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ABSTRACTS ON BIOLOGICAL NITROGEN FIXATION

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## FOREWORD

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## ABSTRACTS ON BIOLOGICAL NITROGEN FIXATION

1. ABD-EL-MALEK, Y., HOSNY, I. and SHAWKY, B.T. Association between *Azotobacter* and other soil bacteria and its effect on nitrogen fixation. *Zentbl. Bakteriologie, Parasitenkunde, Infektionskrankheiten, Hygiene, Zweite Naturwissenschaftliche Abteilung, Mikrobiologie, Landwirtschaft, Technologie, Umweltschutz*, 134(5), 1979: 381-389. The association between *A. vinelandii* and either *Agrobacterium* sp. or *Micrococcus* sp., which are usually found as contaminants in *Azotobacter* cultures, was investigated. In comparison with pure cultures, association increased the microbial counts in addition to increasing N fixation rates and efficiency. In liquid cultures, higher *Azotobacter* densities were observed in the top 5 cm of the column concomitant with lowering the economic coefficient of utilization of carbonaceous compounds, which resulted in low efficiency of N fixation. In deep layers, lower amounts of N gain were obtained, but higher efficiencies of N<sub>2</sub>-fixation were recorded. In sand cultures, the biggest amounts of fixed N were in the 5-15 cm layer of the soil column and in deeper layers economic utilization of sugars occurred, but N gain sharply decreased. - Biol. Abstr. 70, 1980.
2. ABD-EL-MALEK, Y., HOSNY, I. and SHAWKY, B.T. Nitrogen-fixing capacity of *Azotobacter* as affected by the type and depth of substrate. *Zentbl. Bakteriologie, Parasitenkunde, Infektionskrankheiten, Hygiene, Zweite Naturwissenschaftliche Abteilung, Mikrobiologie, Landwirtschaft, Technologie, Umweltschutz*, 134(5), 1979: 390-397. A total of 60 isolates, representing the different types of *Azotobacters* in Egyptian soils, were studied for their N<sub>2</sub>-fixing capacity. When *A. chroococcum* and *A. vinelandii* were grown in shallow layers of N-deficient liquid medium, N gains ranged from 48-92 and from 20-120 ppm with efficiencies of N<sub>2</sub>-fixation from 15.8-50.0 and from 16.6-21.2 mg N fixed/g<sup>2</sup> C oxidized, respectively. Culturing in deep layers generally lowered the N gains and the oxidation of C but at different rates. This results in the increase of the efficiency of N<sub>2</sub>-fixation by 2-78%, indicating that the depth of the liquid medium has a definite effect on the outcome of N<sub>2</sub>-fixation. In another experiment, A.

*vinelandii* was grown in increasing depths of liquid or or solid substrates and consequently at variable ratios of surface area:depth. In liquid medium, maximum counts, sugar consumption, and N gains were detected in the widest surface area:depth ratio, but the efficiency of N<sub>2</sub>-fixation increased with the narrowing of the ratio. In sand cultures an opposite trend was observed. - Biol. Abstr. 70,1980.

3. ABD-EL-MALEK, Y., HOSNY, I. and SHAWKY, B.T. Studies on the aerobic nonsymbiotic nitrogen-fixing bacteria, other than *Azotobacter*, in Egyptian soils. *Zentbl. Bakteriolog. Parasitenkd. Infektionsker. Hyg. Zweite. Naturw. Abt. Mikrobiol. Landw. Technol. Umwelt. Schutz.*, 134(6), 1979: 507-512. Twenty isolates of microorganisms capable of growing on N-deficient medium and found as contaminants in *Azotobacter* cultures were isolated from Egyptian soils and studied for their morphological, cultural and physiological properties. These microorganisms are members of Rhizobiaceae, Pseudomonadaceae, Achromobacteriaceae, Enterobacteriaceae, Micrococcaceae, Bacillaceae and Streptomycetaceae (*Agrobacterium*, *Pseudomonas*, *Alcaligenes*, *Achromobacter*, *Flavobacterium*, *Klebsiella*, *Escherichia*, *Citrobacter*, *Sarcina*, *Micrococcus*, *Bacillus*, *Streptomyces*) as well as some yeasts (unidentified). In N-free medium the microorganisms fixed only small amounts of atmospheric N, hardly exceeding 3 ppm and because of their low sugar consumption rates, efficiencies of N<sub>2</sub>-fixation sometimes reaching 18 mg N fixed/g C oxidized were recorded. Addition of 15 ppm combined N to the medium increased the amounts of N fixed to 3-9 ppm. - Biol. Abstr. 69,1979.
4. ABDEL WAHAB, A.M. and WAREING, P.F. Nitrogenase activity associated with rhizosphere of *Armophila arenaria* and effect of inoculation of seedlings with *Azotobacter*. *New Phytol.*, 84(4), 1980: 711-722. A marked gain in N was obtained when plants of *A. arenaria* L. were grown in pots in dune sand and supplied with N-free nutrient solution. Nitrogenase activity was associated with the roots but the estimated rates of N-fixation based upon the acetylene reduction technique were less than 1/10 of those obtained by the Kjeldahl method. Significant rates of acetylene reduction were also demonstrated both for detached roots taken from plants growing naturally in sand dunes and from

measurements made in situ in the field, but the estimated rates of N fixation were much lower than calculated rates of N gain by actively-growing plants. Some possible reasons for this discrepancy are discussed. Acetylene reduction was greatly stimulated by the addition of glucose, suggesting that N fixation by micro-organisms in the rhizosphere is limited by the supply of root exudates. Seedlings of *Ammophila* grown under aseptic conditions and inoculated with *Azotobacter* showed greatly increased growth compared with that of uninoculated seedlings. - Biol. Abstr. 70,1980.

5. ABDEL WAHAB, A.M. and EL SHAROUNY, H.M. Nitrogen-fixing *Bacillus* species from Egyptian soils: acetylene reduction and cultural conditions. *Egypt Plant and Soil*, 51 (2), 1979: 187-196, graphs; ref. Studies of the characteristics of 15 facultative N fixing *Bacillus* spp. measuring  $N_2$  ( $C_2H_2$ ) fixing activities indicate that at least some of them are new nitrogen fixing *Bacillus* species. - Abstr. on Trop. Agri. 5,1979.
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7. ADHIKARY, S.P. and PATNAIK, H. Growth response of *Westiellopsis prolifica* to organic substrates in light and dark. *Hydrobiologia*, 67 (3), 1979: 241-248. Experiments are described to characterize the heterotrophic potential of *W. prolifica* Janet, which fixes N under light and dark conditions. The growth of the organism in terms of dry weight increase was more in fructose, lactose, sucrose, sorbose, galactose, glucose, sodium acetate, mannitol, sorbitol, glycerol, ethyl alcohol and butyl alcohol, when the alga was pretreated with light and subsequently incubated with the substrates in light. Mannose, xylose, acetic acid,

propionic acid, fructose-1, 6-di phosphate, pyruvic acid, dihydroxyacetone and succinic acid decreased the growth of the organism in the same condition. In dark incubation after pretreatment with light and in the dark *Westiellopsis* showed a better growth response to almost all the exogenous substrates. After pretreatment either with light or dark, the test organism utilized exogenous substrates quicker in light than in dark incubations. The substrate specificity and efficiency of substrate utilization by the alga during its heterotrophic growth may be governed by the growth conditions. - Biol. Abstr. 69,1979.

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(*Eragrostis curvula*, *Brachiaria nigropedata*, *Hyparrhenia hirta* and *Cynodon dactylon*) showed a positive nitrogenase activity, indicating that these grasses have potential for root associated free N-fixation. Maximum nitrogenase activities were found in these grasses at the young age of the plants. Among these four, 2 grass species (*B. nigropedata* and *H. hirta*) revealed maximum nitrogenase activities (800 and 950 nmoles  $C_2H_4$ /g-dry roots/h, respectively) at this age. However, the nitrogenase activity did decline at the maturity stage of the plants. Influence of different C and N sources on the nitrogenase activities were also investigated. Sucrose among C sources stimulated nitrogenase activity in all 4 grasses, whereas both ammonium and nitrate used as N sources repressed the nitrogenase activity. Other grass species studied were *Pennisetum typhoides*, *Digitaria smutsii* and *Setaria chevalieri*. - Biol. Abstr. 69,1979.

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H<sub>2</sub> that otherwise would be lost as a by-product of the nitrogen fixation process. Soybeans inoculated with *R. japonicum* strains that synthesized the hydrogenase system fixed significantly more N and produced greater yields than plants inoculated with strains lacking H<sub>2</sub>-uptake capacity. *Rhizobium* strains used as inocula for legumes should have the capability to synthesize the hydrogenase system as one of their desirable characteristics. - Biol. Abstr. 68,1978.

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15. ALI, Sikander, RAJOKA, M.I. and SANDHU, G.R. Blue-green algae of different rice growing soil series of the Puniab, India. *Pakistan Journal of Botany*, 10 (2), 1978: 197-208. A survey of blue-green algae of the rice growing areas belonging to 12 different soil series was carried out. Of 103 spp. belonging to 21 genera, more than 32 spp. belonging to 10 genera were heterocystous and are potential N fixers. They were of the genera *Nostoc* (4 spp.), *Anabaena* (13 spp.), *Nodularia* (2 spp.), *Aulosira* (3 spp.), *Tolypothrix* (1 sp.), *Fortiea* (2 spp.), *Calothrix* (4 spp.), *Rivularia* (1 sp.), *Gloeotrichia* (1 sp.), and *Phormidium* (17 spp.) among non-heterocystous types, while *Anabaena* (13 spp.) and *Aulosira* (3 spp.) among the heterocystous types were most frequently observed in these soils. In the heterocystous types *Anabaena fertilissima* was the most commonly occurring alga in these soils. - Biol. Abstr. 69,1979.

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20. ANDREEVA, I.N. SIMONOV, I.N., TIBILOV, A.A., IL'YASOVA, V.B., FEDOROVA, E.E. and KHAILOVA, G.F. Endophyte ultrastructure in root nodule cells of sea buckthorn and their nitro-

gen fixing activity (In Russ). *Izvestiya Timiryazevskoi Sel'sko-khozyaistvennoi Akademii*, 0 (4), 1979: 186-191. A comparison was made of N-fixing activity and ultrastructure of an endophyte and infected root nodule cells in the process of their development during cultivation of sea-buckthorn sprouts and at various periods of the vegetation of the plant. Studies in sea-buckthorn from root nodule formation to the 4.5 mo. old plant showed that N-fixing activity was minimal in young 1- and 2-lobed root nodules, and reached a maximum in 3 mo. old sprouts. This quantity ( $32 \mu\text{mol C}_2\text{H}_4/\text{g}$  raw mass per h) was not less than the magnitude of N-fixation in soy root nodules. The ultrastructure of the actinomycete endophyte is complicated according to the degree of development in cortical cells of the root nodule from a single hypha to a complex system of hyphae and vesicles. Simultaneously, endophyte destruction occurs in cells of the basal part of the root nodule. During wintering the root nodule and endophyte cells degrade and wash away. In a small number of live cells, endophyte hyphae are preserved, which again induce formed cells during germination of root nodules in the spring. - Biol. Abstr. 70,1980.

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22. ANDREYUK, E.I. and DULGEROV, A.N. Using correlation analysis to evaluate the biological activity of irrigated soils (In Russ.). *Mikrobiologichnyi Zhurnal*, 4 (13), 1979: 211-216, Engl. summ. The correlation analysis was performed for the data on the quantity of microorganisms, biological and enzymatic activity of irrigated soils. A correlation dependence is established between the moisture and microbiological processes of the given soil. Moisture has a pronounced effect on the oligonitrophilic microorganisms ( $r$  [correlation coefficient] = 0.85) and cellulose-decomposing microorganisms ( $r = 0.65$ ). Their effect on the nitrifying bacteria ( $r = 0.50$ ) and azotobacter ( $r = 0.55$ ) is less pronounced. An inverse correlation is established for the moisture and actinomycetes ( $r = 0.40$ ). Moisture

- as an ecological factor produces a more developed effect on the total number of microorganisms ( $r = 0.56$ ) and a less expressed effect on the biological activity: the correlation coefficient for the cellulose activity is 0.36, for nitrification and N fixation  $r = 0.38$  and 0.45. The corresponding high correlation between the quantity of microorganisms and respiration of irrigated soils ( $r = 0.85$ ) permits this index to be considered as one of the diagnostic characters of biological activity of these soils. - Biol. Abstr. 70,1980.
23. ANDREYUK, E.I. and MAL'TSEVA, N.N. Oligonitrophilic microorganisms and oligonitrophilia (In Russ.). *Mikrobiologichnyi Zhurnal*, 40 (2), 1978: 173-185. A literature review and original data were presented dealing with the concept of oligonitrophilia and the evolution of microorganisms. *Clostridium pasteurianum*, *Bacillus oligonitrophilus*, *Fusobacterium glutinosum*, *Mycobacterium oligonitrophilum*, *Micrococcus oligonitrophilus*, *Agrobacterium radiobacter*, *Pseudomonas aurantiaca*, *Chromobacterium*, *Actinomyces*, *Azotobacter*, *Mycococcus*, *Rhodotorula* *Cytophaga* and *Pullularia* were included in the discussion. Criteria for nitrophilia and data on growth activity and N use, effect of fixed N on respiration and correlations of N fixing activity to numbers of N fixing microorganisms in soils of the Ukrainian SSR [USSR] were presented. - Biol. Abstr. 68,1978.
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  26. ANON. Bean nitrogen fixation-fertilizer from the plant instead of a bag. *Noti. CIAT*. Series AE, no. 6, 1978: 1-3, illus. Research has advanced closer to understanding the genetic and environmental factors affecting carbohydrate transfer and achieving potential benefits for the small farmer from

fixed nitrogen in beans. The combination of an effective Rhizobium with promising beans with high fixation rates needing no additional nitrogen fertilizer can be a boon for the small farmer. - Abstr. on Trop. Agri. 5,1979.

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33. ANON. Organic recycling in Africa. Papers presented at the FAO/SIDA Workshop on the Use of Organic Materials as Fertilizers in Africa, Buea, Cameroon, 5-14 December 1977. Rome, FAO, FAO Soils Bulletins no. 43, 1980, 308p., illus; tables; graphs; bibliog.; ref. Reviews main cropping systems practised and methods of crop residue management in the three ecological zones of Africa. Stresses the needs for promoting a biological nitrogen fixation programme and for an adequate utilization of organic material resources in the region.
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35. ANON. Research on biological nitrogen-fixation (In It.). *Ricerca Scientifica Consiglio Nazionale della Ricerca He*, 46(5), 1976: p. 1140.
36. ANON. Soya bean production: fertilizers and nitrogen fixation. In: Proceedings of the World Soybean Research Conference. Danville, Illinois, Interstate Printers & Publishers, 1976, pp.83-179, graphs; illus.; tables; bibliog.; summ. The 10 papers from the World Soybean Research Conference grouped under this subject heading deal with the following matters: (1) fertilizer needs (p.85-100); (2) the contribution of N<sub>2</sub> and soil or fertilizer N to soya bean production (p.101-107); (3) N<sub>2</sub> fixation in soya beans: measurement techniques and their applications (p.108-124); (4) biochemistry of N<sub>2</sub> fixation (p.125-134); (5) the relation of N<sub>2</sub> fixation to photosynthesis (p.135-143); (6) competition amongst *Rhizobium* strains (p.144-150); (7) genetics of *Rhizobium japonicum* (p.151-155); (8) host genetics and N<sub>2</sub> fixation (p.156-163); (9) symbiotic rhizobial N<sub>2</sub> fixation (p.164-169); and (10) obtaining adequate soya bean inoculation (p.170-179). The papers are mostly reviews of research results and experience. - Abstr. on Trop. Agri. 4,1978.

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41. APARICIO-TEJO, Pedro M., SANCHEZ-DIAZ, Manuel F. and PENA, Jose I. Nitrogen fixation, stomatal response and transpiration in *Medicago sativa* cultivars Tierra-de-Compos and Aragon, *Trifolium repens* cultivar Aberystwyth S-184 and *Trifolium subterraneum* cultivar Clare under water stress and recovery. *Physiologia Plantarum*, 48 (1), 1980: 1-4. Stomatal behavior, transpiration and N fixation were investigated in *M. sativa* L. (cv. Tierra de Campos and Aragon, Hidalgo-Maynar 1966), *T. repens* L. (cv. Aberystwyth S-184)



and *T. subterraneum* L. (cv. Clare) subjected to drought by withholding water and then to 3 days' recovery after re-watering. Dawn leaf water potential was measured with pressure chamber, stomatal response with a diffusion porometer and N fixation by using acetylene reduction technique. At low water potentials, the leaf resistance was higher in *Medicago* than in *Trifolium*. As water stress developed all species decreased their transpiration, *T. subterraneum* being the one most affected by moderate deficits. During water stress Tierra de Campos' always maintained higher acetylene reduction levels than 'Aragon' and the *Trifolium* species, except for the lowest water potentials. During recovery from water stress only 'Tierra de Campos' reached predeficit transpiration rates. In 'Tierra de Campos' acetylene reduction recovery after rewatering was more rapid and intense than in 'Aragon'. Of the plants investigated, apparently 'Tierra de Campos' was best adapted to water deficits. - Biol. Abstr. 69,1979.

42. ARARAGI, Michio and TANGCHAM, Banharn. Microflora related to the nitrogen cycle in the tropical paddy soils. *Soil Science and Plant Nutrition*, 25(3), 1979: 297-310. Paddy soils collected in 103 sites of Thailand consisted of surface soil (0-1 cm) and subsurface soil (1-10 cm). Collections were made twice, in the middle of the rainy season and in the middle of the dry season. The counts of 12 groups of microbes related to the N cycle were determined. In the soils sampled in the rainy season the population level of aerobic bacteria per 1 g of dry soil ranged from  $10^7$ - $10^8$ . For other microorganisms, the values were as follows: actinomycetes,  $10^5$ - $10^5$ ; anaerobic bacteria,  $10^5$ ; cellulose decomposer,  $10^4$ ; denitrifier,  $10^5$ ; ammonifier,  $10^5$ - $10^4$ ; nitrite oxidizer,  $10^4$ ; ammonia oxidizer,  $10^3$ ; *Clostridium*,  $10^5$ - $10^4$ ; N-fixing blue green algae, *Azotobacter* and purple nonsulfur bacteria,  $10^3$ , respectively. Populations of all 12 groups examined were larger in the oxidized surface soil than in the subsurface soil and, in particular, the populations of aerobic nitrite oxidizer and photosynthetic purple nonsulfur bacteria were more than 4 times higher than those in the subsurface soil. The populations

of microorganisms, except for cellulose decomposer, decreased in the dry season compared with those in the rainy season. The largest decrease was recorded in the population on nitrite oxidizer which dropped to the level of 1/26 especially in the surface soil, but only to 1/5 in the subsurface soil, and was followed by the population of purple nonsulfur bacteria. The populations of 12 groups of microorganisms except those of nitrite oxidizer and purple nonsulfur bacteria recorded the largest value in fresh water alluvial soils with rather high organic matter content and heavy clay followed by low humic gley soils with low organic matter content, while the smallest value was generally recorded in brackish water alluvial soils with low available P content and low pH value. The populations of nitrite oxidizer were the largest in low humic gley soils were the oxidized layer developed, while those of purple nonsulfur bacteria showed the largest value in brackish water alluvial soils. The population of nitrite oxidizers was noticeably higher in tropical than in Japanese soils. The ratio of aerobic bacteria to actinomycetes in the tropical soils showed a small value, namely 1.60 in the rainy season, while that of Japanese soils was about 10. - Biol. Abstr. 70,1980.

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44. ARIAS, O.E., GATEL, I.M., SILVA, D.M., RUSCHEL, A.P. and VOSE, P.B. First electron microscope observations of N-fixing bacteria in sugar cane roots (*Saccharum officinarum* L.) (In Es). *Turrialba (ITICA)*, 28 (3), 1978: 203-207, illus.,

ref.; Engl. summ. The colonization of N-fixing bacteria in sugar-cane roots (*Saccharum officinarum* var. NA 56-62) was studied with the transmission electron microscope. Plants obtained by rooting of cuttings were grown in the greenhouse. The study indicates the presence of bacteria belonging to the genus *Azotobacter* as well as others which are probably *Spirillum*. Some bacteria were also found colonizing the inside of the root cells. Acetylene reduction tests carried out with roots incubated in culture gave positive values for nitrogenase activity. - Abstr. on Trop. Agri. 5,1979.

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46. ASPIRAS, R.B., et al. Biological nitrogen fixation (from Philippine soils). *NSDB Technology Journal*, 2 (3), 1977:74-81, tables; ref.
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responsible for N fixation, ammonification, nitrification, denitrification and for degradation of hemicellulose, starch and cellulose is susceptible to seasonal variations. Aerobic N fixation, nitrification, denitrification and cellulolysis are weak in Feb. but become strong in May. Anaerobic N fixation is progressively weaker from Feb. to May. Hemicellulolysis varies depending on soil type. Root exudates control the type of microbial species, more strongly near the proximal than near the distal root system. More intense infections with *Fusarium* tend to increase ammonification and amylolysis. The varieties more resistant to fusariosis are accompanied by weaker microbial activity in the root environment in addition to a hereditary resistance to *Fusarium*. - Biol. Abstr. 70,1980.

48. ATKINS, Craig A., RAINBIRD, Ross and PATE, John S. Evidence for a purine pathway of ureide synthesis in nitrogen-fixing nodules of cowpea (*Vigna unguiculata* cultivar Caloona). *Zeitschrift für Pflanzenphysiologie: International Journal of Plant Physiology*, 97 (3), 1980: 249-260. The principal nitrogenous solutes produced from N<sub>2</sub>-fixation and exported from the nodules of cowpea [*V. unguiculata* (L.) Walp.] were allantoin and allantoic acid. Evidence suggests that these ureides were derived from purines. Nodules were active in enzymes of purine oxidation (xanthine dehydrogenase, uricase, allantoinase). These enzymes were restricted to the cytosol of the bacteroid containing cells (i.e., in close proximity to the sites of N<sub>2</sub> fixation) and increased in activity with nodule development. Allopurinol (4-hydroxypyrazolo [3, 4-d] pyrimidine) was an effective inhibitor of the xanthine dehydrogenase extracted from cowpea nodules and low concentrations (0.08-0.31 mM) applied to the root systems of intact plants in liquid culture rapidly (within 1 h) inhibited ureide export, reduced the nodule pools of ureides and caused an accumulation of xanthine in nodules. Glycine-2, <sup>14</sup>C supplied to slices of nodule tissue was more readily incorporated into allantoin and allantoic acid than glucose-U, <sup>14</sup>C or acetate-1, 2, <sup>14</sup>C. - Biol. Abstr. 70,1980.
49. AUGER, Sandi, BAULCOMBE, David and VERMA, Desh Pal S. Sequence complexities of the polyadenylic acid containing messenger RNA in uninfected soybean (*Glycine max*) root and the nodule tissue developed due to the infection by *Rhizo-*

*bium japonicum*. *Biochimica and Biophysica Acta*, 563(2), 1979: 496-507. To determine the number of structural genes expressed specifically in root nodules, the total complexities of poly(A) + polysomal RNA populations from uninfected roots and mature nodules were compared. Hybridization kinetics of nodule poly(A) + RNA (NRNA) to its c (complementary)DNA (NcDNA) revealed an abundant component comprising 18-20% of the NRNA. This component was shown to be leghemoglobin (Lb) by the similarity of its kinetics of hybridization to that of purified Lb-cDNA. The hybridization kinetics of uninfected root cDNA (RcDNA) to root poly(A) + RNA (RRNA) indicate that this abundant RNA fraction is absent in RRNA. The extent of sequence homologies between root and nodule tissue was determined by heterologous hybridizations of RcDNA to NRNA and vice versa. The data suggest that the mRNA populations of the 2 tissues are substantially homologous though shifts in abundance of certain sequences are quite marked. The hybridization of purified Lb-cDNA to total polysomal RNA from developing nodules shows that the increase in concentration of Lb-mRNA sequences parallels the leghemoglobin synthesis in this tissue. Lb sequences apparently increase 8-13 days after infection with *Rhizobium*. - Biol. Abstr. 69,1979.

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- in these strains which confer the GlnR<sup>-</sup> phenotype map at or near *glnA*, the structural gene for glutamine synthetase. - Biol. Abstr. 69,1979.
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  52. AWONAIKE, K.O., LEA, P.J., DAY, J.M., ROUGHLEY, R.J. and MIFLIN, B.J. Effects of combined nitrogen on nodulation and growth of *Phaseolus vulgaris*. *Experimental Agriculture*, 16 (3), 1980: 303-312. The effect of *Rhizobium* strain and low levels of N on growth and N fixation was studied on 5 seed lines of *P. vulgaris*. All plants responded to irrigation when low levels of N were supplied throughout each experiment during vegetative growth, but the final seed yield was not significantly affected. All strains induced less nodule tissue and lower nitrogenase activity per plant when N was applied; some strains were less sensitive than others. The proportion of plant N derived from fixation (based on acetylene reduction) and fertilizer was affected by host genetics. Nodulated plants had nitrogenase activities comparable with other grain legumes and responded to combined N during vegetative growth, but this was not reflected in grain yield. - Biol. Abstr. 70,1980.
  53. AYALA B, L.B. Study of some aspects of symbiotic nitrogen fixation by groundnuts (*Arachis hypogaea*). 2. Biochemical evaluation of fixation and related factors on the groundnut. *Rhizobium* spp. system (In Es). *Agronomia Tropical*, 27 (4), 1977: 427-449, graphs; tables; bibliog; Engl. summ. Effectiveness of 8 *Rhizobium* strains was evaluated on one variety of groundnut on the basis of nodule nitrogenase activity and plant nitrogen content. *Rhizobium* strains effected significant differences in specific nitrogenase activity and plant nitrogen content. Nitrogenase activity and mg nitrogen per plant showed a poor correlation between the activity of the enzyme and plant dry matter. Total nitrogenase activity and nodule leghaemoglobin content were significantly and positively correlated. Nitrate reductase activity of intact root nodules appeared to be the most promising test

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  55. AYANABA, A. and DART, P.J. Biological nitrogen fixation in farming systems of the tropics. Based on papers presented at a symposium held at the International Institute of Tropical Agriculture, Ibadan, Nigeria, in October, 1975. Chichester, John Wiley & Sons, 1977, 389p. The book consists of 30 articles which are grouped under separate headings. Section 1 deals with general considerations. In Section 2 legumes in farming systems of the tropics are discussed. Information on ecology and physiology of Rhizobia, nitrogen fixation in legumes, non-legume sources of biological nitrogen in nature, and measuring nitrogen against and losses in farming systems has been compiled in Sections 3, 4, 5 and 6. - Abstr. on Trop. Agri. 5,1979.
  56. BAGYARAJ, D.J. and HEGDE, S.V. Response of cowpea (*Vigna unguiculata* (L.) Walp.) to rhizobium seed inoculation. *Current Science*, 47(15), 1978: 548-549, tables; ref. A field experiment with cowpea, conducted in India, showed that different *Rhizobium* strains had had different effects on cowpea yields. Grain yield with *Rhizobium* strains UASB 94 was 1224 kg/ha as compared to 795 kg/ha for the control. Strains UASB 120 and 125 were associated with yields of 876 and 625 kg/ha, respectively. An Australian strain CB 756 reduced grain yield by 200 kg/ha as compared to the untreated control. - Abstr. on Trop. Agri. 5,1979.
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tion did not have any significant effect on sporulation of *G. fasciculatus* in the rhizosphere. Although soybean plants inoculated with *G. fasciculatus* recorded increased P content, dry weight and grain yield than uninoculated plants the differences were not statistically significant. In *Rhizobium* only inoculation markedly increased the N content of the plant and grain yield. Dual inoculation with both the symbionts increased significantly the dry weight of the shoot and its N content over single inoculation with *Glomus* or *Rhizobium*. Vesicular-arbuscular (VA) mycorrhiza may greatly assist nodulation and N fixation in field-grown soybean inoculated with rhizobia. - Biol. Abstr. 68,1979.

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- for 15 days, the N and C contents were estimated. - Biol. Abstr. 69,1979.
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It was shown that Tierra del Fuego peat is the most suitable carrier, because it provides an excellent support for the *Rhizobium* strains, retaining their symbiotic properties and N fixation capacity. - Abstr. on Trop. Agri. 6,1980.

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'Forest' by 75 days. At all other intervals,  $N_2$  fixation was either depressed or unaffected by nematodes. The susceptibility of 'Lee 68' is associated with greater rates of penetration by larvae and more favorable responses of host tissues to nematodes than occur in 'Forrest'. With time, however, the histological reactions of both hosts became less favorable for nematode development. Resistant or hypersensitive responses became common in 'Forest' by 75 days but not in 'Lee 68' until 90 days after inoculation. This population of *M. incognita* may stimulate  $N_2$  fixation at a specific time interval and depress it at others; therefore, disease of susceptible soybeans caused by this nematode is probably not primarily due to a net loss of fixed N but to pathogenicity similar to that which occurs on nonlegume hosts. - Biol. Abstr. 68,1979.

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fixation by blue-green algae associated with *Sphagnum* and *Drepanocladus* mosses growing in wet depressions and pools was studied in minerotrophic parts of the Stordalen mire in Swedish Lapland. N fixation rates of 0.5-6.4 g m<sup>-2</sup> yr<sup>-1</sup> were estimated on *S. riparium* with the acetylene reduction method. Fixation varied considerably along moss plants and for *Sphagnum* was found to be lower on apical and non-green parts. Fixation was higher at the periphery of a moss community. Activity was strongly light dependent and seemed little affected by pH-variations between pH 4.3-6.8. A daily fixation maximum around noon and an annual maximum around the middle of the growing season were indicated. - Biol. Abstr. 68,1979.

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- of ammonia N by lichens was roughly estimated to be 0.8 kg ha<sup>-1</sup> for the gray beech forest in beech gaps. - Biol. Abstr. 70,1980.
83. BECKING, J.H. Environmental requirements of *Azolla* for use in tropical rice production. In: Proceedings of Symposium on Nitrogen and Rice IRRI, Los Banos, 1979, pp.345-373, illus.; graphs; tables; bibliog. This paper describes the environmental requirements of *Azolla* the requirements of the fern plant and the symbiont *Anabaena azollae* in relation to the growth, N<sub>2</sub> fixation and the survival of the intact association in the soil-water system of irrigated paddy fields. The genus *Azolla* comprises a number of species of worldwide distribution. Thus, it is likely that there are species or clones especially adapted to different climatic conditions. Moreover, human interference may select certain varieties or clones for special purposes. This has occurred in Vietnam, China and Thailand, and is probably the first step to domesticate and exploit *Azolla* for agricultural systems. - Abstr. on Trop. Agri. 7,1981.
84. BECKING, J.H. *Beijerinckia* in irrigated soils: environmental role of N-fixing blue-green algae and asymbiotic bacteria. Stockholm, Swedish Natural Science Research Council, Ecological Bulletins/NFR No.26, 1978, pp.116-129, illus.; graphs; tables; bibliog.; ref. In this review, ecological factors affecting the occurrence and distribution of *Beijerinckia* in irrigated rice soils are dealt with. The possibility and efficiency of N fixation under the conditions of lowland rice soils are also discussed. It is concluded, among other things, that: (1) full employment of biological nitrogen fixation in the rice agro-ecosystem is of real importance; (2) nitrogenase of *Beijerinckia* is oxygen-sensitive; (3) in planted lowland rice soils, 50-60 kg N may be fixed, whereas in unplanted soils N fixation is very low; and (4) for the isolation of *Beijerinckia* an acid medium should be used to diminish competition from often faster-growing microbes such as *Azotobacter*. - Abstr. on Trop. Agri. 5,1979.
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by *P. parviflora* Miq. reported by Akkermans et al. was confirmed. The evidence given, that Trinick's *Trema* is a *Parasponia* species was confirmed by cytological and structural studies of *Parasponia* root nodules. *T. cannabina* Lour. growing in natural habitat on Java and 2 imported, hitherto unexamined, *Trema* spp. (*T. micrantha* and *T. guineensis*) bore no root nodules. Isolates from *P. parviflora* root nodules produced effective root nodules both in sterile *Parasponia* seedlings and sterile *Vigna unguiculata* (cowpea) and *Macroptilium atropurpureum* plants confirming their identity as *Rhizobium*. - Biol. Abstr. 69,1979.

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sponses were obtained with 30 mM ATP and  $Mg^{2+}$  and 150 mM sodium dithionite. The high concentrations of ATP,  $Mg^{2+}$ , and sodium dithionite required may indicate barriers to the uptake. The temperature optimum was 25-28°C. Activity was retained after storage for 30 min at -10°, 5° and 10°C but was lost at 50° C and reduced by 60% at 27°C. The preparation of active  $C_2H_2$ -reducing homogenates from this symbiotic association opens the way to further physiological and biochemical studies on the bayberry nitrogenase. - Biol. Abstr. 69,1979.

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maintain moist conditions on the leaf surface and thus create a microenvironment suitable for prolonged fixation by the microorganisms. - Biol. Abstr. 70,1980.

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sence of *Azospirillum* is not of the rapid nature known for hypersensitivity reactions. Rather, this production of phenolics apparently is due to the accumulation of extra-cellular bacterial metabolites. The ultrastructure of this and other callus reactions is described. As evidenced by organogenesis, the associated cultures have remained viable for at least 18-20 mo. - Biol. Abstr. 69,1979.

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CBl809, the one with lowest affinity was insensitive to CO and less sensitive to N-phenylimidazole and azide, while the oxidases of higher affinity were very sensitive to these inhibitors. Terminal oxidase systems of the same strains from O<sub>2</sub>-limited continuous cultures resembled those of bacteroids, when assayed in the same way. The properties of terminal oxidases of *Azotobacter vinelandii* strain AVO, *Azospirillum brasilense* strain Sp7 and *Klebsiella pneumoniae* strain 50231, when grown in O<sub>2</sub>-limited continuous cultures, were examined in the same experimental systems. In all culture states examined there was no evidence for multiple oxidases as seen with the *Rhizobium* spp. In 2 of these bacteria, *A. brasilense* and *K. pneumoniae*, the oxidases appeared to be allosteric, but their affinities were very different (apparent K<sub>s</sub> 0.006 and 0.11 μM, respectively). The terminal oxidase of *A. vinelandii* obeyed Michaelis-Menten kinetics, but had a lower affinity for O<sub>2</sub> (apparent K<sub>s</sub> 0.48 μM). - Biol. Abstr. 70,1980.

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grown in a sterile rooting medium watered daily with a nutrient solution containing 4, 20, 100, or 500  $\mu\text{-M}$  P. Plants were inoculated with *Rhizobium japonicum* strain 61A118 and grown in the presence or absence of the endomycorrhizal fungus *Glomus fasciculatus* Gerdemann et Trappe. Plants grown at the highest P regime had six times higher shoot dry weight than those grown in the lowest P regime. Nodulation did not occur at 4  $\mu\text{-M}$  P. Nodule dry weight increased 200 - fold from the 20 to the 500  $\mu\text{-M}$  P treatment. Percentage P in shoots and nodules differed significantly among all treatment levels. Acetylene reduction by nitrogenase increased logarithmically with increasing amounts of P. Hydrogen evolution was not detectable at the 20  $\mu\text{-M}$  P level. The relative efficiency of nitrogen fixation increased with increasing P stress. Infection by *Glomus fasciculatus* at the 500  $\mu\text{-M}$  P level was negligible and did not affect the parameters measured. At all other treatment levels the mycorrhizal plants had significantly higher rates of N(2) fixation, plant and nodule mass and P content. (EN)

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119. BOHLOOL, B. Ben. Nitrogen fixation in polluted intertidal sediments of Waimea Inlet, Nelson. *New Zealand Journal of Freshwater Research*, 12(3), 1978: 271-276.  $N_2$  fixing potential was measured in summer 1975 by acetylene reduction in situ at 5 stations on the intertidal flats of the Waimea Inlet, Nelson, New Zealand, which receive nutrients from several sources. Highest values ( $644 \mu\text{mol} \cdot \text{m}^{-2} \cdot \text{d}^{-1}$ ) were obtained on sediments near an apple cannery effluent discharge and were linear through at least 2 tidal cycles. The cannery waste had the highest C:N ratio (10.3:1.0) of all the effluents examined and exhibited the highest rate of acetylene reduction ( $14.0 \mu\text{mol} \cdot \text{l}^{-1} \cdot \text{d}^{-1}$ ). Sizeable populations of the  $N_2$  fixing bacteria *Klebsiella pneumoniae* were isolated from the cannery effluent ( $2 \times 10^4/\text{ml}$ ) and also from the mud adjacent to the discharge pipe ( $5 \times 10^5/\text{ml}$ ). The stimulatory effect of the cannery effluent on  $N_2$  fixation in the sediment was shown to be restricted to close to the discharge point. Sediments in areas affected by slaughterhouse and sewage effluents exhibited the 2nd and 3rd highest rates of acetylene reduction, ( $130$  &  $28 \mu\text{mol} \cdot \text{m}^{-2} \cdot \text{d}^{-1}$  respectively). In both places, the activities were not restricted to the immediate vicinity of the effluent channels.  $N_2$  fixation was lowest in sediments fronting a catchment of grazed pasture. Fixation was low also in sediments affected by effluents from the hydraulic debarker of a woodchip mill. - Biol. Abstr. 68, 1979.
120. BONARTSEVA, G.A. and SHENAKHANOVA, N.M. Action of metabolites of isolated (Nodule bacteria) plant tissues on the nitrogenase activity of *Rhizobium vigna* and *Rhizobium meliloti* (sweetclover). *Biology Bulletin Academy of Sciences of the USSR*, 5(5), 1979: 628-633, illus., ref.
121. BONARTSEVA, G.A. and SHENAKHANOVA, N.M. The influence of isolated plant tissue's metabolites on the nitrogenase activity of *Rhizobium vigna* and *Rhizobium meliloti*. (In Russ.) *Izvestiya Akademii Nauk SSSR*, No. 5, 1978: 781-786, illus.; tables; ref.; Engl. summ.
122. BONARTSEVA, G.A., SHEMAKHANOVA, N.M. and IL'YASOVA, V.B. Determination of the nitrogen fixing activity of *Rhizobium*

- japonicum* in sterile microvegetative conditions (In Russ.). *Mikrobiologiya*, 47 (5), 1978: 961-963, Engl. summ. The N-fixing activity of *R. japonicum* in symbiosis with soybean grown in sterile microvegetative conditions at 70% air humidity, 20°C temperature and 16 h light day was assayed using the acetylene technique. The plants were cultivated in phytotron in glass tubes (245 cm<sup>3</sup>) illuminated with xenon lamps. - Biol. Abstr. 68,1979.
123. BOONCHEE, S. and SCHILLER, J.M. Inoculation responses of soybean grown under rainfed conditions in northern Thailand. *Thai Journal of Agricultural Science*, 11 (2), 1978: 87-104, tables; ref.; Engl. summ. Results of a series of rainfed field trials on the effect of *Rhizobium* (strain CB 1809) inoculation on soya bean nodulation and yield conducted on terrace soils in northern Thailand revealed: (1) grain yield increased markedly and grain size improved from 9 to 22% in response to inoculation; (2) plants of the varieties SJ 1 and SJ 2 were completely devoid of nodules when inoculation was not carried out; and (3) supplementary N applied at sowing did not produce a yield response on red yellow podzolic soil. - Abstr. on Trop. Agri. 5,1979.
124. BOONKIRD, N., et al. Selection of efficient *Rhizobium japonicum* strains under field condition. In: Proceedings of the First Technical Conference, Plant Pathology and Microbiology, Bangkok, 20 April 1976 (In Thai). Bangkok, Department of Agriculture, Plant Pathology and Microbiology Division, 1976, vp., tables; ref.; Engl. summ. (INDC REF 63:016 (593) A8)
125. BOONKIRD, N., et al. Studies on the competition between inoculated strains and local strains of *Rhizobium japonicum* (In Thai). In: Proceedings of the First Technical Conference, Plant Pathology and Microbiology, Bangkok, 20 April 1976. Bangkok, Department of Agriculture, Plant Pathology and Microbiology Division, 1976, vp.
126. BOONKIRD, N., WADISIRISAK, P. and VASUVAT, Y. Studies on the increasing of soybeans by using inoculant fertilizer and lime (In Thai). In: Proceedings of the First Technical

Conference, Plant Pathology and Microbiology, Bangkok, 20 April 1976. Bangkok, Department of Agriculture, Plant Pathology and Microbiology Division, 1976, vp., tables; ref.; Engl. summ.

127. BOONKIRD, N., WEBER, D.F. and BEZDICEK, D.F. Influence of *Rhizobium japonicum* strains and inoculation methods on soybeans grown in Rhizobia-populated soil. *Agronomy Journal*, 70 (4), 1978: 547-549, ref.
128. BOPAIHAH, B.M., PATIL, R.B. and REDDY, D.D.R. Effect of *Meloidogyne javanica* on nodulation and symbiotic nitrogen fixation in mung, *Vigna radiata*. *Indian Journal of Nematology*, 6 (2), 1976: 124-130. Effect of *M. javanica* on growth, nodulation and N fixation in mung plants was investigated. Inoculation of root-knot nematode alone, simultaneously or 2-7 days preceding *Rhizobium* inoculation had a deleterious effect on plant growth compared to plants inoculated with *Rhizobium* alone. The nematode inoculation prior to rhizobia resulted in maximum reduction of nodules. In plants where *Rhizobium* inoculation preceded nematode inoculation or inoculated with *Rhizobium* alone, growth and nodulation were normal. Infestation by the nematode interfered with N fixation and reduced the N content of shoot and root. - Biol. Abstr. 69, 1979.
129. BOPAIHAH, B.M., RAI, Vittal and KHAN, N.A. The influence of leaf surface organisms on the vegetative growth of coffee plants. *Journal of Coffee Research*, 7 (3), 1977: 65-68, tables; ref. N fixing phyllosphere (i.e. inhabiting the leaf surface) microorganisms were isolated from coffee plants (*Coffea arabica*) collected from Mudigere area. Two different types of colonies appeared on a N-free (Waksman-77) medium. They were tentatively identified as *Azotobacter* spp. Application of these isolates to coffee leaves enhanced plant vigour. Six-week old untreated coffee plants weighed 20.3 g, whereas the *Azotobacter* treated plants weighed 23 to 24 g on a dry weight basis. Similarly the untreated plants recorded 1.36 per cent N against 1.5 to 1.7 percent N for the treated plants. - Abstr. on Trop. Agri. 5, 1979.

130. BORENSTEIN, E. Soil management and conservation, Santa Cruz, Bolivia. Rhizobium-Leguminosae: biological nitrogen fertilization and environmental protection (Inoculant production) (In Es.). FAO, Agricultural Operation Division, FAO-AGO-BOL/78-013. Santa Cruz, 1982, 10p., Engl. summ.
131. BORGES DE TESORO, D. Isolation, identification and effectiveness of two strains of *Rhizobium* of cowpea (*Vigna sinensis* L. Savi) (In Es.). *Revista de la Facultad de Agronomia*, 9 (3), 1977: 5-53, illus.; graphs; tables; ref.; Engl. summ. Two nodulating strains of native *Rhizobium* on cowpea were isolated and studied on their nitrogen fixation ability. - Abstr. on Trop. Agri. 5, 1979.
132. BOS, R.C. Van. den., BISSELING, T. and VAN KAMMEN, A. Analysis of DNA content, nitrogenase activity and in vivo protein synthesis of *Rhizobium leguminosarum* bacteroids on sucrose gradients. *Journal of General Microbiology*, 109 (1), 1978: 131-139, 21 ref.
133. BOTHE, H. Biological nitrogen fixation (In De.). *Naturwissenschaftliche Rundschau*, 29 (9), 1976: 316-324, illus.; tables; bibliog.; ref.
134. BOULDIN, D.R., MUGHOGHO, S., LATHWELL, D.J. and SCOTT, T.W. Nitrogen fixation by legumes in the tropics. Ithaca, Cornell University, Department of Agronomy, Cornell International Agriculture Mimeograph No. 75, 1979, 40p., illus.; tables; bibliog. This review summarizes the estimated amounts of nitrogen fixed by legumes and conditions which maximize benefits from the legumes-*Rhizobium* symbiosis. Sections deal with potential legume benefits, N fixation in general, benefits of legumes to non-legumes, use of legumes and effects in cropping systems. In many tables quantitative data are presented. - Abstr. on Trop. Agri. 6, 1980.
135. BOUTON, J.H., et al. Response of pearl millet inbreds and hybrids to inoculation with *Azospirillum brasilense*. *Crop Science*, 19 (1), 1979: 12-16. Plant yield and acetylene reduction were measured on 6 hybrids and 15 inbreds (including the hybrid parents) of pearl millet, *Pennisetum americanum* (L.) K. Shum., after field inoculation with A.

*brasiliense*, sp 13t (reclassified from *spirillum lipoferum* Beijerinck). During the 1st yr of testing, inoculation responses were investigated among all plant genotypes by measuring plant dry weight, percent N, total N and acetylene reduction activity. A smaller population of genotypes were tested a 2nd yr for repeatability of inoculum response. The 1st year, one hybrid, Tift 23DA x Tift 186 ('Gahi 3'), gave significantly higher plant dry weight and total N in response to inoculation. Inoculated 'Gahi 3' produced 31.7% more dry weight and 37.4% more total plant N when compared to autoclaved inoculum controls. No inbred was found to respond. Acetylene reduction values were low among all genotypes (range 0.54 nmole/[g dry root x hour]) and did not support yield effects or confirm inoculum treatments. Inoculation responses were repeatable for all genotypes tested during the 2nd yr (positive or negative) but not of a statistically significant magnitude. Of the genotypes tested both years, a combined analysis of the 2 yr yields revealed significant dry weight increases after inoculation of 19.2 and 14.0% with 'Gahi 3' and the inbred, Bil 3B, respectively. Again, acetylene reduction values did not explain any data. A N balance study was conducted in greenhouse containers on inoculated 'Gahi 3' plants to repeat the yield differences observed in the field and to monitor inputs of N into the soil-plant system. No significant yield increase of N into the soil-plant system was found due to inoculation. Sampling error possibly negated an accurate measurement of all N. - Biol. Abstr. 68,1979.

136. BOZZINI, A. Implications of BNF (Biological Nitrogen Fixation) on legumes production in AGP (Plant Production and Protection Division) programmes. In: FAO/UNEP Meeting on Biological Nitrogen Fixation (Symbiotic), Rome, 16 June 1980. Rome, FAO, 1980, 3p.
137. BRAUN, H. FAO activities in the field of biological dinitrogen fixation. In: Report of Proceedings on Isotopes in Biological Dinitrogen Fixation, Joint FAO/IAEA Division of Atomic Energy in Food and Agriculture, Vienna, 21 November 1977. Vienna, International Atomic Energy Agency, 1978, pp.245-251.

138. BRILL, W.J. Biological nitrogen fixation. In: Proceedings of a Conference on Genetic Engineering for Nitrogen Fixation, Brookhaven National Laboratory, 13-17 March 1977, New York, Plenum Press, 1977, pp.18-20.
139. BRILL, W.J. Genetics and regulation of nitrogen fixation. In: Proceedings of a Conference on Limitations and Potentials for Biological Nitrogen Fixation in the Tropics, Brasilia, 1977, New York, Plenum Press, 1978, vol. 15th, pp.237-245; ref.
140. BROCK, J.L. and HOGLUND, J.H. Nitrogen fixation in pasture: 7. Recent alluvium, Palmerston North, New Zealand. *New Zealand Journal of Experimental Agriculture*, 7(1), 1979: 27-30. A dry warm year and a cool moist year resulted in 184 and 232 kg N fixed/ha annum, respectively. Between year, and between season within year, variation in N fixation was explained by variation in clover [*Trifolium repens*] growth and soil N available to the clover. The depth profile of N fixation ranged 90-10% in the top 75 mm of soil in response to soil moisture changes. - Biol. Abstr. 69, 1979.
141. BROSE, Edemar, FREIRE, J.R. Jardim and MULLER, Ludwig. Relations between genotypes of soybean (*Glycine max*): Symbiotic nitrogen fixation and yield of seeds (In Port). *Agronomia Sulriograndense*, 15(2), 1979: 179-198., Engl. summ. Soybean lines with high potential for N<sub>2</sub> fixation were identified and parameters were established as indicators of such potential. Four soybean cultivars with short growth period (maturity groups IV to VII) and 4 with long growth period (maturity group VIII) were used. The cultivars were sampled 4 times during their growth period, from the 28th day after sowing to pod-filling stage. There were differences in dry weight of nodules only between different maturity groups. Nitrogenase activity as measured by the acetylene reduction method, was highest at flowering and declined during pod-filling as a consequence of low N<sub>2</sub>-fixation efficiency of the nodules during this period. N<sub>2</sub> concentration in the shoots was statistically different only for the first 2 sampling periods. There were no grain yield differences among cul-



tivars of long growth period. Those with short growth period presented differences in grain yield; there were no correlations regarding grain yield, dry nodule weight and nitrogenase activity. - Biol. Abstr. 70,1980.

142. BROWN, N.S., GRAY, M.H. and SINCLAIR, D.P. Nitrogen fixation in pasture: 3. Gisborne Plains, Manutuke, New Zealand. *New Zealand Journal of Experimental Agriculture*, 7(1), 1979: 11-14. N fixation rates were low at all times, with very low rates in some months probably because of low rainfall and dry soils. As soil moisture decreased, relatively more fixation occurred below 75 mm. Estimates of annual total N fixed were 92 and 122 kg/ha for 1974-75 and 1975-76, respectively. High levels of available N must be present to support the high levels of pasture production (14.1 t DM [tons dry matter]/ha and 15.2 and t DM/ha for the 2 trial years). - Biol. Abstr. 69,1979.
143. BUCHANAN, Alfred G. and LEES, H. Superoxide dismutase (EC 1.15.1.1) from nitrogen-fixing *Azotobacter chroococcum*: Purification, characterization and intracellular location. *Canadian Journal of Microbiology*, 26(4), 1980: 441-447. Superoxide dismutase (SOD, EC 1.15.1.1) from  $N_2$ -fixing *A. chroococcum* was purified and identified as being similar to the manganese SOD of other prokaryotes. The enzyme was relatively thermostable and insensitive to cyanide. A MW of approximately 33,000 was estimated. Superoxide dismutase was cytoplasmic (not bound to cell membranes) in *A. chroococcum*, but some enzyme was released by sonication of membrane vesicles. - Biol. Abstr. 70,1980.
144. BUCHANAN-WOLLASTON, A.V., BERINGER, J.E., BREWIN, N.J., HIRSCH, P.R. and JOHNSTON, A.W.B. Isolation of symbiotically defective mutants in *Rhizobium leguminosarum* by insertion of the transposon TN5 into a transmissible plasmid. *Molecular General Genetics*, 178(1), 1980: 185-190. Selection was made for the transposition of the kanamycin resistance transposon Tn5 from a location on the chromosome of *R. leguminosarum* into a transmissible, bacteriocinogenic plasmid that also carries genes required for the induction of  $N_2$  fixing nodules on peas. One hundred and sixty independent insertions into transmissible plasmids

were isolated. When these plasmids were transferred by conjugation into a nonnodulating strain, which carries a deletion in 1 of its resident plasmids, of the 160 isolates tested 14 yielded transconjugants that formed nodules that did not fix  $N_2$  ( $Fix^-$ ) and in a further 15 cases the transconjugants were unable to form nodules (were  $Nod^-$ ). When transferred to a symbiotically proficient strain (i.e.,  $Nod^+ Fix^+$ ) none of the transconjugants was symbiotically defective; thus the mutations were not dominant. When kan was transduced from the clones that generated  $Fix^-$  transconjugants into a  $Fix^+$  recipient the majority of transductants inherited  $Fix^-$  indicating that the insertion of Tn5 had induced the symbiotic mutations. Transduction of kan, from the clones that failed to donate  $Nod^+$  by conjugation to strain 6015, occurred at barely detectable frequencies and it was not possible to demonstrate transduction of  $Nod^-$ . Kan was co-transduced with  $Nod^+$  from some of the clones and some of these transductants also inherited the ability to produce medium bacteriocin and to transfer at high frequency by conjugation. Thus the genes for all these characters are closely linked. - Biol. Abstr. 70,1980.

145. BUI, Min' DYK SHAPOSHNIKOV, G.L. and ASEVA, K.B. Nitrogen-fixing activity of nodules and content of free amino acids in roots and aboveground parts of mung bean (*Phaseolus aureus*) and cowpeas (*Vigna catjang*) (In Russ). Prikl. Biokhim. Mikrobiol., 15(3), 1979: 444-449, Engl. summ. Seeds of mung (*P. aureus* L.) and vigna (*V. catjang* Walp.) were inoculated with bacteria *Rhizobium* sp. *P. aureus* str. 468. N-fixing activity of nodules and the content of free amino acids in roots and overground parts of mung and cowpea were measured. Roots of plants grown from inoculated seeds developed nodules. N-fixing activity of nodules of mung was significantly higher than that of cowpea. Mung and cowpea plants grown from inoculated seeds showed a far greater weight than those grown from noninoculated (control) seeds. The content of total N in roots and aboveground parts of plants grown from inoculated seeds was 23-38% higher than that of controls. The N content in nodules of mung was higher than of cowpea. The content of amino acids, except to serine, in plants grown from inoculated seeds was essentially higher than that in plants grown from noninoculated seeds. - Biol. Abstr. 70,1980.

146. BULOW, J.F.W. von. Plant influence in symbiotic nitrogen fixation (Legume, grass). In: Proceedings of a Conference on Limitations and Potentials for Biological Nitrogen Fixation in the Tropics, Brasilia. 1977. New York, Plenum Press, 1978, vol. 15th, pp.75-94, bibliog.; ref.
147. BUNEVA, V.N., KUDRYASHOVA, N.V., KURBATOV, V.A. and ROMASH-CHENKO, A.G. Affinity alkylation of *Escherichia coli* RNA-dependent DNA polymerase with TTP  $\gamma$ -amide derivatives (In Russ.). *Biokhimiya*, 43 (12), 1979: 2261-2264, Engl. summ. TTP  $\gamma$ -benzylamides act as competitive inhibitors of poly (dT) synthesis catalyzed by *E. coli* RNA-dependent DNA polymerase. The  $K_m$  value for TTP and  $K_i$  [inhibition constant] values for the  $\gamma$ -analogs were determined. TTP  $\gamma$ -4-(N-2-chloroethyl-N-methyl-amino)benzylamide is an effective affinity reagent for this enzyme. - Biol. Abstr. 68,1979.
148. BUNKHOED, Nanthakon, KHOTRAPHONG, Somsak, CHUNRUCHANON, Somphong, WADISIRISAK, Pricha and WASUWAT, Yenchai. Studies on the competition between inoculated strains and local of strain *Rhizobium japonicum* (In Thai). In: Annual Research Report 1975-1976, Plant Pathology Division, Department of Agriculture, Ministry of Agriculture and Cooperatives, Bangkok, Ministry of Agriculture and Cooperatives, 1976, pp.184-190. Nine strains of *R. japonicum* were studied for strain competition in field grown soybeans at Hua Hin in wet season, 1975. Result indicated that all applied strains (except THA 6) recovered significantly over the local strains. - Thai Abstracts No. 8,1981.
149. BUNKHOED, Nanthakon, RUNGRATTANAKASIN, Worawit, CHUNLUCHANON, Somphon, PHANUWAT, Wichian, CHAOWASAN, Phonphop and TANWINUKUN, Chirayut. Nitrogen fixation of *Rhizobium japonicum* and nitrogen fertilizer equivalent (In Thai). In: Proceedings of the National Conference on Agricultural and Biological sciences, 14th Session, Plant Science, at Kasetsart University, 2-4 February 1975. Bangkok, Kasetsart University, 1975, pp.166-174, Engl. summ. The amount of N fixed symbiotically depended largely upon the availability of soil N, water and ranged from 1 to 16.8 kg/rai, that is, 0.7 to 69% of the total N uptake, respectively. The amount of symbiotic N fixation decreased rapidly with increases in fertilizer N. Under moderately moisture stress, the un-

- inoculated soybean responded linearly to applied N.
150. BUNKHOED, Nanthakon, WADISIRISAK, Pricha and WASUWAT, Yenchai. Influence of pesticides on *Rhizobium japonicum* (In Thai). In: Annual Research Report 1975-1976, Plant Pathology Division, Department of Agriculture, Ministry of Agriculture and Cooperatives. Bangkok, Ministry of Agriculture and Cooperatives, 1976, pp.202-208. Six kinds of pesticide (benlate, difolatan, morestan, thiomate, terrachlor and furadan) were studied for their harmful effect on *R. japonicum* in field grown soybean at two locations. The results indicated that difolatan when applied at the recommended rate had seriously harmful effect on nodulation and yield of soybeans at Roi Et. - Thai Abstracts No. 8, 1981.
  151. BUNKHOED, Nanthakon, WADISIRISAK, Pricha and WASUWAT, Yenchai. Studies on the increasing yield of soybeans by using inoculant, fertilizer and lime (In Thai). In: Annual Research Report 1975-1976, Plant Pathology Division, Department of Agriculture, Ministry of Agriculture and Cooperatives. Bangkok, Ministry of Agriculture and Cooperatives, 1976, pp.191-201. Studies on the increasing yield of soybeans by using inoculant, fertilizer and lime were evaluated at three locations in wet season, 1975. Results shown that all inoculation treatments (Inoculation alone; Inoculation + Fertilizer; Fertilizer; Inoculation + Lime; Inoculation + Phosphorus; Inoculation + Fertilizer + Lime.) gave better results in increasing yield of soybeans obtained by treated with inoculation + fertilizer + lime. However, by using inoculation alone could guarantee yield increase more than using fertilizer alone in sandy soil having adequate phosphorus, and obtain maximum profit. - Thai Abstract No. 8, 1981.
  152. BUNKHOED, Nanthakon, WADISIRISAK, Pricha, KHOTRAPHONG, Som-sak and WASUWAT, Yenchai. Selection of efficient *Rhizobium japonicum* strains under field condition. (In Thai). In: Annual Research Report 1975-1976, Plant Pathology Division, Department of Agriculture, Ministry of Agriculture and Cooperatives. Bangkok, Ministry of Agriculture and Cooperatives, 1976, pp.174-183. Nine selected strains of *R. ja-*

*ponicum* for S.J. 2 soybeans were tested under field condition at three locations. Results shown that all tested strains increased yield of soybeans more than uninoculated treatment and among strains were not significantly different from one another. In field containing sufficient amount: of P and Mo. Yield of soybeans could be increased up to 384 kg/rai. However, in field having low soil fertility and essentially free of soybean rhizobia inoculated with good strains could increase soybean yield more than 80%. - Thai Abstracts No. 8,1981.

153. BUNKHOED, Nanthakon, WADISIRISAK, Pricha, RUNGRATTANAKASIN, Worawit and WASUWAT, Yenchai. Selection of efficient *Rhizobium japonicum* strains under farming condition (In Thai). In: Proceedings of the National Conference on Agriculture and Biological Sciences, 15th Session, Plant Science Section, at Kasetsart University, 3-5 February 1976. Bangkok, Kasetsart University, 1976, pp.227-236, Engl. summ. The effects of *R. japonicum* strains on growth characteristics and seed yield of S.J. 2 soy-beans grown in field under farming condition at three locations were evaluated. In field where essentially free of soybean rhizobia and high P and K level, all strains tested were better than check in increasing seed yield of soybeans without applying any fertilizer. The highly effective strain could increase the seed yield of soybeans up to 200 Kg/rai over the check. However, in fields where the level of P is rather low, inoculation with good strain could still get more yield than check but the yield was lower than usual average yield.
154. BUNKHOED, Nanthakon, WADISIRISAK, Pricha, RUNGRATTANAKASIN, Worawit and WASUWAT, Yenchai. Study on the influence of molybdenum rates on *Rhizobium japonicum* and soybean yield (In Thai). In: Proceedings of the National Conference on Agricultural and Biological Sciences, 15th Session, Plant Science Section, at Kasetsart University, 3-5 February 1976. Bangkok, Kasetsart University, 1976, pp.220-226, Engl. summ. The results of two experiments revealed that when molybdenum rates were applied from 0.01 ppm up to 20 ppm, soybean yields were increased better than non-molybdenum applied. However, a suitable rates of molybdenum applied was 1 ppm.

155. BUNKHOED, Nanthakon, WADISIRISAK, Pricha, RUNGRATTANAKASIN. Worawit, KHOTARAPHONG, Somsak and WASUWAT, Yenchai. Studies on the competition between inoculated strain and local strain of *Rhizobium japonicum* (In Thai). In: Proceedings of the National Conference on Agricultural and Biological Sciences, 15th Session, Plant Science Section, at Kasetsart University, 3-5 February 1976. Bangkok, Kasetsart University 1976, pp.238-247, Engl. summ. Strain competition study in the greenhouse showed that strain THA 1, 122 and 15-7 were equally competitive to one another, where as strain 8-0 was much more competitive than three strains. The results of field studies at Mae Jo and Lampang showed that soybean seed yields were not significantly different in both area. With regard to strain competition at Mae Jo. The percent recovery of applied 8-0 strain was increased significantly. At Lampang the percent recoveries of all, applied strains (76, 8-0, 122, 15-7) were increased significantly.
156. BURGOON, A.C. and BOTTINO, P.J. Uptake of the nitrogen fixing blue-green algae *Gloeoecapsa* into protoplasts of tobacco and maize (Possible initial step toward transferring the capability of nitrogen fixation to non-leguminous plants). *Journal of Heredity*, 67(4), 1976: 223-226, ref.
157. BURNS, T.A., BISHOP, P.E. and ISRAEL, D.W. Enhanced nodulation of leguminous plant roots by mixed cultures of *Azotobacter vinelandii* and *Rhizobium*. *Plant and Soil*, 62(3), 1981: 399-412. illus.; tables; ref. *Azotobacter vinelandii* strains caused the formation of increased numbers of root nodules on *Glycine max*, *Vigna unguiculata* and *Trifolium repens* by their respective rhizobial symbionts. A split-root experiment suggested that the agent (s) responsible for the increased nodulation was not translocatable throughout the plant. The results suggest a non-excretable protein, produced by *A. vinelandii*, as a possible mechanism for nodulation enhancement. - *Abstr. on Trop. Agri.* 7, 1981.
158. BURRIS, R.H. Advances in biological nitrogen fixation (Electron transfer, *Clostridium pasteurianum*, *Azotobacter vinelandii*, nodule bacteria). *Developments in Industrial Microbiology*, vol. 19, 1973: 1-13, ref.

159. BURRIS, R.H., ALBRECHT, S.L. and OKON, Y. Physiology and biochemistry of *Spirillum lipoferum* (Nitrogen fixing bacteria). In: Proceedings of a Conference on Limitations and Potentials for Biological Nitrogen Fixation in the Tropics, Brasilia, 1977. New York, Plenum Press, 1978, vol. 15th, pp.303-315, ref.
160. BURRIS, R.H. Energetics of biological N<sub>2</sub> (Nitrogen) fixation. In: MITSUI, A., ed. Biological solar energy conversion. United States - Japan Cooperative Science Program; National Science Foundation; Nihon Gakujutsu Shinkukai. New York, Academic Press, 1977, pp.275-289, ref.
161. BURRIS, R.H., LJONES, T., EMERICH, D.W. Nitrogenase systems (Nitrogen fixation). In: Proceedings of a Conference on Limitations and Potentials for Biological Nitrogen Fixation in the Tropics, Brasilia, 1977. New York, Plenum Press, 1978, vol. 15th, pp. 191-207.
162. BURRIS, R.H. Overview of biological N<sub>2</sub> (nitrogen fixation). In: Proceedings of a Conference on Genetic Engineering for Nitrogen Fixation, Brookhaven National Laboratory, 13-17 March, 1977. New York, Plenum Press, 1977, pp.21-30.
163. BURTON, J., HOLLAENDER, A., JOHNSTON, A., LARUE, T., OWENS, L., SCHUBERT, K., VALENTINE, R. and WEBER, D. Environmental consequences of genetic engineering of *Rhizobium* to improve symbiotic biological nitrogen fixation. In: Proceedings of a Conference on Genetic Engineering for Nitrogen Fixation, Brookhaven National Laboratory, 13-17 March 1977. New York, Plenum Press, 1977, pp.107-112.
164. BURTON, J.C. Associations of some uncommon leguminous plants with various rhizobia. College of Tropical Agriculture Hawaii, Legume Rhizobium Workshop, Miscellaneous Publication no. 145, 1977, pp.381-384, table. The full potential of a leguminous plant can be measured only when the proper rhizobia are provided for effective nodulation, so that the plant can utilize the vast reservoir of free nitrogen (N<sub>2</sub>) in air. The objectives of this paper are: to study the nodulating characteristics of various leguminous species imported into the US for evaluation as food or forage

- legumes; and, if possible, prepare an effective *Rhizobium* inoculum for each plant species. The reactions of some uncommon leguminous plants to inoculation with various rhizobia are listed. - Abstr. on Trop. Agri. 6,1980.
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167. BURTON, J.C. Some important considerations of *Rhizobium* inoculants for developing countries. In: FAO/UNEP Meeting on Biological Nitrogen Fixation (Symbiotic), Rome, 16 June 1980. Rome, FAO, 1980, 10p., ref.
168. CANIZO, A. and RODRIGUEZ-BARRUECO, C. Nitrogen fixation by *Coriaria nepalensis*. *Revue d' Ecologie et de Biologie du Sol*, 15(4), 1978: 453-458. *C. nepalensis* Wall. bearing root nodules grew satisfactorily in culture solution free of combined N. The nodules showed substantial acetylene reducing activity. A description of the nodule endophyte



is given. Nodule efficiency, expressed as mg N fixed per g nodule dry weight, was 546. The geographic distribution of the species examined is restricted to Nepal. - Biol. Abstr. 70,1980.

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170. CARRAN, R.A. Nitrogen fixation in pasture: 10 Southland, Gore, New Zealand. *New Zealand Journal of Experimental Agriculture*, 7 (1), 1979: 39-42. Data from periodic N fixation assays of soil cores from rotationally [sheep] grazed pasture showed, over 2 yr, marked similarity in seasonal pattern. The pattern was characterized by 2 distinct peaks in activity: the first in early spring, the 2nd in early summer. While the N fixation patterns were similar in both years, clover [*Trifolium repens*] growth rate curves were dissimilar. - Biol. Abstr. 69, 1979.
171. CARTER, Ians S. and DAWES, Edwin A. Effect of oxygen concentration and growth rate on glucose metabolism, poly- $\beta$ -hydroxybutyrate biosynthesis and respiration of *Azotobacter beijerinckii*. *Journal of General Microbiology*, 110 (2), 1979: 393-400. The effect of dissolved  $O_2$  concentration on glucose metabolism, poly- $\beta$ -hydroxybutyrate (PHB) synthesis and respiration of  $N_2$ -fixing *A. beijerinckii* was investigated over a range of values spanning  $O_2$  limitation and sufficiency (N limitation) in continuous culture. The activities of the Entner-Doudoroff enzymes decreased with increasing  $O_2$  supply while glucose-6-phosphate dehydrogenase was unaffected;  $\beta$ -ketothiolase and acetoacetyl-CoA reductase decreased more markedly, reflecting the fall in PHB content. The metabolic quotients for  $O_2$  and  $CO_2$  increased rapidly with increasing  $O_2$  supply, in keeping with the respiratory protection of nitrogenase. The specific activities of all these enzymes, and also of fructose-1, 6-bisphosphate aldolase, increased with increasing dilution rate under

either O<sub>2</sub> or N limitation, except that both β-ketothiolase and acetoacetyl-CoA reductase activities fell at the highest dilution rate (0.23 h<sup>-1</sup>) under O<sub>2</sub> limitation. The role of the Entner-Doudoroff sequence as the major route of glucose metabolism in *A. beijerinckii* was unaffected by O<sub>2</sub> concentration and growth rate. - Biol. Abstr. 68, 1979.

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174. CHANTADISAI, Thasanee. Biological nitrogen fixation in the rice field. Bangkok, Mahidol University, Faculty of Graduate Studies, 1978, 74p., tables; ref.
175. CHANTANAO, Amara and SRIMAHASONGKHAM, S. Nitrogen fixation of *Azotobacter* in tropical soil. In: Kasetsart University Research Report for 1979-1980. Bangkok, Kasetsart University, nd., p.209. Soil samples were collected from rice fields in the central region of Thailand and from the dry evergreen and dry dipterocarp forest of Sakaerat experiment station, Nakornrajsima province, about 300 km by road from Bangkok. For samples from rice fields, sampling was performed

while the soils were submerged as well as dry condition. Fifty-nine isolates of *Azotobacter* were obtained from these samples by dilution plate technique. Acetylene reduction assay was used for screening efficient strains of the fifty-nine isolates. Distinctively higher nitrogenase activities were obtained from 6 isolates. In order to estimate the maximum attainable nitrogen fixed by these efficient strains, total numbers of *Azotobacter* in the fields were examined by using a dilution plate method. The estimated maximum attainable nitrogen fixed by the most effective isolate was  $43.7 \text{ kg ha}^{-1} \text{ yr}^{-1}$ . - Authors.

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177. CHARYULU, P.B.B.N. and RAO, V. Rajahamamohan. Nitrogen fixation in some Indian rice soils. *Soil Science*, 128(2), 1979: 86-89. Heterotrophic N fixation, as influenced by water treatment, cellulose and  $(\text{NH}_4)_2\text{SO}_4$  was investigated in 4 tropical, Indian rice soils; the  $^{15}\text{N}$  tracer technique was used for the 1st time. Despite high salinity and acidity, appreciable N fixation occurred in the acid sulfate and the saline soils under both flooded and non-flooded conditions. Soil submergence accelerated N fixation in all soils. Addition of cellulose to both nonflooded and flooded soils enhanced N fixation. In flooded alluvial and laterite soils, N fixation decreased with increasing concentrations of  $(\text{NH}_4)_2\text{SO}_4$ ; under nonflooded conditions, this inhibition was more pronounced, particularly in laterite soil. N fixation was completely inhibited by

(NH<sub>4</sub>)<sub>2</sub>SO<sub>4</sub> in the acid sulfate and the saline soils. - Biol. Abstr. 69,1979.

178. CHARYULU, P.B.B.N., RAMAKRISHNA, C. and RAO, V. Rajaramamohan. Facultative symbiotrophic nitrogen-fixing associations in rice soils of India. *Proceedings of the Indian Academic of Science, Section B*, 87(10), 1978: 243-246. Associations from rice straw-amended alluvial soil under both flooded and non-flooded conditions exhibited higher N<sub>2</sub>-fixing efficiency than those from unamended soils of both water regimes. Despite high salinity and acidity an acid sulfate soil harbored N<sub>2</sub>-fixing symbiotrophic organisms with appreciable efficiency. Application of rice straw to the soil under flooded and non-flooded conditions stimulated N<sub>2</sub>-fixation in alluvial, laterite and acid sulfate saline soils. These observations suggested the significant contribution of these associations to the N economy of different soil types. - Biol. Abstr. 68,1979.
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nodules per hour. - Biol. Abstr. 69,1979.

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Taiwan are also included. - Abstr. on Trop. Agri. 8, 1982.

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186. CHILD, J.J. and KURZ, W.G.W. Inducing effect of plant cells on nitrogenase activity by *Spirillum* and *Rhizobium* in vitro. *Canadian Journal of Microbiology*, 24(2), 1978: 143-148; ref.
187. CHOMCHALOW, S. Rhizobium-soybeans symbiotic relationships. *Thai Journal of Agricultural Science*, 8(3), 1976: 119-129, tables; ref. In order to study the relationships between the *Rhizobium* strains and soybean varieties, an experiment was conducted at ASRCT during January-March 1973 employing 3 varieties of soybean, namely SJ 2, Acadian, and Taichung 12, inoculated with 6 strains of *Rhizobium* bacteria CBI795, CBI809, US38, CN1, SPT and 15-7 strains. Three varieties of soybean were grown in pots filled with Yasothon soil which has never been used to grow soybean before. They were then kept in the greenhouse until the end of the experiment. It was found that for SJ2 variety the most effective strain of *Rhizobium* was CBI795, the second and third ranks were US38 and SPT. For both Acadian and Taichung varieties the most effective was SPT and the runners up were CBI795 and US38. Regarding to soybean variety, Taichung 12 gave the highest response in terms of dry weight but it is not significantly different from SJ2. As for *Rhizobium* strains, SPT was the most effective strain whereas CBI795 and US38 were the

runners up. This study has the prime importance in selecting proper strains of *Rhizobium* for each variety of soybean.

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189. CHOMCHALOW, Srivan. The effectiveness of introduced *Rhizobium* strains on "Rayong" peanut. In: Proceedings of the National Conference on Agricultural and Biological Sciences, 10th Session, Plant Science, at Kasetsart University, 3-5 February 1971. Bangkok, Kasetsart University, 1971, pp.200-208. Three strains of *Rhizobium* bacteria (CB 746, CB 749, and CB 756) received from CSIRO, Australia, were inoculated onto "Rayong" peanut seeds in an attempt to compare the effectiveness of these strains which have been known to be effective in inducing nodulation on foreign peanut varieties. It was found that CB 756 was the most effective strain on the bases of plant height, number of nodules per plant, dry weight of whole plant, and amount of nitrogen uptake per plant. Peanut grown in sterile media under nitrogen-free condition without *Rhizobium* inoculation gave the least yield in all criteria. - Author.
190. CHOMCHALOW, Srivan. The effectiveness of local strain of *Rhizobium* on "S.J.2" soybean grown in various soil series (In Thai). Bangkok, Applied Scientific Research Corporation of Thailand, 1975, 6p. (Research Project No. 44/3,

Report No. 8). A pot experiment was conducted at ASRCT using Yasothorn, Korat, and Nam Phong Soil series in order to study the effectiveness of a locally isolated strain of *Rhizobium* on the growth of SJ 2 soybean. Among the data collected were dry weight per plant, number of nodules per plant, weight of 100 seeds, number of pod per plant, number of seed per plant and total seed. It was found that inoculation treatments in all three soil series significantly outyielded the uninoculated treatments. It is noted that inoculation on Yasothorn soil series significantly produced the highest dry weight of 100 seeds. It is anticipated that the employment of proper strain of *Rhizobium* inoculum increase the yield of soybean, and the use of proper strain on specific soil series improves the quality of seed obtained.  
- Author.

191. CHOMCHALOW, Srivan. The effectiveness of *Rhizobium* strain CB 756 in inducing nodulation on mung bean varieties (In Thai). Bangkok, Applied Scientific Research Corporation of Thailand, 1975, 4p. (Research Project No. 44/3, Report No. 7). Preliminary pot experiment has been conducted at ASRCT under aseptic condition in order to study the effectiveness of introduced, cowpea type *Rhizobium* strain, CB 756 in inducing nodulation on nine mung bean varieties, namely: Black seed, Burken, M-7A, M-21E, Philippine Commercials, Rough Indian Selection No. 1, Rough Tainan, Shiny black seed, and shiny white pod. After 21 days of the bean growth, observation was made and recorded. It was found that variety Shiny black seed (a local variety) and Burken (an introduced variety) exhibited the highest amount of nodulation (100 and 95.23% respectively). The next in order of nodule formation were shiny white pod (80.64%), M-7A (69.33%), Rough Indian Selection #1 (54.94%), Philippine Commercials (39.02%) and black seed (10.0%). - Author.
192. CHOMCHALOW, Srivan and NORMAN, B. A comparative study on the effectiveness of local and introduced *Rhizobium* strains on "S.J.2" soybean. Bangkok, ASRCT, 1971, 10p. (Research Project No. 44/3, Report No. 3). By modified "Leonard's jar" assembly, seven strains of introduced *Rhizobium japonicum* received from the United States (US 38, US 62, US 94, US 110, and US 112), and from Australia (CB 1795 and



CB 1809) were inoculated onto "S.J.2" soybean seeds in an attempt to compare the effectiveness of these introduced strains which have been known to be effective in inducing nodulation on foreign soybean varieties. A locally isolated strain from Chai Nat (CN 1) was also tested. It was found that strain CB 1795 was the best and strains US 38, US 110, and CB 1809 were equally effective on the bases of nodulation, dry weight per plant, and nitrogen uptake per plant. Strain CN 1 was effective in nodulation but its ability to fix atmospheric nitrogen was inferior to that of some of the introduced strains. - Authors.

193. CHOMCHALOW, Srivan and PIRAMAN, Pradit. Preliminary study on the method of production and application of *Rhizobium* inoculant to increase "S.J.2" soybean yield (In Thai). Bangkok, Applied Scientific Research Corporation of Thailand, 1975, 14p. (Research Project No. 44/3, Report No. 9). Preliminary study was conducted on the method of production and application of *Rhizobium* inoculant (or root nodule bacteris) to increase SJ.2 soybean yield, instead of using nitrogen fertilizer which was more expensive. The inoculant is also known as "legume inoculant" or "bacterial fertilizer". The inoculant was prepared by using local materials as carrier mixing with selected strain of *Rhizobium* at the moisture of 40-50%. The carrier for mixing comprised coir dust, charcoal and lime ground and sifted through 100-mesh sieve, with pH 6.8. It was found from the test that the carrier sterilized before mixing with the broth was better than the non-sterilized one. And sterilizing the carrier through gamma radiation at the dose of  $4.5 \times 10^6$  M rads gave better result than steam treatment of  $120^\circ\text{C}$  at 15 lbs. The viability of the inoculants stored in refrigerator ( $12^\circ - 15^\circ\text{C}$ ) was better than in room temperature ( $26^\circ - 32^\circ\text{C}$ ). Field experiment indicated that inoculated treatment outyielded the uninoculated one by 61 kg/rai in the northeast and 36 kg/rai in the central plain and the east. The use of inoculant alone at the cost of  $\text{฿ } 15/\text{rai}$  was able to increase the yield by 38.1/kg/rai, equivalent to  $\text{฿ } 190.5/\text{rai}$ , whereas the use of fertilizer at the rates of 3 and 6 kg N/rai (at the cost of  $\text{฿ } 75$  and  $150/\text{rai}$ ) was able to increase the yield by 36.5 and 20.9 kg/rai respectively. It is anticipated that

the application of N fertilizer to soybean is not only expensive, but also reduces the yield of soybean with the higher rate of N fertilizer applied. - Authors.

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195. CHUNDEROVA, A.I. and ALISOVA, S.M. Daily dynamics of symbiotic nitrogen fixation activity in pea during the phase of budding and flowering. *Soviet Plant Physiology*, 26(3, pt. 2), 1979: 475-479, illus., ref.
196. CLARHOLM, M. and GRANHALL, U. Biological nitrogen fixation in relation to energy forest production (*Salix* spp., *Myrica gale*, *Alnus incana*, pasture legumes, intercrop, pot experiments, field experiment, Sweden). Progress Report 1978-1980. Teknisk Rapport (Projekt Energiskogsodling (Sweden). Uppsala (Sweden) - Sveriges Lantbruksuniv no. 22, 1981, 41p.; ref.
197. CLARK, D.A., CAUSLEY, D.C. and BROUGHAM, R.W. Nitrogen fixation in pasture: 6 Manawatu plains, Kairanga, New Zealand. *New Zealand Journal of Experimental Agriculture*, 7(1), 1979: 23-26. Pasture production varied considerably between years, 11,400 kg/ha in 1974-75 and 16,100 kg/ha in 1975-76, but legume content was relatively constant (21-23% of total dry matter). Estimates of total annual N fixation were 211 and 242 kg/ha in 1974-75 and 1975-76, respectively, indicating the importance of white clover (*Trifolium repens* L.) in the pastures studied. Of the total annual N fixation 41-43% occurred in the spring of each year, 20-26% in summer, 12-18% in autumn and 18-22% in winter. - Biol. Abstr. 69, 1979.
198. CLARK, K.W. Fababeans require K (potassium) for growth and nitrogen fixation in Manitoba (Canada). *Better Crops with*

*Plant Food*, vol. 64, 1980: 14-17, illus.

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200. CONNOLLY, V. and O'KEEFEE, M. Acetylene reduction assay on white clover genotypes and on grass and clover swards. *Annals of Applied Biology*, 93 (1), 1979: 55-62. Acetylene reduction assay was used to measure the nitrogenase activity of white clover genotypes in pots and of grass/clover swards in situ. Much of the variation in nitrogenase activity of single genotypes and hybrid populations was associated with plant dry weight. After adjustment for plant dry weight there was limited scope for selection for increased nitrogenase activity. In plant breeding this technique would seem to have greatest application in the selection for continued N fixation activity in the presence of inhibitory factors such as high levels of mineral N. The in situ studies revealed differences in nitrogenase activity of grass/clover swards based on contrasting cultivars of white clover. These differences were due to variation in clover density and also to variation in activity per unit clover dry weight. The variation in nitrogenase activity per unit dry weight reflected differences in growth pattern of the cultivars in the autumn when these assays were made. The in situ studies offer a means whereby the nitrogenase activity of cultivars and selected families can be monitored under varying levels

of mineral N and other husbandry treatments without disruption of the sward. - Biol. Abstr. 69,1979.

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202. CROOME, R.L. Nitrogen fixation in the algal mats on Marion Island, Antarctica. *South African Journal of Antarctic Research*, 0(3), 1973: 64-67. The 1965-1966 expedition to Marion Island found that the surface of many of the mires was covered by a thick gelatinous layer of Cyanophytes. This mat was investigated with particular emphasis placed on the determination of atmospheric N<sub>2</sub> fixation by the cyanophytes present. *Calothrix* sp. and *Tolypothrix* sp. were successfully isolated from the mat. The most common alga of the mires was *Stigonema ocellatum*. - Biol. Abstr. 70,1980.
203. CROUCHLEY, G. Nitrogen fixation in pasture: 8 Walraraapa plains dryland, Masterton, New Zealand. *New Zealand Journal of Experimental Agriculture*, 7(1), 1979: 31-34. N fixation in pasture yielding 9.4 - 12.2 t DM[tons dry matter]/ha varied from 90 to 241 kg N/ha per annum over 2 consecutive years. Factors appearing to effect N fixation and clover [*Trifolium repens*] growth included soil moisture deficits, clover root cyst nematode [*Heterodera trifolii*] predation, and possibly clover flowering. There was a large growth response to a winter fertilizer N treatment over the 1st & 2 yr of the trial, but no response in the 3rd winter, after a season of exceptionally high N fixing activity. - Biol. Abstr. 69,1979.
204. CRUSH, J.R. Nitrogen fixation in pasture: 9. Canterbury plains, Kirwee, New Zealand. *New Zealand Journal of Experimental Agriculture*, 7(1), 1979: 35-38. N fixation by *Trifolium repens* L., cv. Grasslands Huia in rotationally grazed, dryland and irrigated sheep pastures, was estimated over 2 yr, using the acetylene reduction assay. Estimates of total N fixed annually ranged 106-145 kg N/ha (dryland) to 152-226 kg N/ha (irrigated). There was negligible fixation over winter and pronounced peaks of activity in spring

and autumn, with a trough in summer. Spring and autumn fixation rates correlated well with clover growth rates and temperature. Summer fixation rates were affected by drought on the dryland farmlet and a further factor, probably N mineralization. - Biol. Abstr. 69,1979.

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206. DAFT, M.J. Nitrogen fixation in nodulated and mycorrhizal crop plants beans (phaseolus). *Annals of Applied Biology*, 88(3), 1978: 461-462, ref.
207. DATE, R.A. and HALLIDAY, J. Selecting rhizobium for acid, infertile soil of the tropics. *Nature*, 277(5691), 1979: 62-64, illus.; tables; ref. Selecting *Rhizobium* strains adapted to acid infertile soil of the tropics is very difficult due to alkali production by rhizobia and the consequent rise in pH. This paper reports that interference from alkali production can be eliminated by a minor change in the screening medium. Usually mannitol is used as the standard carbon source for culturing rhizobia. This, however, usually results in a rise in pH from 4.5 to approximately 7.5. By substituting arabinose or alternatively galactose for mannitol it appeared that the pH decreased slightly (to 3.8) yet growth was essentially the same as in media incorporating mannitol. - Abstr. on Trop. Agri. 5,1979.
208. DATE, R.A. and NORRIS, D.O. *Rhizobium* screening of *Stylosanthes* species for effectiveness in nitrogen fixation. *Australian Journal of Agricultural Research*, 30(1), 1979: 85-104. The *Rhizobium* strain specificity and effectiveness in N fixation of 336 accessions of the genus *Stylosanthes* were determined in glasshouse screening trials. In preliminary screening, against a wide spectrum strain CB756, 224 accessions were effective (> 50% dry weight of N control). Sixty-two of these were evaluated subsequently against a spectrum of 22 strains of *Rhizobium* selected on the basis of host and geographic origins. Thirty-three were effective

with 10 or more strains. Seventy-two accessions that were ineffectively nodulated in preliminary tests were also screened against the 22 strains. Fifty-four of these were effective with 1 or more strains of *Rhizobium*. A minimum spanning tree (MST) analysis was used to examine the inter-relationships between, and the distribution of, accessions according to their effectiveness response (ER) to the 22 strains of *Rhizobium*. Accessions were classified into 6 groups, also according to their effectiveness response, by the program MULTBET. Groups I-IV were nodulated effectively by a large number of strains (mean 9.4) and groups V and VI by a limited number of strains (mean 1.3). Significant and wide-ranging *Stylosanthes* accession x strain of *Rhizobium* interactions for effectiveness in N fixation were observed, particularly in *S. guianensis* and *S. hamata*. Various reclassifications were made by MULTBET on a reduced number of strains which were selected on the basis of discriminatory powers between groups (eident values), contribution to the classification (Cramer measures) and intuitively on the basis of level of effectiveness specificity and soil pH adaption. Classifications based on Cramer measures gave least (9%) non-conforming accessions, but intuitively selected strains the widest range of effective associations. The majority of non-conforming accessions were found in effectiveness response groups ER-III and ER-IV and were mostly *S. guianensis* from M-A groups 2 and 14 and *S. hamata* M-A 28. For future screening programs strains CB 82, CB 159, CB 530, CB 756, CB 1408 and CB 2126 will be used as diagnostic strains for classification of accessions by effectiveness response, and strains CB 82, CB 1650 and CB 2126 as 'key strains' for provision of inocula for experimental purposes. Classification of strains of *Rhizobium* into 6 groups was obtained by a MULTCLAS analysis of the data matrix. A principal coordinates analysis suggested distinct clustering of strains on the basis of host specificity for effective nodulation. These corresponded very closely to the 6 classificatory groups. - Biol. Abstr. 68,1979.

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- 1979: 858-861, Engl. summ. The acetylene reduction method indicated that the root system of the Kentucky blue grass [*Poa pratensis*] and meadow foxtail [*Alopecurus pratensis*] have  $N_2$  fixing activity.  $N_2$  fixation was observed at the stages of earing and flowering. - Biol. Abstr. 70,1980.
210. DATTA, S.K.de, PONNAMPERUMA, F.N. and NEUE, H.U. Straw and organic matter (nitrogen source) management and BNF (biological nitrogen fixation) on tropical rice culture. In: IRRI Annual Program Review, at International Rice Research Institute, 21 January 1983. College, Laguna, International Rice Research Institute, 1983, 14p.; tables.
211. DAY, J.M. and WITTY, J.F. Novel aspects of nitrogen fixation. *Outlook on Agriculture*, 9(4), 1977: 180-185, illus.; bibliog.; ref. Only a fraction of the total agricultural need for nitrogen comes from natural or synthetic fertilizers. The remainder is satisfied largely through the biological fixation of atmospheric nitrogen. Whilst this is most efficiently effected by the Rhizobium-legume root nodule, free-living bacteria and blue-green algae are known to be capable of fixing appreciable amounts. Recently, attention has been focused on bacteria closely associated with roots of certain tropical grasses. Author's summary. - Abstr. on Trop. Agri. 4,1978.
212. DEAN, J.R. and CLARK, K.W. Inoculum specificity in faba beans and peas. *Canadian Journal of Plant Science*, 59(1), 1979: 27-34. The effect of inoculum specific to peas (*Pisum sativum* L.) on the nodulation, acetylene reduction and yield of faba beans (*Vicia faba* L.) was studied in 3 experiments. Faba beans, inoculated with pea inoculum or uninoculated (indigenous soil inoculum), were significantly inferior to faba beans inoculated with rhizobia specific for faba beans. Various mixtures of specific and non-specific inoculum (simulating competition between different rhizobia) were tested. One type was favored by slurring it onto the seed. When favored, the specific faba beans inoculum was equally effective with or without competition from non-specific inoculum. Favoring the pea inoculum led to a significant decrease in acetylene reduction, but this was not sufficient to reduce yield. Indigenous pea rhizobia

in the soil should not reduce N fixation and yields of faba beans when specific inoculum is slurried onto the seed. - Biol. Abstr. 68,1979.

213. DEAN, J.R., TOOMSAN, B. and CLARK, K.W. *Rhizobium* strain selection for fababeans (*Vicia faba*). *Canadian Journal of Plant Science*, 60 (2), 1980: 385-398. Strains of *R. leguminosarum* from a number of geographical origins were tested for N-fixing effectiveness on fababeans (*V. faba* L.). Initial screening in the greenhouse was followed by field testing of the best strains on soils low and high in nitrate-N in 1976. Strains F1 and F15 from Morocco produced significantly higher fixation rates than other effective strains during pod-filling in the low nitrate soil. Percent N in the seed and N yields were also highest with these strains. Strains F1 and F15 were tested again in 1978 with 3 other effective strains against 3 fababean cultivars. There were no strain x cultivar interactions, but N-fixation during pod-filling and seed N% were higher with F<sub>1</sub> and F<sub>15</sub>. The value of testing strains through to plant maturity<sup>15</sup> is illustrated by this result. F<sub>1</sub> also produced the highest N yield but differences among strains were not significant. Differences in N yield among cultivars were significant in 1978. - Biol. Abstr. 70,1980.
214. DEJONG, T.M., BREWIN, N.J. and PHILLIPS, D.A. Physiological interactions between Alaska peas and strains of *Rhizobium leguminosarum* that differ in plasmid - linked genes (*Pisum sativum*). *Genetic Engineering of Symbiotic Nitrogen Fixation and Conservation of Fixed Nitrogen*, 1980: 207-216, ref.
215. DELVAUX, B. Progress in the field of biological nitrogen fixation in Upper Volta: trials on groundnut inoculation with *Rhizobium* strains. In: *Proceedings of a Seminar on Recycling of Organic Agricultural Residues in Africa*, FAO, Rome, 24-28 November 1980. Rome, FAO, 1982, pp. 97-105. (Bulletin Pedologiques de la FAO, No. 47)
216. DEMONRANVILLE, C.J., KAMINSKI, A.R., BARNETT, N.M., BOTTINO, P.J. and BLEVINS, D.G. Substances from cultured soybean cells which stimulate or inhibit acetylene reduction by



free-living *Rhizobium japonicum* (Culture conditions, submerged culture, surface, *Streptomyces*, protease, *Daucus carota*, *Psophocarpus tetragonolobus*). *Physiologia Plantarum*, 52 (1), 1981: 53-58, tables; ref. The effect of cultured soybean (*Glycine max* (L.) Merr. cv. Acme) cells and extracts thereof on acetylene reduction by *Rhizobium japonicum* 61A76 was determined under two culture conditions. In the first (submerged culture) *Rhizobium* growing on solid medium were submerged in an aqueous layer containing soybean cell suspension or extract; both soybean cells and crude cell extract inhibited free living rhizobial nitrogenase measured by acetylene reduction. In the second culture condition (surface culture) *Rhizobium* was grown on the surface of an agar medium which contained expressed soybean cell sap (7.4% v/v), which caused an increase in free living rhizobial nitrogenase activity. Larger concentrations (12.9 to 19.4% v/v) of soybean cell extract inhibited acetylene reduction also in surface culture. Inhibition in submerged culture or surface culture was found after autoclaving of cells or extract, or treating the extract with pH extremes or with *Streptomyces protease*. Each of these treatments destroyed stimulatory activity of cell extract in surface cultures. Fractionation of the soybean cell extract on a Biogel P-6 column showed that there are three inhibitory fractions and at least one stimulatory fraction. Using column data and the fact that stimulatory and inhibitory factors were dialysable against 0.1 M phosphate buffer, we estimated the molecular weights of the factors. The stimulatory factor has a molecular mass (M, r) between 6,000 and 14,000. The inhibitory factors have molecular masses less than 6,000. Crude extracts from cultured carrot (*Daucus carota* (L) cv. Danvers) cells gave results similar to those seen with soybean cell extract. Extracts from cultured winged bean (*Psophocarpus tetragonolobus* (L.) DS. cv. TPt2) cells gave inhibition but no stimulation. (EN)

217. DENARIE, J., TRUCHET, G. The respective roles of *Rhizobium* and the legumes in their symbiotic relationship (biological nitrogen fixation) (In Fr.). *Physiologie Vegetale*, 17 (3), 1979: 643-667, bibliog.; Engl. summ.

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219. DE SMEDF, J., BAUWENS, M., TYTGAT, R. and DE LEY, J. Intrageneric and intergeneric similarities of ribosomal RNA cistrons of free-living, nitrogen-fixing bacteria. *International Journal of Systematic Bacteriology*, 30 (1), 1980: 106-122. <sup>14</sup>C-labeled RNA was prepared from *Azotobacter chroococcum* NCIB 8002, *A. paspali* 8A, *Azomonas agilis* NCIB 8636, *Azomonas insignis* WR 30, *Beijerinckia indica* NCIB 8712 and *Azospirillum brasilense* ATCC 29145. These rRNA were hybridized under stringent conditions with filter-fixed DNA from a great variety of gram-negative bacteria. Each hybrid was described by: the temperature at which 50% of the hybrid was denatured and the percent rRNA binding (amount in micrograms of rRNA duplexed to 100  $\mu$ g of DNA). These data were used to construct rRNA similarity maps. The following conclusions could be drawn concerning rRNA cistron similarities. Bacterial genera with free-living, aerobic N<sub>2</sub>-fixing members are very diverse and belong to different rRNA superfamilies. The present family Azotobacteriaceae is not a biological unit and its status as a family is highly questionable. *A. chroococcum*, *A. vine-landii*, *A. beijerinckii*, *A. paspali*, *A. miscellum*, *A. armeniae* and *A. nigricans* belong in the genus *Azotobacter*. Any synonymy of these names remains to be determined. *Azomonas agilis*, *Azomonas insignis* and *Azomonas macrocytogenes* constitute independent branches, which are about equidistant from *Azotobacter* and section I of *Pseudomonas* as presented in *Bergey's Manual of Determinative Bacteriology*, 8th ed. *Xanthomonas*, *Alteromonas vaga* and *Alteromonas communis* are located in the same rRNA superfamily. The genus *Beijerinckia* appears to be rather heterogeneous. Its closet relatives appear to be *Xanthobacter autotrophicus*, *Mycobacterium flavum*, *Pseudomonas azotocolligans*, *Pseudomonas diminuta*, the authentic rhodopseudomonads and some other organisms. These organisms belong in the same rRNA superfamily as *Azospirillum*, *Agrobacterium*, *Rhizobium*, *Acetobacter*, *Gluconobacter* and *Zymomonas*. *Derxia* belongs

in still another rRNA superfamily, together with *Chromobacterium*, *Janthinobacterium*, the *P. acidovorans* and *P. solanacearum* groups, *Alcaligenes*, and a few other taxa. The following organisms were generically misnamed: *Azomonas insignis* ATCC 12523 *Mycobacterium flavum* 301, *Pseudomonas azotocolligans* ATCC 12417, *Pseudomonas diminuta* CCEB 513 and *Rhodopseudomonas gelatinosa* (all strains examined). - Biol. Abstr. 70,1980.

220. DICKER, Howard J. and SMITH, David W. Enumeration and relative importance of acetylene-reducing (nitrogen-fixing) bacteria in a Delaware, USA, salt marsh. *Applied Environmental Microbiology*, 39(5), 1980: 1019-1025. Three groups of N<sub>2</sub>-fixing bacteria were enumerated from the top 1 cm of the surface in 4 vegetational areas in a Delaware salt marsh. Over the 9 mo, sampling period there were no discernible seasonal patterns for any group enumerated (*Azotobacter* sp., *Clostridium* sp. and *Desulfovibrio* sp.). *Azotobacter* sp. were present in numbers of 10<sup>4</sup>/g dry mud; the 2 anaerobic fixers were present in much lower number (10<sup>3</sup> - 10<sup>4</sup>/g dry mud). There were no differences in the numbers of each group among the different vegetational areas; there was a heterogeneous population of N<sub>2</sub> fixers present. The activity of sulfate reducers (*Desulfovibrio* sp.) may account for as much as 50% of the total observed acetylene reduction activity. O<sub>2</sub> exerted little effect on the observed acetylene reduction activity, indicating that stable aerobic and anaerobic microenvironments exist in the surface layer of marsh sediments. - Biol. Abstr. 70,1980.
221. DICKER, Howard J. and SMITH, David W. Physiological ecology of acetylene reduction (nitrogen fixation) in Delaware, USA, salt marsh. *Microbial Ecology*, 6(2), 1980: 161-172. The effects of several fixed N compounds on acetylene reduction activity (N fixation) of surface sediments from a Delaware salt marsh were studied. NH<sub>3</sub> addition caused little decrease in activity early in the summer, but resulted in a considerable decrease (85-95%) in activity late in the summer and early in the fall. Nitrate caused a near complete suppression of activity at all times. Other compounds such as glutamate, urea and yeast extract caused a slight increase in activity in tall *Spartina* sediments and caused more than

a 2.5 - fold increase in short *Spartina* sediments. There was a lag period (1-2 days) before the commencement of in vitro acetylene reduction activity during the spring and early summer, but this lag period was not present in the late summer. The addition of chloramphenicol to samples from a short *Spartina* zone caused decreases in activity similar to those obtained with  $\text{NH}_3$ , whereas chlorate amendments yielded results which, when compared on an electron basis, were comparable to those obtained with nitrate. The observed lag period may be the result of a physiological response to the in situ levels of  $\text{NH}_3$  and/or nitrate. In situ nitrogenase activity may be controlled by 2 processes: repression and derepression of nitrogenase synthesis mediated by the levels of  $\text{NH}_3$ , and competition for reducing power (electrons) and energy (ATP) between the processes of nitrate reduction and N fixation. - Biol. Abstr. 70,1980.

222. DILWORTH, M.J., ROBSON, A.D. and CHATEL, D.L. Cobalt and nitrogen fixation in *Lupinus angustifolius* L. II Nodule formation and function. *New Phytology*, 83(1), 1980: 63-80. The effects of Co deficiency on nodule formation and function in sweet lupin (*L. angustifolius* L. cv. Unicrop) were studied in Co-deficient Lancelin sand in the glass-house. Bacteroid [*Rhizobium lupini*] densities in Co-deficient nodules were lower than in normal nodules. Recovery from Co deficiency in inoculated treatments was associated with increases in bacteroid density and Co accumulation in lateral nodules. Such changes did not occur in treatments infected with rhizobia from the soil. Acetylene-reducing activity of Co-deficient plants was not initiated until plants were nearly 6 wk old, at which time Co-treated plants were at their peak of activity. Specific activities of Co-deficient nodules remained very low even when nitrogenase did develop. Their large mass of nodules allowed Co-deficient plants to reach 20-50% of the normal activity per plant, but specific activities

- were only 5-13% of peak activities in Co-treated nodules. Nodule bacteroid content and leghemoglobin content were linearly related to cobalamin content, each with a single relationship. Plotting acetylene-reducing activity against cobalamin content or leghemoglobin content generated 2 different linear response curves in each case. The slopes of the lines were different, depending on the presence or absence of cobalt. There may be a function in  $N_2$  fixation in legume nodules for a non-cobalamin form of Co. - Biol. Abstr. 69,1979.
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224. DIXON, R.O.D. Nitrogenase-hydrogenase inter-relationships in Rhizobia. *Biochimie*, vol. 60, 1978: 217-344.
225. DIXON, R.O.D., BERLIER, Y.M. and LESPINAT, P.A: Respiration and nitrogen fixation in nodulated roots of soya bean and pea. *Plant and Soil*, 61 (1), 1981: 135-143, ref. Oxygen uptake, carbon dioxide evolution and nitrogenase activity, measured either as hydrogen evolution (under argon 80%, oxygen 20%) or as the reduction of acetylene to ethylene, were assayed over the same time period by a direct mass-spectrometric method. When carbon dioxide evolution was used to estimate carbohydrate consumption, the results agreed with other work on whole plants. The RQ values obtained in these experiments were always less than 1.0 and thus the carbohydrate consumption calculated from oxygen uptake suggests that previous estimates, using carbon dioxide evolution as a measure of the cost of

nitrogen fixation may be underestimated. Lag periods observed in the reduction of acetylene to ethylene suggest that there is a resistance to diffusion of gases in the root nodules. (EN)

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227. DOBEREINER, J. Potential for nitrogen fixation in tropical legumes and grasses. *In*: Proceedings of a Conference on Limitations and Potentials for Biological Nitrogen Fixation in the Tropics, Brasilia, 1977. New York, Plenum Press, 1978, vol. 15th, pp.13-24, bibliog.; ref.
228. DOBEREINER, J. Biological nitrogen fixation in tropical grasses-possibilities for partial replacement of mineral N fertilizers. *Ambio*, 6 (2-3), 1977: 174-177. (Conference paper - 38. Nobel Symposium, Oersundsbro, 30 August 1976, graphs; illus.; table; ref.)
229. DOBEREINER, J. and DUQUE, F.F. Contribution of research on biological nitrogen fixation for the development of Brazil (In Port.). *Revista de Economia Rural*, 18 (3), 1980: 447-460, tables; ref. (18. Congresso Brasileiro de Economia e Sociologia Rural, Rio de Janeiro, RJ, 20 July 1980)
230. DOBEREINER, Johanna. Nitrogen fixation in tropical grasses (In Port.). *Interciencia*, 4(4), 1979: 200-206, Engl. summ. In tropical agriculture biological N fixation represents a much larger part of the N inputs than in temperate regions. This is partly due to more intensive agriculture in the latter but mainly to a larger choice of possibilities and environmental conditions which are more favorable to micro-biological activities in the tropics. Legumes represent the most perfect N<sub>2</sub> fixing symbiotic associations and the extension of this process to grasses and especially cereals is a major challenge in agricultural research in the tropics. These plants, due to their more efficient photosynthetic pathway (C<sub>3</sub>), not only yield more but also can

make available more easily the amounts of photosynthates necessary for  $N_2$  fixation. The contribution of associations of  $N_2$  fixing bacteria with various forage grasses and cereals is variable but can reach substantial potentials, particularly associations with *Azospirillum*. This bacterium occurs abundantly in tropical soils, mainly those under grasses. The endo-rhizosphere nature of these associations was demonstrated. One characteristic of *Azospirillum* is the interaction between dissimilation and assimilation of nitrates with  $N_2$  fixation which may represent the key for complementing  $N_2$  fixation with mineral fertilizer in grasses. First results on a host plant specificity among cereals in *Azospirillum* spp. infection reveal important tools which may help to establish selected or manipulated bacteria in cereal roots. Plant controls of the infection of the roots by bacteria involve selective assimilation by the plant of streptomycin which is produced in the rhizosphere. Various agricultural practices which eliminate limiting factors are discussed.

231. DOMMERGUES, Y., GARCIA, J.L. and GANRY, F. Microbiological considerations of the nitrogen cycle in West African ecosystems. In: Nitrogen Cycling in West African Ecosystems: Proceedings of a Workshop, IITA, 11-15 Dec. 1978. Stockholm, SCOPE/UNEP Royal Swedish Academy of Sciences, 1980, pp.55-72, graphs; tables; bibliog.; ref.
232. DONAWA, A.L. and GRAHAM, R. Biological nitrogen fixation research at the University of the West Indies (Trinidad and Tobago). *Tropical Agriculture*, 58(4), 1981: 289-290. (Regional Workshop on Biological Nitrogen Fixation, St. Augustine, Trinidad and Tobago, 4-8 January 1981)
233. DONAWA, A.L. and GRAHAM, R.A. Regional Workshop on Biological Nitrogen Fixation, St. Augustine, Trinidad and Tobago, 4-8 January 1981. *Tropical Agriculture*, 58(4), 1981: 289-367, illus.; tables; ref. A special issue of the journal comprising the papers and workshop discussion presented at the Regional Workshop on Biological Nitrogen Fixation, jointly sponsored by the Department of Soil Science, Faculty of Agriculture, University of the West Indies, and the Department of Agronomy, College of Agriculture and Life Sciences,

Cornell University, held at the University of the West Indies, St. Augustine, Trinidad from 4 to 8 January 1981. Most of the papers will be abstracted separately in ATA. - Abstr. on Trop. Agri. 7,1981.

234. DONAWA, A.L. and QUILT, P. Response of pigeon peas *Cajanus cajan* (L.) Millsp. to inoculation in a nutrient deficient soil. *Tropical Agriculture*, 58(4), 1981: 307-312, (Regional Workshop on Biological Nitrogen Fixation, St. Augustine, Trinidad and Tobago, 4-8 January 1981)
235. DOUKA, Catherine E. An unsterilized soil-agar technique for studying *Rhizobium*-plant relationships. *Journal of Applied Bacteriology*, 46(3), 1979: 615-622. The value of unsterilized soil-agar slopes for studying the effect of chemical and biological characteristics of soil on the rhizobia-plant relationships was demonstrated by examining the characteristics of 4 strains of *R. meliloti* isolated from salt-affected soils of Greece. The technique enabled information to be obtained on the survival of indigenous rhizobia and bacteria, the survival of rhizobia added to soil and the antagonistic-symbiotic effects. The effectiveness of inoculation on N<sub>2</sub> fixation could also be closely followed. - Biol. Abstr. 68,1979.
236. DREVON, J.J. A deficiency of the symbiotic nitrogen fixation in a dry tropical agrosystem: the nitrogen chlorosis of groundnut (*Arachis hypogaea*) in Senegal, In: Nitrogen Cycling in West African Ecosystems: Proceedings of a Workshop, IITA, 11-15 Dec. 1978. Stockholm, SCOPE/UNEP Royal Swedish Academy of Sciences, 1980, pp.221-231, illus.; graphs; tables; ref. Various types of chlorosis on groundnut (*Arachis hypogaea*) occur in Senegal. One that spreads over northern Senegal is described here, and identified as a nitrogen chlorosis due to a deficiency of nitrogen fixation resulting from poor nodulation. This chlorosis arises in acid soils, where there may be aluminum and manganese toxicity. No micronutrient deficiency has been found so far. Biotic factors, including the inadequacy of the *Rhizobium* population and the attacks of nematodes, may be responsible while the existing antagonism of actinomycetes towards *Rhizobium* would not interfere. Liming and, above



- all, organic matter application have proved to be means of control of the chlorosis. Author's summary. - Abstr. on Trop. Agri. 7,1981.
237. DREVON, J.J. and DIABAYE, A. Influence of bio-edaphic factors *Rhizobium* and nematodes on a peanut chlorosis in sahelo-sudanian zone of western Africa (In Fr.). *Plant and Soil*, 62 (3), 1981: 385-398, ref.; Engl. summ. This research is a field study of a peanut chlorosis observed in sahelo-soudanian area of western Africa. Measures and observations on plants and nitrogenase activity (C(,2)H(,4)) of nodules show that the studied chlorosis is due to a delay and general deficiency of nodulation. These two phenomena are associated with a limited number and a poor activity of *Rhizobium* in the chlorotic plants' rhizosphere. The nematode *Scutellonema cavenessi* which infects more these latest than the neighbouring plants, is also limiting the peanut nodulation through its negative effect on the root system. The action of these bio-edaphic factors is linked to the physico-chemical status of the soils under chlorosis. These are characterized by a low pH, the presence of exchangeable aluminum and a low content of calcium and magnesium. (EN)
238. DREVON, J.J. FAO/UNEP mission report on inoculation trials in Upper Volta, Senegal, Ivory Coast and Zaire, 1979. In: FAO/UNEP Meeting on Biological Nitrogen Fixation (Symbiotic), Rome, 16 June 1980. Rome, FAO, 1980, 33p., tables.
239. DREVON, J.J. Field trials of legume inoculation and some prospects of extension of nitrogen symbiotic fixation in West Africa. In: FAO/UNEP Meeting on Biological Nitrogen Fixation (Symbiotic), Rome, 16 June 1980. Rome, FAO, 1980, 12p., ref.
240. DUKE, Stanley H., COLLINS, Michael and SOBERALSKE, Ronald M. Effects of potassium fertilization on nitrogen fixation and nodule enzymes of nitrogen metabolism in alfalfa (*Medicago sativa* cultivar Vernal). *Crop Science*, 20 (2), 1980: 213-219. Studies with 4-yr-old 'Vernal' alfalfa (*M. sativa* L.) fertilized yearly from planting with 673 kg/ha K as  $K_2SO_4$  or KCl and 448 kg/ha K as  $K_2SO_4$  were made to determine the

effects of K on nodulation, acetylene reduction and nodule enzyme activities. The high rates of K fertilization increased nodule number and acetylene reduction rates over control plants, although the greatest increase in nodule mass and acetylene reduction rates was with the 673 kg/ha K as  $K_2SO_4$  treatment. This indicates that  $Cl^-$  and/or S may alter or mask the effects of K fertilization. Increases in acetylene reduction rates on a plant basis with K fertilization were due to increases in nodule mass and not increases in activity per unit weight of nodule tissue. With all treatments a positive linear correlation ( $P < 0.01$ ,  $r = 0.854$ ) was found between nodule number and acetylene reduction rate. The greatest increase in shoot weight per plant over control plants was with the 673 kg/ha K as KCl treatment. Positive linear correlations were found between rates of acetylene reduction and the activities of enzymes involved in ammonia assimilation (NAD-glutamate dehydrogenase, glutamine synthetase, NADP-glutamate dehydrogenase), amino acid interconversions (glutamate oxaloacetate transaminase), C supply (NADP-isocitrate dehydrogenase) and energy transduction (glucose-6-phosphate dehydrogenase, malate dehydrogenase). Due to lower nodule protein concentrations and higher nodule masses in the K treatments, specific activities and, in general, activities on a per plant basis of enzymes assayed from K treatments were much higher than those of the control treatment. Malate dehydrogenase and NADP-glutamate dehydrogenase specific activities were significantly higher than control plants for both 673 kg/ha K treatments. There were few differences between treatments for enzyme data calculated on a gram fresh-weight basis. Yields of the two 673 kg/ha K treatments were nearly equal at 3rd cut and were significantly higher than those of control plants. These data suggest that K fertilization increases alfalfa yields by increasing nodulation and  $N_2$ -fixation. - Biol. Abstr. 70,1980.

241. DUL'GEROV, A.N. and ANDREYUK, E.I. A statistical evaluation of the effect of ecological factors on biological processes in irrigated soils (In Russ.). *Mikrobiologichnyi Zhurnal* (Kiev), 41 (3), 1979: 217-221, Engl. summ. Microbiological [bacteria] processes in irrigated soils depend on changes in moisture, temperature, pH of soil solution and amount

of the introduced N fertilizers. Changes in the soil biological activity, in particular in the process of nitrification, N fixation and respiration of soil, are due to the factor by 40, 30 and 50%, respectively. Under conditions of irrigation the process of N fixation, nitrification and respiration is active at a temperature of 25-30° C. The fraction participation of temperature in the soil biological activity variation is 17-20%. The environmental reaction has a less pronounced effect on the biological processes: its fraction in changes in the activity of soil nitrification activity and respiration is not higher than 3-5%, and for the N-fixing capacity it is 20%. The fraction of mineral N as an ecological factor in changes of the soil nitrifying capacity and respiration is 30-45% and for the N-fixing capacity it is not higher than 10-12%. - Biol. Abstr. 70, 1980.

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those microorganisms. Purified cultures of soil isolates were capable of  $C_2H_2$  reduction.  $SO_4^{2-}$  reducing bacteria were considered responsible for the increase in  $N_2$  fixation but only 1-2  $\mu g$   $N_2$  were fixed  $g^{-1}$   $SO_4^{2-}$  reduced. The contribution of  $SO_4^{2-}$  reducing bacteria to the total  $N_2$  fixation in flooded soil is unimportant. - Biol. Abstr. 69,1979.

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- varying light diurnally under constant temperature; varying temperature diurnally under constant light; and maintaining both light and temperature constant. Apparent  $N_2$  fixation (acetylene reduction) showed diurnal fluctuations under constant light and under 12/12h light/dark regimes when root and air temperature fluctuated by 7 and 14° C, respectively. In constant temperature and either normal photoperiods or constant light, no significant diurnal fluctuation of acetylene reduction was measured. Under both constant temperature regimes a gradual increase in acetylene reduction activity, which may have been an artifact, was observed. These results show that diurnal changes in acetylene reduction by subterranean clover result more from fluctuations in temperature than from diurnal changes in light and suggest that  $N_2$  fixation by root nodules of this species is buffered against short-term changes in photosynthate supply. - Biol. Abstr. 70,1980.
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These glycolipids are of taxonomic significance. The pattern of lipids representative for heterocysts allow a differentiation between the phycobionts within the genera *Peltigera*, *Nephroma*, *Solorina*, *Sticta*, *Lobaria* (incl. *Dendriscoaulon*) and others. Frequency of heterocysts (in % of total algal cells) and the intensity of heterocyst lipid synthesis are intimately correlated. For the 1st time the photosynthetic  $^{14}\text{C}$ -labeling of polar lipids in blue-green algae lichens was reported. - Biol. Abstr. 69,1979.

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leghemoglobin nicotinate complexes. The separation is sensitive enough to permit analytical experiments on leghemoglobin from single nodules. Leghemoglobins *a* and *c1* prepared by ion exchange chromatography are homogeneous by isoelectric focusing criteria. Leghemoglobin *c2* prepared by ion exchange chromatography is an approximately 1:2 mixture of leghemoglobins *c2* and *c3*. Leghemoglobin *d* consists of 3 components. The ratio of leghemoglobin *a* to leghemoglobin *c3* content increases dramatically as very young nodules mature. The increase in relative leghemoglobin *a* content suggests that leghemoglobin *a* might be required for regulation of nodule  $O_2$  concentration only when the nodule structure is complex. The ratio of leghemoglobin *c1* content to leghemoglobin *c3* content increases somewhat during the early period of nodule development, while the ratio of leghemoglobin *c2* content to leghemoglobin *c3* content increases slowly throughout nodule development. Ratios of leghemoglobin *b* content to leghemoglobin *a* content and of total leghemoglobin *d* content to total leghemoglobin *c* content were almost independent of nodule age. Leghemoglobins *a* and *b* might be related biosynthetically, as might leghemoglobins *c* and *d*.  
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(Philippines), University of the Philippines, November 1981, 113p., tables, ref. Twelve *Rhizobium* spp. strains were isolated directly from the soil. However, only one strain, P5 was able to infect all the host plants: narra (*Pterocarpus indicus* Willd.), akleng parang (*Albizia procera* (Roxb) Benth), ipil-ipil (*Leucaena leucocephala* (Lam) de Wit), and cadios (*Cajanus cajan* (L.) Millsp.). On the average, the total dry matter yield of the host plants was increased significantly by 44% upon inoculation with this strain. Narra inoculated with *Rhizobium* spp. strain G7, P-pelleted and applied with 500 ppm Mo fixed nitrogen effectively. Inoculation of akleng parang with either HAP2 or P5 gave significant nitrogen fixation on Annam sandy clay loam. P-pelleting increased significantly the total dry matter yield of akleng parang by 29%. Application of 30 kg N/ha increased significantly the growth attributes and total dry matter yield of akleng parang grown on undisturbed core samples of the three grassland soils used. Similar to the previous result on Annam clay loam, significant nitrogen fixation was also obtained by inoculating akleng parang with *Rhizobium* spp. strain HAP2. (EN).

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it is known that Protozoa (which were predominant) do not affect heterocysts. Protozoa may stimulate nitrogen fixation, while reducing chlorophyll *a* and carbon fixation by grazing on the vegetative cells. - Biol. Abstr. 70,1980.

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20 Hz. The rate of synthesis of specific amino acids by *Azotobacter* depends on the frequency and potential of the electric field applied. The concentration of each amino acid present in the post-culture medium is increased according to the electric field employed and the amino acid biosynthesis in culture medium is activated during the 1st days of incubation. - Biol. Abstr. 70,1980.

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for the 5 strains ranged from 24.5-46.7 nmol C<sub>2</sub>H<sub>4</sub>/mg protein x min. The organisms all belong to the genus *Anabaena*. The growth and nitrogenase activity of these strains are much higher than those of the heterocystous blue-green algae commonly used for investigation of N metabolism; they should be useful physiological tools. Their prevalence, as judged by the ease of their enrichment and isolation, in bay and estuarine environments suggests that they are important contributors of combined N. - Biol. Abstr. 68,1978.

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- heterotrophs, catabolic activities of aerobic heterotrophs, regulation of bacterial metabolism, bacterial fermentations, chemolithotrophic and phototrophic metabolism and  $N_2$  fixation. Numerous diagrams, tables, and organism and subject indexes complement the text. - Biol. Abstr. 68,1978.
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duced per plant/h at 35-25° C to 73.0  $\mu\text{mol C}_2\text{H}_4$  produced per plant/h at 25-15° C, but the peak in fixation was increasingly delayed as growth temperature was reduced. In the 25-15° C treatment this delay in the onset of fixation led to decreasing leaf N concentrations and visible N-deficiency symptoms at the 28 day harvest. Varietal differences in response to temperature were not marked, though 1 cultivar achieved greater nodule development at 35-25° C than the others. This early flowering cultivar again appeared weak in  $\text{N}_2$  ( $\text{C}_2\text{H}_2$ ) fixation with low specific nodule activity at all temperatures studied. Results are related to bean production in Latin America and to the possible need for starter N in the cooler bean-producing regions. - Biol. Abstr. 69,1979.

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were introduced into an Ultisol from Santander de Quilichao, Colombia, which had been limed to differing pH values the tolerant strain CIAT 899 survived better from pH 4.15 to 4.90. In a field trial with soil limed to pH values from 3.8 to 4.4, the percentage of plants nodulated and the number of nodules per plant was greater when CIAT 899 was used as inoculant, instead of the strain CIAT 632, shown sensitive to pH in both nutrient media and soil tests. In this trial granular, soil applied inoculants gave better results than those which were seed applied. In a second field trial, on a Typic Distrandept limed from pH 4.45 to 5.20, yields of *P. vulgaris* were enhanced by inoculation, but again CIAT 899 performed better than did CIAT 632. In this trial there was no significant difference between inoculation methods. The possible value of granular inoculation methods to the production of *P. vulgaris* under small-farm conditions is discussed. (EN)

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328. GRANHALL, U. and LINDBERG, T. Nitrogen input through biological nitrogen fixation (Scot pine, *Pinus sylvestris*, Norway spruce, *Picea abies*, central Sweden). In: Persson, T., ed. Structure and function of northern coniferous forests - and ecosystem study. Stockholm, NFR, 1980, pp.333-340, ref. (Swedish Natural Science Research Council Stockholm, Ecological Bulletin/NFR no. 32).
329. GRANHALL, U., ed. Environmental Role of Nitrogen-fixing Blue-green Algae and Asymbiotic Bacteria. Proceedings of an International Symposium, Uppsala, Sweden, 20-24 September 1976, 39lp., illus.; graphs; map; tables; bibliog. (Swedish Natural Science Research Council Stockholm, Ecological Bulletin/NFR no. 26). This bulletin presents the proceedings of an international symposium held at Uppsala, Sweden, from 20 to 24 Sep. 1976. The aim was to sustain international cooperation and gather information on the environmental role of N fixing blue-green algae and asymbiotic bacteria, without dealing in detail with the physiological and biochemical aspects of N fixation, which have been adequately covered previously. - Abstr. on Trop. Agri. 5, 1979.
330. GRANT, D.A. and LAMBERT, M.G. Nitrogen fixation in pasture: 5. Unimproved North Island hill country, Ballantrae, New Zealand. *New Zealand Journal of Experimental Agriculture*, 7(1), 1979: 19-22. N fixation was measured at 15 sites on an area of poorly developed, hill-country pasture in the southern Ruahine Range. The average total of N fixed in 1 yr was estimated to be 34 kg/ha, about half of which was attributed to non-symbiotic, free-living microorganisms. The relationships between N fixation, seasonal climatic

variables, differences in growth patterns of legume species and total legume dry matter production are discussed. - Biol. Abstr. 69,1979.

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- (5.1-18.7 ppm). Agarose gel electrophoresis analysis of plasmids enabled subdivision of these extra-slow-growing strains into four groups on the basis of differences in plasmid number and size. These strains carried combinations of 2 or more of 4 plasmids, ranging in mass from 49-118 Mdaltons and comprising approximately 20% of the total DNA/cell. Biological and symbiotic data, along with plasmid analysis, were useful in identifying a wild-type strain (RJ23A) that shows potential as a soybean inoculant in alkaline soils. - Biol. Abstr. 69,1979.
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334. GUPTA, U.P. and JOSHI, R.D. Influence of mosaic virus on the nitrogen-fixing efficiency of root nodules in soybean [*Glycine max.*: (L) Merr.]. *Fertilizer Technology*, 13(4), 1976: 316-318, graph, ref. The nitrogen-fixing efficiency of root nodules was significantly influenced by soya bean mosaic virus infection. The soil of the infected planted pots had less nitrogen content than the soil of healthy planted pots. Authors' summary. - Abstr. on Trop. Agri. 4,1978.
335. HABIT, M.A. FAO activities on legume development. In: FAO/UNEP Meeting on Biological Nitrogen Fixation (Symbiotic), Rome, 16 June 1980. Rome, FAO, 1980, 4p.
336. HABTE, M. and ALEXANDER, M. Nitrogen fixation by photosynthetic bacteria in lowland rice culture. *Applied Environmental Microbiology*, 39 (2), 1980: 342-347. Propanil (3', 4'-dichloropropionanilide) was a potent inhibitor of the nitrogenase activity of blue-green algae (cyanobacteria) in flooded soil, but the herbicide at comparable concentrations was not toxic to rice, protozoa and nitrogen-fixing bacteria. Ethanol-amended flooded soils treated with propanil exhibited higher rates of nitrogenase activity than those not treated with the herbicide. The enhanced nitrogenase activity in propanil-treated soils



- was associated with a rise in the population of purple sulfur bacteria, especially of cells resembling *Chromatium* and *Thiospirillum*. By employing propanil and a means of excluding light from the floodwater to prevent the development of phototrophs during rice growth under lowland conditions, the relative activities of blue-green algae, photosynthetic bacteria and the rhizosphere microflora were determined. The results suggest that the potential contribution of photosynthetic bacteria may be quite high. - Biol. Abstr. 70,1980.
337. HAGEDORN, Charles. Nodulation of *Trifolium subterraneum* by introduced rhizobia in southwest Oregon, USA, soils. *Soil Science Society of America Journal*, 43 (3), 1979: 515-519. The establishment of *T. subterraneum* L. in response to inoculation and fertilization treatments was determined at 5 field sites in southwest Oregon [USA]. Both strains of *Rhizobium trifolii* (TAI and C6) were capable of successful nodulation of subclover (cv. Mt. Barker) at all sites although differences in performance of the strains occurred at 3 locations. Fertilization (P, S and Mo) significantly increased the overall nodulation of the plants and the proportion of nodules occupied by the inoculum strains. Plant dry weights and total N levels reflected an additive effect of inoculation and fertilization. Subclover apparently was a suitable crop for hill pastures in western Oregon and, with adequate fertilization and a suitable inoculum, the subclover and the amended rhizobia can become established and productive during the 1st growing season. - Biol. Abstr. 69,1979.
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enriched estuarine water with and without added ammonium chloride. The most rapid decreases in ash-free dry weight (AFDW) and increases in microbial biomass (estimated by increases in ATP and in particulate N as % of AFDW) were under aerobic conditions with added N. Material in the aerobic treatment without added N degraded only slightly faster than in the anaerobic treatments. The dissolved organic carbon (DOC) in the cultures was < 5% of the total detrital C; the DOC content decreased during the 1st week, most rapidly in the aerobic cultures, and then began to increase slowly. Rates of N fixation in the cultures were low, and were depressed by the presence of  $O_2$  and  $NH_4$  and by a higher N content of the detritus. *Salicornia* detritus initially degraded the fastest but showed the lowest conversion efficiency of plant material to microbial biomass (19.4%). *Spartina* detritus had the highest conversion efficiency (64.3%), while *Juncus*, which decomposed most slowly, had a conversion efficiency of 55.6%. From 87-100% of the increase in N content of the plant detritus is ascribed to protein-nitrogen. Results suggest that optimum in situ sites for rapid degradation of plant detritus in estuaries are the sediment-air and sediment-water interfaces, and detritus made from the  $C_4$  plant *Spartina* yields a richer food source for estuarine consumers than detritus made from the  $C_3$  plants *Salicornia* and *Juncus*. - Biol. Abstr. 69,1979.

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341. HALLIDAY, J. Present constraints to, and a future strategy for, fuller utilization of legume-fixed nitrogen for crop production in tropics. Honolulu, University of Hawaii, College of Tropical Agriculture and Human Resources, 1982, 24p., illus.; bibliog. (Technical Bulletin (ASPAC/FFTC) no. 60). This paper discusses the biological nitrogen fixation (BNF) process; agrotechnologies based on BNF by legumes; the use of legumes; inoculant technology; current use of legume-based BNF technology; how BNF by legumes increases crop yields and soil fertility; future potential of legume-based BNF technology; constraints to implementation of BNF technology; and the scenario for full implementation of BNF technology. - *Abstr. on Trop. Agri.* 8, 1982.
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343. HAMDI, Y.A. Application of nitrogen fixing systems in soil improvement and management. Rome, FAO, 1982, 188p. (FAO Soil Bulletin no. 49)
344. HAMDI, Y.A. Legume inoculants, legume inoculation and improving soil fertility (Organic materials and soil productivity in the North East, Alexandria, 1978). Rome, FAO, 1982, pp.193-202, tables; ref. (FAO Soil Bulletin no. 45) Legume inoculants are widely used in different parts of the world. Response to inoculation has been confirmed in many areas but there have been occasional failures. The amounts of nitrogen fixed by different legumes varies from one host to another. Forage legumes fix more nitrogen

than pulse legumes. Under Egyptian conditions, clover fixes about 100 kg N/feddan/5 cuts (238 kg N/ha). Other legumes, e.g. termis, broad bean, fenugreek, chickpea, lentils, groundnut and soya bean, fix between 17 and 58 kg N/feddan (40-138 kg N/ha). The residual nitrogen in soil after legumes is higher than after non-legumes. Author's summary. - Abstr. on Trop. Agri. 8,1982.

345. HAMDI, Y.A., ALAA-EL-DIN, M.N., TEWFIK, M.S. Nitrate reductase and dehydrogenase activities of cowpea (*Vigna sinensis* cultivar Giza I) nodules as affected by ammonium sulfate and urea fertilizers. *Zentralbl fuer Bakteriologie, Parasitenkunde, Interfektionskrankheiten und Hygiene. Zweite Naturwissenschaft Abteilung Mikrobiologie Landwirtschaft Technologie Umweltschutzes*, 133(5), 1978: 400-407. Cowpea seeds, cv. Giza I, were planted in Nile silt soil. The seeds were inoculated with cowpea rhizobia. Two weeks after planting, the plants were fertilized at the rate of 5, 10, 20 and 40 kg N/feddan in the form of ammonium sulfate and urea. After 8 wk, the plants were uprooted and assayed for fresh weight of nodules, dry weight of tops, total N and total amino N. Samples of fresh leaves were assayed for nitrate reductase and dehydrogenase activities and phenol content. The dry weight of tops, fresh weight of nodules and total N increased progressively with the increase of the rate of fertilizers up to the rate of 20 kg N/feddan. The rate of 40 kg N/feddan caused a great decline in these indices. The response to urea was higher than to ammonium sulfate. A significant and positive correlation existed between N fixed and total dry weight, amino and total N of tops, and fresh weight of nodules. A negative correlation, but not significant, was observed between N fixed and total phenols in plants fertilized with ammonium sulfate. With urea, this trend was not clear. Nitrate reductase activity in leaves was of positive and significant correlation with the total N of plants, receiving all rates of urea fertilizers. With ammonium sulfate, however, no significant correlation was found. Nitrate reductase activity in nodule homogenate was not correlated with N fixation. The dehydrogenase activity in the nodule homogenate was negatively but non-significantly correlated with N fixation. The highest level of dehydro-

genase activity in the presence of urea was obtained at the rate of 5 kg N/feddan, then started to decrease up to the rate of 20 kg N/feddan. A slight increase in activity was then noted at 40 kg N/feddan. With ammonium sulfate an appreciable increase in activity occurred with the application of 5 and 10 kg N/feddan, followed by a drop at 20 kg N/feddan. A sharp increase at the rate of 40 kg N/feddan was observed. - Biol. Abstr. 69,1979.

346. HAMDI, Y.A. and YOUSEF, A.N. Nitrogen fixers in the rhizosphere of certain desert plants. *Zentralbl fuer Bakteriologie, Parasitenkunde, Interfektionskrankheiten und Hygiene. Zweite Naturwissenschaft Abteilung Mikrobiologie Landwirtschaft Technologie Umweltschutzes*, 134(1), 1979: 19-24. Six species of common desert range plants (*Achillea* sp., *Aristida plumosa*, *Artemisia herba-alba*, *Haloxylon articulatum* and *Heliotropium ramosissimum*) were collected from Western Desert in Iraq. Counts of *Azotobacter* spp. and total bacteria were estimated in both rhizosphere and non-rhizosphere soils. Biomass and total nitrogen content of the plants were determined. The R/N ratio (ratio between rhizosphere to non-rhizosphere) for *Azotobacter* sp. ranged between 1-19.5 with an average of 4.96. The number of *Azotobacter* in the rhizosphere ranged between  $6.8 \times 10^3$  to  $47 \times 10^3$  cells/g, while in the non-rhizosphere it ranged from  $2 \times 10^3$  to  $21 \times 10^3$ . *Aristida plumosa* harbored the highest number, i.e.,  $47 \times 10^3$  cells/g, while *Artemisia herba-alba* showed the least, i.e.,  $6.8 \times 10^3$  cells/g. Total counts of bacteria in the rhizosphere ranged between  $17.2 \times 10^6$  and  $97 \times 10^6$  cells/g. that of the non-rhizosphere between  $1.5 \times 10^6$  and  $18 \times 10^6$  cells/g. The R/N ratio ranged between 2.03 x 22.5 with an average of 7.28. An appreciable grain of dry weight and total N was observed. Between 13-152 g with an average of 78.9 g dry weight and between 347-6684.0 mg with an average of 2452.0 mg N/plant were found. The possible contribution of *Azotobacter* to the N economy of the plants is discussed. - Biol. Abstr. 69,1979.

347. HARDARSON, G. and JONES, D. Gareth. Effect of temperature on competition among strains of *Rhizobium trifolii* for nodulation of 2 white clover (*Trifolium repens*) varieties.

*Annals of Applied Biology*, 92 (2), 1979: 229-236. The effect of temperature and soil type on the relative success in nodulating cultivars of white clover (*Trifolium repens*) by mixtures of antibiotic-resistant mutants of *R. trifolii* was studied. Under aseptic test-tube culture, 75 *str* nodulated the plants 5 days earlier than 33 *spe* at the lowest temperature, but the temperature X *Rhizobium* strain interaction was not significant. The 33 *spe* was more effective than 75 *str* at 25° C and, although no significant difference was found between the 2 mutant strains at the lower temperatures, the temperature X *Rhizobium* strain interaction was highly significant. In soil, when inoculated with mixed inoculum, cv. S100 was more uniformly nodulated by 75 *str* (81%) than S184 (49%). Success in nodulation could be altered by temperature and the temperature x bacterial strain interaction was significant. In the mixed inoculum treatments, 75 *str* was most compatible with S100 at 12° C, whereas 33 *spe* was most compatible with S184 at 25° C; the bacterial strain X variety X temperature interaction was highly significant. The results are discussed from the point of view of improving symbiotic N fixation by selecting effective strains of *Rhizobium* which are compatible with the particular host cultivar, which are competitive with the indigenous population and whose optimum temperatures for nodulation and competitiveness are similar to the soil temperature at the times of inoculation. - Biol. Abstr. 69,1979.

348. HARDARSON, G. and JONES, D. Gareth. The inheritance of preference for strains of *Rhizobium trifolii* by white clover *Trifolium repens*. *Annals of Applied Biology*, 92 (3), 1979: 329-334. The preference or selection of *Rhizobium* strains by both parental and F<sub>1</sub> white clover plants was studied using antibiotic resistant mutants of *R. trifolii*. Highly significant differences were found between crosses in their preference for the strain 75 *str*. Progenies from crosses between plants in which the preference for 75 *str* was 90-100% had 85% of the nodules inhabited by that strain. Progenies of crosses between plants in which the preference for 75 *str* was < 50% had only 13% of their nodules inhabited by 75 *str*. Intermediate values were found for progenies from other crosses. The inheritance for this particular

character was clearly additive and without any dominance or maternal effect. The results are discussed from the point of view of improving symbiotic N fixation by breeding white clover for uniform preference for effective strains of *R. trifolii*. - Biol. Abstr. 69,1979.

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351. HARDY, R.W.F. Translating basic research on biological nitrogen fixation to improved crop production in less-developed countries: a user's view. In: Linking research to crop production. New York, Plenum Press, 1980, pp.137-151, tables; ref. This paper calculates the need for nitrogen in times to come and analyses the possibilities of meeting this need through the increase in fertilizer production, the improved efficiency of fertilizer use, abiological nitrogen fixation with zero direct energy input, and a biological nitrogen fixation system for cereals that is compatible with high yield. - Abstr. on Trop. Agri. 7,1981.
352. HARRIS, S.C., ed. Planning an International Network of Legume Inoculation Trials: the proceedings of a workshop held at Kahului, Maui, Hawaii, January 15-19, 1979. Honolulu, College of Tropical Agriculture, University of Hawaii, 1979, 24lp., illus.; tables; bibliog. These proceedings of a workshop, held in Hawaii, deal with the subject matter in 3 plenary sessions and 6 working sessions. The plenary sessions discuss general background information and current research and progress on biological N fixation in separate regions. The working sessions discuss and report the need for development of a network programme for field testing of inoculation effects; a network plan and procedures were

presented and endorsed by the participants for field implementation. - Abstr. on Trop. Agri. 7, 1981.

353. HARRISON, P. Food, fuel and zero tillage. *D + C : Development and Cooperation*, no. 6, 1981: 13-14, illus. (Repr. from Development Forum, Apr. 1981) An account is presented of the practical value for agricultural production in the Third World of the recycling of organic wastes, methods of maintaining a cover of organic materials on the soil and the biological fixation of nitrogen. - Abstr. on Trop. Agri. 7, 1981.
354. HAUSINGER, Robert P. and HOWARD, James Bryant. Comparison of the iron proteins from the nitrogen fixation complexes of *Azotobacter vinelandii*, *Clostridium pasteurianum* and *Klebsiella pneumoniae*. *Proceedings of the National Academy of Science USA*, 77(7), 1980: 3826-3830. The MW, amino acid compositions, amino- and carboxyl-terminal sequences, and ion-exchange peptide maps of the cysteine-containing tryptic peptides were determined for the Fe proteins from the N<sub>2</sub> fixation complexes of *A. vinelandii* (Av2) and *K. pneumoniae* (Kp2). Results are compared to the known amino acid sequence of the Fe protein from *C. pasteurianum* (Cp2). Previous studies showed the Fe proteins to have similar enzymatic functions and spectroscopic properties. DNA coding for the Fe protein from many different species cross-hybridize. The protein structures are similar, yet they have significant differences. The amino-terminal sequences of Av2 and Kp2 are extended, compared to the amino-terminal methionine of Cp2 and may indicate a different initiation site in these proteins. The amino-terminal sequences for Av2 and Kp2 are more homologous with each other than either of these are with Cp2. The carboxyl-terminal sequences are extended in Av2 (14 residues) and Kp2 (≈ 30 residues) compared to Cp2. The amino- and carboxyl-terminal sequences establish that either the structural gene sizes are different in the 3 organisms or extensive post-translational modification must occur in some species. Because cysteinyl residues are involved at the active site of the Fe protein, a sensitive peptide mapping technique was used to compare cysteinyl peptides of the Fe protein from the 3 species. Av2 and Kp2 have a redistribution of cysteinyl residues



when compared to Cp2. Three important differences in the cysteine distributions were found: residue 4 is valine and residue 148 is alanine in Cp2, but cysteinyl residues occupy these positions in Av2; residue 231 is cysteine in Cp2 but alanine in Av2. The peptide mapping technique provides a method for the investigation of selective chemical modification of cysteinyl residues. - Biol. Abstr. 70,1980.

355. HAVELKA, U.D., BOYLE, M.G. and HARDY, R.W.F. Biological nitrogen fixation (soils, bacteria, cyanobacteria, *Rhizobium*, Frankia, Azolla, *Azospirillum lipoferum*). *Agronomy*, No. 22, 1982: 365-422, illus.; ref.; rev. article.
356. HAYSTEAD, A., KING, J. and LAMB, W.I.C. Photosynthesis, respiration and nitrogen fixation in white clover. *Grass and Forage Science*, 34 (2), 1979: 125-130. An apparatus in which shoot and root CO<sub>2</sub> exchange and acetylene reduction can be simultaneously measured in specific white clover-*Rhizobium* associations is described. In mature stolonating clover there was a fairly constant ratio between net photosynthesis, root respiration and acetylene reduction. Of the net C fixed daily (12 h light of 80 W m<sup>-2</sup>, 400-700 nm; day/night temperature 15° C) 12% was lost during the dark period by the shoot and 17% by the nodulated root. Changes in the rate of acetylene reduction by nodulated root systems occurred more slowly than those in rates of root respiration in response to reduced irradiance. In 21.5 h continuous darkness the rate of acetylene reduction remained constant. Responses to increased irradiance were more immediate in both root respiration and acetylene reduction. In plants maintained at 15° C in a 12 h, 80 W m<sup>-2</sup> photoperiod there was no significant diurnal variation in acetylene reduction or root respiration. Acetylene depressed root respiration by 20%. Assuming the energy requirement of the nitrogenase system to be the same when reducing acetylene and N the depression can be used as an indication of the energy requirement of fixed N assimilation, metabolism and export in the nodulated root. Of the net carbon fixed daily 3.4% was utilized in this way in plants growing in a 12 h photoperiod (80 W m<sup>-2</sup>, 400 - 700 nm) at 15° C. - Biol. Abstr. 70,1980.

357. HAYSTEAD, A. and MARRIOTT, Carol. Effects of rates and times of application of starter dressings of nitrogen fertilizer to surface sown perennial ryegrass-white clover on hill peat. *Grass and Forage Science*, 34(4), 1979: 241-248. The effects on clover and grass growth of 5 levels of  $\text{NH}_4\text{-N}$  applied before sowing, at sowing and after nodule initiation were investigated. A pot experiment in which S184 white clover was grown in a peat soil showed that  $\text{NH}_4\text{-N}$  up to 688 mg N/pot (equivalent to a field rate of  $120 \text{ kg ha}^{-1} \text{ N}$ ) applied before sowing and at sowing did not affect clover growth. N-fixing activity ( $\text{C}_2\text{H}_2$ -reduction) was reduced progressively up to the highest level (688 mg N/pot). Application after nodule initiation increased growth relative to the zero-N treatment at all levels of application. Maximum growth and N fixation occurred at 516 mg N per pot where the DM [dry matter] yield was 70% higher than in the absence of added N. A field trial in which S184 clover and S24 perennial ryegrass were surface sown on to a peat soil showed an increase in grass and clover growth in the 1st yr in response to  $120 \text{ kg ha}^{-1} \text{ N}$  applied at sowing. Grass growth alone was increased at  $120 \text{ kg ha}^{-1} \text{ N}$  applied 40 days before sowing. Lower rates of application before sowing and at sowing did not affect clover or grass growth. The effect of the delayed application of  $\text{NH}_4\text{-N}$  on legume growth was less marked than that in the pot experiment,  $90 \text{ kg ha}^{-1} \text{ N}$  stimulating clover growth by 40% in the 1st yr. The effect was however different from that in the pot experiment, in that, while  $30 \text{ kg ha}^{-1} \text{ N}$  increased N fixation relative to the zero-N treatment, plants exposed to higher levels showed a depression in N-fixing capacity. N-fixation was correlated with nodule numbers in the delayed  $\text{NH}_4\text{-N}$  application, the closest correlation being with the number of multilobed nodules which was highest at  $30 \text{ kg ha}^{-1} \text{ N}$  and lowest at  $120 \text{ kg ha}^{-1} \text{ N}$ . It is suggested that circumstances exist when the use of a relatively low starter N dressing ( $20\text{-}60 \text{ kg ha}^{-1} \text{ N}$ ) at sowing would not increase clover or grass growth in the early stages of the establishment of a hill reseed. Under such circumstances higher rates of application ( $100 \text{ kg ha}^{-1} \text{ N}$ ), preferably delayed until the seedlings are in a position to take up the N rapidly, would have the greatest effect. - Biol. Abstr. 70,1980.

358. HEGAZI, N.A., EID, M., FARAG, R.S. and MONIB, M. Asymbiotic nitrogen-fixation in the rhizosphere of sugarcane planted under semiarid conditions of Egypt. *Rev. Ecol. Biol. Sol.*, 16 (1), 1979: 23-38. Asymbiotic  $N_2$ -fixing bacteria in rhizosphere of sugarcane planted under Egyptian conditions were counted and enriched in different culture media. *Beijerinckia* were absent, while *Azotobacter* (particularly *A. vinelandii*) and  $N_2$ -fixing spirilla of different physiological characteristics were common. Isolates of *Klebsiella* and *Bacillus* capable of fixing  $N_2$  were originally reported in soils of Nile Delta. Certain characteristics including nitrogenase activity of representative isolates of different asymbiotic  $N_2$ -fixing bacteria in the presence of different concentrations of various C sources, mainly TCA [tricarboxylic acid] cycle intermediates, were tested. The role of these bacteria in biological  $N_2$  fixation under sugarcane cultivation is discussed. - *Biol. Abstr.* 69, 1979.
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360. HEGAZI, N.A. and VLASSAK, K. Cell morphology and flagellation of nitrogen-fixing spirilla. *Folia Microbiologica*, 24 (5), 1979: 376-378. Twenty isolates of N<sub>2</sub>-fixing spirilla were isolated from the rhizosphere of maize and sugar cane grown in Egyptian and Belgian soils. EM distinguished 2 morphological groups. The first includes short and thick curved rods with an unipolar flagellum while cells of the 2nd group are much longer with the typical appearance of spiral cells and probably possess a bipolar tuft of flagella. - Biol. Abstr. 69, 1979.
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- effectiveness at ambient N levels. - Biol. Abstr. 69,1979.
362. HEISEY, Rod M., DELWICHE, C.C., VIRGINIA, Ross A., WRONA, Anne F. and BRYAN, Barbara A. A new nitrogen-fixing non-legume: *Chamaebatia foliolosa* (Rosaceae). *American Journal of Botany*, 67(3), 1980: 429-431. Specimens of *C. foliolosa* Benth. with nodule structures on their roots fix atmospheric  $N_2$ . The nodules are similar to those of other non-legumes in gross morphology and structure containing hyphal strands, some with club-shaped vesicles at their ends. A fixation rate of 130 nmol  $N_2$ /g fresh wt per h is reported by using  $^{15}N_2$  as a tracer. Equivalent rates of acetylene reduction were observed. - Biol. Abstr. 70,1980.
363. HENNECKE, H. and SHANMUGAM, K.T. Temperature control of nitrogen fixation in *Klebsiella pneumoniae*. *Archives of Microbiology*, 123(3), 1979: 259-266. At growth temperatures above  $37^\circ C$ , *K. pneumoniae* does not grow in a medium containing  $N_2$  or  $NO_3$  as N sources. Growth in the presence of other N sources and the in vitro nitrogenase activity are not affected at this temperature. The inability to fix  $N_2$  at high temperature is due to the failure of the cells to synthesize nitrogenase and other N fixation (nif) gene encoded proteins. When cell grown under N fixing conditions at  $30^\circ C$  were shifted to  $39^\circ C$ , there was a rapid decrease of the rate of de novo biosynthesis of nitrogenase (component 1), nitrogenase reductase (component 2) and the nifJ gene product. There was no degradation of nitrogenase at the elevated temperature since performed enzyme remained stable over a period of at least 3 h at  $39^\circ C$ . Temperature seems to be represent a 3rd control system, besides  $NH_4^+$  and  $O_2$ , governing the expression of nif genes of *K. pneumoniae*. - Biol. Abstr. 69,1979.
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of retorted oil shale additions on the microbiological characteristics of surface soils were investigated in a laboratory study to evaluate possible effects of mixing of soils and retorted shales which might occur as a part of revegetation programs in areas disturbed by oil shale processing. Soils were mixed with retorted oil shale at 5, 10 and 25% addition levels, and compared with normal soil and retorted shale over 2.5 mo., with evaluation of microbiological parameters carried out at 2 wk intervals. With retorted shale present at up to 10% by weight, no negative effects on O uptake or on actinomycete and bacterial populations were noted, while significant reductions of N fixation rates, as measured by acetylene reduction, and of dehydrogenase activity, fungal populations, radioactive glucose mineralization and ATP concentrations occurred, with N fixation being most affected by shale material. Nonsymbiotic N fixation in surface soils may be especially sensitive to the presence of retorted oil shale. It may be necessary to assure that sufficient surface soil is used to cover retorted oil shales to allow development and functioning of a diverse vegetation-microbiological community in such a way that physical mixing or movement of water-soluble retorted oil shale constituents into this surface soil layer would be minimized. - Biol. Abstr. 69, 1979.

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plant species. The capabilities of *Triticum* and *Sorghum* to induce nitrogenase activity in *Azospirillum* and *Rhizobium* were in the same range. (EN)

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No  $O_2$  consumption or net synthesis of ATP could be demonstrated with phosphorylating membranes of mutant AV-11 using reduced  $Ph(NMe_2)_2$  as substrate. The oxidase-negative properties of mutant AV-11 appear to be associated with an inability of the terminal oxidases cytochromes *o* and *a1* to reoxidize cytochromes *c4* + *c5* in membrane particles. Cytochrome *c4* + *c5* of mutant AV-11 could not be reoxidized by normal procedures (bubbling with  $O_2$  or with 0.05 mM ferricyanide). These could only be reoxidized by excess ferricyanide (10-20 mM). Oxidized cytochromes *c4* + *c5* of mutant AV-11 are readily reduced by reduced  $Ph(NMe_2)_2$  and studies on partially purified cytochromes *c4* and *c5* showed no unusual properties. A comparison of the respiratory kinetics for membrane particles of strains AV-11 and AV-OP showed no differences in the oxidation of NADH or malate via cytochrome oxidase *d* [ $V = 3.2 \mu\text{mol } O_2 \text{ consumed } \times \text{min}^{-1} \times \text{mg protein}^{-1}$ ;  $K_m(O_2) = 18 \mu\text{M}$ ]. The respiratory kinetics exhibited for oxidation of reduced  $Ph(NMe_2)_2$  via the oxidases cytochrome *o* and *a1* could only be determined for strain AV-OP ( $V = 0.7 \mu\text{mol } O_2 \times \text{min}^{-1} \times \text{mg protein}^{-1}$ ;  $K_m = 3.1 \mu\text{M}$ ). The very high  $V$  value observed for oxidation of cytochrome *d* (strains AV-11 and AV-OP) suggests that this oxidase is capable of handling the electron flow generated by the very active dehydrogenases. Since the respiratory chain of mutant AV-11 appears to be blocked between cytochromes *c4* + *c5* and the oxidases cytochromes *o* and *a1*, for the  $Ph(NMe_2)_2$ -oxidase-negative mutants, cytochrome *d* may be the only functional oxidase. - Biol. Abstr. 69,1979.

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for 9 grazing-trial throughout New Zealand. Measured clover [*Trifolium repens*] growth and N fixation were not necessarily closely related, giving substantial seasonal and annual variation in N fixation per unit clover grown. Other factors, including weather and soil characteristics, influenced the extent to which clovers obtained their N requirements from fixation or by direct uptake of soil N. Annual N fixation in developed lowland pastures was around 184 kg N/ha, less than half the value previously thought to occur. This lower value was consistent with lower yields and higher soil N status than recorded in earlier studies. Annual N turnover in the pastures was large, but showed no simple relationships with either N fixation or soil characteristics. Grass yields were relatively insensitive to climatic variation and not simply related to either clover yields or N fixation. - Biol. Abstr. 69,1979.

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table; ref. This article deals with the effect of  $\text{NO}_3\text{-N}$ ,  $\text{NH}_4\text{-N}$ , oxygen, pH, temperature and osmotic stress on nitrogenase and nitrate reductase in the N assimilation process in the *Azolla-Anabaena* symbiosis. - Abstr. on Trop. Agri. 6,1980.

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377. HONG, C.W. Research activities on biological nitrogen fixation in Korea. Taipei, Asian and Pacific Council, Food and Fertilizer Technology Center, 1982, pp. 1-11, illus.; graph; tables. (ASPAC/FFTC Extension Bulletin no. 171) Investigations on the rhizobial inoculation of soya beans has produced inconclusive results, pot trials indicating that the rhizobium increased yields but these not being obtained in field trials. A survey of biological N fixation in wetland rice soils showed the presence of *Azotobacter* and other N-fixing organisms. The effect of soil

chemical and physical properties and the effect of soil ameliorants on N fixation are discussed. - Abstr. on Trop. Agri. 8, 1982.

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379. HORNE, Alexander J., SANDUSKY, James C. and CARMIGGET, Coen J.W. Nitrogen fixation in Clear Lake: 3. Repetitive synoptic sampling of the spring *Aphanizomenon* blooms. *Limnology and Oceanography*, 24 (2), 1979: 316-328. N fixation (as acetylene reduction) and factors most likely to influence it were estimated simultaneously for 31 sites at 8 stages of the 1971 and 1972 spring blooms of *Aphanizomenon* in naturally eutrophic Clear Lake [California, USA]. The major factor controlling rates of  $N_2$  fixation was the number of *Aphanizomenon* heterocysts ( $P < 0.001$ ). Environmental influences on fixation were largely mediated through heterocyst induction or repression. Regression analysis showed heterocysts highly negatively related to  $NO_3$  ( $P < 0.05$ ). At high (linear regressions) but not at

low (log-transformed regressions) numbers, heterocysts were positively correlated with phosphate ( $P < 0.05$ ). At low rates of  $N_2$  fixation, heterocysts were also positively related to water clarity, chlorophyll (both  $P < 0.05$ ), and temperature ( $P < 0.01$ ). The role of very low levels of nitrate ( $2-22 \mu\text{g} \cdot \text{l}^{-1} \text{NO}_3\text{-N}$ ) in (apparently) indirectly suppressing heterocyst induction was unexpected. Only at high rates was  $N_2$  fixation correlated with phosphate. Presumably at low rates sufficient P is available in this P-rich lake ( $14-43 \mu\text{g} \cdot \text{l}^{-1} \text{PO}_4\text{-P}$ ) to permit repression of heterocyst formation by low  $\text{NO}_3$  levels. Ammonium suppressed  $N_2$  fixation and heterocyst formation only where it was present in relatively large quantities ( $20-170 \mu\text{g} \cdot \text{l}^{-1} \text{NH}_4\text{-N}$ ). Early in the blooms, low rates of vegetative (i.e. nonheterocyst)  $N_2$  fixation were indicated in the flake colonies of *Aphanizomenon*. These may have an anoxic center like that of *Trichodesmium*. - Biol. Abstr. 68,1979.

380. HOUMARD, Jean, BOGUSZ, Didier, BIGAULT, Regis and ELMERICH, Claudine. Characterization and kinetics of the biosynthesis of some nitrogen fixation (*nif*) gene products in *Klebsiella pneumoniae*. *Biochimie*, 62(4), 1980: 267-276. Analysis of  $^{14}\text{C}$  pulse-labeled proteins synthesized by a  $\text{Nif}^+$  *K. pneumoniae* strain and by several genetically mapped *nif::Mu* and *nif* deletion mutants was performed by 2-dimensional gel electrophoresis. By comparison of the autoradiograms, 6 *nif*-specific polypeptides were identified. In addition to the previously characterized *nifK*, *nifD*, *nifH* and *nifJ* products, the product of *nifF* was identified as a polypeptide of 10,000 daltons and pI [isoelectric point] about 4.5 and the product of *nifU* as a polypeptide of 22,000 daltons and pI 5. The biosynthesis of *nifF* and *nifU* polypeptides was prevented in mutants affecting the regulatory gene *nifA* which controls the biosynthesis of the other *nif* gene products so far identified. The biochemical phenotypes of different polar mutants were in good agreement with those expected from the transcriptional organization of the *nif* cluster previously established by genetic analysis. Kinetic studies of nitrogenase activity and of the biosynthesis of the 6 *nif*-specific polypeptides were performed with the  $\text{Nif}^+$  strain incubated under conditions of depression or repression by  $\text{NH}_4^+$ . Upon derepression,

the biosynthesis of the 6 *nif* polypeptides, which belong to 4 different transcriptional units, seems to be coordinated since they appear simultaneously after a lag of 45 min. Under those conditions, in vivo and in vitro nitrogenase activities were detectable only 30 min later. Upon addition of  $\text{NH}_4^+$ , the biosynthesis of 6 *nif* polypeptides was rapidly abolished. The kinetics of residual biosynthesis, probably due to the transcription of preexisting mRNA, was not similar for the 6 *nif* products. The *nifU* product was no longer detectable after 5 min; the *nifF*, *K*, *D* and *J* products were not detectable after 30 min; some *nifH* product was still slightly detectable after 60 min. - Biol. Abstr. 70,1980.

381. HOUWAARD, F. Effect of ammonium chloride and methionine sulfoximine on the acetylene reduction of detached root nodules of peas (*Pisum sativum*) (Relation to nitrogen fixation, *Rhizobium leguminosarum*). *Applied and Environmental Microbiology*, 37 (1), 1979: 73-79, illus.; ref.
382. HOUWAARD, F. Effect of combined nitrogen on symbiotic nitrogen fixation in pea plants. Thesis for the Degree of Doctor in de Landbouwwetenschappen. Wageningen, Landbouwhogeschool, 1979, 96p., bibliog.; ref.
383. HOUWAARD, F. Influence of ammonium and nitrogen on nitrogenase activity of pea plants as affected by light intensity and sugar addition. *Plant and Soil*, 54 (2), 1980: 271-282, ref. Addition of ammonium chloride or potassium nitrate to nodulated pea plants resulted in a decrease in acetylene-reducing activity. Both nodule growth and specific activity of the nodules were diminished. Acetylene-reducing activity of isolated bacteroids, treated with EDTA-toluene and supplied with ATP and dithionite, had not decreased after a 3-day treatment of the plants with  $\text{NH}_4\text{Cl}$  or  $\text{KNO}_3$ . The effect of combined nitrogen could be counteracted by raising the light intensity or by the addition of sucrose to the growth medium. The latter treatment reduced the nitrogen uptake by the plants. It is concluded that combined nitrogen affects symbiotic nitrogen fixation via the carbohydrate supply to the bacteroids. (EN).

384. HOUWAARD, F. Influence of ammonium chloride on the nitrogenase activity of nodulated pea plants (*Pisum sativum*) (*Rhizobium leguminosarum*). *Applied and Environmental Microbiology*, 35 (6), 1978: 1061-1065, ref.
385. HOUWAARD, F. Nitrogenase activity of pea bacteroids as affected carbohydrates and ammonium chloride. *Plant and Soil*, 54 (1), 1980: 51-63, ref. Regulation and efficiency of the nitrogen-fixing system of the rhizobium-pea symbiosis were investigated. Acetylene reduction of detached root nodules was measured with various substrates added. Succinate, fumarate and malate were most effective in stimulating nitrogenase activity; glucose, pyruvate and citrate were also active. Acetylene reducing activity of detached nodules was inhibited by the addition of  $\text{NH}_4\text{Cl}$ , irrespective of the substrate present. Nitrogenase activity of isolated bacteroids was not influenced by  $\text{NH}_4\text{Cl}$ . Respiration of detached nodules was not significantly stimulated by the addition of substrates. Ammonium chloride did not influence respiration. With detached nodules and isolated bacteroids a consumption of about 16 g of carbohydrate per g of nitrogen fixed could be calculated. Detached nodules produced more hydrogen relative to the acetylene reduced than did isolated bacteroids and intact plants. Results obtained indicate that the regulation of nitrogenase activity and the efficiency of substrate consumption depend on environmental conditions. (EN)
386. HUANG, Chi-Ying. The responses of soybean (*Glycine max*) plants to molybdenum treatment. *Taiwania*, 24 (0), 1979: 38-46. Mo is an essential microelement for the symbiotic growth of soybean plants, *G. max*. With treatments of Mo, soybeans became taller, leaves expanded larger and the leaves contained more chlorophyll. The sizes and numbers of nodules increased. The fluctuations of N fixing activity of root nodules in the growing season could not entirely be interpreted by these 2 parameters. Plants which were treated with Mo at pre-pod filling stage, had heavier nodules than those ones treated with Mo at pre-flowering stage; the latter plants had higher N fixing activity than the former ones. The leghemoglobin content in root nodules did not change as much by the Mo treatments as the N fixing

activity did. This means that leghemoglobin content in root nodules could not be considered as a criteria for judging the activity of N fixation of plants. Although 4 components of leghemoglobin were separated by gel electrophoresis, these electrophoretic components of leghemoglobin did not vary with the treatments of Mo. This suggests that all of these 4 components of leghemoglobin may be present simultaneously carrying O<sub>2</sub> to the N fixing rhizobia. The N fixing activity of plants was remarkably stimulated by Mo treatments, because Mo enhances the nitrogenase activity and promotes the photosynthetic capacity of plants. The increments of N fixing activity induced the soybeans to form more numerous pods and seeds, consequently the overall productivity of the plants was increased, and plants receiving Mo through the roots give better yields than those receiving Mo through the leaves. The proper time of supplying Mo to plants is at the pre-flowering stage. - Biol. Abstr. 69,1979.

387. HUANG, C.M., CHANG, C.H. and WANG, C.C. The effect of the application of a soil inoculant on sugarcane growth. In: Selection, physiology and application of biological N fixers. Taipei, Asian and Pacific Council/Food and Fertilizer Technology Center, 1982, pp. 17-23, tables; ref. (ASPAC/FFTC Extension Bulletin No. 66). Groundwater pollution due to nitrate nitrogen is a serious problem following over-application of chemical N fertilizers. As an alternative, biological N fixation may be a method by which sugar-cane (*Saccharum officinarum*) production can be achieved at lower cost. For this purpose, a soil inoculant was incubated in growth media to isolate blue-green algae with a strong capacity for N fixation. The culture media are described. Tests showed that strains of filamentous and heterocystous blue-green algae (T2 and T28) were very efficient N fixers. Although the strain T16 (*Merismopedia* spp.) had a low N-fixing capacity, its vigorous growth made up for this. Results suggest that soil inoculants may be used to some extent as a substitute for N fertilizer. - Abstr. on Trop. Agri. 8,1982.

388. HUANG, Po-Chao, LEE, Ning-Yuean and CHEN, Shu-Hua. Evidence suggestive of no intestinal nitrogen fixation for improving protein nutrition status in sweet potato eaters. *American Journal of Clinical Nutrition*, 32(8), 1979: 1741-1750. Seven teenagers and 2 adults were given sweet potato [*Ipomoea batatas*] diets that supplied slightly below the requirement levels of protein for 32 (experiment 1) or 53 days (experiment 2) in 2 separate experiments. In experiment 1 and during the first 36 days of experiment 2, N balance studies with the teenagers were conducted with 0.67 and 0.71 g of protein/kg of body weight, respectively. Results of the N balances including skin N loss were -0.5 mg N/kg per day in experiment 1 and -3.2 mg N/kg per day in experiment 2. Two adults were given 0.63 g/kg of protein and had an average N balance of +6.0 mg N/kg per day (experiment 2). One of them had a slightly negative cumulative N balance if miscellaneous N losses were included in the calculation. Plasma urea N of teenagers and adults decreased significantly from 8-11 to 2-3 mg/100 ml in experiment 2. After 32 or 53 days on the sweet potato diets, the plasma-free amino acid pattern of the teenager subjects was abnormal. The subjects were easily fatigued by physical exercise and took longer naps due to sleepiness during the latter days of the experiments. Although the mean Hb, hematocrit, plasma total protein and plasma albumin levels were within the normal ranges, the protein nutritional status of the teenagers and 1 of the 2 adults was considered to be abnormal. Intestinal N fixation purported to occur in sweet potato eaters probably did not occur. When the subjects' feces were examined, N-fixing ability was not demonstrated. During the last 17 days of experiment 2, the effect of excess calories on N balance was examined. - Biol. Abstr. 69, 1979.
389. HUBBELL, D.H. Plant roots and biological nitrogen fixation. *Proceedings Soil and Crop Science Society of Florida*, vol. 36, 1977: 37-40, ref.; rev.
390. HUBEI INSTITUTE OF MICROBIOLOGY. GROUP OF BIOLOGICAL NITROGEN FIXATION (CHINA). Nitrogen fixing bacteria in association with maize bio-nitrogen fixation group. (In Chin.) *Acta Microbiologica Sinica*, 19(2), 1979: 160-165, Engl.



summ. A number of similar microorganisms possessing active nitrogenase activity were isolated from root systems of maize, kaoliang and millet in Wuhman and Nanning, China. The characteristics of strains 99 and 224 were examined and their property of  $N_2$ -fixation in association with maize were briefly studied. Both strains are gram-negative rods possessing a single polar flagellum and are motile. On N-free malate medium, spirals 1-1 1/2 rounds appear after 5-7 days incubation. Cells contain highly refractive lipid droplets. Catalase is positive. Voges-Proskauer and indole are negative. Optimal temperature for growth and nitrogenase activity is at 32° C. Optimal pH is 6.5-7.0. Nitrogenase activities amounting to 600-1100  $\mu M$   $C_2H_2$  reduced/g root per h were detected after an induction period of 24 h. There is no nitrogenase activity without a proper induction period. In pot culture, the associated  $N_2$  fixation of strain 99 and maize was proved. The organism is identified as *Spirillum lipoferum*, as compared with Doeberli's culture ATCC 29145 (SP7). - Biol. Abstr. 70, 1980.

391. HUDD, G.A., LLOYD-JONES, C.P. and HILL-COTTINGHAM, D.G. Comparison of acetylene-reduction and nitrogen-15 techniques for the determination of nitrogen fixation by field bean (*Vicia faba* cultivar Maris-Bead) nodules. *Physiologia Plantarum*, 48 (1), 1980: 111-115. Field bean (*V. faba* L.) cv. Maris Bead seeds were inoculated with *Rhizobium* Catalogue No. 1001, supplied by Rothamsted Experimental Station, and grown in sand culture supplied with a complete nutrient solution which included nitrate at either 1.5 or 6.0 mM. Nodules were detached from the roots at intervals during plant development and their rates of  $^{15}N$  fixation estimated by both acetylene reduction and  $^{15}N$  gas technique. There was a constant relationship, independent of nitrate supply, between the results obtained by these 2 methods at all samplings. The amounts of acetylene reduced divided by a factor of 5.75 gave the amount of true N fixation; this factor is about twice the theoretical value. This discrepancy probably arose because, with acetylene, all the electrons available to the nitrogenase were used to form ethylene, whereas during normal fixation only about half the electron supply was used to fix N, the remainder

having been consumed in the production of hydrogen gas. - Biol. Abstr. 69, 1979.

392. HUYNH, B.H., HENZL, M.T., CHRISTNER, J.A., ZIMMERMANN, R., ORME-JOHNSON, W.H. and MUENCK, E. Nitrogenase: 12 Moessbauer studies of the molybdenum protein from *Clostridium pasteurianum* W5. *Biochemica & Biophysica Acta*, 623(1), 1980: 124-138. The MoFe protein from *C. pasteurianum* was studied with Moessbauer spectroscopy in the temperature range from 1.5-200° K in magnetic fields up to 55 kG (gauss). Except for some small differences in the hyperfine parameters the results for the *C. pasteurianum* protein are essentially the same as those published previously for the protein from *Azotobacter vinelandii*, i.e., (30 ± 2) Fe atoms partition into 2 identical cofactor centers M (each center most likely containing 6 Fe atoms and 1 Mo atom), 4 P-clusters (each center containing 4 Fe atoms) and 1 Fe environment labeled S (about 2 Fe atoms/holoenzyme). The spectra of the cofactor centers in 3 distinct oxidation states,  $M^{\overset{e^-}{\text{ox}}} \rightleftharpoons M^{\overset{e^-}{\text{N}}} \rightarrow M^{\text{R}}$ , were analyzed. The diamagnetic (electronic spin  $S = 0$ ) state  $M^{\text{ox}}$  is attained by oxidation of the native, EPR-active ( $S = 3/2$ ) state  $M^{\text{N}}$ . The reduced state  $M^{\text{R}}$  is observed in steady state under  $\text{N}_2$  fixing conditions; high-field Moessbauer studies show that the cofactor centers are paramagnetic (integer electronic spin  $S \geq 1$ ) in the state  $M^{\text{R}}$ . The complex high-field spectra resulting from the P-clusters in the oxidized state  $M^{\text{ox}}$ . The analysis shows that 1 iron site is characterized by a positive hyperfine coupling constant  $A_0$  while the other 3 sites have  $A_0 < 0$ . A slightly modified set of parameters fits the high-field data of the MoFe protein from *A. vinelandii*. A discussion summarizing principle results obtained to date for the proteins from *A. vinelandii* and *C. pasteurianum* is proposed. - Biol. Abstr. 70, 1980.
393. HYNES, R.K. and KNOWLES, R. Denitrification, nitrogen fixation and nitrification in continuous flow laboratory soil columns. *Canadian Journal of Soil Science*, 60(2), 1980: 355-364. Apparent steady state denitrification

and  $N_2$  fixation were simultaneously detected in soil columns supplied with a solution containing glucose (250  $\mu\text{g C/ml}$ ) and  $\text{KNO}_3$  (10  $\mu\text{g N/ml}$ ). The addition of 10.1 kPa [kilopascal] (0.1 atm)  $\text{C}_2\text{H}_2$  to the air-flow through the column resulted in depth profiles of  $\text{N}_2\text{O}$  and  $\text{C}_2\text{H}_2$ , which showed that a zone of active denitrification was underlain by a zone of  $\text{C}_2\text{H}_2$  reduction. Approximately 90% of the added  $\text{NO}_3^-$  was denitrified and ~ 10% of the products was  $\text{N}_2\text{O}$ . Continuous addition of  $\text{NH}_4\text{Cl}$  (25  $\mu\text{g N/ml}$ ) resulted in steady-state oxidation of all the  $\text{NH}_4^+$ . The introduction of  $\text{C}_2\text{H}_2$  (10.1 kPa) inhibited nitrification and caused washout and disappearance of  $\text{NO}_3^-$  from the column effluent. On removal of  $\text{C}_2\text{H}_2$ , nitrification activity returned very slowly. Nitrification of added  $\text{NO}_2^-$  was not affected by  $\text{C}_2\text{H}_2$ . No  $\text{N}_2\text{O}$  was detected during steady-state oxidation of  $\text{NH}_4^+$  or  $\text{NO}_2^-$  in the presence or absence of  $\text{C}_2\text{H}_2$ , indicating that nitrification-denitrification coupled reactions did not occur under the conditions employed. - Biol. Abstr. 70,1980.

394. IDRIS, M., SANDHU, G.R. Rhizobium inoculation as an aid in the mung bean (*Phaseolus aureus/Vigna radiata*) cultivation. *Pakistan Journal of Scientific Research*, 31 (3-4), 1979: 165-173, graph; tables; ref.; summ. In this pot experiment from Pakistan the effect of Rhizobium inoculation on nodulation response, dry matter and pod yield, and  $N_2$ -fixing efficiency of mung bean was studied. Inoculation with all test strains of *R. phaseoli* significantly improved the number of nodules and the fresh nodule weight. Dry matter yield of shoots and roots per plant increased by 13.0 to 42.0%, pod yield by 15.3 to 71.3%, and  $N_2$ -fixing efficiency by 31.6 to 141.0%. These yield increases were significantly correlated with the  $N_2$ -fixing efficiency of the legume - Rhizobium symbiosis. Uninoculated plants showed no nodules. - Abstr. on Trop. Agri. 6,1980.
395. IDRIS, M., SANDHU, G.R. and CHUGHTAI, M.I.D. Biological nitrogen fixation: some problems and their solution. *Pakistan Journal of Science*, 32 (1-2), 1980: 21-38, tables; bibliog. This review surveys the process of biological dinitrogen fixation in the soil with emphasis on practical utilization of N fixation in agriculture. The biochemical

and physiological pathways involved in biological dinitrogen fixation and recent advances in the genetics of biological dinitrogen fixation are also briefly discussed. - Abstr. on Trop. Agri. 7,1981.

396. IKRAM, Ahmad and BROUGHTON, W.J. Rhizobia in tropical legumes: 7. Effectiveness of different isolates on *Psophocarpus tetragonolobus*. *Soil Biology and Biochemistry*, 12(1), 1980: 77-82. Rhizobia isolated from 14 different genera of legumes were tested for their N-fixing effectiveness with *P. tetragonolobus* in standard Leonard jar trials. Isolates from all plants except *Pithecellobium jiringa* were able to form nodules with *P. tetragonolobus* although a wide range of effectiveness among the different rhizobia was demonstrated. Thus *P. tetragonolobus* may be considered promiscuous with respect to its rhizobial requirements. Based on this experiment, a group of rhizobia comprising 3 elite strains (RRIM 56 from *P. tetragonolobus*, UMKL 36 from *Lablab purpureus* and CB 756 from *Macrotyloma africanum*), a moderately effective strain (NGR 258 from *P. tetragonolobus*), and 2 strains of low effectivity (RRIM 968 from *Centrosema pubescens* and UMKL 12 from *Phaseolus angularis*) were selected for further study. When these were used to inoculate *P. tetragonolobus* growing in soil taken from virgin jungle ( $< 1.54$  rhizobia  $g^{-1}$  soil); RRIM 56 and UMKL 36 again performed well, but NGR 258 outperformed CB 756. - Biol. Abstr. 69,1979.
397. INTERNATIONAL CENTER FOR AGRICULTURAL RESEARCH IN THE DRY AREAS (ICARDA). Pasture and forage crops improvement. In: ICARDA Annual Report 1981. Aleppo, Syria, International Center for Agricultural Research in the Dry Areas, 1982, pp.119-147, illus.; tables; summ. This programme was established to improve the supply of pasture and forage for animal production and so promote a rational and effective land use system. Selection and development of a range of multipurpose forage species, including *Medicago* spp., *Vicia sativa*, *Pisum sativum*, *Lolium perenne*, *Festuca* spp. and *Phalaris aquatica*, was undertaken for different climatic ecozones. Nitrogen fixation in forage plants, disease resistance and weed control practices were also studied. - Abstr. on Trop. Agri. 8,1982.

398. INTERNATIONAL RICE RESEARCH INSTITUTE. Nitrogen and Rice Symposium Proceedings. Los Baños, Laguna, International Rice Research Institute, 1979, 503 p., illus.; graphs; tables; bibliog.; summ. This publication contains the papers presented at the symposium on nitrogen and rice, organized by the IRRI, Los Baños, Philippines. These papers are grouped under the following headings: (1) role of nitrogen in rice production; (2) nitrogen transformation in rice soils; (3) heterotrophic nitrogen fixation in rice soils; (4) nitrogen fixation by algae; (5) azolla and its utilization for rice production; (6) agronomic practices to increase nitrogen in rice soils. The summaries of the discussions and the recommendation remarks for further research and international cooperation are also included. Important papers will be abstracted separately. - Abstr. on Trop. Agri. 7, 1981.
399. IRUTHAYATHAS, E.E. and VLASSAK, K. Symbiotic specificity in nodulation and nitrogen fixation between winged bean and Rhizobium. *Scientia Horticulturae*, 16 (4), 1982: 313-322, ref. Four selections of winged bean (syn. Indies Goa bean, *Psophocarpus tetragonolobus*) annual selection of the closely related species *P. palustris* were tested with 3 Rhizobium strains, in a glasshouse with simulated tropical conditions, to study their symbiotic specificities in terms of nodulation and N(,2) fixation. There were highly significant differences in nodulation factors such as nodule distribution within root-zone, nodule morphology and nodule mass, and in N(,2) fixation factors such as nitrogenase activity and the amount of effective nodule tissues between the plant selections, Rhizobium strains and their interactions at sixth and ninth week after seedling emergence. The strain NGR 258 was highly effective on winged bean and highly ineffective on *P. palustris* in terms of nodulation and N(,2) fixation. The strain SRI I was highly ineffective and could not be used in field practice, while strain MAR 655 showed a good symbiotic association with some of the winged bean genotypes, formed a good amount of effective nodulé tissues equal to that of NGR 258, but performed poorly compared to NGR 258 in terms of total nodule mass and N(,2) fixation. The winged bean selection LBNC(,1) was the best genotype in terms of

nodulation and N(,2) fixation. The symbiotic specificities observed in the host and Rhizobium combination showed that winged bean selections LBNC(,1) and TPT(,2) with strain NGR 258 were excellent symbiotic systems while *P. palustris* and NGR 258 should not be used in field practice. *P. Palustris* could be used in hybridization programs with winged bean without the nodulation and N(,2) fixation, although care should be taken in selecting the strain of Rhizobium inoculum for such lines, *P. palustris* was equally good as winged bean selections as a potential mulch/cover crop in terms of N(,2) fixation.

400. ISELY, D. Leguminosae and *Homo sapiens*. *Economic Botany*, 36(1), 1982: 46-70, bibliog. The legume plant family and its present role in agriculture are described. Critical agricultural problems in the immediate future may centre about the maintenance of soil nitrogen supplies, a consequence of spiralling costs of fertilizers and the need to improve the quantity and quality of protein in high-population countries. Unexploited legumes, if developed through research, may be of major importance in agriculture's response to this challenge. Author's summary. - Abstr. on Trop. Agri. 7,1981.
401. ISICHEI, A.O. Nitrogen fixation by blue-green algal soil crust in Nigerian savanna. In: Nitrogen Cycling in West African Ecosystem: proceedings of a workshop, IITA, 11-15 Dec. 1978, SCOPE/UNEP Royal Swedish Academy of Sciences, Stockholm, Royal Swedish Academy of Science, 1980, pp.191-198, illus.; graphs; map; tables; ref. Blue-green algal crusts were collected from the surface of soils from all of the savanna zone. Algae of the genus *Scytonema*, which are N-fixers, appeared to be dominant. These crust samples fixed N 24 h after rewetting. If adequate environmental requirements are available, an algal cover (crust) can fix from 3.3 to 9.2 kg/ha/year. This amount would replace much of the N lost from the grass standing crop as a result of the annual burning of the savanna. - Abstr. on Trop. Agri. 7,1981.

402. ISLAM, M.S. and NOOR, S. Performance of groundnut under different levels of phosphate fertilization in grey floodplain soil of Jamalpur (Bangladesh). *Bangladesh Journal of Agricultural Research*, 7 (1), 1982: 35-40. A field experiment on groundnut (var. Dhaka-2) with four levels of phosphate (0, 30, 60 and 90 kg P<sub>2</sub>O<sub>5</sub>/ha) conducted in the grey floodplain soils of Jamalpur, Bangladesh during the rabi season of 1980-81 showed that the application of phosphate significantly increased the pod yield of 100-kernel weight up to 60 kg P<sub>2</sub>O<sub>5</sub>/ha and straw yield up to 30 kg P<sub>2</sub>O<sub>5</sub>/ha. Percent N and P content and their uptake were markedly increased by applied phosphate up to 60 kg P<sub>2</sub>O<sub>5</sub>/ha but per cent protein and oil content were hardly affected. Groundnut yield, N and P uptake and increase in pod and straw yields per cent of control correlated with applied phosphate showed a significant positive relationship. Nitrogen fixation by the groundnut rhizobial strain in the soils was also favourably influenced by phosphate fertilization.
403. ISLAM, R., AYANABA, A. and SANDERS, F.E. Response of cowpea (*Vigna unguiculata*) to inoculation with VA-mycorrhizal fungi and to rock phosphate fertilization in some unsterilized Nigerian soils. *Plant and Soil*, 54 (1), 1980: 107-117, 18 ref. The effects of cowpea of inoculation with vesicular-arbuscular (VA) mycorrhizal fungi and rock phosphate (RP) fertilization were studied in pots using Alagba and Araromi series soils and in the field on Alagba, Apomu and Egbeda series soils. Inoculation of the plants with VA-mycorrhizal fungi caused very rapid infection of the roots. A higher per cent mycorrhizal infection was maintained during subsequent plant growth in the field. RP application reduced the degree of infection without affecting plant growth in the field and in pot experiments. Nodulation, nitrogen fixation and utilization of RP were increased by inoculation with mycorrhizal fungi in the pot experiments but not in the field experiments. In the pot experiments, inoculated plants supplied with RP flowered earlier, and took up more phosphorus than either inoculated plants without RP or uninoculated plants. The largest response to inoculation in terms of shoot dry matter, nodule yield and nitrogen content of shoots was obtained in

Alagba soil under both pot and field conditions.

404. ISLEIB, T.G., WYNNE, J.C., ELKAN, G.H. and SCHNEEWEIS, T.J. Quantitative genetic aspects of nitrogen fixation in peanuts. *Proceedings - American Peanut Research and Education Association, Inc.*, 10 (1), 1978: 71.
405. ISWARAN, V., PATIL, V.D. and SEN, A. Effect of spray of the culture of a bacterium from the phyllosphere of water hyacinth (*Eichornia crassipes* Mort Solms) on the yield of paddy and wheat. *Plant and Soil*, 50 (2), 1978:253-255, tables; ref.; summ. A culture of a bacterium present in the phyllosphere of water hyacinth (*Eichornia crassipes*) which was identified earlier to be *Azotobacter chroococcum* was sprayed on two varieties of paddy and a variety of wheat in microplots under field conditions. There was considerable increase in the yield of the crops. In both the crops, the increase in yield due to spray could easily be compared to that by treatment with fertilizers. Authors' summary. - *Abstr. on Trop. Agri.* 5,1979.
406. JAISWAL, V., RIZVI, S.J.H. and MUKERJI, D. Nitrogenase activity in root nodules of *Vigna mungo*: the role of nodular cytokinins. *Angewandte Botanik*, 56 (1-2), 1982: 143-148, illus.; tables; ref.; summ. Effects of some cytokinins, zeatin (Z), zeatin riboside (ZR), isopentenyl adenine (IPA) and isopentenyl adenosine (IPAS) isolated from root nodules of *Vigna mungo* on the nitrogenase activity of root nodules of *V. mungo* and on the growth of *Rhizobium leguminosarum* were studied. While IPA and IPAS showed maximum stimulation of bacterial growth, they caused a marked inhibition in the enzyme activity. With respect to Z and ZR, both the bacterial growth and the enzyme activity were stimulated. It is suggested that activity of nitrogenase can be affected, in one way or another, by some cytokinins independently of their effect on bacterial growth. - *Abstr. on Trop. Agri.* 8,1982.
407. JANSSEN, K.A. and VITOSH, M.L. Effect of lime, sulfur, and molybdenum on N<sub>2</sub> (nitrogen) fixation and yield of dark red kidney beans. *Agronomy Journal*, 66 (6), 1974: 736-740, ref.



408. JARDIM, Freire, Jr. Research into Rhizobium/Leguminosae symbiosis in Latin America. *Plant and Soil*, 67 (1), 1982: 227-239, ref.; summ. More than 60 institutions and 100 researchers were involved in Rhizobium research in 1978 in Latin America. Half of these researchers were located in Argentina and Brazil. Research activity and the application of research findings vary widely among countries. Problems that plague research include (1) inadequate training of research personnel and insufficient attention paid to the Rhizobium/Legume symbiosis at agriculture schools; (2) poorly-established research priorities that do not sufficiently weight the immediate needs for the farmers such as the identification of limiting environmental factors (e.g. nutritional deficiencies), techniques for small-scale inoculant production, and quality control of available inoculants; (3) isolation of the researchers and a lack of adequate library support; (4) poorly integrated research teams (e.g. in many institutes researchers are either microbiologists with no agricultural background or agronomists lacking microbiological training); and (5) insufficient dissemination of research findings. Problems with inoculant production and control include (1) a local dependence on national or imported inoculants rather than of locally-selected strains, (2) poor inoculat quality control which results in low inoculation success rates and subsequent discredit to the inoculation practice, and (3) high prices for inoculants. Extension problems include (1) lacking or deficient legume-promotion programs by government agencies, (2) poor contact between research and extension workers, and (3) administrators, leaders, extension workers and agronomists working in the field that lack adequate knowledge of the Rhizobium/Legume symbiosis. Immediate measures to foster extension and legume promotion programs and informal and/or official quality control are needed in Argentina, Uruguay, Brazil, Mexico, and probably Colombia. Countries where combined efforts should primarily be directed toward stimulating research and extension include Peru, Venezuela, Costa Rica, and Chile. In Ecuador, Paraguay, Bolivia, Nicaragua, Honduras, Guatemala, the Dominican Republic and Panama, priority should be given to research. Colombia should also be included in this group as national research institutions need to be strengthened.

409. JAUHRI, K.S., BHATNAGAR, R.S. and ISWARAN, V. Associative effect of inoculation of different strains of *Azotobacter* and homologous *Rhizobium* on the yield of mung (*Vigna radiata*), soybean (*Glycine max*) and pea (*Pisum sativum*). *Plant and Soil*, 53(1-2), 1979: 105-108, table; ref.; summ. Strains of *Azotobacter chroococcum* isolated from the rhizosphere of berseem (*Trifolium alexandrinum* or pea, and strains of *Rhizobium* isolated from mung bean, soya bean or pea were used in this study. Effects of inoculating seeds of the last 3 legumes with these strains on their yield are briefly discussed. It is indicated that screening of several strains of *Azotobacter* for their beneficial association with *Rhizobium* in legume inoculants may yield several promising strains of *Azotobacter*. - Abstr. on Trop. Agri. 6, 1980.
410. JAYACHANDRAN, S. Influence of various phenolic compounds on *Azotobacter*. *Zentralblatt für Bakteriologie, Parasitenkunde, Infektionskrankheiten und Hygiene, Zweite Naturwissenschaft Abteilung Mikrobiologie Landwirtschaft Technologie Umweltschutzes*, 135(1), 1980: 38-44. All the phenolic compounds, i.e., nitrophenol, hydroquinone, coumarin and benzoic acid, inhibited the growth, polysaccharide production, respiration and  $N_2$  fixation of different *Azotobacter* isolates in vitro. Both in the presence and absence of various phenolic compounds a direct correlation between the polysaccharide production and  $N_2$  fixation was observed. No such direct effect was observed with respect to respiration and  $N_2$  fixation in the *Azotobacter* isolates tested. [This study has relevance to  $N_2$  fixation by *Azotobacter* in the soil.] - Biol. Abstr. 70, 1980.
411. JIAXI, L. Composite "String bag" cluster model for the active center of nitrogenase (Biological nitrogen fixation). In: Nitrogen fixation, vol. 1. Baltimore, University Park Press, 1980, pp.343-371. illus.; bibliog.
412. JOHANSEN, C. and KERRIDGE, P.C. Nitrogen fixation and transfer in tropical legume-grass swards in southeastern Queensland, Australia. *Tropical Grasslands*, 13(3), 1979: 165-170. The amount of fixed N in tops of tropical legume-grass swards and transfer of fixed N to the grass were

estimated for swards at 3 sites in southeastern Queensland over 5 yr. Swards were sampled for dry matter and N content usually twice each growing season and all plant material above 10 cm was removed from plots after each sampling. The amount of fixed N in tops was in the range 100-140 kg N ha<sup>-1</sup> for *Macroptilium atropurpureum* cv. Siratro, *Glycine wightii* cv. Cooper and *Desmodium intortum* cv. Greenleaf while values of 51 and 74 kg N ha<sup>-1</sup> were estimated for *Lotononis bainesii* cv. Miles. Estimated transfer of fixed N below cutting height to the tops of the companion grass, relative to total fixed N in tops, was 12-15% for 'Siratro' and *Lotononis*, 16% for *Glycine* and 17% for *Desmodium*. - Biol. Abstr. 70,1980.

413. JOHNSTON, A.W.B. and BERINGER, J.E. Genetic hybridization of root-nodule bacteria (Rhizobium) (of peas). In: HOLLANDER, A., ed. Genetic engineering for nitrogen fixation. New York, Plenum Press, 1977, pp.81-90, ref.
414. JOHNSTON, A.W.B., BREWSTER, V. and DAVIES, D.R. Seed proteins of peas in relation to nitrogen fixation. *Annals of Botany*, 41 (172), 1977: 381-385, ref.
415. JO, Jinki, YOSHIDA, Shigekata and KAYAMA, Ryosei. Growth and nitrogen fixation of some leguminous forages grown under acidic soil conditions. *Journal of Japanese Society of Grassland Science*, 25 (4), 1980: 326-334. The purpose of this investigation was to clarify the acidity tolerance and the effect of soil acidity on symbiotic N fixation of 10 leguminous forages. Alfalfa (*Medicago sativa* L.), alsike clover (*Trifolium hybridum* L.), birdsfoot trefoil (*Lotus corniculatus* L.), common vetch (*Vicia sativa* L.), chinese milk vetch (*Astragalus sinicus* L.), hairy vetch (*V. villosa* Roth.), common lespedeza (*Lespedeza striata* Thunb.), ladino clover (*T. repens* L. var. *giganteum*), white clover (*T. repens* L.), and red clover (*T. pratense* L.) were grown in each pot containing 4 kg of an acidic mineral soil (pH 5.0: unlimed soil) and the same soil adjusted to pH 7.0 with CaCO<sub>3</sub> (limed soil). Plant growth, nodulation, plant total N and N fixing capacity with acetylene reduction method were measured. Plant yield and plant total N of the legumes were lower in unlimed plot than in limed

plot except in common lespedeza. Though the degree of depression differed depending on the species, it showed a similar tendency with plant yield and the amount of plant total N. Acidity tolerance of the legumes assessed by relative plant yield and the amount of plant total nitrogen in unlimed plots to those of limed plots were ranked: common lespedeza > alsike clover > ladino clover > white clover > red clover > alfalfa. Species excluded from this ranking difficult to place precisely. Nodule formation on roots and symbiotic N fixation capacity were considerably depressed under acidic soil conditions especially in alfalfa and chinese milk vetch. In common lespedeza, the improvement of nodule formation induced by liming was not consistent with that of symbiotic N fixation capacity. Symbiotic N fixation capacity per unit fresh nodule weight was not directly related with liming. The decrease of plant yield under acidic soil conditions was attributed to decreased N symbiosis. A heavy application of N fertilizer to grow leguminous forages under acidic conditions is recommended. Al toxicity as an inhibitory factor for symbiotic N fixation system was also discussed. - Biol. Abstr. 70,1980.

416. JONES, Benjamin L. and MONTY, Kenneth J. Glutamine as a feedback inhibitor of the *Rhodospseudomonas sphaeroides* nitrogenase system. *Journal of Bacteriology*, 139 (3), 1979: 1007-1013. In whole cells of *R. sphaeroides*,  $N_2$  fixation, as measured by  $H_2$  production and acetylene reduction, was totally inhibited by micromolar concentrations of  $NH_3$ . This inhibition could not be duplicated by glutamate or glutamine alone. The inhibition by  $NH_3$  was abolished by methionine sulfoximine, a glutamine synthetase inhibitor. Inhibition by glutamine was complete in the presence of methionine sulfone, a preferential inhibitor of glutamate synthase, presumably by permitting a rise in the glutamine pool. The level of the glutamine pool controlled the activity of nitrogenase. None of these effects could be duplicated with cell-free nitrogenase, indicating there is probably a mediator which responds to the glutamine pool and inhibits nitrogenase, rather than glutamine itself being a direct inhibitor. - Biol. Abstr. 69,1979.

417. JONES, J.P. and COLLINS, F.C. Performance of *Azotobacter* seed inoculants for nitrogen fixation in wheat and oats. Fayetteville, University of Arkansas, Agricultural Experiment Station, 1979, 7p., tables; summ. (University of Arkansas, Agricultural Experiment Station, Mimeograph Series no. 272). Certain species of the *Azotobacter* bacteria can fix nitrogen from the air, and grow in root surfaces of non-leguminous crop plants. Conversion of atmospheric N to a form usable by such crops would be a boon to agriculture. This study from the USA concludes from tests with such inoculants that no advantage in yield or bushel weight was obtained. Only in 1 test with oats (*Avena sativa*) an increase in tiller number was obtained and also in 1 test with wheat (*Triticum aestivum*) a slight yield increase took place. That indicates some potential for future research on this type of organism. - Abstr. on Trop. Agri. 6, 1980.
418. JONES, M.B., BURTON, J.C. and VAUGHN, C.E. Role of inoculation in establishing subclover on California annual grasslands. *Agronomy Journal*, 70 (6), 1978: 1081-1085. A study was conducted to develop dependable inoculum and methods of establishing annual clovers in northern California [USA]. *Rhizobium* was isolated from nodules of vigorous clover (*Trifolium subterraneum* L.) plants growing among plants showing extreme N-deficiency symptoms. These rhizobia were screened in growth chamber tests for effectiveness and competitiveness against native ineffective rhizobia. The best strains were further tested in the field with several stickers and seed coating materials, and were compared with commercial inoculants available at the time. In the field tests rhizobial strains differed in ability to compete with ineffective native rhizobia and in ability to survive the long summer drought. In composites, poor or moderately effective rhizobial strains reduced the effectiveness of the good strains. Subclover growth increased in field experiments as the amount of inoculum was increased, indicating that high rhizobial numbers were important. Peat inoculum applied with 40% gum arabic solution as a sticker and a lime coating was much superior to peat inoculum applied as a water slurry. Vacuum inoculation treatment gave no better results than uninoculated seed. The effectiveness of inoculation sticker materials

fell generally in the following order: "PELGEL [a sticker with a gum arabic base]-PELINOC" [peat mass inoculum] > gum arabic-lime > methyl-cellulose-lime > sugar lime. - Biol. Abstr. 69,1979.

419. JORDAN, D.C., McNICOL, P.J. and MARSHALL, M.R. Biological nitrogen fixation in the terrestrial environment of a high arctic ecosystem (Truelove Lowland, Devon Island, N.W.T.) (North West Territories). *Canadian Journal of Microbiology*, 24 (6), 1978: 643-649, ref.
420. JORDAN, D.C. Reduction of the nodulation barrier in *Medicago lacinata* by alteration of the root temperature. *Plant and Soil*, 61 (1), 1981: 93-111, ref. *Medicago lacinata*, an annual leguminous plant of Saharo-Sindian origin, is particularly refractory to root nodulation by most strains of *Rhizobium meliloti*. Using a series of such bacterial strains belonging to the 8 groups of Brockwell and Hely, and a variety of environmental conditions, it was noted that several normally non-nodulating strains (at 20 deg C) produced ineffective nodules at root temperatures of 24 deg C to 28 deg C. Nodulation at 20 deg C failed to occur in the presence of a wide variety of test compounds and physical conditions. No phytoalexins or anti-*Rhizobium* growth inhibitors were isolated from inoculated root tissue at any temperature. Temperature shift experiments indicated no infection of the root hairs at 20 deg C, and infection threads produced at the permissive root temperature failed to elongate after transfer to 20 deg C. However, if meristematic activity had been initiated in the inner root-cortical cells as a result of infection thread penetration at 28 deg C, no blockage of nodule maturation occurred upon subsequent transfer to 20 deg C root temperature. Nodules produced at 28 deg C were completely devoid of nitrogenase activity, although the apical (but not the distal) regions contained normal-appearing bacteroids, surrounded by enclosing membranes, and possessed a fully functional leghaemoglobin. A shortage of metabolic energy did not appear to be involved in the ineffective response. A hypothesis to explain the nodulation phenomenon observed was based on the observation in the roots of 2 factors present at 20 deg C but not at 28 deg C.

421. JUANG, T.C. and TANN, C.C. Effect of nitrogen fertilization on nodule nitrogenase activity and yield of soybeans. Taiwan, Asian and Pacific Council (ASPAC)/Food & Fertilizer Technology Center (FFTC), 1982, pp.12-25, illus.; tables; ref. (Extention Bulletin ASPAC/FFTC no 171). The objectives of this study were to investigate the influence of N fertilizer treatments (different forms and various times of application) on the status of soil N, on the relative relationships of nitrate reductase and nitrogenase, and on the yield components of the soya bean plant. The results show that the highest growth efficiency of plant N occurred during early growth stages, suggesting that by increasing the accumulation of plant N at this time higher soya bean yields are obtained. - Abstr. on Trop. Agri. 8,1982.
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423. KAMPEE, T. Survey and classification of *Rhizobium* spp. in root nodule of local leguminous plants (In Thai). Thesis for the degree of Master of Science in Microbiology. Bangkok, Kasetsart University, 1975, 107p., tables; bibliog.; Engl. summ.
424. KANT, Shri and NARAYANA, H.S. Effect of water stress on growth, nodulation and nitrogen fixation in *Casuarina equisetifolia*. *Annals of Arid Zone*, 17(2), 1978: 216-221. The shoot and root lengths, the shoot and root weights, nodule size and number, nodule weight and the amount of N fixed decreased with increased water stress. There was no nodule degeneration and cessation of N fixation when the soil moisture was raised to the field capacity once in 72 h. - Biol. Abstr. 68,1978.
425. KAPOOR, K. and SHARMA, V.K. Micronutrient for in vitro nitrogen fixation by a blue-green algae (*Anabaena doliolum*). *Geobios*, 6(6), 1979: 254-256. Fe, Mo and Co were essential for growth and fixation of elemental N. in *A. doliolum*. - Biol. Abstr. 69,1978.

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427. KAVIMANDAN, S.K.M., KUMARI, Lakshmi and SUBBA RAO, N.S. Non-symbiotic nitrogen fixing bacteria in the rhizosphere of wheat, maize and sorghum. *Proceedings of the Indian Academy of Sciences Sect. B*, 87 (11), 1978: 299-302. Rhizosphere effect of 20 varieties of wheat, 2 of maize and 3 of sorghum on N fixing bacteria was measured. The rhizosphere effect of wheat with regard to *Clostridium*-like anaerobes was higher than those of maize and sorghum. The reverse was true with regard to *Azotobacter chroococcum*. - Biol. Abstr. 68, 1979.
428. KAYAMA, Ryosei, YOSHIDA, Shigekata, KUBOTA, Hiroo, SUGI, Tomomitsu and ANDO, Yutaka. Studies on the agricultural utilization of factory waste . I. Effect of crude ettringite on the growth and the nitrogen fixation of some leguminous forages (In Jpn.). *Journal of Japanese Society of Glass-land Science*, 25 (1), 1979: 55-61, Engl. summ. The effect of crude ettringite (CET) on growth and N-fixation of ladino clover, red clover and alfalfa was investigated. CET was synthesized from blastfurnace slag and gypsum produced during desulfurization at an electric power station. The leguminous forages were sown in 1/2000 are wagner pot containing 15 kg of acidic mineral soil of which pH was adjusted at 5.5, 6.5 and 7.5 with CET or calcium hydroxide. The culture was carried out in an unheated glasshouse from Sept. 12, 1977 - May 10, 1978. Plant shoots were cut 3 times (Jan. 21, Apr. 15 and May 10, 1978) and the growth of forages compared. K uptake and N-fixing capacity were also measured. The neutralizing capacity of CET was less than calcium hydroxide, while the values of initial soil pH adjusted by CET were almost constantly maintained through the experimental period. Forage growth was markedly affected by soil pH and was considerably improved by the application of CET compared with calcium hydroxide. The species were ranked according to the effectiveness of CET: alfalfa > red clover > ladino clover. Its effectiveness seemed to be enhanced by cutting. Although K uptake in-



- creased with the application of CET, no growth effects were noted due to the increase of K uptake. CET application resulted in increased N-fixing capacity per plant by improving nodule formation and N-fixing capacity per unit nodule weight. CET is a much better material for neutralizing soil acidity than calcium hydroxide in the cultivation of leguminous forages. - Biol. Abstr. 69, 1979.
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430. KELLAR, Penelope E. and GOLDMAN, Charles R. A comparative study on nitrogen fixation by the *Anabaena Azolla* symbiosis and free-living populations of *Anabaena* spp. in Lake Ngahewa, New Zealand. *Oecologia*, 43 (3), 1979: 269-282. The symbiotic fern *Azolla filiculoides* var *rubra*, which contains a blue-green N fixing algal *Anabaena azollae*, fixed 164 Kg N/ha per yr in the littoral zone of a small eutrophic lake. Associated planktonic *Anabaena* spp. blooms, dominated by *Anabaena spiroides*, fixed 29.5 Kg N/ha per yr. N fixation in both organisms was not obviously related to ambient dissolved inorganic N levels. By comparing  $^{15}\text{N-N}_2$  and acetylene reduction techniques, a ratio of 3 mol  $\text{C}_2\text{H}_2$  reduced to 1 mol of  $\text{N}_2$  fixed was determined. Combining this with results from 1 diurnal investigation, it was estimated that 24% of the total daily fixation by *Azolla* occurred at night. Highest N fixation rates in *Azolla* occurred when plant density was lowest. N fixation by planktonic *Anabaena* spp. generally paralleled changes in biomass. Frond breakage due to wind caused a decrease in *Azolla* N fixation and growth which was followed by a bloom of planktonic *Anabaena* spp. A 2nd *Anabaena* spp. bloom was instrumental in the summer decline of *Azolla*. Maximum growth and N fixation of both organisms did not occur simultaneously. If physical disruption to the *Azolla* mat does not occur, it is likely that growth of the population would continued throughout the year. - Biol. Abstr. 69, 1979.

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432. KEYA, S.O. Ecological aspects of feeding of protozoa and Bdellovibrio on cowpea Rhizobium. *East African Agricultural and Forestry Journal*, 42(4), 1977: 397-407, graph; tables; ref.; summ. This study examines the persistence of some cowpea Rhizobium strains in culture and laboratory soil and how the bacterium might be influenced by its biotic and abiotic environment. - Abstr. on Trop. Agri. 6, 1980.
433. KHAILOVA, G.F. A study on the cell structure of bacteroid tissue in legume root nodules in relation to starch deposition (In Russ.). *Fiziologiya Rastenii*, 25(6), 1978: 1172-1178, Engl. summ. Starch deposition in root nodule bacteroid tissue of legumes (Soybeans, lupine, broad beans) at the time of various N-fixing activity does not have any casual relationship with cell destruction. Starch accumulates in the tissue when influx of carbohydrates exceeds their expenditure in the nodules; it is consumed with the enhancement of N<sub>2</sub> fixation. Cell destruction of bacteroid tissue occurs both in effective nodules with aging, when bacteroids lose their ability to fix N, and in ineffective nodules with the bacteria incapable of combining N at the beginning of nodule formation. Cell destruction is mainly due to disturbances in the functioning of the nitrogenase enzyme complex of endophytes. - Biol. Abstr. 68, 1978.
434. KHAILOVA, G.F., SHIL'NIKOVA, V.K. and MAMEDOV, K.Yu. Formation and functioning of nitrogen-fixing associations of lucerne (*Medicago sativa*) root tissue culture with *Rhizobium meliloti* (In Russ.). *Fiziologiya Rastenii*, 26(5), 1980: 1103-1109, Engl. summ. N-fixing associations of lucerne root tissue culture with *Rhizobium* (strains 87, 441 and L-4) were obtained. The associations were capable of fixing N under certain conditions, provided that plant tissues were bacterized in the middle of logarithmic growth phase, and 7 days later were exposed to 2, 4-D and kinetin-

- free medium with bound N content equal to 20% that of the norm. The lucerne root tissue retained the ability to produce N-fixing associations during a long-term subculturing (at least 12 passages). The level of nitrogenase activity in the associations varied with respect to the bacterium strain employed; the activity with strain 87 was twice as high as that with strains 441 and L-4. All the 3 bacterial strains did not reveal nitrogenase activity when grown in pure culture on the same medium. Localization and initial steps of *Rhizobium* incorporation into lucerne root tissue were also studied. - Biol. Abstr. 70, 1980.
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436. KITAMURA, Y. and ABE, J. Efficiency of N<sub>2</sub>-fixation by tropical pasture legumes (In Jpn.). *Journal of Japanese Society of Grassland Science*, 28 (2), 1982: 154-160, illus.; tables; ref.; Engl. summ. Effects of soil, plant age, strains of *Rhizobium* and host plant spp. on the relative efficiency of N<sub>2</sub> fixation by tropical pasture legumes were studied. The results indicate that screening of *Rhizobium* strains for efficiency of N fixation is necessary to increase the dry matter production of the legumes. However, the target plant and the soil properties of the target cropping area should be identified before the *Rhizobium* screening. - Abstr. on Trop. Agri. 8, 1982.
437. KITAMURA, Y. and FUKUYAMA, K. Vegetative regrowth, nodule development, and nitrogen fixation of tropical legumes after harvest. 2. Siratro (In Jpn.). *Journal of Japanese Society of Grassland Science*, 27 (4), 1982: 364-371, illus.; graphs; tables; ref.; Engl. summ. The legume *Macroptilium atropurpureum*, cv. Siratro was grown in sand in the greenhouse. At harvest cutting was done at the heights 0, 7.5 and 15.0 cm above the soil surface. Root and shoot dry matter weight was much reduced when all the leaves on the stubble were cut or with the lower cutting height, showing different roles for leaves and stems in vegetative regrowth.

N fixation (NF) did not drop with the higher cutting heights when leaves were kept on the stubble; with the lower cutting height some drop in NF occurred for a short period. The periods required for the recovery of NF were shorter for the higher cutting heights and for greater leaf areas remaining on the stubble. A high root total non-structural carbohydrate concentration seems to mitigate adverse effects of the cutting treatments and accelerate vegetative regrowth. Results indicate that higher cutting heights with longer cutting intervals can be recommended. - Abstr. on Trop Agri. 8,1982.

438. KITAMURA, Yukio and NISHIMURA, Shuichi. Studies on mixed cultivation of tropical legume and grass: VII. The effect of temperature on nitrogen fixation and nitrogen absorption during the seedling stage of 'Greenleaf' *Desmodium*. (In Jpn.). *Journal of Japanese Society of Grassland Science*, 24(2), 1978: 128-132, Engl. summ. Temperatures of 20°, 25° and 30° C were imposed on *D. intorium* cv. Greenleaf seedlings inoculated and treated with starter N. Plants were harvested 8 times at 5 day intervals starting 8 days after germination. DM [dry matter] yield decreased in the order 30° > 25° > 20° C with wide difference between 25° and 20° C. Better nodulation was seen at higher temperature. N content was high at higher temperature; wider differences between temperatures were recognized in the plant top. Total N yield and the portion of N from the nodule was high at higher temperature. The N from nodule outyielded that from fertilizer at 25° C and 30° C, but not at 20° C. The N fixed per nodule weight at 25° C and 30° C doubled that at 20° C. - Biol. Abstr. 68,1978.
439. KITAMURA, Yukio and NISHIMURA, Shuichi. Studies on mixed cultivation of tropical legumes and grasses. 8. Growth and nitrogen fixation in the cowpea-corn intercropping as affected plant competition for light and for soil nutrients (In Jpn). *Journal of Japanese Society of Grassland Science*, 25(1), 1979: 34-42, Engl. summ. A field experiment was conducted in Fukuoka, Japan for evaluating effects of plant top and root competition on DM [dry matter] yield, N yield and N<sub>2</sub>-fixation. There were 7 treatments replicated 3 times: 3 monocultures of cowpea (*Vigna unguiculata*, TVu

4557), tall corn (*Zea mays*, Koh-1), and dwarf corn (TX-74) and 4 cowpea/corn inter-croppings of 2 levels of plant top competition X 2 levels of plant root competition. Inter-cropping cowpea with tall corn or with dwarf corn facilitated 2 levels of plant top competition. Burying wooden partitions in between rows of corn and cowpea or at right angle with these rows facilitated 2 levels of plant root competition. When compared with other coppings, the tall corn/cowpea inter-cropping created a favorable canopy structure for increasing DM yield, showing even vertical distribution of leaves throughout the canopy. Dry matter yield was higher in the tall corn-cowpea intercropping, followed by the dwarf/cowpea inter-cropping, showing relative yields totals of 132 and 124, respectively. Root competition created favorable effects on increasing DM production in the tall corn/cowpea but not in the dwarf corn/cowpea intercropping. Nodule formation and  $N_2$ -fixation changed significantly with combinations of cowpea and corn. Among the factors comprising  $N_2$ -fixation ( $C_2H_2$  reduction), nodule number and nodule weight decreased as light environments on cowpea worsened while specific nodule activity increased.  $N_2$ -fixation decreased with root competition in the tall corn/cowpea but not in the dwarf corn/cowpea inter-cropping. N yield in the inter-croppings was higher than in the corn monocultures and lower than in the cowpea monocultures showing lower relative yield totals. Relative yield totals of N were reduced with root competition. Plant top competition for light is more significant in determining DM yield than competition for soil nutrients. A suggestion was made for the ideal types which maximize productivity in the corn/cowpea inter-cropping, viz., tall stem with leaves on the top layer for corn and non-climbing type for cowpea. - Biol. Abstr. 69, 1979.

440. KITAMURA, Yukio, NISHIMURA, Shuichi and TANAKA, Shigeyuki. Studies on mixed cultivation of tropical legume and grass: VI. Change in mixture effect on increasing dry matter production (In Jpn.). *Journal of Japanese Society of Grassland Science*, 24(2), 1978: 123-127, Engl. summ. Yields of dry matter and N and the magnitude of mixture effect on increasing dry matter production were investigated for 2 yr with the mixed stand of *Desmodium intortum* cv. Green-

leaf (De) and *Setaria anceps* cv. Kazungula (Ks) and the pure stands of De and Ks. Dry matter yields in the mixed stand were higher in the 2nd yr than in the 1st yr. N contents in De increased after the 2nd harvest while those in Ks increased with later harvests. N yields were, in decreasing order, the pure stand of De, followed by the mixed stand and the pure stand of Ks. Mixture effect significantly increased in the 2nd yr, especially in Ks component. These results are discussed in relation to N transfer from the legume to the grass. Lower grassland productivity at the early stage of the sward establishment was due to longer periods required for the beginning of active N fixation by the legume and of N transfer from legumes to the grass. Application of starter N was suggested as a means of increasing grassland productivity at the early stage of establishment. - Biol. Abstr. 68,1979.

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442. KLEINER, D. Regulation of ammonium uptake and metabolism by nitrogen fixing bacteria. III. *Clostridium pasteurianum*. *Archives of Microbiology*, 120 (3), 1979: 263-270. Addition of ammonium salts to  $N_2$  fixing continuous cultures of *C. pasteurianum* caused an immediate stop of nitrogenase synthesis, while the levels of glutamine synthetase, glutamate dehydrogenase and asparagine synthetase remained constant. No evidence for an interconversion of the glutamine synthetase was found. The activities of glutamate synthase in crude extracts were inversely related to the nitrogenase levels. The intracellular glutamine pool rapidly expanded during nitrogenase repression and decreased as fast during derepression while the pool sizes of all other amino acids were not strongly related to the rate of nitrogenase formation. Glutamine is suggested as corepressor of nitrogenase synthesis. - Biol. Abstr. 68,1979.
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- Great Basin *Artemisia*, *Ceratoides* and *Atriplex* plant communities contain a significant heterotrophic  $N_2$ -fixing microbial population in addition to the predominating filamentous cyanobacteria. The bacterial association with the cyanobacteria exhibits a phycosphere-like effect. Heterotrophically fixed N gains reached  $17.5 \mu\text{g N} \cdot \text{g}^{-1}$  of soil (23.1% increase above the initial soil N content) and  $45.9 \mu\text{g N} \cdot \text{g}^{-1}$  of soil (57.4% increase) after 3 and 5 wk, respectively.  $(\text{NH}_4)_2\text{SO}_4$  and native plant material amendments to soil resulted in a 41-100% reduction in  $N_2$ -fixation. The potential input of N to soil crusts may be reduced in the presence of shrub-produced allelochemic agents and by concurrent denitrification. - Biol. Abstr. 70,1980.
444. KNOWLES, R. Free-living (or asymbiotic nitrogen-fixing) bacteria. Proceedings of a Conference on Limitations and Potentials for Biological Nitrogen Fixation in the Tropics, Brasilia, 1977. New York, Plenum Press, 1978, vol. 15th, pp.25-40, ref.
445. KOCH, B.L. Associative nitrogenase activity by some Hawaiian grass roots. *Plant and Soil*, 47(3), 1977: 703-706, tables; ref.; summ. Nitrogenase activity by the roots of some tropical grasses was detected by the acetylene reduction technique. Acetylene reduction by root samples which had undergone preincubation under low  $O_2$  displayed a five-fold increase. This increase in nitrogenase activity corresponds to an increase in the number of nitrogen-fixing bacteria associated with the roots. - Abstr. on Trop. Agri. 4,1978.
446. KOHL, Daniel H. and SHEARER, Georgia. Isotopic fractionation associated with symbiotic nitrogen fixation and uptake of nitrate ion by plants. *Plant Physiology*, 66(1), 1980: 51-56. Isotopic fractionation associated with  $N_2$  fixation and  $\text{NO}_3^-$  uptake by plants are relevant to the accuracy of estimates of  $N_2$  fixation based on differences in the natural abundance of  $^{15}\text{N}$  between  $N_2$  fixing and nonfixing plants. The isotope effect on  $N_2$  fixation by soybeans (*Glycine max*[L] Merrill, cv. Harosoy) and red clover (*Trifolium pratense* [L]) was determined from the difference in  $^{15}\text{N}$  abundance between atmospheric  $N_2$  and the total N of

plants grown hydroponically with N-free nutrient solution. In soybeans the isotope effect was found to be  $+ 0.98 \pm 0.18\%$ . ( $\beta = 0.99902$ ). In clover the isotope effect was  $+ 1.88 \pm 0.14\%$  ( $\beta = 0.99812$ ). The magnitude of these inverse isotope effects is small. They would lead to an underestimation of the amount of  $N_2$  fixed, since the N of atmospheric origin which finally appears in the plant is made richer in  $^{15}N$  by the inverse isotope effects than is atmospheric  $N_2$ , and to that degree is attributed to soil-derived N in the calculation. Isotopic fractionation associated with  $NO_3^-$  uptake by plants does not have a critical effect on estimates of  $N_2$  fixation which are based on natural abundance of  $^{15}N$  since the  $^{15}N$  abundance of soil-derived N in plants is measured directly (i.e., after the N has undergone fractionation). Nevertheless, such fractionation is of some interest from the viewpoint of determining the most appropriate sampling time. The isotope effect on  $NO_3^-$  uptake by a nonnodulating isolate of soybeans (cv. Harosoy), marigold (*Tagetes erecta* [L]) and ryegrass (*Lolium perenne* [L]) was estimated from the difference between the  $^{15}N$  abundance of the total N of plants grown hydroponically and that of  $NO_3^-$  supplied in the medium. It was about -5%. ( $\beta = 1.005$ ). - Biol. Abstr. 70,1980.

447. KOHL, Daniel H., SHEARER, Georgia and HARPER, James E. Estimates of nitrogen fixation based on differences in the natural abundance of nitrogen-15 in nodulating and nonnodulating isolines of soybeans (*Glycine max*). *Plant Physiology*, 66 (1), 1980: 61-65. Estimates of the contribution of biologically fixed N to the total N of nodulating soybeans (*G. max* (L) Merrill, cv. Harosoy) grown under a variety of conditions were made from differences in N yield between nodulating and nonnodulating isolines, and differences in  $^{15}N$  abundance between the 2 isolines. For plants grown in a greenhouse in nutrient-poor soil, both estimates showed a high level of  $N_2$  fixation; from 58-89% N fixed by differences in N yield and from 51-95% by differences in  $^{15}N$  abundance. Decreasing contributions of fixed N were estimated by both methods with increasing levels of added  $NO_3^-$ . Results of field experiments carried out over 2 yr on an unamended highly fertile midwestern



[USA] soil showed a modest level of  $N_2$  fixation by both methods (7.3-51% by differences in N yield, and 5.4-46% by differences in  $^{15}N$  abundance). When the soil was amended with ground corn cobs, both methods showed higher contributions of fixed N. The 2 methods of estimating  $N_2$  fixation gave similar results. Both appear to be semiquantitative and the standard errors of the estimates were about the same (6% on the average). - Biol. Abstr. 70,1980.

448. KONDRATEVA, E.N., GOGOTOV, I.N. and GRUZINSKII, I.V. The effect of nitrogen-containing compounds on hydrogen photoevolution and nitrogen fixation in purple bacteria (In Russ.). *Mikrobiologiya*, 48 (3), 1979: 389-395, Engl. summ. The cells of *Rhodospirillum rubrum* and *Thiocapsa roseopersicina* grown in media containing glutamate and arginine, respectively, and under conditions of  $N_2$  fixation, evolve  $H_2$  in the light. If the cultures were grown in media with  $NH_4^+$ ,  $NO_3^-$ , urea, glutamine or asparagine,  $H_2$  photoevolution by the cells and acetylene reduction started after the lag-phase and proceeded at a low rate. Extracts of such cells did not display the activity of nitrogenase which could be assayed by the ATP-dependent evolution of  $H_2$  from dithionite.  $H_2$  photoevolution by purple bacteria involves nitrogenase whose synthesis is regulated (according to the action of glutamine) with the participation of glutamine synthetase.  $NH_4^+$ , glutamine and asparagine also inhibit  $H_2$  photoproduction by purple bacteria and acetylene photoreduction. They have no effect on  $H_2$  evolution in the dark by the photoreduction. They have no effect on  $H_2$  evolution in the dark by the cells of *R. rubrum* and *T. roseopersicina* in the presence of formate or pyruvate, respectively, whereas CO inhibits  $H_2$  production. Therefore,  $H_2$  production by purple bacteria in the dark must be catalyzed by hydrogenase. - Biol. Abstr. 70, 1980.
449. KONONKOV, F.P., UMAROV, M.M. and MIRCHINK, T.G. Nitrogen-fixing associations of fungi and bacteria (In Russ.). *Mikrobiologiya*, 48 (4), 1979: 734-737, Engl. summ.  $N_2$  fixing associations of fungi and bacteria were isolated from the soil and flooring of coniferous forests. The special composition and the  $N_2$  fixing activity of components

in associations were determined. Pure fungal cultures did not possess the  $N_2$  fixing activity. The  $N_2$  fixing activity of pure bacterial cultures was always lower than that of their associations with fungi. The possibility of existence and the specificity of species composition in the  $N_2$  fixing associations of fungi and bacteria are discussed. - Biol. Abstr. 70,1980.

450. KOSYAK, A.V., GOGOTOV, I.N. and KULAKOVA, S.M. Photoproduction of hydrogen by the cyanobacterium *Anabaena cylindrica* (In Russ.). *Mikrobiologiya*, 47(4), 1978: 605-610, Engl. summ. The cells of *A. cylindrica* containing heterocysts are capable of simultaneous  $H_2$  and  $O_2$  evolution in the light in the absence of exogenous substrates. Photoevolution of  $H_2$  is not inhibited by DCMU [duiron],  $CO$ ,  $O_2$ , glutamine and asparagine but is inhibited by  $N_2$ ,  $C_2H_2$ ,  $NH_4^+$ ,  $NO_3^-$  and uncouplers of phosphorylation (dinitrophenol and carbonylcyanide chlorophenylhydrazone). Acetylene does not initiate photoevolution of  $H_2$  in the presence of  $CO$ . The cultures grown in the media with  $NH_4^+$  or glutamine do not contain heterocysts, and do not fix  $N$  and photoevolve  $H_2$ . Extracts of such cells do not show ATP-dependent evolution of  $H_2$  from dithionite. The cells of *A. cylindrica* are also capable of  $H_2$  evolution and absorption in the dark in the presence of reduced or oxidized methyl viologen, respectively, but  $CO$  inhibits these processes. Such evolution or absorption of  $H_2$  and isotopic  $D_2$ - $H_2O$  exchange take place regardless of the  $N$  source used for the growth. Apparently, photoevolution of  $H_2$  in *A. cylindrica* is catalyzed by nitrogenase. This process is associated with the action of the first pigment system, and is spatially separated from  $O_2$  formation. Hydrogenase is not involved in  $H_2$  photoevolution but it can be responsible for evolution of  $H_2$  in the dark in the presence of an exogenous hydrogen donor. However, hydrogenase is not a  $H_2$ -recycling enzyme providing  $N$  fixation in the light. - Biol. Abstr. 68,1979.
451. KOVALY, K.A. Better ways to fix nitrogen. *Development Digest*, 19(4), 1981: 12-15, summ. (*Technology Tomorrow*, 2(5), 1979: 6-7). This paper describes the principal method used to make chemical nitrogen fertilizer. Some

new alternatives are discussed, such as the creation of new types of bacteria by genetic engineering, the use of new chemicals to replace the need for gas and oil in manufacturing, and ultimately the introduction of N-fixing capability into common food plants. - Abstr. on Trop. Agri. 7,1981.

452. KOYAMA, T. The transformation and balance of nitrogen in Japanese paddy fields. *Fertilizer Research*, 2(4), 1981: 261-278, ref. Research on the transformations and balance of nitrogen in Japanese paddy field is reviewed. During the past decade substantial progress has been made in estimating more accurate nitrogen balance. However, available data do not provide reliable assessments of nitrogen losses or gains, especially of biological nitrogen fixation, denitrification and leaching. Accordingly, data obtainable now permit only a partial accounting of the nitrogen balance in flooded paddy soils. Accurate estimates on inputs and outputs of nitrogen are required. The problems in estimating these gains and losses are discussed, and the need for more nitrogen balance studies in the field is emphasized.
453. KOZHEVIN, P.A., POLYANSKAYA, L.M. and ZVYAGINISEV, D.G. Dynamics of development of various soil microorganisms (In Russ.). *Mikrobiologiya*, 48(3), 1979: 490-494, Engl. summ. The dynamics of individual components from the complex of soil microorganisms (bacteria, fungi, actinomycetes) and the population of *Streptomyces olivocinereus* introduced into soil was studied by luminescent microscopy and inoculation. The population density maxima for individual components from the complex of soil microorganisms were separated in time, suggesting a succession. Fungi developed in the 1st steps of succession and dominated in biomass over the remaining components of the complex. Bacteria and actinomycetes developed in the later steps of succession. Glucose addition stimulated still earlier growth of fungi (the maximal mycelial length was registered by the 2nd day) but had hardly any effect on the dynamics of other components of the complex. - Biol. Abstr. 70,1980.
454. KRETCHMER, Norman and ROBERTSON, William van B. Human nutrition. San Francisco, W.H. Freeman, 1978, 275p., illus;

bibliog. The collection of articles introduces the reader to the variety of subjects encompassed within nutritional science. Food is a major component of the biosphere. Photosynthesis and nitrogen fixation are two of the most important biological processes that contribute to food supply. Plants, wheat, cattle and milk are staples of various societies. Food selection is determined by color, texture, availability, religious or cultural factors. Food choice influences culture and a society's chances of survival. Transport of nutrients to cells for proper utilization is a complicated, vital process that involves energy expenditure and participation of cellular proteins, carbohydrates, and lipids. Poor nutrition may cause disease; nutrition is a factor in disease treatment. Present and future nutritional programs must plan to achieve a balance of food supplies, energy sources, and population throughout the world.

455. KRETOVICH, W.L., ROMANOV, V.I., YUSHKOVA, L.A., SHRANKO, V.I. and FEDULOVA, N.G. Nitrogen fixation and poly- $\beta$ -hydroxybutyric acid content in bacteroids of *Rhizobium lupini* and *Rhizobium leguminosarum*. *Plant and Soil*, 48(2), 1977: 291-302, graphs; tables; ref.; summ. Poly- $\beta$ -hydroxybutyric acid (PHB) occurs as a reserve substance in many bacteria. In a sand culture broad bean (*Vicia faba*), lupin (*Lupinus luteus*) and pea (*Pisum sativum*) were inoculated with *Rhizobium*. Comparisons made between bacteroids isolated from effective nodules, either at midday or at midnight, showed a reverse correlation between the intensity of nitrogen fixation and respiration on the one hand, and the content of PHB on the other. This suggests an important role of PHB in the supply of symbiotic fixation with energy and carbon substrates. Glucose and  $\beta$ -hydroxybutyrate were the best substrates for PHB synthesis in the suspension of bacteroids of an effective strain of *R. lupini* during plant growth. At the stage of active N fixation PHB was synthesized in the presence of succinate. In the absence of exogenous substrates the polymer degraded, which process was enhanced in the presence of ammonium ions. - Abstr. on Trop. Agri. 4, 1978.

456. KRETSCHMER, M. Problems of vigor testing: Examinations on seeds of F<sub>1</sub> cabbage varieties (In Ger.). *Gartenbauwissenschaft*, 44 (4), 1979: 155-158, Engl. summ. A series of cabbage seeds (F<sub>1</sub> varieties) were examined with respect to germination and vigor. On testing vigor in soil, dressing the seed alone was apparently insufficient; they were also treated with orthocide after sowing. Some seed varieties were less vigorous; showed necroses with the tetrazolium test. These defects arise in heterosis breeding. Inbred lines appear in *Brassica* due to self fertilization. - Biol. Abstr. 70, 1980.
457. KRIEG, N.R. and TARRAND, J.J. Taxonomy of the root-associated nitrogen-fixing bacterium *Spirillum lipoferum*. In: Proceedings of a Conference on Limitations and Potentials for Biological Nitrogen Fixation in the Tropics, Braxilia, 1977, New York, Plenum Press, 1978, vol. 15th, pp.317-333, ref.
458. KULASOORIYA, S.A., ROGER, P.A., BARRAQUIO, W.L. and WATANABE, I. Biological nitrogen fixation by epiphytic microorganisms (blue-green algae) in (Philippine) rice fields. College, Laguna, International Rice Research Institute, 1980, 10p., tables; ref. (IRRI Research Paper Series no.47)
459. KUMAZAWA, K. Dr. Keijiro Aso (Japanese soil scientist) and the development of biological nitrogen fixation studies. *Hiryō Kagaku*, no. 2, 1979: 7-33, ref.
460. KUSH, A.K. Interaction between symbiosis and root pathogenesis in green gram (*Vigna radiata* L. Welczek). *Plant and Soil*, 65 (1), 1982: 133-135, ref. A pot experiment, using cowpea *Rhizobium* and one percent inoculum of *Rhizoctonia botanica* (Taub.) Butler was carried out on green gram (*Vigna radiata* cv. PS 16) to study the interaction between symbiosis and root rot in terms of plant growth and nitrogen fixation. The microtomy of the infected roots showed distortion of the outer layers of root as a possible cause for antagonistic interaction of these two bio-processes.

461. LAANE, Colja, HAAKER, Huub, and VEEGER, Cees. Efficiency of oxidative phosphorylation in membrane vesicles of *Azotobacter vinelandii* and of *Rhizobium leguminosarum* bacteroids. *European Journal of Biochemistry*, 97 (2), 1979: 369-378. The effect of  $O_2$  on the rate of ATP synthesis and the P/O ratio was studied in membrane vesicles of *A. vinelandii* and *R. leguminosarum* bacteroids (strain PRE). The P/O ratio rises to a maximum value when the  $O_2$  input is increased, but declines when  $O_2$  becomes detectable in the medium. Evidence is presented that *A. vinelandii*  $H_2$  donates its electrons at a 4 proton-translocating site. The presence and the efficiency of this site are independent of the growth conditions and it appears that no flavo-proteins are directly involved in the oxidation of  $H_2$ . The unidirectional hydrogenase in membrane vesicles of *A. vinelandii* is not inhibited by acetylene. The function of hydrogenase in the process of  $N_2$  fixation by *A. vinelandii* is discussed. Two types of membrane vesicles of *R. leguminosarum* bacteroids were prepared. Membranes isolated in a low salt medium lose the ability to couple succinate oxidation to oxidative phosphorylation; upon isolation in a high salt medium this ability is preserved. The efficiency of energy coupling in membrane vesicles of *R. leguminosarum* bacteroids can be enhanced by the addition of fatty-acid-free bovine serum albumin. No active membrane-bound hydrogenase could be detected in membrane vesicles of *R. leguminosarum* bacteroids. - Biol. Abstr. 69, 1979.
462. LAANE, Colja, KRONE, Willy, KONINGS, Wil, HAAKER, Huub and VEEGER, Cees. Short-term effect of ammonium chloride on nitrogen fixation by *Azotobacter vinelandii* and by bacteroids of *Rhizobium leguminosarum*. *European Journal of Biochemistry*, 103 (1), 1980: 39-46. Evidence is presented that the direct depressing effect of  $NH_4Cl$  on  $N_2$  fixation by *A. vinelandii* is due to inhibition of the electron transport system to nitrogenase. The observation that  $NH_4Cl$  has no short-term effect on  $N_2$  fixation by isolated bacteroids of *R. leguminosarum* was confirmed. Using the flow dialysis technique, it was demonstrated that in *A. vinelandii* ammonium is taken up as a cation in response to the  $\Delta\psi$  and that uptake of ammonium specifi-

cally inhibits the flow of reducing equivalents to nitrogenase by lowering the  $\Delta \psi$  across the cytoplasmic membrane. In *A. vinelandii*, like in bacteroids, the generation of reducing equivalents at a potential low enough to reduce nitrogenase was extremely sensitive towards changes in  $\Delta \psi$ . At  $\Delta \psi$  values less than 80 mV, interior negative, no such reducing equivalents were generated, while at a  $\Delta \psi$  value of 110 mV nitrogenase is supplied optimally with reducing equivalents. The nature of the ammonium transport system in *A. vinelandii* and its significance as a regulator for the rapid switch off/switch on of nitrogenase activity is discussed. Bacteroids of *R. leguminosarum* did not accumulate ammonium and no effect of ammonium on  $\Delta \psi$  was observed. On the contrary, bacteroids, excrete ammonium in response to the  $\Delta \text{pH}$ . - Biol. Abstr. 69, 1979.

463. LAHBIB, M., SASSON, A. and RENAUT, J. Symbiotic fixation of atmospheric nitrogen by leguminous plants cultivated in Mali [In Fr.]. *Cahiers ORSTOM, Serie Biologie*, no. 43, 1981: 33-44, illus.; tables; ref. Symbiotic N fixation was studied for two legumes, cowpea and groundnut. By counting the free rhizobium population in the soil, an attempt was made to evaluate climatic and edaphic effects on rhizobium survival. - Abstr. on Trop. Agri. 7, 1981.
464. LAING, William A., CHRISTELLER, John T. and SUTTON, William D. Carbon dioxide fixation by lupin root nodules: II. studies with  $^{14}\text{C}$ -labeled glucose, the pathway of glucose catabolism, and the effects of some treatments that inhibit nitrogen fixation. *Plant physiology*, 63(3), 1979: 450-454. Labeling studies using detached lupin (*Lupinus angustifolius*) nodules showed that over times of less than 3 min, label from [3, 4- $^{14}\text{C}$ ] glucose was incorporated into amino acids, predominantly aspartic acid, to a much greater extent than into organic acids. Only a slight preferential incorporation was observed with [1- $^{14}\text{C}$ ]- and [6- $^{14}\text{C}$ ] glucose, while with [U- $^{14}\text{C}$ ]-glucose more label was incorporated into organic acids than into amino acids at all labeling times. These results are consistent with a scheme whereby the carbon skeletons for amino acid synthesis are provided by the phosphoenolpyruvate carboxylase [EC 4.1.1.31]

reaction. A comparison of  $^{14}\text{CO}_2$  release from nodules supplied with [1- $^{14}\text{C}$ ]- and [6- $^{14}\text{C}$ ]glucose indicated that the oxidative pentose phosphate pathway accounted for less than 6% of glucose metabolism. Several enzymes of the oxidative pentose phosphate and glycolytic pathways were assayed in vitro using the 12,000 g supernatant fraction from nodule homogenates. In all cases, the specific activities were adequate to account for the calculated in vivo fluxes. Three out of 4 diverse treatments that inhibited nodule N fixation also inhibited nodule  $\text{CO}_2$  fixation, and in the case of the 4th treatment, replacement of  $\text{N}_2$  with He, it was shown that the normal entry of label from exogenous  $^{14}\text{CO}_2$  into the nodule amino acid pool was strongly inhibited. - Biol. Abstr. 68, 1979.

465. LAM, Catherine W.Y., VINCENT, Warwick, F. and SILVESTER, Warwick B. Nitrogenase activity and estimates of nitrogen fixation by freshwater benthic blue-green algae. *New Zealand Journal of Marine Freshwater*, 13 (1), 1979: 187-192. The sandy substrate of Lake Taharoa (west coast, North Island, New Zealand -35°50'S, 173°41'E) is covered by communities of filamentous algae that extend from the exposed beach down to 21 m depth. The algae bind the sand to form crusts and mats which may break off as discrete plates. The dominant species are the blue-greens *Microcoleus*, *Nostoc*, *Phormidium*, *Lynxbya*, *Oscillatoria*, *Scytonema*, *Stigonema*, *Schizothrix*, *Calothrix*, *Dictyothrix*, *Tolypothrix*, and *Anabaena*, with occasional high concentrations of the desmid *Cylindrocystis*. Nitrogenase activity, measured by acetylene reduction, showed a wide range of rates (4-150  $\mu\text{mol C}_2\text{H}_4/\text{m}^2$  per h). Estimates of annual rates of nitrogen fixation by the Taharoa communities are comparable with those for periphytic blue-green algae-dominated systems reported elsewhere. - Biol. Abstr. 69, 1979.
466. LAMBERT, Robin Lee and REINERS, William A. Nitrogen-fixing moss associations in the subalpine zone of the White Mountains, New Hampshire, USA. *Arctic and Alpine Research*, 11 (3), 1979: 325-334. Nitrogenase activities of moss associations in the White Mountains were assayed by the acetylene reduction method. A *Sphagnum* association growing



under upper subalpine forest was the only moss association found to have significant activity. Acetylene reduction occurred in the green head of the moss and was probably caused by bacteria, although possibly by bluegreen algae. The average reduction rate for the subalpine *Sphagnum* association was 34 nmoles  $C_2H_4/g$  dry wt moss per day. The estimated contribution by these associations to the subalpine ecosystem was 0.02 Kg N/ha per yr. - Biol. Abstr. 69,1979.

467. LAMBORG, M.R. Biological nitrogen fixation: a fertilizer strategy potentially beneficial for the poor in developing countries. *In: Linking research to crop production*, New York, Plenum Press, 1980, pp.115-136, illus.; tables; bibliog. The author reviews present-day knowledge of legume and non-legume symbiotic nitrogen fixation. - Abstr. on Trop. Agri. 7,1981.
468. LAMBORG, M.R. The role of blue-green algae enhancing crop production (Biological nitrogen fixation). *In: Proceedings of a Conference on Genetic Engineering for Nitrogen Fixation*, Brookhaven National Laboratory, 13-17 March 1977. New York, Plenum Press, 1977, pp.56-60.
469. LANGKAMP, Peter J., SWINDEN, Lindsay B. and DALLING, Michael J. Nitrogen fixation (acetylene reduction) by *Acacia pellita* on areas restored after mining at Groote Eylandt, Northern Territory, Australia. *Australian Journal of Botany*, 27 (4), 1979: 353-362. Factors affecting the reduction of acetylene to ethylene by nodules of *A. pellita* O. Schwarz were studied on 3-yr-old trees in the field. The specific activity of rooted nodules ( $22.8 \pm 3.3$  nmol  $mg^{-1}$  fresh wt  $h^{-1}$ ) was greater than that of detached nodules alone ( $13.5 \pm 2.1$  nmol  $mg^{-1}$   $h^{-1}$ ). Acetylene reduction started without a lag phase and remained linear for about 4 h. The apparent  $K_m$  value for acetylene was  $11.2 \times 10^{-3}$  atm. Nodule material was kept successfully without loss of activity when moist and shaded from direct sunlight for periods of up to 1 h. Acetylene reduction ceased when the assay temperature was  $0^\circ C$ , activity increasing to  $20.3 \pm 2.3$  nmol  $mg^{-1}$  at  $22^\circ$ . The *Acacia* plants exhibited a diurnal cycle of N (acetylene) fixation; the greatest specific

activity at midday was  $27.7 \pm 4.8 \text{ nmol mg}^{-1} \text{ h}^{-1}$  when the shaded soil temperature was  $32^{\circ}\text{C}$  and photosynthetically active radiation was  $2550 \mu\text{E m}^{-2} \text{ s}^{-1}$ . Using a regression of nodule number per tree on stem diameter to obtain the total number of nodules per hectare, the total  $\text{N}_2$  fixation per wet season was estimated to be  $12 \pm 4 \text{ kg ha}^{-1}$  where the planting density in the study area was 1110 trees  $\text{ha}^{-1}$ . The work is discussed with reference to its implications for management of the restored areas and the role of acacias as N-fixing plants in the pre-mining native *Eucalyptus tetrodonta* open-forest. - Biol. Abstr. 69,1979.

470. LARSEN, M.J. JURGENSEN, M.F., HARVEY, A.E. and WARD, J.C. Dinitrogen fixation associated with sporophores of *Fomitopsis pinicola*, *Fomes fomentarius* and *Echinodontium tinctorium*. *Mycologia*, 70(6), 1978: 1217-1222. Fixation of atmospheric dinitrogen by bacteria associated with contextual tissues of sporophores of *F. pinicola*, *F. fomentarius* and *E. tinctorium* is reported. Low nitrification rates apparently show that an autolysis-recycling mechanism of N from large volumes of woody tissue is the principal means by which wood-destroying fungi obtain N for sporophore production and sporulation. - Biol. Abstr. 68,1979.
471. LARUE, T.A. and PATTERSON, T.G. How much nitrogen do legumes fix?. *Advances in Agronomy*, vol. 34, 1981: 15-28, tables; bibliog; summ. The following aspects are discussed: (1) introduction - the importance of obtaining reliable estimates, the energy cost of symbiotic fixation versus nitrate utilization, published estimates of nitrogen fixation by legume crops; (2) methods of estimating nitrogen fixation by crops - nitrogen accumulation, difference methods, isotopic methods, acetylene reduction, other methods of comparing fixation; and (3) estimates for major crops - the forages, seed legumes. A summary giving an evaluation of studies and requirements for future research concludes this article. - Abstr. on Trop. Agri. 7,1981.
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Tobago, 4-8 January 1981).

473. LAUENROTH, W.K. and DODD, J.L. Response of native grassland legumes to water and nitrogen treatments. *Journal of Range Management*, 32(4), 1979: 292-294. The response of native shortgrass prairie legumes to water and N additions was evaluated utilizing a replicated factorial design of 2 water and 2 N treatments. Responses measured were densities and aboveground biomass by species. Water treatment greatly increased both density and biomass of legumes, presumably because of more favorable conditions for N fixation and increased competitive advantage under N deficient conditions. - Biol. Abstr. 69,1979.
474. LAWN, R.J. and BUSHBY, H.V.A. Effect of root, shoot and *Rhizobium* strain on nitrogen fixation in four *Asiatic Vigna* species. *New Phytologist*, 92(3), 1982: 425-434, ref.
475. LAWRIE, A.C. and WHEELER, C.T. Nitrogen fixation in the root nodules of *Vicia faba* L. in relation to the assimilation of carbon. *New Phytologist*, 74(3), 1975: 437-445, ref.
476. LAWRIE, A.C. and WHEELER, C.T. Nitrogen fixation in the root nodules of *Vicia faba* L. in relation to the assimilation of carbon. 1. Plant growth and metabolism of photosynthetic assimilates. *New Phytologist*, 74(3), 1975: 429-436, ref.
477. LAYZELL, David B., RAINBIRD, Ross M., ATKINS, Craig A. and PATE, John S. Economy of photosynthate use in nitrogen-fixing legume nodules: Observations on 2 contrasting symbioses. *Plant Physiology*, 64(5), 1979: 888-891. The economy of C use by root nodules was examined in 2 symbioses, *Vigna unguiculata* (L.) Walp. (cv. Caloona): *Rhizobium* CB756 and *Lupinus albus* L.(cv. Ultra): *Rhizobium* WU425 over a 2 wk period in early vegetative growth. Plants were grown in minus N water culture with cuvettes attached to the nodule zone of their primary roots for collection of evolved CO<sub>2</sub> and H<sub>2</sub>. Increments in total plant N and in C and N of nodules, and C:N weight ratios of xylem and phloem exudates were studied by periodic sampling from the plant populations. Itemized budgets were constructed for the partitioning and

utilization of C in the 2 spp. For each mg N fixed and assimilated by the cowpea association,  $1.54 \pm 0.26$  (SE) mg C as  $\text{CO}_2$  and negligible  $\text{H}_2$  were evolved and 3.11 mg of translocated C utilized by the nodules. Comparable values for nodules of the lupin association were  $3.64 \pm 0.28$  mg C as  $\text{CO}_2$ ,  $0.22 \pm 0.05$  mg  $\text{H}_2$ , and 6.58 mg C. More efficient use of C by cowpea nodules was due to a lesser requirement of C for synthesis of exported N compounds, a smaller allocation of C to nodule dry matter, and a lower evolution of  $\text{CO}_2$ . The activity of phosphoenolpyruvate carboxylase in nodule extracts and the rate of  $^{14}\text{CO}_2$  fixation by detached nodules were greater for the cowpea symbiosis ( $0.56 \pm 0.06$  and  $0.22$  mg C as  $\text{CO}_2$  fixed/g fresh wt per h, respectively) than for the lupin ( $0.06 \pm 0.02$  and  $0.01$  mg C as  $\text{CO}_2$  fixed-g fresh wt per h). The significance of the data was discussed in relation to current information on theoretical costs of nitrogenase functioning and associated nodule processes. - Biol. Abstr. 69,1979.

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479. LEE, K.H. and LEE, H.J. Effects of seed inoculation methods on the nodulation and the growth of alfalfa seedling. *Korean Journal of Crop Science*, 26 (2), 1981: 192-197, ref. Alfalfa (*Medicago sativa* L. cv. Luna) seeded in agar was inoculated with two strains of *Rhizobium meliloti* isolated from root nodules of alfalfa for assessment of nodulation. The seedling growth after six weeks was remarkably increased by adding each rhizobia strains into agar media and also by nitrate application (70 ug N/ml), but there was no significant difference among them. Nodulations started one week after inoculation and increased its numbers and sizes as seedling grew. Therefore, the two strains isolated from alfalfa root were concluded to be effective strains. For determining seed inoculation method the same cultivar was inoculated with both rhizobia strains using different inoculation methods such as broth-vacuum, peat-adhesive, peat and lime pelleting. They were seeded in pots of river sand and supplied with culture solution excluding nitrogen. The

- peat and lime pelleting was recognized as the best method in both nodulation and seedling growth after eight weeks growth. There was significant correlations between the weight of nodules and the shoot or root dry weight of alfalfa in both rhizobia strains.
480. LEE, K.K., ALIMAGNO, B. and YOSHIDA, T. Field technique using the acetylene reduction method to assay nitrogenase activity and its association with the rice rhizosphere. *Plant and Soil*, 47 (3), 1977: 519-526, fig.; graph; table; ref. A technique is described to measure nitrogen-fixing activity in paddy fields. A field assay of rice at the grain ripening stage showed that nitrogen-fixing activity increased linearly after a lag phase of 0 to 3 hours during a time-course experiment. Detachment of the aerial part of the rice plant from its root remaining in the field did not affect the nitrogen-fixing activity of the root. - Abstr. on Trop. Agri. 4, 1978.
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Experiments on the in vivo incorporation of radioactive methionine and subsequent analysis of the labeled proteins on polyacrylamide gels showed that the biosynthesis of nitrogenase polypeptides was inhibited. It appears that the time of addition of cGMP is important since the effect was only seen during the early stages of *ni<sub>5</sub>* gene expression. The intracellular level of cGMP was found to respond to physiological changes in the cell, and there was a fall in cGMP concentrations when nitrogenase was induced. Microaerophilic-aerobic shift experiments showed that intracellular levels increased from 0.25 pmol/mg of cell protein under microaerophilic conditions to 2.6 pmol/mg of cell protein under aerobic conditions, suggesting that the cellular pool size of cGMP may be under redox control. - Biol. Abstr. 69, 1979.

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grown in sand-filled Leonard jars and watered with N-free nutrient solution. Soybean root temperatures were held constant at 15, 20, 25 and 30°C in a growth chamber environment. At harvest, plant height and weight, nodule number and weight and acetylene reduction activity were measured. Interactions between root temperature, *R. japonicum* strain, and soybean variety were complex and changed with plant age. Temperature by strain interactions were more common than temperature by variety, variety by strain, or temperature by variety by strain interactions. Plant height was solely dependent on root temperature, but nodulation and acetylene reduction activity parameters depended on temperature, strain and variety. Such interactions were more complex at later growth stages. Maximum plant dry weight and nodule number occurred at 25°C. Nodule weight and acetylene reduction activity were greater at 25°C than at the other root temperatures early in plant growth (3-4 wk after planting). However, 5-6 wk after planting, these parameters were greater at 20°C than at 25°C. Apparently more nodules were formed at 25°C, but eventual nodule development, size and acetylene reduction activity was greater at 20°C. Nodules also degenerated sooner at 25°C. N fixation significantly increased plant growth over that of the uninoculated controls except at 15°C. The confined root environment of the Leonard jar may have restricted further nodulation after 5 wk from planting and may have influenced nodule weight and acetylene reduction activities as well as nodule numbers. - Biol. Abstr. 69,1979.

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sugar fermentation and aerobic respiration at low  $O_2$  tension. Although growth on  $N_2$  is optimal under photosynthetic conditions, the results show that reduction of  $N_2$  is not obligatorily coupled to activity of the photosynthetic apparatus. - Biol. Abstr. 68,1978.

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root tissue. TTC-reducing bacteria were also observed in xylem vessels in nodal regions of the stems, and *Azospirillum* was isolated from internal tissues of stems, suggesting that root infections spread into the stem. TTC-reducing bacteria were furthermore observed in and between cells within 2 cm from the root apices, indicating that stele infections can occur via apical infection, without disruption of the endodermis. - Biol. Abstr. 69,1979.

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- spectively. *Azotobacter* was absent in soils containing 5 to 6.7% total soluble salts. Laboratory experiments showed, among other things, that increase in salt concentration resulted in a progressive decrease in the N fixation capacity of the non-saline isolates. - Abstr. on Trop. Agri. 5,1979.
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were accompanied by high nitrate reductase activities. In bacteroids of *R. trifolii*, *R. leguminosarum* and *R. phaseoli*, high N<sub>2</sub> fixation activities were not accompanied by high nitrate reductase activities. - Biol. Abstr. 69,1979.

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522. MATSUGUCHI, Tatsuhiko, SHIMOMURA, Tadao and LEE, Sang Kyu. Factors regulating acetylene reduction assay for measuring heterotrophic nitrogen fixation in waterlogged soils. *Soil Science & Plant Nutrition*, 25(3), 1979: 323-336. In the  $C_2H_2 - C_2H_4$  assay for measurement of heterotrophic  $N_2$  fixation in waterlogged soils, the diffusion of  $C_2H_2$  into the soil and the recovery of  $C_2H_4$  from it are critical factors regulating the assay result. To establish an  $C_2H_2 - C_2H_4$  assay technique suitable for waterlogged soils, the  $C_2H_2$  reducing activities (ARA), assayed by varying the method of assay gas filling, the  $pC_2H_2$  of the assay gas,

the duration of assay incubation and of soil vibration before the gas sampling, were compared. A maximum ARA was measured when the following set of procedures was applied to the soil sample in assay flasks: a 4-fold repetition of 1-min evacuation under 0.01 atmospheric pressure and the subsequent 1-min filling under 1 atmospheric pressure with assay gas at  $p_{C_2H_2}$  of 0.1 atm, an assay incubation for 3 h and a sampling of an aliquot of the headspace gas after strongly vibrating the flask for 1 min. The ARA measured by this technique was several times larger than those measured by the techniques hitherto applied, and corresponded to an almost 80% of the  $V_{max}$  of the sample. This technique was, therefore, proposed for the assay of heterotrophic  $N_2$  fixation in waterlogged soils. A striking depression of ARA in the soil sample prepared with agitation indicated that a microbial ecosystem established in the soil should be kept as undisturbed as possible throughout the  $C_2H_2$ - $C_2H_4$  assay. - Biol. Abstr. 70,1980.

523. MAZUR, Barbara J., RICE, Douglas and HASELKORN, Robert. Identification of blue-green algal nitrogen fixation genes by using heterologous DNA hybridization probes. *Proceedings of the National Academy of Sciences USA*, 77(1), 1980: 186-190. In the filamentous blue-green alga *Anabaena* 7120, aerobic N fixation is linked to the differentiation of specialized cells called heterocysts. To study control of heterocyst development and N fixation in *Anabaena*, cloned fragments of the *Klebsiella pneumoniae* N fixation (*nif*) genes were used as probes in DNA-DNA hybridizations with restriction endonuclease fragments of *Anabaena* DNA. With this technique, *Anabaena nif* genes were identified and cloned, demonstrating the feasibility of using heterologous probes to identify genes for which no traditional genetic selection exists. Patterns of hybridization suggested that, although DNA sequence homology has been retained between some of the *nif* genes of these divergent organisms, the *nif* gene order has been rearranged. - Biol. Abstr. 70,1980.

524. MCCARTHY, James J. and CARPENTER, Edward J. *Oscillatoria thiebautii* (Cyanophyta) in the central North Atlantic Ocean. *Journal Phycology*, 15 (1), 1979: 75-82. Physiological rate measurements were made with *O. thiebautii* (Gom.) Geitler in the subtropical north Atlantic Ocean between Spain and Bermuda during May and June, 1975. The near surface C:N fixation ratios averaged 6.5; the cellular composition ratio was 6.2, suggesting that  $N_2$  fixation is the major path of nitrogenous nutrition for this alga. Compared to other oceanic phytoplankters, it has a low affinity for Pi at oceanic concentrations ( $k_s = 9.0$ ); it has a high potential for utilizing phosphomonoesters ( $170-300 \text{ ng atoms P} \cdot \mu\text{g chl a} [\text{chlorophyll a}]^{-1} \cdot \text{h}^{-1}$ ). Maximal photosynthesis occurred at  $450-700 \mu \text{ Einstein} \cdot \text{m}^{-2} \cdot \text{s}^{-1}$ , and was inhibited by full sunlight. Calculated cell division rates (about 180 days) suggest that, relative to other phytoplankters in this oceanic region, *O. thiebautii* must be subjected to negligible grazing pressure. No major differences in C, N, chl a or ATP are observed between the tuft (fusiform) and puff (spherical) colonies. ATP concentrations relative to other cellular constituents varied greatly between colonies, suggesting a general intercolony physiological variability in the open Atlantic. With increasing depth in the euphotic zone, there is no evidence for chromatic adaption. *O. thiebautii* represents only a small fraction of total phytoplankton biomass and its growth rate is 10-100 times slower than that of the other indigenous phytoplankton, strongly suggesting that  $N_2$  fixation by this alga is a virtually insignificant component of the nitrogenous nutrition for the phytoplankton of the North Atlantic central gyre in late spring. - Biol. Abstr. 69,1979.
525. MCNIEL, R.E. and CARPENTER, P.L. Effect of temperature on acetylene-reducing activity associated with root nodules on woody trees and shrubs. *Journal of American Society of Horticultural Science*, 105 (4), 1980: 543-546.  $C_2H_2$  reduction activity of excised root nodules of 9 woody species was studied to determine the  $N_2$  fixation capabilities at various temperatures. Nodules of nonlegumes [*Alnus glutinosa* (L.) Gaertn., *A. rugosa* (Du Roi) Spreng., *Comptonia peregrina* (L.) Coult., *Elaeagnus angustifolia* L.,

*E. commutata* Bernh., *E. umbellata* Thunb. and *Shepherdia argentea* Nutt.] had maximum  $C_2H_2$ -reduction rates near 30° C. Nodules of the non-legume *Hippophae rhamnoides* L. and the legume *Robinia pseudoacacia* L. showed maximum activity at 20° and showed no significant change at 30°. The  $C_2H_2$ -reduction activity of all species except *E. angustifolia* declined at 40°. High temperature injury (40°) was irreversible. Activity was very slight at temperatures near 0°. Arrhenius plots of the data indicate the reduction rate is biphasic with the change in activation energy occurring from 11° to 20° depending on species. - Biol. Abstr. 70, 1980.

526. MELLO, F. Nitrogen fixation of some legumes (In Pt.). *Revista de Agricultura*, 53 (1-2), 1978: 59-63, tables, ref.; Engl. summ. The author used published data in order to calculate the approximate quantities of N fixed in soils in the State of Sao Paulo, Brazil, by various green manures. The obtained quantities are as follows: *Cajanus cajan* 207 kg N/ha, *Stizolobium aterrimum* 157 kg N/ha, *Canavalia ensiformis* 190 kg N/ha, *Crotalaria juncea* 154 kg N/ha and *Glycine max* 170 kg N/ha. - Abstr. on Trop. Agri. 5, 1979.
527. MENZ, K.M. and NEUMEYER, C.F. Evaluation of five emerging biotechnologies for maize. Staff Paper P-Minnesota University, Department of Agriculture and Applied Economics (USA) No. P81-28, September 1981, 9p., 1 ref. Extract: Scientists were surveyed as part of an assessment of five emerging biotechnologies which are potentially applicable to commercial U.S. maize production by the year 2000. The largest gains expected by scientists were from plant growth regulators, followed by photosynthetic enhancement, cell or tissue culture and biological nitrogen fixation.
528. MERBACH, Wolfgang and SCHILLING, Guenther. Effectiveness of symbiotic nitrogen-fixation in leguminous plants, as affected by inoculation with rhizobia, by substrate, nitrogen-fertilization, and carbon-14 labeled sucrose application (In Ger.). *Zentralbl. Bakteriol. Parasitenkd. Infektionskr. Hyg. Zweite Naturwiss. Abt. Mikrobiol. Landwirtsch. Technol. Umweltschutzes.*, 135 (2), 1980: 99-118, Engl. summ. Cultivation experiments (Mitscherlich

vessels, quartz sand,  $^{15}\text{N}$ -labeled soil,  $^{15}\text{N}$  fertilizer) showed that various strains of *Rhizobium lupini* (white and yellow lupines) and of *R. leguminosarum* (field beans and peas) induced a different  $\text{N}_2$ -fixation of the inoculated plants, the most effective  $^2\text{Rhizobium}$  strains being 367a  $\text{C}_2$ ,  $\text{T}_3$ , 271 (*R. lupini*) and Azotogen (*R. leguminosarum*). Yellow lupines and field bean plants were supplied with  $\text{N}_2$  from the air considerably better than white lupines and peas after inoculation with the most effective *Rhizobium* strains. Application of mineral N to the white lupines and peas not only substituted the inhibited  $\text{N}_2$  fixation, but increased N amounts in the plants. White lupines fixed more  $\text{N}_2$  under soil conditions than in quartz sand. An experiment with steam-sterilized and  $^{15}\text{N}$ -labeled soil as a comparative substrate showed, that this finding was mainly caused by an additional *Rhizobium* infection from the soil. Contrary to field beans and yellow lupines which fix  $\text{N}_2$  up to ripeness, white lupines and peas finished  $\text{N}_2$  fixation at the time of flowering. Mineral-N applied at that time was an additional source of N for peas which utilized it for production of higher protein yields. Continual spraying of white lupine plants with  $^{14}\text{C}$ -labeled sucrose solution after the time of flowering caused continuance of  $\text{N}_2$ -fixation up to the stage of ripeness. This effect was probably due to the competition of growing seeds and nodules for the photosynthates. The supply of nodules was inadequate without external sucrose application. Mineral N inhibited the sucrose-induced  $\text{N}_2$ -fixation of white lupine nodules and their consumption of photosynthates. Consequently, the applied  $^{14}\text{C}$  was transported into seeds to a larger extent. For effective  $\text{N}_2$  fixation nodules must be a rich sink for assimilates on the basis of a highly efficient photosynthetic system of the host plant. - Biol. Abstr. 70,1980.

529. MERRICK, Mike, FILSER, Mechthild, DIXON, Ray, Elmerich, Claudine, SIBOLD, Lionel and HOUMARD, Jean. The use of translocatable genetic elements to construct a fine-structure map of the *Klebsiella pneumoniae* nitrogen fixation (*nif*) gene cluster. *Journal of General Microbiology*, 117(2), 1980: 509-520. The transposons Tn5, Tn7 and Tn10 and bacteriophage Mu were used to derive insertion mutations in the *K. pneumoniae nif* gene cluster. A large

number of deletion mutants were derived by imprecise excision of insertion mutations and these deletions were used to construct a fine-structure map of the *nif* cluster. Comparison of this genetic map with a physical map of the *nif* cluster derived by Reidel et al. showed a very good correlation between genetic and physical mapping methods. A new complementation group, designated *nif<sup>u</sup>*, was identified and mapped between *nif<sup>N</sup>* and *nif<sup>S</sup>*. Polarity studies on the 14 *nif* cistrons now identified suggests that they are organized in at least 7 transcriptional units and that all the multicistronic units are transcribed in the same direction. - Biol. Abstr. 70,1980.

530. MEYER, J., GERMANI, G. and DREYFUS, B. Estimate of the effect of two limiting factors (drought and nematodes) on nitrogen fixation ( $C_2H_2$ ) by groundnut and soya bean (In Fr.). *Oléagineux*, 37(3), 1982: 127-134, illus.; tables; Engl. summ. An attempt was made to quantify the effect of two limiting factors in groundnut and soya bean: drought and nematode attacks. On the basis of three postulates resulting from previous observations in the field, a simple model was proposed making it possible to predict the effect of these two factors. On the agronomic plane, the results obtained confirm the unfavourable effect of drought on nitrogen fixation and show that nematode infestation slows down fixation, not only by reducing nodulation but also by diminishing the specific nitrogen-fixing activity of the nodules. Authors' summary. - Abstr. on Trop. Agri. 8, 1982.
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- cultivars were tested for N fixation. N was applied as  $\text{Ca}(\text{NO}_3)_2$ . Nitrogenase activity decreased with increasing rates of N.  $\text{NO}_3$  effects on  $\text{N}_2$  fixation activity inhibited nodule growth rather than nodule initiation. Data showed no advantage of applied  $\text{NO}_3$  on promoting maximum genotypic differences for  $\text{N}_2$  fixation. - Abstr. on Trop. Agri. 8, 1982.
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535. MISHUSTIN, Ye. N. and SHEMAKHANOVA, N.M. Indirect methods of determination of activity of root-nodule bacteria. *Folia Microbiologica*, 25(2), 1980: 148-154. Significant correlations exist between the ability of root-nodule bacteria to fix  $\text{N}_2$  and some of their properties (accumulation of riboflavin, cobalamin, ATP, cell pyrolysis, effect on plant vegetation characteristics) which can be used for quickly assessing the activity of the process in individual strains of rhizobia. - Biol. Abstr. 70, 1980.
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537. MISRA, R.V. Raising blue-green algae is easy. *Intensive Agriculture*, 26(2), 1979: 14-15, illus. Blue-green algae such as *Anabaena*, *Nostoc*, *Aulosira*, *Celothrix*, *Tolypothrix*, *Cylindrosperma*, *Scytonema* and *Plectonema* are highly efficient utilizers of solar energy and have the ability to fix molecular nitrogen. Algal inoculum can be prepared in shallow water in 2 weeks. Algae are applied to rice fields at 8-10 kg/ha, forming 30 to 40 kg N/ha in a growth cycle,

increasing grain yields by 200 to 300 kg/ha and resulting in a cost-benefit rate of about 10. - Abstr. on Trop. Agri. 6, 1980.

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539. MIYAMOTO, Kazuhisa, HALLENBECK, Patrick C. and BENEMANN, John R. Nitrogen fixation by thermophilic blue-green algae (Cyanobacteria): Temperature characteristics and potential use in biophotolysis. *Applied Environmental Microbiology*, 37 (3), 1979: 454-458. Thermophilic, N<sub>2</sub>-fixing, blue-green algae (cyanobacteria) were investigated for use in biophotolysis. Three strains of *Mastigocladus laminosus* were tested and were equally effective in biophotolysis as judged by nitrogenase activity. The alga, *M. laminosus* NZ-86-m, which was chosen for further study, grew well in the temperature range from 35-50° C, with optimum growth at 45° C, at which temperature acetylene reduction activity was also greatest. The maximum tolerable temperature was 55° C. Acetylene reduction activity was saturated at a light intensity of  $1 \times 10^4$  ergs/cm<sup>2</sup> per s. Atmospheric O<sub>2</sub> tension was slightly inhibitory to acetylene reduction of slowly growing and exponentially growing cultures. Nonsterile continuous cultures, which were conducted to test problems of culture maintenance, could be operated for 2 mo. without any significant decrease in nitrogenase activity or contamination by other algae. N-starved cultures of *M. laminosus* NZ-86-m produced H<sub>2</sub> at comparable rates to *Anabaena cylindrica*. The conversion efficiency of light to H<sub>2</sub> energy at maximum rates of H<sub>2</sub> production was 2.7%. - Biol. Abstr. 69, 1979.
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were incubated in the field and assayed for N-fixing activity by acetylene reduction method. In green alder the nitrogenase activity took place with the first opening of buds (June); maximum values were attained in July-Aug.; the activity decreased steadily until leaf fall, and then ceased. Diurnal fluctuations in acetylene reducing activity were observed, the 1400-h values being twice those of 1000 h. The optimal temperature for nitrogenase activity was below 20° C; this fact is consistent with the better adaptation of *A. viridis* to cold climate. The nodular biomass being only 40 kg/ha, the nitrogen fixed during the vegetative season (mid-June to mid-Oct.) was only about 8 kg/ha. Symbiotic fixation accounted for only 10% of the N requirements of green alder. - Biol. Abstr. 69,1979.

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- Africa, FAO, Rome 24-28 November 1980. Rome, FAO, 1982, pp.81-95. (Bulletins Pedologiques de la FAO no. 47)
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- that nodulation and N fixation increase with the number of *Rhizobium* inoculum cells per seed. Nodulation and N fixation decreased when groundnut was intercropped with millet (*Pennisetum typhoides*), maize (*Zea mays*) or sorghum (*Sorghum bicolor*). Photosynthesis is one of the major limiting factors in N fixation. There is a genotypic variation in nodulation and N fixation. Nodulating lines observed in the F<sub>2</sub> populations of some crosses have been purified and advanced to F<sub>6</sub>. - Abstr. on Trop. Agri. 7, 1981.
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and higher yield potential than the South Asian cv. It is, therefore, important to combine the desirable characteristics of these two distinct groups of soya bean cultivars in the breeding programme to develop improved cultivars suitable for and adapted to tropical environments. - Abstr. on Trop. Agri. 6,1980.

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cortical cells have enlarged and some have undergone mitosis. The wall ingrowths begin to form in the xylem parenchyma cells 7-8 days after inoculation or the approximate time that rhizobia begin to be released from the infection thread. In both instances the wall ingrowths begin to form before the onset of dinitrogen reduction, although previous workers have suggested that a flux of nitrogenous compounds (containing fixed N) induces their formation. The development of wall ingrowths in ineffective pea nodules also occurs independently of N fixation. Similarly, the wall ingrowths located near soybean nodules also begin to develop before the onset of N fixation. - Biol. Abstr. 69,1979.

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the coupling. The products of the *nifF* and *nifJ* genes apparently constitute essential elements of the physiological electron pathway to nitrogenase. The electron-transfer-active product of the *nifF* gene, a flavoprotein, was purified. - Biol. Abstr. 70,1980.

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activity was obtained under 10% O<sub>2</sub> in the atmosphere, and this activity was 1.5 times higher than in 20% O<sub>2</sub> concentration. N-fixing activity was measured of the litter and organic layer samples from several locations of Brown Forest Soil of various soil types under Japanese cedar forests. Again, the activity was found generally in F1 fraction. The F1 fraction was characterized by higher moisture content and pH, higher rate of CO<sub>2</sub> evolution and little activity for N mineralization relative to the other decomposition stages. Result of the proximate analysis supported the assumption that F1 is fairly an early stage of decomposition, where organic solvent-extractable materials are much reduced from the leaf litter. - Biol. Abstr. 70, 1980.

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- in Israel were compared with *A. brasilense* from Brazil and California [USA] for their ability to fix  $N_2$  in association with grasses under greenhouse conditions. The plants were grown in a system which avoided cross inoculation from the inoculated soil to the control while maintaining the natural soil microflora and humidity level in the soil close to field capacity. The organisms tested significantly increased the dry weight of *Z. mays* and *S. italica* leaves, the total N content of these leaves (as measured by the Kjeldahl method), and supported acetylene reduction in intact nonsterile systems as compared with the noninoculated controls. Ethylene production in intact systems could be detected after 6 h and was linear for 72 h, providing a constant soil temperature (28-32° C) was maintained. - Biol. Abstr. 70,1980.
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nitrate levels in the case of *Centrosema*. The response of *Calapogonium* in terms of dry weight yields of nodules and tops was the reverse while *Pueraria* was not affected by nitrogen application. The application of nitrate-nitrogen enhanced both nodule size and nitrogen fixation in *Centrosema* but depressed nitrogen fixation and had no effect on nodule size in *Calapogonium* and *Pueraria*. Varying amounts of nitrogen were excreted by all the plants. - Abstr. on Trop. Agri. 4, 1978.

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5450 kg seed/ha was obtained in a field of sandy soil, inoculated with commercial granular inoculant, by maintaining soil at a moisture level near to field capacity during the growing season. Nitrogen fixation was highest with strain 31-SM. Under local conditions soya bean plants showed 100% nodulation when inoculated by the slurry method, by granular inoculant or by spraying bacteria into the furrow. - Abstr. on Trop. Agri. 6,1980.

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nitrogenase activity. The distribution of bacteroids in the rejuvenated nodules was similar to that of the light-grown plants.

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584. PAAU, A.S. and COWLES, J.R. Population dynamics of bacteroids in alfalfa nodules during establishment of nitrogenase activity. *Plant Science Letters*, 19 (4), 1980: 319-323, ref.; summ. Changes in the bacteroid populations of 2-12-week-old alfalfa nodules were monitored with respect to bacteroid DNA and RNA content by flow-microfluorometry. Nodules that are most active in nitrogen fixation (acetylene reduction) contain larger populations of bacteroids with increased DNA and RNA content than vegetative *Rhizobium meliloti* cultures and nodules that are less active in nitrogenase activity. As nodules begin senescence and exhibit a decline in specific nitrogenase activity, the relative number of bacteroids with increased nucleic acid content decreases in the nodules. The bacteroids with increased nucleic acid content, therefore, are associated with active nitrogen fixation in alfalfa nodules. This observation suggests that the establishment and maintenance of nitrogenase activity in alfalfa depends on the composition of the bacteroid populations in the nodules.
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studied on a N<sub>2</sub>-fixing blue-green alga (*W. prolifica*) in pure cultures. Concentrations of alloxan, 10-50 µg/ml stimulate the growth of the alga and increase the chlorophyll, carotene and phycocyanin content of the cultures. - Biol. Abstr. 70,1980.

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587. PAERL, Hans W. and KELLAR, Penelope E. Nitrogen-fixing *Anabaena*: Physiological adaptations instrumental in maintaining surface blooms. *Science*, 204 (4393), 1979: 620-622. Laboratory and in situ studies indicate that the N-fixing blue-green nuisance algae *Anabaena* spp. have

developed adaptive means of dominating surface lake waters. During the dramatic diurnal shifts in surface light intensity and  $O_2$  saturation accompanying blooms, *Anabaena* [*A. spiroides*, *A. oscillarioides* and *A. circinalis*] can overcome  $O_2$  toxicity by sequential optimization of  $CO_2$  and N fixation and by pigment alteration. The mechanisms allow optimal utilization of the radiant energy while minimizing competition for photoreductant between 2 main energy-demanding processes. - Biol. Abstr. 68,1978.

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589. PANICHASAKPATANA, Supamard, WADA, Hidenori, KIMURA, Makoto and TAKAI, Yasuo. Nitrogen fixation in paddy soils: 3. Nitrogen fixation and its active-sites in soil and rhizosphere. *Soil Science & Plant Nutrition*, 25 (2), 1979: 165-172. Several important features of the  $N_2$  fixation in paddy fields which were reported previously were confirmed and some new additional results regarding the evaluation of the  $N_2$  fixation in the rhizosphere were obtained by reinvestigation in the fields. In addition, rice plants were cultivated in the submerged soil in pots and various parts of the soil were analyzed for the  $N_2$ -fixing activity as well as several other properties. The results of the pot experiments were fairly similar to those observed in the field investigations, indicating the validity of the submerged soil in a pot as a rather simulated model for the actual paddy field. By using this model system, the following facts were ascertained: water-percolation had almost no effect on the  $N_2$ -fixing activities of both the rhizosphere and the non-rhizosphere soils; the suppressing effect of washing the rice root on the  $N_2$ -fixing activity was slight in the seedling stage and marked in the tillering and flowering stages; the  $N_2$ -fixing activity of a single rice root varied from tip to base. - Biol. Abstr. 69,1979.

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method. A formal analogy between the catalytic reactions and the photochemical, radical and ionic reactions is assumed. The symmetrical and donor-acceptor properties of the effective catalyst result from the dependence of the energy characteristics and electron structure on the reaction coordinate. - Biol. Abstr. 68,1979.

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gut wall. The significance of fructose in fruits is indicated. - Biol. Abstr. 70, 1980.

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and nodule-weight basis and nodule number and nodule weight did not differ significantly at the different ploidy levels in either experiment. For measurements taken only during experiment A, NCE was greater in the 4x compared to the 8x on a chlorophyll basis; transpiration was significantly greater in the 8x than in the 4x, and the chlorophyll *a:b* ratio was lower in the 8x than the 4x. Root respiration did not differ. When nonhomogeneous variances between ploidy levels were compared, in 17 of 18 comparisons the lower ploidy level had the greater variance. The ploidy level had little effect on physiological processes in the isogenic populations of this study. Because greater variance exists with lower ploidy levels, selection should be more easily performed at lower ploidy levels. - Biol. Abstr. 70,1980.

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are associated with communities of heterocystous and non-heterocystous blue-green algae, which are widespread and abundant in the coastal mangrove forests of the Sinai Peninsula. Heterocystous forms, particularly representatives of the Rivulariaceae, grow in aerobic environments, where nitrogenase activity may be limited by the availability of nutrients such as Fe and  $PO_4-P$ . Desiccated communities of *Scytonema* sp. reduce acetylene within 10 min of wetting by tidal sea water. Communities dominated by the non-heterocystous *Hydrocoleus* sp., *Hyella balami*, *Lyngbya aestuarii*, *Phormidium* sp. and *Schizothrix* sp., occur in close contact with anaerobic sediments and reduce acetylene in the dark and in the light. N fixation in all these communities is light dependent and may be supplemented by an alternative source of reductant in the dark. The indications are that N fixation by these communities of blue-green algae, makes a significant contribution to the overall N input of the mangrove ecosystem. - Biol. Abstr. 68,1979.

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and PAP2 (MW 64 Mdal) were isolated by [phage] P1 transduction of the plasmid PRD1 (MW 101 Mdal). These plasmid mutants still carry the *his-nif* region of *K. pneumoniae*. They are self-transmissible and mediate resistance to ampicillin, kanamycin and tetracycline. Comparing the HindIII maps of PRD1, PAP1 and PAP2 showed that PAP1 was derived from PRD1 by an 8  $\mu$ m deletion and PAP2 by 2 deletions, the same 8  $\mu$ m deletion and a further 9  $\mu$ m deletion. The plasmids PAP1 and PAP2 were helpful in locating the *his-nif* region of PRD1 on 3 adjacent HindIII fragments (number 5, 4 and 3 according to gel electrophoresis). The MW of these fragments were 8.2, 10 and 15 Mdals. These 3 fragments were cloned separately on the multicopy plasmid vehicle pWL625 giving rise to the hybrid plasmids pWK1 (pWL625 + HindIII fragment 4), pWK2 (pWL625 + HindIII fragment 3) and pWK4 (pWL625 + HindIII fragment 5). None of these hybrid plasmids conferred N<sub>2</sub> fixation capacity on *E. coli* C cells. By combining HindIII fragment 4 and 3 in the same alignment as in PRD1 and cloning them together on pWL625, the hybrid plasmid pWK120 (pWL625 + HindIII fragments 4 and 3) was found to carry the entire *nif* region. An *E. Coli* C strain harboring the plasmid pWK120 grew on N-free medium and reduced acetylene. The plasmid pWK 120 had a contour length of 17  $\mu$ m, a buoyant density of 1.715 g/ml and a copy number up to 65. - Biol. Abstr. 69,1979.

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and organic N were supplied at 60 kg N/ha equivalent, as a basal dose at transplanting. It was shown that nitrogenase activity (NA) varied throughout and was highest on the 60th day after transplanting. No correlation seemed to exist between NA and crop yield. Significant stimulation of NA occurred when low levels (20-40 kg N/ha) of mineral N were present. It is concluded that both source and level of mineral N are important. - Abstr. on Trop. Agri. 8,1982.

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ferences in the various algal populations according to the 2 gradients. Regression studies indicated deterioration in algae as the sampling depth increased. In the horizontal gradient, the following groups were considered: Cyanophyceae, Diatomacea and Chlorophyceae. Cyanophyceae were characterized by heterocysts, among these the genera *Nostoc*, *Tolypothrix*, *Calothrix* and *Lyngbya*. This technique is applicable to the study of numerous ecological factors which might modify the N-fixing flora of the soil. - Biol. Abstr. 69,1979.

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641. REDDY, V.M. and TANNER, J.W. The effect of irrigation, inoculant type and nitrogen fertilizer on nitrogen fixation and yield of Spanish peanuts. *Proceedings - American Peanut Research and Education Association, Inc.*, 10 (1), 1978: 74.
642. REDEI, G.P., ed. *Stadler genetics symposia*, vol. 9. Columbia, Missouri Agricultural Experiment Station, 1977, 218p., illus. This volume represents the proceedings of a symposium reporting recent advances in experimental genetics. The 10 papers discuss in vivo BrdU[bromodeoxyuridine]-dye analysis

of DNA replication and sister chromatid exchanges; genetic complexity of the *R* locus in maize, polygene number and development, composition of fraction I protein in the study of plant evolution, dauer larva formation in *Caenorhabditis elegans*, historical aspects of wild wheats, genetics of nitrogen fixation, organization of DNA in bacterial chromosomes, *Neurospora* gene-enzyme relationships and regulation of histone gene expression in mammalian cells. Photographs, micrographs, diagrams, tables and summaries of included papers complement the text. Individual papers are indexed in BIORESEARCH INDEX. - Biol. Abstr. 68,1979.

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644. RENNIE, R.J. and LARSON, R.I. Dinitrogen fixation associated with disomic chromosome substitution lines of spring wheat (*Triticum aestivum*). *Canadian Journal of Botany*, 57(24), 1979: 2771-2775. The modification of the genotype of the 'Cadet' and 'Rescue' cultivars of spring wheat (*T. aestivum* L. emend. Thell) by disomic chromosome substitution altered the amount of plant N derived from N<sub>2</sub> fixation by the associated bacterium in a phytotron experiment. With the exception of the C-R5B line, inoculation of the parent Cadet or its substitution lines with either the bacillus C-11-25 or *Azospirillum brasilense* increased plant dry matter and the total N yield. Rescue lines were unaffected by inoculation unless genotypically altered by substitution of the 5B or 5D chromosome from Cadet. Different substitution lines reacted uniquely to inoculation with the

specific bacteria: C-R2A and R-C2D promoted greater  $N_2$  fixation by *A. brasilense*; C-R5D, R-C5B, and R-C5D promoted greater  $N_2$  fixation by the C-11-25 bacillus. Both bacteria had high and identical levels of  $N_2$  fixation in association with the C-R2D line; neither bacterium fixed N when grown in association with the C-R5B, Rescue or R-C2A lines. Although the ability of spring wheat to induce  $N_2$  fixation in associated bacteria is influenced by chromosomes 5B (which controls root rot reaction) and 5D, it does not appear to be directly related to reaction to common root rot. - Biol. Abstr. 70,1980.

645. REYNAUD, Pierre Adrien. Nitrogenase from cyanobacteria: Comparison of the activity in vivo and in vitro of heterocystous, homocystous and unicellular forms (In Fr.). *Cahiers ORSTOM. Serie Biologie*, 13(2), 1978: 143-156, Engl. summ. Three strains of Cyanobacteria: *Anabaena* 7120, *Gleocapsa* 6909 and *Plectonema* 73110, were used to compare the 3 possible patterns of N fixation: aerobiose with heterocysts, aerobiose with unicellular forms and microaerophylic conditions. Comparison was based on in vivo and in vitro acetylene reducing activity (A.R.A.) and solubility of nitrogenase. Algae were grown in BG 11 medium free of combined N, bubbled with Ar-CO<sub>2</sub> (99.1) for 48 h. After harvesting, extracts were prepared by suspending the cell concentrate in 0.1 M glyc-glyc buffer pH 7.4 (vol/vol) with ATP 1 mM, Na<sub>2</sub>S<sub>2</sub>O<sub>4</sub> 0.9 mg/ml; disrupted in a French Press (20,000 psi) under strict anaerobic conditions, then stored in liquid N. Each factor of A.R.A. reaction in vitro was tested, then optimum concentrations were used: a significant difference was noted for dithionite (optimum 5 mM for *A.* 7120 and *G.* 6909, 10 mM for *P.* 73110). Two preparative centrifugations showed a close relation between *A.* 7120 and *P.* 73110 nitrogenase solubility. - Biol. Abstr. 69,1979.

646. REYNAUD, P.A. and ROGER, P.A.  $N_2$ -fixing algal biomass in Senegal rice fields. Environmental role of N-fixing blue-green algae and asymbiotic bacteria. Stockholm, Swedish Natural Science Research Council, 1978, pp.148-157, graph; tables; ref.; summ. (*Ecological Bulletins/NFR* no. 26).



Results of investigations conducted in rice fields in Senegal are reported. Total algal biomass was greatest between tillering and panicle initiation, it decreased after heading. Measured values varied from a few hundred kg to many tons of wet algae per ha.  $N_2$  fixing algal biomass was small at the beginning of the crop cultivation cycle, reached an absolute maximum after heading and a relative maximum at the end of the cultivation cycle. Values observed generally amounted to a few hundred kg. The  $N_2$  fixing algal biomass was positively correlated with soil pH and with density of plant cover. Intensity of light reaching the soil is an important factor in the evaluation of algal flora composition. Algal  $N_2$  fixation in Senegalese lowland rice fields was found to be in the order of a few kg of N per ha per cultivation cycle. - Abstr. on Trop. Agri. 5, 1979.

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649. RICHARDS, J.E. and SOPER, R.J. Effect of nitrogen fertilizer on yield, protein content, and symbiotic nitrogen fixation in Fababeans (*Vicia faba* var. *minor*). *Agronomy Journal* 71(5), 1979: 807-811. Fababeans (*V. faba* L. var. *minor*) are potentially an important source of crude protein in Western Canada. Thus the effect(s) of combined inorganic N on fababean growth performance are of considerable interest. This experiment was conducted to determine the effect(s) of fertilizer-N on fababean shoot and root yields, protein contents, N uptake, N fertilizer uptake and symbiotic N fixation. N fertilizer as  $NH_4NO_3$ , was applied to fababeans grown in an Udic Haploborall soil in rates up to 900 mg N/pot (300 mg N/kg soil), as split applications of 75 mg N/pot (25 mg N/kg soil) and as single large, mid-season applications of 300 mg N/pot (100 mg N/kg soil).  $^{15}N$ -labeled fertilizers were used to measure N fertilizer uptake and were also used with a reference crop to measure

symbiotic N fixation. The split application treatment received labeled- $^{15}\text{N}$  in the manner described by Fried et al. (1975), enabling efficiency of N fertilizer uptake for each application time to be determined. Fababeans, when nodulated with effective strains of *Rhizobium*, obtain their N from soil and symbiotic fixation. Results obtained from this experiment indicate that these 2 sources of N were able to fully satisfy fababeans' N demand throughout their entire growth cycle. Aerial yield was not affected by N fertilizer up to 600 mg N/pot (200 mg N/kg soil) applied at seeding, by 300 mg N/pot applied in 4 75-mg portions, nor by single mid-season applications of 300 mg N/pot. Only the highest rate of N employed, 900 mg N/pot at seeding, significantly increased fababean yield, the increase being 13.2%. Protein content and total N uptake into fababean shoots were unaffected by all N applications used. Fababeans, nodulated with an effective *Rhizobium* strain were efficient symbiotic fixers. Fababeans receiving no N fertilizer fixed 708 mg N/plant, or 87.1% of their total N content. Fababeans were capable of fixing substantial amounts of N after pod-fill, amounting to at least 28% of the total seasonal symbiotically fixed N. A significant ( $r^2 = 0.99$ ) linear inverse relationship occurred between fertilizer-N uptake and symbiotic N fixation. Increasing quantities of fertilizer uptake into fababean tissues decreased plant N derived from fixation. Fababeans were as adept as barley in extracting available soil and fertilizer-N, and evidence indicates fababeans preferentially feed from soil and fertilizer N sources. - Biol. Abstr. 69,1979.

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DNA was digested with a restriction endonuclease, fractionated by agarose gel electrophoresis, denatured and blotted onto nitrocellulose filter paper. The DNA on the filters was hybridized with  $^{32}\text{P}$ -labeled DNA fragments derived from amplifiable plasmids carrying cloned *nif* DNA fragments from *K. pneumoniae*. Altered hybridization patterns caused by insertions into *nif* genes allowed the mapping of *nif* mutations with respect to the previously mapped cleavage sites for various restriction endonucleases. The same method was used to map the end points of *nif* deletions. Using this procedure, physical locations on the *K. pneumoniae* chromosome to 86 *nif* insertion mutations and 13 *nif* deletion end points were assigned. This mapping procedure provides a convenient alternative to deletion mapping as a definitive method for mapping insertion mutations within a gene or for ordering genes within a gene cluster. This procedure will be especially useful for mapping mutations conferring phenotypes that are difficult to monitor and for mapping mutations in bacterial species in which techniques for conducting deletion mapping were not devised. - Biol. Abstr. 68,1978.

651. RIGAUD, J. Nitrate effect on the nitrogen fixation in root nodules from French bean *Phaseolus vulgaris* L. (In Fr.). *Physiologie Vegetale*, 14 (2), 1976: 297-308, ref., Engl. summ.
652. RINAUDO, G. Important of plant variety on  $\text{N}_2$ -fixing activity in the rhizosphere of rice (In Fr.). <sup>2</sup>*Cahiers ORSTOM Série Biologie*, 12 (2), 1977: 117-119, tables; ref.; Engl. summ. This investigation from Senegal assays the influence of the plant on the acetylene reducing activity in the rhizosphere of rice (*Oryza sativa*) by screening 28 rice varieties. It appeared that the efficacy of the rice-bacteria-nitrogen fixing association was closely related to the variety of rice. Apparently genetic characters of the rice plants influence the process. - Abstr. on Trop. Agri. 4,1978.

653. RINAUDO, G., AUFEUVRE, M.A. and BOUREAU, M. A device to estimate rhizospheric-nitrogen fixation in submerged and non-submerged soil (In Fr.). *Cahiers ORSTOM. Série Biologie*, 13(2), 1978: 165-170, illus.; graphs; tables; ref.; summ. A device to study nitrogen fixation in the rhizosphere of three week old seedlings is described. The seedlings were grown in dry or submerged conditions, and acetylene measurements were made without disturbing the physiological systems studied. - Abstr. on Trop. Agri. 5,1979.
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655. RIVERO, C.R., GIRALDO, O.C.T. and GRAHAM, P.H. Comparison of nodulation and nitrogen fixation by *Rhizobium* in bean *Phaseolus vulgaris* L. and soya bean *Glycine max* (L.) Merrill. *Acta Agronomica*, 26(3-4), 1976: 104-115, graphs; tables; ref. The number of nodules on bean roots is larger than on soya bean, but the nodules of the latter are larger in size and weight. N fixation in soya bean starts later than in bean. - Abstr. on Trop. Agri. 5,1979.
656. ROBSON, A.D. Mineral nutrients limiting nitrogen fixation in legumes. In: Mineral Nutrition of Legumes in Tropical and Subtropical Soils, Proceedings. Brisbane, Australia, January 1978. Melbourne, CSIRO, 1978, pp.277-293, tables; bibliog.; summ. Mineral nutrients may limit N fixation by affecting growth and survival of rhizobia, infection and nodule development, and nodule function as well as by affecting plant growth. In this paper procedures for assessing whether symbiotic N fixation has a higher external or internal requirement than host plant growth are described. It can be concluded that Co (cobalt) and Mo

(molybdenum) are required in greater amounts for symbiotic N fixation than host legume growth under all circumstances. The roles of nutrients in each phase of symbiotic N fixation is considered. It is concluded that the major area of ignorance is the mineral nutrition of *Rhizobium* - Abstr. on Trop. Agri. 5,1979.

657. ROBSON, A.D., DILWORTH, M.J. and CHATEL, D.L. Cobalt and nitrogen fixation in *Lupinus angustifolius* L.: I. Growth, nitrogen concentrations and cobalt distribution. *New Phytology*, 83(1), 1979: 53-62. Co application markedly increased the growth of and N concentrations in tops of *L. angustifolius* irrespective of inoculation with an effective strains of *Rhizobium* [*R. lupini*]. Co-deficient plants produced a greater weight of lateral nodules and total nodule weight than Co-adequate plants. Co-sufficient plants produced more crown nodule weight than Co-deficient plants. Co concentrations were higher in roots and nodules than in tops irrespective of Co application. In plant tops Co concentrations in young leaves were considerably lower than those in old leaves at both Co levels. Co concentrations and contents increased in old leaves throughout the experiment. Under Co deficiency Co appeared to be preferentially distributed to nodules. Six weeks after sowing Co contents of nodules of Co-deficient plants were similar to those in whole tops. By contrast at this time Co contents of nodules of Co-adequate plants were only ~ 1/3 those of whole tops. - Biol. Abstr. 69,1979.
658. ROBSON, R.L. and POSTGATE, J.R. Oxygen and hydrogen in biological nitrogen fixation. *Annual Review of Microbiology*, vol. 34, 1980: 183-207, ref.; lit. rev.
659. ROGER, P.A., KULASOORIYA, S.A. and TIROL, A.C. Deep placement: a method of nitrogen fertilizer application compatible with algal nitrogen fixation in wetland rice soils. *Plant and Soil*, 57(1), 1980: 137-142, tables; ref.; summ. The effect of different methods of nitrogen fertilizer application on the algal flora and biological nitrogen fixation (acetylene-reducing activity) in a wetland rice soil was studied in pot and field experiments. Broadcast application of urea inhibited nitrogen fixation and favoured the

growth of green algae. In contrast, deep placement of urea supergranules (1-2 urea granules) did not suppress the growth of  $N_2$ -fixing blue-green algae and permitted acetylene-reducing activity on the soil surface to continue virtually uninhibited. - Abstr. on Trop. Agri. 7,1981.

660. ROGER, P.A. and KULASOORIYA, S.A. Blue-green algae and rice. Los Baños, Laguna, International Rice Research Institute, 1980, 119p., illus.; tables; bibliog. For paddy rice (*Oryza sativa*) one of the important biological resources of combined nitrogen is blue-green algae. With increasing cost of N fertilizer and the widening gap between supply and demand of N in the developing countries, heavy constraints have been placed on the farmers. Arising from discussions at the IRRI symposium on N and rice in September 1980, research priority for biological N fixation by azolla, blue-green algae and heterotrophic microorganisms in the root zone was recommended. IRRI was asked to compile all relevant information on these organisms in relation to rice cultivation. This review is primarily in response to that recommendation. - Abstr. on Trop Agri. 7,1981.
661. ROGER, P.A. and REYNAUD, P.A. First results on the ecology of *Azolla africana* in Senegal (In Fr.). *Oecologia Plantarum*. 14(1), 1979: 75-84, Engl. summ. *Azolla* does not grow spontaneously in paddy fields in Senegal and was rarely observed in natural ecosystems. High light intensities and high temperatures had an inhibitory effect on the isolated strain (*A. africana*). However, this effect was insufficiently marked to explain the lack of spontaneous growth, this was most probably related to a problem of conservation during the long dry period occurring in Senegal (8 mo.). The isolated strain had a high  $N_2$ -fixing specific activity and a high potential productivity evaluated at 300-600 kg Na fixed/ha per yr. - Biol. Abstr. 68,1978.
662. ROGER, P.A. and WATANABE, I. Research on algae, blue-green algae, and phototrophic nitrogen fixation at the International Rice Research Institute (1963-81), summarization, problems, and prospects. Los Baños, Laguna, International Rice Research Institute, IRRI Research Paper Series no. 78, 1982, 21p., illus.; tables; bibliog.; summ. This paper

provides general information on one of the major research areas of IRRI's Soil Microbiology Department. Conclusions made after an extensive survey of the literature on the role of blue-green algae in rice cultivation are summarized. Microbiological research at IRRI on algae, blue-green algae, and phototrophic nitrogen fixation is reviewed. The paper also provides information on problems encountered and prospects for future research. - Abstr. on Trop. Agri. 8, 1982.

663. ROGERSON, Allen C. Modifiers of heterocyst repression and spacing and formation of heterocysts without nitrogenase in the cyanobacterium *Anabaena variabilis*. *Journal of Bacteriology*, 140 (1), 1979: 213-219. Twelve amino acid analogs and related compounds were screened for their ability to induce heterocysts in  $\text{NH}_3$ -repressed, undifferentiated filaments of *A. variabilis*. As previously described, 1-methionine-*dl*-sulfoximine induces both heterocysts and nitrogenase. In contrast, *dl*-7-azatryptophan and  $\beta$ -2-thienyl-*dl*-alanine induced heterocysts but not nitrogenase activity (measured as acetylene reduction) even under microaerobic conditions. When the initial ammonium concentration was reduced, *dl*-7-azatryptophan-treated cultures sequentially produced heterocysts and then nitrogenase activity, but nitrogenase was detected only when a parallel culture without analog also became capable of acetylene reduction. Neither of the 2 latter analogs affected  $\gamma$ -glutamyl transferase activity in crude extracts. All 3 analogs significantly reduced the mean interheterocyst distance in  $\text{N}_2$ -fixing cultures. - Biol. Abstr. 69,1979.
664. ROHATGI, A. and SINGH, S.P. Isolation and characterization of pigment mutants of the blue-green alga *Aphanizomenon stagnina*. *Molecular & General Genetics*, 169 (1), 1979: 59-62. Nitrosoguanidine-induced pigment mutants with elevated phycocyanin content and diminished phycoerythrin were isolated from the phycoerythrin rich wild type blue-green alga *A. stagnina*. The phycocyanin:chlorophyll ratio varied among the mutant strains which invariably showed an impairment in their  $\text{N}_2$ -dependent growth and accumulation of fixed N. Phycoerythrin was virtually eliminated from

the mutant strains in contrast with the wild type. The observations are inconsistent with the biosynthetic interconvertibility of chromophoric precursors of the 2 phycobilins and perhaps a greater efficiency of phycocyanin in the oxygenic part (PS II) of photosynthesis. - Biol. Abstr. 68,1978.

665. ROHRMANN, G.F. and ROSSMAN, A.Y. Nutrient strategies of *Macrotermes ukuzii* (Isoptera Termitidae). *Pedobiologia*, 20 (2), 1980: 61-73, Engl. summ. All fungi isolated from *M. ukuzii* combs were capable of degrading cellulose. *Termitomyces*, the conspicuous fungus covering the comb, produced lignin degrading enzymes whereas *Nyctelia* did not. *Termitomyces synnemata* and comb material contained 2.7 and 0.8-1.0% chitin respectively. Based on chitin content *Termitomyces* was estimated to comprise 27-33% of the comb mass. *Termitomyces synnemata* were composed of 38% protein which contained all the amino acids termites require. *Termitomyces* conidia were found in termites guts. *M. ukuzii* termites possessed a chitinase enzyme system localized in the gut and gut bacteria capable of decomposing cellulose and chitin. No N fixation by either *M. ukuzii* termites or comb was detected. Chitinase enzyme systems occur in *Cubitermes* sp., *Trinervitermes trinervoides*, and *Zootermopsis angusticollis*. *T. trinervoides* fixed significant amounts of N whereas *Cubitermes* sp. fixed slight amounts. - Biol. Abstr. 70,1980.
666. ROHWER, Frauke and Flueckiger, w. Effect of atrazine on growth, nitrogen fixation and photosynthetic rate of *Anabaena cylindrica*. *Angewandte Botanik*, 53 (1/2), 1979: 59-64, Engl. summ. At atrazine concentrations above  $10^{-6}$  M/l the apparent  $O_2$  production as well as  $N_2$  fixation and growth of *A. cylindrica* were inhibited. Inhibition of  $N_2$  fixation was delayed compared with the apparent  $O_2$  production. The possible effect of normal application rate of atrazine on  $N_2$  fixation is discussed. - Biol. Abstr. 69,1979.
667. ROMANOV, V.I., FEDULOVA, N.G., SHRAMKO, V.I., MOLCHANOV, M.I. and KRETOVICH, V.L. Metabolism of poly- $\beta$ -hydroxybutyric acid in lupine root nodule bacteroids and its



relation to nitrogen fixation and photosynthesis (In Russ.). *Fiziologiya Rastenii*, 25 (4), 1978: 726-730, Engl. summ. Darkening of lupine (*Lupinus luteus*) plants at the beginning of the flowering phase resulted in a sharp decrease of the intensity of N fixation and poly- $\beta$ -hydroxybutyric acid (PHB) accumulation in bacteroids (*Rhizobium lupini*). During a subsequent exposure of plants to light, N-fixation intensity rose while PHB content declined. When lupine plants were exposed to light in the presence of  $^{14}\text{CO}_2$  the label was distributed among PHB, bacteroids and the whole nodules. Active metabolism of PHB in bacteroids may be closely related to N-fixation and photosynthesis. - Biol. Abstr. 68,1978.

668. ROSE, Sharon L., LI, Ching-Yan and STIEBERS, Anita Hutchins. A streptomycete antagonist to *Phellinus weirii*, *Fomes annosus* and *Phytophthora cinnamomi*. *Canadian Journal of Microbiology*, 26 (5), 1980: 583-587. An actinomycete isolated from the rhizoplane of N fixing nodules of *Ceanothus velutinus* was identified as a variety of *Streptomyces griseoloalbus*. *S. griseoloalbus* is a strong antagonist to 3 destructive root pathogens. *Phellinus weirii*, *F. annosus* and *Phytophthora cinnamomi* inhibiting all 3 on several culture media and preventing establishment of *F. annosus* on hemlock wood disks. The stability and longevity of the antimicrobial substance produced by it, its consistent effect on the pathogens on all substrates, its ability to colonize wood and its ability to grow at  $10^{\circ}\text{C}$  suggest biological control possibilities for this organism in the Pacific Northwest. - Biol. Abstr. 70,1980.
669. ROUGHLEY, R.J., NUTMAN, P.S. and CHANDLER, M.R. Effect of host plant selection and temperature on the structure of root nodules of red clover (*Trifolium pratense* L.). *Plant and Soil*, 61 (1), 1981: 113-124, ref. 1. Nodule structure was examined in the red clover cultivar S123 and in lines (designated H('2)) separately bred for high yield with *Rhizobium trifolii* strains RCR 0403 and RCR 5. Plants were grown at 16/11, 22/17, and 27/22 deg C in a 16 h day at 25,000 lux. 2. The larger yields of bred lines compared with S123 were directly correlated with larger aggregate nodule size, larger infected zones and with more bacteroid tissue. Over all treatments the correlation of

plant dry weight with aggregate areas of bacteroid tissue, assessed in median longitudinal section, accounted for 79% of the variance. 3. Yields were unrelated to the proportion of uninfected cells and vacuoles within the bacteroid zone. 4. Effects of host type and strain on nodule structure and yield were greatest at the moderate temperature and least and most irregular at high temperature. 5. Bacteroid tissue degenerated more rapidly in S123 than in the bred lines, more rapidly with RCR 0403 than RCR 5 and more rapidly at the high temperature than at moderate or low temperatures. 6. Aggregate nodule size irrespective of treatment was correlated with the aggregate sizes of nodule meristem and differentiating tissues. Nodule cortex comprised a larger proportion of the nodule section at 17 days than subsequently. 7. At 22/17 deg C over a 17-25 day period the increment in dry matter per mm<sup>2</sup> active nodule tissue was similar for H<sup>2</sup> and S123 plants and was less for RCR 0403 (3.33 mg) than for RCR 5 (6.87 mg). At 27/22 deg C the efficiency of bacteroid tissue was much less. 8. Nodule tissue areas and volumes were closely related so that unit volumes of active bacteroid tissue in general promoted similar dry matter increment in S123 and bred lines. 9. Specific nitrogenase activity was greater with RCR 5 than RCR 0403, least at 27/22 deg but was unaffected by host type.

670. ROUSSOS, S., GARCIA, J. L., RINAUDO, G. and GAUTHIER, D. Distribution of heterotrophic aerobic microflora and specially denitrifying and free-living nitrogen-fixing bacteria in the rhizosphere of rice (In Fr.). *Ann. Microbiol.* (PARIS), 131 (2), 1980: 197-208, Engl. summ. The distribution of heterotrophic aerobic bacteria, actinomycetes and fungi was estimated in 3 samples (rhizospheric soil (SR), rhizoplane (R) and endorhizosphere (ER) obtained from 1 rice seedling which had grown in a pot during 4 mo. in a Casamance grey soil. The number of microbial populations were about the same from 1 sample to another:  $1.1-2 \times 10^8$  bacteria,  $3.3-8.6 \times 10^6$  actinomycetes and  $0.2-8.9 \times 10^4$  fungi/g of dry soil (SR) or dry roots (R and ER). The denitrifying and free-living N<sub>2</sub>-fixing bacteria were numerous ( $10^7$  bacteria/g) but lower for ER where the number of actinomycetes remained high. Thirty-six bacterial strains were isolated from every sample

with the use of a grid for isolation. Gram-negative bacteria were dominant in SR and R where they represented 70 and 94%, respectively, of the total count. The major groups were nonsporulated gram-variable rods (SR) and *Alcaligenes*-like bacteria (ER). The pseudomonads represented 15% of total count in the 3 samples. The frequency of endospore-forming gram-positive bacteria was high only in R where the *Bacillus* group was estimated to 45% of total count. Only 5 free-living  $N_2$ -fixing bacterial strains showed denitrifying ability. - Biol. Abstr. 70,1980.

671. ROY, R.N. and BRAUN, H. Integrated plant nutrition systems. *News in Brief* (ESCAP). 5 (2), 1982: 3-5. The concept of integrated plant nutrition systems (IPNS) is defined and the various components involved are briefly discussed. Attention is paid to organic recycling, biological N factors and mineral fertilizers. The practical approach of the FAO fertilizer programme regarding IPNS is outlined. - Abstr. on Trop. Agri. 8,1982.
672. RUAYSOONGNERN, Sawaeng. The effect of phosphorus on nodulation in *Stylosanthes hamata*. Khon Kaen University Annual Report 1978. Khon Kaen, Thailand, Khon Kaen University, n.d., pp.92-94. Mineral nutrients may limit nitrogen fixation of legumes in some soils by affecting the growth and survival of Rhizobia, infection and nodule development. Nodule function may also be adversely affected by a mineral deficiency in the soil. Many nutrients required for good growth of plants are also required for one or more phases in the symbiotic fixation of nitrogen. Phosphorus, which has been shown to be deficient in many soils in Northeast Thailand, may also be specifically involved in symbiotic nitrogen fixation. The aim of this experiment was to examine the effect of various rates of phosphorus on nodulation in *Stylosanthes hamata* cv. Verano. A pot experiment with nine rates of phosphorus (0, 5, 10, 20, 40, 60, 80, 120, 160 Kg P ha<sup>-1</sup>) as sodium dihydrogen phosphate and three replications of each treatment was conducted in the glasshouse using Yasothon soil. A complete basal application of nutrients except phosphorus and nitrogen was added to each pot. Eighteen plants were established

- in each pot and grown for 12 weeks. When harvested the number of nodules on plant roots in each pot were counted and the dry weight of nodules per pot recorded. - Author.
673. RUAYSCONGNERN, S. and AITKEN, R.L. Nitrogen fixation by cultivars of *Stylosanthes hamata* in two upland soils from Northeastern Thailand. *Thai Journal of Agricultural Science*. 13(4), 1980: 291-301, tables; ref.; Engl. summ. Twenty-one cultivars of *Stylosanthes hamata* were assessed for their ability to effectively fix nitrogen using native rhizobia in a Nam Phong and a Khorat soil from NE Thailand. In the Nam Phong soil 10 cultivars failed to fix adequate  $N_2$  for maximum yield, indicating that these cultivars show some degree of rhizobium specificity and that these strains were absent in this soil. In the Khorat soil only one cultivar was unable to fix sufficient  $N_2$ , indicating that this soil contains adequate rhizobia for most *Stylosanthes* cultivars. Cv. Verano fixed adequate  $N_2$  and produced good yields and a number of other cultivars were comparable. Further research comparing these cultivars with cv. Verano in terms of ability to use low levels of phosphorus and sulphur and to withstand heavy grazing, are suggested. - Abstr. on Trop. Agri. 7,1981.
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675. RUIZ-ARGUESO, Tomas, EMERICH, David W. and EVANS, Harold J. Hydrogenase system in legumes nodules: A mechanism of providing nitrogenase with energy and protection from oxygen damage. *Biochemical and Biophysical Research Communications*, 86(2), 1979: 259-264. Some strains of rhizobia [in legume symbiosis] possess a hydrogenase system which catalyzes the oxidation of the  $H_2$  that is evolved from nitrogenase during  $N_2$  fixation. Oxidation of  $H_2$  by a hydrogen uptake positive strain of *Rhizobium japonicum* provides energy for support of the  $N_2$  fixation reactions and protects nitrogenase from  $O_2$  damage. - Biol. Abstr. 68, 1979.

676. RUMBALL, P.J. Nitrogen fixation in pasture: 2. Northland warm temperate, Kaikohe, New Zealand. *New Zealand Journal of Experimental Agriculture*, 7(1), 1979: 7-10. Annual totals of N fixed by legumes in an intensively managed pasture on a podzol in Northland in 1974-1975 and 1975-1976 were 368 and 392 kg/ha. The pasture produced 11.4-14.1 t DM[tons dry matter]/ha, of which 1/3 was white clover (*Trifolium repens* L.). Variation in the rate of fixation was small within and between years, and seemed to be most influenced by soil moisture. The generally close correspondence between legume growth rate and N fixation rate, as well as periods of apparent N deficiency, suggest that rates of N mineralization are very low at this site. - Biol. Abstr. 69,1979.
677. RUNGRATTANAKASIN, Worawit. Study on the growth, nodulation and nitrogen fixation (Acetylene reduction) in field soybeans, mungbeans and peanuts (In Thai). Plant Pathology and Microbiology Division/Agricultural Chemistry Division, Department of Agriculture Research Report 1977. Bangkok, Department of Agriculture, 1980, p.36, summ. only.
678. RUNGRATTANAKASIN, Worawit and WASUWAT, Yenchai. Strains of *Rhizobium japonicum* for use on S.J. 2 soybean (*Glycine max* L. merr.) in field environment (In Thai). In: Proceedings of the National Conference on Agricultural and Biological Sciences, 12th Session, Plant Science, at Kasetsart University, 5 February 1973. Bangkok, Kasetsart University, 1973, p.44.
679. RUNGRATTANAKASIN, Worawit, BUNKOET, Nanthakon and WASUWAT, Yenchai. Influence of nitrogen fertilizer on soybean - *Rhizobium* (In Thai). In: Proceedings of the National Conference on Agricultural and Biological Sciences, 14th Session, Plant Science, at Kasetsart University, 2-4 February 1975, pp.150-165.
680. RUNGRATTANAKASIN, Worawit, CHOONHALUECHANON, Somporn and BUNKOET, Nanthakon. Study on growth, nodulation and nitrogen fixation (acetylene reduction) in fields of soybeans, mungbeans and peanuts (in Thailand) (In Thai). In: Research report on oil crops in dry season 1978, Bangkok,

Ministry of Agriculture and Cooperatives, Department of Agriculture, 1978, pp.296-302, ref.

681. RUSCHEL, A.P. and VOSE, P.B. Nitrogen cycling in sugarcane. *Plant and Soil*, 67 (1), 1982: 139-146. Sugarcane has been grown extensively in Brazil for more than 50 years, and in the northeast from the time Brazil was discovered. Use of N-fertilizer started in the 1940s with applications of sodium nitrate, and little yield improvement was obtained in most cases. Average yield is around 70 t/ha/yr (4-harvest mean), with the first harvest 1.5 year from planting and a ratoon harvest each year thereafter. Nitrogen responses are obtained only with ratoon crops. Nitrogen inputs to the plant come from native soil-N, fertilizer-N, and biological fixation. Sources of loss include N-leaching from leaves and decomposing roots and loss of stems and leaves at harvest. There are technical and economic problems with returning factory waste (vinhoto) to the fields as fertilizer. A reasonably conservative estimate of biological nitrogen fixation holds that 1.7% of total plant nitrogen is fixed by the plant, or 16.6 kg N/ha for a harvest of  $70 \times 10^3$  kg/ha. Rotation and intercropping of legumes with sugarcane could increase N(2)-fixation by 35 kg N/ha/yr (soybean rotation) and 25 kg N/ha/yr (*Phaseolus* beans intercropping).
682. RUSCHEL, A.P., SAITO, S.M.T. and TULMANN NETO, A. Efficiency of *Rhizobium* inoculation on *Phaseolus vulgaris* L. 1. Effect of nitrogen sources and plant varieties (In Pt.). *Revista Brasileira de Ciência do Solo*, 3 (1), 1979: 13-17, graphs; tables; ref.; Engl. summ. The effect of N fertilization and sources of N on symbiotic N fixation and yield of various bean (*Phaseolus vulgaris*) varieties was studied in 2 field experiments. - Abstr. on Trop. Agri. 6, 1980.
683. RUSCHEL, A.P., VICTORIA, R.L., SALATI, E. and HENIS, Y. Nitrogen fixation in sugarcane (*Saccharum officinarum* L.) In: Environmental role of N-fixing blue-green algae and symbiotic bacteria. Stockholm, Swedish Natural Science Research Council, 1978, no. 26, pp.297-303, illus.; tables; ref.; summ. (Ecological Bulletins/NFR). Results

are reported of research work conducted on the nitrogen fixing potential of sugar-cane in intact and disturbed soil-plant systems. The composition of the microflora associated with sugar-cane roots was also examined. The presence of a dinitrogen fixing system associated with roots and with the rhizosphere soil was demonstrated. Plants and roots of both systems incubated under  $15$ -dinitrogen enriched atmosphere fixed N at a similar rate. Addition of glucose increased N fixation in both intact and disturbed soil-plant systems. - Abstr. on Trop. Agri. 5,1979.

684. RYABOV, A.K. and DENISOVA, A.I. Elements of biogenic and organic substance metabolism in water of reservoirs and their relation to bioproductivity (In Russ.). *Gidrobiologicheskii Zhurnal*, 14(5), 1978: 95-101, Engl. summ. Seasonal dynamics of main biogenic elements and organic substances of N-fixing bacteria, phytoplankton and heterotrophic microorganisms is traced in waters of the Tsybul'nian Bay of the Kremenchug reservoir [Ukrainian SSR, USSR]. Their changes are established to be closely connected with photosynthetic processes in the water body. The stages and duration of the production, destruction, processes are determined. - Biol. Abstr. 68,1979.
685. RYLE, G.J.A., POWELL, C.E. and GORDON, A.J. The respiratory costs of nitrogen fixation in soybean, cowpea and white clover: I. Nitrogen fixation and the respiration of the nodulated root. *Journal of Experimental Botany*, 30(114), 1979: 135-144. Soybean [*Glycine max*], cowpea [*Vigna unguiculata*] and white clover [*Trifolium repens*], inoculated with effective rhizobia [*Rhizobium*], were grown singly with a standard mineral nutrition and light regime in controlled environments until seed maturation (in soybean and cowpea) or late vegetative growth (white clover). Day/night temperature regimes were 23/18, 30/24 and 20/15°C in soybean, cowpea and white clover, respectively. The respiratory losses of CO<sub>2</sub> from the nodulated root systems were studied in relation to the concurrent rate of fixation of atmospheric N. Despite differences in development, the effectiveness of the symbioses and the temperature of growth, all 3 legumes exhibited similar respiratory losses from nodulated roots per unit of N fixed. During intense N fixation, the average

respiratory losses for the 3 legumes varied between 6.3-6.8 mg C mg<sup>-1</sup>; within each species, the losses varied more widely at different stages of development. These respiratory burdens reflect the total cost to the plant of the nodule per N fixation syndrome including the subtending roots. The respiratory effluxes from nodules and roots and biochemical investigations of the costs of N fixation are discussed. - Biol. Abstr. 68,1978.

686. RYLE, G.J.A., POWELL, C.E. and GORDON, A.J. The respiratory costs of nitrogen fixation in soybean, cowpea and white clover: II. Comparisons of the cost of nitrogen fixation and the utilization of combined nitrogen. *Journal of Experimental Botany*. 30 (114), 1979: 145-154. Plants of soybean [*Glycine max*], cowpea [*Vigna unguiculata*] and white clover [*Trifolium repens*] were grown singly in pots in Saxcil growth cabinets at 23/12° C, 30/24° C and 20/15° C, respectively, until seed maturation or for 85 days (white clover). Two populations were produced within each species: one population nodulated [*Rhizobium*] and wholly dependent for N on fixation in the root nodules and the other completely lacking nodules but receiving abundant nitrate N. In each species, the 2 populations were compared in terms of rate of gross photosynthesis, rate of shoot respiration and rate of root respiration. Source of N had little or no effect on rate of photosynthesis or shoot respiration. The rate of respiration of the nodulated roots of plants fixing their own N was greater, sometimes 2-fold greater, than that of equivalent plants lacking nodules and utilizing nitrate N. This superiority in terms of rate of root respiration was generally confined to the period of intense N fixation. An analysis of the magnitude of this respiratory burden in terms of daily photosynthesis indicates that, in all 3 legumes, plants fixing their own N respire 11-13% more of their fixed C each day than equivalent plants lacking nodules and utilizing nitrate N. - Biol. Abstr. 68,1978.
687. SAENGCHIAN, Sontanah. Early enzymes involved in the biosynthesis of isoprenoids in *Azotobacter* sp., In: 2nd JSPS-NRCT Seminar: Agro-industry Including Microbial Technology, Hat Yai,



Songkhla, Faculty of Natural Resources, Prince of Songkhla University, 1981. Songkhla, Prince of Songkhla University, Faculty of Natural Resources, n.d., pp. 25, Engl. summ. (Bibliography on Agriculture in Thailand, 1983, 2 (1-2))

688. SAGARDOY, M. and LABORDE, H. Inoculation of *Vicia sativa* L. and *Medicago sativa* L. with *Rhizobium* in soils of Rio Colorado valley (In Es.). *Revista Latinoamericana de Microbiologia*, 19 (3), 1977: 145-150, graph; tables; ref.; Engl. summ. The objective of this field trial was to determine the efficiency of different commercial inoculants on vetch (*Vicia sativa*) and lucerne (*Medicago sativa*) when planted in soils already containing natural populations of *Rhizobium* sp. Both crops were inoculated with inoculum applied at 10 times the rate recommended by the manufacturer. It was shown that artificial inoculation did not influence productivity of either crop. - Abstr. on Trop. Agri. 5, 1979.
689. SAHA, K.C. and MANDAL, L.N. A greenhouse study on the effect of inoculation of N-fixing blue-green algae in an alluvial soil treated with P and Mo on the yield rice and changes in the N-content of soil. *Plant and Soil*, 57 (1), 1980: 23-30, tables; ref.; summ. In these studies 3 cultures of N-fixing blue-green algae were used. These were *Aulosira fertilissima*, *Nostoc muscorum*, and their mixture. Nitrogen (as urea) was added at 0, 10, 20 or 40 ppm. Inoculation significantly increased the grain and straw yield of rice and nitrogen uptake in grain, but the efficiency of inoculation gradually decreased with increased levels of applied urea, the extent of decrease varying with the algal cultures inoculated. The total nitrogen content in inoculated soils, after crop harvest, under wet conditions, recorded a significant increase. But after air drying the soil showed a considerable decrease. This indicates that most of the nitrogen fixed by blue-green algae in rice soils did not persist after air drying the soil.
690. SAHA, K.C. and MANDAL, L.N. Distribution of nitrogen fixing blue-green algae in some rice soils of West Bengal. *Journal of the Indian Society of Soil Science*, 27 (4), 1979:

- 470-477, illus.; tables; ref.; summ. In an incubation experiment with ten alluvial rice soils of West Bengal, the potentiality of algal fixation of nitrogen was found to be 27.66 to 73.33 mcg/g soil/week. The dominant genera in these soils were *Nostoc*, *Anabaena* and *Cylindrocapsa*, followed by *Scytonema*, *Calothrix* and *Mastigocladus*. The magnitude of fixation of nitrogen in soil culture and in mineral nutrient culture was found to be different. Among the eight algal species isolated, three of *Nostoc* and one of *Scytonema* were found to be efficient nitrogen fixers, *Nostoc muscorum* being the most efficient, in media either with or without combined nitrogen. - Abstr. on Trop. Agri. 6, 1980.
691. SAHA, K.C. and MANDAL, L.N. Fixation of nitrogen by blue-green algae in acidic and lateritic rice soils of West Bengal. *Journal of the Indian Society of Soil Science*, 28(1), 1980: 98-103, tables; ref.; summ. Laboratory studies showed that inoculation of acid and lateritic rice soils with N-fixing blue-green algae (*Nostoc muscorum*) may be beneficial if soils were treated with lime phosphate and molybdate. Liming. - Abstr. on Trop. Agri. 6, 1980.
692. SAHAB, A.F., NOFAIL, M.A., MORSY, A.A. and ALY, M.D.H. Effect of broad bean mosaic virus infection on nodulation and nitrogen fixation of broad bean (*Vicia faba*) plants I. - Effect on certain micro-organisms in the rhizosphere (*Rhizobium leguminosarum*; Egypt. *Bulletin of the National Research Centre*, 3(4), 1978: 403-409, illus.; ref.
693. SAHNI, V.P. Inoculants for India. In: College of Tropical Agriculture Hawaii. Miscellaneous Publication. Legume-Rhizobium Workshop no. 145, 1977, pp.413-427, graph; tables; bibliog. Of all countries India grows the greatest variety of legumes. It has 35% of the world area under pulse crops. Still the daily per capita availability remains a low 50 g. Therefore there is great scope for increasing legume production through massive inoculation programmes. Educating the farmers in the use of *Rhizobium* inoculation is fundamental to such programme. Systematic attempts to build up a country-wide legume inoculant

potential may be traced back some 15 years. This paper discusses the problems of the production and application of inoculants for some 30 million ha of legumes, each year. - Abstr. on Trop. Agri. 6, 1980.

694. SAHRAWAT, K.L. Ammonium fixation in some tropical rice soils. *Communications in Soil Science and Plant Analysis*, 10 (7), 1979: 1015-1023, tables; ref.; summ. In the Philippines,  $\text{NH}_4$  was extracted with 2M KCl from 12 rice soils samples treated with  $(\text{NH}_4)_2\text{SO}_4$  solution. The  $\text{NH}_4$  fixing capacity of the soils tested ranged from 3.8 to 7.7 meq./100 g of soil. Fixation was not related to pH, organic matter or clay content but correlated with the amount of active Fe in the soils. - Abstr. on Trop. Agri. 5, 1979.
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696. SAINO, Toshiro and HATTORI, Akihiko. Diel variation in nitrogen fixation by a marine blue-green alga, *Trichodesmium thiebautii*. *Deep Sea Research*, 25 (12), 1978: 1259-1264. A diel variation was demonstrated with respect to N fixing capacity of a marine blue-green alga, *T. thiebautii*, collected from subtropical waters of the western North Pacific. A 200-fold difference was observed between day and night activities when measured at a light intensity of 12,000 lx. The pattern and extent of variation were different from diel variations reported for photosynthesis, nutrient uptake and N fixation of natural populations of marine phytoplankton. - Biol. Abstr. 68, 1979.
697. SAINT MACARY, H., BEUNARD, P. and PICHOT, J. Nodulation and nitrogen fixation in five soya bean varieties under mist culture conditions (In Fr.). *Agronomie Tropicale*, 36 (1), 1981: 1, 3, 42-53, illus.; graphs; tables; ref.; Engl. summ. The N-fixing symbiosis between soya bean (*Glycine max*) and *Rhizobium japonicum* was achieved in a nutrient mist culture, and nodule distribution on the roots

- was observed. The mist was produced with the help of a vaporizer, in a closed glass container in which the roots were hanging. An apparatus for measuring the acetylene reduction activity was devised, measurements being made during growth. Symbiosis efficiency varied between varieties, a finding which may be applicable in soya bean growing. - Abstr, on Trop. Agri. 7,1981.
698. SAISAMORN, Lumyong and TAKAHASHI, H. Comparative studies of nitrogenase activities both in vivo and in vitro of wild type and azide resistant mutants of *Acetobacter vinelandii* (In Thai). In: 2nd JSPS-NRCT Seminar: Agro-industry Including Microbial Technology, Hat Yai, Songkhla, Faculty of Natural Resources, Prince of Songkhla University, 1981. Songkhla, Prince of Songkhla University, n.d., p. 24, Engl. summ.
699. SAITO, S.M.T., ZAIA, V.M. and RUSCHEL, A.P. Efficiency of N<sub>2</sub> (nitrogen) - fixation of *Rhizobium phaseoli* strains inoculated in the bean cultivar Venezuela - 350. Annual Report of the Bean Improvement Cooperative, vol. 21, 1978. Geneva, New York (State), Agricultural Experiment Station, n.d., pp.12-14.
700. SALATI, E., SYLVESTER - Bradley, R. and VICTORIA, R.L. Regional gains and losses of nitrogen in the Amazon basin (Brazil). *Plant and Soil*. 67(1), 1982: 367-376, ref. In order to better understand the relative importance of different ecosystems and nitrogen cycling processes within the Amazon basin to the nitrogen economy of this region, we constructed a generalized nitrogen budget for the region based on data for hydrologic losses of nitrogen and nitrogen fixation in Amazon forests. Data included information available for nitrogen in water entering and leaving both the entire basin and watersheds on oxisol and ultisol soils near Manaus, Brazil, in addition to biological nitrogen fixation in forests on ultisol, oxisol and entisol ('varzea') soils in Central Amazonia. Available data indicate that 4-6 kg N/ha/yr are lost via the River Amazonas, and that a similar amount enters in rainfall. Root-associated biological nitrogen fixation contributes ca. 2 kg N/ha/yr to forests on oxisols, 20 kg N/ha/yr to forests on utisols,

and 200 kg N/ha/yr to forests on fertile varzea soils. There is 5-10 fold more  $\text{NH}_4^+$ -N than  $\text{NO}_3^-$ -N in rain and stream water entering and leaving the waterbasin near Manaus. Calculations based on these data plus certain assumptions yield the following regional nitrogen balance estimate: inputs through bulk deposition of  $36 \times 10^8$  kg N/yr and through biological nitrogen fixation of  $120 \times 10^8$  kg N/yr, and outputs via the River Amazonas of  $36 \times 10^8$  kg N/yr and via denitrification and volatilization (by difference) of  $120 \times 10^8$  kg N/yr.

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accumulation of nitrogen in the surface (1-4 mm) layer of flooded soil was measured. Field experiments suggested that there is at least 7.0 kg/ha of nitrogen that is accumulated at the surface layer of flooded soil during a rice crop. The nitrogen accumulated is assumed to be derived from phototrophic nitrogen fixation. Several crops of rice were grown in continuously flooded soil in pots under greenhouse conditions. Flooded soil planted to rice had a statistically significant nitrogen balance which was found to be the result of both phototrophic and heterotrophic nitrogen fixing agents and was dependent upon the presence of the plant. Addition of phosphorus and iron and inoculation of azolla significantly increased the positive nitrogen balance by stimulating biological nitrogen fixation. One crop of rice showed a significant positive nitrogen balance. However, significant differences in the positive nitrogen balance in flooded soils could not be detected.

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tion followed by diazinon (71.4%), chlorfenvinphos (70.4%), mephosfolan (68.7%) and quinalphos (66.4%). In control plots there was an increase of 34.4% insect population during the same period. - Biol. Abstr. 70,1980.

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directly from the  $^{15}\text{N}$  NMR spectrum. - Biol. Abstr. 68,1978.

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crease in nodule efficiency, later in the season, in high N treatments was most marked at Ridgelytown. - Biol. Abstr. 69,1979.

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systems were depleted during a 40 h dark treatment; plants were then exposed to a 24 h light period during which different  $\text{CO}_2$ -exchange rates were maintained with various  $\text{CO}_2$  concentrations. In 3- and 5-wk old soybeans and 4-wk old alfalfa plants, acetylene-reduction capacity was used fully with  $\text{CO}_2$ -exchange rates as low as  $10 \text{ mg CO}_2/\text{plant per h}$ . In 6-wk old alfalfa plants, acetylene reduction rates increased linearly, and apparent  $\text{N}_2$ -fixation capacity was not used fully when  $\text{CO}_2$ -exchange rates were higher than  $40 \text{ mg CO}_2/\text{plant per h}$ . Under the conditions established, the energy cost of  $\text{N}_2$  fixation, measured as  $\Delta$  (respiration of roots + nodules) /  $\Delta$  acetylene reduction over dark treatment values, was  $0.453 \text{ mg CO}_2/\mu\text{mol C}_2\text{H}_4$  for all rates of acetylene reduction and for both ages of soybean and alfalfa plants. Thus, root-plus-nodule respiration was not promoted by higher rates of apparent photosynthesis after  $\text{C}_2\text{H}_2$ -reduction capacity became saturated, and all available capacity for apparent  $\text{N}_2$  fixation had the same energy requirement. - Biol. Abstr. 70,1980.

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- solved as a function of time. Theory and experiment both indicate that the binding at very short times is much less than the equilibrium values. The binding of *Azotobacter vinelandii* 12837 to wheat roots was also measured. Root-associated *Azotobacter* fixes N, whereas under aerobic growth conditions, root-associated 61A89 and 32H1 do not. The effect of metabolic inhibitors and antibiotics on the binding of *Rhizobia* and *Azotobacter* was examined. - Biol. Abstr. 69,1979.
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*Rhizobium* strains, in the selection of strains and in the quality control of the inoculants for pasture legumes and soya beans (*Glycine max*), are given in detail. The results of the inoculant quality control, the history of strain recommendations, and the functional relationship between industry and laboratory are presented. - Abstr. on Trop. Agri. 6,1980.

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- 7-20 days. About 333 ton fresh azolla/ha, containing about 840 kg N could be harvested annually. Azolla decomposes rapidly in soil releasing 56 and 80% of its N as ammonia at 3 and 6 weeks, respectively. A gradual organic carbon buildup was seen in soils incorporated with 5-20 t/ha before planting. - Abstr. on Trop. Agri. 7,1981.
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genase activity and this inhibition is most probably effected through a regulator factor coded by *chlA* and *chlB*. - Biol. Abstr. 69,1979.

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in nodule efficiency were not attributed to differences in this parameter. In the 3rd experiment (on soil with higher nutrient levels), establishment of mycorrhizas was also accompanied by increased growth, P and N contents within a 35 day experimental period. P inflow into roots (mol P/cm root per s) was higher in mycorrhizal plants. Delay in formation of mycorrhizas (by reduction in the amount of inoculum in soil) was accompanied by lower inflow and delay in the establishment of high root P concentration and in the onset of enhanced nodulation and nitrogenase activity. - Biol. Abstr. 69,1979.

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$10/1^{\circ}$  C but at  $35/25^{\circ}$  C increases to at least  $1000 \mu\text{E} \times \text{m}^{-2} \times \text{s}^{-1}$ . Nitrogenase activity increases with temperature between  $10/1^{\circ}$  C and  $30/20^{\circ}$  C, but is insensitive to light over a range of  $50-1000 \mu\text{E} \times \text{m}^{-2} \times \text{s}^{-1}$ . Optimum N fixation for *A. filiculoides* is between  $250-300 \text{ mg N} \times \text{g initial dry wt}^{-1} \times \text{wk}^{-1}$  and occurs at  $25/15$  to  $30/20^{\circ}$  C and  $500 \mu\text{E} \times \text{m}^{-2} \times \text{s}^{-1}$ . At  $40/30^{\circ}$  C the growth and nitrogenase activity of *A. filiculoides* is nil. However, if ferns are grown at lower temperatures and then subjected to a stepwise increase in temperature simulating dawn to midday of a diurnal cycle, nitrogenase activity increases with temperature up to  $40^{\circ}$  C and remains high at  $45^{\circ}$  C. Similar increases in nitrogenase activity with temperature are observed for field-grown *A. filiculoides* during hot ( $40-45^{\circ}$  C) afternoon periods. Inoculation of *A. filiculoides* equivalent to  $1.2 \text{ kg N} \times \text{ha}^{-1}$  onto  $22.4 \text{ m}^2$  plots of a fallow, flooded rice paddy results in N yields between  $33-93 \text{ kg} \times \text{ha}^{-1}$ . Rice paddies used for 1977 studies were a Capay silty clay (Typic Chromoxererts), while 1978 studies were on a Hillgate loam (Typic Palexeralfs). On both soil series N yield of *Azolla* was correlated positively with the length of time the fern cover had developed prior to sporulation. Sporulation, which was followed by termination of nitrogenase activity and frond senescence, was hastened by high temperature. Thus, a mat of *A. filiculoides* developing in hot summer weather fixed only  $1/3$  as much N as a population which developed over a longer period during early spring. Incorporation of  $40 \text{ kg N} \times \text{ha}^{-1}$  into soil as dry *A. filiculoides* in spring 1977 increased rice yield about  $2.0 \text{ metric tons (MT)} \times \text{ha}^{-1}$  over unfertilized controls. This effect was the same as would derive from an equal amount of N fertilizer in the form of  $(\text{NH}_4)_2\text{SO}_4$  and remained true when *Azolla* was supplemented with  $40$  and  $80 \text{ kg N} \times \text{ha}^{-1}$  as  $(\text{NH}_4)_2\text{SO}_4$ . Incorporation of  $93 \text{ kg N} \times \text{ha}^{-1}$  as dry *A. filiculoides* grown over a 46 day period in spring 1978 increased rice yield  $2.6 \text{ MT} \times \text{ha}^{-1}$ , or 70% of the increase obtained with an equivalent amount of  $(\text{NH}_4)_2\text{SO}_4$ . While more data are needed for *A. filiculoides* at different sites and years, results from this 2-yr study suggest up to 50% of the N requirement for rice in California could be supplied by 1 fallow-season crop of *Azolla*. Further experiments will be needed to determine the optimum levels of inorganic nutrients (P and Fe) and labor inputs needed to grow *Azolla* before this source of

biologically fixed N can be compared to N fertilizers currently used in temperate-zone rice culture. - Biol. Abstr. 70,1980.

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- tree species were sampled. The rate of N fixation for most soil cores was  $1 \text{ g N ha}^{-1} \text{ day}^{-1}$  or less, which extrapolates to less than  $0.2 \text{ kg N ha}^{-1} \text{ yr}^{-1}$ . The highest rates, with values of up to  $23 \text{ g N ha}^{-1} \text{ day}^{-1}$  were observed in old fields being invaded by trees. The time course of acetylene reduction was usually linear for a 24 h period, most of the activity was in the upper 15 cm of soil and the maximum rates were observed in midsummer. No significant N fixation was observed in preliminary measurements of decaying woody litter or of aerial surfaces of trees and rocks. Nitrogen fixation is apparently not a significant input of N for the forests studied. There may be significant unrecognized N inputs to forests, such as dry absorption of ammonia from the atmosphere. - Biol. Abstr. 68,1979.
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791. TORRES, R.O. Soybean (*Glycine max* (L.) Merr.) growth and nitrogen fixation as influenced by rhizobial strains and inoculation methods-rates (study conducted in the Philippines). Thesis for the Degree of Master of Science (Soil Science). College Laguna, University of the Philippines at Los Banos, 1981, 108p., graphs; tables; bibliog.; Engl. summ.; appdx. To determine the potential of increasing symbiotic N fixation of soybean by inoculation with *Rhizobium japonicum* and to study the inoculation management factors that could minimize *Rhizobium* efficiency at different soils, field experiment were conducted at 2 locations: Manaoag, Pangasinan and IRRI (International Rice Research Institute), Los Banos, Laguna. The factors in the experiment were *R. japonicum* strain, inoculation method and rate, nitrogen application and soybean variety. In a field previously planted to soybean IRRI, no benefit was derived from *Rhizobium* inoculation because the rhizobia present in the soil caused heavy nodulation and exhibited an efficiency comparable to inoculum strains. In a soil where soybean had not been grown previously (Manaoag) nodulation by native rhizobia was low and all nitrogen fixation parameters used were increased by inoculation. The *Rhizobium* isolate S38 had effects comparable to those produced by the recommended strain CB 1809. The effects of recommended seed

inoculation method and rate (10 to the fifth power cells/seed) were comparable to the uninoculated treatment. Additional application of inoculant to the seed furrow at 5x the rate directly applied to the seed increased the nodule number, nodule weight, N fixation activity and grain yield of soybean by 193, 147, 130 and 30%, respectively, over the recommended seed inoculation method and rate. Although Orba produced more nodules than UPL-SY2, the nitrogen fixation activity of the two varieties were similar. A 20 kg N/ha basal nitrogen application produced no significant inhibitory effect on nodulation and N fixation; instead, it enhanced plant growth and contributed to a 13% increase in grain yield. (E)

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nitrogenase activity during the growth of batch cultures and may provide a protective mechanism for nitrogenase. - Biol. Abstr. 68,1979.

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799. TRIPATHI, S.K. and EDWARD, J.C. Response of *Rhizobium* culture inoculation, zinc and molybdenum application on rhizosphere and phyllosphere microbial population of soya-bean (*Glycine max* Merrill). *Current Science*, 47 (14), 1978: 503-504, tables; ref. In this trial from India, *Rhizobium* (Rh.) was applied as a seed inoculant, Zn was applied to the soil as zinc sulphate and Mo as ammonium molybdate. Soya bean inoculated with Rh. registered higher populations of total bacteria in the rhizosphere. Application of Zn and Mo separately or combined decreased total bacterial population, with or without Rh. In the phyllosphere Rh. reduced the population of total bacteria; the same occurred with the application of the trace elements. The effects of the different treatments on the populations of *Azotobacter* and on Rh. itself were recorded separately from the effects on total bacteria. - Abstr. on Trop. Agri. 5, 1979.
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- 371-380. Annual and diurnal  $N_2$  fixation by red alder was monitored using the acetylene ( $C_2H_2$ ) reduction method. Two and 3 yr old red alder, which had naturally seeded on spoil materials from a coal mine near Centralia, Washington USA, were used in this study. Dinitrogen ( $C_2H_2$ ) fixation occurred during 7 mo. which corresponded to the growing season for alder. Mean  $C_2H_2$  reduction for the period was  $27.5 \mu\text{moles/g dry nodule per h}$ . Maximum rates of fixation occurred in May and June. Diurnal patterns showed highest rates at midday, with midday rates being 4-6 times greater than night rates. Total N fixed for the growing season averaged  $7.7 \text{ g N/tree}$ , which represented approximately 70% of the total N accumulated by the plant during the growing season. At a stand density of 8000 trees/ha, which is the average stand density of the area sampled, annual N fixed was estimated at  $62 \text{ kg/ha}$ . [Low fertility is a common problem in establishing vegetation on coal stripmine lands.]. - Biol. Abstr. 69,1979.
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hibited a ploidy gradient, while in ineffective  $\text{Leu}^-$  nodules it was monosomatic. The initiation of nodule formation is therefore independent of polyploidy. Supplying the defective plant-bacterial system with L-leucine or one of its precursors,  $\alpha$ -ketoisovalerate or  $\alpha$ -ketoisocaproate, caused the release of rhizobia into the plant cytoplasm and a restoration of N-fixation. In the central tissue infected cells were polyploid and enlarged, and uninfected cells remained small and contained small nuclei. Induction of differentiation of the central tissue requires the presence of bacteria in the cytoplasm. The role of a bacterial central tissue differentiation inducing principle (CTDIP) was hypothesized which cannot pass from cell to cell. - Biol. Abstr. 70,1980.

802. TU, C.M. Influence of pesticides on acetylene reduction and growth of microorganisms in an organic soil. *Journal of Environmental Science and Health. Part B: Pesticides, Food Contaminants, and Agricultural Wastes*, 14 (6), 1979: 617-624. The effects of 32 pesticides at 2 concentrations on acetylene reduction (non-symbiotic N fixation), N fixers, bacteria and fungi [*Trichoderma*, *Penicillium* spp.] in an organic soil were assessed. None of the pesticide treatments suppressed  $\text{C}_2\text{H}_2$  reduction as compared to controls. No significant inhibition of the population of non-symbiotic N fixers occurred. Stimulatory effects were observed with treatments of fensulfothion, fonofos, oxamyl, DD [dichloropropene-dichloropropane], Telone and Telone C. Bacterial and fungal populations showed temporary decline but all recovered within 7 days to levels similar to or higher than those in the controls. - Biol. Abstr. 69,1979.
803. TU, C.M. Influence of pesticide seed treatments on *Rhizobium japonicum* and symbiotically grown soybean in soil under laboratory conditions. *Protection Ecology* (Netherlands) 3 (1), 1981: 41-46, ref.; summ. The effects of the relative toxicity of the protectant pesticides currently used for seed treatments on nitrogenase activity of soybean plants in symbiotic nitrogen fixation and subsequent growth of soybean plants in a sandy loam were determined. Thiram singly or in combination with lindane and/or diazinon significantly depressed the formation of ethylene ( $\text{C}(,2)\text{H}(,4)$ ) from acetylene ( $\text{C}(,2)\text{H}(,2)$ ) for 3 weeks and with thiram

alone for 5 weeks. No significant difference in the C(,2)H(,2)-reducing activity of the soybean plants was noticed after 7 weeks. The weights of leaves + stems and roots were not significantly different from controls after 7 weeks. Although nodulation was affected slightly with treatment of thiram after 7 weeks, no permanent deleterious effect of any of the pesticide treatments on soybean plants growth and nitrogen fixation could be observed from this study.

804. TU, J.C. Alternations of membranes of bacteroidal cells in soybean root nodules as revealed by freeze-fracturing. *Physiological Plant Pathology*, 15(1), 1979: 35-41. The process of root nodulation in soybeans [*Glycine max* cv. Amsoy] by the symbiotic incorporation of rhizobia [*Rhizobium japonicum*] was studied using freeze-fracture electron microscopy. The appearance, at various stages of nodulation, of the plasma membrane of bacteroidal cells (host cells), the membrane envelope encasing bacteroids (rhizobia) in the cytoplasm of the bacteroidal cell, and in the bacteroid cell membrane is described. The plasma membrane of a bacteroidal cell in the early stages of nodulation contained a significantly higher density of intramembranous particles (IMP) compared with non-bacteroidal cells. The density of IMP increased further as nodulation progressed to the intermediate stage. Similarly, the membrane envelope, during the early stage, showed an increased number of IMP compared with non-bacteroidal cell plasma membrane, from which the membrane envelope is originally derived. At the intermediate stage, the density of IMP in the membrane envelope decreased, but still remained higher than in the plasma membrane of non-bacteroidal cells. A 2nd morphological change was noted both in the plasma membrane of bacteroidal cells and in the membrane envelope. During the early stage, small areas devoid of IMP were noticeable. These aparticulate areas became larger and more numerous in the intermediate stage and were frequently bounded by an area of high IMPs density. In the plasma membrane of bacteroidal cells, bumps and depressions, which seemed to be vesicular in nature, were seen in the aparticulate areas. No striking changes were noted in the structure of the bacteroid cell membrane during nodulation compared with rhizobia grown in culture. The plasma membrane of bacteroidal cells and the membrane envelope

become highly active during nodulation. The aparticulate areas may represent membrane growth, and/or areas of endo- and exocytosis. These changes are significant in light of the importance of these membranes in the regulation of transport of materials involved in N fixation. - Biol. Abstr. 69,1979.

805. UBBEN, M.S. and HANSON, R.B. Tidal induced regulation of nitrogen fixation activity (acetylene production) in a Georgia, USA, salt marsh. *Estuarine and Coastal Marine Science*, 10 (4), 1980: 445-454.  $N_2$  fixation potential, determined by the acetylene reduction technique, was measured at 14 sites across a Georgia salt marsh. The transect spanned tall and short *Spartina alterniflora* and natural *Juncus roemerianus* and *Salicornia virginica* monocultures, and small tidal creek which usually floods over a levee into a short *Spartina* marsh during high tides. Spring tides usually flood the entire marsh and enter the *Juncus* zone.  $N_2$  fixation potential in the soil was related to sites of daily tidal inundation and not to interstitial salinity. The salinity in cores from short and tall *Spartina* zones were artificially altered to investigate whether  $N_2$ -fixing populations were tolerant to fluctuations in salt concentration. Populations in the marsh are diverse and fluctuate monthly with respect to salinity tolerance in Sapelo Island salt marsh soils. - Biol. Abstr. 70, 1980.
806. UDOMYAMCKUL, N. Effect of physico-chemical conditions on survival and effectiveness of *Rhizobium japonicum* in carriers (In Thai). Thesis for the Degree of Master of Science in Microbiology. Bangkok, Kasetsart University 1974, 65p., tables; bibliog.; Engl. summ.
807. ULLOA, Miguel, HERRERA, Teofilo and TABOADA, Javier. *Saccharomyces cerevisiae* and *Saccharomyces uvarum* isolated from different samples of tesquino from the State of Jalisco, Mexico (In Span.) *Bol. Soc. Mexicol. Micol.*, 0 (11), 1977: 15-22, Engl. summ. The identification of 2 spp. of *Saccharomyces*, *S. cerevisiae* and *S. uvarum*, isolated from 2 different samples of tesquino (alcoholic beverage produced by fermentation of maize kernels) from the State of Jalisco,

- Mexico, was discussed. The constancy in tesguino of the 1st species is mentioned, and the 2nd species is reported for the 1st time in this fermented beverage.  $N_2$  fixation, as shown by the acetylene reduction test, was registered in a sample of tesguino from Guadalajara. In the other sample studied, from La Barca, the acetylene reduction test was negative. - Biol. Abstr. 70, 1980.
808. VALENTINE, R.C. High energy cost of biological nitrogen fixation. *Proceedings - Annual California Fertilizer Conference*, vol. 26th, 1978, p.75.
809. VAN BERKUM, P. Evaluation of acetylene reduction by excised roots for the determination of nitrogen fixation in grasses. *Soil Biology and Biochemistry*, 12 (2), 1980: 141-146. Prolonged pre-incubation of excised sorghum [*Sorghum vulgare* cv. Redlan] roots increased the rates of nitrogenase activity. Damage of nitrogenase by  $O_2$  is unlikely to cause a prolonged delay before  $C_2H_2$  reduction. Washing the collected roots with distilled water to prevent dessication and pre-incubating them at  $30^\circ C$  caused proliferation of the  $N_2$ -fixing microflora and synthesis of nitrogenase. Growth of the  $N_2$ -fixing microflora also occurred under  $C_2H_2$  during the inactive period. The length of time before nitrogenase activity commenced was probably related to the initial concentration of available combined N.  $C_2H_2$  reduction measurements with the excised grass roots tested overestimate the rates of  $N_2$  fixation. The possible causes for the prolonged period before detection of nitrogenase activity by excised grass roots are discussed. - Biol. Abstr. 70, 1980.
810. VAN BRUSSEL, A.A.N. The wall of *Rhizobium leguminosarum* in bacteroid and free-living forms. *Journal of General Microbiology*, 101 (1), 1977: 51-56, ref.
811. VAN BRUSSEL, A.A.N., COSTERTON, J.W. and CHILD, J.J. Nitrogen fixation by *Rhizobium* sp. 32H1: A morphological and ultrastructural comparison of asymbiotic and symbiotic nitrogen-fixing forms. *Canadian Journal of Microbiology*, 25 (3), 1979: 352-361, Engl. summ. The induction of nitrogenase ( $C_2H_2$ ) activity in asymbiotically cultured *Rhizobium*

sp. 32H1 was associated with morphological changes in the cells, which were more pronounced than those seen in bacteroids. Polyphosphate granules were found in both bacteroids and cultured cells, but poly- $\beta$ -hydroxybutyrate vesicles were almost absent in bacteroids but were present in cultured cells. Freeze-etching techniques revealed no differences between the asymbiotically cultured  $N_2$ -fixing forms and bacteroids in that both the cell wall and cytoplasmic membrane cleavage planes were normal for gram-negative bacteria. - Biol. Abstr. 68,1979.

812. VANCE, C.P. and JOHNSON, L.E.B. Nodulation: a plant disease perspective (Biological nitrogen fixation, Rhizobium). *Plant Diseases*, 65 (2), 1981: 118-124, illus.; ref.
813. VANCE, Carroll P., HEICHEL, Gary H., BARNES, Donald K., BRYAN, Jeff W. and JOHNSON, Loise E. Nitrogen fixation, nodule development and vegetative regrowth of alfalfa (*Medicago sativa*) following harvest. *Plant Physiology*, 64 (1), 1979: 1-8. Nitrogenase-dependent acetylene reduction, nodule function and nodule [*Rhizobium meliloti*] regrowth were studied during vegetative regrowth of harvested (detopped) alfalfa (*M. sativa* L.) seedlings grown in the glasshouse. Compared with controls, harvesting caused an 88% decline in acetylene reduction capacity of detached root systems within 24 h. Acetylene reduction in harvested plants remained low for 13 days, then increased to a level comparable to the controls by day 18. Protease activity increased in nodules from harvested plants, reached a maximum at day 7 after harvest and then declined to a level almost equal to the control by day 22 after harvest. Soluble protein and leghemoglobin decreased in nodules from harvested plants in an inverse relationship to protease activity. Nitrate reductase activity of nodules from harvested plants increased significantly within 24 h and was inversely associated with acetylene reduction. The difference in nitrate reductase between nodules from harvested plants and control plants became less evident as shoot regrowth occurred and as acetylene reduction increased in the harvested plants. No massive loss of nodules occurred after harvest as evidenced by little net change in nodule fresh weight. There was a rapid localized senescence which

occurred in nodules of harvested plants. Histology of nodules of harvested plants. Histology of nodules from harvested plants showed that they degenerated at the proximal end after harvest. Starch in the nodule was depleted by 10 days after harvest. The meristem and vascular bundles of nodules from harvested plants remained intact. The senescent nodules began to regrow and fix N after shoot growth resumed. - Biol. Abstr. 69,1977.

814. VANGNAI, S., PORNTAVEEVATANA, S. and SUWANNARONG, K. Economic growth media for mass production of some strains of *Rhizobium japonicum*. *Thai Journal of Agricultural Science*, 12(1), 1979: 17-26, graphs; tables; ref.; Engl. summ. New growth media for the mass production *Rhizobium japonicum* strains S-18, UB-138, UB-80 and UB-8T, effective in fixing nitrogen with soya bean variety SJ2, are proposed. They are obtained by substituting some of the components of the conventional yeast extract mannitol medium with materials such as cane sugar and baker's yeast which are readily available in Thailand. Mineral contents required for optimal growth of these strains of organisms are also adjusted. The new media are markedly cheaper than the conventional medium. - Abstr. on Trop. Agri. 6,1980.
815. VANGNAI, Somsak and PANOMTORANITKUL, Mattika. Improvement of soybean and peanut yields by the use of *Rhizobium*. Kasetsart University Research Reports 1974-1975. Bangkok, Kasetsart University, 1976, p.5-6. In 1973-1974, two experiments were separately conducted. The first was designed to evaluate factor requirements of soybean grown after rice in the paddy soils. The second was to test the effects of some low-cost raw-materials, substituted for carbon source of the complete medium using for mass culture production of *Rhizobium* on abilities to form nodule and to fix nitrogen by the bacteria. Results of the first experiment indicated that optimal growth and yield of soybean (S.J. 2) grown in Sapphaya and Roi-Et soils were substantial when the seeds were inoculated (with *Rhizobium japonicum* strain Soil-18) and planted in the rice stubble without liming and fertilizer application. Results of the second experiment indicated that several raw-materials could be used as carbon source for

mass culture production of Rhizobium, among these cane sugar was considered the most proper one. Cells produced by using the cane-sugar substituted medium were also found to be as active, in modulation and nitrogen fixation, as those from the complete medium.

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818. VENKATASAMY, D.R. and PEERALLY, M.A. Seasonal changes in the nitrogen fixing activity of *Phaseolus vulgaris* cv. Long Tom. *Revue Agricole et Sucrière de l'île Maurice*, 60 (1), 1981: 5-9, ref.; Engl. summ. In pot trials nodule development, leghaemoglobin build-up, dry matter production and N accumulation in *P. vulgaris* cv. Long Tom inoculated with an effective strain of *Rhizobium phaseoli* were studied. Pink nodules appeared on day 12 after germination, indicating that this cultivar was a late nodulator. A steep rise in leghaemoglobin content of nodules occurred from day 12 to day 39 and was followed by a period of c. 10 days when leghaemoglobin content was constant after which it declined. N-fixing activity increased until day 29 (at flowering) and continued until day 39 (at pod filling) and then decreased. Peak N-fixing activity occurred between days 29 and 39. Long Tom had a comparatively short N-fixing cycle lasting about a month. Such a short cycle did not permit the fixation and accumulation of sufficient N in the plant for medium pod production. Hence supplementation with mineral N was necessary between germination and pod filling. - Abstr. on Trop. Agri. 8, 1982.



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820. VENKATARAMAN, G.S. Algal inoculation in rice fields. In: Proceedings - Symposium on Nitrogen and Rice. Los Baños, International Rice Research Institute, 1979, pp. 311-321, illus.; graph; tables; ref.; summ. This paper discusses the use of the free-living N<sub>2</sub> fixing blue-green algae (BGA) as a biofertilizer in a rice production programme. Blue-green algae represent a self-supporting system, since they can photosynthetically provide the energy required for N<sub>2</sub> fixation. Extensive field trials in recent years have shown that: (1) in areas where chemical N fertilizers are not used for various reasons algal inoculation can give the farmers the benefit of applying 25-30 kg N/ha; (2) where N fertilizers are used, the dose can be reduced by about one-third through algal supplementation; and (3) even at high levels, algal complementation has a beneficial effect. The cost-benefit ratio of algal biofertilizer is quite lucrative and within the reach of average farmers.- Abstr. on Trop. Agri. 7,1981.
821. VENKATARAMAN, G.S. Blue-green algae for rice production: a manual for its promotion. Rome, FAO, 1981, 110p., illus.; tables; bibliog. (FAO Soil Bulletin no. 46) This manual, the first in a series on practical aspects of various methodologies of organic recycling, presents detailed information on the development and use of blue-green algae in rice production, with special reference to India, where the technology is currently being used by many rice farmers. If properly extended, the technology may provide 25 to 30 kg N/ha every season to the growing crop. The appendices of this manual present scientific background information. - Abstr. on Trop. Agri. 7,1981.
822. VERMA, D.P.S., HAUGLAND, R., BRISSON, N., LEGOCKI, R.P. and ZACROIX, L. Regulation of the expression of leghaemoglobin genes in effective and ineffective root nodules of

soybean. *Biochimica et Biophysica Acta Nucleic Acids and Protein Synthesis*, 653 (1), 1981: 98-107, ref. The expression of leghaemoglobin genes in effective and ineffective (unable to fix nitrogen) root nodules of soybean developed by *Rhizobium japonicum* strains 61A76, 61A24 and SM5 was measured by using a cDNA probe or a cloned leghaemoglobin sequence and in vitro translation of Lb-mRNA. Hybridization of the poly(A)-containing nodule polysomal RNA from 3-week-old nodules with a kinetically purified Lb-cDNA or with plasmid (pLB1) containing a leghaemoglobin sequence showed that Lb-mRNA is present in ineffective nodules formed by strains SM5 and 61A24 at reduced levels. Of the two major classes of electrophoretically distinguishable leghaemoglobins in soybean, LbS was not synthesized in 3-week-old strain 61A24-induced nodules while both sorts of leghaemoglobin were synthesized and accumulated in ineffective nodules formed by strain SM5 of *Rhizobium*. Ineffective nodules formed by strain 61A24 are green inside and do not appear to accumulate leghaemoglobin as measured by the haemochromogen assay, although low levels of apoleghaemoglobin were detected using leghaemoglobin antibodies. SM5-induced nodules were found to have about half as much as leghaemoglobin of that of effective (61A76-induced) nodules. This study demonstrates that while the appearance of leghaemoglobin is independent of nitrogenase activity in bacteroids, its synthesis is influenced to different degrees both by a mutation (SM5) and incompatibility (61A24) of *Rhizobium*. The primary regulation appears to be at the level of transcription or processing of mRNA since ineffective nodules contain Lb-mRNA approximately in proportion to the amount of apoleghaemoglobin present in these nodules.

823. VIANDS, D.R., VANCE, C.P., HEICHEL, G.H. and BARNES, D.K. An ineffective nitrogen fixation trait in alfalfa (*Medicago sativa*). *Crop Science*, 19 (6), 1978: 905-908. An alfalfa (*M. sativa* L.) plant designated MnPL-480 formed large, white nodules incapable of fixing atmospheric N when grown in association with 5 strains of *Rhizobium meliloti* Dang. in nil-nitrate greenhouse sand culture. Under the same conditions, control plants capable of fixing atmospheric N were vigorous, dark green and had pink

corraloid nodules. To verify the ineffectiveness of the *Rhizobium*-MnPL-480 association, cuttings from control plants and from MnPL-480 were compared for both physiological and histological characteristics. MnPL-480 was self-pollinated and cross-pollinated with control plants having functional nodules to determine if the ineffective association was a heritable trait. Acetylene reduction rates and nodule leghemoglobin concentrations were zero in MnPL-480. Forage and root dry weights of control plants were both about 5-fold greater than those of MnPL-480. N concentrations in forage and shoots of control plants were 1.5-fold greater than those of MnPL-480. However, nodule fresh weight and root nonstructural carbohydrates were greater in MnPL-480 than in controls. Histological examinations of MnPL-480 nodules showed only a few cells that contained bacteroids. Bacteroids that were found in MnPL-480 nodule cells apparently underwent rapid senescence. Nodules collected from MnPL-480 showed larger numbers of starch granules than nodules from control plants. MnPL-480 formed white, ineffective nodules with 5 *Rhizobium* strains tested in Leonard jar culture. Progenies from self-pollination of MnPL-480 produced only ineffective nodules. F<sub>1</sub> progenies from crosses of control plants and MnPL-480 produced functional nodules, thereby indicating that the ineffective association was a heritable (probably recessive), host-conditioned trait. The MnPL-480 ineffective trait should be useful in studying the morphogenesis of alfalfa nodules, the genetic control of N fixation by the host, and the N economy of the alfalfa plant. - Biol. Abstr. 70,1980.

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application of these materials on plant growth, nutrient uptake, microbiological and chemical properties of soils and crop yields, and the use of bacterial fertilizers, blue-green algae and *Azolla* are discussed. Considerable attention is being given in India to the development of programmes like mechanized composting, sewage sludge utilization, biogas popularization, cultivation of legumes, production of urban and rural compost and use of bacterial and biofertilizers. - Abstr. on Trop. Agri. 8,1982.

825. VINCENT, J.M., WHITNEY, A.A. and BOSE, J., eds. Exploiting the Legume-Rhizobium Symbiosis in Tropical Agriculture. Proceedings of a workshop held at Kahului, Maui, Hawaii, 23-28 August 1976. University of Hawaii, College of Tropical Agriculture, Miscellaneous Publication no. 145, 1977, 483p., illus.; graphs; map; tables; bibliog.; summ. These proceedings record the presentations and discussion sessions of an international workshop sponsored by the University of Hawaii project to promote Nitrogen Fixation by Tropical Agricultural Legumes (NifTAL). The project is administered by the Department of Agronomy and Soil Science of the University. The workshop is part of the overall NifTAL Project, which includes a range of research, training and service programmes designed to assist Rhizobium and legume workers throughout the tropics. Most of the papers will be abstracted separately in ATA. - Abstr. on Trop. Agri. 6,1980.
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829. VONDRYS, J. and BIEDERMANNNOVA, E. Seasonal variation in symbiotic nitrogen fixation by broad bean (*Faba vulgaris* L.) estimated by means of the acetylene reduction method (In Cs). *Rostlinna Vyroba - UVTIZ*, 26 (10), 1980: 1031-1039, graphs; tables; ref.; Engl. summ.
830. VRIES, G.E.de, VELD, P. in't and KIJNE, J.W. Production of organic acids in *Pisum sativum* root nodules as a result of oxygen stress. *Plant Science Letters*, 20 (2), 1980: 115-123, ref. Higher specific activities of phosphoenolpyruvate carboxylase (PEPC), malate dehydrogenase (MDH) and alcohol dehydrogenase (ADH) were found in root nodule tissue than in root tissue from *Pisum sativum* plants, inoculated with *Rhizobium leguminosarum*. ADH from root nodule tissue possessed a higher affinity towards acetoaldehyde than ADH from root tissues. Dynamic changes in properties and specific activities of these enzymes could be demonstrated in root tissue by restriction of aeration. Accumulation of malic acid, the first stable product of C(,2) dark fixation, resulting in a considerable concentration of L-malate in root nodules and the rapid uptake of C(,4)-dicarboxylic acids by isolated bacteroids are discussed in relation to the energy demand of *R. leguminosarum* during nitrogen fixation in symbiosis.
831. WAGNER, G.H., KASSIM, G.M. and MARTYNIUK, S. Nodulation of annual *Medicago* by strains of *R. meliloti* in a commercial inoculant as influenced by soil phosphorus and pH. *Plant and Soil*, 50 (1), 1978: 81-89, graphs; tables; ref.; summ. Four species of annual medics showed poor growth and little or no nodulation in an inoculated, acid soil low in available phosphorus. Nodulation was significantly increased by adding

phosphorus to the soil. The number of nodules found on the roots of each species was approximately the same for soil at pH 5.5 or 6.8. A commercial inoculant of *Rhizobium meliloti* was adequate for nodulation of all four species and two strains of rhizobia predominated in the nodules which were assayed by immunodiffusion. - Abstr. on Trop. Agri. 5,1979.

832. WAHAB, A., ABDEL, M. and EL-SHAROUNY, H.M. Nitrogen-fixing *Bacillus* spp. from Egyptian soils: Acetylene reduction and cultural conditions. *Plant and Soil*, 51 (2), 1979: 187-196. Among 390 isolates from Egyptian soils initially grown on Brown's N-free agar, 15 facultative *Bacillus* isolates were able to reduce acetylene in Stanier's N-poor broth under both aerobic and anaerobic ( $N_2$  atmosphere) conditions. Some of these isolates were Gram-positive, with unswollen sporangia and thin-walled endospores. Other strains were with slightly or definitely bulged sporangia. Yeast extract (0.01%) was essential for growth stimulation and  $N_2[C_2H_2]$  fixation by these isolates. Replacing yeast extract with 20  $\mu\text{g/ml}$   $(NH_4)_2SO_4$  or biotin, thiamine and amino acids (singly or in combination) resulted in stimulation of growth and  $N_2[C_2H_2]$  fixation, though at lower rates than in yeast extract. One isolate was able to grow and reduce  $C_2H_2$  in Stanier's N-free liquid medium. Nitrogenase [ $C_2H_2$ ] activity of the anaerobically grown and incubated cultures was greater than aerobic cultures. Addition of 0.1%  $CaCO_3$  to the culture media significantly increase and  $O_2$  partially inhibited,  $N_2[C_2H_2]$  fixation by these *Bacillus* isolates. Studies of the characteristics and  $N_2[C_2H_2]$  fixing activities of these isolates indicate that at least some of them are new N-fixing *Bacillus* spp. - Biol. Abstr. 69,1979.
833. WAHUA, T.A.T. and MILLER, D.A. Effects of intercropping on soybean  $N_2$ -fixation and plant composition on associated sorghum and soybeans. *Agronomy Journal*, 70 (2), 1978: 292-295, graphs; tables; ref.; summ. In a field trial, soya bean was grown alone or intercropped with a semi-dwarf and a tall sorghum cultivar each at 16 population densities (1.38 to 33 plants/ $m^2$ ). Intercropping with the tall cultivar significantly reduced nitrogen fixation by soya bean. The reverse was true with the semi-dwarf cultivar. Both cultivars

reduced soya bean dry matter and seed oil contents, but had no effect on soya bean seed protein and leaf nitrogen contents. Effects of the treatments on nodule number, nodule weight and nodule activity are discussed. Protein yield (kg/ha) of intercropped tall and semi-dwarf sorghum was reduced by 15 and 71% respectively. Only intercropping with the semi-dwarf cultivar increased sorghum grain protein by 15%. Intercropping had no effect on sorghum grain oil content. - Abstr. on Trop. Agri. 4, 1978.

834. WAIDYANATHA, U.P.De S., PATHIRATNE, L.S.S. and ARIYARATNE, W.A. Studies on inoculation of cover legumes for improving nitrogen fixation. *Journal of the Rubber Research Institute of Sri Lanka (RRISR)*, 54 (1), 1977: 284-290, tables; ref.; summ. Many rhizobial strains were screened for their nodulating ability against *Pueraria*, *Centrosema*, *Calopogonium* and *Desmodium* spp. using seedlings grown in nutrient agar. *Pueraria* and *Calopogonium* spp. formed effective nodules and fixed nitrogen in sterile sand culture with most of the strains that produced nodules on them in nutrient agar. Inoculation of seeds with some effective strains improved growth of *Pueraria* in pots but not in the field. This is probably due to natural populations of rhizobia in the soil which were able to successfully compete with the introduced strains in nodulating on the legume. There was evidence that indigenous rhizobia themselves formed effective nodules and fixed nitrogen. - Abstr. on Trop. Agri. 5, 1979.
835. WAIDYANATHA, U.P.D.S., YOGARATNAM, N. and ARIYARATNE, W.A. Mycorrhizal infection on growth and nitrogen fixation of *Pueraria* and *Stylosanthes* and uptake of phosphorus from two rock phosphate. *New Phytology*, 82 (1), 1979: 146-152. Growth and nodulation of *Pueraria* and *Stylosanthes*, and also nitrogenase activity of *Pueraria* grown in methyl bromide treated soil were severely retarded unless the plants were infected with vesicular-arbuscular (VA) mycorrhiza or given large amounts (500 mg/kg of soil) of rock phosphate. Added rock phosphate further stimulated growth, nodulation and nodule activity of mycorrhizal plants. Mycorrhizae also enhanced uptake of P, which was increased further by the addition of rock phosphate. The

comparative levels of P in plants and growth responses were clearly different with respect to the 2 sources of rock phosphate in both mycorrhizal and non-mycorrhizal plants. These observations refer in particular to *Pueraria*; the treatment effects being less pronounced with *Stylosanthes* as the uninoculated plants were naturally contaminated with mycorrhizae, but to a lesser degree than those inoculated. - Biol. Abstr. 68,1979.

836. WANGNAI, Somsak, CHINTAKANON, Suradet, SOMSUT, Mangkon, KANCHANASOEM, Chawalit and CHANKHONG, Wanna. Strains of *Rhizobium* effective on some leguminous plants. In: Proceedings of the National Conference on Agricultural Sciences, 7th Session, Plant and Biological Sciences, at Kasetsart University January 29 - February 1, 1968, (In Thai). Bangkok, Kasetsart University, 1968, pp.109-110, Engl. summ. Pure *Rhizobium* strains from nodules of various leguminous plants collected from different parts of the country, were isolated in the laboratory and reinoculated into soybean, mung bean, peanut and crotalaria planted in sand culture. Crone's solution was used in the sand culture. The *Rhizobium* strain isolated showed similar characteristic, namely colorless colony about 0.3-1.0 mm. in size after one week of incubation, rod-shape each cell being 0.5-1.0  $\mu$  by 1.0-3.0  $\mu$  in size and gram negative. The strains isolated from soybean obtained from Prabhudhabat and Saraburi gave the best result with regard to dry weight, nodule count, nitrogen content and total nitrogen of the inoculated plants.
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838. WATANABE, I. Biological nitrogen fixation by *Azolla-Anabaena* symbiosis and its use in agriculture (In Japan). *Journal of the Science of Soil and Manure*, 52 (5), 1981: 455-464, ref.



839. WATANABE, I. Biological nitrogen fixation in paddy field - Current studies in IRRI (International Rice Research Institute) Soil Microbiology Department. In: FAO/SIDA Workshop on the Use of Organic Materials as Fertilizers in Asia on Organic recycling in Asia, Bangkok (Thailand), 26 October - 5 November 1976. FAO, Rome (Italy). Land and Water Development Division. Rome, FAO, 1978, p.373. (FAO Soils Bulletins no. 36)
840. WATANABE, Iwao and CABRERA, Delfin R. Nitrogen fixation associated with the rice plant grown in water culture. *Applied Environmental Microbiology*, 37(3), 1979: 373-378. Acetylene reduction activity of intact rice plants was measured in closed assay chambers with plants grown in water culture. Acetylene was added to the liquid medium, and the ethylene formed was measured from both gas and liquid phases. After cutoff of mineral N supply and inoculation of fresh soil, rice plants grown from the seedling stage in water culture exhibited acetylene reduction activity after a lag period. However, in rice plants grown in a paddy field and transferred to water culture were more suitable for [microbial]  $N_2$  fixation studies because of their higher, less variable acetylene reduction activity. The time course of acetylene reduction was monitored by continuous circulation of gas between the gas phase and the liquid phase, and the result showed an initial 2 or 3 h period of lower activity, followed by increased and almost constant activity up to 24 h. The effects on acetylene reduction activity of aeration, ammonium, chloramphenicol, and 3-(3, 4-dichlorophenyl)-1, 1-dimethylurea addition are reported. Ammonium was inhibitive at 0.33 mM, and its depressive effect was alleviated by ammonium uptake by the plants. - Biol. Abstr. 69,1979.
841. WATANABE, Iwao, BAI, K.Z. and BERJA, N.S. The *Azolla-Anabaena* complex and its use in rice culture. Los Baños, International Rice Research Institute, 1981, 11p., illus.; tables; ref.; summ. (IRRI Research Paper Series no. 69) This paper presents results of recent research with the symbiosis of *Azolla* and the alga *Anabaena*. The rate of nitrogen fixation in the *Azolla-Anabaena* symbiosis rivals

that in the Rhizobium-legume symbiosis. More than 50 strains of 5 *Azolla*-species, collected from all over the world, are maintained at IRRI. Screening tests showed that no strain was satisfactorily tolerant of high temperatures in the dry season. Preliminary studies on the conditions needed for *Azolla* sporulation were made. Differences in *Azolla*'s growth with limited phosphorus were observed among strains and species. The mineralization rate of nitrogen fixed by the *Azolla-Anabaena* complex was also different among species and strains. *Azolla* has an ability to fix as much as 1.5 kg N/ha daily or 5000 kg N/ha annually in a paddy field. - Abstr. on Trop. Agri. 8,1982.

842. WATANABE, Iwao, BARRAQUIO, Wilfredo L., DE GUZMAN, Marcelino R. and CABRERA, Delfin A. Nitrogen-fixing (acetylene reduction) activity and population of aerobic heterotrophic nitrogen-fixing bacteria associated with wetland rice. *Applied Environmental Microbiology*, 37(5), 1979: 83-819. N-fixing activity associated with wetland rice varieties was measured at various growth stages by an in situ acetylene reduction method after the activities of blue-green algae (cyanobacteria) in the flood water and on the lower portion of the rice stem were eliminated. N-fixing activities associated with rice varieties differed with plant growth stages. The activities increased with plant age and the maximum was about at heading stage. The N fixed during the whole cropping period was estimated at 5.9 kg of N/ha for variety IR26 (days) and 4.8 kg of N/ha for variety IR36 (95 days). The population of aerobic heterotrophic N<sub>2</sub>-fixing bacteria associated with rice roots and stems was determined by the most-probable-number method, using semisolid glucose-yeast extract and semisolid malate-yeast extract media. The addition of yeast extract to the glucose medium increased the number and activity of aerobic heterotrophic N<sub>2</sub>-fixing bacteria. The glucose-yeast extract medium gave higher counts of aerobic N<sub>2</sub>-fixing bacteria associated with rice roots than did the malate-yeast extract medium, on which *Spirillum*-like bacteria were usually observed. The lower portion of the rice stem was also inhabited by N<sub>2</sub>-fixing bacteria and was an active site of N<sub>2</sub> fixation. - Biol. Abstr. 68,1978.

843. WATANABE, Iwao. Biological nitrogen-fixation in (Philippines) rice soils. In: International Rice Research Institute Symposium on Soils and Rice, draft papers, College, Laguna (Philippines), 20 September 1977. College, Laguna (Philippines) International Rice Research Institute, Vol. 3, 1977, pp.127-161, tables; bibliog.; ref.
844. WATANABE, Iwao, ESPINAS, C.R., BERJA, N.S. and ALIMAGNO, B.V. Utilization of the *Azolla-Anabaena* complex as a nitrogen fertilizer for rice. Los Banos, Laguna, International Rice Research Institute, 1977, 16p., illus.; tables; ref.; summ. (IRRI Research Paper Series no. 11) With N fixing blue-green algae (*Anabaena azollae*) in its fronds, *Azolla* grows on a N-free solution, doubles its mass in 3-5 days, and accumulates 30-40 kg of N/ha in 2 weeks. Ca or P deficiency in the *Azolla* culture solution severely reduces growth. The optimum solution pH for *Azolla* is 5.5; a higher pH produces Fe deficiency. A temperature higher than 31°C (35° day - 27° night), causes reddish-brown discoloration and reduces vigor. N in *Azolla* is slowly mineralized in a submerged soil; about 75% of total N mineralizes in 6-8 weeks. Pot experiments reveal that N in dried *Azolla* increases rice growth, but its availability to rice is 40% lower than that of ammonium fertilizer N. In the rice paddy, *Azolla* is easily multiplied. Five crops of *Azolla* (Oct. to Jan.) produced a total of 117 kg N/ha in 106 days. P fertilizer was effective in promoting abundant growth. *Azolla* is a self-supplying N fertilizer source in wetland rice growing. - Abstr. on Trop. Agri. 4,1978.
845. WATANABE, Iwao, LEE, Kuk-ki, ALIMAGNO, B.V., SATO, M., DEL ROSARIO, D.C. and DE GUZMAN, M.R. Biological nitrogen fixation in paddy field study by in situ acetylene-reduction assays. Los Banos, Laguna, International Rice Research Institute, 1977, 17p., illus.; tables; ref.; summ. (IRRI Research Paper Series no. 3) To assess the contribution of blue-green algae and the rice root zone to N fixation in the submerged rice soil, an in situ acetylene-reduction assay technique was developed at IRRI. In unfertilized plots, in situ acetylene-reduction activity was highest late in the growing season, in both wet and dry-season crops, when the activity of blue-green

- algae in flood water was highest. By replacing flood water with distilled water, to eliminate the bulk of algal activity, the contribution of blue-green algae to the N fixing process was assessed. When algal growth was visible in the field, nitrogenase activity of the assay system decreased sharply after water replacement. Nitrogenase activity estimated by the in situ assay technique fluctuated greatly with the activity of blue-green algae. Nitrogenase activity in the rice root zone was at an almost constant but low rate. - Abstr. on Trop. Agri. 4,1978.
846. WATANABE, Iwao, LEE, Kuk-ki and DE GUZMAN, Marcelino. Seasonal changes of  $N_2$  fixation rate in rice field assayed by in situ acetylene reduction technique: II. Estimate of nitrogen fixation associated with rice plants. *Soil Science and Plant Nutrition*, 24 (4), 1978: 465-472. A technique to estimate the quantity of  $N_2$  fixed in the flooded water on the rice field and in association with the rice plant is described. Removal of the flood water and the surface soil and addition of fresh water eliminated the bulk of  $N_2$  fixation associated with the blue-green algae. After the algal activity was eliminated, the acetylene reduction activity was higher in planted soils than that in fallow soils. Some  $N_2$  fixation was associated with the presence of the rice plant. In an IRRI [International Rice Research Institute, Philippines] unfertilized flooded rice field, algal acetylene reduction activity was  $200 \text{ mmol } C_2H_4/m^2$  in the wet season (163 days) and  $300 \text{ mmol } C_2H_4/m^2$  in the dry season (168 days). Acetylene reduction activity associated with the rice plant (IR26) was  $90 \text{ mmol } C_2H_4/m^2$  in wet season (163 days) and  $50 \text{ mmol } C_2H_4/m^2$  in the dry season (168 days, IR36). Similar rates were obtained at a 2nd site in the Philippines.  $N_2$  fixation was associated with stems and roots of wetland rice. - Biol. Abstr. 68,1978.
847. WATANABE, Iwao, VENTIURA, W. and CHOLITKUL, W. Potential of biological nitrogen fixation in deep water. In: Proceedings of the 1981 International Deepwater Rice Workshop. International Rice Research Institute, College, Laguna/Ministry of Agriculture and Cooperatives, Department of Agriculture, Bangkok 2-6 November 1981. College, Laguna, International Rice Research Institute, 1982, pp.191-200.

Direct evidence of  $N_2$ -fixation associated with deepwater rice was obtained by exposing deepwater rice to  $15N_2$  gas for 9 days. Higher enrichment of  $15N$  from molecular nitrogen was found in the aquatic root and leaf sheath where blue-green algae grow epiphytically. Eight mg N/plant was fixed during this period and about 40% of fixed nitrogen was found at maturity in the portions not directly exposed to  $15N_2$ .

848. WATERS, Luther Jr., BREEN, Patrick J. and MACK, Harry J. Translocation of carbon-14 labeled-photosynthate, carbohydrate content, and nitrogen fixation in *Phaseolus vulgaris* cultivar Puelba 152 during reproductive development. *Journal of American Society of Horticultural Science*, 105 (3), 1980: 424-427. Leaves at nodes 4 or 8 of greenhouse grown beans, *P. vulgaris* L., cv. Puelba 152, were briefly exposed to  $^{14}CO_2$  at 35, 48, 63 or 70 days after planting. Prior to flowering, over 85% of the recovered  $^{14}C$ -activity translocated in 24 h from node 4 was in roots, nodules and lower stem. At flowering, radioactivity translocated to the lower stem decreased but correspondingly increased in nodules. Roots sequestered 45% of translocated- $^{14}C$  throughout the life of the node-4 leaf. About 80% of the  $^{14}C$ -activity exported from node 8 at flowering was in middle and upper stem sections, but during pod-fill over 85% moved into the pods and less than 1% to the nodulated root system. Starch concentration in the lower stem increased continuously from flowering, but in other plant parts declined after early pod-fill. At mid pod-fill, the concentration of soluble sugars in nodules and roots declined and reached a common value in stem sections. Nitrogen ( $C_2H_2$ ) fixation decreased rapidly after peaking at early pod-fill. This decline, which was accompanied by loss of lower leaves, occurred in the presence of a high concentration of starch in the stem. - Biol. Abstr. 70,1980.

849. WATERS, Luther Jr., GRAHAM, Peter H., BREEN, Patrick J., MACK, Harry J. and ROSAS, Juan C. The effect of rice-hull mulch on growth, carbohydrate content and nitrogen fixation in *Phaseolus vulgaris*. *HortScience*, 15 (2),

1980: 138-140. Mulching 'Puebla 152' beans with rice hulls to a depth of 4 cm reduced afternoon soil temperature, soil temperature fluctuation, and slowed the loss of soil moisture. These effects were greatest prior to canopy closure. Freshweight of nodules, roots, stems, leaves and total plant increased 50, 38, 49, 24 and 38%, respectively, with mulching, but pod and final seed weight were unaffected. Mulching had little effect on the concentration of soluble and insoluble carbohydrates.  $N_2$  fixation rates ( $C_2H_2$  reduction) were low ( $\leq 0.6 \mu\text{mol/plant} \cdot \text{h}^{-1}$ ) but were as much as 3 times higher in mulched than unmulched plants. - Biol. Abstr. 70,1980.

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853. WERNER, D. Dinitrogen fixation and primary production (In Ger.). *Angewandte Botanik*, 54 (1/2), 1980: 67-76, Engl. summ. The ecological and economical relevance of biological N<sub>2</sub> fixation is emphasized by comparing world wide industrial N-fertilizer production of 46 million metric ton/yr in 1977 with the biological production of between 100 and 200 million metric ton/yr. At present, only about 20-30% of the biological N<sub>2</sub> fixation is used directly in the agricultural economy, mainly by legumes. Contributions of basic research to improve this rate in the near future by physiological and biotechnological methods are: screening and breeding for new N<sub>2</sub> fixing organisms and associations, selection of high efficiency *Rhizobium* strains and legume varieties in the development of the symbiosis, utilization of H<sub>2</sub> recycling N<sub>2</sub> fixing strains. Associations such as the *Azospirillum*-grass and the *Azolla*-rice ecosystem. - Biol. Abstr. 70,1980.
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optimum nitrogen fixation double that of the control, a pod yield increased by 45% and a haulm yield increased by 83%. - Abstr. on Trop. Agri. 5,1979.

856. WHITTON, Brian A., DONALDSON, Alan and POTTS, Malcolm. Nitrogen fixation by *Nostoc* colonies in terrestrial environments of Aldabra Atoll, Indian Ocean. *Phycologia*, 18(3), 1979: 278-287. The rates of acetylene reduction were compared in situ for 6 different types of terrestrial and semi-aquatic *Nostoc* colonies on Aldabra as an indication of their rates of N fixation. The rates per unit chlorophyll [chl] *a* were all rather similar during standard assays in mid- to late morning, with a mean rate of  $C_2H_4$  production for all experiments of  $0.0388 \text{ nM } C_2H_4 \mu\text{g}^{-1} \text{ chl } a^{-1} \text{ min}^{-1}$ . The rates for *Nostoc* colonies were at least 10 times those for mature cushions of *Tolypothrix byssoidea*. Marked variation in rates of  $C_2H_4$  production occurred throughout the day, with the peak rates occurring in early afternoon. Three of the types of *Nostoc* were re-wetted in the laboratory 1 yr after they had been dried. All showed high rates of  $C_2H_4$  production after a lag of up to 1 day. The lag was much shorter in a population of *N. commune* freshly collected in England. Colonies of *Nostoc* are apparently especially suitable for comparative studies of N fixation in different parts of the world, in view of the ease with which viable colonies can be stored for later extraction of chlorophyll or laboratory experiments. - Biol. Abstr. 69,1979.
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- 0.545  $\mu\text{M}$   $\text{CdCl}_2$  decreased nitrogenase activity 6-31%. When non-nodulated *A. rubra* seedlings were inoculated in the presence of 0.054 and 0.109  $\mu\text{M}$   $\text{CdCl}_2$ , N fixation decreased 52 and 89%, respectively. Plant growth decreased in a similar fashion. When non-nodulated seedlings were given 0.545  $\mu\text{M}$   $\text{CdCl}_2$  and 6 mM  $\text{NH}_4\text{NO}_3$  or  $\text{Ca}(\text{NO}_3)_2$ , nitrate reductase activity decreased 22 and 24%, respectively, when compared to plants receiving no  $\text{CdCl}_2$ . N accretion and plant dry weights were decreased by  $\text{Cd}$  treatments in which plants were supplied with  $\text{Ca}(\text{NO}_3)_2$  and 0.273 and 0.545  $\mu\text{M}$   $\text{CdCl}_2$ , when compared to controls without  $\text{CdCl}_2$ . Cd apparently can inhibit, nitrogenase activity and therefore N fixation. Growth, nodulation and nitrate reductase activity are also inhibited by Cd. - Biol. Abstr. 70,1980.
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1979: 43-44. White clovers (*Trifolium repens* L.) from the trial sites at Kaikohe Manutuke, Wairakei, Palmerston North and Gore were predominantly 'Grasslands Huia' types. Plants from Kirwee were larger leaved than commercial 'Huia', while populations from Masterton, Ballantrae and Kairanga were about 50% 'Huia' and 50% smaller leaved, more prostrate types of non-pedigree origin. - Biol. Abstr. 69,1979.

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863. WILSON, John T., GREENE, Sarah and ALEXANDER, Martin. Effect of interactions among algae on nitrogen fixation by blue-green algae (cyanobacteria) in flooded soils. *Applied Environmental Microbiology*, 38(5), 1979: 916-921. Nitrogen fixation ( $C_2H_2$  reduction) by algae in flooded soil was limited by  $C_2H_2$  interactions within the algal community. N fixation by either indigenous algae or *Tolypothrix tenuis* was reduced several-fold by a dense suspension of the green alga *Nephrocytium* sp. Similarly, interactions between the N-fixing alga (cyanobacterium) *Aulosira* 68 and natural densities of indigenous algae limited N-fixing activity in 1 of 2 soils examined. This was demonstrated by developing a variant of *Aulosira*

68 that was resistant to the herbicide simetryne at concentrations that prevented development of indigenous algae. More N was fixed by the resistant variant in flooded soil containing herbicide than was fixed in herbicide-free soil by either the indigenous algae or indigenous algae plus the parent strain of *Aulosira*. Interference from indigenous algae may hamper the development of N-fixing algae introduced into rice fields in attempts to increase biological N fixation. - Biol. Abstr. 69,1979.

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period had lowest seed yields. Flower and pod numbers of a particular stem order were reduced by water deficit imposed during flowering of that order and also when water stress occurred during previous growth stages. Water stress stimulated seed and pod growth rates which then declined when adequate water was re-applied. Vegetative growth rates from early-stressed plants recovered fully. The potential for recovery of seed yield from stress was not realized. *S. albus* seed yield is unlikely to recover from the effects of drought during a normal season. During the main seed-filling stage, N fixation supplied directly an estimated 33% of the seed N requirement in non-stressed plants. Leaves of these plants supplied an estimated 47% and pods contributed 15% of seed N requirement. For 2 late-stressed treatments, leaves supplied 21 and 32% of the seed N and pods supplied 44 and 32%. Some of this pod N may have been translocated from leaves which had senesced earlier. Most of the reserve N supplied to the seed arose directly or indirectly from the leaves. - Biol. Abstr. 69,1979.

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from the nitrate-grown plants weighed 71% less than nodules from the nitrate-free plants. Nitrate-grown plants also fixed much less N (measured by acetylene reduction) than the nitrate-free plants. When lentils were grown in a solution containing 15 mM nitrate and 75 mM fructose, glucose or sucrose, the N fixation activity of their nodules was similar to that of nodules from nitrate-free plants. Leaves of lentils grown in the nitrate-sugar solutions had only about 7% as much nitrate reductase activity and accumulated only 10% as much nitrate as leaves from lentils grown in the nitrate solution alone. Roots of lentils grown in the nitrate-sugar solutions had similar nitrate reductase activity but accumulated only 17-25% as much nitrate as roots from lentils grown in the nitrate solution. The added sugars may alleviate the inhibitory effects of nitrate on symbiotic N fixation not only by increasing the carbohydrate supply so that lentils could support both N fixation and nitrate reduction but also by inhibiting the accumulation of nitrate and, hence, lowering nitrate reductase activity in the leaves. - Biol. Abstr. 70,1980.

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associated with whole plant specimens of these species varied from 515-920 nmol C<sub>2</sub>H<sub>4</sub> / (g dry weight) x (6 days). Nitrogenase activity was associated with the rhizosheaths. *Bacillus polymyxa*-like N fixers were isolated from the rhizosheaths of each grass. The isolates reduced acetylene and assimilated <sup>15</sup>N<sub>2</sub>. - Biol. Abstr. 68,1979.

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to shading caused by the sugar-cane. N application to pigeon pea and to sugar-cane proved deleterious for nodule development in mung bean and black gram. Intercropping of black gram decreased cane yield compared with pure sugar-cane stands supplied with P. - Abstr. on Trop. Agri. 7, 1981.

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- fixing activity was increased from the 2nd level. Combinations of x1, x3 and x2, x3 did not give similar results. Combined application of the 3 factors accompanied by the increasing of their levels resulted in rapid development of the process of N fixation. - Biol. Abstr. 68,1978.
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field experiments in Japan gave the same results. Active biological  $N_2$  fixation is suggested as one of the main factors of the high fertility. Because  $N_2$  fixation is photosensitive, photosynthetic microorganisms, especially blue-green algae, seem to play an important role in paddy fields, although rhizospheric  $N_2$  fixation is also significant. Inoculation of N fixing blue-green algae to make good use of their  $N_2$  fixation activity involves a delicate technique, and its effect fluctuates with environmental conditions in Japan. More ecological considerations are needed to effect a stable increase in rice yield. Nitrogen fixation by *azolla* is easier to use because the inoculum is easier to establish in a rice field. - Abstr. on Trop. Agri. 7,1981.

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did not. Manganese could not be shown to be required for the biosynthesis of either nitrogenase or glutamine synthetase or for glutamine synthetase turnover, but it was required for the in vitro activation of  $N_2$ ases from  $N_2$  and glutamate-grown *R. rubrum* and *R. capsulata* cells.<sup>2</sup> Chromatium  $N_2$ ase, in contrast, was always fully active and did not require  $Mn^{2+}$  activation, suggesting that only the purple nonsulfur bacteria are capable of controlling their  $N_2$ ase activity by this new type of regulatory system. Although *R. rubrum* could not substitute  $Fe^{2+}$  for  $Mn^{2+}$  in the in vivo  $N_2$  fixation process,  $Fe^{2+}$  and to a lesser extent  $Co^{2+}$  could substitute for  $Mn^{2+}$  in the in vitro activation of  $N_2$ ase. EPR spectroscopy of buffer-washed *R. rubrum* chromatophores showed lines characteristic of  $Mn^{2+}$ . Removal of the  $Mn^{2+}$ -dependent  $N_2$ ase activating factor by a salt wash of the chromatophores removed 90% of the  $Mn^{2+}$ , which suggested a specific coupling of this metal to the activating factor.  $Mn^{2+}$  probably plays an important physiological role in regulating the  $N_2$  fixation process by these photosynthetic bacteria. - Biol. Abstr. 69,1979.

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- of *Limnology*, 40 (1), 1979: 1-9, Engl. summ. The biological N fixation and denitrification were studied in Lake Kasumiga-ura to evaluate the significance of the biological processes of N-enrichment and self-purification in aquatic environments. The water and sediment samples were collected from several sites and analyzed for the amount of inorganic nitrogen, the N-fixing activity by the acetylene reduction method, the denitrifying activity by nitrous oxide formation and the numbers of total heterotrophic bacteria and denitrifying bacteria. No significant activities of N fixation and denitrification were found in the lake water. The rate of denitrification in sediments was about 2 orders of magnitude higher than that of N fixation. The average microbial activities of N fixation in sediments sampled in July, Aug. and Dec. were 0.02, 0.11 and 0.14  $\mu\text{g N/g}$  per day, respectively; those of denitrification were 4.1, 8.1 and 93.4  $\mu\text{g N/g}$  per day, respectively. The surface sediments in Lake Kasumiga-ura apparently have a high potential for self-purification of nitrogenous compounds in water and sediments. - Biol. Abstr. 69,1979.
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889. ZABLOTOWICZ, R.M., RUSSELL, S.A. and EVANS, H.J. Effect of the hydrogenase system in *Rhizobium japonicum* on the nitrogen fixation and growth of soybeans (*Glycine max* cultivar Wilkin) at different stages of development. *Agronomy Journal*, 72 (3), 1980: 555-559. The process of N fixation is energy consuming and inefficient. In most cases 20 to 40% of the energy that is supplied to nitrogenase for the reduction of  $\text{N}_2$  is utilized for the reduction of protons to  $\text{H}_2$ . Some strains of *R. japonicum* contain a membrane-bound hydrogenase that is capable of oxidizing all of the  $\text{H}_2$  that is produced during  $\text{N}_2$  fixation. This study was conducted to evaluate the effects of inoculation of soybeans [*G. max* (L.) Merr.]

with *R. japonicum* containing H<sub>2</sub> recycling capability on N fixation efficiency and soybean yield at various physiological stages of growth. In these experiments, a H<sub>2</sub>-oxidizing strain SR (Hup<sup>+</sup>) and SR3 (Hup<sup>-</sup>), a mutant derived from SR which is unable to oxidize H<sub>2</sub>, were utilized. Soybeans cv. Wilkin were grown under bacteriological conditions utilizing a drip-irrigated nutriculture system. Nodules from plants inoculated with SR evolved no measurable amount of H<sub>2</sub>, while nodules from plants inoculated with SR3 evolved between 2.7 and 10 μmol of H<sub>2</sub>/g nodules/h depending upon physiological age. Acetylene reduction rates by strain SR were significantly higher than those of nodules formed from SR3 during the vegetative, late pod-fill and leaf senescence stage of growth, respectively. Dry matter accumulation was significantly higher in plants inoculated with SR than in plants inoculated with SR3 (31% increase during vegetative stage, 25% during flowering, and 27% during pod-fill stage). N contents of shoots and seeds were significantly higher in plants inoculated with strain SR, demonstrating increased N fixation by nodules formed by Hup<sup>+</sup> *Rhizobium*. The results support the conclusion that strains of *R. japonicum* selected for inoculation purposes should contain H<sub>2</sub>-oxidizing capability as one of their desired characteristics. - Biol. Abstr. 70,1980.

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897. ZHIZNEVSKAYA, G. Ya., IL'YASOVA, V.B., TROITSKAYA, G.N., KHAILOVA, G.F. and ANDREEVA, I.N. A comparative study of symbiotic nitrogen fixation in root nodules of various leguminous plant species (In Russ.). *Fiziologiya Rastenii*, 26 (1), 1979: 93-102, Engl. summ. N-fixing activity in root nodules was compared in various legumes [*Lupinus luteus*, *Medicago sativa*, *Trifolium pratense*, *Ornithopus sativus*, *Vicia faba*, *Glycine hispida* and *Pisum sativum*] grown in the field. The plants studied belonged to various phylogenetic tribes of *Leguminosae*, and their root nodules differed in shape: cylindrical or comb-like (clover, lucern, pea and broad beans), round (soybeans, serradella) and muff-shaped (lupine). The 1st plants, which are younger phylogenetically, have a peculiar structure of nodule tissue with very large bacteroids, and possess a high N-fixing activity per unit weight of the nodule. Soybeans and serradella occupy the intermediate position. Lupine, as the oldest plant phylogenetically, has low N-fixing activity. In cultivating plants, it is possible to raise N-fixing effectiveness of lupine, soybeans, pea and broad beans by promoting nodule growth and number. As to clover and lucern, a selection of most effective nodule bacterium strains is of main importance. - Biol. Abstr. 69,1979.
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the mechanism of microbial pool survival in soils. The principle of duplication states that each essential process in soils (cellulose decomposition, N fixation, nitrification etc.) is operative due to the activity of some or many varieties and groups of microorganisms which duplicate each other. Duplication provides the stability of the system. The concept of the soil having a greater number of habitats of microorganisms is developed. - Biol. Abstr. 68,1978.

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MANHART, James R.	513, 514	MILLER, Yu. M.	251
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NEMCOVA, M.	754,756	ONDREJ, Milos	579
NEUE, H.U.	210	OPENSHAW, S.J.	580
NEUMEYER, C.F.	527	ORME-JOHNSON, W.H.	392,581
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PANKHURST, C.E.	590	PINCHBECK, B.R.	613
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PATIL, V.D.	405	PORNTAVEEVATANA, S.	814
PATYUT, S.	600	POSTGATE, J.R.	620,658,788
PATRICK, W.H.	640	POTTS, M.	622
PATRIQUIN, D.	502	POTTS, Malcolm	621,856
PATRIQUIN, D.G.	601,758	POWELL, C.E.	685,686
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PEREGO, J.L.	604	PRIME, P.N.	571
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		Latin America	314, 315, 408
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		Leaf spots	303
		Leaf surfaces	773
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		Legume cultivation	324, 595
		Legume inoculation	130, 850
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<u>Cryptomeria japonica</u>			
<u>Juncus gerardii</u>	758		
<u>Juncus roemerianus</u>	338, 805		
Jute	618		
Kentucky bluegrass	209, 728		
Kenya	432		
Khon Kaen	600		
Kidney beans	26, 30, 38, 39, 105, 108, 110, 272, 316, 317, 320, 322, 407, 411, 478, 484, 485, 489, 508, 542, 561, 611, 651, 655, 682, 795, 818		
<u>Klebsiella pneumoniae</u>	50, 223, 354, 363, 380, 529, 564, 570, 592, 625, 650, 717, 728, 765		
Korea	377, 479, 482		
L-methionine	740		
<u>L. angustifolius</u>	657		
<u>Lablab purpureus</u>	436, 731, 892		
Lactic acids	795		
<u>Laguncularia racemosa</u>	898		

	648,654,656,	Lupine	78,86,455,
	672,674,675,		464,477,513,
	676,688,693,		528,667,768,
	702,703,705,		852,866,877,
	713,731,736,		897
	750,761,763,	Lupine (sweet)	179
	776,780,787,	<u>Lupinus angustifolus</u>	
	796,797,801,	see Lupine (sweet)	
	825,833,834,	<u>Lupinus luteus</u>	see Lupine
	836,855,865,	<u>Lynobva</u>	639
	874,875,885,		
	886,891,897	<u>Maceotermes kukzil</u>	665
Leguminous plants	528	Macronutrients	772
<u>Lens culinaris</u>	see Lentils	<u>Macroptilium atropurpureum</u>	
<u>Lens esculenta</u>	see Lentils	see Legumes	
Lentils	255,344,869	Magnesium (fertilizers)	518
<u>Leucaena leucocephala</u>	261,293,	Maize	see Corn
	436	Malaysia	6,396,599,
Lichens	82,270,331,		783,871
	339,732	Mali	463,702,703
Ligases	see Synthetases	Manganese	647,883
Light effects	851	Mangrove forests	621,622,898
Light field	512	Manure applications	825
Light intensity	271,383	Manures	498,526,537,
Light intensity see also			745,824
Luminous intensity		Mapping methods	529
Lime	151,280,407	Marine bacteria	309
Limestone	126,785	Massachusetts	789
Lindane	see Insecticides	Mauritius	611,818
Liquid culture	593	Meadow foxtail	209
Loamy soils	302,735	<u>Medicago</u>	31,397,831
<u>Lolium perenne</u>	397	<u>Medicago lupulina</u>	375
Lowland rice	13,27,69,	<u>Medicago sativa</u>	see Alfalfa
	84,117,118,	<u>Medicago truncaluta</u>	
	377,480,844,	see Barrel medic	
	845,881	Melezitose	606
Lucerne	see Alfalfa	<u>Meloidogyne incognita</u>	
Luminescent light	512	see Plant nematodes	
Luminous intensity	727	<u>Meloidogyne javanica</u>	128
		Membrane vesicles	461

Metabolism	476,667	Mung beans	64,145,182,
Methionine sulfoximine	381		191,297,302,
Methyl viologen	793		333,394,409,
Methylamine	740		422,460,561,
Metronidazole	786		596,677,680,
Mexico	67,273,807		836,875,886
Microbial colonization	898	<u>Musa sapientum</u>	see Bananas
Microbiology	505	Mutagenic agents	see Mutagens
<u>Micrococcus</u>	1	Mutagens	740
Microcrustaceans	864	Mutant properties	751
<u>Microcystis aeruginosa</u>	45	Mutants	497,564,625,
Microelements	386		698,860
Microfauna	301	Mutation	50,143,268,
Microflora	42,116,670		269,310,369,
Micronutrients	422,425,883		650
Microorganisms	390,500,605,	<u>Mycobacterium flavum</u>	510
	684,899	Mycorrhizae	57,107,108,
Millet	390		169,206,403,
Mineral fertilizers	228		760
Mineral nutrients	862	Mycotoxins	516
Minesoils	776	Myoglobin	60,95
MIRCEN	431	<u>Myrica gale</u>	196,714
Mixed cropping	438,439,440,	<u>Myrica pennsylvanica</u>	
	900	see Bayberry	
Mixed farming	601	<u>Myriophyllum heterophyllum</u>	116
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Molybdenum	278,280,298,	<u>Nasutitermes</u>	779
	386,392,407,	Nematodes	70,237,530
	541,552,615,	Netherlands	13,66,72,84,
	634,656,689,		85,112,114,
	712		201,225,250,
Molybdenum compounds	296		266,300,382,
Monoculture	322		383,385,399,
Morphogenesis	560		420,426,452,
Morphological studies	811		460,461,462,
Mosaic virus	334,511,692		487,534,584,
Mosses	79,80,466		605,669,681,
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	371, 430, 464,		76, 77, 78,
	465, 571, 676,		122, 133, 137,
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<u>Nicotiana tabacum</u>			162, 163, 168,
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<u>Parasponia andersonii</u>	796	781, 798, 815,
<u>Parasponia parviflora</u>	85	816, 865, 876,
<u>Parasponia rugosa</u>	796	897
<u>Paspalum urvillei</u>	626	
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Pathogenesis	460	<u>Pennisetum purpureum</u>
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	847,872,880	<u>Pisum</u>	31
<u>Phoenix dactylifera</u>	47	<u>Pisum sativum</u>	see Peas
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Phosphate (fertilizers)	402,727	Plant breeding	404,481,555, 702
Phosphate rock	403,835	Plant budding	195
Phosphorus	735,835	Plant cells	186
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Phosphorus availability	745	Plant density	320
Phosphorylation	461,752	Plant diseases	334,812
Photochemical reaction	603	Plant enzymes	406
Photoevolution	450	Plant genetics	49
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Phyllosphere	554,799	Plant metabolism	654
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Polymerases	147	<u>Rhizobium</u>	6,11,26, 34,52,53, 55,56,62, 67,81,85, 93,95,96, 102,123,128, 130,131,134, 148,151,152, 157,159,163, 164,165,166, 167,172,173, 184,186,187, 189,190,193, 205,207,208, 215,217,224, 233,237,246, 247,253,255, 271,274,277, 279,283,291, 293,297,302, 304,308,317, 319,324,337, 340,349,352, 355,356,364, 366,367,368, 372,385,391, 394,395,396, 399,406,408, 409,413,418, 423,429,431,
Polypeptides	380		
Polysaccharide	410		
Population density	764		
Portugal	648		
<u>Portulaca glandiflora</u>	499		
Post-harvesting	437		
Potash (fertilizers)	734		
Potassium	198,240		
Potassium (fertilizers)	271,518		
Protein compounds	896		
Protein content	388		
Protein production	218,364		
Protein synthesis	132		
Proteins	483,638,708		
Protoplasm	781		
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Protozoa	432		
<u>Psophocarpus tetragonobus</u>	216, 396,399,872		
Pteridophyta	562,782		
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<u>Pueraria</u>	835		
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<u>Rhizobium lupini</u>	60, 78, 222,
	455, 514, 616,
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<u>Rhizobium meliloti</u>	40, 76, 120,
	121, 235, 268,
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<u>Rhizobium phaseoli</u>	104, 108,
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	376, 485, 514,
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<u>Rhizophora mangle</u>	898		557,589,646,
Rhizosheaths	873		690,691,694,
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Rhodesia	626		44,47,48,
<u>Rhodopseudomonas capsulata</u>	5,		52,64,65,
	883		66,67,73,
<u>Rhodopseudomonas</u>			85,86,87,
<u>sphaeroides</u>	416		88,92,94,
<u>Rhodospirillum rubrum</u>	448,883		106,107,112,
Ribosomal proteins	219		113,114,125,
Rice	8,32,117,		128,144,145,
	290,398,405,		150,157,158,
	480,481,509,		164,168,169,
	537,554,635,		172,180,191,
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	733,742,743,		254,259,280,
	744,778,819,		281,283,288,
	820,837,841,		289,295,302,
	844,845,880		308,315,320,
Rice cultivation	15,210,243,		322,334,337,
	282,336,452,		345,347,356,
	458,481,486,		357,361,362,
	520,548,557,		367,370,375,
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