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OCCURRENCE OF THE VARIOUS GROUPS OF LEGUME BACTERIA IN IOWA SOILS

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For a long time it has been known that the root-nodule bacteria of the *Leguminosae* differ considerably in their ability to inoculate plants. An outstanding example of this fact was brought to the attention of the early investigators when it was found that soybeans failed to produce nodules in European soils, while many other species of legumes were naturally inoculated. Kirchner (4), the first investigator to inoculate soybeans in Germany, found that it was necessary to use soil from Japan where the soybean was native and naturally inoculated. Since that time many such examples have been recorded. Just recently Gangulee (3), at the Rothamsted Experiment Station, England, has reported that the legume, *Crotalaria juncea*, was not naturally inoculated in British soils, and could not even be inoculated artificially until soil from India, where the plant is native, was used for that purpose.

As a result of a large number of facts that have been secured during the past fifty years the legume bacteria have been divided into a number of so-called "cross-inoculation groups" based upon their ability to inoculate various species of legumes. Burrill and Hansen (2) of Illinois, made a rather extended study of this problem and concluded that these bacteria could be divided into at least eleven cross-inoculation groups. These groups have been referred to in the literature a number of times and appear to be of considerable value from the standpoint of a systematic consideration of the legume bacteria of the genus *Rhizobium*.

A detailed study of the genus *Rhizobium* is now in progress at the Iowa Agricultural Experiment Station. One of the main objectives in this study is to secure sufficient accurate data which will eventually lead to the justification of differentiating species within the genus. This has necessitated the isolation and study of the bacteria producing nodules on a number of species of the family *Leguminosae*. During the search for nodules on legumes in Iowa soils many interesting observations have been made and it is the purpose of this paper to present some of these findings and especi-

ally those concerning the natural occurrence of bacteria belonging to the various cross-inoculation groups.

The legumes which have been examined are listed below, being divided into three main divisions: first, those found inoculated and growing in cultivated soils; second, those found inoculated and growing wild in native or uncultivated soils; and third, those which have been found to be uninoculated. They have been further subdivided into the cross-inoculation groups to which the bacteria of each species of legume belongs as far as this has been established.

INOCULATED LEGUMES GROWING IN CULTIVATED SOILS

Group 1 (Pea Group).

- Lathyrus odoratus* (sweet pea).
- Lathyrus latifolius* (perennial pea).
- Lathyrus pratensis*.
- Pisum sativum* (common garden pea).
- Pisum arvense* (Canada field pea).
- Vicia hirsuta* (hairy vetch).
- Vicia sativa* (common vetch).
- Lens esculenta* (lentil).

Group 2 (Red Clover Group).

- Trifolium pratense* (red clover).
- Trifolium hybridum* (alsike clover).
- Trifolium repens* (white clover).
- Trifolium repens* (ladino clover).
- Trifolium procumbens* (smaller hop clover).
- Trifolium incarnatum* (crimson clover).

Group 3 (Alfalfa Group).

- Medicago sativa* (alfalfa).
- Medicago lupulina* (black medic).
- Melilotus alba* (biennial white sweet clover).
- Melilotus officinalis* (yellow sweet clover).

Group 4 (Lupine Group).

- Lupinus albus* (white lupine).

Group 5 (Cowpea Group).

- Arachis hypogoea* (peanut).
- Lespedeza striata* (Japan clover).
- Acacia armata*.
- Vigna sinensis* (cowpea).
- Phaseolus aureus* (mung bean).

*Group 6 (Bean Group).**Phaseolus vulgaris* (string bean).*Group 7 (Dalea Group).**Parosela dalea* (Wood's clover).*Group 8.**Robinia pseudacacia* (black locust).*Group 9.**Onobrychis viciaefolia* (sanfoin).*Group Unknown.**Amorpha fruticosa.**Kraunkia frutescens* (wisteria).*Caragana arborescens* (siberian pea tree).*Mimosa pudica* (sensitive plant).*Cassia marylandica* (wild senna).*Cytisus scoparius* (scotch broom).*Baptisia australis* (wild indigo).

INOCULATED LEGUMES GROWING IN UNCULTIVATED SOILS

*Group 5 (Cowpea Group).**Pueraria thunbergiana* (kudzu).*Group 10 (Hog Peanut Group).**Amphicarpa comosa* (hog peanut).*Group 11.**Amorpha canescens* (lead plant).*Group 12.**Strophostyles helvola* (trailing wild bean).*Group Unknown.**Vicia Americana* (American vetch).*Kunistera candida.**Kunistera purpurea.**Astragalus canadensis* (cow vetch).*Psoralea argophylla.**Baptisia leucantha.**Lespedeza capitata.*

UNINOCULATED LEGUMES IN IOWA SOILS

Cercis canadensis (red bud).*Gleditsia triacanthas* (honey locust).*Gymnocladus dioica* (Kentucky coffee tree).*Ornithopus sativa* (seradella).

Galega officinalis (goat's rue).

Trigonella foenum-graecum (fenugreek).

All of the legumes listed in the first division have been found naturally inoculated either on the Iowa State College campus, growing in the greenhouse or on the experimental farm. Seven of the thirty-five legumes in this list have not been studied and placed into cross-inoculation groups. The remaining twenty-eight species fall into nine groups based upon their ability to cross-inoculate the legumes within the group. These nine groups represent the nodule bacteria which inoculate all of the important legumes with the exception of *Glycine hispida*, the soybean. This fact is of considerable importance to the soil bacteriologist. Nodules have been found also on the soybean, but it has been necessary to introduce the soybean bacteria artificially in Iowa Soils.

The Kudzu, *Pueraria thunbergiana*, was found growing along the car track south of the State College and was well inoculated. This legume was also grown in soil in the greenhouse where abundant nodule formation was observed. The hog peanut, *Amphicarpa comosa*, was found well inoculated in the north woods of the State College Campus. The trailing wild bean has also been found growing along the car track in virgin soils, where it was well inoculated. *Amorpha canescens* was found naturally inoculated along fence rows near the State College Campus. The other legumes listed were found on native prairie land near the College. This list adds three more cross-inoculation groups making a total of twelve groups represented in Iowa Soils.

The third list presents six species of legumes, which the authors have not found to be inoculated in Iowa Soils. About six red bud trees on the Iowa State College Campus have been examined for nodules with negative results. Two Kentucky coffee trees were examined. On one nodules were not present. On the other some odd-shaped growths appearing on the ends of the fibrous roots were found which proved to be something other than nodules. Examination of a number of honey locust trees and seedlings on the College Campus have yielded negative results for nodule formations. These observations are in agreement with those made by Leonard (5) and a number of other investigators. The only statement found in the literature reporting the presence of nodules on *Gleditsia triacanthos* and *Cercis canadensis* is that made by Buchanan (1). So far as we are aware nodules on *Gymnocladus dioica* have never been found.

CONCLUSION

From these observations, it may be concluded that representatives of all but one of the various cross-inoculation groups of legume bacteria are naturally present in Iowa Soils.

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