

to be obtained if grain was grown after grain or after potatoes. This behaviour of these crops was explained by Schultz in this way : that lupines or deep-rooted plants leave in the soil after harvest a residue of root, in which a considerable amount of nitrogen has accumulated, an amount sufficient to supply the wants of the following grain crops : that, on the other hand, the application of potash and phosphates, to grain, after a preceding grain crop, is without effect, for the reason that the latter has consumed the stock of nitrogen. Grain crops always reduce this stock ; never increase it. Schultz has given the name of "nitrogen collectors" to the lupines and similar plants, while grains are called "nitrogen consumers." His system of rotation is therefore the following :—Sow first nitrogen collectors (lupines, pease, beans, vetches, clover, lucerne, serradella, &c.), or, as they have been called, renovating crops, and give them 300 pounds kainite per morgen, with perhaps an addition 20 pounds phosphoric acid. After harvesting the nitrogen collectors, sow a nitrogen consumer, raising a grain or exhausting crop, giving it also 300 pounds kainite and 20 pounds phosphoric acid. The grain crop is perfectly successful, because the first crop left behind it nitrogen enough to supply the wants of the grain. In this way the keeping of stock, which is expensive on a poor sandy soil, can be reduced and the purchase of nitrogenous fertilizers dispensed with, because the nitrogen collectors are able to stock the soil with that valuable element.

The foregoing description is taken from Professor König's 'Stickstoff Vorrath,' published in 1887 (Paul Parey, Berlin). It was in 1884, nearly thirty years after the purchase of his sandy farm, that Schultz, of Lupitz, published the results of his experience, although they did not contain anything very new and although they only confirmed experiences still older than his own. But his case was surprising and his explanation of the cause of his successful farming challenged the attention of scientific agriculturists. The consequence has been the issue of many pamphlets on the subject, and an activity in the region of agricultural experimenting which is not yet ended. Atwater, Wagner, Heiden, Hellriegel and many others have participated in these investigations, and Professor Wood, of the Storrs Agricultural School in Connecticut, has given the following general conclusions as the result of the work :—

1. 'Pease, alfalfa, serradella, lupine, clover in all probability, and apparently leguminous plants in general, are able to acquire large quantities of nitrogen from the air during their period of growth.
2. 'There is scarcely room to doubt that the free nitrogen of the air is thus acquired by plants.
3. 'That is a connection between root tubercles and this acquisition of nitrogen is clearly demonstrated. What this connection is, what are the relations of micro-organisms to the root tubercles and the acquisition of nitrogen, and in general how the nitrogen is obtained are questions still to be solved.
4. 'The cereals with which the experiments have been completed have not manifested this power of acquiring nitrogen, nor do they have such tubercles as are found on the roots of legumes.
5. 'In the experiments here reported, the addition of soil infusions did not seem necessary for the production of root tubercles. A plausible supposition is that the micro-organisms or their spores were floating in the air and were deposited in the pots in which the plants grew.
6. 'As a rule the greater the abundance of root tubercles in these experiments, the larger and more vigorous were the plants and the greater was the gain of nitrogen from the air.
7. 'In a number of these experiments, as in similar ones previously reported, there was a loss of nitrogen instead of gain. The loss occurred where there were no root tubercles ; it was especially large with oat plants, and largest where they had the most nitrogen at their disposal in the form of nitrates. As the gain of nitrogen by the legumes helps explain why they act as renovating crops, the loss in the case of the oats suggests a possible reason why they should appear to be an exhausting crop.

Practical inferences :—The ability of legumes to gather nitrogen from the air helps to explain the usefulness of clover, alfalfa, pease, beans, vetches and cow pease as renovating crops, and enforces the importance of these crops to restore fertility to exhausted