THE USE OF PEA TO STUDY THE PLANT GENETICS OF SYMBIOTIC NITROGEN FIXATION

LaRue, T.A.
Boyce Thompson Institute
Ithaca, NY 14853-1801, USA

1964

Gelin, O. and S. Blixt. 1964. Root nodulation in peas. Agri Hort Genetica 22: 149-159.

1971

Lie, T.A. 1971. Temperature dependent root nodule formation in pea cv. Iran. Plant and Soil 34: 751-752.

Lie, T.A. 1971. Symbiotic nitrogen fixation under stress conditions. Plant and Soil, Special Vol., Biological Nitrogen Fixation in Natural and Agricultural Habitats (T.A. Lie and E.G. Mulder, eds.) Martinus Nijhoff, The Hague. Pp. 117-127.

1975

Hall, F.B. 1975. Host plant control of the inheritance of dinitrogen fixation in the *Pisum Rhizobium* symbiosis. Euphytica 24: 767-770.

1976

Degenhardt, T.L., T.A. LaRue and E.A. Paul. 1976. Investigation of a non-nodulating cultivar of *Pisum sativum.* Can. J. Bot. 54: 1633-1636.

Lie, T.A, D. Hille, D. Lambers and A Houwers. 1976. Symbiotic specialisation in pea plants: Some environmental effects on nodulation and nitrogen fixation. In: Symbiotic Nitrogen Fixation in Plants, International Biological Programme, Vol. 7, (P.S. Nutman, ed.) Cambridge University Press. Pp. 319-333.

1978

Lie, T.A. 1978. Symbiotic specialisation in pea plants: the requirement of specific *Rhizobium* strains for peas from Afghanistan. Ann. Appl. Biol. 88: 462-465.

1979

Winarno, R. and T.A. Lie. 1979. Competition between *Rhizobium* strains in nodule formation: Interaction between nodulating and non-nodulating strains. Plant and Soil 51: 135-142.

1980

Broughton, W.J., A.W.S.M. van Egeraat and T.A. Lie. 1980. Dynamics of *Rhizobium* competition for nodulation in *Pisum sativum* cv. Afghanistan. Can . J. Microbiol. 26: 562-565.

1982

Broughton, W.J., U. Samrey and B.B. Bohlool. 1982. Competition for nodulation of *Pisum sativum* cv. Afghanistan requires live rhizobia and a plant component. Can. J. Microbiol. 28: 162-168.

Hobbs, S.L.A. and J.D. Mahon. 1982. Heritability of N2(C2H2) fixation rates and related characters in peas (*Pisum sativum* L.) Can. J. Plant Sci. 62: 265-276.

Hobbs, S.L.A. and J.D. Mahon. 1982. Effects of pea (*Pisum sativum*) genotypes and *Rhizobium leguminosarum* strains on N2(C2H2) fixation and growth. Can. J. Bot. 60: 2594-2600.

Lie, T.A., P.C.J.M. Timmermans and G. Ladizinsky. 1982. Host-controlled nitrogen fixation in the legume-*Rhizobium* symbiosis: Incompatibility of *Pisum sativum* L. ecotypes *Elatius* Bieb. and *Abyssinicum* Braun with European *Rhizobium leguminosarum* strains. Israel Journal of Botany 31: 163-167.

Mahon, J.D. 1982. Field evaluation of growth and nitrogen fixation in peas selected for high and low photosynthetic CO2 exchange. Can. J. Plant Sci. 62: 5-17.

Young, J.P.W., A.W.B. Johnston and N.J. Brewin. 1982. A search for peas (*Pisum sativum* L.) showing strain specificity for symbiotic *Rhizobium leguminosarum.* Heredity 48: 197-201.

Young, J.P.W. and P. Matthews. 1982. A distinct class of peas (*Pisum sativum* L.) from Afghanistan that show strain specificity for symbiotic *Rhizobium.* Heredity 48: 203-210.

1983

Bisseling, T., C. Been, J. Klugkist, A. van Kammen and K. Nadler. 1983. Nodule specific proteins in effective and ineffective root nodules of *Pisum sativum*. EMBO J. 2: 961-966.

Hobbs, S.L.A. and J.D. Mahon. 1983. Variability and interaction in the *Pisum sativum* L. - *Rhizobium leguminosarum* symbiosis. Can. J. Plant Sci. 63: 591-599.

Lie, T.A., and P.C.J.M. Timmermans. 1983. Host genetic control of nitrogen fixation in the legume - *Rhizobium* symbiosis: Complication in the genetic analysis due to maternal effects. Plant and Soil 75: 449-453.

Ohlendorf, H. 1983. Selektionaufresistenz von *Pisum sativum* gegen *Rhizobium leguminosarum* Stamm 311d. Z. Pflanzenzuhtg. 90: 204-221.

Ohlendorf, H. 1983. Untersuchungen zur vererlung der resistenz von *Pisum sativum* gegen *Rhizobium leguminosarum* Stamm 311d. Z. Pflanzenzuchtg. 91: 13-24.

1984

Jacobsen, E. 1984. Modification of symbiotic interaction of pea (*Pisum sativum* L.) and *Rhizobium leguminosarum* by induced mutations. Plant and Soil 82: 427-438.

Jacobsen, E. and W.J. Feenstra. 1984. A new pea mutant with efficient nodulation in the presence of nitrate. Pl. Sci. Lett. 33: 337-344.

Kneen, B.E. and T.A. LaRue. 1984. Nodulation resistant mutant of *Pisum sativum.* J. Hered. 75: 238-240.

Kneen, B.E. and T.A. LaRue. 1984. Peas (*Pisum sativum* L.) with strain specificity for *Rhizobium leguminosarum.* Heredity 52: 383-389.

Lie, T.A. 1984. Host genes in *Pisum sativum* conferring resistance to European *Rhizobium leguminosarum* strains. Plant and Soil 82: 415-425.

Lie, T.A. and D. Goktan. 1984. Gene centres, a source for genetic variants in symbiotic nitrogen fixation: The symbiotic response of the cultivated pea to *Rhizobium leguminosarum* strains from Europe and the Middle East. Plant and Soil 82: 359-367.

1985

Bisseling, T., F. Govers, T. Gloudemans, M. Moerman and A. van Kammen. 1985. Expression of pea nodulin genes in effective and ineffective nodules. In: Analysis of the Plant Genes Involved in the Legume-Rhizobium Symbiosis (R. Marcellin, ed.) OECD, Paris. Pp. 105-111.

Govers, F., T. Gloudemans, M. Moerman, A. van Kammen and T. Bisseling. 1985. Expression of plant genes during the development of pea root nodules. EMBO J. 4: 861-867.

LaRue, T.A., B.E. Kneen and E. Gartside. 1985. Plant mutants defective in symbiotic nitrogen fixation. In: Analysis of the Plant Genes Involved in the Legume-Rhizobium Symbiosis (R. Marcellin, ed.) OECD, Paris. Pp. 39-48.

Messager, A. 1985. Selection of pea mutants for nodulation and nitrogen fixation. In: Analysis of the Plant Genes Involved in the Legume-Rhizobium Symbiosis (R. Marcellin, ed.) OECD, Paris. Pp. 52-60.

Ohlendorf, H. 1985. Kontrollmechanismen der leguminosen - *Rhizobium* symbiose in zusammenhang mit dem infektionsprozel. Angewandte Botanik 59: 279-303.

Young, J.P.W. 1985. Linkage of *sym-2*, the symbiotic specificity locus of *Pisum sativum.* J. Heredity 76: 207-208.

1986

Govers, F., M. Moerman, J.A. Downie, P. Hooykas, H.J. Franssen, J. Louwerse, A. van Kammen and T. Bisseling. 1986. *Rhizobium* nod genes are involved in inducing an early nodulin gene. Nature 323: 564-566.

Jensen, E.S., L.H. Sorensen and K.C. Engvild. 1986. Danish *Rhizobium leguminosarum* strains nodulating 'Afghanistan' pea (*Pisum sativum*). Physiol. Plant. 66: 46-48.

1987

Dowling, D.N., U. Samrey, J. Stanley and W.J. Broughton. 1987. Cloning of *Rhizobium leguminosarum* genes for competitive nodulation blocking on peas. J. Bacteriol. 169: 1345-1348.

Engvild, K.J. 1987. Nodulation and nitrogen fixation mutants of pea, *Pisum sativum.* Theor. Appl. Genet. 74: 711-713.

Govers, F., J.-P. Nap, M. Moerman, H.J. Franssen, A. van Kammen and T. Bisseling. 1987. cDNA cloning and developmental expression of pea nodulin genes. Plant Mol. Biol. 8: 425-435.

Govers, F., J.-P. Nap, A. van Kammen and T. Bisseling. 1987. Nodulins in the developing root nodule. Plant Physiol. Biochem. 25: 309-322.

Kneen, B.E., D. vam Vikites and T.A. LaRue. 1987. Induced symbiosis mutants of *Pisum sativum*. In: Molecular Genetics of Plant-Microbe Interactions (D.P.S. Verma and N. Brisson, eds.) Martinus Nijhoff, Dordrecht. Pp. 79-84.

Lie, T.A., D. Goktan, M. Engin, J. Pijenborg and E. Anlarsal. 1987. Co-evolution of the legume-Rhizobium association. Plant and Soil 100: 171-181.

Nap, J.-P., M. Moerman, A. van Kammen, F. Govers, T. Gloudemans, H. Franssen and T. Bisseling. 1987. Early nodulins in root nodule development. In: Molecular Genetics of Plant-Microbe Interactions (|D.P.S. Verma and N. Brisson, eds.) Martinus Nijhoff, Dordrecht. Pp. 96-101.

1988

Davis, E.O., I.J. Evans and A.W.B. Johnston. 1988. Identification of *nodX,* a gene that allows *Rhizobium leguminosarum* biovar *viciae* strain TOM to nodulate Afghanistan peas. Mol. Gen. Genet. 212: 531-535.

Kneen, B.E. and T.A. LaRue. 1988. Induced symbiosis mutants of pea (*Pisum sativum*) and sweetclover (*Melilotus alba annua*). Plant Sci. 58: 177-182.

Nash, J.H.E., S. Ma and V.N. Iyer. 1988. Characterization of *Sym* plasmids of *Rhizobium leguminosarum* strains able to nodulate*Pisum sativum* cv Afghanistan. Plant Mol. Biol. 11: 427-432.

Postma, J.G., E. Jacobsen and W.J. Feenstra. 1988. Three pea mutants with an altered nodulation studied by genetic analysis and grafting. J. Plant Physiol. 132: 424-430.

Taylor, D.C., B.J. Shelp, L.M. Nelson and B. Grodzinski. 1988. Carbon and nitrogen partitioning in young nodulated pea (wild type and nitrate reductase-deficient mutant) plants exposed to NH_4NO_3. Physiol. Plant. 74: 593-601.

1989

Bharma, S.B. and S. Kumar. 1989. Genetic variation in *Rhizobium leguminosarum* Rld 1 induced root nodulation among isogenic mutants of pea (Pisum sativum). Indian J. Exp. Biol. 27: 101-117.

Dowling, D.N., J. Stanley and W.J. Broughton. 1989. Competitive nodulation blocking of Afghanistan pea is determined by *nodDABC* and *nodFE* alleles in *Rhizobium leguminosarum.* Mol. Gen. Genet. 216: 170-174.

Duc, G. and A. Messager. 1989. Mutagenesis of pea (*Pisum sativum* L.) and the isolation of mutants for nodulation and nitrogen fixation. Plant Sci. 60: 207-213.

Duc, G., A. Trouvelot, V. Gianinazzi-Pearson and S. Gianinazzi. 1989. First report of non-mycorrhizal plant mutants (Myc$^-$) obtained in pea (*Pisum sativum* L.) and fababean (*Vicia faba* L.*)* Plant Sci. 60: 215-222.

Gloudemans, T., T.V. Bhuvaneswari, M. Moerman, T. van Brussel, A. van Kammen and T. Bisseling. 1989. Involvement of *Rhizobium leguminosarum* nodulation genes in gene expression in pea root hairs. Plant Mol. Biol. 12: 157-167.

Le Gal, M.F. and S.L.A. Hobbs. 1989. Cytological studies of the infection process in nodulating and non-nodulating pea genotypes. Can. J. Bot. 67: 2435-2443.

Le Gal, M.F., S.L.A. Hobbs and C.M.O, Delong. 1989. Gene expression during the infection process in nodulating and nonnodulating pea genotypes. Can. J. Bot. 67: 2535-2538.

Rosendahl, L., C.P. Vance, S.S. Miller and E. Jacobsen. 1989. Nodule physiology of a supernodulating pea mutant. Physiol. Plant. 77: 606-612.

Walker, E.L. and G.M. Coruzzi. 1989. Developmentally regulated expression of the gene family for cytosolic glutamine synthetase in *Pisum sativum.* Plant Physiol. 91: 702-708.

1990

Fearn, J.C. and T.A. LaRue. 1990. An altered constitutive peptide in *sym5* mutants of *Pisum sativum* L. Plant Mol. Biol. 14: 207-216.

Fearn, J.C. and T.A. LaRue. 1990. A temperature-sensitive nodulation mutant *(sym5*) of *Pisum sativum* L. Plant, Cell and Environ. (in press).

Kneen, B.E., T.A. LaRue, R.M. Welch and N.F. Weeden. 1990. Pleiotropic effects of *brz.* A mutation in *Pisum sativum* (L.) cv. 'Sparkle' conditioning decreased nodulation and increased iron uptake and leaf necrosis. Plant Physiol. 93: 717-722.

Kneen, B.E., T.A. LaRue, A.M. Hirsch, C.A. Smith and N.F. Weeden. 1990. *sym* 13 - A gene conditioning ineffective nodulation in *Pisum sativum.* Plant Physiol. (in press).

Ma, S.-W. and V.N. Iyer. 1990. New field isolates of *Rhizobium leguminosarum* biovar *Viciae* that nodulate the primitive pea cultivar Afghanistan in addition to modern cultivars. Appl. Environ. Microbiol 56: 2206-2212.

Ohlendorf, H. and A.M. Martensson. 1990. Studies on the nodulation of strain- specific resistant pea lines using single, mixed and delayed inoculation by *Rhizobium leguminosarum*. Plant and Soil 121: 235-242.

Postma, J.G., D. Jager, E. Jacobsen and W.J. Feenstra. 1990. Studies on a non-fixing mutant of pea (*Pisum sativum* L.) I. Phenotypical description and bacteroid activity. Plant Sci. 68: 151-161.

Scheres, B., C. van de Wiel, A. Zalensky, B. Horvath, H. Spaink, H. van Eck, F. Zwartkruis, A.-M. Wolters, T. Gloudemans, A. van Kammen and T. Bisseling. 1990. The ENOD12 gene product is involved in the infection process during the pea-rhizobium interaction. Cell 60: 281-294.

Scheres, B., F. van Engelen, E. van der Knaap, C. van de Wiel, A. van Kammen and T. Bisseling. 1990. Sequential induction of nodulin gene expression in the developing pea nodule. Plant Cell 2: 687-700.

van de Wiel, C., B. Scheres, H. Franssen, M.-J. van Lierop, A. van Lammeren, A. van Kammen and T. Bisseling. 1990. The early nodulin transcript ENOD2 is located in the nodule parenchyma (inner cortex) of pea and soybean root nodules. EMBO J. 9: 1-7.

Weeden, N.F., B.E. Kneen and T.A. LaRue. 1990. Genetic analysis of *sym* genes and other nodule-related genes in *Pisum sativum.* In: Nitrogen Fixation: Achievements and Objectives. (P.M. Gres-shoff, ed.) Chapman and Hall, Lon., N.Y. (in press).