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Symbiotic Nitrogen Fixation by Legumes Requires Extra Phosphorus

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Fig. 1. Soybean supplied with fixed N was scarcely nodulated but developed a vigorous root system.

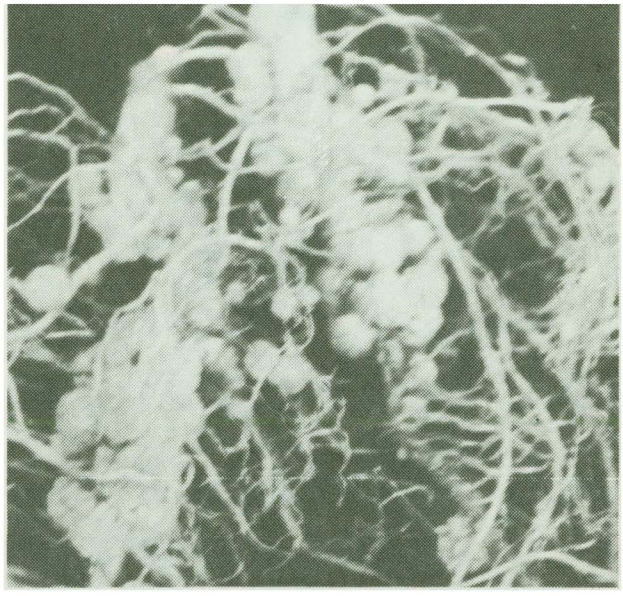

Fig. 2. Soybean roots that grew in nutrient solution which supplied no N produced abundant nodules and relatively less root mass.

When grain legumes are grown on nitrogen-deficient soils, they may symbiotically fix enough N for good yields, even if no N fertilizer is applied. However, legumes preferentially assimilate N from the soil if this source is available to them. As a result, excess N via the soil may inhibit symbiotic N_2 fixation by legumes.

The physiological and morphological modifications that make symbiotic N_2 fixation by legumes possible include: (1) the invasion of host roots by effective strains of *Rhizobium,* (2) the development of nodules to "house" the *Rhizobium* and, (3) the translocation of mineral nutrients and photosynthate from the host to the nodules to maintain *Rhizobium* activity. Nodules represent an extra sink for plant assimilates, a sink that non-nodulated legumes do not have.

The partitioning of dry matter between roots and nodules is affected by the phosphorus supply. When soybean plants were grown in N-deficient and P-deficient sand culture, nodules comprised 4% of the total plant dry matter and 12% of the root dry weight. When adequate P was supplied in the nutrient solution, but N was still deficient, nodule dry weight comprised 9% of total plant dry matter and 61% of root dry weight. The P requirement for optimal nodulation and N_2 fixation was greater than the requirement for root or shoot growth. When soybean plants were supplied with combined N in the nutrient solution so that nodule development was poor, root weight and length were greater than in N-fixing plants grown at comparable P levels.

These results suggest that soybean plants that depend upon symbiotic N_2 fixation for their N have a higher requirement for P than their counterparts supplied with fixed N from an external source. A field experiment conducted on Haiku clay soil (Humoxic Tropohumult) showed that N-fixing soybean plants did indeed have a higher external soil P requirement than N-fertilized plants.

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