

5  
T  
549

EFFECT OF DATE OF PLANTING AND HARVESTING  
ON WINTER FORAGE YIELDS.

by  
Akhtar Beg

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

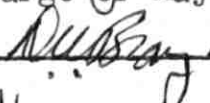
Major: Agronomy-Plant Breeding

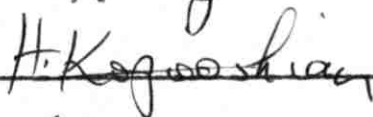
Minor: Plant Pathology

Approved:



In Charge of Major Work





Nasir S. Kawan



Chairman, Graduate Committee

American University of Beirut

1963

Yield Trials of Winter Forages

Beg

## ACKNOWLEDGEMENT

The writer wishes to express his sincere and deep appreciation for the many suggestions and criticism offered by his advisor, Dr. Wallace W. Worzella. His infinite patience, invaluable guidance and helpful advice have been a constant source of enlightenment.

To Miss Marie-Louise Davidian who suggested the method for statistical analysis of the experiment, spared her valuable time to derive a formula for the estimation of missing plots and her advice over the statistical preparation of the thesis, the author owes a special debt of gratitude.

Thanks are due to Miss Mona Jabbour for typing and retyping the manuscript of this thesis.

Akhtar Beg

## ABSTRACT

The effects of two dates of planting and two dates of harvesting on the forage yield, protein percentage and protein yield of five winter forages, oats, rye, vetch, oats-vetch and rye-vetch were studied for the two years at the American University Farm.

Forage crops produced higher yield when planted in November and harvested nearer maturity. Likewise, the crops gave higher protein yield when planting was done early and harvesting at near full growth. The percentage protein, on the other hand, was high in crops planted in December and harvested when still immature.

There was no difference between the forage yield of oats-vetch, rye-vetch and vetch. Rye and oats planted alone produced the lowest yield of forage. Vetch forage gave the highest percent of protein, while vetch and rye-vetch mixture produced the highest amount of total protein per dunum.

## TABLE OF CONTENTS

	Page
INTRODUCTION .....	1
REVIEW OF LITERATURE .....	3
MATERIAL AND METHODS .....	12
RESULTS AND DISCUSSION .....	15
Oats .....	15
Rye .....	19
Vetch .....	23
Oats-vetch .....	27
Rye-vetch .....	31
SUMMARY AND CONCLUSIONS .....	45
LITERATURE CITED .....	47
APPENDIX I .....	49
APPENDIX II .....	61

## LIST OF TABLES

Table	Page
1. Effect of date of planting and date of harvesting on the forage yield of oats in kg. per dunum during 1961-62 and 1962-63 in the Beqa'a, Lebanon...	16
2. Effect of date of planting and date of harvesting on the protein percentage of oats forage during 1961-62 and 1962-63 in the Beqa'a, Lebanon .....	17
3. Effect of date of planting and date of harvesting on the protein yield of oats in kg. per dunum during 1961-62 and 1962-63 in the Beqa'a, Lebanon....	18
4. Effect of date of planting and date of harvesting on the forage yield of rye in kg. per dunum during 1961-62 and 1962-63 in the Beqa'a, Lebanon .....	20
5. Effecting of date of planting and date of harvesting on the protein percentage of rye forage during 1961-62 and 1962-63 in the Beqa'a, Lebanon .....	21
6. Effect of date of planting and date of harvesting on the protein yield of rye forage in kg. per dunum during 1961-62 and 1962-63 in the Beqa'a, Lebanon ..	22
7. Effect of date of planting and date of harvesting on the forage yield of vetch in kg. per dunum during 1961-62 and 1962-63 in the Beqa'a, Lebanon ..	24
8. Effect of date of planting and date of harvesting on the protein percentage of vetch forage during 1961-62 and 1962-63 in the Beqa'a, Lebanon .....	25
9. Effect of date of planting and date of harvesting on the protein yield of vetch forage in kg. per dunum during 1961-62 and 1962-63 in the Beqa'a, Lebanon ..	26
10. Effect of date of planting and date of harvesting on the forage yield of oats-vetch mixture in kg. per dunum during 1961-62 and 1962-63 in the Beqa'a, Lebanon .....	28
11. Effect of date of planting and date of harvesting on the protein percentage of oats-vetch forage during 1961-62 and 1962-63 in the Beqa'a, Lebanon .....	29

12.	Effect of date of planting and date of harvesting on the protein yield of oats-vetch forage in kg. per dunum during 1961-62 and 1962-63 in the Beqa'a, Lebanon .....	30
13.	Effect of date of planting and date of harvesting on the forage yield of rye-vetch mixture in kg. per dunum during 1961-62 and 1962-63 in the Beqa'a, Lebanon .....	33
14.	Effect of date of planting and date of harvesting on the protein percentage of rye-vetch forage during 1961-62 and 1962-63 in the Beqa'a, Lebanon .....	34
15.	Effect of date of planting and date of harvesting on the protein yield of rye-vetch forage during 1961-62 and 1962-63 in the Beqa'a, Lebanon .....	35
16.	Effect of date of planting and date of harvesting on the average forage yield of five species of crops in kg. per dunum during 1961-62 and 1962-63 in the Beqa'a, Lebanon .....	37
17.	Average forage yield of five species of crops planted at two dates and harvested at two dates in kg. per dunum during 1961-62 and 1962-63 in the Beqa'a, Lebanon .....	39
18.	Effect of date of planting and date of harvesting on the average of protein percentages of forages during 1961-62 and 1962-63 in the Beqa'a, Lebanon .....	40
19.	Average protein percentage of five species of crops planted at two dates during 1961-62 and 1962-63 in the Beqa'a, Lebanon .....	41
20.	Effect of date of planting and date of harvesting on the average protein yield of five species of crops in kg. per dunum during 1961-62 and 1962-63 in the Beqa'a, Lebanon .....	42
21.	Average of protein yield of five species of crops planted at two dates and harvested at two dates in kg. per dunum during 1961-62 and 1962-63 in the Beqa'a, Lebanon .....	44
22.	Analysis of variance for forage yield of oats in kg. per dunum .....	49
23.	Analysis of variance for protein percentage of oats forage .....	49

Table	Page
24. Analysis of variance for protein yield of oats forage in kg. per dunum .....	50
25. Analysis of variance for forage yield of rye in kg. per dunum .....	50
26. Analysis of variance for the protein percentage of rye forage .....	51
27. Analysis of variance for the protein yield of rye forage in kg. per dunum .....	51
28. Analysis of variance for the forage yield of vetch in kg. per dunum .....	52
29. Analysis of variance for the protein percentage of vetch forage .....	52
30. Analysis of variance for the protein yield of vetch forage in kg. per dunum .....	53
31. Analysis of variance for the forage yield of oats-vetch in kg. per dunum .....	53
32. Analysis of variance for the protein percentages of oats-vetch forage .....	54
33. Analysis of variance for the protein yield of oats-vetch forage in kg. per dunum .....	54
34. Analysis of variance for the forage yield of rye-vetch in kg. per dunum .....	55
35. Analysis of variance for the protein percentage of rye-vetch forage .....	55
36. Analysis of variance for the protein yield of rye-vetch in kg. per dunum .....	56
37. Analysis of variance for the yield of forages in kg. per dunum .....	57
38. Analysis of variance for the protein percentages of forages .....	58
39. Analysis of variance for the protein yield of forages in kg. per dunum .....	59
40. Rainfall and temperature .....	60



## INTRODUCTION

Increasing population of the world confronts a serious food problem. The world agricultural scientist are making every effort to improve the food condition. Food consists not only of cereals but meat and milk as well. Rather meat, milk and milk products constitute a large portion of our daily diet.

The animal products contain protein which are one of the principal constituent of the muscles and soft structure of the animal body. A liberal and continuous supply of protein is needed in the food throughout life for growth and repair of the animal body.

In the East where agriculture is not yet mechanised the cultivation of the crops for the present also depends on draught animals. The animals thus have two fold importance as a direct consumption commodity and as a producer of the other food crops.

In order to keep a constant and regular supply of animal product there is a connected necessity of having a healthy population of animals. This directly depends upon the production of high quality forages and pastures.

The quality of forages is generally determined by its protein content, which depends on the kind of plant, its stage of maturity and the efficiency with which it is harvested and preserved before being fed to livestock.

Lebanon depends on the importation of a large proportion of its requirements of the animal products from neighboring countries which are not ideally suited for animal production. In order to develop the local resources of animal products it is essential to investigate the quantity and quality of forages present in the region and the methods to improve them. In the Middle East it is the general experience that the farmers are usually short of forages for their animals during winter months.

This study deals with the prospects of winter forages as regards their yield and quality affected by date of sowing and harvesting, and when grown alone and/or in mixtures.

Oats, vetch, rye, oats with vetch and rye with vetch were planted at two dates and harvested at two stages of growth. The species were grown under dryland conditions in the Beqa'a, Lebanon during the two years 1961-62 and 1962-63.

## LITERATURE REVIEW

McCain and Cooperking (7) conducted experiments from 1952 through 1957 to determine the best dates of planting oats for grain only and for forage and grain combined for Northern, Central and Southern Alabama. Their results indicate that early planting will give the maximum yield of forage and grain for these regions.

Pendleton and Brown (12) reported the studies involving the effect of rate of seeding, date of planting, nitrogen fertilization and variety on yield and protein composition of oats cut in the early dough stage. Two dates of planting were made in 1956 and 1957, the average early date being mid-March and the late date in late-April. The mid-March planting date provided 2.1 more tons of forage than a late April seeding date. Although this was a reduction of 18 percent in forage yield for the late seeding, the same comparison for grain yield showed a 31 percent decrease. Protein content of the forage on a dry matter basis averaged 11.7 percent for the early planting and 12.7 percent for the late planting date. However, a total of 852 pounds of protein per acre was produced from the early date compared to 768 from the late date.

The relative yielding ability of barley, oats and rye as affected by planting and harvest dates was determined by Sumner, Stevenson, McNeilly and Miller (22). Their results

show that early sowing and late harvesting gave the highest yield for all the three crops. Barley gave more dry matter yield per acre than rye or oats when sown on September 1 and October 1 and harvested in November, December or January. Rye out-yielded barley and oats when harvested in February and March. The protein percentage of these three species agreed closely at each harvest date, averaging 33.2 in October, 17.8 in November, 12.8 in December and 11.8 in January.

It was observed by Thurman, Stallcup, Stephens and Justus (23) on oats that the green weight obtained per acre were highest during the period from early flower stage of maturity to the milk stage. The percentage of dry matter was lowest (20.4) in the boot stage and increased with the stage of maturity up to 41.67 percent in the hard dough stage. The leaves on the plants with grain in hard or firm dough stage of maturity were still in good green condition. The air dry forage produced per acre increased slowly from the boot stage to the milk stage of maturity with a rather high increase in the milk stage. There was very little difference in the yield of air-dry hay at the milk, soft dough and hard dough stages of maturity. The protein percentage was highest for the boot stage (13.14) and lowest for the hard dough stage (8.87).

Schmidt (18) stated that applied nitrogen was more effective in increasing nitrogen yield and percentage than in increasing dry matter yield of oats. Dry matter yield and nitrogen percentage differed with the varieties. Clipping

when growth reached 10-14 inches in height reduced dry matter and nitrogen yield of both grain and straw. The highest yield of both nitrogen and dry matter were obtained when oats were harvested at maturity as grain and straw.

A study was conducted on spring oats varieties by Gardner and Wiggans (3) for yield and protein percentage when harvested at boot, heading, milk, early dough and late dough stages. The average yield at 65 percent moisture was 4.91, 6.38, 9.4, 11.09 and 11.81 tons per acre at the successive stages. The early to late dough stages were considered the most suitable for ensiling. The average protein content was 14.4, 12.7, 11.0, 9.9 and 9.2 percent for the successive stages.

Stallcup, Roberson, Loooper and Thurman (21) investigated the changes in chemical composition of Arkwin oat forage with advanced stages in maturity. They found that the percentage of protein and ash and the parts per million of carotene generally declined while the percentage of crude fibre increased with advance in maturity from boot to hard dough stages. Nitrogen free extracts and gross energy were high in immature plants, declined until the heads were in the milk stages, and then increased as the grain developed in the head. They also observed that prior to the boot stage the protein content of the forage remains above 15 percent and the crude fiber of the plant is below 20 percent. At the boot and more advanced stages of maturity the dry matter content is more suitable

for the preservation of silage and the curing of hay.

An experiment was conducted by Rosen, Wiser and York (17) on the crude protein of oats forage from November through March and they observed that early growth in the fall was much higher in protein than were the later clippings. Similar studies were made by Norman (9) on barley plants. His results showed that the nitrogen increases in the early stages of growth i.e. during the first three weeks of growth after emergence, and then there is a steady decrease of nitrogen and increase of dry matter.

In 1962 Wedin (24) reported the yield and percentage of crude protein as affected by harvest date on six early summer and six late summer annual forage crops. Early summer crops were oats, oats-rape, rape, oats-peas, peas and winter rye. He observed that differences in dry matter yield and percent crude protein of the first harvest were highly significant among the crops. Weekly delays in harvest caused significant increases in yield of dry matter and highly significant decreases in percent crude protein. Late summer crops tested were solid seeded corn, sudan grass, soybean-sudan grass, and soybean. Yield differences and crude protein percent of the first harvest were highly significant among these crops. Increases in dry matter yields were significant in one year only, whereas crude protein decreases were highly significant due to delay in harvest time. Total seasonal yields were markedly increased for the combination including rape

or sudan grass.

Plummer (14) analysed grasses and legumes at different stages of growth for protein content. The legumes analysed were alfalfa, alsike clover, birdsfoot trefoil, ladino clover, peas, sweet clover, and vetch. The grasses were oats, orchard grass, reed canary grass, timothy and witch grass. He observed that the protein content was greatly influenced by species and stage of maturity. Protein content varied from five percent to 28 percent. The legumes had about twice the amount of protein as in the grasses. The average protein content of the legumes was 18.5 percent while that of grasses was 9.4 percent. Protein content was high in the early stages of growth and decreased as the plant matured. Second crop cuttings of both grasses and legumes were high in protein. Oats had 16.8 percent protein in the early stage and changed to 8.63 percent with delay of one month in harvest. The protein in vetch reduced from 21.51 to 19.95 percent with a delay of 15 days in harvest.

The oats plant chemical composition at various stages of growth was studied by Kohler (6). He concluded that most of the vitamins and the protein, crude fat, and chlorophyll reach a peak in concentration at or near the jointing stage. At this stage the plant is at the peak of its vegetative development and the aerial parts of the plants are made up entirely of leaf blades and sheaths.

Alfalfa, red clover, soybean and lespedeza were

analysed by Pieters (13) at different stages of maturity. The stages of maturity were before bloom, in bloom and past bloom. Protein percentage for alfalfa for each stage was 19.0, 14.9, 14.0 respectively. For red clover it was 18.7, 12.6 and 12.3. Soybean had 17.4, 14.9 and 15.8 percent protein at different successive stages and in lespedeza it was 14.2, 13.4 and 12.5, respectively. These analyses agree substantially that with advancing maturity the percentage of protein tends to decline. This is true in most plants except in case of soybean where it first declines and then rise up.

Hodgson (5) studied the effect of time of harvest on yield and protein content of oat-pea forage. The harvests were begun when the oats were in the early milk stage and continued at weekly intervals. The yield increased while the protein percentage decreased with the advance stages in maturity. The harvests made when the oats were in the late milk stage to early dough stage and pea pods filled were considered the most desirable.

Willard (25) studied the protein content of alfalfa meadow hay. His observations agree with the previous statement that protein decreases steadily with the increasing maturity of plants.

Cereal hays harvested at different stages of maturity were analysed by Sotola (19). The crops analysed were wheat, barley, oats and rye. On a dry matter basis young cereal plants were high in protein resembling alfalfa and sweet



clover. As the cereal plants matured the fiber and nitrogen free extracts increased and fat, protein and ash decreased.

Stallcup (20) studied the lignin and cellulose contents of the dry matter of eleven forages. These included two legume hays, five grass hays, oats straw and oats silage made from plants harvested at the boot, milk and dough stages of growth. He concluded that crude fiber make-up is dependent on the stage of maturity in these plants.

Reid, Kennedy, Turk, Slack, Trimmerger and Murphy (15) stated that early cut fodder is consumed much more readily than the late cut fodder. They pointed out that the time of cutting is a dominant factor determining the rate of voluntary consumption of first cuttings in dairy animals. Total digestible nutrients (TDN) value of alfalfa and timothy decreased with advance in maturity. The hay prepared from forages cut on June 11 was about 30 percent higher in TDN and was consumed at a rate about 30 percent greater than that of the hay harvested on July 9. About 40 percent more milk was produced and 0.5 pounds more body weight was gained per day by the cows consuming the early cut hay than by those fed the late cut hay. They further observed in a study of 28 forages representing a variety of species, ranging in dry matter content from 15 to 40 percent, that the dry matter content and digestibility were correlated to the extent of + 0.8. They also concluded that leaf content of forages reflect their nutritive value. Both the amount and digestibility of protein in

forages decline as growth approaches the mature stage.

In 1961 Manghirmalani (8) observed on oats, vetch, oats-vetch and oats-peas that forage and protein yields decreased significantly with delayed plantings and increases with delayed harvests. Protein percentage tended to increase with delayed sowing and decreased with delayed harvestings. Early planting on November or December were found best for high yields and early heading or full bloom stage was best from a yield and quality stand point.

Robinson (16) reported the forage yield, protein percent and protein yield of oats, oats-peas, and oats-vetch. Oats alone gave 5222 pounds of forage yield, its protein content was 8.4 percent and protein yield was 441 pounds per acre. The oats-peas mixture gave 5422 pounds of forage with a protein content of 10.8 percent and protein yield of 590 pounds. The oats-vetch mixture yielded 5298 pounds of forage with a protein content of 10.2 percent and protein yield of 531 pounds. He concluded that as forage crops, oats-legume mixtures were superior to oats alone in both protein content and protein yield per acre. As feed grain crop oats-pea mixture was superior to oats alone or oats-vetch in protein yield per acre.

It was mentioned by Pendleton (11) that a red clover interseeding reduced oat grain yield and the reduction increased as grain row width increased. The average yield loss due to clover seeding eight inch between row was 7 percent,

16 inch row 10 percent, 24-inch row 14 percent and 32 inch 18 percent.

Henderson and Davies (4) compared productivity at seven stages of growth of oats and legumes sown singly and in mixtures. Legume used were peas and beans. They concluded that oat-legume mixture gave a higher average yield of dry matter than any of the crops grown singly, while the peas yielded the greatest amount of crude protein.

## MATERIALS AND METHODS

This study was conducted at the American University Farm which is situated in the Beqa'a plain, the main agricultural area of Lebanon, on the land similar to that found in many of the Middle East countries. The soil was of clay type and calcareous with a pH value of 8.0. The experiment was conducted during 1961-62 and 1962-63 under dry farming conditions.

The trial was conducted on land which was in fallow the previous year. The seed bed was well prepared by plowing and disking. During the second year four kilograms of nitrogen and four kilograms of  $P_2O_5$  per dunum were applied before sowing in the form of ammonium sulphate nitrate and superphosphate, respectively.

Five kinds of forages, viz., Algerian oats, rye, vetch, oat-vetch and rye-vetch were planted on two dates and harvested on two dates to compare their yield and quality. Dates for the first and second planting were November 11 and December 11 in 1961 and November 11 and December 29 in 1962. In the fall of 1962 there were no rains during the month of November, first rain in December was obtained on the 5th of the month, so second sowing date was delayed.

Oats and rye were planted at the rate of 10 kg per dunum when sown alone and 7 kg per dunum when sown in mixture.

Vetch was planted at the rate of 8 kg per dunum when sown alone and 5 kg per dunum when sown in mixture. The seed of vetch was inoculated before sowing.

The seeding was done with hand driven Planet Junior. Weeding was done regularly to reduce competition between crop plants and weeds for moisture.

The early harvesting was carried out when the oats were in pre-bloom stages, rye 14-16 cms in height, and vetch about fifty percent in bloom. The late harvesting was done when the Oats Kernels were in the dough stage, rye in the bloom stage, and the vetch grain in the soft dough stage.

In the second year due to favourable moisture conditions, regrowth of oats occurred, which was harvested at the pre-bloom stages.

The first year harvesting was done on April 12 and April 26 for the early planting and April 19 and May 3 for late planting. The second year harvesting of all crops except rye was done on April 16 and May 3 for the early planting and April 26 and May 12 for the late planting. Rye harvesting was delayed further due to its slow growth and was harvested on May 12 and May 19 for the early planting and May 19 and May 26 for the late planting.

Two square meters from each plot were harvested with hand clippers for yield and protein determinations. The samples after harvest were air dried in cloth bags for forty days. Their moisture content was determined and the forage

were calculated to a 12.5 percent moisture basis. Analyses for protein were made according to the procedure of the Association of Official Agricultural Chemists (2).

The experiment was laid out on a split-strip plot design involving eight replications. Main plots were assigned to dates of planting. Each main plot was split for five species combination and strip for two dates of harvesting. Each plot represented six rows of three meters length. The distance between rows was 25 cms.

Statistical methods appropriate to the split-strip plot design were used to analyse the data. Analysis of variance and 't' test were employed to determine the differences between the treatments (10).

In the first year two plots of vetch died in the early stages of growth due to an unidentified root disease and a few bags containing harvested samples were lost. Therefore, the missing plot technique was used to estimate the missing data according to the procedure given in the appendix (II).

## RESULTS AND DISCUSSION

This experiment was conducted at the American University Farm during the seasons of 1961-62 and 1962-63, to study the effects of dates of planting and harvesting on the forage yield, protein percentage and protein yield of oats, rye, vetch, oats-vetch and rye-vetch.

The results are presented in Tables 1 to 21 together with the L.S.D. values. The analyses of variance for the characters studied are given in Tables 22 to 39 in the appendix, I.

### OATS

Forage yield in oats was greatly affected by the different dates of planting. As shown in Table 1 the November planting gave higher yields of forage than the December planting during both of the years. Differences in yield were more pronounced in the second year. This may be due to the greater interval in the planting dates during the second year. Early harvest gave lower yield as compared with the late harvest during both of the years. There was a second growth of oats during 1962-63 due to favourable moisture condition in the later stages of the growing season (Table 40).

There were no differences in the protein percentage of the forage of oats due to the date of planting as shown in Table 2. Significant differences in protein percentage of

Table 1. Effect of date of planting and date of harvesting on the forage yield of oats in kg. per dunum during 1961-62 and 1962-63 in the Beqa'a, Lebanon.

Date of harvest	Date of planting						Two-year Average		
	1961-62			1962-63			Nov.	Dec.	Average
	Nov.	Dec.	Average	Nov.	Dec.	Average			
Early	139.4	98.6	119.0	175.0	98.6	136.8	157.2	98.6	127.9
Late	225.0	175.6	200.3	203.0	144.8	173.9	214.0	160.2	187.1
Average	182.2	137.1	159.6	189.0	121.7	155.4	185.6	129.4	157.5

L. S. D.

Source	1961-62		1962-63		Two-year Average	
	1°/o	5°/o	1°/o	5°/o	1°/o	5°/o
Planting	N.S.	42.0	50.5	34.0	38.4	27.6
Harvest	63.5	43.0	N.S.	26.4	30.0	21.6
Interaction	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.



Table 2. Effect of date of planting and date of harvesting on the protein percentage of oats forage during 1961-62 and 1962-63 in the Beqa'a, Lebanon.

Date of harvest	Date of planting						Two-year Average		
	1961-62			1962-63			Nov.	Dec.	Average
	Nov.	Dec.	Average	Nov.	Dec.	Average	Nov.	Dec.	Average
Early	6.96	7.03	6.99	6.83	8.87	7.85	6.89	7.95	7.42
Late	5.05	5.31	5.18	5.60	6.64	6.12	5.32	5.97	5.64
Average	6.00	6.17	6.08	6.21	7.75	6.98	6.10	6.96	6.53

L. S. D.

Source	1961-62		1962-63		Two-year Average	
	1% 5%	N.S. N.S.	1% 5%	N.S. N.S.	1% 5%	N.S. N.S.
Planting	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Harvest	.75	.50	1.04	.70	1.66	1.20
Interaction	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

Table 3. Effect of date of planting and date of harvesting on the protein yield of oats forage in kg. per dunum during 1961-62 and 1962-63 in the Beqa'a, Lebanon.

Date of harvest	Date of planting										
	1961-62				1962-63				Two-year Average		
	Nov.	Dec.	Average		Nov.	Dec.	Average		Nov.	Dec.	Average
Early	9.32	6.86	8.09		15.34	10.56	12.95		12.33	8.71	10.52
Late	12.01	9.30	10.65		14.37	12.90	13.63		13.19	11.10	12.14
Average	10.67	8.08	9.37		14.85	11.73	13.29		12.76	9.90	11.33

L. S. D.

Source	1961-62		1962-63		Two-year Average	
	1°/o	5°/o	1°/o	5°/o	1°/o	5°/o
Planting	N.S.	2.48	N.S.	N.S.	N.S.	N.S.
Harvest	N.S.	2.06	N.S.	N.S.	N.S.	N.S.
Interaction	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

the crop were found due to date of harvest. Oats from the early harvest produced an average of 7.42 percent protein and that from the late harvest 5.64 percent protein. The oats forage obtained from the second growth in 1963 was made up largely of leaves and contained 12.13 percent protein.

The data for the protein yield per dunum are reported in Table 3. The November planting produced a greater amount of protein per dunum during both of the years, however, only the first year data were statistically significant. Likewise, the oats crop from the later harvest produced the greatest amount of total protein per dunum.

The results for forage yield, protein percentage and protein yield found in these trials are in agreement with MaCain and Cooperking (7) Pendleton and Brown (12) Summer et al (22) Thurman et al (23) and Gardner and Wiggans (3).

#### RYE

The data on the effect of date of planting and harvesting on the forage yield of rye are shown in Table 4. The November plantings gave the higher yields, however, only the first year's data are statistically significant. Later harvest of the rye crop gave more than double the forage yield of that from the early harvest in both the years. It will be noted that the average yield of rye harvested early was 44.6 kg. per dunum while 102.3 kg. was obtained when harvested later.

The date of planting did not affect the protein percentage of the rye forage in either year as shown in

Table 4. Effect of date of planting and date of harvesting on the forage yield of rye in kg. per dunum during 1961-62 and 1962-63 in the Beqa'a, Lebanon.

Date of harvest	Date of planting								
	1961-62		1962-63		Two-year Average				
	Nov.	Dec.	Average	Nov.	Dec.	Average			
Early	57.5	31.4	44.4	49.0	40.6	44.8	53.2	36.0	44.6
Late	122.4	73.0	97.7	86.3	77.8	82.0	104.3	100.4	102.3
Average	89.9	52.2	71.0	67.6	59.2	63.4	78.7	68.0	73.4

L. S. D.

Source	1961-62		1962-63		Two-year Average	
	1°/o	5°/o	1°/o	5°/o	1°/o	5°/o
Planting	N.S.	26.3	N.S.	N.S.	N.S.	N.S.
Harvest	12.9	8.7	18.2	12.3	10.6	7.6
Interaction	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

Table 5. Effect of date of planting and date of harvesting on the protein percentage of rye forage during 1961-62 and 1962-63 in the Beqa'a, Lebanon.

Date of harvest	Date of planting								
	1961-62			1962-63					
	Nov.	Dec.	Average	Nov.	Dec.	Average			
Early	10.86	10.83	10.84	9.37	10.73	10.05	10.11	10.78	10.44
Late	7.45	8.35	7.90	7.21	8.83	8.02	7.33	8.59	7.96
Average	9.15	9.59	9.37	8.29	9.78	9.03	8.72	9.68	9.20

L. S. D.

Source	1961-62		1962-63		Two-year Average	
	1%	5%	1%	5%	1%	5%
Planting	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Harvest	1.36	.92	.93	.63	.61	.44
Interaction	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

Table 6. Effect of date of planting and date of harvesting on the protein yield of rye forage in kg. per dunum during 1961-62 and 1962-63 in the Beqa'a, Lebanon.

Date of harvest	Date of planting						Two-year Average	
	1961-62			1962-63			Nov.	Dec.
	Nov.	Dec.	Average	Nov.	Dec.	Average	Nov.	Dec.
Early	6.23	3.37	4.80	4.70	4.37	4.53	5.46	3.87
Late	9.12	6.09	7.60	6.21	6.84	6.52	7.66	6.46
Average	7.67	4.73	6.20	5.45	5.60	5.52	6.56	5.16

L. S. D.

Source	1961-62		1962-63		Two-year Average	
	1%	5%	1%	5%	1%	5%
Planting	N.S.	2.59	N.S.	N.S.	N.S.	N.S.
Harvest	1.61	1.09	1.39	.94	.89	.64
Interaction	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

Table 5. The rye harvested earlier contained the higher protein percentage. The average of the two years shows that the early harvested rye contained 10.44 percent protein and the late harvested crop possessed 7.96 percent protein.

In 1961-62 rye planted in November produced a higher amount of protein than that sown in December as seen in Table 6. In 1962-63 the differences in total protein due to plantings were not significant. The total protein obtained from the rye forage harvested at an early stage was lower in both of the years. On the average the early harvest produced 4.66 kg. of protein per dunum while the later harvest yielded 7.06 kg.

#### VETCH

The forage yield data for vetch are reported in Table 7. Higher yield is noted from the November sowing over that for the December planting, however, only the second year's results are significant. In both years the later harvests produced the highest forage yields. The average yield of the vetch from the early harvest was 160.6 kg. per dunum and from the later harvest 274.1 kg.

The effect of date of planting and harvesting on the protein percentage of the vetch forage are shown in Table 8. The forage harvested from the November plantings produced the greatest percentage of protein. On the basis of two-year average vetch harvested in November contained 13.93 percent protein and that in December had 12.45 percent protein. The

Table 7. Effect of date of planting and date of harvesting on the forage yield of vetch in kg. per dunum during 1961-62 and 1962-63 in the Beqa'a, Lebanon.

Date of harvest	Date of planting								
	1961-62			1962-63					
	Nov.	Dec.	Average	Nov.	Dec.	Average			
Early	158.2	97.8	128.0	230.2	156.5	193.3	194.2	127.1	160.6
Late	289.8	173.6	231.7	372.1	262.1	317.1	330.4	217.8	274.1
Average	224.0	135.7	179.8	301.1	209.3	255.2	262.3	172.4	217.3

L. S. D.

Source	1961-62		1962-63		Two-year Average	
	1°/°	5°/°	1°/°	5°/°	1°/°	5°/°
Planting	N.S.	N.S.	83.6	56.5	N.S.	N.S.
Harvest	42.7	28.9	45.7	30.9	26.6	19.2
Interaction	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.



Table 8. Effect of date of planting and date of harvesting on the protein percentage of vetch forage during 1961-62 and 1962-63 in the Beqa'a, Lebanon.

Date of harvest	Date of planting						Two-year Average		
	1961-62		1962-63		Average		Nov.	Dec.	Average
	Nov.	Dec.	Average	Nov.	Dec.	Average	Nov.	Dec.	Average
Early	14.09	13.52	13.80	18.05	15.59	16.82	16.07	14.55	15.31
Late	11.16	10.15	10.65	12.45	10.55	11.50	11.80	10.35	11.07
Average	12.62	11.83	12.22	15.25	13.07	14.16	13.93	12.45	13.19

L. S. D.

Source	1961-62		1962-63		Two-year Average	
	1°/°	5°/°	1°/°	5°/°	1°/°	5°/°
Planting	N.S.	N.S.	N.S.	1.51	N.S.	N.S.
Harvest	1.01	.68	2.51	1.69	.30	.21
Interaction	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.



protein percentage in the early harvested vetch was significantly higher than that from the later harvest. On the average the early harvested vetch contained 15.31 percent protein, while that from the late harvested crop had 11.07 percent protein.

The seeding made in November produced higher protein yields per dunum in both of the years (Table 9). The increase in protein yield was obtained because of the fact that the November planted vetch produced the higher forage yield. The average of the two years show that the November plantings produced 34.54 kg. of protein per dunum while vetch sown in December made 20.91 kg.

A significant increase in protein yield was obtained by harvesting the vetch at the later date in the first year. The increase obtained in 1962-63 for the later harvest, however, was not significant.

#### OATS-VETCH

The forage yield of the oats-vetch mixture was greatly affected by the dates of planting as seen in Table 10. The plantings made in November resulted in the highest yield of the oats-vetch forage. The two year average shows that the November plantings gave 263.7 kg. of forage per dunum and the December seedings produced 209.1 kg. Also, the later harvest produced the highest forage yield in both of the years. An average of 174.2 kg. of forage per dunum for early harvest and 298.7 kg. per dunum for later harvest

Table 10. Effect of date of planting and date of harvesting on the forage yield of oats-vetch mixture in kg. per dunum during 1961-62 and 1962-63 in the Beqa'a, Lebanon.

Date of harvest	Date of planting									
	1961-62				1962-63				Two-year Average	
	Nov.	Dec.	Average	Nov.	Dec.	Average	Nov.	Dec.	Average	
Early	145.9	128.9	137.4	233.5	188.5	211.0	189.7	158.7	174.2	
Late	313.4	199.9	256.6	362.2	319.3	340.7	337.8	259.6	298.7	
Average	229.6	164.4	197.0	297.8	253.9	275.8	263.7	209.1	236.4	

L. S. D.

Source	1961-62		1962-63		Two-year Average	
	1°/o	5°/o	1°/o	5°/o	1°/o	5°/o
Planting	38.0	25.7	N.S.	32.7	N.S.	18.66
Harvest	48.7	32.9	62.2	42.0	33.19	23.91
Interaction	20.6	13.9	N.S.	N.S.	N.S.	N.S.

Table 11. Effect of date of planting and date of harvesting on the protein percentage of oats-vetch mixture during 1961-62 and 1962-63 in the Beqa'a, Lebanon.

Date of harvest	Date of planting						Two-year Average		
	1961-62			1962-63			Nov.	Dec.	Average
	Nov.	Dec.	Average	Nov.	Dec.	Average	Nov.	Dec.	Average
Early	9.98	10.48	10.23	12.33	14.35	13.34	11.15	12.41	11.78
Late	6.32	6.94	6.88	8.28	8.48	8.38	7.55	7.71	7.63
Average	8.40	8.71	8.55	10.30	11.41	10.86	9.35	10.06	9.70

L. S. D.

Source	1961-62		1962-63		Two-year Average	
	1°/°	5°/°	1°/°	5°/°	1°/°	5°/°
Planting	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Harvest	1.26	.85	1.74	1.18	.28	.20
Interaction	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.



was obtained. A significant interaction of date of planting x date of harvest was observed in the first year only. During this year the greatest amount of forage was obtained when the crop was planted in November and harvested at the more mature stage of development.

The plantings of the oats-vetch mixture either in November or December did not affect the percent protein in the forage as seen in Table 11. However, there were significant differences due to the dates of harvest. The largest percent of protein was obtained when the oats-vetch forage was harvested at the earlier stage of development. The average protein content for the early harvested forage was 11.78 and that for the later crop was 7.63 percent.

The data given in Table 12 reveal that the November planting of the oats-vetch forage produced more total protein per dunum than that from the December plantings, however, the data are significant only for the 1961-62 season. Likewise, the later harvest resulted in the greatest amount of total protein per dunum of the oats-vetch forage, but only the data for the 1961-62 season are statistically significant.

#### RYE-VETCH

In both of the years the November planted rye-vetch produced the higher forage yields as indicated in Table 13. The average of the two years shows that the November planted crop produced 277.7 kg. of forage per dunum, while that sown in December yielded 174.1 kg. Similarly, an increase in the

forage yield was obtained when the rye-vetch mixture was harvested when more mature. The average indicates that the early harvest crop produced 160.3 kg. of forage per dunum, while the later harvest gave 291.5 kg. It may be noted from the interaction of date of planting x date of harvest that maximum forage yields were obtained by planting the rye-vetch mixture in November and harvesting it when it is nearer maturity.

As is evident from the data presented in Table 14 that the date of planting did not influence the protein percentage of the rye-vetch forage in the first year. However, during the second year of the trial the rye-vetch forage obtained from the December planting contained a higher percent of protein than that harvested from the November planting. The percentage protein in the rye-vetch mixture was the highest when the harvesting was carried out at an earlier stage of maturity. Average of the two years result show that the forage of the early harvest possessed 14.16 percent protein while that from the later harvest contained 10.57 percent protein.

The effect of date of planting and date of harvest on the protein yield of the rye-vetch forage is given in Table 15. The total protein per dunum was increased when the mixture of rye and vetch was planted in November, rather than in December. Considerably more total protein per dunum was obtained from the rye-vetch forage that was harvested



Table 13. Effect of date of planting and date of harvesting on the forage yield of rye-vetch mixture in kg. per dunum during 1961-62 and 1962-63 in the Beqa'a, Lebanon.

Date of harvest	Date of planting								
	1961-62		1962-63		Two-year Average		Two-year Average		
	Nov.	Dec.	Average	Nov.	Dec.	Average	Nov.	Dec.	Average
Early	171.4	91.5	131.4	226.6	152.0	189.3	199.0	121.7	160.3
Late	325.8	163.3	244.5	387.2	290.0	338.6	356.5	226.6	291.5
Average	248.6	127.4	187.9	306.9	221.0	263.9	277.7	174.1	225.9

L. S. D.

Source	1961-62		1962-63		Two-year Average	
	1%	5%	1%	5%	1%	5%
Planting	N.S.	72.2	55.3	37.4	N.S.	27.0
Harvest	70.1	47.4	44.7	30.2	33.7	24.3
Interaction	N.S.	44.2	N.S.	N.S.	N.S.	N.S.



Table 15. Effect of date of planting and date of harvesting on protein yield of rye-vetch mixture in kg. per dunum during 1961-62 and 1962-63 in the Beqa'a, Lebanon.

Date of harvest	Date of planting									
	1961-62				1962-63				Two-year Average	
	Nov.	Dec.	Average	Nov.	Dec.	Average	Nov.	Dec.	Average	
Early	22.44	12.87	17.65	31.72	24.77	28.24	27.08	18.82	22.95	
Late	33.87	15.05	24.46	42.71	35.86	39.28	38.29	25.45	31.87	
Average	28.15	13.96	21.05	37.21	30.51	33.76	32.68	22.14	27.41	

L. S. D.

Source	1961-62		1962-63		Two-year Average	
	1°/o	5°/o	1°/o	5°/o	1°/o	5°/o
Planting	N.S.	10.54	N.S.	5.20	N.S.	4.75
Harvest	N.S.	5.83	10.52	7.11	5.74	4.13
Interaction	N.S.	4.73	N.S.	N.S.	N.S.	N.S.

early as compared with that harvested which was more mature. On the basis of the two-year average 22.95 kg. per dunum and 31.87 kg. of protein were obtained from the rye-vetch when harvested early and late, respectively. A positive interaction between date of planting and date of harvesting was found in the first year only. This indicates that the highest amount of total protein per dunum was obtained in 1961-62 from planting of rye-vetch made in November and harvested when near maturity.

To determine the over-all effect of dates of planting, dates of harvest and species on forage yield, percent protein and protein yield a comparison was made on the basis of their averages. The data are presented in Tables 16 to 21.

The data given in Table 16 reveals that the November plantings of the forage crops produced more yield per dunum than that from the December plantings. The two-year average shows that the November planting gave 195.0 kg. of forage per dunum and the December sowing produced 148.1 kg. Similarly, an increase in the forage yield was obtained when the crops were harvested at the later date. The average indicates that the early harvest produced 133.5 kg. of forage per dunum while the later harvest gave 209.6 kg. The interaction of date of planting x date of harvest for the 1961-62 season showed that forage species sown in November and harvested nearer maturity produced the maximum forage yield. Such an interaction for the second year was non-significant.

Table 16. Effect of date of planting and date of harvesting on the average forage yield of five species of crops in kg. per dunum during 1961-62 and 1962-63 in the Beqa'a, Lebanon.

Date of harvest	Date of planting						Two-year Average		
	1961-62			1962-63			Nov.	Dec.	Average
	Nov.	Dec.	Average	Nov.	Dec.	Average			
Early	134.4	89.6	112.0	182.9	127.2	155.0	158.6	108.4	133.5
Late	256.2	157.0	206.6	282.3	218.8	250.6	231.4	187.9	209.6
Average	195.3	123.3	159.3	232.6	173.0	202.8	195.0	148.1	171.5

L. S. D.

Source	1961-62		1962-63		Two-year Average	
	1°/o	5°/o	1°/o	5°/o	1°/o	5°/o
Planting	35.5	24.0	18.2	12.3	15.3	11.0
Harvest	21.9	14.8	19.4	13.1	12.3	8.9
Interaction	134.0	90.6	N.S.	N.S.	N.S.	N.S.

Data in Table 17 gives the average forage yield of different crops. It is obvious from the data that the different crops varied in the production of forage yield in both of the seasons. The average of the two years indicates that the oats-vetch mixture produced the highest yield of 236.4 kg. per dunum. However, it was not statistically significant from the forage yield of the rye-vetch or the vetch. Rye gave the lowest yield of forage of 73.4 kg. per dunum. The significant interaction of crops x date of planting in both the years and crops x date of harvest in the second season only (Table 37), indicates that the high yielding forage crops produced maximum yield when planted early and harvested later.

The average of the protein percentage of the forages given in Table 18 suggests that date of planting did not affect the protein percentage of the forages during the first year. However, during the second year the protein percentage of the forages was increased significantly due to planting in December over that of the planting in November. Considerable variation occurred in the protein percentage of forage crops due to dates of harvest. The early harvested crops produced the highest level of protein as compared to the later harvests. It is evident from the two years averages that early harvest produced a higher quality of forage or 11.82 percent protein while the later harvest produced 8.59 percent protein.

The five species of the forage crops differed in

Table 17. Average forage yield of five species of crops planted at two dates and harvested at two dates in kg. per dunum during 1961-62 and 1962-63 in the Beqa'a, Lebanon.

crops	forage yield		
	1961-62	1962-63	Two-year Average
Oats	159.6	155.4	157.5
Rye	83.5	63.4	73.4
Vetch	179.8	255.2	217.3
Oats-vetch	197.0	275.8	236.4
Rye-vetch	187.9	263.9	225.9
L.S.D. 1°/o	45.5	35.0	28.6
5°/o	34.4	26.2	21.8

protein content as is shown in Table 19. The vetch forage contained the highest percentage of protein while the oats forage gave the lowest protein percentage. It is seen from the average of the two years that the vetch forage gave 13.19 percent protein, rye-vetch 12.36, oats-vetch 9.70, rye 9.20 and oats 6.53 percent. The data further indicate that there were no significant differences between the protein percentage of oats-vetch forage and rye forage. All other crops differed significantly from each other in protein content at 5 percent level.

The interactions of crops x date of planting and

Table 18. Effect of date of planting and date of harvesting on the average protein percentage of species of crop during 1961-62 and 1962-63 in the Beqa'a, Lebanon.

Date of harvest	Date of planting						Two-year Average		
	1961-62		1962-63		1962-63		Nov.	Dec.	
	Nov.	Dec.	Average	Nov.	Dec.	Average	Nov.	Dec.	
Early	10.88	11.12	11.00	12.10	13.18	12.64	11.49	12.15	11.82
Late	8.13	7.95	8.04	8.92	9.32	9.12	8.53	8.64	8.59
Average	9.50	9.54	9.52	10.51	11.25	10.88	10.01	10.39	10.20

L. S. D.

Source	1961-62		1962-63		Two-year Average	
	1°/°	5°/°	1°/°	5°/°	1°/°	5°/°
Planting	N.S.	N.S.	N.S.	.74	N.S.	N.S.
Harvest	.40	.27	.89	.60	.35	.25
Interaction	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.



Table 19. Average protein percentage of five species of crops planted at two dates and harvested at two dates during 1961-62 and 1962-63 in the Beqa'a, Lebanon.

Crops	Protein percentage		
	1961-62	1962-63	Two-year Average
Oats	6.08	6.98	6.53
Rye	9.37	9.03	9.20
Vetch	12.22	14.16	13.19
Oats-vetch	8.55	10.86	9.70
Rye-vetch	11.41	13.32	12.36
L.S.D. 1°/o	.65	.99	.88
5°/o	.49	.75	.67

crops x date of harvest were significant in the second year only (Table 38). This indicates that during 1962-63 the protein content of the forages increased when they were planted late and harvested early.

The data for the protein yield of the forages as affected by planting and harvesting dates are recorded in Table 20. It will be noted that the November planting produced greater amount of total protein per dunum as compared to the December planting. The two year averages show that 22.40 kg. of protein yield per dunum were obtained from the November planting and 15.74 kg. per dunum from December

Table 20. Effect of date of planting and date of harvesting on the average protein yield of five species of crops in kg. per dunum during 1961-62 and 1962-63 in the Beqa'a, Lebanon.

Date of harvest	Date of planting						Two-year Average		
	1961-62			1962-63			Nov.	Dec.	Average
	Nov.	Dec.	Average	Nov.	Dec.	Average			
Early	15.02	10.12	12.57	24.48	18.18	21.33	19.75	14.15	16.95
Late	21.78	12.37	17.08	28.32	22.26	25.29	25.05	17.32	21.19
Average	18.40	11.25	14.82	26.40	20.22	23.31	22.40	15.74	19.07

L. S. D.

Source	1961-62		1962-63		Two-year Average	
	1°/°	5°/°	1°/°	5°/°	1°/°	5°/°
Planting	5.50	3.72	3.91	2.64	2.78	2.00
Harvest	5.39	3.64	4.16	2.81	2.82	2.03
Interaction	2.93	1.98	N.S.	N.S.	N.S.	N.S.

planting. The effect of date of harvest was also significant. On the average the early harvested forage crops produced 16.95 kg. of yield per dunum while the later harvests 21.19 kg.

The forage crops studied were significantly different in their production of total protein (Table 21). The average results show that vetch and rye-vetch produced the highest amount of total protein and oats and rye when planted alone the least. The total protein of vetch was 27.72 kg. per dunum, rye-vetch 27.41, oats-vetch 22.46, oats 11.33 and rye 5.86 kg. per dunum. There was a significant interaction between crops x date of planting and crops x date of harvest (Table 39), signifying that the protein yield of the forage crops was increased when planted early in November and harvested later.

Wedin (24) has determined the effects of harvest dates on the forage yield and percentage of crude protein of a number of forage crops and mixtures. His conclusions that delay in harvest increases forage yield and decreases protein percentage are in line with the results found in this trial. Similar results were found by Plummer (14) on a number of grasses and legumes, Pieters (13) on alfalfa, red clover and lespedeza, and Hodgson (5) on the oats-pea forage. Results found in this trial also agree with the findings of Manghirmalani (8) as regards the effect of planting and harvesting dates on oats, vetch, oats-vetch and oats-pea.

Table 21. Average protein yield of five species of crops planted at two dates and harvested at two dates in kg. per dunum during 1961-62 and 1962-63 in the Beqa'a, Lebanon.

Crops	Protein yield		
	1961-62	1962-63	Two-year Average
Oats	9.37	13.29	11.33
Rye	6.20	5.52	5.86
Vetch	21.58	34.88	27.72
Oats-vetch	15.86	29.06	22.46
Rye-vetch	21.05	33.76	27.41
L.S.D. 1%	11.71	3.90	5.62
5%	7.66	2.95	4.28

## SUMMARY AND CONCLUSIONS

The study reported in this thesis was undertaken to evaluate the effect of two dates of planting and two dates of harvest on the forage yield, protein percentage and protein yield of oats, rye, vetch, oats-vetch and rye-vetch, at the American University Farm, Lebanon, during 1961-62 and 1962-63.

The species that were planted in November produced higher forage yields and total protein per dunum than those planted in December. Likewise, harvests made when the plants were nearer maturity produced the greatest amount of forage and total protein per dunum as compared to those harvested earlier. However, the highest protein content in the forage was obtained when the crop was smaller and immature as compared with that harvested nearer maturity.

To obtain maximum forage and protein yield in the Beqa'a plain the species should be planted preferably in November and harvested when still green but have reached their maximum growth. To obtain higher quality forage later planting together with harvests made at the earlier stages of plant growth should be practiced.

There were no significant differences between the yields of the oats-vetch, rye-vetch and vetch forages. Rye gave the lowest amount of forage per dunum. The vetch forage produced the highest protein percentage and total protein, however, its total protein was not different from that of rye-vetch mixture.

Oats contained the lowest protein percentage, while rye gave the lowest amount of total protein.

From the point of view of forage yield, quality and total protein per dunum, vetch and rye-vetch mixture can be recommended as the best winter forages during seasons of high rainfall for the Beqa'a, Lebanon. Oats or rye when sown alone produce low yields under these conditions and cannot compete with the legume mixtures.

Manghirmalani (8) in his study at the University Farm during the two previous seasons found oats as the higher producer of forage and total protein and vetch the least. The present investigations are not in accord with his findings, since vetch and rye-vetch were found to be the best. It should be noted that Manghirmalani's data were obtained during two seasons that were drier than those during which the present data were obtained. The total rainfall for the four seasons was as follows: 219.0, 285.0, 469.7 and 526.00 mm. for the 1959-60, 1960-61, 1961-62 and 1962-63 seasons, respectively.

It is suggested that the trial be conducted for at least two additional years in order to sample more seasons so as to arrive at more definite recommendations.

## LITERATURE CITED

1. Anderson, R.L. Missing plot techniques. *Biom. Bul.* 2: 41-46. 1946.
2. Association of Official Agricultural Chemists. Official Methods of Analysis. 8th ed. Washington D.C. 1955.
3. Gardner, F.P. and Wiggans, S.C. Yield, moisture and protein composition of spring oats cut for silage at different stages of maturity. *Agron. J.* 53: 251-254. 1961.
4. Henderson, J.L. and Davies, R.O. The yield and composition of mixed cereal legume crops at different stages of growth. *Emp. J. Exp. Agr.* 23: 131-144. 1955.
5. Hodgson, H.J. Effect of seeding rates and time of harvest on yield and quality of oats-peas forage. *Agron. J.* 48: 87-90. 1956.
6. Kohler, G.O. The effect of stage of growth on the chemistry of grasses. *J. Biol. Chem.* 152: 215-223. 1944.
7. McCain, F.S. and Coopeking, Jr. Planting dates for oats for forage and grain. *Agr. Sta. Au. Un. Bul.* 329. 1960.
8. Manghirmalani, C.R. Effect of planting dates and stages of harvest on yield and protein content of forages. M.S. Thesis submitted to the graduate faculty of the School of Agriculture. *Amer. Un. Beirut.* 1961.
9. Norman, A.G. A preliminary investigation of the development of structural constituents in the barley plant. *J. Agr. Sci.* 23: 216-227. 1933.
10. Panse, V.G. and Sukhatme, P.V. Statistical Methods for Agricultural Workers. 2nd Ed. In. Coun. Agr. Res. New Delhi. 1961.
11. Pendleton, J. W. Effect of clover, row spacing and rate of planting on spring oat yields. *Agron. J.* 49: 555-558. 1957.

12. \_\_\_\_\_, and Brown, C.M. Effect of cultural treatments on the yield and protein content of oats cut for silage. *Agron. J.* 53: 41-42. 1961.
13. Pieters, A. J. Effect of maturity on chemical composition of leguminous forage plants. *J. Amer. Soc. Agron.* 29: 436-440. 1937.
14. Plummer, B.E. Chemical composition of grasses and legumes in Maine. *Maine Agr. Exp. Sta. Bul.* 513. 1953.
15. Reid, J.T. Kennedy, W.K. Slack, S.T., Trimberger, G.W. and Murphy, R.P. Effect of growth stage, chemical composition and physical properties upon nutritive value of forages. *J. Dairy Sci.* 42: 567-571. 1959.
16. Robinson, R.G. Oat-pea or oat-vetch mixtures for forage or seed. *Agron. J.* 52: 546-549. 1960.
17. Rosen, H.R. Wisler, W.J. York, J.O. Arkwin, a disease resistant oat and comparison of small grain as winter forage. *Ark. Agr. Exp. Sta. Bul.* 533. 1953.
18. Schmidt, D.R. Response of spring oat varieties to different planting dates and soil fertility levels. *Agron. J.* 52: 695-696. 1960.
19. Sotola, J. The chemical composition and nutritive value of certain cereal hays as affected by plant maturity. *J. Agr. Res.* 54: 399-315. 1937.
20. Stallcup, O.T. Composition of crude fibre in certain roughages. *J. Dairy Sci.* 41: 963-968. 1958.
21. \_\_\_\_\_, Roberson R.R., Looper, C.O. and Thurman, R.L. The influence of stage of maturity on the nutritive value of oat forage. *Ark. Agr. Exp. Sta. Bul.* 642. 1961.
22. Sumner, D.C. Stevenson, E.E. McNeilly, D. Miller, M.D., Planting date effects on cereal production for winter feed. *Calif. Agr.* 12-13 Feb. 1963.
23. Thurman, R.L. Stallcup, O.T. Stephens, J.L. and Justus N.E. When to harvest oats for hay and silage, *Ark. Agr. Exp. Sta. Bul.* 586 1957.
24. Wedin, W.F. Yields and percentages of crude protein and moisture of several annual forage crops as affected by harvest date. *Agron. J.* 54:37-40 1962.
25. Willard, C.J. The management of alfalfa meadow. Advances in Agronomy. III 95-96. 1951.



APPENDIX

I

Table 22. Analysis of variance for forage yield of oats  
in kg. per dunum.

Source	D.F.	M.S.1961-62	M.S.1962-63
Replications	7	717.17	6640.28
Date of planting	1	17437.80 †	36248.00 ††
Error (a)	7	2528.70	1609.28
Date of harvest	1	57037.50 ††	11064.00 †
Error (b)	7	2647.18	1004.28
Planting x harvest	1	344.50	656.00
Error (c)	7	3048.70	1067.57

Table 23. Analysis of variance for protein percentage  
of oats forage

Source	D.F.	M.S. 1961-62	M.S.1962-63
Replications	7	70.571	2.857
Date of planting	1	70.000	19.000
Error (a)	7	35.142	4.571
Date of harvest	1	2264.000 ††	24.000 ††
Error (b)	7	36.714	.714
Planting x harvest	1	2.000	2.000
Error (c)	7	18.000	4.28

† denotes F value significant at 5 percent level.

†† denotes F value significant at 1 percent level.

Table 24. Analysis of variance for protein yield of oats forage in kg. per dunum.

Source	D.F.	M.S.1961-62	M.S.1962-63
Replications	7	1.857	56.571
Date of planting	1	52.000 †	78.000
Error (a)	7	8.857	24.714
Date of harvest	1	52.000 †	4.000
Error (b)	7	6.142	27.428
Planting x harvest	1	1.000	22.000
Error (c)	7	10.142	7.571

Table 25. Analysis of variance for forage yield of rye in kg. per dunum.

Source	D.F.	M.S.1961-62	M.S.1962-63
Replications	7	251.197	1469.571
Date of planting	1	11400.600 †	604.000
Error (a)	7	999.342	292.285
Date of harvest	1	22791.000 ††	11213.000 ††
Error (b)	7	110.214	222.428
Planting x harvest	1	1104.400	-
Error (c)	7	436.728	501.000

† denotes F value significant at 5 percent level.

†† denotes F value significant at 1 percent level.

Table 26. Analysis of variance for the protein percentage of rye.

Source	D.F.	M.S.1961-62	M.S.1962-63
Replications	7	3.428	1.571
Date of planting	1	70.000 †	18.000
Error (a)	7	7.285	3.571
Date of harvest	1	63.000 ††	33.000 ††
Error (b)	7	1.714	.571
Planting x harvest	1	-	-
Error (c)	7	4.857	1.000

Table 27. Analysis of variance for the protein yield of rye forage in kg. per dunum.

Source	D.F.	M.S.1961-62	M.S.1962-63
Replications	7	169.710	12.571
Date of planting	1	154.000	1.000
Error (a)	7	257.714	3.285
Date of harvest	1	6938.000 ††	32.000 ††
Error (b)	7	121.285	1.285
Planting x harvest	1	173.000	1.000
Error (c)	7	377.000	5.857

† denotes F value significant at 5 percent level.

†† denotes F value significant at 1 percent level.

Table 28. Analysis of variance for the forage yield of vetch in kg. per dunum.

Source	D.F.	M.S.1961-62	M.S.1962-63
Replications	7	4261.928	2998.428
Date of planting	1	61075.100	67528.000 //
Error (a)	7	13694.128	4595.714
Date of harvest	1	85284.500 //	122513.000 //
Error (b)	7	1199.271	1370.571
Planting x harvest	1	5995.100	2628.000
Error (c)	7	1142.785	940.000

Table 29. Analysis of variance for the protein percentage of vetch forage.

Source	D.F.	M.S.1961-62	M.S.1962-63
Replications	7	441.000	2.857
Date of planting	1	490.000	38.000 /
Error (a)	7	147.714	3.285
Date of harvest	1	7941.000 //	226.000 //
Error (b)	7	67.428	4.142
Planting x harvest	1	40.000	1.000
Error (c)	7	356.857	3.571

/ denotes F value significant at 5 percent level.

// denotes F value significant at 1 percent level.

Table 30. Analysis of variance for the protein yield of vetch forage in kg. per dunum.

Source	D.F.	M.S.1961-62	M.S.1962-63
Replications	7	164.571	81.000
Date of planting	1	1058.000 †	2522.000 ††
Error (a)	7	113.428	71.285
Date of harvest	1	363.000 ††	120.000
Error (b)	7	17.142	28.571
Planting x harvest	1	89.000	2.000
Error (c)	7	16.285	46.142

Table 31. Analysis of variance for the forage yield of oats-vetch in kg. per dunum.

Source	D.F.	M.S.1961-62	M.S.1962-63
Replications	7	20.714	80.857
Date of planting	1	163.000 †	85.000
Error (a)	7	15.000	64.571
Date of harvest	1	104.000 †	39.000
Error (b)	7	17.000	26.142
Planting x harvest	1	78.000	8.000
Error (c)	7	22.571	36.428

† denotes F value significant at 5 percent level.

†† denotes F value significant at 1 percent level.

Table 32. Analysis of variance for the protein percentage of oats-vetch forage.

Source	D.F.	M.S.1961-62	M.S.1962-63
Replications	7	186.428	7.142
Date of planting	1	65.000	10.000
Error (a)	7	168.285	4.000
Date of harvest	1	8998.000 //	197.000 //
Error (b)	7	102.285	2.000
Planting x harvest	1	106.000	7.000
Error (c)	7	176.290	1.714

Table 33. Analysis of variance for the protein yield of oats-vetch forage in kg. per dunum.

Source	D.F.	M.S.1961-62	M.S.1962-63
Replications	7	1978.242	1204.428
Date of planting	1	34125.500 //	15444.000 /
Error (a)	7	905.757	1540.000
Date of harvest	1	113883.560 //	134811.000 //
Error (b)	7	1559.142	2504.285
Planting x harvest	1	18480.300 //	9.000
Error (c)	7	140.262	1257.142

/ denotes F value significant at 5 percent level.

// denotes F value significant at 1 percent level.

Table 34. Analysis of variance for the forage yield of rye-vetch in kg. per dunum.

Source	D.F.	M.S.1961-62	M.S.1962-63
Replications	7	4843.71	1797.00
Date of planting	1	117612.00 †	59082.00 ††
Error (a)	7	7481.10	2008.86
Date of harvest	1	102604.00 ††	178354.00 ††
Error (b)	7	3227.00	1312.00
Planting x harvest	1	13613.00 †	1024.00
Error (c)	7	1401.42	1069.71

Table 35. Analysis of variance for the protein percentage of rye-vetch forage.

Source	D.F.	M.S.1961-62	M.S.1962-63
Replications	7	353.857	8.571
Date of planting	1	11.000	23.000 ††
Error (a)	7	524.714	1.142
Date of harvest	1	10636.000 ††	100.000 ††
Error (b)	7	105.142	2.714
Planting x harvest	1	907.000	5.000
Error (c)	7	178.571	1.571

† denotes F value significant at 5 percent level.

†† denotes F value significant at 1 percent level.



Table 36. Analysis of variance for the protein yield of rye-vetch forage in kg. per dunum.

Source	D.F.	M.S.1961-62	M.S.1962-63
Replications	7	107.428	173.000
Date of planting	1	1612.000 †	381.000 †
Error (a)	7	159.428	38.857
Date of harvest	1	370.000 †	975.000 ††
Error (b)	7	48.857	72.571
Planting x harvest	1	171.000 †	-
Error (c)	7	16.000	20.000

† denotes F value significant at 5 percent level.

†† denotes F value significant at 1 percent level.

Table 37. Analysis of variance for yield of forages in  
kg. per dunum.

Source	D.F.	M.S.1961-62	M.S.1962-63
Replications	7	4409.91	4777.57
Date of planting	1	207216.02 $\dagger\dagger$	141848.00 $\dagger\dagger$
Error (a)	7	4143.87	1089.71
Date of harvest	1	357871.80 $\dagger\dagger$	364655.00 $\dagger\dagger$
Error (b)	7	1575.85	1210.71
Planting x harvest	1	29512.06 $\dagger\dagger$	763.00
Error (c)	7	2593.50	1347.42
Crops	4	83580.94 $\dagger\dagger$	267693.50 $\dagger\dagger$
Crops x planting	4	9035.59 $\dagger\dagger$	9264.50 $\dagger\dagger$
Crops x harvest	4	5718.65	23324.25 $\dagger\dagger$
Crops x planting x harvest	4	9925.76 $\dagger\dagger$	1079.25
Error (d)	105 $\dagger$ -112	2434.72	1500.84

$\dagger$  7 degrees of freedom reduced due to missing plots.

$\dagger\dagger$  denotes F value significant at 1 percent level.

Table 38. Analysis of variance for the protein percentage of forages.

Source	D.F.	M.S.1961-62	M.S.1962-63
Replications	7	52.53	8.67
Date of planting	1	.34	22.22 †
Error (a)	7	57.29	3.93
Date of harvest	1	3494.28 ††	496.00 ††
Error (b)	7	15.40	2.60
Planting x harvest	1	17.87	4.00
Error (c)	7	14.79	4.75
Crops	4	1932.53 ††	282.27 ††
Crops x planting	4	22.44	21.25 ††
Crops x harvest	4	45.88	21.25 ††
Crops x planting x harvest	4	28.74	3.75
Error (d)	105 <sup>+</sup> -112	338.13	2.33

+ 7 degrees of freedom reduced due to missing plots for 1961-62.

† denotes F value significant at 5 percent level.

†† denotes F value significant at 1 percent level.

Table 39. Analysis of variance for protein yield of forages  
in kg. per dunum.

Source	D.F.	M.S.1961-62	M.S.1962-63
Replications	7	108.75	159.14
Date of planting	1	2045.54 <i>††</i>	1526.00 <i>††</i>
Error (a)	7	96.82	50.28
Date of harvest	1	811.84 <i>††</i>	626.00 <i>†</i>
Error (b)	7	13.24	56.71
Planting x harvest	1	203.11 <i>††</i>	0
Error (c)	7	13.65	32.42
Crops	4	1516.96 <i>††</i>	5543.25 <i>††</i>
Crops x planting	4	228.01 <i>††</i>	385.00 <i>††</i>
Crops x harvest	4	35.35	135.75 <i>††</i>
Crops x planting x harvest	4	86.59 <i>††</i>	8.50
Error (d)	105 <sup>+</sup> -112	32.33	35.63

<sup>+</sup> degrees of freedom reduced due to missing plots.

*†* denotes F value significant at 5 percent level.

*††* denotes F value significant at 1 percent level.

Table 40. Rainfall and Temperature †

The amount and distribution of rainfall and the mean monthly temperature during 1961-62 and 1962-63 at the American University Farm in the Beqa'a.

Month	Rainfall (mm.)		Temperature (°C) mean	
	1961-62	1962-63	1961-62	1962-63
September	3.0	-	18.7	21.6
October	5.9	19.3	16.9	17.1
November	41.1	Nil	11.1	14.1
December	138.5	164.1	8.0	7.7
January	93.1	124.1	6.3	7.1
February	130.6	70.0	5.1	7.4
March	10.5	82.3	10.9	7.0
April	43.3	53.3	11.3	11.9
May	3.7	11.4	17.1	14.0
June	0.0	0.0	21.4	-
July	0.0	0.0	22.9	-
August	0.0	0.0	24.6	-
Total	469.7	526.0	-	-

† Data obtained from the American University Farm Meteorological data.

APPENDIX

II

## MISSING PLOT TECHNIQUE

Anderson (1) has given the formula for the estimation of a missing unit in split-plot design. This experiment was conducted on a split-strip plot design. The available literature does not give any method for the estimation of missing value in a split-strip plot design. The following method was suggested by Miss Marie-Louise Davidian for the estimation of missing value in this design.

In the experiment main plots are assigned to dates of planting denoted by  $D_1$  and  $D_2$ , sub plots to dates of harvesting denoted by  $d_1$  and  $d_2$  and sub-sub plots to five species denoted by  $V_1, V_2, V_3, V_4$  and  $V_5$ .

By concentrating on the experiment with one main plot say  $D_1$ , the reduced experiment can be regarded as a split plot design with  $d_1$  and  $d_2$  as main plots and  $v_1, v_2, v_3, v_4, v_5$  as sub-plots.

Suppose  $v_2$  in  $d_1$  is missing in first replication, compute:

$U$  = Sum of main plot ( $d_1$ ) over the replication where the missing plot occurs.

$A$  = Sum of main plot ( $d_1$ ) over all the replications.

$B$  = Sum of  $d_1v_2$  over all the replications.

Then the estimate will be

$$Y = \frac{rU + sB - A}{(r-1)(s-1)}$$

where  $r = \text{no of replications} = 8$   
 $s = \text{no of sub-plots} = 5$

Since there were more than one missing plots, first estimate of all but one missing plot was obtained by taking the average of the missing plot from other replication, and the above formula was applied.

The above procedure was repeated till the estimates converged. From the degrees of freedom of the error (d) (Table 37), a number equal to the number of missing observations was subtracted.