EFFECT OF CULTIVATION AND NON-CULTIVATION ON GRAPEVINE NUTRITION

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A THESIS

Submitted to the
AMERICAN UNIVERSITY OF BEIRUT

In partial fulfillment of
the requirements for the
degree of

MASTER OF SCIENCE IN
AGRICULTURE

October 1966

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Date Thesis is presented: October , 1966

TILLAGE VERSUS NON-TILLAGE

ABOZEID

ACKNOWLEDGEMENTS

I wish to express my indebtedness and my great appreciation to Dr. Ramzi M. Khalidy Associate Professor of Sub-tropic Horticulture, for his guidance, help and time given in directing the research and preparing this manuscript.

To Dr. Constantine Rubeiz my gratitude for his cooperation in making available the vineyards for the study.

AN ABSTRACT OF THE THESIS OF

Hassan Tewfik Abozeid for M.S. in Horticulture

Title: Effect of Cultivation and non-cultivation on Grapevine Nutrition.

Studies were conducted to find out the effect of three different cultural practices on the inorganic composition of the grapevine leaves. The three practices are namely:

A. Cultivation and no Irrigation.

B. Non-cultivation and Irrigation (Weeds are controlled with the weedicides).

C. Cultivation and Irrigation.

Leaf analysis was carried out on samples collected on July 1, and on September 10, 1965, from three vineyards located in the Beqaa plain for the determination of N, P, K, Ca, Fe, Mg, Mn, Na, and B.

The results obtained from the first collected samples showed that the cultivation and no irrigation method (A) compared to non-cultivation and irrigation (B) was more effective in inducing high N content in the vine leaves and less effective in the building up of K, Ca, and Na, while both systems were found to be equally effective in maintaining equal amounts of P, Mn, Mg, and B. It was found from the samples collected during September that higher percentage of Ca, Mg, B, and Na, and lower percentage of K were obtained from vines under cultivation and irrigation compared to those from vines under non-cultivation and irrigation. However, equal amounts of N, P, K, Mn, and Fe were found in leaves from vines growing under the two systems.

The comparison between vineyards under non-cultivation and irrigation, and cultivation with no irrigation as to their effects on grapevine leaf inorganic content, in samples collected during July showed that higher Mn, Mg, and Ca, and lower K were found in the leaves sampled from vines grown under non-cultivation as compared to those sampled from vines grown under cultivation and no irrigation. Mean-

while leaf N, Fe, B, and Na mean percentage values were not different. The leaf analysis of samples collected during September resulted in higher N, P, K, Mn, and Ca, and lower Mg and B in vines from the non-cultivated and irrigated vineyard as compared to the cultivated and non-irrigated one.

Studying the seasonal variation of the elements analysed for, it was found that a decrease in N, P, K and Fe as well as a simultaneous increase in Ca and Mg showed within the period from July to September in all grapevines under the 3 systems. Leaf B content decreased in vines under non-cultivation while it increased in vines under the two other systems. In the period from July to September Na content of the leaves decreased in the grapevines grown under non-cultivation and irrigation, and cultivation and no irrigation, while it increased in vine leaves under cultivation and irrigation. Leaf mean percentage Mg was equal in samples collected in July and September from the vineyard where cultivation was combined with no irrigation. During this period leaf Mg content decreased in the vineyards which were non-cultivated and irrigated, and cultivated and non-irrigated respectively.

All the levels of the leaf inorganic constituents were found to be above the critical values and within the range for vigorous grapevine growth.

It was concluded that the non-cultivation and irrigation system had no adverse effects on the inorganic composition of the nine elements tested. Moreover the practice brought about an increase in the grape yield. Sparing the process of cultivation has definitely made a far-reaching contribution in reducing production expenses.

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I. INTRODUCTION

Grapes are among the important cash crops in the Mediterranean region. In Lebanon, grapes are grown under cultivation and no irrigation. The main merit of cultivation is the removal of weeds. In spite of this merit, cultivation brought about many drawbacks resulting in the deterioration of the physical condition of the soil by compaction. It slowed down the penetration rate of water into the soil, and destroyed the roots causing a retardation in the absorption rate and consequently reduced the growth and yielding ability of the plants (28) (32) and (40). Further, cultivation is a major item of cost in grape production particularly in places like Lebanon due to the high cost of labor and machinery, especially in vineyards on terraces.

The practice of non-cultivation has been studied in many California citrus orchards and cultivation was replaced by spray weed control. By practicing non-tillage, the citrus yields increased and the rate of water penetration was found to be faster, the cost of production was lowered, and the ill effects resulting from root destruction were overcome by keeping the soil undisturbed (22).

This investigation was conducted to study the nutritional status of grapevine leaves in vineyards under different cultural practices, namely: cultivation and irrigation, non-cultivation and irrigation using herbicides to control weeds, and cultivation without irrigation.

II. REVIEW OF LITERATURE

Introduction

The main purposes of cultivation are to destroy the weeds, prepare the soil for the cover crops, and incorporate cover crops and manure into the soil. Cultivation, beside its high cost (19), destroys the soil structure and texture and limits the root expansion in the soil surface (28). It is associated with orchard soil compaction as a result of the increasing use of heavy equipments, this soil compaction may be a major factor limiting fruit production.

Essential nutrient elements for grapevine growth and production

The literature contains a number of ways for expressing the optimum levels of elements in the leaves of grapevines for efficient plant growth and production. Bergman (4) reviewed the methods of Lagato and Maume who employed the ratio of N: P_2O_5:K_2O in the leaves, and Vidal who added the N,P, and K content of the leaf together and considered 3.9% to be sufficient and 4.3 optimum for production. Beattie and Forshey (2) suggested the following as a tentative concentration in leaf petiole: 0.77% N, 0.14% P, 0.70% Ca, and 0.15 Mg. They also showed that high yielding vineyards with high K content had lower Na than high yielding vineyards with lower K. Sodium in the former was 0.031% and in the latter 0.042%. They found a significant correlation between each of N and K content in the leaf and yield. Bergman *et al.* (4) have treated the vines with different levels of fertilizers and found that low N treatment in sand culture showed severe N deficiency symptoms after 4 weeks. The low levels of P fertilizer produced deficiency symptoms after 6 weeks, while low K levels produced deficiency symptoms after 9 weeks. The low levels of Fe produced the deficiency symptoms after 10 weeks, followed one week later by the deficiency symptoms of Mg, Mn, B, and Cu. It was shown from the above work that P and K had the greatest influence on shoot growth as compared with the other nutrient elements. Comparing two fertilizers, one with Mg and the other without Mg, the vines under the former had a significantly reduced growth. Potassium when used as K_2SO_4 was more effective than KCl in producing more shoot growth. Low levels of N and K were not significantly effective in reducing the per-cent dry weight of roots. Those former low levels of N and K reduced the dry weight of the stem.

According to Shaulis and Kimball (34) there was no vine response to N, P, or K fertilization when the leaf con-centrations of the 3 elements on a dry weight basis in autumn were as high as 1.5% N, 0.19% P, and 1.03% K. It was also found that K deficiency symptoms were present in the vine leaves when the % K was in the range of 0.25 - 0.6 while the leaves were free of such symptoms when the range was 0.5 to 0.8% K. A 0.25% K in leaves collected during September was associated with severe K deficiency as reported by Boynton (6). He also mentioned that leaves with 0.11% K showed slight deficiency symptoms of this element.

Beattie and Forshey (2) found that in vineyards where plants showed good vigor the leaf petiole concentration of some elements was as follows: 1.08% N, 0.99% Ca, 0.207% P, 2.53% K, 645 ppm Mn, 91 ppm Fe, and 12.9 ppm B. Such vineyards produced as much as 5.5 tons of fruit per acre.

Shaulis and Kimball (34) found that certain concentrations in the vine leaf petiole were suggestive or associated with deficiency symptoms. These concentrations are presented on a dry weight basis and are: $<$ 1.5% N, $<$0.6% K, $<$0.2% Mg, $<$0.0035% Mn, while the range of each of these elements in vigorous vineyards was: 1.70 - 2.4% N, 0.40 - 2.0% K, 0.18 - 1.5% Mg, and 0.003 - 0.15% Mn

The effect of soil management system on leaf inorganic composition of grapevines and some fruit trees

In a comparison between clean cultivation and mulch treatment, Magoon (23) found no significant difference in the grape leaf composition for K, Fe, or Al. However, Mg and Cu were significantly higher under the mulch treatment. He stated that, "The insignificant difference between these two systems was due to the insufficient decomposition of the mulch". This statement agrees with what Bould (5) found in an apple orchard where leaves were collected from trees grown under mulch. These leaves showed significantly higher content of K and P over those collected from trees under clean cultivation. He found that the leaf nitrogen was higher under clean cultivation. Similar to Bould, Smith (36) found higher nitrogen in the leaves of pacan trees grown under clean cultivation as compared to trees under mulch, but there was no significant difference in leaf K and Mg content, while P was significantly increased under the mulch system.

Proebsting (29) studied the effect of cover crop on the soil N. He stated that under the warm semi arid conditions of Davis, in an irrigated orchard, cover crops did not increase the soil N. According to Beattie and Baldauf (1) vine leaf N, P, and K was higher under mulch compared to cultivation, while Ca and Mg were higher under cultivation

Common chemicals and their use for controlling weeds in vineyards

Many experiments have been conducted with chemicals to control weeds. The herbicides 2, 4-D, sodium trichloro acetate, and oil emulsions have been reported by Nelson (27) to maintain as much wood growth of the grapevines as when the weeds were removed by tillage. He found also that no significant difference resulted in yield between the use of herbicides and tillage. Winkler (42, pp.319-327) reviewed the findings of Shaulis and Kimball, and Hemstreet. Shaulis and Kimball found that a mixture of 10 to 15 gallons of aromatic oil with 2 pints of dinitro secondary butyl phenol in 100 gallons of water has been effective when applied at the rate of 50 gallons per acre. According to Hemstreet 75 to 80 gallons per acre of a mixture made of one part oil to two parts water effectively controlled the weeds, while the work of Lidar _et al_. (23) has shown that Diuron and Monuron could be used effectively to replace the row plow in controlling most of the annual weeds in the grapevine row. Soyez (37) has also reported that Diuron had no adverse effects on soil fertility; it did not affect the grape yield or quality.

Comparison between the effects of spray weed control and other weed controlling methods on fruit trees, grapevines and soil

The results obtained by La Rue, Moore, Puffer _et al_. and Yarrick as reviewed by Kimball (21), indicated that spray weed control was associated with greater yields, earlier fruit maturity, lower costs, less erosion, less frost damage, greater convenience, and increased rate of water penetration when compared to tillage practices in citrus.

Williams (41) studying the effect of spray weed control in vineyards, reported a marked increase in the growth of Tokey vines (*Vitis vinifera*). He also found a small increase in yield, a decrease in color of fruits, and a marked increase in the rate of water penetration as compared to vineyards where the weeds were allowed to grow after the spring cultivation. He compared clean cultivation and spray weed control and found no significant difference in growth, yield, or in fruit quality, but the water penetration rate was slightly increased as a result of spray weed control. Julliard (19) has shown that herbicides can replace cultivation. He reported that a 15% solution of iron sulfate killed *Stellaria media*, and Donac at 5 Kg./ hectar in fuel oil gave a rapid and complete kill of weeds and a lower cost as compared to hand hoeing.

The effect of soil management systems on soil moisture

The depletion of soil moisture has a great effect on yield, growth, and fruit quality. The depletion of 80% of the available soil moisture was found by Kenworthy (20) to decrease the total chlorophyll per tree, shoot growth, trunk diameter, dry weight, and leaf area.

According to Eggert (9), Tonge has found that blue grass sod benefited orchards planted in heavy soils. It increased water penetration during rains and slowed down the surface run off. In his conclusion, he has shown that deep rooted cover crops deplete soil moisture and should not be used in orchards unless irrigation is practiced. Goodman (13) reported that the mulch system was preferable to sod and stated that field capacity was realized sooner under mulch than under sod due to the increased infilteration capacity of mulched soils.

Eggert (9) reported that the available soil moisture was found to increase rapidly in apple plots where the cover crop was removed, while it rapidly decreased in the unmowed plots. Comparing plots with the cover crops being mowed and removed with plots where the cover crops were mowed but left on the soil surface, he found a decrease in soil moisture in the plots from which the mowed cover crops were removed due to the delayed start of the second growth of the cover crops in the plots.

The effects of cultivation and non-cultivation were compared by Proebsting (28) as to their influence on water penetration after a rainfall. The penetration was found to be 24" in the non-cultivated area and only about 12" in the cultivated plots. Proebsting (30) studied orchards of apples, pears, and cherries and reported that annual cover crops did not increase the moisture holding capacity of the soil. He found that alfalfa sod has increased total nitrogen but it did not increase the moisture holding capacity of soil.

Harais and Gourley (16) studied the effects of mulch, sod, and cultivation on the penetration of water into the soil and reported that both mulch and sod increased the porosity of soil of an apple orchard.

Soil density and root distribution
as affected by soil management

Soil compaction is reported by Proebsting (28) and Ruckmnbouer (32) to be associated with cultivation. Proebsting mentioned that a layer of hard soil, 6-12" thick, lies below the depth of cultivation in many California orchards as a result of the action of plows and disks. He compared cultivation with non-cultivation as to their effect on soil density, root distribution and water penetration and found that the soil density was 1.44 in plots under cultivation, while it was 1.28 in the non-cultivated plots. No roots were found in the surface layer of cultivated soil as a result of root destruction by disking. However, where no machinary was used for 7 years, the soil was found to contain a large amount of roots. Following the same study in two almond orchards, he found similar results. There was no surface rooting under cultivation, but there were roots throughout the whole surface of the soil with no cultivation. The soil density was 1.76 and 1.56 under cultivation and non-cultivation respectively. According to him, the soil density of 1.76 falls in a range considered too dense to permit root growth or water penetration. Results from his work on olives and nectarines follow the same pattern.

Bechenback and Gourley (3) found that apple trees grown in a mulched soil had a large amount of roots in the upper soil surface just below the deep mulch. The roots in mulched soil were more than in unmulched soil.

Effects of soil management on production and growth of some fruit trees and grapevines

Griggs (12) compared both the use of sawdust and mulch with clean cultivation, as to their effects on blueberry production. He found no difference between the two systems in the first and second year of his work, while in the third year, plants under the sawdust had a significantly higher yield. Also the mean linear shoot growth was higher during the third year from plants under sawdust.

According to Chandler and Mason (7), the mulch treatment maintained more available moisture, lowered the soil temperature and reduced the growth of blueberry plants in sandy soils, while it increased the growth of plants in clay soil. Kramer _et al_. (22) obtained increased yields with various mulches, and found twice as much soil moisture under mulch as compared to cultivated plots.

Non-cultivation using chemical weed control "dinitro" was compared by Proebsting (31), with grass sod , cultivation and various mulches. He found that the yield from trees under non-cultivation was among the highest, leaf N was found low and the growth was satisfactory. The highest yield was found from trees under mulch.

Beattie (1) found that mulched vines produced more vegetative growth, had higher leaf petiole content of N, P, and K, smaller clusters and less fruit per bud when compared to vines under cultivation. The soluble solid content of the juice of cultivated vines was higher than that of fruits from mulched vines.

Summary

The comparison between the different soil management systems showed that clean cultivation increased the leaf N of grapevines, apples, peach and pecan trees. It induced higher Ca and Mg and lower P and K in the vine leaves compared to the mulch system, while no significant difference in grape leaf composition was found for Fe or Al in plants growing under these two systems.

Spray weed control was found to be more convenient than cultivation, it increased the growth, yield and water penetration. The mulch and sod methods compared to cultivation were found to increase the soil porosity and water penetration beside inducing higher P and K in the leaves of fruit trees.

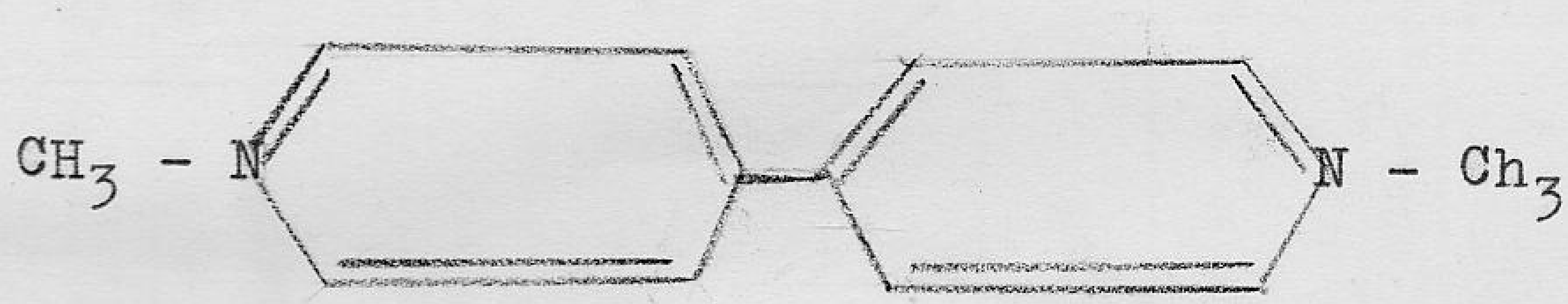
Nitrogen and P were found to have the greatest influence on the grapevine shoot growth. There was no vine response to N, P, K fertilizer when their concentration on dry weight basis was as high as 1.5, 0.19 and 1.03% respectively. Vines with $<$1.5% N, $<$0.6% K, $<$0.2% Mg, or $<$0.0035% Mn, were reported to be deficient in these elements while the range of these elements in vigorous vineyards was reported to be 1.70 - 2.4% N, 0.40 - 2.00% K, 0.18 - 1.5% Mg and 0.003 - 0.15 Mn.

The seasonal variation reported for the inorganic constituents of the grapevine leaves showed a decrease in N, P, and K content, and an increase in Ca, Mn, and Mg as the season advanced.

III. MATERIALS AND METHODS

The study to be reported in this thesis was conducted in the Beqaa Plain: the largest grape growing areas in Lebanon.

Three adjacent vineyards under different cultural practices, in the central part of the plain, were selected for the study. The first vineyard hereafter known as vineyard A is under clean cultivation and not irrigated. The second vineyard is under no cultivation and irrigated, weed control being achieved by spraying with Gramaxone (20% paraquat and 10% wetting agent). Paraquat is one of the bibyridylium compounds having the following chemical formula:



This vineyard is refered to as vineyard B. The third vineyard is under clean cultivation and irrigation and will be refered to as vineyard C.

The three vineyards are planted to the table variety "Tififihi" (Vitis vinifera), grafted on the rootstock41 B (Berlandieri). The vines in all vineyards are planted to the square system with 5m between plants. Each vine receives annually half a Kg of ammonium sulfate as fertilizer. All vines were trained to the arbor system. The pest control program consisted of spraying the vines with sulfur and Parathion when required.

Thirty vines spread along the two diagonals in each vineyard were selected and marked, making a total of 90 vines. From these vines, random leaf samples made of about 60 healthy mature leaves were collected from the centre of the shoots and each sample was put in a separate paper bag. The leaves were brought to the laboratory and immediately washed with a detergent by rubbing both surfaces with a sponge, rinsed in tap water, immersed in 0.1% hydrochloric acid for about 30 seconds, and then washed twice with distilled water. The excess water was shaken off and the leaves were placed in a paper bag, and then dried in an oven at $70 \pm 1^{\circ}C$ for 48 hours, the dried leaves were ground through a Willey Mill using a 40 mesh sieve. Each ground leaf sample was collected in a clean dry bottle. Before sample weighing the ground leaves were dried by placing the bottles with the cap off in the oven at $70 \pm 1^{\circ}C$ for about 6 hours. The sample bottles then were recapped and cooled in a dessicator.

Leaves were collected twice during the growing season of 1965. The first sampling was on July 1 while the second sampling was carried out on September 10.

Nitrogen was determined by the Kjeldahl method (17), while Fe, Mg, Mn, P, K, Ca and Na were determined by the method suggested by Toth *et al*. (39). Boron was analysed for by the method described by Johnson and Ulrich (18).

The results were calculated on a dry weight basis. Each 30-leaf sample collected from a vineyard represented a treatment and the data obtained for the three treatments were statistically analysed by the analysis of variance (11, PP.240); the Tokey method (11, PP.153) was followed for the comparison between means.

The yield data for vineyard B where no cultivation was practiced, was obtained from the owner of this vineyard. The yield for the other two vineyards were obtained from the records of the merchant who contracted the fruit.

IV. RESULTS AND DISCUSSION

This study was undertaken to find out the effect of cultivation and irrigation, non-cultivation and irrigation, and cultivation with no irrigation, on inorganic leaf composition of the grapevine. Non-cultivation hereafter will refer to the practice of controlling weeds with the weedicide gramaxone.

Leaf samples were collected on July 1, 1965 and September 10, 1965. The results of the chemical leaf analysis for each element are discussed separately.

Nitrogen

The leaf N data from samples collected on July 1, are presented in tables 1 and 2. The results in table 2 show that leaf mean % N was significantly higher in vineyard C (cultivation and irrigation) as compared to vineyard A (cultivation and no irrigation) and to vineyard B (non-cultivation and irrigation). The average leaf N was statistically equal in both vineyards A and B.

This data shows that cultivation with irrigation induced higher N in the grapevine leaves as compared to the N in plants cultivated and not irrigated or plants from vineyards where only weedicides and irrigation were applied.

The data on leaf mean % N in table 3 for leaves collected in September shows that leaf N from vines in vineyard A was significantly lower as compared to those from vineyards B and C, while vineyard B and C had statistically equal leaf mean % N.

By studying the yield records in table 24, a trend towards a higher yield was observed in vineyard B, where no cultivation was practiced and the plants were irrigated. However, leaf N was significantly lower in this vineyard compared to vineyard C. This finding is contrary to that reported by Beattie (1) who showed that increased yields were found in vines high in leaf N. The possible explanation could be that N in vineyard B was already at an optimum level. Also the roots of the vines in said vineyard were not disturbed by cultivation and were more effective in producing high yield, and the lack of disturbance of the soil increased water penetration resulting in a greater depth of wet soil from where the roots could draw up more water. This ideal condition for growth and the higher yield must have consumed more N, thus showing a lower level of this element in the leaves. Williams (41) and Nelson (27) reported increased growth of vines as a result of non-cultivation, and according to Williams (38) and Yarric (20), non-cultivation is associated with increased water penetration.

It is apparent from figure 1 that the mean % N

Table 1. Nitrogen content of grapevine leaves collected on July 1 and Sept. 10 from three vineyards under different cultural practices (% dry weight basis)

Vine No	% N					
	A		B		C [x]	
	July 1	Sept. 10	July 1	Sept. 10	July 1	Sept. 10
1	2.45	1.54	2.63	1.80	2.73	1.87
2	2.33	1.33	2.74	1.86	2.66	2.22
3	2.37	1.20	2.64	2.28	2.80	1.96
4	2.78	1.00	2.50	1.89	2.56	2.03
5	2.44	1.45	2.89	2.02	2.37	2.10
6	2.55	1.53	2.46	1.71	2.50	1.88
7	2.38	1.57	2.61	1.90	2.81	2.19
8	2.70	1.68	2.48	1.91	2.67	2.12
9	2.32	1.55	2.37	1.95	2.95	2.31
10	2.66	1.49	2.46	1.99	2.74	1.99
11	2.48	1.70	2.34	1.48	2.56	1.72
12	2.37	1.90	2.30	2.00	2.82	2.34
13	2.77	2.77	2.82	1.89	2.73	1.90
14	2.65	1.92	2.61	1.97	3.27	1.20
15	2.58	1.82	2.25	1.03	3.09	2.10
16	2.66	2.01	2.28	1.81	2.84	1.79
17	2.96	1.93	2.57	1.90	2.58	1.82
18	2.94	2.19	2.54	1.66	2.71	1.93
19	3.20	2.00	2.88	1.99	3.38	1.93
20	2.63	1.73	2.35	1.75	3.23	1.97
21	2.77	1.90	2.93	1.86	3.15	1.90
22	2.60	1.90	2.69	1.87	2.86	1.89
23	2.78	1.90	2.11	1.84	2.23	2.03
24	2.17	1.68	3.46	1.70	2.27	1.89

Table 1 (continued)

Vine No	July 1	Sept. 10	July 1	Sept. 10	July 1	Sept. 10
25	2.45	1.75	2.40	1.60	3.37	2.09
26	2.68	1.72	2.35	1.83	2.81	1.90
27	2.44	1.90	2.63	1.67	2.87	1.78
28	2.60	1.80	2.33	1.86	3.07	1.88
29	2.83	1.90	2.54	1.77	2.66	1.82
30	2.43	1.77	2.54	1.88	3.07	1.63
Mean	2.59	1.71	2.56	1.86	2.81	1.93

(x) Vineyard A under cultivation and no irrigation.
Vineyard B under non-cultivation and irrigation.
Vineyard C under cultivation and irrigation.

Analysis of Variance for Samples collected Sept. 10.

Variation	d.f.	S.S.	M.S.	F-ratio	1%	5%
Block	2	0.73	0.365	15.2 ØØ	4.83	3.51
Vines	29	1.81	0.062	2.5 N.S.		
Residual	58	1.37	0.024			
Total	89	3.91				

Analysis of Variance for Samples collected on July 1.

Variation	d.f.	S.S.	M.S.	F-ratio	1%	5%
Block	2	1.14	0.57	11.4 ØØ	4.83	3.51
Vines	29	4.19	0.14	2.8 N.S.		
Residual	58	3.03	0.05			
Total	89	8.36				

ØØ High significant difference.
N.S. Non-significant difference.

Table 2. Comparison between mean nitrogen content of grape leaves collected on July 1 from three vineyards.

Vineyard [x]	Mean	mean - 2.56	mean - 2.59
C	2.81	(0.14) 0.25 ∅	(0.11) 0.22 ∅
A	2.59	(0.11) 0.03 N.S.	
B	2.56		

(x) Vineyard A under cultivation and no irrigation.
Vineyard B under non-cultivation and irrigation.
Vineyard C under cultivation and irrigation.

∅ Significant difference.
N.S. Non-significant difference.

Table 3. Comparison between mean nitrogen content of grape leaves collected Sept. 10, from three vineyards.

Vineyard [x]	Mean	mean - 1.71	mean - 1.86
C	1.93	(0.12) 0.22 ∅	(0.10) 0.07 N.S.
B	1.86	(0.10) 0.15 ∅	
A	1.71		

(x) Vineyard A under cultivation and no irrigation.
Vineyard B under non-cultivation and irrigation.
Vineyard C under cultivation and irrigation.

∅ Significant difference.
N.S. Non-significant difference.

decreased as the season advanced from July to September. The decrease was from 2.59 % to 1.71%, from 2.56% to 1.86%, and from 2.81% to 1.93% in vineyards A, B, and C respectively. The above results are in agreement with those reported by Smith *et al*. (35).

Potassium

The findings on leaf K content are reported in tables 4, 5 and 6. The average K in samples collected during July was 1.87%, 1.59% and 1.20% from vineyards A (cultivation and no irrigation), B (non-cultivation and irrigation), and C (cultivation and irrigation) respectively. Vineyard C was found to be significantly lower in leaf K than each of vineyards A and B. Also vineyard B was significantly lower in leaf K than vineyard A. This shows that the non-cultivation system induced a higher leaf K in the grapevine leaves compared to cultivation when both systems were followed with irrigation. However, the highest K level was obtained in leaves of vines under cultivation and no irrigation. This high K in vineyard A may be due to the soil K being less subject to leaching due to the limited water as compared to the irrigated vineyards B and C.

The averages of leaf K obtained from leaves sampled on September 10 and presented in table 4 are: 0.69%, 1.10% and 0.75% from vineyards A, B and C, respectively. As shown in table 6, there was no significant dif-

Table 4. Potassium content of grapevine leaves collected on July 1 and Sept. 10 from three vineyards under different cultural practices (% dry weight basis).

Vine No	% P					
	A		B		C x	
	July 1	Sept. 10	July 1	Sept. 10	July 1	Sept. 10
1	1.60	0.75	1.83	1.05	1.41	0.90
2	1.71	1.05	1.84	1.45	1.32	0.95
3	1.91	0.85	1.84	1.60	1.12	0.65
4	1.87	1.10	1.55	1.00	1.24	0.65
5	1.56	0.75	1.99	1.10	1.24	0.55
6	1.54	0.75	2.03	0.80	1.14	0.55
7	1.72	0.80	1.59	1.15	1.07	0.80
8	1.64	0.75	1.56	1.20	1.09	1.05
9	1.93	0.80	1.67	1.30	1.14	0.75
10	1.53	0.50	1.75	1.00	1.07	0.70
11	1.29	1.15	1.52	0.95	1.10	0.80
12	1.90	0.60	1.42	1.15	1.07	0.80
13	1.65	0.50	1.44	0.95	1.12	0.70
14	1.69	0.85	1.44	0.70	1.23	0.95
15	1.54	0.75	1.39	1.05	1.24	0.80
16	1.73	0.55	1.78	1.30	1.23	0.55
17	1.91	0.70	1.59	1.10	1.32	0.65
18	1.59	0.70	1.65	1.30	1.21	0.70

Table 4 (continued)

Vine No	July 1	Sept. 10	July 1	Sept. 10	July 1	Sept 10
19	2.00	1.00	1.40	1.00	1.02	0.95
20	1.94	0.80	1.58	1.00	1.24	0.95
21	2.27	0.85	1.44	1.10	1.23	0.70
22	2.06	0.55	1.62	1.05	1.21	0.65
23	2.10	0.03	1.57	1.25	1.23	0.80
24	2.33	0.95	1.56	1.20	1.24	0.70
25	1.94	0.95	1.31	1.20	1.39	0.95
26	2.23	0.15	1.63	0.95	1.22	0.60
27	2.38	0.03	1.64	1.05	1.23	0.60
28	2.21	0.60	1.08	0.95	1.23	0.80
29	2.23	0.05	1.42	0.90	1.23	0.75
30	1.99	0.80	1.54	1.25	1.21	0.60
mean	1.87	0.69	1.59	1.10	1.20	0.75

(x) Vineyard A under cultivation and no irrigation
Vineyard B under non-cultivation and irrigation
Vineyard C under cultivation and irrigation

Table 5. Comparison between mean potassium content of grape leaves collected on July 1 from three vineyards.

Vineyard	Mean	Mean - 120	Mean - 1.59
A	1.87	(0.14) 0.67 ø	(0.11) 0.28 ø
B	1.59	(0.11) 0.39 ø	
C	1.20		

ø Significant difference.

Table 6. Comparison between mean potassium content of grape leaves collected September 10, from three vineyards.

Vineyard	Mean	Mean - 0.69	Mean - 0.75
B	1.10	(0.11) 0.41 ø	(0.09) 0.35 ø
C	0.75	(0.09) 0.06 N.S.	
A	0.69		

ø Significant difference.
N.S. Non-significant difference.

ference between mean % leaf K of vines from vineyard C and vines from vineyard A, while leaves from vineyard B had a significantly higher mean % leaf K.

Beattie and Forshey (2) reported 2.53 % K to be in the leaf petiole of vigorous vines, while Shaulis and Kimball (34) reported that 0.4 - 2.0 % is a range for leaf K in vigorous grapevines. The values obtained in this study in all three vineyards seem to fall within the sufficient level and are also far from the 0.62 % leaf K reported by Boynton (6) to be associated with deficiency symptoms.

By studying figure 1, it is clearly seen that leaf K dropped in all vines under the three cultural systems from July to September. This drop has been witnessed by other workers (8) (35).

Phosphorus

Tables 7 and 8 contain the data for leaf P. The leaf P average for samples from the three vineyards collected on July 1, were found to be statistically equal. However, by studying the data of the leaves sampled on September 10, and presented in table 7, equal averages were found in vineyard B (non-cultivation and irrigation) and vineyard C (cultivation and irrigation) while vineyard A (cultivation and no irrigation) had a significantly lower mean % P as compared to the other two vineyards. The above results indicate that both cultivation and non-cultivation

Table 7. Phosphorus content of grapevine leaves collected on July 1, and Sept. 10 from three vineyards under different cultural practices (% dry weight basis).

Vine No	Leaf P					
	A		B		C x	
	July 1	Sept. 10	July 1	Sept. 10	July 1	Sept. 10
1	0.15	0.11	0.19	0.17	0.19	0.13
2	0.12	0.13	0.14	0.14	0.15	0.13
3	0.13	0.16	0.14	0.18	0.13	0.17
4	0.17	0.11	0.15	0.13	0.20	0.14
5	0.51	0.12	0.16	0.13	0.25	0.13
6	0.14	0.12	0.16	0.11	0.22	0.12
7	0.14	0.13	0.15	0.14	0.19	0.20
8	0.13	0.13	0.14	0.15	0.21	0.18
9	0.15	0.12	0.17	0.14	0.14	0.15
10	0.14	0.10	0.17	0.14	0.23	0.20
11	0.16	0.13	0.14	0.15	0.15	0.12
12	0.14	0.11	0.16	0.14	0.18	0.14
13	0.17	0.13	0.15	0.14	0.15	0.14
14	0.14	0.14	0.14	0.14	0.17	0.14
15	0.13	0.09	0.14	0.13	0.18	0.13
16	0.17	0.12	0.21	0.11	0.17	0.14
17	0.14	0.12	0.19	0.18	0.17	0.13
18	0.14	0.12	0.18	0.14	0.06	0.07

Table 7 (continued)

Vine No	July 1	Sept. 10	July 1	Sept. 10	July 1	Sept. 10
19	0.12	0.01	0.17	0.25	0.12	0.17
20	0.17	0.12	0.15	0.13	0.06	0.13
21	0.17	0.11	0.15	0.12	0.19	0.16
22	0.14	0.12	0.15	0.13	0.13	0.15
23	0.14	0.06	0.17	0.14	0.10	0.16
24	0.14	0.12	0.15	0.14	0.19	0.14
25	0.17	0.13	0.15	0.17	0.23	0.18
26	0.21	0.09	0.18	0.15	0.18	0.15
27	0.22	0.01	0.19	0.18	0.15	0.12
28	0.17	0.15	0.13	0.12	0.16	0.15
29	0.18	0.17	0.22	0.18	0.14	0.15
30	0.18	0.14	0.25	0.25	0.16	0.12
mean	0.17	0.11	0.16	0.15	0.16	0.15

(x) Vineyard A under cultivation and no irrigation.
Vineyard B under non-cultivation and irrigation.
Vineyard C under cultivation and irrigation.

Analysis of variance for samples collected on July 1

	d.f.	S.S.	M.S.	F-ratio	1%	5%
Block	2	0.01	0.005	2.5 N.S.	4.83	3.51
Vines	29	0.12	0.004	2.0 N.S.		
Residual	58	0.10	0.002			
Total	89	0.23				

N.S. Non-significant difference.

Analysis of variance for samples collected on Sept. 10

	d.f.	S.S.	M.S.	F-ratio	1%	5%
Block	2	0.037	0.013	8.6 ØØ	4.83	3.51
Vines	29	0.010	0.0005	0.3 N.S.		
Residual	58	0.084	0.0015			
Total	89	0.128				

ØØ High significant difference.
N.S. Non-significant difference.

Table 8. Comparison between mean phosphorus content of grapes leaves collectedon Sept. 10 from three vineyards.

Vineyard	mean	mean - 0.11	mean - 15
C	0.15	(0.03) 0.04 ∅	-
B	0.15	(0.02) 0.04 ∅	
A	0.11		

∅ Significant difference.

were equally effective in inducing high leaf P when irrigation was practiced.

Shaulis and Kimball (34) suggested a range of 0.10 - 0.30 % leaf petiole P for vigorous grapevine growth. The leaf P data obtained in this study suggests a sufficiency of this element in the leaves. Unfortunately no data is available for leaf P for comparison.

The seasonal variation in leaf P content as presented in figure 1 showed similar results to those reported by Smith et al. (35). The mean % P decreased from 0.17 % to 0.11 % in vineyard A. There was also a decrease from 0.16 % to 0.15 % in each of vineyard B and C.

Manganese

The data for leaf % Mn are presented in tables 9, 10 and 11. Table 10 shows that vine leaves in vineyard A (cultivation and no irrigation) had the lowest mean %, Mn as compared to leaves from each of vineyard B (non-cultivation and irrigated) and vineyard C (cultivation and irrigation). There was no significant difference between mean % Mn from vines under cultivation and those from vines under non-cultivation and irrigation.

Leaves sampled on Sept. 10 and whose % Mn are presented in table 11, were found to follow the same pattern as the data reported in table 9. From these results it is seen that vines under cultivation and no irrigation had the lowest average leaf Mn in samples collected on both

Table 9. Manganese content of grapevine leaves collected on July 1 and Sept. 10 from three vineyards under different cultural practices in Beqaa.

Vine No	Leaf Mn (ppm)					
	A		B		C [x]	
	July 1	Sept. 10	July 1	Sept. 10	July 1	Sept. 10
1	7.7	200	126	165	196	260
2	88	220	185	135	182	295
3	49	245	163	220	127	195
4	64	305	222	135	163	155
5	78	295	170	195	89	110
6	65	180	124	150	150	115
7	39	180	90	245	129	130
8	30	95	49	295	177	180
9	35	110	103	310	88	180
10	114	130	107	330	148	200
11	110	125	103	320	130	230
12	63	145	216	320	195	220
13	44	155	110	305	150	185
14	65	125	100	330	153	230
15	105	125	144	265	165	250
16	79	110	89	360	239	433
17	39	150	87	360	179	250
18	34	90	92	340	163	260
19	34	185	98	330	123	250

Table 9 (continued)

Vine No	July 1	Sept. 10	July 1	Sept. 10	July 1	Sept. 10
20	75	170	153	310	191	295
21	63	70	310	500	168	220
22	49	285	182	185	141	185
23	135	180	49	130	114	260
24	40	180	244	200	169	250
25	40	150	110	115	164	250
26	50	130	109	70	107	195
27	95	135	129	80	95	220
28	79	125	127	195	154	200
29	50	110	54	95	179	200
30	65	150	129	110	112	195
Mean	65	162	132	220	151	237

(x) Vineyard A under cultivation and no irrigation.
Vineyard B under non-cultivation and irrigation.
Vineyard C under cultivation and irrigation.

Table 10. Comparison between mean Mn content of grape leaves collected on July 1 from three vine.

Vineyard	Mean ppm	Mean - 65	Mean - 132
C	151	(31.03) 86 ∅	(25.5) 19 N.S.
B	132	(25.5) 67 ∅	
A	65		

∅ Significant difference.
N.S. Non-significant difference.

Table 11. Comparison between mean Mn content of grape leaves collected on Sept. 10 from three vineyards.

Vineyard	Mean ppm	Mean - 162	Mean - 220
B	237	(65) 75 ∅	(42) 17 N.S.
C	220	(42) 58 ∅	
A	162		

∅ Significant difference.
N.S. Non-significant difference.

sampling dates. This is probably due to the reduced vigor and less root expansion of vines grown under a limited supply of water.

By comparing results in this study on leaf Mn content to petiole Mn levels suggested by Shaulis and Kimball (34) all the % leaf mean values obtained from the vineyards fall below the optimum range and above the critical level. Shaulis and Kimball (34) reported 0.0033 % petiole Mn being associated or suggestive of deficiency symptoms and suggested 0.003 - 1.5 % Mn as a range in vigorous vineyards. It is expected to have higher Mn value in whole leaves as compared to petioles alone.

Studying the seasonal variation in leaf Mn, it was found that there was an increase in this element between the first sampling date and the second. This finding is in agreement with the results reported by Smith et al. (35).

Magnesium

Data showing the leaf content of Mg is reported in tables 12, 13 and 14. Leaf samples collected in July showed that the mean % Mg obtained from vines grown under cultivation and irrigation was significantly higher as compared to vines grown under cultivation and no irrigation. However, there was no significant difference between mean % Mg of leaves from the cultivated and irrigated vineyard as compared to leaves of the irrigated and non-

Table 12. Magnesium content of grapevine leaves collected on July 1 and Sept. 10 from three vineyards under different cultural practices (% dry weight basis).

Vine No	Leaf Mg					
	A		B		C [x]	
	July 1	Sept. 10	July 1	Sept. 10	July 1	Sept. 10
1	.28	.26	.17	.14	.44	.25
2	.24	.24	.27	.23	.44	.28
3	.25	.28	.04	.25	.23	.23
4	.25	.25	.28	.23	.29	.23
5	.24	.24	.33	.24	.29	.28
6	.24	.29	.30	.26	.33	.25
7	.29	.29	.31	.30	.38	.40
8	.37	.25	.29	.15	.25	.37
9	.25	.26	.29	.21	.25	.37
10	.24	.30	.33	.21	.25	.40
11	.30	.30	.30	.21	.38	.37
12	.30	.25	.29	.25	.33	.33
13	.30	.24	.33	.20	.30	.30
14	.37	.25	.44	.20	.24	.28
15	.24	.26	.44	.26	.24	.28
16	.24	.25	.33	.26	.30	.27
17	.23	.25	.30	.20	.40	.25
18	.28	.30	.30	.22	.40	.25

Table 12 (continued)

Vine No	July 1	Sept. 10	July 1	Sept. 10	July 1	Sept. 10
19	.29	.24	.34	.19	.40	.25
20	.29	.20	.30	.23	.30	.25
21	.13	.28	.33	.19	.43	.17
22	.26	.24	.34	.19	.41	.22
23	.24	.23	.34	.15	.40	.25
24	.24	.24	.35	.20	.38	.20
25	.25	.23	.33	.19	.24	.28
26	.29	..28	.33	.15	.41	.28
27	.26	.29	.30	.24	.40	.27
28	.26	.30	.33	.23	.38	.28
29	.21	.30	.34	.23	.38	.28
30	.21	.35	.33	.24	.40	.23
Mean	.26	.26	.31	.22	.34	.28

(x) Vineyard A under cultivation and no irrigation.
Vineyard B under non-cultivation and irrigation.
Vineyard C under cultivation and irrigation.

Table 13. Comparison between mean Magnesium content of grape leaves collected on July 1 from three vineyards.

Vineyard	Mean	Mean-.26	Mean-.31
C	0.34	(0.05) 0.08 ∅	(0.035) 0.03 N.S.
B	0.31	(0.035) 0.05 ∅	
A	0.26		

∅ Significant difference.
N.S. Non-significant difference.

Table 14. Comparison between mean magnesium content of grape leaves collected on Sept. 10 from three vineyards.

Vineyard	Mean	Mean - 0.22	Mean - 0.26
C	.28	(0.17) 0.06 ∅	(0.014) 0.02 ∅
A	.26	(0.014) 0.04 ∅	
B	.22		

∅ Significant difference.

cultivated ones. But the latter compared to the vineyard under cultivation and no irrigation was statistically higher. The data for leaves sampled during September and presented in table 14 show a significant difference between all the means, with the system of cultivation and irrigation having induced the highest mean Mg and the non-cultivation with irrigation system inducing the lowest.

The results for K analysis in tables 5 and 6 for K with tables 13 and 14 for Mg confirm the antagonistic concept between leaf K and leaf Mg reported by Smith et al. (35). The tables show that vineyard A had the highest mean % K and the lowest mean % Mg, contrary to vineyard C, whose average K was the lowest and its average Mg was the highest. The vine leaf Mg range of vigorous vines reported by Shaulis and Mimball (34) was 0.18 - 1.5 % for leaf petiole. From the results of this study it was found that leaf Mg content ranged from 0.22 to 0.32 %. This latter amount seems to be sufficient.

Studying figure 2 that shows the seasonal variation of vine leaf inorganic content it was found that the average Mg of leaves collected on July 1 from vineyard A did not differ from that of leaves collected on Sept. 10. Meanwhile the average Mg of leaves from vineyards B and C decreased with the advance of the season. The decrease was in both irrigated vineyards where more growth is expected and higher yields were found.

Iron

The average Fe content of leaves from the three vineyards under study are shown in table 15. Mean Fe values were not found to differ significantly among one another in leaves collected on the two sampling dates. Beattie (2) reported that a 68 ppm Fe in concord grape leaf petiole was to be associated with high vigor. No information on leaf Fe content was found available in the literature. Taking into consideration the leaf petiole values set by Beattie and the fact that no visual Fe deficiency symptoms were apparent, it could be concluded that Fe was sufficient in the leaves of all vines under this study.

Figure 3 shows that leaf Fe followed a similar trend as N, P and K. The values decreased from 149 to 73, from 108 to 103, and from 133 to 70 ppm leaf Fe in vineyards A, B and C respectively. This shows a definite consumption of Fe as the growing season advanced.

Calcium

Tables 16, 17 and 18 show the Ca content of leaves collected during July and September. The mean leaf Ca content in table 16 shows high levels of leaf Ca in the vines due to the calcareous type of soil in Beqaa (43) where the three vineyards under this study are located. The data for samples collected on July 1 and presented in table 17, show that vineyard B where the non-cultivation and irrigation

Table 15. Iron content of grape leaves collected on July 1 and Sept. 10 from three vineyards under different cultural practices.

Vine No	Leaf Fe (ppm)					
	A		B		C x	
	July 1	Sept. 10	July 1	Sept. 10	July 1	Sept. 10
1	233	60	38	95	270	105
2	36	60	125	90	217	75
3	103	90	49	125	166	60
4	123	75	58	75	94	80
5	196	120	90	70	119	60
6	154	75	45	90	135	45
7	197	70	155	120	229	75
8	299	95	123	105	138	80
9	79	60	123	80	118	60
10	108	70	68	125	138	90
11	395	70	78	120	105	55
12	210	60	88	105	161	70
13	146	75	75	140	120	75
14	119	60	124	120	94	95
15	134	120	60	155	90	50
16	119	60	119	110	206	135
17	123	70	150	95	109	55
18	146	70	41	95	69	70
19	122	70	147	110	54	70

Table 15 (continued)

Vine No	July 1	Sept. 10	July 1	Sept. 10	July 1	Sept. 10
20	289	70	74	80	176	70
21	121	75	425	205	123	60
22	49	70	94	110	104	70
23	379	50	94	95	95	95
24	69	85	88	120	94	60
25	190	50	107	95	244	50
26	60	55	90	105	105	60
27	70	60	75	120	120	55
28	40	75	162	110	69	60
29	80	90	162	120	120	55
30	90	75	104	105	105	70
Mean	149	73	108	106	133	70 N.S.

(x) Vineyard A under cultivation and no irrigation.
Vineyard B under non-cultivation and irrigation.
Vineyard C under cultivation and irrigation.

N.S. Non-significant difference.

Table 16. Calcium content of grapevine leaves collected on July 1 and Sept. 10 from three vineyards under different cultural practices (% dry weight basis).

Vine No	% Ca					
	A		B		C x	
	July 1	Sept. 10	July 1	Sept. 10	July 1	Sept. 10
1	2.25	2.80	2.33	3.10	2.40	10.52
2	1.70	2.60	2.25	2.60	1.97	9.65
3	2.22	3.25	2.95	2.80	2.10	10.75
4	1.67	2.15	3.33	3.70	2.12	10.30
5	1.84	3.25	3.18	3.80	1.83	11.25
6	1.67	3.10	2.92	3.70	1.83	10.50
7	1.70	3.10	2.84	3.25	1.84	11.00
8	1.40	3.00	2.11	3.10	1.98	11.10
9	1.98	2.70	2.22	2.40	2.10	9.05
10	1.70	2.80	2.63	4.35	1.97	11.85
11	1.83	2.70	2.65	3.70	2.50	10.65
12	1.94	3.00	2.84	3.10	3.95	10.15
13	1.95	3.45	2.60	4.45	2.15	11.95
14	2.20	2.80	2.79	4.35	1.97	11.20
15	1.50	2.25	2.14	3.70	2.50	10.55
16	1.70	2.40	2.57	3.45	2.00	11.75
17	1.67	2.25	2.51	4.40	2.10	11.50

Table 16 (continued)

Vine No	July 1	Sept. 10	July 1	Sept. 10	July 1	Sept. 10
18	1.66	2.70	2.18	3.70	2.32	10.85
19	1.84	2.15	2.83	4.35	2.10	11.45
20	1.40	1.70	2.22	3.45	1.32	9.60
21	1.52	2.50	2.40	3.70	2.43	10.80
22	1.50	2.40	2.55	3.80	1.39	10.80
23	1.50	0.65	2.55	3.70	1.88	8.40
24	1.40	1.60	2.93	3.00	2.43	9.30
25	1.65	2.00	2.43	3.80	2.00	10.51
26	2.14	1.10	1.98	4.35	1.58	10.05
27	1.84	0.65	2.01	4.10	2.00	9,45
28	1.52	4.20	2.93	2.15	1.82	10.70
29	1.24	1.60	2.23	3.35	1.94	9.80
30	1.69	2.50	2.24	3.45	1.98	10.00
Mean	1.73	2.45	2.54	3.57	2.02	4.47

(x) Vineyard A under cultivation and no irrigation.
Vineyard B under non-cultivation and irrigation.
Vineyard C under cultivation and irrigation.

Table 17. Comparison between mean calcium content of grape leaves collected on July 1 from three vineyards.

Vineyard	Mean	Mean - 1.73	Mean - 2.04
B	2.54	(.18) 0.81 ∅	(.15) 0.52 ∅
C	2.02	(.15) 0.29 ∅	
A	1.73		

∅ Significant difference.

Table 18. Comparison between mean calcium content of grape leaves collected on Sept. 10 from three vineyards.

Vineyard	Mean	Mean - 2.45	Mean - 3.57
C	4.47	(.14) 2.02 ∅	(.11) 0.90 ∅
B	3.57	(.11) 1.12 ∅	
A	2.45		

∅ Significant difference.

system is followed, had a markedly higher mean leaf % Ca as compared to each of vineyard C under the system of cultivation, and irrigation, and vineyard A where cultivation and no irrigation was followed. The mean % Ca of samples from vineyard C was also higher than that of samples from vineyard A. The highest leaf mean % Ca of leaves sampled during September, as given in table 18, was from vines, grown in vineyard C, while the lowest was from vines grown in vineyard A.

The low leaf Ca found in July and September in vines grown in vineyard A where cultivation and no irrigation was followed, together with the low yield produced in this vineyard and shown in table 24, compared to vineyard C with cultivation and irrigation, seem to be due to less water being received by the vines in vineyard A that resulted in the low vigor of vines. The non-cultivation and irrigation method, as shown in table 17, had an increased effect in inducing high Ca in the vine leaves. Table 18 indicates that more Ca was consumed by plants in vineyard B during the period from July to September compared to those in vineyard C. This latter finding seems to have resulted from the larger root system being not destroyed by cultivation in vineyard B, and also due to the increased growth of grapevines grown under no cultivation as reported by Nelson (27). No growth measures were conducted in this study. Mean leaf Ca levels obtained from this study in all three vineyards were higher than the range reported by Shaulis and Kimball (34) for leaf petiole.

The seasonal variation in grapevine leaf Ca as presented in figure 2 shows that leaf mean % Ca increased as the season advanced. The increase was from 1.73 % to 2.45 % from 2.54 % to 3.57 %, and from 2.02 % to 4.47 % in vineyards A, B and C respectively. This clearly shows that the highest accumulation of Ca was in the vineyard C where the system of cultivation and irrigation was followed. It is seen from this figure that there is a negative relationship between Ca and K. There was an increase in leaf mean % Ca while leaf K decreased. The results in tables 5 and 17 shows also that vineyard A had a significantly higher leaf K and a significantly lower leaf Ca in samples collected on July 1. However the above relationship was not apparent in leaves collected during September. The possible explanation may be that the plants in vineyard A consumed more K as compared to plants in vineyards B and C during the period from July to September. Smith et al. (35)found that there is a simultaneous antagonistic effect between the elements Ca and K.

Boron

The data for leaf B is reported in tables 19 and 20. Leaf samples collected on July showed that leaf mean ppm B obtained from vineyards A, B and C were statistically equal.

On the other hand, the difference between all three means from leaves sampled during September was significant with vineyard C (cultivation and irrigation) having the highest mean ppm B and vineyard B (non-cultivation and irrigation) having the lowest. The above results indicate that B uptake by vines was not affected by the different soil managements practices at the first part of the growing season. However, towards the end of summer, it was found that B uptake was increased in plants from the vineyard where cultivation and irrigation was practiced as compared to the other two differently managed vineyards.

According to leaf B levels reviewed by Winkler (42, pp. 360), all leaf B values of vines under this investigation were at a satisfactory level. He reported that deficiency symptoms were apparent when the leaves had 5 ppm of B while 200 to 300 ppm showed symptoms of excess. The levels found from this study ranged from 14 ppm to 108 ppm in July and 11 ppm to 90 ppm in August.

The mean leaf B levels as shown in figure 3, increased from 44 to 63 ppm in the leaves of vineyard A, from 46 to 53 ppm in the leaves of vineyard C, and decreased from 56 to 47 ppm in the leaves of vineyard B between July and Sept. This indicates that more B is used by vines during the period of the growing season under non-cultivation as compared to those under cultivation.

Table 19. Boron content of grapevine leaves collected on July 1 and Sept. 10 from three vineyards under different cultural practices (% dry weight basis).

Vine No	% B					
	A		B		C x	
	July 1	Sept. 10	July 1	Sept. 10	July 1	Sept. 10
1	23	38	45	51	25	79
2	33	90	56	48	26	62
3	25	65	81	72	14	42
4	26	81	46	36	25	13
5	25	61	69	44	24	58
6	26	81	58	38	37	46
7	23	81	63	39	54	85
8	25	28	41	43	33	34
9	25	20	46	45	56	11
10	41	73	43	43	33	62
11	25	52	48	55	61	30
12	57	38	50	50	22	08
13	20	72	61	50	28	17
14	23	65	57	51	37	19
15	46	67	58	46	31	62
16	56	12	72	41	49	62
17	46	74	80	45	57	73
18	81	81	103	38	78	77

Table 19 (continued)

Vine No	July 1	Sept. 10	July 1	Sept. 10	July 1	Sept. 10
19	62	74	41	46	65	83
20	43	66	58	39	55	20
21	63	56	43	49	61	14
22	70	64	45	52	78	67
23	52	72	56	55	61	56
24	63	89	43	30	56	63
25	108	66	58	50	56	81
26	62	55	41	62	54	40
27	52	67	39	44	57	86
28	39	51	41	55	65	73
29	61	59	45	51	35	83
30	52	79	81	52	56	75
Mean	44	63	56	47	46	53

(x) Vineyard A under cultivation and no irrigation.
Vineyard B under non-cultivation and irrigation.
Vineyard C under cultivation and irrigation.

Table 20. Comparison between mean Boron content of grape leaves collected on Sept. 10 from three vineyards.

Vineyard	Mean	Mean-47	Mean-53
A	63	(5.8) 16 ∅	(4.8) 10 ∅
C	53	(4.8) 6 ∅	
B	47		

∅ Significant difference.

Sodium

The leaf Na data for samples collected on July 1 are in tables 21, 22 and 23. Average values for vineyards A, B, and C were found to be 0.072, 0.073 and 0.028 % in samples collected on July 1, and 0.032, 0.029 and 0.0608 % in samples collected on September 10, respectively.

Vineyard B (non-cultivation and irrigation) had a significantly higher leaf mean Na as compared to that of vineyard C, cultivation and irrigation, while the mean Na of leaves from vineyard A, cultivation and no irrigation, did not differ from that of vineyard B. Vineyard A had a markedly higher mean than vineyard C. This shows that cultivation with no irrigation had caused an increase in Na of the grapevine leaf content when compared to cultivation and irrigation.

Leaves sampled on September 10 and whose Na data is presented in table 23 shows that leaf mean % Na from vines grown under non-cultivation and irrigation was lower than that from vines grown under cultivation and irrigation and equal to mean % leaf Na of vines under cultivation and no irrigation. Leaf Na % of vineyard C was also higher than that of vineyard A.

As seen from figure 2 mean % Na in leaves from cultivated and non-irrigated vineyard decreased within the period from July to September, vines under non-cultiva-

Table 21. Sodium content of grapevine leaves collected on July and Sept. 10 from three vineyards under different cultural practices (% dry weight basis).

Vine No	% Na					
	A		B		C x	
	July 1	Sept. 10	July 1	Sept. 10	July 1	Sept. 10
1	0.97	0.040	0.48	0.035	0.39	0.065
2	0.88	0.035	0.49	0.025	0.49	0.060
3	1.10	0.035	0.49	0.025	0.48	0.060
4	0.89	0.025	0.77	0.025	0.20	0.060
5	0.78	0.035	0.60	0.025	0.20	0.065
6	0.60	0.035	0.65	0.025	0.50	0.065
7	0.54	0.035	0.50	0.025	0.49	0.060
8	0.24	0.035	0.39	0.025	0.54	0.065
9	0.74	0.025	0.64	0.025	0.64	0.060
10	1.08	0.025	0.77	0.035	0.48	0.060
11	1.08	0.025	1.20	0.025	0.025	0.060
12	0.88	0.040	0.83	0.025	0.39	0.060
13	0.78	0.035	0.90	0.035	0.40	0.065
14	0.74	0.035	0.89	0.025	0.49	0.060
15	0.78	0.035	0.77	0.035	0.54	0.060
16	0.89	0.035	0.83	0.125	0.10	0.060
17	0.64	0.125	0.72	0.035	0.15	0.160
18	1.11	0.025	0.75	0.035	0.10	0.060
19	0.74	0.035	0.73	0.035	0.15	0.060

Table 21 (continued)

Vine No	July 1	Sept. 10	July 1	Sept. 10	July 1	Sept. 10
20	0.88	0.025	0.72	0;035	0.15	0.060
21	0.53	0.035	0.77	0.025	0.16	0.060
22	0.49	0.035	0.65	0.036	0.14	0.060
23	0.49	0.025	0.72	0.025	0.20	0.060
24	1.10	0.035	0.90	0.025	0.10	0.060
25	0.39	0.035	0.73	0.025	0.14	0.060
26	0.39	0.025	0.77	0.025	0.10	0.060
27	0.49	0.025	0.80	0.035	0.16	0.060
28	0.60	0.035	0.83	0.025	0.10	0.060
29	0.39	0;025	0.78	0.025	0.16	0.060
30	0.49	0.035	0.74	0.035	0.14	0.060
Mean	0.072	0.032	0.073	0.029	0.028	0.0608

(x) Vineyard A under cultivation and no irrigation.
Vineyard B under non-cultivation and irrigation.
Vineyard C under cultivation and irrigation.

Table 22. Comparison between mean Sodium content of grape leaves collected on July 1.

Grapevine	Mean	Mean - .028	Mean - .072
B	.073	(.038) .45 ∅	(.031) .01 N.S.
A	.072	(.031) .44 ∅	
C	.028		

∅ Significant difference.
N.S. Non-significant difference.

Table 23. Comparison between mean sodium content of grape leaves collected on Sept. 10.

Vineyard	Mean	Mean - .0290	Mean - .0320
C	0.0608	(.008) .0318 ∅^	(.005) .0288 ∅
A	0.0320	(.005) .0030 N.S.	
B	0.0290		

∅ Significant difference.
N.S. Non-significant difference.

tion and irrigation showed this same pattern, while the mean % leaf Na increased during this period in vines under cultivation and irrigation.

Table 24. Average yield of grapes per dunum from three vineyards under different cultural practices.

Vineyard x	Average yield per dunum (kg) (1000 m)
A	437.5
B	800
C	763

(x) Vineyard A under cultivation and no irrigation.
Vineyard B under non-cultivation and irrigation.
Vineyard C under cultivation and irrigation.

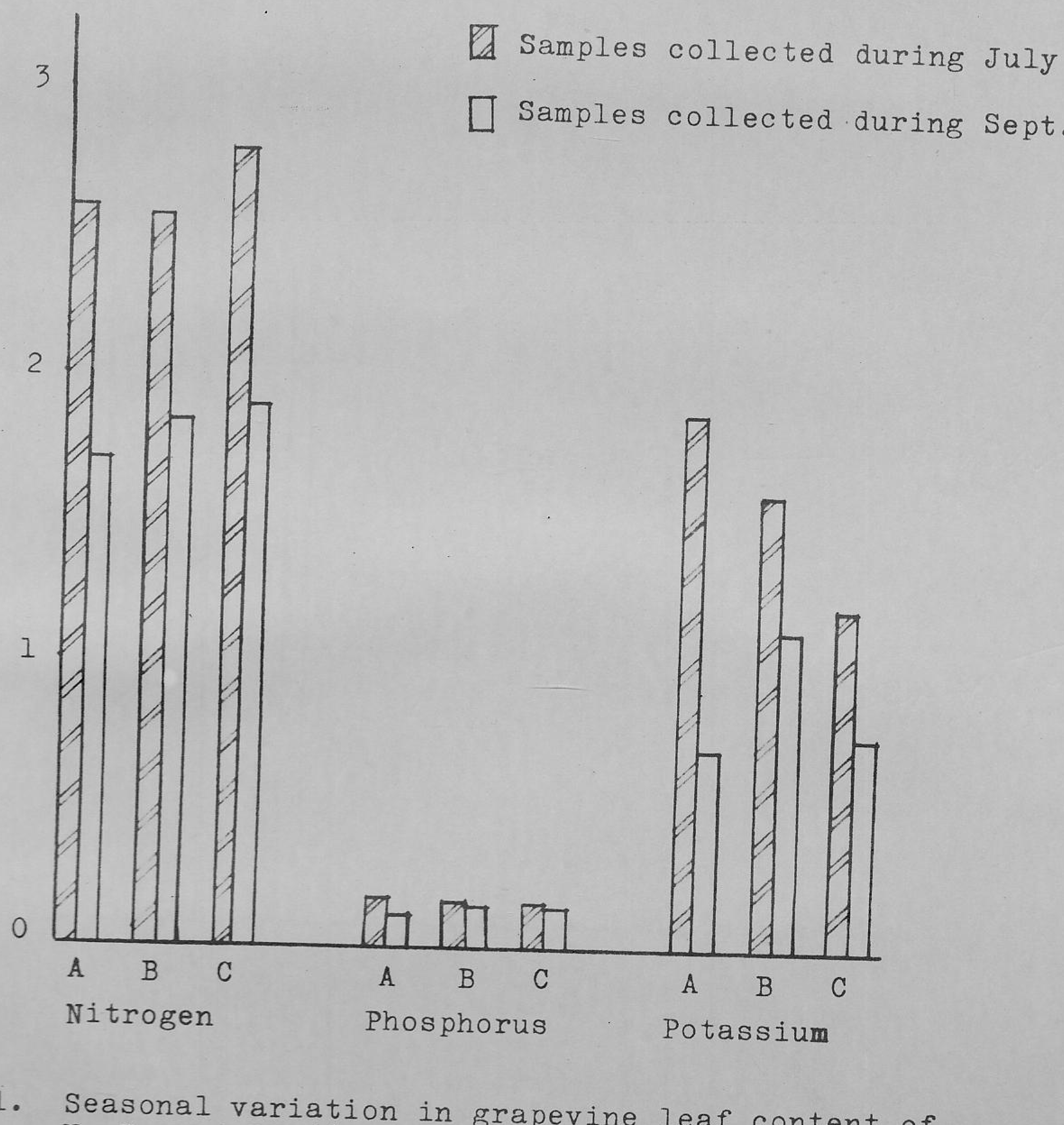


Fig. 1. Seasonal variation in grapevine leaf content of N, P, and K. (% dry weight basis).

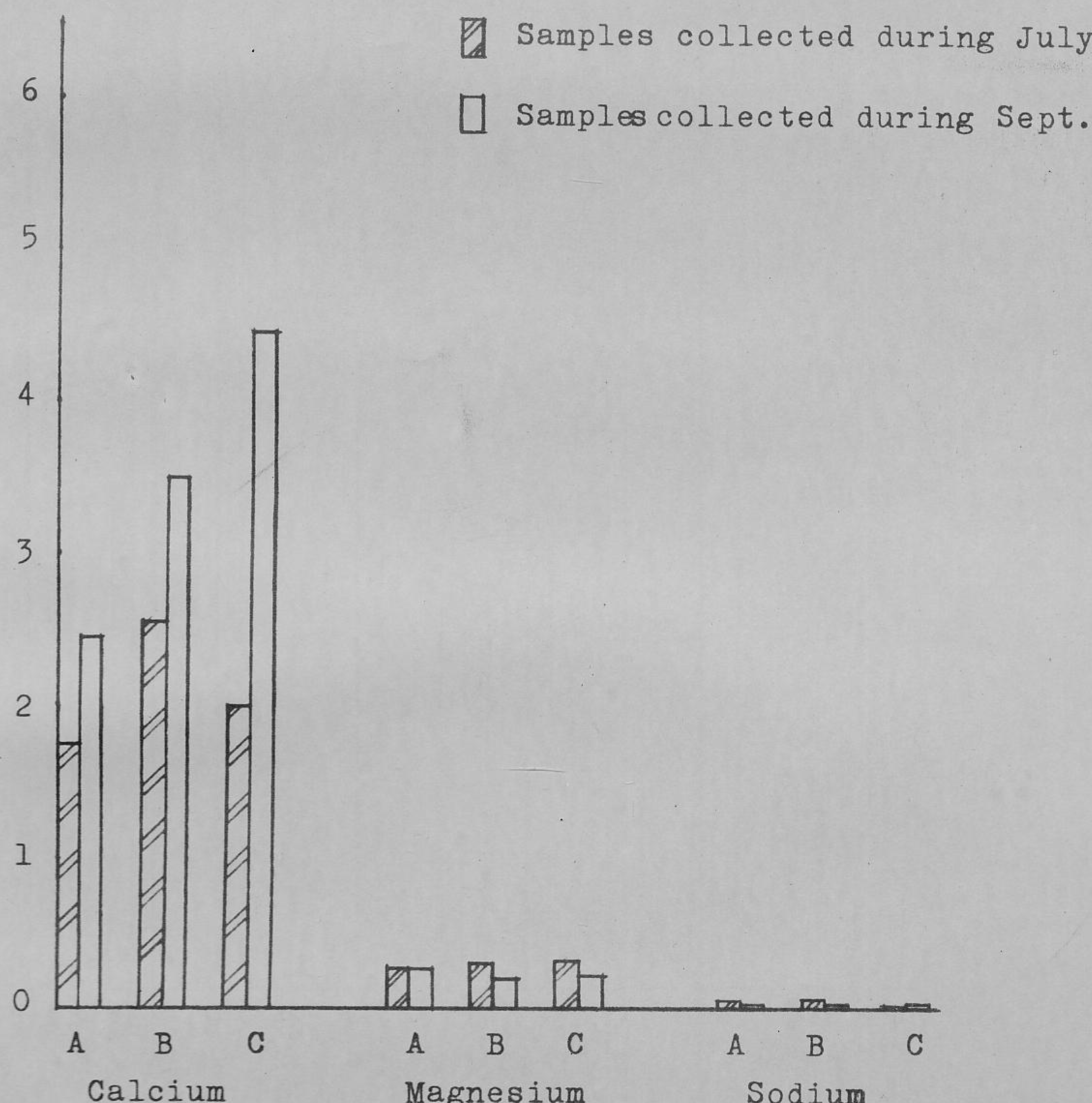


Fig. 2. Seasonal variation in grapevine leaf content of Ca, Mg, and Na (% dry weight basis).

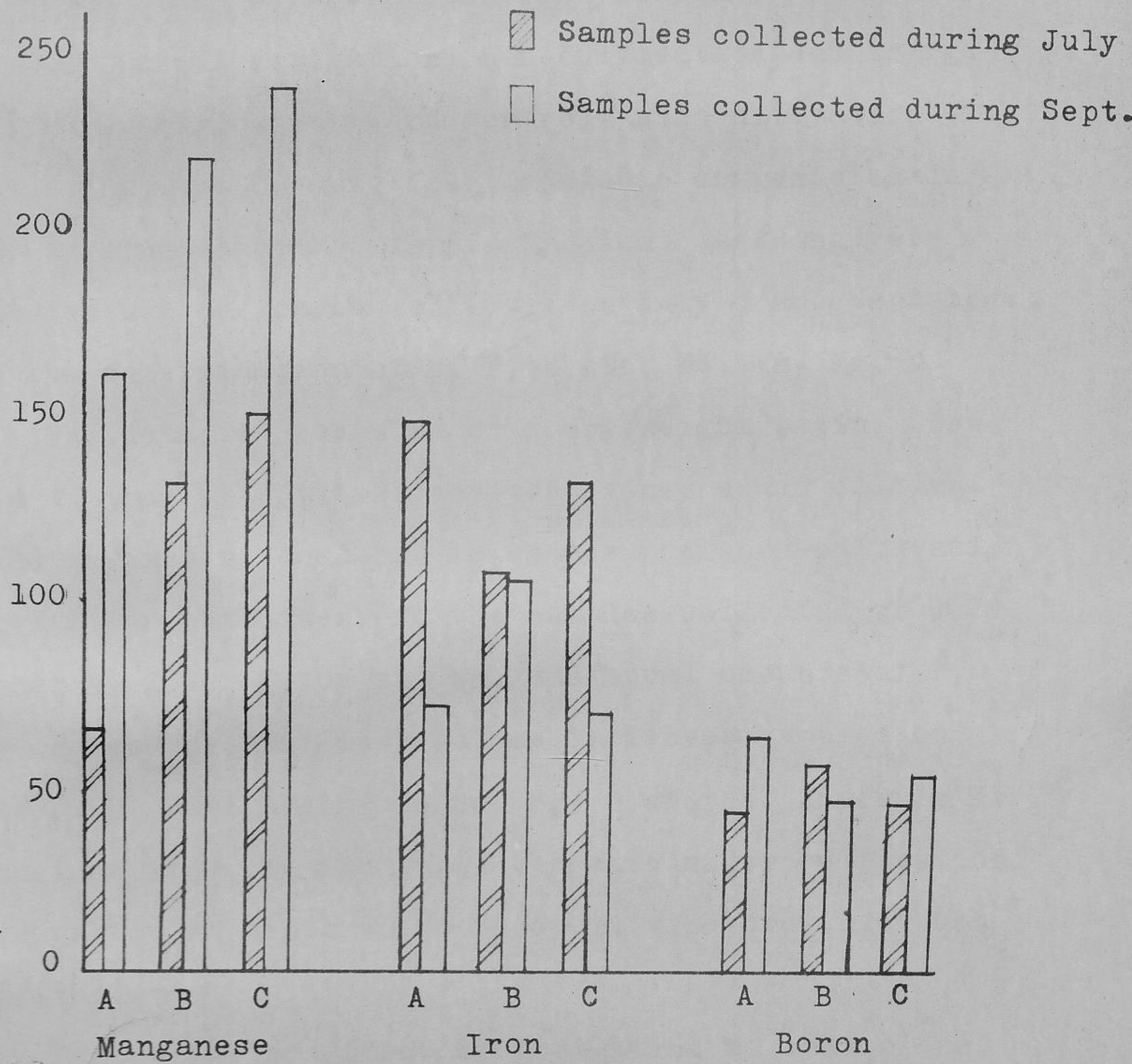


Fig. 3. Seasonal variation in grapevine leaf content of Mn, Fe, and B (ppm dry weight basis).

V. SUMMARY AND CONCLUSION

Three vineyards under different cultural practices in the Beqaa plain were selected for the study of the effect of cultivation and irrigation, non-cultivation and irrigation using Gramaxone for weed control, and cultivation with no irrigation, on the vine leaf inorganic composition during the growing season of 1965. Chemical leaf analysis was carried out on leaves collected on July 1 and September 10 for the determination of N, P, K, Ca, Fe, Mn, Mg, Na and B. The data is presented on a dry weight basis. The results of leaf analysis showed that vines under cultivation and irrigation compared to those under non-cultivation and irrigation contained, in the samples collected on July 1, higher N, lower K, Ca and Na, and equal amounts of P, Mn, Mg, Fe and B. The mean values in leaves sampled on September 10, were higher in Ca, Mg, B and Na, lower in K, and equal in N, P, Mn and Fe in vineyard under cultivation and irrigation as compared to those in vineyard under non-cultivation.

Comparing the effect of irrigation to that of no irrigation, it was found that grapevine leaves from vineyard under no irrigation had lower leaf mean % P, Ca, and Mn throughout the season. Leaf K content was higher in the first part of the season, while it was lower in samples collected on September 10. Contrary to K, leaf Mg content from non-irrigated vineyard was lower in the first part and higher in the second part of the season compared to that of leaves from irrigated vineyard. Mean % Fe values were found to be equal in all three vineyards in leaves collected during July and September.

However, leaf mean % B values were equal in samples collected on July 1, and significantly different in those collected on September 10 with leaves from vines under cultivation and irrigation having the highest mean value and leaves from vines under non-cultivation having the lowest.

The values of leaf mean % N were statistically equal in leaves sampled, during July, from vines grown under cultivation and no irrigation, and from those grown under non-cultivation and irrigation, while the mean % leaf N from the cultivated and irrigated grapevines was higher as compared to those growing under the other two systems. The leaves sampled during September showed equal leaf mean % N in samples from the cultivated and irrigated vineyard and samples from the non-cultivated and irrigated, the two former had higher leaf mean % N than those vines from the cultivated and non-irrigated vineyard.

Studying the inorganic seasonal variation, it was found that N, P, K and Fe decreased while Ca and Mn increased within the period from July to September in all the grapevines under this study. Leaf B content increased in vines under cultivation and decreased in vines under non-cultivation. There was a decrease with the advance of season in Na content of leaves collected from grapevines grown under cultivation and no irrigation and from those grown under non-cultivation and irrigation, while vines under cultivation and irrigation showed an increase in leaf Na content.

Leaf mean % Mg was equal in samples collected during July and September from the vineyard where cultivation and no irrigation was practiced. It decreased from July to September in the leaves sampled from both vineyards that were under non-cultivation and irrigation and cultivation and irrigation respectively.

All the levels of leaf inorganic constituents found in this study were above the critical values and within the range for vigorous grapevine growth as compared to available data (34)(35).

Vines under non-cultivation and irrigation showed a trend to produce the highest yield, while those under cultivation and no irrigation produced the lowest yield.

It could be seen from this study that the non-cultivation and irrigation method compared to cultivation and irrigation was more effective, in the first part of the season, in inducing high K and Ca in the grapevine leaves. It was less effective in the building up of leaf

N, while both systems were equally effective in inducing same amounts of P, Mn, Mg, Fe, Na and B. The cultivation and irrigation cultural method produced in the samples collected on September 10, higher values of Ca, Mg, B and Na, lower values of K, and equal values of N, P and Mn, in the grapevine leaves compared to non-cultivation. It could also be seen that a high yield was produced in the vineyard having been under non-cultivation and irrigation.

Leaf N and B content found in all vines under this study were at a satisfactory level. In case higher levels are required for yield increase, this element could be increased by applying small amounts of inorganic N fertilizer at a fraction of the cost of cultivation in vines growing under no cultivation. The higher levels of Mg, Ca and Na found under cultivation and irrigation during September are not desirable, and since their levels in the samples of July was statistically equal as found in vines under cultivation and irrigation, and in vines under non-cultivation and irrigation, therefore the high levels of these elements found in the cultivated and irrigated grapevines indicate that less amounts of these nutrients were consumed by these grapevines as compared to the amounts consumed by grapevines growing under non-cultivation and irrigation.

Hence it could be concluded that the cultivation system may be replaced by the use of spray weed control in grape growing without any deliterious effects on the grapevine nutrition. This system also showed to produce high yields. It is desirable however to further study the effect of increased N fertilization on leaf N and yield.

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