ALFALFA AIDED BY SOIL INOCULATION

SUMMARIZED BY
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FROM BULLETIN BY
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POPULAR EDITION*

OF

BULLETIN NO. 300.

ALFALFA AIDED BY SOIL INOCULATION.

F. H. HALL.

Nitrogen, essential for plants. All plants must have a constant supply of nitrogen or die. Without this element, and a few others, no protoplasm can be produced; and protoplasm is the vital constituent of every living plant cell. Accordingly nitrogen has been considered, ever since the world has known anything of the chemistry of plants, as an essential component of plant food; and it is now, as it has always been, the most costly element in fertilizers.

Nitrogen is, also, in combination with other elements in the group of substances which we call protein, one of the essential constituents, and the most expensive one, of human and animal food.

Though essential to all plants, few of them can take nitrogen from its nearest and most abundant source. Nitrogen makes up four-fifths of the bulk of the atmosphere which covers all plants with a blanket miles in thickness and penetrates the deepest plant tissues; yet none of the higher plants can secure the smallest fraction of their need of nitro-

*This is a brief review of Bulletin No. 300 of this Station, on Inoculation as a Factor in Growing Alfalfa, by H. A. Harding and J. K. Wilson. Any one interested in the detailed account of the investigations will be furnished, on application, with a copy of the complete bulletin. The names of those who so request will be placed on the mailing list to receive future bulletins of the Station, popular or complete as desired. Bulletins are issued at irregular intervals, as investigations are completed, not monthly.
gen direct from the air. They must get it, in a round-about way, from some mineral or chemical supply in the soil or soil water or from the breaking down of animal or vegetable matter.

By reason of the importance and comparative scarcity of nitrogen in available form, the desirability of increasing the supply for farm crops and of growing the crops rich in protein for the feeding of farm animals is increasingly manifest,—the more so, as some sources of fertilizer nitrogen are nearing exhaustion and commercial sources of food protein are increasing in price. Indeed, so serious did the situation appear to one English scientist that he prophesied, a decade or so ago, that the human race was rapidly approaching a time of starvation and numerical decimation through failure in nitrogen supply. More optimistic views prevail to-day; but great effort is still being made to increase the available supply of nitrogen. New physico-chemical methods of securing nitrogen from the air in forms available to plants have proven fairly successful; and we are daily learning more of the possibilities latent in the fact that the crop-grower can secure nitrogen from the air, without chemicals or machinery, by the aid of one group of plants,—the legumes.

Legumes aid in securing nitrogen.

The legumes differ from practically all other plants in this one respect. Through them we can secure nitrogen from the air. Just how much they take from the air or from the soil under different condition no one knows with exactness; but, in some cases, after growing a good crop of alfalfa, clover, cowpeas or soy beans, the soil may be as rich or richer in nitrogen than it was before the seed was sown. The roots, stubble and fallen leaves return to the soil as much or more nitrogen, drawn from the air, than the harvested crop removes from the soil.

The legumes are also richer in protein than other plants; so that by their growth the protein in the feed bin or hay mow is greatly increased; and, at the same time, the soil is enriched in nitrogen.
But the legumes do not, in themselves, have any more power than other species of higher plants of taking nitrogen directly from the air and turning it to their own uses. It is only because the legumes serve as hosts (or homes) of a particular group of plants of extremely low order — one species among the thousands of species of bacteria — that they differ from wheat, cabbages or potatoes.

The bacteria of this particular group have this wonderful power of taking in the free nitrogen of the air and turning it into forms that very soon become available to the pea, bean, clover and alfalfa plants on whose roots and in whose tissues the bacteria live. These minute single-celled plants live principally in colonies in the form of small globes, knots or protuberances, which we call nodules, on the roots or root hairs of the host plants. Why they thus associate themselves with legumes and legumes only; what, if anything, they secure from the legumes; how they utilize the nitrogen from the air; or how the host legumes avail themselves of it we do not know with certainty. That they do get nitrogen from the air and that the legumes use it is proven beyond doubt; and we can turn the process to advantage even though we know far less than we would like about the details of the transformation.

Preeminent among all the legumes it is possible to grow in New York State is alfalfa. This is richer in protein than any other legume that can be grown successfully in the north, a field of it once established gives three or four cuttings each season for several years, and the yields under favorable conditions are remarkable. The praises of the crop have been widely and loudly sung, but not more widely or louder than the plant deserves; for where it will grow well no crop can approach it in value of food nutrients produced, and, when it is finally necessary to break up an alfalfa sod, the store of vegetable matter and accumulated nitrogen in the soil gives an impulse to the following crop which proves the great value of the plants as nitrogen gatherers.
But all too often attempts to grow alfalfa in this State have failed; and one of the causes for failure has been the lack in the soil of enough of the nitrogen-gathering bacteria to inoculate well the seedling plants. Alfalfa is slow in starting and quite tender at first, though very hardy later. Without the stimulus given by the readily available nitrogen secured from the bacterial nodules on their roots, the little seedlings fail to conquer slight adverse conditions and die during the first summer, fall or winter. With nodules numerous and bacteria active, the young plants grow rapidly, become dark green in color, branch freely, send strong roots deep into the soil and are ready by winter to endure hardship. The difference between total failure and good success is often a question of the presence or absence of the proper bacteria.

The bacteria upon all legumes are so nearly alike that the bacteriologist cannot tell them apart under the microscope or by the most delicate tests known to him, and he therefore places them all in a single species; yet there are, apparently, strains of this species, each of which will live only upon particular legumes or small groups of legumes, as upon the red clover and its close relatives, upon certain vetches, upon the cowpea, upon the common bean, or upon alfalfa and sweet clover, but will not live upon any other legume than the one to which it has become accustomed. For example, clover or peas or beans might grow well upon a particular soil and show large and plentiful nodules of bacteria upon their roots, yet alfalfa seedlings on the same soil would be entirely free from nodules and would grow but feebly. To make them do well it is necessary to furnish the plants with some of the bacteria that have grown on other alfalfa roots, or their descendants.

This furnishing of bacteria to the plants is known as "inoculation." It may be "natural," when the proper bacteria already exist in the soil and sowing the alfalfa seed brings the little plants under conditions where they benefit by the presence of the bacteria; or it may be "artificial," when the bac-
teria are lacking and have to be introduced into the soil in some way.

With our common legumes artificial inoculation is seldom needed, since crops like clover, alsike, peas and beans have been so long and so generally grown that practically all soils are well supplied with the necessary bacteria to inoculate the plants. When a new leguminous plant is introduced into a section, however, artificial inoculation is often of great advantage. Alfalfa has been grown in some parts of New York State for a quarter of a century or more, as upon the Station farm and over a considerable area near Syracuse. In such places artificial inoculation is not needed for alfalfa any more than for red clover; but in most of the counties of the State alfalfa was practically unknown five years ago and its cultivation is not general even to-day. Under such conditions inoculation is quite liable to be needed; and the Station has collected data that show this to be true in a large majority of cases.

One of the most common and as yet, most effective means of inoculating alfalfa with the desired bacteria is to sow on the new field, just before seeding or with the seed, from 150 to 300 pounds to the acre of soil from an old, successful alfalfa field. Believing in alfalfa, as the Station investigators do, and having very successful fields of it, the Station has offered to supply to intending growers sufficient soil from these fields to inoculate an acre of land. Beginning with 1905, a record has been kept of the inoculating soil sent out and a careful effort made to secure trustworthy reports as to the success or failure of the inoculation. One requirement imposed upon the growers was that each should leave an uninoculated area for comparison with that inoculated. At various times report blanks were sent out, on which the growers were requested to state the condition of the alfalfa on inoculated and uninoculated areas, and also to make careful examination of the roots of several plants on each plat to ascertain whether nodules were present and whether they were abundant.
or scanty. Wherever possible—and this was in a large majority of the fields—the test plats were visited by a member of the Station staff to confirm and extend the grower’s data. As the first winter is a critical period for alfalfa no report of success or failure is considered final until crops have been harvested the second season; therefore this bulletin does not consider fields established in 1907. The data cover only fields started in 1905 and 1906, upon which proper test conditions were observed and upon which trustworthy and accurate reports were secured. The reports include 65 fields in 33 different counties of the State. More than 50 other experiments were started, in several of which excellent yields of alfalfa were secured; but through omission of check plats, errors in distributing the soil, transfer of inoculation by drainage water and similar mishaps, or through failure to secure full reports, the results cannot be used.

As examinations of the roots of plants in each untreated plat were made, we have an index to the distribution and extent of natural inoculation for alfalfa. In only 13 of the 65 experiments was the natural inoculation sufficient to give a satisfactory crop of alfalfa. In other words, without artificial inoculation the chances are about five to one against success with alfalfa outside the accepted alfalfa sections of the State.

In many cases where the natural inoculation was not sufficient for a successful crop on the check plats, there would be a few scattering plants which stood out among their neighbors through their greenness and vigor. The roots of these few plants would usually show the nodules in considerable abundance. In other cases some few, small nodules might be found on some plants by careful examination. In both cases, the crop was a failure, since the inoculation was either not generally distributed or was too scanty. Had the owners been content to waste a year or two and seed for one or two sowings, it is possible that success might have been secured by reseeding the plat to alfalfa; as the bacteria would be likely to spread and to multiply during the fitting process and subsequent seedings.
Just where the natural inoculation originates is uncertain; possibly, though not probably, from germs on the alfalfa seed; more likely from germs on some other legume like sweet clover or burr clover, which adapt themselves with little or no difficulty to alfalfa.

On those portions of the test plats where the inoculating soil was distributed, 46 of the 65 artificial crops were successful. That is, artificial inoculation by means of soil from an established alfalfa field raised the percentage of success to 70 per ct. as compared with 20 per ct. from natural inoculation. This is an excellent showing and would seem to indicate that the prospect for success with alfalfa when the land is properly fitted and when careful attention is given to inoculation is nearly as good as for farm crops in general.

Of course the number of test fields, 65, is too small to prove that it is possible to grow alfalfa anywhere in New York State; but the successes were widely distributed and the soil of the fields varied from loose sand to heavy clay loam underlaid with resistant hardpan. It is at least safe to say that “the successful growing of alfalfa is not a matter of regional or climatic differences but depends upon the past treatment and present condition of the particular field in which it is grown.”

Farmers were much interested and their hopes of were raised high by the announcement made a few years ago that a much less cumbersome method of inoculating legumes had been perfected. This was the “dried cotton culture” method or, as distributed commercially, “Nitroculture.” By this method some central agency grows the alfalfa bacteria in pure cultures until the culture liquid becomes heavily charged with the germs. Absorbent cotton is then saturated with the culture, dried rapidly and divided into packages which are sent or sold, with certain chemicals, to the intending grower. The latter renews the culture by dissolving in water the chemicals sent and immersing the cotton in the solution. This new culture is allowed to grow for a day or two and then used to inoculate the seed of the legume for which it is intended.
Unfortunately the method has not been successful. It proved impossible, in the bacteriological laboratories of this station and other investigating institutions, to find enough living germs in the cultures propagated from the dried cotton to insure successful inoculation even under most favorable conditions. Other tests, in the field, by many other stations confirmed the results secured in our laboratory; and, in consequence, the method has been practically abandoned. The U. S. Department of Agriculture and a few stations have reported success from the use of seed-inoculating cultures sent out in liquid form, but in tests made at this Station by a very similar method the percentage of successes has been small.

In these tests eighteen farmers co-operated and Station test of reported the result. Each farmer sent to the seed Station a portion of the seed he intended to inoculation. sow. These samples were inoculated by soaking in pure cultures of the alfalfa bacteria grown in the Station laboratory and apparently well stocked with vigorous germs. After drying, the seed was returned to its sender and soon sown in part of the field devoted to alfalfa. In all cases check plats were left, and in most cases the growers also used inoculating soil on other plats.

In only two of the eighteen experiments was there any apparent effect from the bacteria upon the inoculated seed, a disappointing and somewhat surprising result.

In farm practice, then, it seems safest to depend on the use of 150 to 300 pounds to the acre of soil from a successful alfalfa field in order to secure the desired bacterial inoculation. Without this inoculation the chances are 4 or 5 to 1 against success, while with it 70 per ct. of the fields gave satisfactory crops. At present, no method of seed inoculation can be recommended.