on in the soil whereby nitrogenous matters are converted into nitric acid; and that these processes, like most other chemical processes going on in the soil, are achieved through the instrumentality of living organisms. The characters of some of these organisms, their life history, the work in which they are engaged, and the means by which that work may be controlled in some measure, so as to serve specific ends, will, I understand, be demonstrated at an early meeting of the Society, and it is to form a kind of introduction to that practical aspect of the subject that I have asked you to listen to this short historical sketch.

EXPERIMENTS WITH NITRAGIN. By WILLIAM SOMERVILLE, D.Ec., D.Sc., Professor of Agriculturè, Durham College of Science.

(Read, Thursday, 14th January 1897.)

Those who have been following the various developments of "the nitrogen question" during the past few years would be more or less prepared for the announcement that appeared in the "*Deutsche Landwirtschaftliche Presse*," on the 8th of April last, to the effect that the bacteria, which establish themselves on the roots of Papilionaceous plants, and enable them to utilise the free nitrogen of the air, were on sale as a commercial article by the firm of Meister Lucius & Brüning's successors at Höchst am Main. The work of many distinguished investigators during the past decade had established the fact that the Papilionaceous family of the Leguminosæ could make use of the supplies of atmospheric nitrogen in a way that was impossible for other plants. This power, however, is not inherent in the plants themselves, but is due to colonies of bacteria, which find a habitation in the wart-like nodules that are normally present in abundance on their roots. Without these bacteria the plants in question are in no better a position than others, and although our clover, peas, vetches, etc., may usually be trusted to find in the soil a sufficient number of the particular bacteria that they consort with, still there is always the chance that

these minute organisms may be absent, and that, in consequence, the vigorous development of the plants may be prevented. Professor Nobbe, of Tharandt, and Dr. Hiltner, devoted much attention to the subject, and proved, amongst other things, that each Papilionaceous plant has its own varietal, if not specific, organism, and that for full development it is necessary that the roots of a Papilionaceous crop should have access to the bacterium which is specially adapted to it. They therefore instituted a series of pure cultures of the various varieties of bacteria that inhabit the roots of our more important Papilionaceous plants, and having patented these cultures, they entrusted their manufacture to the well-known chemical firm above mentioned. This pure gelatinous culture is known as "Nitragin," and is sold at M. 2.75 per bottle, this quantity being sufficient to dress a morgen. It will thus be seen that for 4s. 6d. one can obtain as much Nitragin as will treat an acre, so that if it produces practically any good effects at all, its use can hardly fail to be profitable.

To apply the Nitragin to the land or the crop one is recommended either to mix it with water and then to add the seed to the solution immediately before sowing, or to mix it with some soil and afterwards scatter the mixture over the field.

Early in May I obtained a few bottles of Nitragin, and at once started some small experiments to test its practical value. Without going into the details of the arrangement and conduct of these experiments, I may say that I was careful (*a*) to apply the same quantity of seed to comparative plots, (*b*) to see that the Nitragin was not exposed to light, and was liquified at a temperature of less than 100° F., and (*c*) that in the various cultural operations of covering the seed, weeding the plots, etc., the worker should never go from inoculated to uninoculated ground. As a matter of fact the weeding was all done from planks, each plot being provided with a sufficient number, which were utilized as occasion required.

EXPERIMENTS WITH PEAS.

Each plot consisted of a row 24 feet long, an interval of $2\frac{1}{2}$ feet occurring between adjoining rows. Five

grammes of Nitragin were taken for each plot and mixed with half a pint of water, after which the seed (1 pint) was poured into the mixture and rendered thoroughly wet. Dry sand was next added to absorb the surplus moisture and facilitate the distribution of the seeds. The peas ("Dicksons' First and Best") were then sown in a drill and covered in the usual way. This experiment was carried out in duplicate. The following are the weights of produce in an air-dry condition :—

	"A" Plots.		"B" Plots.		Total Weight of Seed, Straw, and Husks.
	Seed.	Straw and Husks.	Seed	Straw and Husks.	
Not Inoculated .	oz. 33·75	oz. 37·50	oz. 44·50	oz. 40·00	oz. 155·75
Inoculated . .	39·25	38·75	45·50	42·50	166·00
Gain by Inoculation	5·50	1·25	1·00	2·50	10·25

In both sets of plots the Nitragin has apparently increased the yield, the gain of total produce being 6·6 per cent.

EXPERIMENTS WITH BROAD BEANS.

This experiment was carried out in exactly the same way as the preceding one, except that here the rows were 2 ft. apart, and only two thirds of a pint of seed ("Early Long Pod") was employed.

	"A" Plots.		"B" Plots.		Total Weight of Seed, Straw, and Husks.
	Seed.	Straw and Husks.	Seed.	Straw and Husks.	
Not Inoculated .	oz. 33·50	oz. 59·50	oz. 45·75	oz. 58·75	oz. 202·50
Inoculated . .	35·25	54·50	34·75	54·25	178·75
Loss by Inoculation	3·25	5·00	11·00	4·50	23·75

In this case the inoculation failed to increase the yield, and, as before, the "B" plots confirmed the "A"s. The total produce is 11·7 per cent. less when Nitragin was added than when it was withheld.

EXPERIMENTS WITH LUCERNE AND BROAD RED CLOVER.

Here each plot measured 24 ft. by 9 ft., a path $2\frac{1}{2}$ ft. wide being left between adjoining plots. Three ounces of seed were employed for each plot of lucerne, and $1\frac{1}{2}$ oz. for each clover plot. In neither case were the plots duplicated. The produce was weighed green immediately after cutting, with the following result.

	Weight of Lucerne.	Weight of Clover.
Not Inoculated . . .	lbs. 105	lbs. 159.5
Inoculated	102	155.0
Loss by Inoculation .	3	4.5

In neither case did the Nitragin benefit the plants, the uninoculated produce being heavier by 2.9 per cent. in the case of the lucerne, and 2.8 per cent. in the case of the clover, than that grown upon inoculated ground.

It will thus be seen that only in the case of the peas did the application of Nitragin result in an increase in the yield, but in any case the variations in the weights of of produce are too small to make it possible to say definitely that the inoculating substance had affected growth either one way or another.

These experiments were carried out in a garden attached to the College, in which it may be assumed that peas and beans have frequently been cultivated during recent years. As the soil will thus be well supplied with the bacteria that associate with the roots of these plants, it is not surprising that the application of a pure culture of these bacteria should have been inoperative. But as regards red clover and lucerne, it may safely be assumed that neither of these plants has ever been *cultivated* in the garden, and the probability is that not a single plant of lucerne ever grew in the garden or indeed in any fields in the neighbourhood. The conditions, therefore, were to be regarded as distinctly favourable for exhibiting the action of the specific bacteria of these plants, and yet they failed to produce any effect.

Our experiences in the North of England appear to have been much the same as those of the few other investigators who have tried Nitragin in a practical manner in two or three other parts of the country. Nor does a greater measure of success appear to have attended the use of the substance on the Continent. The manufacturers of Nitragin recently sent a communication to the press, in which they contended that the many cases of failure that had been brought to their notice were to be ascribed to lack of care on the part of investigators, who, it was asserted, had exposed the Nitragin to too much heat or light, or had allowed the bacteria to be conveyed from inoculated to uninoculated ground. Such an explanation carries no conviction to the mind of anyone who is acquainted with the inoculation of soil by bacteria. At a recent meeting of the Associated Chambers of Agriculture, held at Halle, Dr. Kühn gave an account of the experiments with Nitragin which had been carried out during last season by himself, Menzel, and Falcke. All the more important leguminous crops were made use of in these investigations, with the result that in no case did Nitragin produce an increase that could be said to be beyond the range of experimental error admissible in field experiments. In some cases the uninoculated crop was considerably better than that which had been treated with Nitragin, and Kühn finishes his paper by expressing the hope that improvements in the methods of manufacture or application may yet make Nitragin of service in agriculture and horticulture.

There is no doubt that Nitragin will next season get a very careful and extended trial on the part of scientists and practical farmers, although it would have been more encouraging had the trials of the past season given more successful results.