FORD

The Power of Young

Roots to Resist Desiccation

General Science

A. B.

1911

UNIVERSITY OF ILLINOIS
LIBRARY

Class
1911

Book
F75

Volume

THE POWER OF YOUNG ROOTS
TO RESIST DESICCATION

938
34
21/2

BY

BERNICE FORD

THESIS FOR THE DEGREE OF BACHELOR OF ARTS

IN GENERAL SCIENCE

IN THE

COLLEGE OF SCIENCE

OF THE

UNIVERSITY OF ILLINOIS

June 1, 1911

THE POWER OF YOUNG ROOTS TO RESIST DESICCATION.

INTRODUCTION.

Dr. C. B. Davenport in his "Experimental Morphology," treats of the effects of varying moisture upon living protoplasm. The fact that water forms from sixty to ninety per cent of the entire mass of the living organism would indicate that it plays an extremely important role. This role is varied. It serves to maintain the unstable foam-like structure of the protoplasm; it dissolves other substances taken into the body of the organism, and it serves as a medium of transportation of dissolved substances from place to place in the body of the organism. "In a word, it is essential to movement, and to those chemical processes which constitute metabolism."

Partial or complete desiccation of protoplasm tends to inhibit metabolism and to retard protoplasmic movements. The immobile condition produced by partial desiccation resembles death very closely, except that upon addition of water, life activities are resumed. To this condition Dr. Davenport applies the term, "desiccation-rigor." There is not sufficient evidence to conclude that an adult organism can lose all of its, "free water," without a destruction of its finer structure and death following. Some protoplasmic bodies may be dried as completely as possible by ordinary chemical methods, without death ensuing, other bodies, especially the adult forms of higher organisms are killed by desiccation.

The object of the experiments following is:-

(1) To determine the degree of desiccation to which the radicals of *Lupinus albus* can be subjected and still revive, upon the addition of water.

(2) To determine the effect of, (a) the age of the seedling, (b) the rate of growth and germination, and (c) acclimatization to a dryer environment, upon the degree of desiccation to which radicals of *Lupinus albus* may be subjected and revive.

Digitized by the Internet Archive
in 2013

<http://archive.org/details/powerofyoungroot00ford>

MATERIALS AND METHODS.

Unless otherwise stated, the seedlings of *Lupinus albus* were used throughout this series of experiments. They were soaked in water for twenty-four hours, and then planted in moist sphagnum. Before each sowing the sphagnum was allowed to stand in water for a short time. It was then placed under pressure, and the water forced out until the sphagnum retained that degree of moisture best suited for normal and rapid germination. When the age of the seedlings is mentioned it refers to the interval between the time of soaking and the time the seedlings were used for experimentation. Unless otherwise indicated the seedlings were taken directly from the sphagnum, and exposed to the drying influence of the atmosphere. They were either placed with their radicals extending downward through the meshes of a wire netting, or placed with their cotyledons down upon the table, the radicals pointing upward, and freely exposed to the drying influence of the air. Both methods gave the same results. After exposure to the air for varying periods of time they were placed for twenty-four hours on a wire netting, through which the radicals projected into tap water. Careful records were made of the thermal and hygrometric conditions of the atmosphere during the experiments. When the relative humidity of the atmosphere was more than forty-five per cent, it required an unusually long period of exposure to produce any results. I endeavored to maintain a temperature of about twenty degrees Centigrade during the experiments, but at times it varied from eighteen to twenty-four

degrees. Final records were taken twenty-four hours after the seedlings had been placed in water subsequent to their exposure to the drying influence of the air. Observations taken two, four, six, and eight hours after exposure to the atmosphere, except in a very few cases showed no results.

EXPERIMENT 1.

In order to insure a relatively uniform temperature throughout this series of experiments, the seeds were soaked as well as germinated in pans surrounded by running water, the temperature of which varied from seventeen to twenty degrees Centigrade. As the thermal and hygrometric conditions of the atmosphere varied to a considerable extent from day to day, the experiments were made using seedlings in sets of twenty on different days. In this way a more average moisture and temperature condition was obtained.

The seedlings used, were three days old. One hundred were exposed to the drying influence of the atmosphere for thirty minutes; one hundred for forty-five minutes; and one hundred for sixty minutes. After this exposure they were placed upon a wire netting through which the radicals projected into tap water.

Twenty-four hours after exposure to the atmosphere, many of the radicals showed the phenomena described in the tables following, as "cracked." The cracks appeared about one or two millimeters back of the tip, extending back for from one to three millimeters. Some extended through to the plerome, and in many cases the periblem peeled back. Some times the tip cracked off.

Some of the radicals bent in a region about two or three millimeters back of the tip. Some bent forming a right angle, others formed a hook, and still others coiled completely around forming a knot. This phenomena is described as "bent," in the tables following.

Sometimes in one, two, or even three regions, beginning one or two millimeters back of the tip, abnormal growth took place, causing bulb-like formations to occur. Frequently any two of these phenomena occurred on the same radical.

Records taken twenty-four hours after the exposure of the lupine radicals to the drying influence of the atmosphere are tabulated in Table 1.

TABLE 1.

Time of exposure	30 min.	45 min.	60 min.
Number used	100	100	100
" not affected	45	29	20
" cracked	54	64	58
" bent	17	24	28
" bulbous	1	7	2
" dead	0	0	18
Average relative humidity	36.2% ₀	29.8% ₀	21.4% ₀
" temperature	20.1	20.4	22.4

These results show:-

(1) The death point is not reached until the seedlings are exposed to the drying influence of the air for more than forty-five minutes. Between forty-five and sixty minutes exposure, the death rate increases rapidly.

(2) The maximum amount of cracking and bulbous formations occurs upon about a forty-five minute exposure to the air; while bending gradually increases, the greatest number

of seedlings bending when exposed to the atmosphere for sixty minutes.

(3) The seedlings show a marked individuality. Twenty per cent of those seedlings exposed for sixty minutes showed no results from the exposure, while eighteen per cent were killed.

(4) Rise in temperature during the period of exposure accelerates wilting.

(5) Rise in the relative humidity of the atmosphere, during the period of exposure, retards wilting.

The percentage of those seedlings recorded in the table as showing no results from the thirty minute exposure is a little high, due to the high average relative humidity of the atmosphere during the periods of exposure.

EXPERIMENT 11.

This series of experiments was performed in a room the temperature of which varied from twenty-four to twenty-seven degrees Centigrade. All of the water and sphagnum used had previously stood for twenty-four hours in this room. Seventy-five normally developed seedlings, three days old were selected. Twenty-five of them were placed on a wire netting, the radicals extending through into tap water; twenty-five were placed on a wire netting in a damp air chamber, and twenty-five were left in moist sphagnum. The damp air chamber was formed by lining two granite pans with wet filter paper, and inverting one over the other. Water was allowed to stand in one of the pans to the depth of from one-third to one-half inch. Care was taken that the radicals did not come in contact with the filter paper, or grow down into the water. After twenty-four hours all of the seedlings were exposed for a period of thirty minutes to the drying influence of the atmosphere. The seedlings at the time of experimentation were four days old, and varied from forty to sixty millimeters in length. The thermometer during the experiment registered twenty-four degrees Centigrade, and the relative humidity was twenty-seven per cent. The results of this experiment are tabulated in Table 11.

TABLE 11.

	Exposed for 30 minutes.		Age 4 days.			
	No.	No	used effect	cracked	bent	bulb dead
Taken directly from sphag.	25	1		22	12	3 0
Placed in H o for 24 hrs.	25	1		22	3	4 1
2						
Placed in damp air 24 hrs.	25	24		1	0	0 0

Sixty seedlings, two days old, germinated as already described, were placed; twenty, on a wire netting with their roots extending through into tap water; twenty, in a damp air chamber, and twenty were left in sphagnum. When three days old they were exposed to the air for forty-five minutes. The average length of the radicals was about twenty-five millimeters. The relative humidity during the experiment was twenty per cent, and the temperature, twenty-five degrees Centigrade. Results are tabulated in Table 111.

TABLE 111.

	Exposed for 45 minutes.		Age 3 days.			
	No.	No	Crack	Bent	Bulb	Dead
	used	effect				
Left in Sphagnum	20	1	6	3	3	13
Placed in H o for 24 hrs.	20	7	11	2	0	1
2						
Left in moist air 24 hrs.	20	13	3	1	0	3

Seventy-five seedlings, two days old were selected. Twenty-five were placed for forty-eight hours in a damp air chamber, twenty-five, in water, and twenty-five were left in

the sphagnum. When they were four days old all of them were exposed to the drying influence of the air for sixty minutes. The temperature during the experiment was twenty-four degrees Centigrade, and the relative humidity was forty-eight per cent. At the time of experimentation, those seedlings which had remained in the sphagnum for the entire period, and those which had been in water for forty-eight hours, varied from twenty-five to fifty-five millimeters in length. Those grown in moist air for the last forty-eight hours were about thirty millimeters in length. The average length of these seedlings was less than that of those grown in water or sphagnum, but the variation in length among individuals was markedly less. The results of this experiment are recorded in Table IV.

TABLE IV.

	Exposed to the air for 60 min.		Age 4 days.			
	No. used	No effect	crack	bent	bulb	dead
Left in sphagnum	25	0	1	1	0	24
Placed in H ₂ O 48 hrs.	25	3	4	2	1	17
Placed in moist air 48hrs.	25	24	0	0	0	1

The amount of moisture present in the medium in which the seedlings are grown has a marked effect upon the powers of endurance of the seedlings. The death point of from seventy to ninety-six per cent of those seedlings grown in water or moist sphagnum is reached before they are exposed for sixty minutes to the drying influence of the atmosphere, while those seedlings grown in moist air, other conditions being identical, are

unaffected by sixty minutes exposure.

EXPERIMENT 111.

Two sets of seedlings of fifty each, germinated as already described under identical moisture and temperature conditions were exposed to the drying influence of the air for fifty minutes, one set when three, the other when four days old. The results of this experiment are recorded in Table IV.

TABLE IV.

Exposed for fifty minutes.

Age	Temp.	Relative Humidity	Number used	No effect	Number cracked	Number bent	Number dead
3 days	20 ^o	20%	45	3	22	0	20
4 days	24 ^o	30%	50	0	1	0	49

Another series of seedlings, two, three, and four days old was exposed to the air for forty-five minutes. Results are recorded in Table V.

TABLE V.

Exposed for forty-five minutes.

Age	Average length	Temp.	Relative humidity	No. used	No effect	Cracked	bent	dead
2 days	10 mm	24 ^o	33%	20	8	7	3	2
3 days	Under 25 mm	22 ^o	39%	25	0	4	2	20
4 days	25-50mm	23 ^o	34%	25	0	0	0	25

These results show that the younger seedlings withstand exposure to the drying influence of the atmosphere much more readily than do those which have grown for a longer period of time.

EXPERIMENT IV.

Variations in temperature and moisture conditions during germination and growth cause variations in the rate of growth and germination of the seedlings. For this reason there often is a marked difference in the length of the radicals of seedling of the same age, germinated at different temperatures. The radicals of those seedlings which had grown rapidly because of a more favorable temperature, were therefore longer at the time of experimentation than were the radicals of seedlings of the same age, grown at a lower temperature. By comparison of the following tables it will be seen that seedlings, grown slowly at a low temperature have greater powers of endurance, than those of the same age which have longer radicals due to the fact that they have been grown at a higher temperature.

TABLE VI.

Age of seedlings --- 3 days

Exposed to air -----30 minutes

Length of radicals -Under 30 millimeters.

Relative Humidity	Temp.	No. used	No effect	cracked	bent	bulbous	dead
42%	22 1/2°	20	13	6	3	0	0
41	20	20	12	8	1	0	0
34	20	20	6	14	4	0	0
32	18 1/2	20	6	14	8	0	0
45	19	10	0	10	2	0	0
Total		90	37	52	18	0	0

No effect ----- 41%

Cracked ----- 57%

Bent ----- 20%

Showing results of drying -- 59%

TABLE VII.

Age of seedlings ---- 3 days

Exposed to air -----30 minutes

Length of radicals --30 - 50 millimeters

Relative Humidity	Temp.	Number used	No effect	cracked	bent	bulbous	dead
	^o						
43%	21	10	0	10	3	1	0
43	21	10	0	7	3	0	0
43	21	10	0	8	5	1	0
52	24	48	9	35	0	4	0
52	24	48	3	43	11	3	2
Total		126	12	103	22	9	2

No effect ----- 9.6%

Cracked ----- 81.7%

Bent ----- 17.4%

Bulbous ----- 7.1%

Dead ----- 1.5%

Showing results of the drying -- 90.4%

EXPERIMENT V.

Seedlings of *Vicia faba*, germinated as already described, are capable of enduring a surprising amount of exposure to the drying influence of the atmosphere, and recover. When exposed for a sufficient length of time, however, they show the same phenomena as do the seedlings of *Lupinus albus*. Results obtained from a number of experiments upon the seedlings of *Vicia faba* are tabulated below.

TABLE VIII.

Exp. No.	Age	Av. Length	Rel. Hum.	Temp.	Time exp.	No. used	No eff.	crack.	bent	bulb.	dead
1	3 da.	5 mm	42%	23	2 hrs.	4	3	1	0	0	0
2	4		53	23	1/2 2	14	9	2	3	0	0
3	4	15-23	41	24	2	6	4	2	0	0	0
4	5	40-60	45	23	1 3/4	6	2	3	0	0	0
5	5	40-60	45	23	1 3/4	7	4	1	0	0	2
6	5		35	22	1 1/2	12	3	6	0	2	1
7	5	55-60	60	21	1/2 3 hrs.	7	2	2	0	0	3
8	6	50-70	45	23	1hr. 50m.	11	4	5	2	0	1
9	6	55-60	50	21	1/2 2" 10"	9	3	4	0	0	2
10	7	60-70	45	23	1" 45"	11	5	4	0	0	2

SUMMARY.

The conclusions drawn from the preceding experiments may be summarized as follows:

1. The percentage of seedlings affected by exposure to the drying influence of the atmosphere varies directly as the period of exposure.

2. Variation in the powers of endurance of seedlings of *Lupinus albus*, grown under identical conditions is marked, due to the individuality of the seedlings.

3. The powers of endurance of seedlings of *Lupinus albus* vary inversely as the amount of moisture present in the medium in which the seedlings are germinated and grown.

Seedlings grown in water or moist sphagnum grow rapidly, but from seventy to ninety-six per cent of them are killed by an exposure of sixty minutes to the drying influence of the air. All show the effects of this exposure, either by cracking, bending, or dying. Seedlings grown in moist air show no effects of a sixty minute exposure to the drying influence of the atmosphere.

4. The ability to withstand exposure to the drying influence of the air varies inversely with the age of the seedlings.

Of seedlings two days old, forty per cent showed no results and five per cent were killed by an exposure for forty-five minutes to the atmosphere. Of seedlings three days old, all showed results, and eighty per cent were killed by an

exposure for the same length of time. Seedlings four days old were all killed by a forty-five minute exposure.

5. The powers of endurance of the seedlings vary inversely as their rate of growth and germination.

Ninety per cent of those seedlings, which have grown very rapidly, due to growth at a more favorable temperature, showed results when exposed to the drying influence of the air for thirty minutes. Of those which had grown slowly, due to germination and growth at a low temperature, only fifty-nine per cent showed results, upon exposure for the same length of time.

6. Rise in temperature during the period of exposure to the drying influence of the air accelerates wilting.

7. Rise in the relative humidity of the air during the period of exposure retards wilting.

8. *Vicia faba* seedlings are capable of enduring a much longer period of exposure than are those of *Lupinus albus*. When exposed for a sufficient length of time *Vicia faba* seedlings show the same phenomena as do those of *Lupinus albus*.

UNIVERSITY OF ILLINOIS-URBANA

3 0112 086857932