Growth and nutrient absorption of grapes as affected by soil aeration. I.

With non-bearing Delaware grapes

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It is well known that growth of fruit trees becomes less vigorous when the oxygen concentration in the soil atmosphere is depressed too much by poor aeration. This experiment was conducted with grapes to study this subject from the standpoint of nutrient absorption.

MATERIALS AND METHODS

In mid-January of 1962, one-year-old Delaware grapes were planted in WAGNER's pots of 1/2,000 a (15 liters) with sandy loam (pore space 36.1%, pH 6.4, water equivalent 40.8%). One vine in each pot and three vines each of five plots were prepared. One g N (ammonium sulphate), 0.5 g P_2O_5 (fused phosphate), 0.5 g K_2O (potassium chloride), 15 g CaO (slake lime) and 0.5 g MgO (magnesium sulphate) were applied on each pot in mid-February.

As shown in Fig. 1, the soil surface of the pot was covered tightly with vinyl film of 0.2 mm thickness on May 15. The air in these soils was renewed every day through an opening on the bottom-side of the pot by the BOVNTON's hydraulic pressure method. Five liters of controlled air was circulated in each pot for 4 hours each day. The experiment consisted of 20, 10, 5, 2 and 0% oxygen plots. Oxygen concentration was controlled with a gas flow meter before the air was released into soils by mixing it with nitrogen in a 50 liter gas tank. The constitution of the soil air in the pot was determined with the HALDEN's gas analyzing apparatus every two weeks before renewing. The data obtained are presented in Table 1. Treatments were continued for three months from May 15 to August 13.

To observe the seasonal change of vine growth, shoot length was measured every week during the treatments. After removing the vines from the pots on August 13, their leaf, stem and root weights were determined

Fig. 1. Diagram of aerating system used in the study

Table 1. Growth of grapes as affected by soil oxygen concentration.

Plot	Percent in soil air before renewing *		Shoot length	Total fresh wt.	Top fresh wt.	Root fresh wt.
	O ₂	CO ₂				
20% O ₂	17.6 %	2.0 %	417 cm (100)	229 g (100)	172 g (100)	57 g (100)
10	10.0	3.2	185 (44)	120 (52)	93 (54)	27 (47)
5	5.7	3.2	69 (17)	50 (22)	26 (15)	24 (42)
2	2.1	2.6	Died	Died	Died	Died
0	0.4	1.9	64 (15)	39 (17)	24 (14)	15 (27)

* Figures indicate an average value for the experimental period from May 15 to Aug. 13.

separately. Chemical analysis for N, P, K, Ca and Mg was made of these plant parts by the following methods; N by the semimicro-KJELDAHL method, P by the DENIGE's method, K by the flame photometer, and Ca and Mg by the chelate titrating method. To estimate the water up-take of different pots, transpiration rate of leaves was observed by the cobalt chloride paper method on both July 26 and August 8.

RESULTS

1. Shoot length and top and root fresh weights

Seasonal change of vine growth as indicated by shoot length is shown in Fig. 2. In late June, nearly 6 weeks after the beginning of the treatments, distinct differences were found among the plots, and they became more marked as the season advanced. Total shoot length and top and root fresh weights of plants as of August 13, are shown

in Table 1 and Fig. 3. It is obvious in every respect that the lower the soil oxygen concentration, the less the vines grew. For example, total shoot length was as follows; 417 cm (100) at 20% O₂, 185 cm (44) at 10% O₂, 69 cm (17) at 5% O₂ and 64 cm (15) at 0% O₂.

2. Nutrient content of a plant

The result of leaf analysis for N, P, K, Ca

Fig. 2. Seasonal change of total shoot length per vine as affected by soil oxygen concentration.

Fig. 3. Growth of grapes as affected by soil oxygen concentration (photographed Aug. 13).

and Mg is shown in Table 2. The content of P, K and Mg in leaves decreased with a lowering soil oxygen concentration. The trend was in the order of K, P and Mg. Thus, the K content of leaves at the 5 and 0% O₂ plots reached a level of deficiency, showing the values of 0.53 and 0.46% on dry matter basis, respectively. On the other hand, the soil oxygen concentration correlated significantly at the 1 % level with K content ($r=+0.8540$), and at the 5% level both with P content ($r=+0.8312$) and with Mg content ($r=+0.7342$).

Table 2. Nutrient content of leaves on Aug. 13 as affected by soil oxygen concentration.

Plot	N	P	K	Ca	Mg
20 % O ₂	2.18 % (100)	0.22 % (100)	1.00 % (100)	4.25 % (100)	0.27 % (100)
10	2.57 (118)	0.14 (64)	1.08 (108)	5.33 (125)	0.23 (85)
5	2.32 (106)	0.13 (59)	0.53 (53)	6.65 (156)	0.22 (81)
2	Died	Died	Died	Died	Died
0	2.69 (123)	0.14 (60)	0.46 (46)	5.00 (118)	0.21 (78)
Correlation coef.	-0.6230	+0.8312 *	+0.8540 **	-0.4671	+0.7342 *

** Significant at 1 % level. * Significant at 5 % level.

Table 3. Total amount of each nutrient in a plant as affected by soil oxygen concentration.

Plot	N	P	K	Ca	Mg
20 % O ₂	1,084 mg (105)	146 mg (100)	531 mg (100)	1,987 mg (100)	142 mg (100)
10	574 (53)	72 (49)	254 (48)	1,133 (57)	54 (38)
5	177 (16)	19 (13)	62 (12)	449 (23)	21 (15)
2	Died	Died	Died	Died	Died
1	155 (11)	11 (8)	27 (5)	210 (11)	8 (6)

The total amount of each nutrient in a plant is presented in Table 3. The plant decreased greatly in K content at a higher rate than in any other nutrient as the soil oxygen concentration was lowered.

3. Transpiration rate of leaves

The transpiration rate of leaves as observed by the cobalt chloride paper method is indicated in Table 4. The lower the soil oxygen concentration, the more time required for the paper to change color. That is, the transpiration rate was lowered with a decreasing oxygen concentration.

Table 4. Transpiration rate measured by the cobalt chloride paper method.

Plot	Time taken for the paper to change color *	
	On July 26	On Aug. 8
20 % O ₂	sec. 22.9 (100)	sec. 26.0 (100)
10	25.8 (118)	26.5 (102)
5	30.4 (133)	32.5 (125)
2	Died	Died
0	35.2 (154)	30.6 (117)

* The longer the time, the less was the transpiration rate.

DISCUSSION

There are available publications concerning the effects of soil oxygen concentration on the growth of fruit trees, such as citrus trees (CANNON 1925), apples (VILLIERS 1939, BOYNTON 1940, and CHILDS 1941) and seedlings of various species including grapes (MORITA 1953). Through all of these experiments it was found that when the soil oxygen concentration

was lowered less than 10 to 15%, growth of trees was greatly retarded. Particularly, new roots never developed under the soil oxygen concentration of less than 2%. The same tendency was also observed in this experiment with grapes, in which vines grown at 2% O₂ pot were all dead by mid-June.

CHILDERS and WHITE (1942) reported that when the roots of young apple trees were submerged to check their respiration, leaf growth and transpiration rate were both reduced. A similar trend was also found in this experiment though the root respiration was retarded by lowering the oxygen concentration in soils.

COMPTON (1947) observed with apples grown in controlled air soil that plants absorbed less K as the oxygen concentration decreased in the soil atmosphere. HEINICKE et al. (1939) and BOYNTON (1954) stated with apples that trees planted on soils of poor drainage and bad aeration manifested hunger signs of potassium, while trees planted on the well drained soils of the same orchard grew normally even if the exchangeable potassium was not high. The K content of leaves in this experiment was equivalent to a deficiency level at the lower concentration of soil oxygen, though no marked symptom of K deficiency appeared. The total amount of K in a plant decreased also at a higher rate than any other nutrients when the oxygen concentration of the soil air was lowered. Also, the soil oxygen concentration correlated most highly with K content of leaves, followed by P content and by Mg content. These facts suggest that grape vines grown on poorly aerated soils may often produce a poor crop, or berries of unfavorable quality mainly induced by a potassium deficiency.

SUMMARY

Growth of Delaware grapes based on shoot length, and top and root weights decreased greatly with lowering soil oxygen concentration. In this case, the lower the soil oxygen concentration, the less was the content of K, P and Mg in leaves. Particularly, K content reached a deficient level when the oxygen concentration was depressed less than 5% of the soil air.

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土壌通気がブドウの生長と養分吸収に及ぼす影響 (第1報)

デラウェアの無着果樹について

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摘 要

土壌空気中の酸素濃度が 20, 10, 5, 2, 0% と低下するに伴って、ブドウ (デラウェア) の樹体の生長および葉内の K, P, Mg 含量はいちじるしく劣った。とくに葉内の K 含量は酸素濃度が 5% 以下になると欠乏値

に達した。

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抄 録

Gibberellin A₃ および A₄ によるリンゴの単為結果の誘起について

Gibberellin A₃ (GA₃) および A₄ (GA₄), GA₃ の Cellosolve ester (BCA₃), 2-chloro, 4-fluorophenoxy acetic acid (CFPA), 1-naphthyl N-methylcarbamate (NMC) がリンゴの単為結果の誘起並びに果実の発育に及ぼす影響について調査した。リンゴ品種 Sops-of-Wine を用い、除雄後上記物質の 10⁻⁵, 10⁻³, 5×10⁻³, および 10⁻²M 濃度を花柱の切断面と花柱部分に塗布した。対照として、花粉をしや断しラノリンのみ塗布する区および花粉交配区をもうけた。これらのうち、5×10⁻³M 濃度の GA₃ および GA₄ が特に単為結果を誘起し、それらの果実は成熟期まで良好な発育を示した。すなわち、処理 90 日後 (収穫時) の着果率は花粉交配区の 62%, 花粉しや断しラノリン塗布区の 0% に対し、GA₃ は 9%, GA₄ は 61% であった。BCA₃ 区の果実は初期の肥大が促進されたが、処理 55 日後までにすべて落果した。CFPA (5×10⁻³M) 区は処理 90 日後に 44% の着果率を示したが、果実はほとんど肥大しなかった。NMC は単為結果の誘起に全く効果がなかった。

次に、GA₄ の 5×10⁻³M ラノリン塗布によつて Sops-of-Wine, Wealthy, Delicious, Jonathan および Rhode Island Greening に対する単為結果の誘起について品種間差異を観察した。その結果、収穫時の単為結果率は Sops-of-Wine 61%, Wealthy 35%, Delicious

21% であった。前二者の成熟時における果実の横径はそれぞれ花粉交配果とほとんど変らなかつたが、Delicious ではやや劣り、Jonathan および Rhode Island Greening では初期肥大のみが促進され、その後、落果した。

これらのうち、Sops-of-Wine の単為結果果実について形態的観察をした。処理 2~8 週後における単為結果果実と花粉交配果の横径にはほとんど差が認められなかつたが、10 週後および収穫時 (約 12 週後) では花粉交配果が著しくすぐれた。また、縦径についてみると処理して 8 週までは単為結果果実が花粉交配果よりすぐれていたが、収穫時には両者の間に差がなかつた。花粉交配果は処理 2 週後を除いて常に横径が縦径より大であつたが、単為結果果実では横径が縦径よりも常に小さかつた。収穫時における両者の横径および縦径は花粉交配果がそれぞれ 64.3mm および 57.3mm, 単為結果果実が 53.9mm および 57.9mm であり、横径と縦径の比に著しい差異がみられた。また、単為結果果実は花粉交配果に比べて、子室および果心径が小さく、果頂部の果肉組織が著しく肥厚した。(向井 武)

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