier that nutritive value in alfalfa hay is generally considered to be the necessary consequence of a relationship between leaf and stem ratio. Present observations have implicitly shown that it would be unwise to assume a constant relationship between these two factors. It was clearly demonstrated that management practices adopted in the previous year affected significantly the protein content in the alfalfa plants, harvested in May of 1964 (table 10).

The behaviour of full and half population plots under 2 and 3 harvest frequency systems remained similar. This trend is discernible in all the harvest treatment combinations. Plots subjected to a fall cut gave the lowest (12.64) protein percentage in the following spring (May 1964).

The results suggest that harvesting of the alfalfa in the seeding year decreased the protein content of the material harvested in the spring of the following year and the effect of the fall cut was more pronounced in decreasing the protein content than was the July cut.

Plant height

Table 6 represents the average alfalfa plant height recorded at the time of harvest in May 1964, one year after seeding. The tallest plants were recorded for the check plots. In the check plots no clipping was done until May 1964. The shortest plants were observed in the December plots, which had been clipped twice during 1963. The data revealed a pronounced

Table 7. Effect of population and harvest frequency on the stem number of alfalfa plants per meter of row, shown as percentage increase over the original plant population+.

Plant stand	Harvest frequency			Means of stands
	check[a]	July[ab]	December[abc]	
Full	73.36	95.34	101.35	90.01
Half	147.60	208.88	214.20	190.22
Means of harvests	110.48	152.11	157.77	

\+ Original count made on 25th March 1963.

Final count made on 9th May 1964.

a. One cut per year (May 1964).
ab. Two cuts per year (July 1963 and May 1964).
abc. Three cuts per year (July, December 1963 and May 1964.

highest percentage increase 214.20, was recorded from December harvest plots. These plots were cut twice before the final count was made. In contrast, the lowest percentage increase 73.36, in stem numbers was observed from the "check", where the plots were not harvested during the seeding year, that is before the final count was made.

The increase in stem number in the half population plots was more than twice as great as the increase in the full population plots. This trend towards increase in stem number, especially in half population plots is reflected in all the observations of table 7.

The differences in stem numbers due to different populations and harvest frequency treatments are significant statistically. The results indicate that stem number per meter of row increased with an increase in the number of harvests made during the seeding year, and this increase was considerably greater in the half population plots.

These observations lent support to the views expressed by earlier workers (9, 36) that stand density and frequent cutting of alfalfa had the most pronounced effect on the number of stems produced by the plants.

SUMMARY AND CONCLUSIONS

The effect of two populations, and three harvest frequencies on the yield of green forage and dry matter, quality of forage, plant height and increase in the number of stems per plant of alfalfa, grown under non-irrigated conditions was studied. In addition, the effect of harvesting the plants in the seeding year was evaluated by studying the performance of alfalfa in the spring harvest of subsequent year.

The harvest treatments adopted during the seeding year influenced the green forage yield of alfalfa in the following spring. The highest total green forage yield was obtained from the plots which were harvested three times (July and December of 1963 and May 1964). This frequent harvesting had a depressing effect on the performance of the second year production. Plots harvested either once or twice during the seeding year yielded only 75 percent as much as did the plots that were not harvested until one year after seeding. Thus, no material gain was achieved by cutting dryland alfalfa during the seeding year.

Yields of dry matter nearly 11 percent higher were recorded from full and half population plots harvested during the seeding year. These harvest treatments were also instrumental in increasing the dry matter yields by 5-10 percent in the spring of the following year, irrespective of plant populations.

Frequent harvesting during the seeding year affected the quality of alfalfa. A gradual reduction in protein percentage occurred with a corresponding increase in the harvest frequencies in the seeding year.

Alfalfa harvested one year after seeding gave nearly 19 percent more total protein than was obtained in the two cut and three cut systems adopted during the seeding year. The highest percentage of protein was recorded from plants cut in December. This increase in protein content was not enough to compensate for the resultant deleterious effect on the total yields and future productivity of the alfalfa.

Alfalfa plants grew better and taller in plots not subjected to any harvest during the seeding year. The tallest plants were harvested from the full population plots of the check, and the shortest plant height was recorded from the half population plots of the December harvest treatments. In general, the plant height decreased with the increase in harvest frequency adopted during the seeding year.

There was somewhat (nearly 95 mm.) more rains, during the 1963-64 season. In dryland experiments, any factor which modifies the water loss causes a modification in the actual soil moisture conditions. Therefore, it is difficult to determine whether the resultant growth was due to differences in soil moisture or to other environmental factors not under control.

Therefore, it is recommended that farmers in the Beka'a should be careful in following management practices during the seeding year of alfalfa, as these have important bearing on the yields and quality of alfalfa forage in the succeeding years of production.

LITERATURE CITED

1. Aldous, A.E. Relation of organic food reserves to the growth of some Kansas plants. Jour. Amer. Soc. Agron. 22:385-392. 1936.

2. Anonymous, What is New in Farm Science. Wisc. Agri. Expt. Sta. Bul. No. 440. 1938.

3. Blaser, R.E., Taylor, T., Griffeth, W.L., and Skradla, W. Seeding competition in establishing forage plants. Agron. J. 48: 1-6. 1956.

4. Bolton, J.A. Alfalfa, its botany, cultivation and utilization. Leonard Hill Ltd. London. 1962.

5. Canode, C.L., and Klages, K.H. Management of alfalfa for high quality hay and non-irrigated lands of Northern Idaho. Agri. Expt. Sta. Res. Bul. 36. 1957.

6. Carmer, S.G., and Jackobs, J.A. Establishment and yield of late-summer alfalfa seedlings as influenced by placement of seed and phosphate fertilizer. Agron. J. 55:28-31. 1963

7. Clements, F.E., Weaver, J.E., and Hanson, H. Plant competition, Carnegie Inst. Washington, D.C. 1929.

8. Comstock, V.E., and Law, A.G. The effect of clipping on the yield, botanical composition and protein content of alfalfa-grass mixtures. Agron. J. 40:1074-1084. 1948.

9. Cowett, E.R., and Sprague, M.A. Factors affecting tillering in alfalfa. Agron. J. 54:294-297. 1962.

10. ____________ and ____________. Effect of stand density and light intensity on the micro-environment and stem production of alfalfa. Agron. J. 55: 432-434. 1963.

11. Crowder, L.V., Vaneges, J., and Silva, J. The influence of cutting interval on alfalfa production in the high Andes. Agron. J. 52:128-130. 1960.

12. Davies, R.O., Morgan, T.B., and Davies, W.E. The yield and composition of lucerne, grass and clover under different systems of management -I. Jour. Brit. Grassl. Soc. 8:149-167. 1953.

13. Davies, W.E., and Davies, R.O. The yield and composition of lucerne, grass and clover under different systems of management-II. Jour. Brit. Grassl. Soc. 11:127-138. 1956.

14. Davies, W. Ellis. Recent progress in herbage legume research at Aberystwyth. World Crops. 9:103-106. 1957.

15. ______________. The relative effect of frequency and time of cutting lucerne. Jour. Brit. Grassl. Soc. 15:262-268. 1960.

16. Dennis, R.E., Harrison, C.N., and Erickson, A.E. Growth response of alfalfa and Sudan grass in relation to cutting practices and soil moisture. Agron. J. 51:617-621. 1959.

17. Dent, J.W. Seasonal yield and composition of lucerne in relation to time of spring cutting. Jour. Brit. Grassl. Soc. 10:330-340. 1955.

18. Dotzenko, A., and Ahlgren, G.H. Response of alfalfa in an alfalfa-bromegrass mixture to various cutting treatments. Agron. J. 42:246-247. 1950.

19. ______________ and ______________. Effect of cutting treatments on the yield, botanical composition and chemical constituents of an alfalfa-bromegrass mixture. Agron. J. 43:15-17. 1951.

20. Graber, L.F., and Moore, R.A. Wisconsin's opportunity with alfalfa. Wisc. Agri. Expt. Sta. Bull. 374. 1925.

21. Graber, L.F., and Sprague, V.G. The productivity of alfalfa as related to management. Agron. J. 30:38-54. 1938.

22. Graber, L.F. A century of alfalfa in America. Agron. J. 42:525-534. 1950.

23. Grandfield, C.O. The trend of organic food reserves in alfalfa roots as affected by cutting practices. Jour. Agri. Res. 50:697-700. 1935.

24. Hilderband, S.C. and Harrison, C.H. The effect of height and frequency of cutting alfalfa upon consequent top growth and root development. Agron. J. 31:790-799. 1939.

25. Horwitz, W. (Chairman) Official Methods of Analysis. Assoc. of Agri. Chem. Inc. Washington. 9th Ed. 1960.

26. Jackobs, J.A. The influence of spring-clipping interval between cuttings, and date of last cutting on alfalfa yields in the Yakima Valley. Agron. J. 42:594-597. 1950.

27. ______________. The influence of cutting practices on the N-content of Ladak alfalfa in the Yakima Valley. Agron. J. 44:132-135. 1952.

28. Kramer, H.H., and Davis, R.L. The effect of stand and moisture content on computed yields of alfalfa. Agron. J. 470-473. 1949.

29. Law, A.C., and Patterson, J.K. The influence of early spring clipping on alfalfa yields. Agron. J. 47:323-324. 1955.

30. LeClerg, E.L., Leonard, W.H., and Clark, A.G. Field Plot Technique. 2nd Ed. Burgess Publishing Co. Minneapolis 23, Minn. 1962.

31. Loomis, R.S., and Williams, W.A. Maximum crop productivity; an estimate. Crop Sci. 3:67-72. 1963.

32. Mathews, R.O., and Cole, J.S. Special dry farming problems. U.S.D.A. Year book, pp. 679-692. 1938.

33. Mckenzie, R.E. The effect of harvesting practices on yield and winter survival of alfalfa under irrigation. Sci. Agri. 31:457-462. 1951.

34. Morrison, F.B. Feeds and feeding, 9th Ed. (abridged) pp. 204-213. The Morrison Publishing Co. Clinton, Iowa. 1961.

35. Manghirmalani, C.R. Effect of planting dates and stages of harvest on yield and protein content of forages. M.S. Thesis, Faculty of Agricultural Sciences, A.U.B. Beirut. 1961.

36. Nelson, N.T. The effect of frequent cutting on the production, root reserves, and behaviour of alfalfa. Jour. Amer. Soc. Agron. 12:100-113. 1925.

37. Parsons, J.L., and Davis, R.R. Forage production of Vernal alfalfa under differential cutting and phosphorus fertilization. Agron. J. 52:441-443. 1960.

38. Reynolds, J.H., and Smith, D. Trend of carbohydrate reserves in alfalfa, smothebrome grass and timothy, grown under various cutting schedules. Crop Sci. 2:332-337. 1962.

39. Rumbaugh, M.D. Effects of population density on some components of yield of alfalfa. Crop Sci. 3:423-425. 1963.

40. Russel, J. High quality forages. Wisc. Ext. Ser. Cir. 396. 1951.

41. Sayegh, A. The agricultural guide of Lebanon. Samia press, pp. 81-82, Beirut. 1962.

42. Smith, D., and Kust, C.A. Influence of harvest management on the level of carbohydrate reserves, longevity of stands and yields of hay and protein from Vernal alfalfa. Crop Sci. 1:267-269. 1961.

43. Snedecor, G.W. Statistical methods. 5th Ed. The Iowa State Univ. Press, Ames, Iowa. pp. 291-394. 1955.

44. Stahler, L.M. Shade and soil moisture as factors in competion between selected crops and field bind weed (Convolvulus arvensis). Jour. Amer. Soc. Agron. 40:490-502. 1948.

45. Tysdal, H.M. "Alfalfa", forages, the science of grassland agriculture, Iowa State college press. Ames, Iowa. pp. 138-154. 1951.

46. Tysdal, H.M., and Westover, H.L. Alfalfa improvement. U.S.D.A. Year book, pp. 1122. 1937.

47. Tysdal, H.M., and Kiesselbach, T.A. The differential response of alfalfa varieties to time of cutting. Jour. Amer. Soc. Agron. 31:513-519. 1939.

48. Willard, C.J. Root reserves of alfalfa with special reference to the time of cutting and yield. Jour. Amer. Soc. Agron. 22:595-602. 1930.

49. ______________. Management of alfalfa meadows after seeding. Adv. in Agron. Vol. III, pp. 93-112. Academic Press.Inc. New York. 1950.

50. Woodman, H.E., Evans, R.E., and Norman, D.B. Nutritive value of lucerne, I-Preliminary studies of yield, composition and nutritive value. Jour. Agri. Sci. 23:419-458. 1933.

51. ______________. Nutritive value of lucerne, IV. The leaf and stem ratio. Jour. Agri. Sci. 25:578-597. 1935.

APPENDIX

Table 8. Analysis of variance for total yield in kgs. per dunum of green alfalfa forage.

Source	D.F.	M.S.	F.
Blocks	3	99347.57	4.87+
Harvest (H)	2	17623.08	0.86
Error (a)	6	20381.04	-
Population (P)	1	31078.81	9.06+
H x P	2	3637.06	1.06
Error (b)	9	3429.38	-

+ Denotes F values significant at the 5% level.

Table 9. Analysis of variance for alfalfa dry matter (oven dry), when harvested one year after seeding.

Source	D.F.	M.S.	F.
Blocks	3	2577.94	4.88[+]
Harvest (H)	2	1320.31	2.49
Error (a)	6	528.26	-
Population (P)	1	1321.65	4.39
H x P	2	82.00	0.27
Error (b)	9	300.73	-

[+] Denotes F value significant at the 5% level.

Table 10. Analysis of variance for protein percentage of alfalfa forage.

Source	D.F.	M.S.	F.
Blocks	3	4.74	2.43
Harvest (H)	2	27.10	13.93++
Error (a)	6	1.95	-
Population (P)	1	1.01	3.37
H x P	2	0.29	0.96
Error (b)	9	0.30	-

++ Denotes F value significant at the 1% level.

Table 11. Analysis of variance for alfalfa plant height.

Source	D.F.	M.S.	F.
Blocks	3	130.85	17.01++
Harvest (H)	2	72.00	9.36+
Error (a)	6	7.69	-
Population (P)	1	29.26	2.42
H x P	2	3.70	0.30
Error (b)	9	12.09	-

\+ Denotes F values significant at the 5% level.

++ Denotes F values significant at the 1% level.

Table 12. Analysis of variance for number of stems per meter of row of alfalfa[x].

Source	D.F.	M.S.	F.
Blocks	3	1.6000	192.77++
Harvest (H)	2	2.4000	289.15++
Error (a)	6	0.0083	-
Population (P)	1	0.5500	33.13++
H x P	2	0.0500	3.01
Error (b)	9	0.0166	-

x Logarithmic transformation of percentage data was used.

++ Denote F values significant at the 1% level.