THE EFFECT OF SPACING AND VARIETY ON SEED YIELD AND OTHER CHARACTERISTICS OF ALFALFA

By

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Seed Production in Alfalfa

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ABSTRACT

A three-year study was carried out at the Agricultural Research and Education Center of the American University of Beirut, to evaluate the effect of various plant populations and varieties of alfalfa upon seed yield, forage yield, plant height, percent seed germination, and 1000 seed weight. The study was conducted under irrigated conditions.

The results reveal that the 50 x 50 cm. plant spacings produced more seed per dunum than did the 50 x 25 cm. and the solid planting, respectively. The solid plantings, however, produced significantly taller plants and higher forage yields than did the other two plant spacings tested. The germination and the size of the seed of alfalfa were not influenced by the various plant populations studied.

Hairy Peruvian produced significantly taller plants and higher seed and forage yields than did the varieties African and Chilean. The size of the seeds in the African variety was larger than that obtained in the other two varieties. The germination percentage of the alfalfa seed was the same for the three varieties tested.

TABLE OF CONTENTS

LIST OF TABLES

Table | Page

INTRODUCTION

Alfalfa, Medicago sativa L., also known as Lucerne in some parts of the world, is a herbaceous perennial plant belonging to the Leguminosae family. It has become an established fact that this crop occupies a place as one of the world's most valuable forage crops. Its wide distribution in the world indicates a remarkable adaptability to different climatic and soil conditions. The crop does best, however, when grown in relatively dry atmospheric conditions, under irrigation and on well drained fertile soil.

Alfalfa is known for its role in balancing crop production. This is accomplished in two ways, namely through soil improvement and by furnishing highly palatable and nutritious feed for livestock.

The production of alfalfa seed in Lebanon has been neglected because of the lack of knowledge of production practices, non-availability of good quality seed, high cost of the seed, and the under-estimation of the value of the crop as a source of potentiality in crop production.

Growing alfalfa seed has become a complicated enterprise in which farmers must give great attention to many production practices. High seed production has been obtained by planting the alfalfa in rows, keeping the soil moist at

all times from the initiation of growth in the spring until a few weeks before harvesting, applying fertilizers, controlling weeds, harmful insects and diseases, and keeping pollinating insects in abundance during the blossoming period. The climatic conditions in the Beqa'a, Lebanon are similar to those of other areas in the world where alfalfa seed production has been successful. During the season of seed production there is no rainfall and the air temperatures are relatively warm and dry. These conditions favor bee activity, seed setting, and seed maturation.

The work reported here was undertaken at the Agricultural Research and Education Center of the American University of Beirut, located in the Beqa'a plain, Lebanon. The purpose was to investigate the effect of plant population and varieties upon seed yield, forage yield, and certain other agronomic characteristics of alfalfa when grown under irrigated conditions during the period of March 1962 to August 1964.

REVIEW OF LITERATURE

With a cross-pollinated crop like alfalfa, there are many factors, apart from climate, which affect seed production and can be controlled by the grower. Density of plant population is one of the most important cultural practices which affects the yield of both seed and forage.

Considerable work was done on the problem of stand density and in general most workers agreed that thin stands were best for seed production. It is the purpose of this section to review the available information pertaining to the effect of spacing and variety on yield and other agronomic characteristics of alfalfa.

Seed Yield

Westgate *et al.* (38) and Westgate (37) recommend thin stands as this causes better development of the single plant by allowing more sunlight to be received by the individual plants. The most promising method was to seed the alfalfa in rows from 30 to 40 inches apart and practice thinning within the rows as the plants became established. Southworth (32) reported that by growing alfalfa in 36 inch rows the crop received more air and sunlight. This helped to produce healthier plants and more vigorous growth of flowers.

There was an increased tendency for the flowers to become fertilized and produce more seed than when the plants were more crowded together in a broadcast plot. Kidder et al. (22) recommended a thin seeding whether in rows or broadcast. The best rate of seeding alfalfa in rows for a seed crop was by planting from one half to one pound of seed to the acre. Carlson and Stewart (6) reported that growing alfalfa in hills for seed production gave an increase in acre yield of seed by approximately 44 and 76 percent compared with the rows and drilling methods, respectively. The authors obtained better results where alfalfa was drilled in rows 28 inches apart and thinned to 21 or 28 inch-hills within rows than where the rows were spaced 14, 35, or 39 inches apart.

Engelbert (10) found that thin stands of alfalfa induce the best seed production by causing better development of the plants. The highest seed yields were obtained from fields with thin stands. Spencer and Stewart (33) reported that alfalfa planted in rows and hills 28 x 21 inches produced 76 percent more seed per acre than when broadcast. Westover (39) concluded that growing alfalfa in rows under limited moisture supply will give larger yields of seeds than close drilling or broadcasting. Carlson (4) obtained, during a four year study under irrigation, higher seed yields from hill spaced plants than from row spaced and drilled stands, respectively. Similar results were found by Carlson et al. (5). Tysdal and Kiesselback (35) found that planting

alfalfa in rows or in spaced hills either under irrigation or dryland conditions resulted in higher average seed yields. Weighing et al. (36) found that seed yields in Colorado averaged 65 pounds per acre for solid stands, 84 pounds for rows 21 inches apart, 97 pounds for plants 21 x 24 inches apart, 96 pounds for rows 35 inches apart and 102 pounds for plants 35 x 36 inches apart. These results indicated the merits of a thin stand for seed production. Grandfield and Franklin (15) concluded that alfalfa planted for seed production should be seeded in rows at the rate of one pound to the acre. Graber (13) reported that the prospects for alfalfa seed production are generally better where the stands are thin.

Jones et al. (20) recommended planting alfalfa in rows 24 x 36 inches apart at a rate of one pound per acre. The authors revealed that planting alfalfa in rows required less water. Also, cultivation for control of weeds was possible with row planting. Graumann and Henson (16) suggested that, with limited moisture available under semiarid conditions, alfalfa in rows usually produces a higher average yield of seed than when drilled or broadcast. Pedersen and McAllister (28) found that crowding was harmful to seed production. In comparing hills 48 inches apart with dense hay-type stands at Newton, Utah, it was found that about twice as much seed was produced on the spaced plants as was produced on the hay-type stand. It was found that spaced plants favored

nectar production, bee visitation, pod setting, and seed production. The authors found that for seed production alfalfa should be planted in rows not closer than 24 inches and at a rate of one pound per acre.

Pedersen (25) reported, over a three year period of experimental work at the United States Legume Research Seed Laboratory, that alfalfa seeded in rows 24 inches apart at a rate of one pound per acre produced 147 percent as much seed as a hay stand planted at a rate of three pounds to the acre. Zaleski (41), during a three year study on lucerne seed production at Cambridge, observed that the highest yield of seed each year was obtained from rows 24 inches apart sown at a low seed rate and uncut in spring for fodder. Pedersen (26) reported that rows 24 inches apart cross-thinned to hills 12 inches apart yielded the highest nectar production and hence the highest seed yield. Pedersen et al. (27) found that the 24 inch plots seeded at the rate of one pound per acre produced an acre yield of 307 pounds on the average compared with 273 pounds from plots with 48 inch rows. Plants in the wider rows were apparently too far apart to take advantage of the area alloted. Garrison (12) suggested that where alfalfa is grown primarily for seed, row spacings of 24 to 42 inches have been superior to solid plantings.

In an F.A.O. report (1) it was suggested that for seed production alfalfa should be planted in rows. Experiments have shown that spacing alfalfa plants at a distance of 30

to 60 cms. within fairly wide rows gave higher seed yields than sowing them in continuous rows. Jones and Pomery (21) observed, during a three year study, that thinning within rows was beneficial for all row widths studied. The highest yields were obtained from rows spaced 24 inches apart and thinned to 6 x 18 inches (6-inch blocks of the row remained, between which 18-inch blocks were removed). Pedersen and Nye (30) reported that for satisfactory management of alfalfa for seed production the seeds should be planted in rows 24 inches apart at a rate of one and a half pounds per acre, and after the second year the stand should be thinned by cutting out every other foot in the row. Zaleski (40) revealed that alfalfa for seed production should be drilled in wide rows at a low seed rate and without a companion grass.

Forage Yield

Bolton (3) stated that for forage production, the distance between rows is closely related to the available moisture. If water is a limiting factor, rows of 12 inches or even 18 inches apart will produce better growth and allow normal harvesting. Graumann and Henson (16) concluded that where rainfall is a limiting factor, the yield of forage from row planting was greater than that from close drilling or broadcasting. Higher yields were obtained from a dense stand under sufficient precipitation. Clements et al. (8) stated that competition between plants became more critical

as stand densities increased. Garner and Sanders (11) found, in a four year study, that alfalfa drilled at a constant seed rate per acre in narrow rows 3.5 and 7 inches apart, gave higher forage yields than when drilled in rows 10.5 and 14 inches apart. The yield of dry matter per acre from narrow rows was half a ton more than from the wide rows. Tysdal (34) obtained the highest forage production per acre from close spacing with frequent irrigation. Weighing and Robertson (36) found that rows spaced 12 inches apart compared to 20 or 36 inches produced more dry matter per acre. Kramer and Davis (23) tested thirty varieties of alfalfa, planted in rows 7 and 18 inches apart and at six inch spacings within the rows, observed a high correlation between yield and stand of alfalfa. It was found that the influence of stand on the yield was greater in the first year than in the second year after seeding. This was due to the ability of alfalfa to adapt itself to thin stands.

Pedersen and McAllister (29) reported that alfalfa spaced in rows 20 and 36 inches apart gave good hay yields under dry conditions. Cowett and Sprague (9) observed that stand density had the most pronounced effect on the number of stems produced by the alfalfa plant. Lower stand densities resulted in less yield per unit area, but a greater number of stems per plant. Rumbaugh (31) studied the effect of four different row spacings, namely 5.25, 10.50, 21 and 42 inches on the yield of alfalfa. It was concluded that the

dry matter yield per acre was higher in close spacing and that as the population density increased the dry matter per plant decreased. Jarvis (19) reported, in a study of different spacings on the forage yield of alfalfa, that as stand density increased the yield of forage increased rapidly up to a certain level, but further increases in stand density did not give any significant increase in yield. Carmer and Jackobs (7) reported the results of an experiment involving seeding rate, row spacing, and fertilizer placement. In general the total yields of dry matter, in tons per acre, were higher from alfalfa planted in rows four inches apart at a rate of eight pounds to an acre compared to plantings made in rows eight inches apart and at a rate of 12 pounds per acre.

Grandfield (14) recommended 10 to 15 pounds of seed per acre for forage production. Hutcheson et al. (18) suggested seeding alfalfa at a rate of 15 to 20 pounds per acre for high yield and good quality hay. This is in agreement with Hosterman (17) who suggested a thick stand to produce higher yields of alfalfa hay.

Other Characteristics

Carmer and Jackobs (7) observed that the height of alfalfa plants and dry weight of the top growth decreased as the seeding rate and consequently the plant population

increased. Rumbaugh (31) reported, from a study involving four spacing treatments, that maximum length of stem was attained at the 21 x 21 inch spacing compared to the narrow and wide plantings. Zaleski (42) revealed that the proportion of hard seed depends chiefly on the weather conditions during the ripening of the seed and harvesting time, density of plant population, and moisture content of the seed. In an exceptionally dry season, alfalfa seed produced at Cambridge, has had as much as 72 percent hard seed and only 23 percent germination.

Tysdal and Kiesselback (35) recommended that the best time to harvest alfalfa seed is when about two-thirds of the pods are black to brown. If cutting is delayed beyond this period considerable seed is lost by shattering. Zaleski (41) concluded that the right stage of seed maturity at which the crop should be harvested is very important. The best stage for harvesting with respect to yield and germination is when 70 to 80 percent of the pods formed are brown. Pedersen and Nye (30) reported a reduction in both the number of seeds per pod and in the seed weight as the age of the stand increased. The number of seeds per pod decreased from 4.9 to 3.1 and the seed weight from 2.48 milligrams to 2.03 milligrams per seed during the four year period of study.

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MATERIALS AND METHODS

The experiment was carried out for three years, 1962 to 1964, at the Agricultural Research and Education Center of the American University of Beirut, located in the north central part of the Beqa'a plain, Lebanon.

The soil in general is low in organic matter, nitrogen, and phosphorus, high in clay and potassium content and is calcareous with a pH of about 8. The monthly average temperature, relative humidity, and annual rainfall at the central Beqa'a plain is shown in Table 1.

A smooth firm seedbed was prepared and the experimental plots received a uniform application of 20 kilograms of P_2O_5 (as superphosphate) per dunum. The first year the fertilizer was broadcast and disked into the soil before planting time. In subsequent years an annual application of 20 kilograms of P_2O_5 was made by broadcasting the fertilizer on the surface in March.

The experiment was laid out in a split-plot design involving three spacings as major plots and three varieties as sub-plots. There were four replicates. Three varieties (not randomized), Hairy Peruvian, Chilean, and African were planted in the sub-plots. The sub-plots consisted of three rows, each four meters long and 0.50 meter apart. The within-row plant spacings were 25 cm., 50 cm., and the solid

Table 1 - Annual rainfall, average monthly temperature, and relative humidity recorded at the Agricultural Research and Education Center of the American University of Beirut+.

Month	Rainfall (mm.)			Temperature (°C)			Relative Humidity (%)		
	1961-62	1962-63	1963-64	1961-62	1962-63	1963-64	1961-62	1962-63	1963-64
September	3.0	0.0	0.0	18.7	21.6	21.0	50.2	51.4	58.4
October	5.85	19.3	49.6	16.8	17.1	16.5	62.4	62.0	61.4
November	41.1	0.0	16.4	11.1	14.1	11.2	64.6	58.0	68.9
December	138.5	164.1	70.6	7.9	7.8	5.3	77.8	-	69.3
January	93.1	124.1	60.6	6.3	7.1	1.0	78.6	77.7	73.7
February	130.6	70.0	183.8	5.1	7.4	3.6	68.2	76.3	75.6
March	10.5	82.4	52.8	10.8	6.9	9.0	63.8	72.1	71.2
April	43.3	53.3	13.9	11.3	11.9	9.6	68.0	70.4	66.6
May	3.7	11.7	23.7	17.0	14.0	12.7	60.1	69.8	61.7
June	0.0	0.0	0.0	21.3	20.6	20.4	53.0	62.2	61.5
July	0.0	0.0	0.0	22.8	22.0	23.1	51.5	58.9	53.3
August	0.0	0.0	0.0	24.6	23.6	23.2	48.0	53.1	54.3
Total	469.65	524.9	471.4						

+ Information obtained from the A.U.B. Agricultural Research and Education Center Meteorological Data, Beqa'a Plain, Lebanon recorded by S. Abu Shakra, H.G. Nasr and F.M. Malouf.

plant rows sown at the rate of 100 grams per dunum.

Alfalfa seedlings were started in flats in soil filled vita-bands containers to facilitate transplanting. Field transplanting was done on April 20, 1962. For the solid row plantings, the seeds were planted by a Planet Junior drill on the same date.

The experimental plots were irrigated weekly by sprinklers. Weekly irrigation by the furrow method was started on June 25, 1962 and continued until two weeks before harvesting the seed crop or until one week before harvesting the forage crop. Weeds were controlled by hoeing and by hand when necessary. Alfalfa plants were sprayed with "Gusathion" and "Heptachlore" early in the spring to control the alfalfa weevil (Hypera sp.).

For seed yield the plants were harvested in August when two-thirds of the seed pods had turned brown in color. For seed and forage yields one square meter was harvested from each of the one row sub-plots. This involved harvesting four plants from the 50 x 50 cm. spacing, eight plants from the 50 x 25 cm. spacing, and a length of two meters from the solid planted row. Harvesting was done with a handsickle by cutting the plants at a height of two to three inches above the soil level. The stems bearing the seeds were put into sacs which were hung in the open air and sun to permit drying. Threshing and cleaning of the seed was done with the nursery equipment. The clean seed was then weighed and the seed

yield calculated as kilograms per dunum. Representative samples were taken to evaluate the seed quality. Germination and weight of 1000 kernels were determined according to the International Rules for Seed Testing (2).

For forage yield, which represented the first crop, not used for seed production, one cutting was taken from the plots in April of each year when the plants had reached the one-tenth bloom stage. Plant heights were determined just before each harvest. Total green forage weights were recorded and moisture samples of one kilogram were taken from each plot harvested. These samples were air dried for six weeks and then reweighed. The forage yield of alfalfa is reported on an air dry basis in kilograms per dunum.

Statistical methods appropriate to the split-plot design were used according to LeClerg, Leonard and Clark (24).

RESULTS AND DISCUSSION

A three-year study was conducted to find the effect of three different plant populations and three varieties on yield of seed, forage, and other agronomic characteristics of alfalfa when grown under irrigated conditions.

The results are summarized and reported in Tables 2 to 6. Analysis of variance tables are given in the Appendix (Tables 7 to 20). The L.S.D. figures are given at the bottom of the tables for treatments that are statistically significant.

Seed Yield

Alfalfa seed yields were affected significantly by the three spacings studied. As shown in Table 2 the highest seed yields per dunum were obtained each year from the 50 x 50 cm. spacing. The beneficial effects of thin stands on seed yield may be attributed to the better development of the single plant by allowing more air and sunlight to be received by the individual plants. It has been suggested by several authors (10, 28, 32, 37, 38, 39) that low seed production by dense stands can be explained by low nectar production, unattractiveness to pollinating insects, and increased ovary abortion.

Table 2 - Average seed yield of alfalfa in kgs. per dunum as affected by spacing and variety. Grown at the Agricultural Research and Education Center, Beqa'a, Lebanon, during the period 1962-1964.

Year	Spacing	Variety			Spacing Mean
		Hairy Peruvian+	Chilean	African	
	50x50 cm.+	79	68	49	65.3
1962	50x25 cm.	52	48	41	47.0*
	Solid	46	44	29	39.6*
	Variety Mean	59.0	53.3	39.6*	
	50x50 cm.	116	84	75	91.6
1963	50x25 cm.	58	77	75	70.0**
	Solid	53	46	45	48.0**
	Variety Mean	75.6	69.0	65.0	
	50x50 cm.	101	95	67	87.6
1964	50x25 cm.	94	79	74	82.3
	Solid	75	70	47	64.0**
	Variety Mean	90.0	81.3	62.6**	
Average	50x50 cm.	98.6	82.3	63.6	81.5
for	50x25 cm.	68.0	68.0	63.3	66.4**
1962-64	Solid	58.0	53.3	40.3	50.5**
	Variety Mean	74.8	67.9*	55.7**	

* Significant at the 5% level.
** Significant at the 1% level.
\+ 50 x 50 cm. spacing and Hairy Peruvian used as check.

The plants in the plots were established in 1962 which accounts for the lower seed yield in that year. The largest seed crop was harvested from the well established plants in 1964.

An average seed yield, for the three-year period 1962-1964, of 81.5 kgs. per dunum was obtained from the 50 x 50 cm. plant spacing. This was followed by the 50 x 25 cm. spacing with 66.4 kgs. and the solid planting with 50.5 kgs. of seed per dunum.

The varieties Hairy Peruvian and African differed significantly in seed yielding ability. Hairy Peruvian produced the highest yield in 1962 as compared to Chilean and African. In 1963 the varieties did not differ significantly, although, as in 1962, Hairy Peruvian showed a trend toward higher production of seed as compared to the other varieties. In 1964 the same trend was obtained, but the difference between Hairy Peruvian and African was highly significant. In all three years there was no significant difference between Hairy Peruvian and Chilean in seed production. Hairy Peruvian averaged 74.8 kgs. of seed per dunum over the three year period. This yield was significantly higher than that of Chilean at 67.9 kgs. and African at 55.7 kgs. per dunum.

Dry Matter Yield

The dry matter yields of alfalfa were greatly affected by plant spacing as is shown in Table 3. Higher dry matter yields were recorded from the solid planting or dense stand than from the 50 x 25 cm. and 50 x 50 cm. spacings. These results are in agreement with several authors (7, 8, 11, 17, 34).

It is well known that competition between plants often becomes more critical as stand density is increased. Plots with plants spaced too far apart within the row yield less because individual plants do not make the maximum use of the environment.

The total dry matter yields were comparatively low, because they represent the yield of only one cutting, and that taken early in the spring. Furthermore, the total yields of dry matter were higher in 1963 and 1964, primarily because of the better establishment of the plants during those years.

In 1962, the alfalfa in both the solid planting and in the 50 x 25 cm. spacing produced significantly higher yields than did that in the 50 x 50 cm. spacing. The solid planting of alfalfa gave the highest dry matter yields in 1963 and 1964. However, no significant difference in the yields of dry matter was found between the 50 x 25 cm. and 50 x 50 cm. spacings.

Table 3 - Average dry matter yield of alfalfa in kgs. per dunum as affected by spacing and variety. Grown at the Agricultural Research and Education Center, Beqa'a, Lebanon, during the period 1962-1964.

Year	Spacing	Variety			Spacing Mean
		Hairy Peruvian+	Chilean	African	
	50x50 cm.+	151	182	167	166.7
1962	50x25 cm.	288**	212**	227**	242.3*
	Solid	318**	375**	273**	322.0**
	Variety Mean	252.3	256.3	222.3*	
	50x50 cm.	261	318*	284	287.7
1963	50x25 cm.	364**	386**	296	348.7
	Solid	466**	478**	341**	428.3**
	Variety Mean	363.7	394.0*	307.0**	
	50x50 cm.	307	398**	250	318.3
1964	50x25 cm.	409**	500**	364	424.3
	Solid	636**	398**	557**	530.3**
	Variety Mean	450.7	432.0	390.3**	
Average	50x50 cm.	239.7	299.3**	233.7	257.6
for	50x25 cm.	353.7**	366.0**	295.7**	338.4**
1962-64	Solid	473.3**	417.0**	390.3**	426.9**
	Variety Mean	355.6	360.7	306.6**	

* Significant at the 5% level.
** Significant at the 1% level.
\+ 50 x 50 cm. spacing and Hairy Peruvian used as check.

The three-year average yields of the solid plantings and 50 x 25 cm. spacing show significantly higher forage production than that obtained from alfalfa plants planted 50 x 50 cm. apart.

Dry matter yields were affected also by the varieties. In 1962 African produced a lower yield than did Hairy Peruvian and Chilean which yielded about the same. However, in 1963 Chilean produced more forage than did Hairy Peruvian or African. In 1964 Hairy Peruvian performed the best, but the difference between Chilean and Hairy Peruvian in dry matter production was not significant.

Considering the average yield for the three years, it can be seen that African produced the least amount of dry matter, whereas Chilean and Hairy Peruvian gave the highest forage yield.

The significant interaction between the varieties and spacings shows the response of the varieties to the variation in stand. At the 50 x 50 cm., or the wide spacing, Chilean outyielded Hairy Peruvian and African. At the 50 x 25 cm. spacing, Chilean and Hairy Peruvian gave higher yields than did African. However, when planted in solid rows, Hairy Peruvian outyielded the other two varieties.

Plant Height

The average plant height in centimeters recorded at the time of seed harvest is reported in Table 4. A study

Table 4 - Average plant height of alfalfa in cms. as affected by spacing and variety. Grown at the Agricultural Research and Education Center, Beqa'a, Lebanon, during the period 1962-1964.

Year	Spacing	Variety			Spacing Mean
		Hairy Peruvian+	Chilean	African	
	50x50 cm.+	66.8	61.8	59.3	62.7
1962	50x25 cm.	69.5	72.0	68.8	70.1
	Solid	81.8	77.0	78.5	79.1**
	Variety Mean	72.7	70.3	68.9	
	50x50 cm.	73.8	74.0	70.8	72.9
1963	50x25 cm.	81.0	79.3	79.3	79.9
	Solid	99.3	91.8	92.8	94.6**
	Variety Mean	84.7	81.7	80.9*	
	50x50 cm.	84.8	87.5	81.5	84.6
1964	50x25 cm.	91.5	96.8	89.0	92.4
	Solid	107.5	113.3	110.0	110.3**
	Variety Mean	94.6	99.2	93.5	
Average	50x50 cm.	75.1	74.4	70.5	73.4
for	50x25 cm.	80.7	82.7	79.0	80.8**
1962-64	Solid	96.2	94.0	93.8	94.7**
	Variety Mean	84.0	83.7	81.1**	

* Significant at the 5% level.
** Significant at the 1% level.
\+ 50 x 50 cm. spacing and Hairy Peruvian used as check.

of the data reveals a highly significant effect of plant spacing on the mean height of alfalfa plants in the three years. The tallest plants were recorded from the dense stand or solid planting and the shortest plants were recorded from the 50 x 50 cm. spacing. As for the average of the three years, both the solid planting and the 50 x 25 cm. plant spacing gave taller plants than did the 50 x 50 cm. spacing and the differences are highly significant.

The varieties did not differ significantly in plant height in 1962 or in 1964. Over the three-year period of the experiment, it was found that the plants of Hairy Peruvian and Chilean were significantly taller than were those of the African variety.

1000 Seed Weight

The weights of 1000 seeds of the three varieties used in the trial are shown in Table 5. In both years, 1963 and 1964, African produced heavier seeds than did Hairy Peruvian, and the lightest seeds were produced by the variety Chilean.

A study of the data in Table 5 reveals that plant spacing did not have any influence on the weight of 1000 seeds of alfalfa.

Table 5 - Average weight of 1000 seeds of alfalfa in grams as affected by spacing and variety. Grown at the Agricultural Research and Education Center, Beqa'a, Lebanon, during the period 1963-1964.

Year	Spacing	Variety			Spacing Mean
		Hairy Peruvian+	Chilean	African	
	50x50 cm.+	2.43	2.04	2.47	2.31
1963	50x25 cm.	2.25	2.03	2.54	2.27
	Solid	2.33	1.95	2.36	2.21
	Variety Mean	2.34	2.01**	2.46	
	50x50 cm.	2.34	2.02	2.42	2.26
1964	50x25 cm.	2.36	2.06	2.46	2.29
	Solid	2.36	1.98	2.38	2.24
	Variety Mean	2.35	2.02**	2.42**	
Average	50x50 cm.	2.38	2.03	2.44	2.28
for	50x25 cm.	2.31	2.04	2.50	2.28
1963-64	Solid	2.34	1.96	2.37	2.22
	Variety Mean	2.34	2.01**	2.44**	

** Significant at the 1% level.
+ 50 x 50 cm. spacing and Hairy Peruvian used as check.

Germination Percentage

The data on the effect of spacing and variety on the germination percentage of alfalfa seed are presented in Table 6. It will be noted from the data that variations in alfalfa plant populations did not influence the resulting germination percentage of alfalfa seed.

The varieties differed significantly in germination percentage as is shown in Table 6. However, according to the International Rules for Seed Testing (2), the results fall within the allowable tolerance range, hence the statistical significance is meaningless in this case. Thus the results obtained could be considered not significant.

Table 6 - Average germination of alfalfa seed as affected by spacing and variety. Grown at the Agricultural Research and Education Center, Beqa'a, Lebanon, during the period 1962-1964.

Year	Spacing	Variety			Spacing Mean
		Hairy Peruvian+	Chilean	African	
	50x50 cm.+	89	86	91	89
1962	50x25 cm.	90	88	92	90
	Solid	87	86	85	86
	Variety Mean	89	87*	89	
	50x50 cm.	91	90	89	90
1963	50x25 cm.	94	88	90	91
	Solid	90	89	89	89
	Variety Mean	92	89**	89**	
	50x50 cm.	87	86	94	89
1964	50x25 cm.	88	88	92	89
	Solid	90	87	92	90
	Variety Mean	88	87	93**	
Average	50x50 cm.	89	87	91	89
for	50x25 cm.	91	88	91	90
1962-64	Solid	89	87	89	88
	Variety Mean	90	87**	90	

* Significant at the 5% level.
** Significant at the 1% level.
\+ 50 x 50 cm. spacing and Hairy Peruvian used as check.

SUMMARY AND CONCLUSIONS

The study was undertaken to evaluate the effect of three different spacings and three varieties of alfalfa on seed yield, forage yield, plant height, 1000 seed weight, and percent germination. The trial was conducted under irrigated conditions at the Agricultural Research and Education Center of the American University of Beirut, during the period of 1962 to 1964.

The within-row alfalfa plant spacings were 50 cm., 25 cm., and solid planting. All of the rows were planted 50 cm. apart. Three alfalfa varieties, Hairy Peruvian, Chilean, and African were evaluated for their performance. The 50 x 50 cm. plant spacing and the variety Hairy Peruvian were used as check.

Highest yields of seed were obtained from the 50 cm. within-row plant spacing. This was followed by the 25 cm. plant spacing and the lowest seed yields resulted from the solid planting. The differences in seed yields are highly significant. The three alfalfa varieties differed significantly in seed yields with Hairy Peruvian giving the highest yield as compared to Chilean and African.

Forage yields were the highest from the solid planting, followed by the 25 cm. within-row plant spacing. The 50 x

50 cm. plant spacing resulted in the lowest forage yields.

The variety African gave the lowest forage yields and the difference was highly significant as compared to Hairy Peruvian which yielded about the same as did the variety Chilean.

Plant height in alfalfa was materially affected by the within-row plant spacings and varieties. The tallest plants were obtained from the solid planting and the shortest ones were obtained from the 50 cm. within-row plant spacing. These differences are highly significant when compared with the 50 x 50 cm. spacing.

The variety Hairy Peruvian produced the tallest plants, followed by Chilean and African. The difference between African and Hairy Peruvian was highly significant.

The germination percentage of alfalfa seed was not affected significantly by the within-row plant spacings and the varieties chosen in this trial.

There was no significant effect of the different within-row plant spacings on the 1000 seed weight, but the varieties differed significantly in seed weight. African had the highest 1000 seed weight and Chilean had the lowest. These differences were highly significant when compared with Hairy Peruvian.

It appears from the present study that the highest seed yield of alfalfa is obtained by seeding the alfalfa in rows 50 cm. apart and 50 cm. between plants within the row.

For forage production, alfalfa should be planted in narrower rows at a higher seed rate per dunum to produce a dense stand that would be profitable for hay production.

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A P P E N D I X

Table 7 - Analysis of variance for alfalfa seed yield - 1962.

Source	D.F.	M.S.	F
Blocks	3	292.04	0.99
Spacings	2	2071.75	7.06*
Error "a"	6	293.23	
Varieties	2	1133.58	5.77*
Varieties x Spacings	4	103.83	0.53
Error "b"	18	196.19	

* Denotes F value significant at the 5% level.
L.S.D. at 5% level for spacing = 17.1; variety = 12.0.

Table 8 - Analysis of variance for alfalfa seed yield - 1963.

Source	D.F.	M.S.	F
Blocks	3	267.15	1.92
Spacings	2	5742.36	41.29**
Error "a"	6	139.06	
Varieties	2	361.86	1.03
Varieties x Spacings	4	1012.36	2.87
Error "b"	18	352.45	

** Denotes F value significant at the 1% level.
L.S.D. at 1% level for spacing = 17.8; variety = N.S.

Table 9 - Analysis of variance for alfalfa seed yield - 1964.

Source	D.F.	M.S.	F
Blocks	3	41.78	0.48
Spacings	2	1878.58	21.89**
Error "a"	6	85.80	
Varieties	2	2322.75	11.59**
Varieties x Spacings	4	157.33	0.78
Error "b"	18	200.32	

** Denotes F value significant at the 1% level.
L.S.D. at 1% level for spacing = 14.0; variety = 16.6

L.S.D. for the average of the 3 years, 1962-1964:
At 5% level for spacing = 5.4; variety = 5.5
At 1% level for spacing = 8.2; variety = 7.6.

Table 10 - Analysis of variance for alfalfa dry matter yield (air dry) - 1962.

Source	D.F.	M.S.	F
Blocks	3	4190.03	1.48
Spacings	2	72400.03	25.66**
Error "a"	6	2821.25	
Varieties	2	4182.86	3.95*
Varieties x Spacings	4	6863.03	6.48**
Error "b"	18	1059.00	

* Denotes F value significant at the 5% level.
** Denotes F value significant at the 1% level.
L.S.D. at 5% level for spacing = 53.2; variety = 27.9; var. x spa. = 48.3.
L.S.D. at 1% level for spacing = 80.5; variety = 38.3; var. x spa. = 66.2.

Table 11 - Analysis of variance for alfalfa dry matter yield (air dry) - 1963.

Source	D.F.	M.S.	F
Blocks	3	5432.93	1.43
Spacings	2	59361.75	15.60**
Error "a"	6	3803.78	
Varieties	2	23496.33	22.19**
Varieties x Spacings	4	5816.96	5.49**
Error "b"	18	1058.86	

** Denotes F value significant at the 1% level.
L.S.D. at 5% level for spacing = 61.7; variety = 27.9; var. x spa. = 48.3.
L.S.D. at 1% level for spacing = 93.5; variety = 38.2; var. x spa. = 66.2.

Table 12 - Analysis of variance for alfalfa dry matter yield (air dry) - 1964.

Source	D.F.	M.S.	F
Blocks	3	4723.63	0.40
Spacings	2	134832.11	11.66**
Error "a"	6	11560.07	
Varieties	2	11555.11	6.53**
Varieties x Spacings	4	44399.78	25.10**
Error "b"	18	1768.70	

** Denotes F value significant at the 1% level.
L.S.D. at 5% level for spacing = 107.5; variety = 36.1;
var. x spa. = 62.5.
L.S.D. at 1% level for spacing = 162.8; variety = 49.5;
var. x spa. = 85.7.

L.S.D. for the average of the 3 years, 1962-1964:
At 5% level for spacing = 31.8; variety = 12.6;
var. x spa. = 30.9.
At 1% level for spacing = 48.2; variety = 17.3;
var. x spa. = 42.3.

Table 13 - Analysis of variance for plant height of alfalfa - 1962.

Source	D.F.	M.S.	F
Blocks	3	178.32	2.24
Spacings	2	819.00	10.31*
Error "a"	6	79.41	
Varieties	2	45.08	1.52
Varieties x Spacings	4	24.21	0.82
Error "b"	18	29.68	

* Denotes F value significant at the 5% level.
L.S.D. at 1% level for spacing = 13.5; variety = N.S.

Table 14 - Analysis of variance for plant height of alfalfa - 1963.

Source	D.F.	M.S.	F
Blocks	3	69.73	1.10
Spacings	2	1479.25	23.41**
Error "a"	6	63.17	
Varieties	2	47.25	4.27*
Varieties x Spacings	4	18.12	1.13
Error "b"	18	16.05	

* Denotes F value significant at the 5% level.
** Denotes F value significant at the 1% level.
L.S.D. at 5% level for spacing = 3.4; variety = N.S.
L.S.D. at 1% level for spacing = 12.0; variety = N.S.

Table 15 - Analysis of variance for plant height of alfalfa - 1964.

Source	D.F.	M.S.	F
Blocks	3	172.32	2.31
Spacings	2	2076.33	27.90**
Error "a"	6	74.41	
Varieties	2	108.58	2.70
Varieties x Spacings	4	11.66	0.29
Error "b"	18	40.16	

** Denotes F value significant at the 1% level.
L.S.D. at 1% level for spacing = 13.0; variety = N.S.

L.S.D. for the average of the 3 years, 1962-1964:
At 1% level for spacing = 5.3; variety = 2.6.

Table 16 - Analysis of variance for 1000 seed weight of alfalfa - 1963.

Source	D.F.	M.S.	F
Blocks	3	0.045	0.23
Spacings	2	0.031	0.16
Error "a"	6	0.189	
Varieties	2	0.649	5.03*
Varieties x Spacings	4	0.021	1.62
Error "b"	18	0.013	

* Denotes F value significant at the 5% level.
L.S.D. at 1% level for variety = 0.04; spacing = N.S.

Table 17 - Analysis of variance for 1000 seed weight of alfalfa - 1964.

Source	D.F.	M.S.	F
Blocks	3	0.008	0.46
Spacings	2	0.008	0.46
Error "a"	6	0.018	
Varieties	2	0.553	79.00**
Varieties x Spacings	4	0.002	0.28
Error "b"	18	0.007	

** Denotes F value significant at the 1% level.
L.S.D. at 1% level for variety = 0.03; spacing = N.S.

L.S.D. for the average of the 2 years, 1963-1964:
At 1% level for variety = 0.02; spacing = N.S.

Table 18 - Analysis of variance for percent germination of alfalfa - 1962.

Source	D.F.	M.S.	F
Blocks	3	11.18	0.69
Spacings	2	54.33	3.36
Error "a"	6	16.18	
Varieties	2	24.25	4.28*
Varieties x Spacings	4	13.08	2.31
Error "b"	18	5.66	

* Denotes F value significant at the 5% level.
L.S.D. at 5% level for variety = 2.0; spacing = N.S.

Table 19 - Analysis of variance for percent germination of alfalfa - 1963.

Source	D.F.	M.S.	F
Blocks	3	11.55	2.72
Spacings	2	7.58	1.78
Error "a"	6	4.25	
Varieties	2	28.58	6.13**
Varieties x Spacings	4	7.41	1.59
Error "b"	18	4.66	

** Denotes F value significant at the 1% level.
L.S.D. at 1% level for variety = 2.5; spacing = N.S.

Table 20 - Analysis of variance for percent germination of alfalfa - 1964.

Source	D.F.	M.S.	F
Blocks	3	6.25	1.19
Spacings	2	1.33	0.25
Error "a"	6	5.22	
Varieties	2	103.00	9.09**
Varieties x Spacings	4	2.08	0.18
Error "b"	18	11.32	

** Denotes F value significant at the 1% level.
L.S.D. at the 1% level for variety = 3.9; spacing = N.S.

L.S.D. for the average of the 3 years, 1962-1964:
At 5% level for variety = 0.94; spacing = 1.2.
At 1% level for variety = 1.3 ; spacing = 1.8.