

MOSCOW, OCTOBER 1947

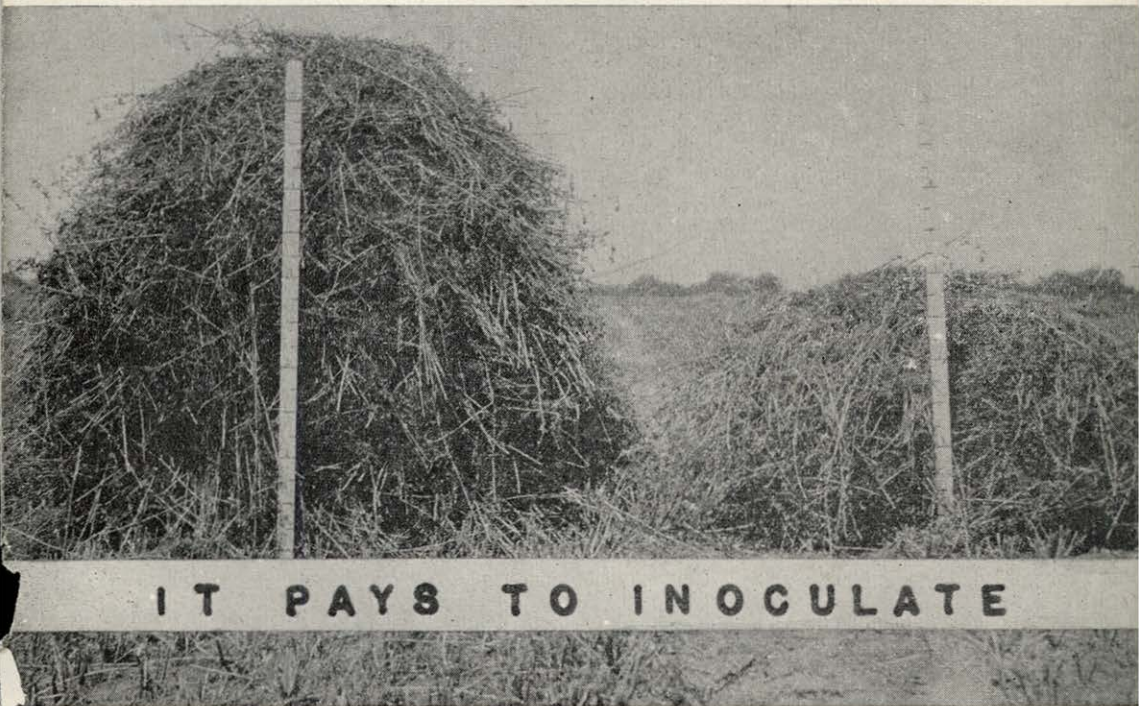
EXTENSION CIRCULAR NO. 101

UNIVERSITY OF IDAHO
COLLEGE OF AGRICULTURE
Extension Division

D. R. THEOPHILUS
Director

Inoculation of Legumes

V. A. CHERRINGTON AND K. H. KLAGES



COOPERATIVE EXTENSION SERVICE IN AGRICULTURE AND HOME ECONOMICS
OF THE STATE OF IDAHO, UNIVERSITY OF IDAHO COLLEGE OF
AGRICULTURE, AND THE UNITED STATES DEPARTMENT
OF AGRICULTURE, COOPERATING

Printed and distributed in furtherance of the purposes of the Cooperative Agricultural
Extension Service provided for in Act of Congress, May 8, 1914.

TABLE OF CONTENTS

	Page
How May Inoculation be Obtained?.....	3
What are Root-Nodules?.....	4
Where are Nodules Found in the Soil?.....	5
When is Inoculation Necessary?.....	5
When is Inoculation Unnecessary?.....	6
Will the Same Bacteria Inoculate all Legumes?.....	6
What are Some Inoculation "Don'ts"?.....	8

Inoculation of Legumes

V. A. CHERRINGTON AND K. H. KLAGES¹

THE problem of raising larger crops and keeping up the fertility of the soil is similar to that of maintaining one's good health. It usually consists of encouraging the friendly bacteria and controlling the harmful ones. The most striking example of friendly bacterial action is found in the growth of all legumes including clover, alfalfa, beans, peas, vetch, and others. When these plants grow in the presence of certain bacteria, they form swellings on their roots called nodules. These nodules enable the plant to make use of nitrogen from the air. Not only is a better growth and an increased yield obtained from legumes having nodules, but the soil is enriched by the addition of readily available organic nitrogen.

The legume, however, is powerless to maintain or increase soil fertility unless the friendly bacteria are present. If nodules are not present, the growth of legumes is limited by the amount of plant food in the soil, and production of legume plants results in depletion of soil fertility. The nodule-producing bacteria take care that the legume does not rob the soil. Properly inoculated legumes leave the soil in better condition than it was before they grew. *In other words, these friendly bacteria make available for the legume crop some of the seventy million pounds of nitrogen contained in the air over every acre of land.*

How May Inoculation Be Obtained?

Inoculating soils with friendly bacteria, capable of producing nodules on legumes, may be done in a number of ways. At one time the soil transfer method was used but at present the pure culture method is most commonly employed. The soil method consists of removing soil from a field known to contain the desired bacteria and spreading it on the field to be inoculated. Naturally, this method has many disadvantages. It requires a great deal of time and labor, and there is always danger of transmitting plant diseases and weed seeds. For these reasons the pure culture method is recommended.

A pure culture is a growth of bacteria that contains only one certain strain of organisms. Cultures for legumes are grown from

¹Bacteriologist and Agronomist, Agricultural Experiment Station, respectively.

a single bacterial cell obtained from the interior of a nodule, and are free from all other types of organisms. Each culture contains many millions of living root-nodule bacteria. These bacteria are capable of producing nodules on the roots of the same variety, or related varieties of legumes, from which they have been isolated. Pure cultures are on sale for the inoculation of all kinds of legumes. Some of these are sold in the form of jelly, others in liquids, and still others in soil preparations. Furthermore, the culture may be sold as a mixed culture, containing all the kinds of bacteria necessary for inoculating legumes, and in addition, other forms of friendly bacteria. All of these cultures should be mixed with water or other liquids and sprinkled over the seed that is to be planted. Care should be taken not to use more water than is necessary to moisten the seed. The seed serves as a carrier of the bacteria to the soil. Inoculation applied in this manner enables the young roots to begin drawing nitrogen from the air as soon as the plant can use it. Cultures can usually be obtained at most seed and feed stores at a reasonable price.

What Are Root-Nodules?

Correctly described, nodules are enlarged root hairs, sometimes resembling galls and occurring principally on the lateral or branching roots. They never occur in the tissues of the larger roots and, most important, they never distort the growth of the main root to which they may be attached. Often, they are of the same color as the main root to which they are attached, but young nodules may be of a pinkish color while the older ones are usually darker. All stages may be found on old alfalfa roots, especially when the new shoots are about six inches high.

The nodules produced on the roots of different legumes vary considerably in size and shape. The spherical nodule of the bean is entirely different from the many-lobed nodule of the pea, and these two are quite different from the small, weakly attached nodule of red clover. This variation often leads to doubt or confusion in recognizing a nodule. The following description will serve to distinguish the various nodule types.

Types of Nodules

1. Field bean nodules are globular or ball-like, resembling small peas. They are usually $\frac{1}{8}$ inch to $\frac{1}{4}$ inch in diameter, but may be as large as a marble. Usually they are found on the secondary roots, hence easily lost when the plant is removed from the soil. Several nodules may be pressed together forming large knots,

gall-like in appearance. These are found on soybeans, cowpeas, and velvet beans.

2. Red clover nodules are pear-shaped, about $\frac{1}{8}$ inch long and half as wide. The sides are sometimes flattened with a distinct notch or constriction in the free end. They are rarely grouped in fringe-like bunches, but thickly scattered along the main and lateral roots. These nodules are found on the various clovers and alfalfas.

3. Vetch nodules are a coalescence of several individuals of the red clover type into one form. The stubby rounded ends form knobs of irregular shapes.

4. Garden pea nodules may occur singly resembling the red clover type, but are more firmly attached to the root. The pear shape is not so pronounced. Usually they are found in clumps similar to the vetches, but the knobs are more elongated. Often the clump assumes a ball-like form $\frac{1}{4}$ to $\frac{3}{4}$ inch in diameter with numerous finger-like projections. These are found on Canada field peas, and sweet peas.

Where Are Nodules Found In the Soil?

Since the nodules of the vetches and peas are attached firmly to the roots, their presence is readily determined, especially in moist soil, by simply pulling up the plant. Where nodules are very delicately attached, the soil must be loosened with a spade or fork, but even this method will break off many of them. The only sure method is to remove the plant with a generous quantity of soil and carefully wash the soil off the roots in a pail of water. In this way even delicately attached nodules can be seen.

When is Inoculation Necessary?

There can be no fixed rules regarding inoculation, but the following suggestions regarding the most favorable conditions for applying cultures are submitted:

1. Inoculate all new soils, both irrigated and non-irrigated.

2. Inoculate with the specific organism for a specific legume if that legume has never been planted on the field in question.
3. Inoculate if the specific legume has not been grown on the field for a period of four or more years.
4. Inoculate if the soil produces a poor growth of legumes. If, however, some of these legumes produce nodules, a vigorous inoculation is usually secured the second year without further attention.

When is Inoculation Unnecessary?

If the legume in question is producing maximum yields and the roots show an abundance of nodules, it is usually unnecessary to inoculate. If, however, the owner is in doubt as to the vigor of the root-nodule bacteria in the soil he should re-inoculate. Cultures of nitrogen-fixing bacteria are not the same as nitrogenous fertilizers and do not increase yields under all conditions. These bacteria are tiny plants and like plants require certain conditions to grow.

The condition of each individual field must be known in order to prophesy whether or not inoculation will be successful. For this reason "Inoculation Don'ts" are appended in order that most questions pertaining to inoculation may be answered.

Will the Same Bacteria Inoculate All Legumes?

There are many strains of nodule-producing bacteria, each of which will cause nodules to be formed on a specific group of legumes, but not on other groups. For instance, the bacteria forming nodules on beans will not form them on clover, vetch, or peas. Likewise, the specific bacteria for clover, vetch, or peas, will inoculate only the specific group of legumes from which it has been isolated. There is only one safe rule to follow, namely, to inoculate a certain legume with the specific form of bacteria that has been cultivated to produce nodules on that legume. The bacteria isolated from any plant in any one of the following groups will inoculate the other members of that group, but no others.

Groups of Legumes Each of Which Has Its Special Bacteria**1. *Alfalfa Group***

Alfalfa
White sweet clover
Yellow sweet clover
Huban clover
Bitter clover
Button clover
Yellow trefoil
Bur clover

2. *Clover Group*

Common red clover
Mammoth red clover
White clover
Ladino clover
Alsike clover
Strawberry clover
Sub or Subterranean clover
Berseem or Egyptian clover
Hop clover

3. *Vetch Group*

Field and garden peas
Lentil
Common vetch
Hairy vetch
Broad or horse bean
Sweet pea

4. *Bean Group*

Field and garden beans
Scarlet runner bean
Pinto Bean

5. *Lupine Group*

Lupines
Serradella

6. *Cowpea Group*

Cowpea
Lima bean
Lespedeza
Peanut
Partridge pea
Velvet bean
Acacia

7. *Soybean Group*

Soybeans

8. *Lotus Group*

Bird's-foot trefoil

9. *Locust Group*

Black or common locust

WHAT ARE SOME INOCULATION DON'TS?

1. Don't inoculate wheat, oats, potatoes, or any other crop except legumes.
2. Don't expect absolutely perfect results if your soil conditions are not good.
3. Don't inoculate seed until ready to plant.
4. Don't expose inoculation material or inoculated seeds to direct sunlight.
5. Don't inoculate the same legume for the same field year after year. If you have not secured good nodule response by the second year, see your County Extension Agent.
6. Don't pull up the plant and expect to find nodules on the few large roots. They are on the root hairs and might be left in the soil.
7. Don't try to cross inoculate, except as indicated. Specific bacteria will inoculate only the plants of the group to which they belong.
8. Don't expect nodules to form in very dry soil. A moisture content sufficient to support the best plant growth will cause the best nodule formation.
9. Don't treat seed with a disinfectant and then inoculate. The disinfectant may kill the bacteria.
10. Don't use 2,4-D on fields planted with inoculated seed. This weed killer is toxic to the root-nodule bacteria and the legume.
11. Don't expect inoculation to overcome poor seed, lack of good preparation and cultivation of soil, deficiencies of available plant nutrients, and decidedly adverse climatic conditions.
12. Don't expect the inoculating material to control insects, weeds or plant diseases.