

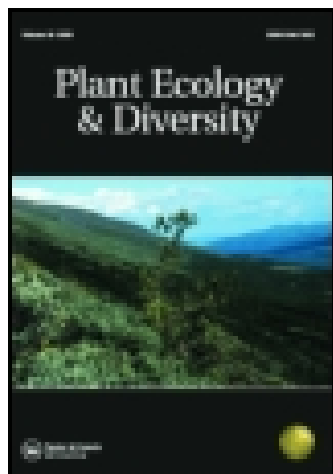
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and his life justified its use. He will be remembered as one of our most successful merchants, a man of large-hearted charity, and a liberal encourager of scientific horticulture.

LIST OF BOTANICAL PAPERS BY MR. CHARLES JENNER.

1. A Comparative View of the more Important Stages of Development of the Higher Cryptogamia and Phanerogamia. Trans. Bot. Soc. Edin., vol. v., p. 55.
2. On the Accessory Organs of the Hybrid Selaginella. Trans. Bot. Soc. Edin., vol. viii., p. 169.
3. On the History and Structure of Urococcus. Trans. Bot. Soc. Edin., vol. viii., p. 318.
4. On the Study of Botany as a Branch of Mental Training. Trans. Bot. Soc. Edin., vol. x., p. 1.
5. Notice of a New *Carduus* gathered during a Botanical Excursion in Ross-shire. By Mr. Charles Howie and Mr. Charles Jenner. Trans. Bot. Soc. Edin., vol. ix., p. 257.
6. On Spores. Edin. New Phil. Jour., vol. iii., p. 269.

THE NON-ASSIMILATION OF ATMOSPHERIC NITROGEN BY GERMINATING BARLEY. (From Experiments made in 1880.)
By T. CUTHBERT DAY.

(With Zincographs, Figs. 1 and 2.)

The question of the direct fixation of atmospheric nitrogen by growing plants seems to have been an attractive problem to workers in the field of vegetable physiology, judging by the number of experimenters who have, at different times, attacked the subject. I believe it is generally acknowledged that plants, by themselves, are not able to make any direct use of the element which constitutes four-fifths of the atmosphere, though, by the aid of certain organisms which attach themselves to the roots of some plants, a direct assimilation of atmospheric nitrogen takes place, as has been amply proved by the researches of Hellreigel and Wilfarth, Berthelot, Frank, Schloesing, Lawes and Gilbert, and others. It is not my purpose to-night to deal with plants as they grow in the soil, but with the germinating seeds of a well-known cereal, namely, barley. Do the seeds of barley take up any nitrogen from the air during the germinating stage of growth? The question does not seem to be of much importance, but as, some years ago, I commenced to study some points in connection with the respiration of germinating barley, it was absolutely

necessary, from the nature of the experiments I required to execute, to satisfy myself whether nitrogen was active or not. I consequently went through a series of determinations on the point, and secured a number of concordant results, the outcome of which I thought might prove of interest to this Society, and I have taken this opportunity of laying them before you.

In a paper published in the Transactions of the Chemical Society (September 1880), I gave the results of three experiments on this subject, showing that atmospheric nitrogen takes no active part in the germination of barley.

Taking into consideration the short length of time occupied by each of those experiments, I thought it desirable to confirm the results then obtained by executing a fresh series of experiments, each extending over a longer period, and to observe the fluctuations in the volume of confined air from day to day.

The apparatus employed was the same as in the former experiments. It is seen in Fig. 1. A is a flask of about 100 C.C. capacity, with M.M. graduations on the neck, and carefully calibrated. The flask is inverted, with its mouth under the surface of mercury, in the small glass vessel B, and the whole is immersed in a large beaker full of water. The changes of temperature are observed by means of a thermometer, D. A small plug of platinum wire, in the neck of the flask, serves to keep the germinating corns in their place in the body of the flask. The specific gravity of the platinum plug and of the steeped barley was determined, so that their volume might be deducted from that of the air in the flask.

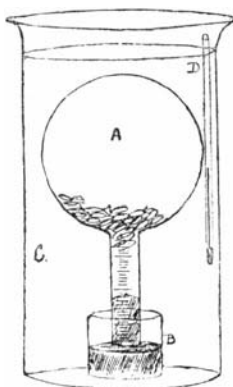


Fig. 1.

When the apparatus was arranged for an experiment, a portion of the confined air was withdrawn by means of a gas syringe, shown in Fig. 2—(The V tube A has a capillary bore; B is a pinchcock on the suction tube.)—and the quantity of nitrogen determined by analysis. At the end of

the experiment, another portion of air was taken from the

flask, and the quantity of nitrogen again determined. In calculating the volume of the confined air, the usual corrections were applied for temperature, pressure, and tension of aqueous vapour.

By the above means, we have the data necessary for ascertaining the quantity of atmospheric nitrogen present in the germinating flask at the commencement and end of each experiment. I give below the results obtained in the series of six experiments.

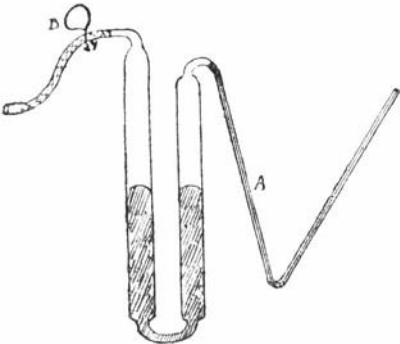


Fig. 2.

EXPERIMENT 1.—2,269 GRAMMES STEEPED BARLEY.
Temperature during Growth, 15·5° to 19·0° C.

VOLUME OF THE CONFINED AIR.		Difference.	State of Germination.
	C.C.	C.C.	
At start of Experiment, Aug. 5.....	99·08	— 0·57	Budding.
Do. do. „ 6.....	98·51	— 0·59	Growing freely.
Do. do. „ 7.....	97·92	+ 0·09	Do.
At end of Experiment, Aug. 8.....	98·01		Rootlets nearly as long as the corns.

COMPOSITION OF THE AIR IN THE FLASK.

	At start of Experiment.	At end of Experiment.
Oxygen	20·77%	6·29%
Nitrogen	79·23%	80·16%
Carbonic Anhydride.....	0·00%	13·55%
	<u>100·00</u>	<u>100·00</u>

VOLUME OF AIR—	C.C.	%	C.C.
At start of Experiment ...	99·08,	containing 79·23 Nitrogen =	78·50
At end of Experiment, ...	98·01,	„ 80·16 „ =	78·56
		Gain =	0·06

EXPERIMENT 2.—2,305 GRAMMES STEEPED BARLEY.
Temperature during Growth, 20·9° to 23·0° C.

VOLUME OF THE CONFINED AIR.		Difference.	State of Germination.
	C.C.	C.C.	
At start of Experiment, Aug. 11 ...	96·85	— 0·24	Just budding.
Do. do. „ 12 ...	96·61	— 0·36	Growing rapidly.
Do. do. „ 13 ...	96·25	+ 0·96	Do.
At end of Experiment, „ 14 ...	97·31		Root as long as corns.

COMPOSITION OF THE AIR IN THE FLASK.

	At start of Experiment.	At end of Experiment.
Oxygen	20·84%	0·23%
Nitrogen.....	78·99%	78·97%
Carbonic Anhydride.....	0·17%	20·80%
	<u>100·00</u>	<u>100·00</u>

VOLUME OF AIR—	c.c.	%	c.c.
At start of Experiment ...	96·85,	containing 78·99 Nitrogen=	76·51
At end of Experiment ...	97·31,	„ 78·97 „	=76·84
			Gain= 0·33

EXPERIMENT 3.—2,138 GRAMMES STEEPED BARLEY.

Temperature during Growth, 13·0° to 15·8° C.

VOLUME OF THE CONFINED AIR.		Differ- ence.	State of Germination.
	c.c.	c.c.	
At start of Experiment, Sept. 16 ...	95·79		Just budding.
Do. do. „ 17 ...	95·70	− 0·09	Showing short root.
Do. do. „ 18 ...	95·07	− 0·63	Roots rather longer.
At end of Experiment, „ 19 ...	94·63	− 0·56	Roots about $\frac{1}{2}$ length of corns.

COMPOSITION OF THE AIR IN THE FLASK.

	At start of Experiment.	At end of Experiment.
Oxygen	20·81%	6·77%
Nitrogen.....	99·15%	79·97%
Carbonic Anhydride.....	0·04%	13·26%
	<u>100·00</u>	<u>100·00</u>

VOLUME OF AIR—	c.c.	%	c.c.
At start of Experiment ...	95·79,	containing 79·15 Nitrogen=	75·82
At end of Experiment ...	94·63,	„ 79·97 „	=75·67
			Loss= 0·15

EXPERIMENT 4.—2,144 GRAMMES STEEPED BARLEY.

Temperature during Growth, 13·2° to 17·0° C.

VOLUME OF THE CONFINED AIR.		Differ- ence.	State of Germination.
	c.c.	c.c.	
At start of Experiment, Sept. 20 ...	99·54		Just starting.
Do. do. „ 21 ...	99·29	− 0·25	Full bud.
Do. do. „ 22 ...	98·99	− 0·30	Short rootlets.
At end of Experiment, „ 23 ...	98·75	− 0·24	Roots nearly $\frac{1}{2}$ length of corns.

COMPOSITION OF THE AIR IN THE FLASK.

	At start of Experiment.	At end of Experiment.
Oxygen	20·61%	7·82%
Nitrogen.....	79·36%	80·06%
Carbonic Anhydride.....	0·03%	12·12%
	<u>100·00</u>	<u>100·00</u>

VOLUME OF AIR—	c.c.	%	c.c.
At start of Experiment ...	99·54,	containing 79·36 Nitrogen=	78·99
At end of Experiment ...	98·75,	,, 80·06 ,,	=79·06
			Gain= 0·07

EXPERIMENT 5.—2,296 GRAMMES STEEPED BARLEY.

Temperature during Growth, 15·3° to 15·5° C.

VOLUME OF THE CONFINED AIR.		Difference.	State of Germination.
	c.c.	c.c.	
At start of Experiment, Oct. 26 ...	94·63		Starting.
Do. do. ,, 27 ...	94·35	- 0·28	Full bud.
Do. do. ,, 28 ...	94·10	- 0·25	Short root.
Do. do. ,, 29 ...	93·65	- 0·45	Growing steadily.
Do. do. ,, 30 ...	93·99	+ 0·34	Do.
Do. do. ,, 31 ...	95·63	+ 1·61	Do.
At end of Experiment, Nov. 1 ...	98·20	+ 2·57	Roots fully as long as corns.

COMPOSITION OF THE AIR IN THE FLASK.

	At start of Experiment.	At end of Experiment.
Oxygen	20·36%	0·05%
Nitrogen.....	79·64%	76·48%
Carbonic Anhydride.....	0 00%	23·47%
	<u>100·00</u>	<u>100·00</u>

VOLUME OF AIR—	c.c.	%	c.c.
At start of Experiment ...	94·63,	containing 79·64 Nitrogen=	75·36
At end of Experiment ...	98·20,	,, 76·48 ,,	=75·11
			Loss= 0·25

EXPERIMENT 6.—2,268 GRAMMES STEEPED BARLEY.

Temperature during Growth, 15·5° to 15·7° C.

VOLUME OF THE CONFINED AIR.		Difference.	State of Germination.
	c.c.	c.c.	
At start of Experiment, Nov. 6...	98·33		Just starting.
Do. do. ,, 7...	98·19	- 0·14	Full bud.
Do. do. ,, 8...	97·41	- 0·78	Short root.
Do. do. ,, 9...	97·26	- 0·15	Growing freely.
Do. do. ,, 10...	97·49	+ 0·23	Do.
Do. do. ,, 11...	98·62	+ 1·13	Do.
At end of Experiment, ,, 12...	100·87	+ 2·25	Long root.

COMPOSITION OF THE AIR IN THE FLASK.

	At start of Experiment.	At end of Experiment.
Oxygen	20·40%	0·00%
Nitrogen.....	79·57%	77·17%
Carbonic Anhydride.....	0·03%	22·83%
	<u>100·00</u>	<u>100·00</u>

VOLUME OF AIR—	c.c.	%	c.c.
At start of Experiment	98·33, containing	79·57 Nitrogen=	78·23
At end of Experiment	...100·87, „	77·17 „	=77·84
			Loss= 0·39

RESULT OF THE SIX EXPERIMENTS—GAIN OR LOSS OF NITROGEN.

	Gain c.c.	Loss c.c.
Experiment 1.	0·06	—
„ 2.	0·33	—
„ 3.	—	0·15
„ 4.	0·07	—
„ 5.	—	0·25
„ 6.	—	0·39
	<u>Sum..... 0·46</u>	<u>0·79</u>

The total loss of nitrogen in the six experiments is therefore $0·79 - 0·46 = 0·33$ c.c., or an average loss of $0·055$ c.c. nitrogen in about 80 c.c. for each experiment, a quite inconsiderable quantity, and well within the limit of experimental error.

The result arrived at shows pretty conclusively that atmospheric nitrogen takes no active part in the germination of barley. An examination of the daily differences in the volume of the confined air in Experiments 5 and 6, reveals the fact that when the oxygen becomes nearly exhausted, the volume of air increases owing to the evolution, by the seeds, of more carbonic anhydride than can be accounted for by true respiration. The cause of this is no doubt due to intercellular fermentation.

The germination of the barley in all the experiments, even in those occupying the longer period, was perfectly healthy, and no still corns were met with. The corns, when extracted from the flask, had that peculiar fragrant odour which is always noticed in barley when germinated in a confined space.