THE INOGULATION OF SEED AND SOIL

BY HUBERT M. SKINNER

ONE of the most remarkable scientific discoveries in recent years has proved by practical experiment to be so valuable to the farmer that it is certain to exercise a vast influence on the agriculture of the future in the United States and elsewhere.

The exhaustion of soils has been a source of great discouragement to farmers, and has been a menace to the future of our agricultural interests; for a soil may be rapidly exhausted to the point almost of worthlessness, and the restoring of it to fertility has been an exceedingly expensive, slow and unsatisfactory process.

Soils need, primarily, to contain nitrogen, potash and phophorous. They also need lime. Concerning the latter there is little difficulty, for most of the lands in the United States are well supplied with lime. Wood ashes will replace the potash that has been exhausted, and various phosphates are available to replace the phosphorous; but when the nitrogen is exhausted from the soil, it is found difficult and expensive to restore, and it is useless to attempt to raise the farmer's usual crop without it. The land is then almost valueless for agricultural purposes.

For sixty years or more we have imported nitrates from a very great distance, and at a heavy expense. Ships from our Atlantic ports have sailed the whole length of South America, rounded Cape Horn, and come northward on the Pacific nearly to the equator, in order to secure the rich nitrates contained in the islands off Peru. Their long return trip, with their heavy cargoes, has brought to the American farmers the material upon which they have chiefly depended for restoring the exhausted nitrogen to the soil.

Now, it is a well known fact that nearly four-fifths of the air is nitrogen; further, that this nitrogen is free—not compounded with any other element, but only mixed with the oxygen of the air. Why should not the plants make use of this? It is well known also that plants derive a very large part of their dry matter from the air. It seems perfectly easy for them to absorb the carbon in the atmosphere.

Strange as it may seem, however, the plants ordinarily raised upon the farm will not take nitrogen from the atmosphere, but only from the soil.

Years ago it was discovered that where clover had been grown the soil seemed to become more fertile; and farmers often gave up their fields to clover for a single season and did not harvest the crop, but "plowed it in," with a view to enriching the soil. There was something strange about this. It seemed unaccountable that any plant should enrich the soil, when logically it should be expected to deplete and impoverish it. The enriching of the soil by means of clover was generally attributed to the "plowing in" of the surface growth, and not to anything relating especially to the roots. Now it is discovered that it is to the roots, and not to the stems and leaves of the clover, that the soil is indebted for the additional nitrogen which it receives, and that the "plowing in" may be unnecessary and wasteful.

For many years microscopists have been studying bacteria, or germs. These minute growths are vegetable in their nature and have the power of increasing enormously in an astonishing short period of time, under certain conditions, though at the same time they may be easily and quickly killed where the conditions are not favorable to them. It is now known that many diseases of humanity are the result of the microscopic bacteria, or germs, taken into the human system, where they find the conditions of warmth and moisture, such as to cause them to multiply very quickly and corrupt the entire system in a very short time. Various "cultures," simple pastes or liquids, have been prepared, in which the bacteria find a specially easy and rapid development; and these have been used by biologists for studying the bacteria.

A careful examination of the roots of the clover brought to notice certain little nodules, or balls, attached to them. Placed under the microscope, these turned out to be busy hives of bacteria. Every nodule was a sort of "culture" for propagating these infinitesimal beings. By some process not fully understood, the bacteria in these nodules take up the nitrogen of the air and deposit it in a durable form, thus adding greatly to the productiveness of the soil. An examination of the plants showed that these nodules are found only on plants described as leguminous—that is to say, podbearing plants, such as peas, beans, alfalfa, clover, etc. The particular kind of microbes inhabiting these tiny nodules was developed in "cultures" for scientific experimentation. It was found that the bacteria could be developed, then reduced to a quiescent state, without losing their life. After an indefinite period passed under favorable circumstances in this quiescent state, the bacteria could be put into water of a certain temperature, when immediately they would resume their enormous development.

It was suggested that the seeds of leguminous plants might receive a better start by being inoculated with these bacteria. The experiment was tried and proved a remarkable success. The plants raised from inoculated seeds developed nodules of unheard of size. This singular development upon the roots did not diminish at all the productiveness of the plant above ground, but, on the contrary, increased it to an astonishing degree. The larger the nodules, and, consequently, the greater the permanent benefit received by the land from them, the greater were the crops of clover or alfalfa that were produced. It was not necessary for the farmer to "plow in" his alfalfa in order to obtain the benefit of the nitrogen for the enrichment of his soil. He could make use of his crop, and at the same time receive all the benefit of the improvement of the ground.

The German agricultural scientists, who have made marvelous advances within recent decades, prepared "cultures" of bacteria for the purpose of inoculating the seeds, and sold them to the farmers of Germany.

It seemed, indeed, that the problem of restoring wornout soils without expense or loss had been solved; and German scientists prepared for sale to farmers the germs necessary for the inoculation of the seed. It was found, however, that the results were exceedingly variable, and not to be depended upon, for the reason that the germs were not always active.

It remained to perfect a "culture" which could be depended upon. In this the highest success has been achieved by Dr. Moore of the department of agriculture at Washington, who is said to have deeded to the department, for the free use of the farmers, the results of his discovery or invention which has solved the problem. The bacteria supplied by the department are placed in water of a stated temperature about thirty hours before the planting of the seed, and when developed the liquid containing them is sprinkled upon the seeds. The results are marvelous.

But this is not all. Perhaps the greatest discovery of all is that of the inoculation of the soil itself. It was found that when the soil from a clover field was slightly sprinkled over the surface of a barren field it seemed to impart to the latter a good deal of its own fertility. Evidently the field was inoculated with the germs brought from the clover field. Why should not the soil be inoculated directly

It was found that by sprinkling the fluid containing the germs upon a wagon load of earth, and then scattering the latter over a large field, the whole of the latter would become inoculated. Even fields of barren sand have been inoculated, and with astonishing results. Two small strips of land were planted side by side, one of which had been thus inoculated, while the other had not. The yield from the former was more than eight times the yield from the latter.

There appears to be now no need for sending to Peru for nitrates. It would seem as if there need be no longer any exhausted soil in America. The rosiest view of the subject is taken by farmers who have tried the experiment of inoculating their soil. The larger the nodules developed upon the roots of the alfalfa or clover planted for this purpose the more enormous will be the yield of the plant above ground; and since there is no need to "plow in" the crop, the farmer does not lose the use of his land while he is thus renewing it. Farms that are now practically worthless may be made to yield large crops, and all because we have learned to form nitrates from the atmosphere instead of sending to Peru for them.

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AMERICA LEADS IN MEDICAL SCIENCE

NEW YORK, March 11.—The recent establishment in the city of Cologne of a post-graduate medical school is another instance of the much talked of "American invasion" of Europe, which is disturbing the old-world traditions of science, as well as of commerce. The Cologne institution is the direct result of the foundation in 1882 of the New York Post Graduate Medical school and the new methods of medical instruction first introduced in this country at that time are now being imitated in London and in Germany, the land which for years has been regarded by Americans as the home of science.

As a matter of fact the day when American students in every profession thought it necessary to finish their education abroad has passed. The famous institutions of the old world still hold much of their fascination, but the opportunity to study at Oxford afforded by the bequests of Cecil Rhodes, the African empire builder, aroused much less enthusiasm in this country than it would have even ten years ago. Formerly every American scholar yearned for the classic halls of Oxford and Cambridge, or the atmosphere of solid learning surrounding Heidelberg, Strassbourg, Bonn and the other German universities. The professional man felt himself handicapped unless he had the prestige of a year or two under some celebrated European teacher.

All this is changed now. Even in the arts, though musicians still flock to Vienna and Berlin, and architects and painters to the famous schools of Paris, "the states" are steadily providing more and better facilities, while in those sciences concerned directly with practical life American ingenuity has been as successful as in everyday business. Nowhere, perhaps, is this development so strikingly seen as in the field of medicine and surgery. American surgeons are already recognized as leading the world, and as a medical center New York now ranks with Berlin and Vienna. Oxford has recently called to a prominent chair one of our leading physicians.

The man on the street who suddenly discovers that he needs a physician is not usually in a mood conducive to curiosity as to how his physician obtained the knowledge necessary to cure him, and in the outside world the problems of medical training have aroused little interest compared with the importance of their results. Three things are necessary for the successful study of modern medicine—good teachers, many and varied cases from which to learn by personal observation, and adequate facilities for treating these cases by advanced methods. It is the abundance of all these essentials that has made New York pre-eminently one of the world's medical centers.

New York is not only the largest city of America and the second largest in the world; it is the dumping ground for thousands of immigrants brought each year to our shores. Here hundreds of them stay, among them many incapable of going anywhere else. Of every race on the face of the globe and reared on all kinds of food and under all kinds of circumstances, the most stringent laws and examinations cannot prevent their bringing with them at least the possibilities of every kind of illness. But the more undesirable a man is as a citizen the more useful he is likely to be to the medical student, and cases of disease are seen daily in New York which would not come to the notice of a physician in a smaller place once a year. It is not immigrants alone who provide work for New York physicians. Every ailment that flesh is heir to, whether it comes from the overtaxed nerves of the rich or the under-nourished bodies of the poor, is to be met with here. In addition, the revolution that is being effected in the city by the expenditure of $200,000,000 in railroad and terminal improvements, the erection of skyscrapers and bridges, brings in its train a constant succession of accidents which also provide varied experience for surgeons. Perhaps the only city which can be compared to New York in the variety of the field for medical work is Vienna, and Vienna was for years the cynosure of medical eyes. London, a larger city than either, has not the diversity of population that characterizes New York and Vienna, and the same objection carries weight in the case of Paris and Berlin.

The wideness of the field and the abundance of good to be accomplished in it has resulted in bringing to New York, and in keeping here, medical men whose ability and standing are recognized the world over. The names of practitioners in the borough of Manhattan alone fill 148 closely printed pages of the medical directory, and 80 more pages are devoted to Brooklyn. From the ablest of these men are drawn the teaching staffs of the New York medical schools, men who turn from lucrative practices to give their time to clinical instruction, frequently for nothing, almost invariably for less than the time is worth to them in dollars and cents. To the multitude of persons anxious for treatment, to the abundance of physicians of the highest standing, is added the number of fully equipped hospitals, built by the philanthropy of one of the wealthiest cities in the world and supplied with all the appliances and facilities which modern skill has devised for the treatment of patients. Sixty-eight of these institutions exist in greater New York, and their services must be estimated by even broader standards than the amount of suffering actually relieved by them. To the young physician, with the ink on his coveted parchment hardly dry, a modern hospital is an invaluable school of experience, and an appointment to the staff of the best ones comes as the reward of years of the hardest kind of work in the schools.

Although medicine is being taught more and more through clinical lectures and in hospitals instead of in lecture rooms, there is much which the beginner can acquire almost as well in one place as another. The American tendency in education is unquestionably toward multiplying the number of institutions instead of strengthening those already in existence. This tendency has been carried to an extreme in medicine, and doctors are turned out each year from schools without number throughout the country, when they could better be taken care of by a few thoroughly equipped, centralized institutions. In New York, for instance, the work done by five undergraduate medical colleges could, many authorities say, be accomplished more satisfactorily, as well as more economically, by two. This centralization of effort is one secret of the fame of Vienna, where what is probably the largest hospital in the world, provides an unequaled training school for young doctors.

This impulse toward the multiplication of schools is felt more in undergraduate work than in advance study. Thus it is estimated that in 1904 there were in Chicago 2,912 medical students, in New York 2,827, and in Philadelphia 2,552. From these figures it seems that the three cities offer practically the same facilities, for one would naturally suppose that the most students go to the place where they can obtain the best training. Another set of figures, however, tells another story. The number of post graduate students in Chicago in 1904 was 647. In New York it was 939, and in Philadelphia only 477. In many ways the post graduate statistics, representing as they do a class of men looking for something more difficult to find than a fair undergraduate medical school, are the most significant.

Post graduate instruction in medicine is of comparatively recent development; in fact, it may be said to have come into being with the opening of the New York Post Graduate Medical school and hospital in November, 1882. The usefulness of the departure was immediately apparent, and several schools modeled after the New York institution are now in existence in the country. Post graduate medical instruction is conducted along lines of its own, differing absolutely from the methods of advanced work in other sciences, and also from the methods until very recently in vogue in Europe. In Vienna or Berlin the student becomes a disciple of some noted master and pays directly for the privilege of following him through the hospitals. In such an institution as the New York Post Graduate school the physicians give their services for nothing—an act which some people, who think more of a physician's work in life than of the prosaic fact that he needs money like the rest of us, regard as quite natural—and the fees of the students are used to maintain the hospital, the indispensable supplement of the school.

But perhaps the most striking thing in connection with such institutions is the fact that they are attended not by young men who have just received their degree and are anxious to push their studies a little further before beginning practice, as is the case with embryo school teachers, professors and others who support the post graduate departments of our universities, but by physicians who have been out in the world for ten or fifteen years, and many of whom have built up excellent practices. Of the physicians attending post graduate courses in the New York Post Graduate Medical school the great majority are men who have felt the need of being in touch with the most recent advances in medicine. A busy doctor has little time to devote to study. No man can work all day and study all night, and as years go by the physician finds himself not infrequently behind the procession. It is largely in that it enables such men to catch up that post graduate instruction, is of highest service.

This explains why New York's population of medical students is so largely post graduate. The man fresh from college and anxious to become a physician usually attends the school that is nearest his home and where he can study at least expense. The physician who has ten years of success behind him usually can afford to go where the best instruction is to be had, where he can study the methods of the ablest men and be in the center of medical progress. Another factor which reduces the number of undergraduate medical students in New York is the stringency of the state laws. The degree of M.D. from the institutions of the highest standing does not admit a man to practice in this state, and the state examination, which must be passed, is very rigorous. Such restrictions tend inevitably to restrict the numbers as well as to raise the standard of the undergraduate medical schools.

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