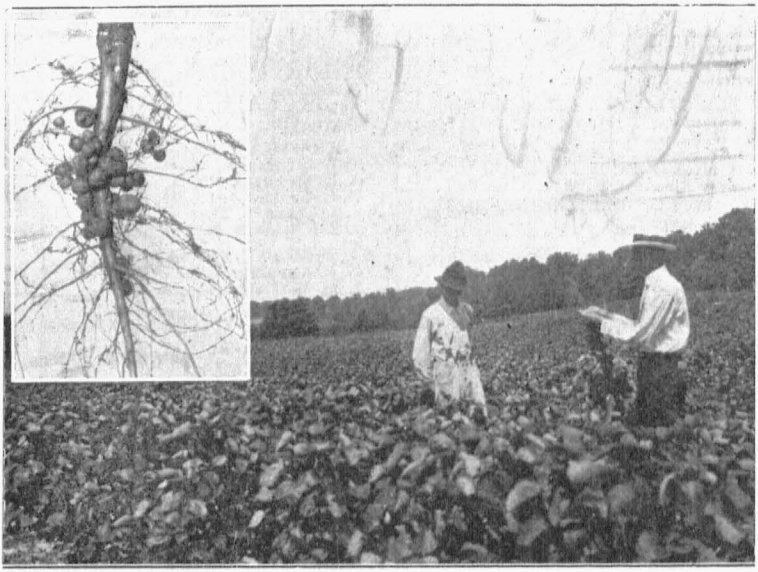
UNIVERSITY OF MISSOURI COLLEGE OF AGRICULTURE
AGRICULTURAL EXPERIMENT STATION
BULLETIN 282

Legume Inoculation



Inoculated legumes make good feed and improve the soil.

COLUMBIA, MISSOURI
MARCH, 1930

Legume Inoculation

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Legumes are so widely recognized as a desirable crop that many questions arise regarding their proper management. Some of the inquiries received with reference to the inoculation of legumes are assembled and their answers given in this bulletin, as a help toward getting the benefits from inoculated legumes as better feed and as greater soil improvement.

Why are legumes so often recommended as a good crop?

Legumes are prominent crops, (1) because they are considered a very good feed, (2) they can do better than other crops on lands which are thin or low in nitrogen fertility, and (3) they can keep up, or even increase, the fertility of the soil with respect to nitrogen.

Why are legumes considered valuable feeds?

Because they are high in protein, which is the essential nutrient that is deficient in most feeds and is costly to purchase in concentrates. They are also rich in phosphorus, lime, and other essential minerals, all of which make them a choice feed.

Why can legumes grow on "thin" land?

Thin lands are low in organic matter, and are consequently low in nitrogen, which is an element necessary for plant growth. Since legumes get their nitrogen from the air, the shortage of nitrogen on thin land does not stunt their growth as it does those crops depending upon the soil for their nitrogen.

How are legumes different from other crops?

Legumes require all the attention in seeding that is given to any crop. In addition they must have present in the soil their own particular kind of bacteria to form nodules on the roots. They are unlike other crops in this one respect. Corn, wheat, and other common crops do not require particular bacteria.

Why should we be concerned about bacteria for legumes?

The bacteria live in the root nodules and are the particular equipment through which the legumes are able to use the nitrogen of the atmosphere. The bacteria make available for the legume crop the seventy million pounds of nitrogen in the air over every acre of land, instead of leaving the crop to depend on two or three thousand pounds of nitrogen in an unavailable form in the soil organic matter, or humus. Without these bacteria the legumes are forced to depend upon soil nitrogen just the same as any other crop, and their growth will be determined by that nitrogen which the soil can provide.

How can one be certain that the soil needs legume bacteria?

Whenever a legume grows on a soil without producing root nodules, it is certain that the proper bacteria are not available to the plant. There is no simple soil test for the presence of the proper legume bacteria, or whether inoculation is necessary.

What is inoculation?

Inoculation is the practice of providing the proper legume bacteria when the crop is seeded. It is merely a means of making certain that when the roots of the legume crop grow through the soil they will find the proper bacteria which supply the nitrogen from the air.

Does inoculation cure sour soil or take the place of limestone?

Since legumes have failed in some cases on account of sour soils, and in other cases on account of lack of proper inoculation, there has been some confusion in thinking that inoculation cures sour soils. Inoculation cannot take the place of limestone in correcting soil acidity. Limestone is the only cure for sour soils and is the only method of establishing legumes sensitive in this respect. The bacteria of these acid sensitive legumes also require a sweet soil and inoculation will be improved in many soils after lime application.

Does inoculation substitute for manure or phosphates?

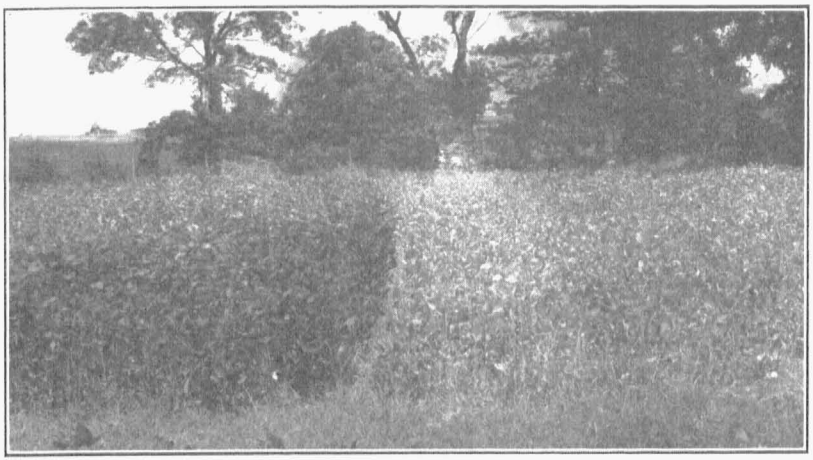
Inoculation is not a substitute for all of the elements needed to produce a crop. It is only a means of enabling the legume crop to help itself to the nitrogen of the atmosphere. It cannot provide the crop with any other plant food. It cannot offset the soil's deficiency in any respect except in its supply of nitrogen.

Does inoculation succeed on all soils?

The simple introduction of legume bacteria into a soil with the first legume crop does not necessarily guarantee extensive activities by these bacteria. They must have time to become established under the soil conditions just as a new plant must become accustomed to new environment. On excessively sour soils, or on wet and poorly drained soils, they do not establish themselves so readily. They multiply more rapidly in the roots of their host legume; consequently, they are more numerous in the soil after two or three legume crops have been grown.

Do soil conditions influence the success of inoculation?

Bacteria are similar to plants in their food requirements, consequently poor soil conditions will disturb the bacteria. They will live and multiply more rapidly in better soils than in poor soils. They are sensitive to acidity, to lack of air by poor drainage, or to low temperatures. In consequence, the inoculation may not be as effective on soybeans planted early, or on alfalfa on very sour land, or any crop on soil with poor drainage.



This field on a Boone county farm shows the effect of inoculation upon soybeans The part on the left was well inoculated while the part on the right received no inoculation.

Differences shown by the soybean roots from the same farm as shown above. The roots on the left are from the inoculated part while those on the right are from the part of the field receiving no inocula tion.

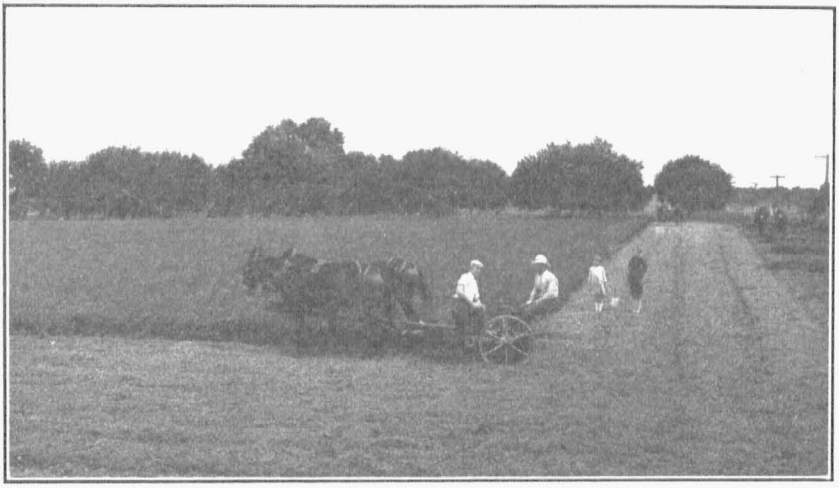
How does inoculation serve as a nitrogen gathering factory?

Inoculation introduces into the soil a particular group of bacteria, that, unlike most other forms of life, can use the gaseous nitrogen of the air instead of being forced to take their nitrogen in a combined form. Common plants cannot use gaseous nitrogen but must have it combined with some other element. Animals demand their nitrogen combined in

the form of protein. The legume bacteria are a simple life form that takes the nitrogen of the air and fixes it, or combines it, with other elements, passing it on to the plant. This nitrogen so combined and put up in the form of plant tissue is the output then of these bacteria as a nitrogen-fixing factory.

How does inoculation improve the feeding value of legumes?

Inoculation provides the plant with an unlimited supply of nitrogen. It is the nitrogen supply which determines the protein that a legume can produce. As more nitrogen is provided, the hay or feed becomes richer



A good stand of alfalfa demands thorough inoculation

in protein. Inoculation, then helps to increase the protein content of the legume hay. If the plant has more bacteria on its roots, the legume hay is richer in protein. Hay from soybeans which were not inoculated contained 151 pounds of protein per ton, while the hay from the inoculated crop contained 298 pounds of protein per ton. Inoculation meant a hay richer by 147 pounds of protein per ton. Because legumes are rich in protein, they can substitute for much of the protein purchased in the form of tankage, cotton seed meal, or linseed meal in common feeding operations. One can well afford to think of inoculation as a help in growing more protein on the farm in place of purchasing it in the market.

Do the root nodules enrich the soil?

The root nodules do not function to put nitrogen into the soil directly. They are not the stored supply of nitrogen taken from the air. They are part of the plant growth in which the bacteria multiply by using air nitrogen which through some unknown means, is passed on

to the plant. The nodules are the factory in which the bacteria multiply and do their beneficial work.

How do inoculated legumes serve to increase soil fertility?

Legumes with their nodule bacteria serve to take the nitrogen out of the atmosphere and fix or combine it into compounds that are retained by the legume plants. When these legume plants are fed and the manure from them returned to the soil, or when plowed under as green

Sweet clover can serve as a soil builder only when well inoculated. This growth was obtained on a Scott county farm.

manure, they put into the soil the nitrogen so taken from the atmosphere. In this manner legumes are a nitrogen-fixing factory to put the air nitrogen into the soil to be used by other plants. Legumes improve the soil fertility only in so far, (1) as they are well inoculated, and (2) as they go back into the soil on which they grew.

How can one get bacteria with which to inoculate?

The soil in which a legume crop grew with plenty of nodules will supply bacteria for the same crop on a new field. Artificial cultures of legume bacteria are grown in many laboratories for the purpose of inoculating soils in which these bacteria are not present.

How is the soil method of inoculation used?

The inoculated soil should be gathered from a field growing the same legume in question and producing plenty of nodules. This soil can either be scattered on a new field at the rate of several hundred pounds per acre, or it may be applied by mixing it with the seed. In the latter method enough soil should be used to make every seed dirty. Increasing amounts of soil improve the inoculation.

Is there any danger in using the soil method?

It is possible to carry plant disease from one field to another by using the soil method. One should be certain that the source of the soil will not also be a source of such trouble.

What are the artificial cultures of legume bacteria?

They are the special bacteria suited for their respective legumes and grown in the laboratory for the purpose of using them to inoculate seedings on soils in which the proper bacteria are not present.

Are artificial cultures reliable?

Artificial cultures are now being produced by many commercial concerns. The method of making and using these cultures has become so well established that they are entirely reliable when the instructions are followed. There is no difficulty in obtaining good commercial cultures.

Where can artificial cultures be obtained?

Artificial cultures for legume inoculation can now be obtained through most seed houses, or commercial concerns. The soils department, of the Missouri College of Agriculture is also able to supply artificial cultures of legume bacteria as a service to Missouri farmers in helping them establish more legumes and thus grow better feed and increase their soil fertility.

How are artificial cultures used?

They are diluted with water and applied to the seed when the crop is planted. Complete instructions are supplied with commercial cultures, and there should be no difficulty in their use.

Do different legumes require different bacteria?

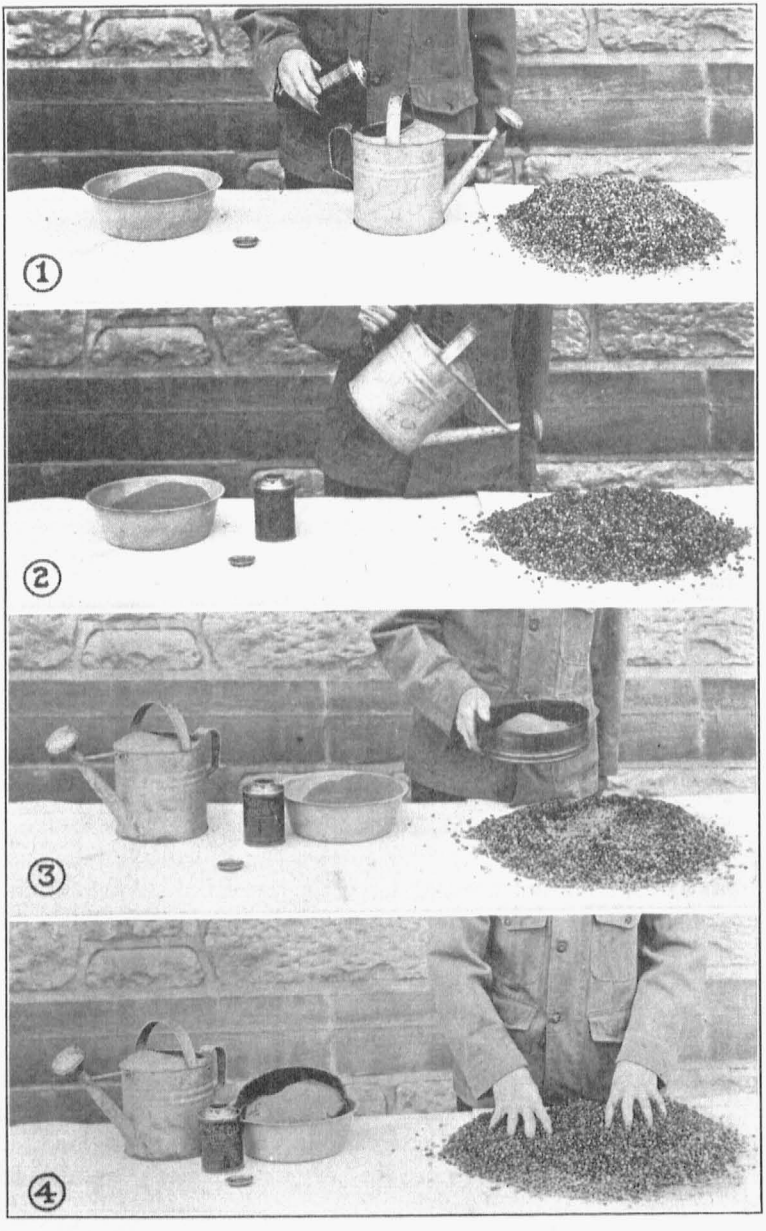
The bacteria are particular in their association with the legume plants and will succeed only on the particular legume to which they are suited. One kind of bacteria will grow on soybeans. Alfalfa and sweet clover require another kind of bacteria. The common clovers have their own bacteria, while for the peas and vetches another kind of bacteria is necessary.

Can artificial cultures be stored for any length of time?

Since bacteria are a living organism and growing on a particular medium, they cannot be stored indefinitely without exhausting their food supply or becoming less active. On this account it is advisable to use fresh cultures and without storing them any undue length of time. These cultures will keep long enough to allow for any irregularity in planting date. Most artificial cultures are labelled with a date beyond which they are not considered reliable.

May one store inoculated seed?

Bacteria, when inoculated on the seed, do not remain alive for any great length of time. It is advisable to plant the inoculated seed promptly.



Inoculation by the Soil Method. (1) Making the glue solution. (2) Sprinkling the seeds. (3) Applying the infected soil. (4) Mixing the soil and seed.

Do commercial fertilizers used with inoculated seed injure the bacteria?

Some experiments on this question indicate that there is no great danger. Some trials suggest that where the fertilizer does not come in contact with the seed, its addition may even improve the success of the inoculation.

Must one inoculate a soil more than once?

In some soils a single inoculation will result in a large number of nodules on the first crop of the legume. In other soils a single treatment may give but a few, sparse nodules. It requires time for the bacteria to become established just as it requires time to establish a crop of grass, for example. As a second seeding of grass is often necessary to guarantee a stand, so a second inoculation may be necessary to establish well the legume bacteria in the soil. Sometimes the second crop of the legume without inoculation will serve to increase the bacteria since the crop growth is a means of multiplying the few scattered bacteria originally present in the soil. In general, it may be said that the repetition of the particular legume crop will increase the thoroughness of the inoculation.

Do legume bacteria help get a stand?

Legume bacteria cannot substitute for poor seed, nor can they take the place of poor seed bed preparation. They can help in guaranteeing a stand only where the deficiency in the soil's nitrogen is a handicap to the legume.

What precautions are necessary in growing legumes?

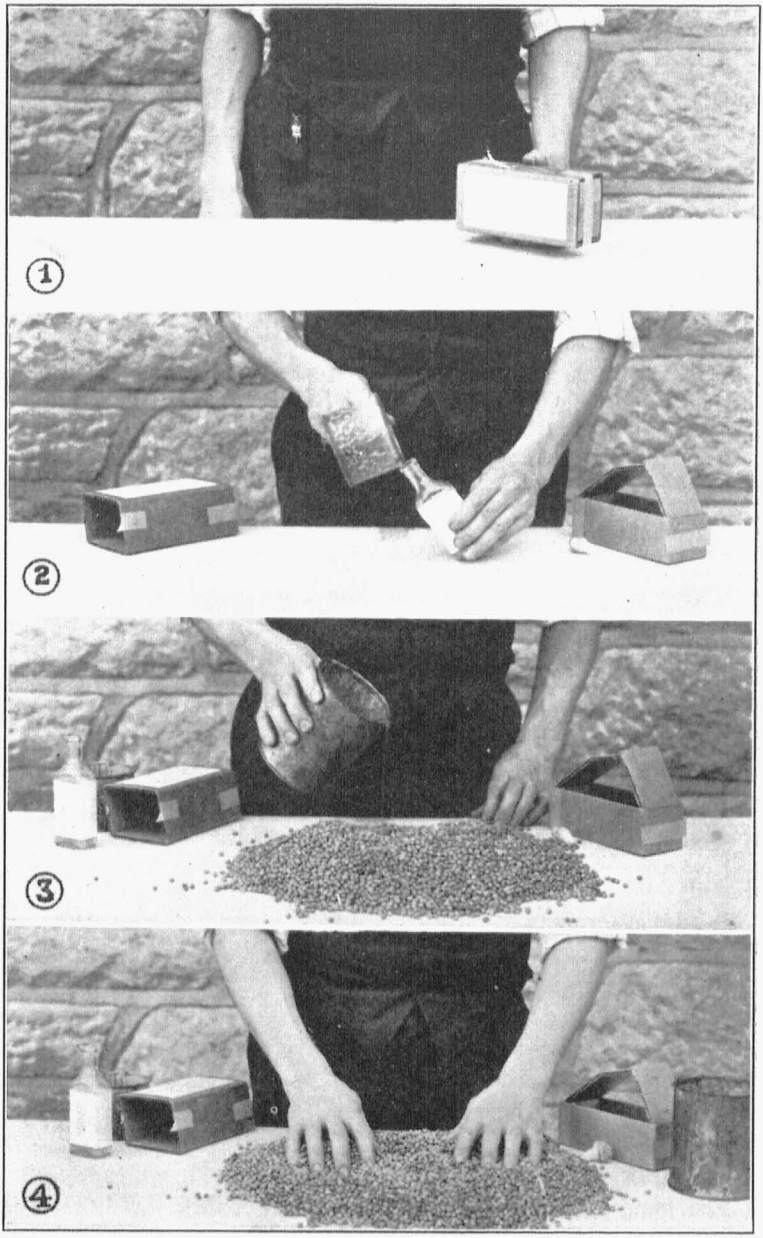
Legumes require a good seed bed. Most legumes require a limed soil. This is especially true for alfalfa and sweet clover. The seed should be free of weeds, should germinate well, and should be suited to the place and purpose of the crop. In addition to this, the legume should be inoculated with a proper bacteria suited to the particular legume. Seeds planted in this way on good soil and in a good seed bed should do much toward guaranteeing a crop that will not only be excellent feed, but that will serve in soil improvement.

Why should Missouri increase the legume acreage?

Because legumes are good feed, and because an increase in acreage of legumes will supply more feed of high nutritive value than is now produced. Because legumes contribute to soil upkeep and as they are grown more extensively the soil will be improved in fertility to raise the yields of other crops. As more acreage is put into legumes, the increased fertility through their use will raise the yields per acre of the grains and result in more economical production.

DISTRIBUTION OF CULTURES

The laboratory of the Department of Soils, University of Missouri, is growing the bacteria for soybeans, sweet clover, alfalfa and other



Inoculation by Artificial Cultures. (1) The Culture. (2) Adding water to culture. (3) Applying culture to seed. (4) Mixing moistened seed.

legumes for distribution among the farmers of the State at cost of production and delivery. These are grown on vegetable jelly, from which they are washed and put on the seed. Complete directions for use are sent with them. They are recommended where no infected soil is readily available. No guarantee for the cultures is possible other than that they leave the laboratory in good condition.

WHY INOCULATE—

Because it makes bigger legume crops.
Because it means hay with higher feeding value.
Because more nitrogen is left by the roots in the soil.
Because it gives more nitrogen to go back to the soil as farm manure or green manure.
Because it makes a deeper rooting crop that helps to bring up to the surface some plant food minerals from the deeper soil layers.

WHEN TO INOCULATE—

When the legume has never been grown before.
When the legume has not been grown on the field recently.
When the legume goes on a field where one is not certain that it has grown before.
When the legume goes on a sour soil recently limed.

LEGUME GUMPTION

When in doubt, inoculate!

Grow legumes for feed and improve the soil at the same time.

The principle of inoculation has never been comdemned although the methods of distributing bacteria once were.

"Bacteria on legumes not only work for nothing, but even pay for the privilege."

Inoculated legumes can use the bountiful stock of nitrogen in the free air which pervades even the soil; other crops must depend on the limited supply of costly soil nitrogen.

Legumes and bacteria are good illustrations of cooperation. Working separately, they suffer; working cooperatively, they prosper.

Earlier farming which did not demand present high yields nor consider the need of maintaining the soil might afford to disregard inoculation; progressive farming cannot.

Inoculation is no cure for all legume failures. It will not replace good seed, good seed-bed, tillage, lime and soil fertility.

A good crop of inoculated legumes is like a Muscle Shoals nitrogen gathering factory on one's own farm.

Farming without legumes may be compared to writing checks on the bank without making any deposits.