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Diffusion of oxygen through lenticels in potato tuber

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Summary

Diffusion into the potato tuber of oxygen for respiration takes place only through lenticels, and not through the rest of the periderm. The number of lenticels which were capable of injection with methylene blue solution was observed to be about 100 per tuber. Rates of oxygen diffusion per lenticel varied from 0.024 to 0.296 $cm^3\ h^{-1}\ atm^{-1}$ with a mean of $0.1105 \pm 0.013\ cm^3\ h^{-1}\ atm^{-1}$.

Introduction

The ability of the potato tuber to respire aerobically is dependent upon a supply of oxygen to the tissue. It has been supposed that most of the diffusion of oxygen takes place through the lenticels and that the remainder of the periderm is impermeable to oxygen (Burton, 1965), but on direct evidence of this has previously been available. This study confirms the former supposition.

Method

Mature tubers of the variety *King Edward* were used.

Number of lenticels. Tubers were placed in a desiccator and covered by a strong solution of methylene blue. The desiccator was evacuated and the vacuum maintained for 30 minutes and then released. The tubers were removed, the surface lightly scrubbed to reveal a pattern of blue spots, and the spots of a reasonable size (over about 0.5 mm) were counted. In trial experiments the pattern of lenticels before evacuating and the pattern of blue spots after evacuating were mapped and were found to correspond. Thereafter the methylene blue method was used as giving a clearer and easier means of counting.

Rate of diffusion. Small, open-ended perspex tubes, 3.75×1 cm, were stuck directly on to the tuber surface over a single lenticel with ICI Tensol No 6 cement, one per tuber. Tubers were placed at 10 °C under water, with the open end of the tube above the water surface, for 24 hours to equilibrate, after which time the end of each tube was closed with a greased cover slip. At various times, t, from 2 hours to 4 days after clo-

sure, tubers were removed from the water and the percentage of oxygen in the tube was measured by gas chromatography. The original concentration of oxygen in the tube was taken to be 20.95%. From the final concentration, and the volume of the tube, the volume of oxygen that had diffused in time t was found.

The method was repeated but with tubes stuck on areas of the periderm devoid of lenticels. Gas analyses were taken as before.

Results and discussion

Number of lenticels. The number of effective lenticels, i.e. those corresponding to blue spots of 0.5 mm diameter and above, varied between 74 and 141 per tuber with a mean of 105. The weight of tubers was in the range 95–227 g, but there was no correlation between weight and number of lenticels.

Rate of diffusion (see Table 1). At 10°C a tuber becomes anaerobic after about 6 hours' submersion (Burton and Wigginton, 1970). In the case of the present experiments, oxygen diffusion would be occurring through one lenticel and thus a completely anaerobic state would not be reached, but for the purposes of calculation the internal oxygen tension, estimted to be perhaps 2×10^{-4} atm at the time of closure, can be taken to be zero and remains so. Oxygen from the tube continues to diffuse through the lenticel into the tuber after closure of the tube and is utilised for respiration. The rate of diffusion will depend both upon the size of the lenticel and the pressure deficit between the internal atmosphere of the tuber and the gas in the tube and could be expected to decrease exponentially as the reservoir tube is depleted of oxygen.

Since the 0_2 deficit between the internal atmosphere of the tuber and the gas in the tube after the tuber has become anaerobic is initially equivalent to the 0_2 tension in the tube (0.2095 atm). The mean 0_2 deficit over the time of the experiment is taken as $(di + dt)/2$

where di = initial 0_2 deficit

dt = deficit after time t.

Lenticels vary considerably in their permeability to oxygen, and this is illustrated by the wide variation in diffusion rates obtained (Table 1). Diffusion rates were related to mean oxygen deficit and varied from 0.024 to 0.296 $cm^3\ h^{-1}\ atm^{-1}$ with a mean of $0.1105 \pm 0.013\ cm^3\ h^{-1}\ atm^{-1}$. The average rate at maximum deficit, i.e. when the tuber is anaerobic, is thus 0.2095 $(0.1105 \pm 0.013)\ cm^3/h$ or $(2.31 \pm 0.27) \times 10^{-2} cm^3/h$.

Oxygen diffusion was found not to take place at detectable rates in areas of the periderm devoid of lenticels.

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Table 1. Rate of diffusion; individual lenticels.

Tuber	Mean 0_2 deficit (atm)	Rate of diffusion (10^{-2} cm^3/h)	Rate/atmosphere (cm^3/h)
1	0.1156	1.39	0.1202
2	0.1252	2.21	0.1765
3	0.1150	0.91	0.0791
4	0.1435	1.70	0.1185
5	0.1197	0.88	0.0735
6	0.1172	1.46	0.0803
7	0.1487	0.90	0.0605
8	0.1107	0.93	0.0840
9	0.1587	0.76	0.0479
10	0.1155	0.85	0.0727
11	0.1442	0.88	0.0610
12	0.1268	0.76	0.0599
13	0.1197	0.67	0.0560
14	0.1122	0.90	0.0802
15	0.1527	0.55	0.0360
16	0.1199	0.69	0.0575
17	0.1442	2.24	0.1553
18	0.1648	1.42	0.0862
19	0.1483	1.61	0.1086
20	0.1312	0.82	0.0625
21	0.1516	0.60	0.0396
22	0.1392	0.73	0.0524
23	0.1339	0.73	0.0545
24	0.1669	0.40	0.0240
25	0.1437	2.57	0.1788
26	0.1833	3.11	0.1697
27	0.1785	3.03	0.1697
28	0.1794	0.82	0.0451
29	0.1536	1.50	0.0976
30	0.1778	2.57	0.1445
31	0.1752	3.03	0.1729
32	0.1922	5.68	0.2955
33	0.1939	4.94	0.2547
34	0.1746	4.78	0.2738
35	0.1902	2.33	0.1255
36	0.1794	3.43	0.1912
37	0.1880	2.35	0.1250

References

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