

Bibliography

- Adams, M.A. & Pate, J.S.** 1992. Availability of organic and inorganic forms of phosphorus to lupins (*Lupinus* spp.). *Plant Soil*, 145: 107–113.
- Ae, N., Arihara, J., Okada, K., Yoshihara, T. & Johansen, C.** 1990. Phosphorus uptake by pigeon pea and its role in cropping systems of the Indian subcontinent. *Science*, 248: 477–480.
- Aigner, M., Fardeau, J.C. & Zapata, F.** 2002. Does the P_i strip method allow assessment of the available soil P?: comparison against the reference isotope method. *Nutr. Cycl. Agroecosys.*, 63(1): 49–58.
- Amberger, A.** 1978. Experiences with soft rock phosphate for direct fertilizer application. In IFDC, ed. *Seminar on phosphate rock for direct application*, pp. 349–356. Muscle Shoals, Alabama, USA, IFDC.
- Amer, F., Boulden, D.R., Black, C.A. & Duke, F.R.** 1955. Characterization of soil phosphorus by anion exchange resin adsorption and P-32 equilibration. *Plant Soil*, 6: 391–408.
- ANDA.** 2001. *Statistics yearbook of the fertilizer sector*. Sao Paulo, Brazil, ANDA – National Association for Fertilizer Diffusion.
- Anderson, D.L., Kussow, W.R. & Corey, R.B.** 1985. Phosphate rock dissolution in soil: indications from plant growth studies. *Soil Sci. Soc. Am. J.*, 49: 918–925.
- Anderson, G.C. & Sale, P.W.G.** 1993. Application of the Kirk and Nye phosphate rock dissolution model. *Fert. Res.*, 35: 61–66.
- Ankomah, A.B., Zapata, F., Danso, S.K.A. & Axmann, H.** 1995. Cowpea varietal differences in uptake of phosphorus from Gafsa phosphate rock in a low P ultisol. *Fert. Res.*, 41: 219–225.
- Appleton, J.D.** 2001. *Local phosphate resources for sustainable development in sub-Saharan Africa*. Keyworth, Nottingham, UK, National Environment Research Council, British Geological Survey and DFID.
- Arihara, J. & Karasawa, T.** 2000. Effect of previous crops on arbuscular mycorrhizal formation and growth of succeeding maize. *Soil Sci. Plant Nutr.*, 46: 43–51.
- Attoe, O.J. & Olson, R.A.** 1966. Factors affecting rate of oxidation in soils of elemental sulphur and that added in rock phosphate-sulphur fusions. *Soil Sci.*, 101: 317–324.
- Axelrod, S. & Greidinger, D.** 1979. Phosphate solubility test – interference of some accessory minerals. *J. Sci. Food Agric.*, 30:153–157.
- Baanante, C.A.** 1998. Economic evaluation of the use of phosphate fertilizers as a capital investment. In A.E. Johnston & J.K. Syers, eds. *Nutrient management for sustainable agriculture in Asia*, pp. 109–120. Wallingford, UK, CAB International.
- Baanante, C.A. & Hellums, D.T.** 1998. An analysis of the potential demand for phosphate fertilizers: sources of change and projections to 2025. In L.D. Currie & P. Loganathan, eds. *Long-term nutrient needs for New Zealand's primary industries: global supply, production requirements and environmental constraints*, pp. 7–31. Occasional Report No. 11. Palmerston North, New Zealand, Fertilizer and Lime Research Centre, Massey University.
- Babare, A.M., Gilkes, R.J. & Sale, P.W.G.** 1997. The effect of phosphate buffering capacity and other soil properties on North Carolina phosphate rock dissolution, availability of dissolved phosphorus and relative agronomic effectiveness. *Aus. J. Exp. Agri.*, 8: 845–1098.

- Bachik, A.T. & Bidin, A., eds.** 1992. *Proceedings of a workshop on phosphate sources for acid soils in the humid tropics of Asia*. 6–7 November 1990. Kuala Lumpur, Malaysian Society of Soil Science.
- Bagayoko, M. & Coulibaly, B.S.** 1995. Promotion and evaluation of Tilemsi phosphate rock in Mali agriculture. In H. Gerner & A.U. Mokwunye, eds. *Use of phosphate rock for sustainable agriculture in West Africa*, p.77–83. Miscellaneous Fertilizer Studies No. 11. Muscle Shoals, USA, IFDC Africa.
- Bagyaraj, D.J.** 1990. Ecology of VA mycorrhizae. In D.K. Arora, R. Bharat, K.G. Mukerji & G.R. Knudsen, eds. *Handbook of applied mycology, Vol. I. Soil and Plants*, pp. 3–34. New York, USA, Marcel Dekker Inc.
- Bagyaraj, D.J. & Padmavathi Ravindra, T.** 1993. Mycorrhiza. In P.K. Thampan, ed. *Organics in soil health and crop production*. Cochin, India, Peekay Tree Crops Developments Foundation.
- Baligar, V.C., Fageria, N.K. & Ze, Z.L.** 2001. Nutrient use efficiency in plants. *Com. Soil Sci. Plant Anal.*, 32: 921–950.
- Bangar, K.C., Yadav, K.S. & Mishra, M.M.** 1985. Transformation of rock phosphate during composting and the effect of humic acid. *Plant Soil*, 85: 259–266.
- Barber, S.A.** 1995. *Soil nutrient bioavailability. A mechanistic approach*. New York, USA, John Wiley & Sons.
- Barea, J.M., Azcon, R. & Azcon-Aguilar, C.** 1983. Interactions between phosphate solubilising bacteria and VA mycorrhiza to improve plant utilization of rock phosphate in non-acidic soils. In IMPHOS, ed. *3rd international congress on phosphorus compounds*, pp. 127–144. Brussels.
- Barea, J.M., Toro, M., Orozco, M.E., Campos, E. & Azcon, R.** 2002. The application of isotopic (³²P and ¹⁵N) dilution techniques to evaluate the interactive effect of phosphate-solubilising rhizobacteria, mycorrhizal fungi and Rhizobium to improve the agronomic efficiency of rock phosphate for legume crops. *Nutr. Cycl. Agroecosys.*, 63 (1): 35–42.
- Barnes, J.S. & Kamprath, E.J.** 1975. Availability of North Carolina rock phosphate applied to soils. *N. C. Agric. Exp. St. Tech. Bull.*, 229. Raleigh, USA.
- Basak, R.K., Karmakar, M. & Debnath, N.C.** 1988. Fertilizer value of partially acidulated Purulia rock phosphate. *J. Ind. Soc. Soil Sci.*, 36: 729–732.
- Bationo, A., Baethgen, W.E., Christianson, C.B. & Mokwunye, A.U.** 1991. Comparison of five soil-testing methods to establish phosphorus sufficiency levels in soil fertilized with water-soluble and sparingly soluble phosphorus sources. *Fert. Res.*, 28: 271–279.
- Baudet, G., Truong, B., Fayard, C. & Sustrac, G.** 1986. La filière phosphate: du minéral à l'engrais, principaux points de repère. *Chron. Rech. Min.*, 484: 19–36.
- Bekele, T., Cino, B.J., Ehlert, P.A.I., Van der Maas, A.A. & Van Diest, A.** 1983. An evaluation of plant-borne factors promoting the solubilization of alkaline rock phosphates. *Plant Soil*, 75: 361–378.
- Besoain, E., Rojas, C. & Montenegro, A., eds.** 1999. *Las rocas fosforicas y su posibilidad de uso agricola en Chile*. Santiago, Instituto Nacional de Investigaciones Agrícolas, Ministerio de Agricultura. 328 pp.
- Bever, J.D., Schultz, P.A., Pringle, A. & Morton, J.B.** 2001. Arbuscular mycorrhizal fungi: more diverse than meets the eye, and the ecological tale of why. *Bio. Sci.*, 51: 923–931.
- Black, C.A.** 1968. *Soil-plant relationships*. New York, USA, John Wiley & Sons.
- Bojinova, D., Velkova, R., Grancharov, I. & Zhelev, S.** 1997. The bioconversion of Tunisian phosphorite using *Aspergillus niger*. *Nut. Cyc. Agroecosys.*, 47: 227–232.
- Bolan, N.S. & Hedley, M.J.** 1990. Dissolution of phosphate rocks in soils. 2. Effect of pH on the dissolution and plant availability of phosphate rock in soil with pH dependent charge. *Fert. Res.*, 24: 125–134.

- Bolan, N.S. & Robson, D.** 1987. Effects of vesicular-arbuscular mycorrhiza on the availability of iron phosphates to plants. *Plant Soil*, 99: 401–410.
- Bolan, N.S., White, R.E. & Hedley, M.J.** 1990. A review of the use of phosphate rocks as fertilizers for direct application in Australia and New Zealand. *Aus. J. Exp. Agric.*, 30: 297–313.
- Bolan, N.S., Hedley, M.J., Syers, J.K. & Tillman, R.W.** 1987 Single superphosphate-reactive phosphate rock mixtures. 1. Factors affecting chemical composition. *Fert. Res.*, 13: 223–239.
- Bolland, M.D.A. & Gilkes, R.J.** 1997. The agronomic effectiveness of reactive phosphate rocks, 2. Effect of phosphate rock reactivity. *Aus. J. Exp. Agric.*, 37: 937–946.
- Bolland, M.D.A., Clarke, M.F. & Yeates, J.S.** 1995. Effectiveness of rock phosphate, coastal superphosphate and single superphosphate for pasture on deep sandy soils. *Fert. Res.*, 41: 129–143.
- Bolland, M.D.A., Lewis, D.C., Gilkes, R.J. & Hamilton, L.J.** 1997. Review of Australian phosphate rock research. *Aus. J. Exp. Agric.*, 37: 845–859
- BPPT-BRGM-CIRAD-TECNIFERT-SPIE BATIGNOLLES.** 1989. *The phosphates of the Ciamis and Tuban Regions (Java - Indonesia)*. Jakarta, Ministry of Research. 110 pp.
- Braithwaite, A.C., Eaton, A.C. & Groom, P.S.** 1989. Some factors associated with the use of the extractants 2% citric acid and 2% formic acid as estimators of available phosphorus in fertilizer products. *Fert. Res.*, 19: 175–181.
- Braithwaite, A.C., Eaton, A.C. & Groom, P.S.** 1990. Factors affecting the solubility of phosphate rock residues in 2% citric acid and 2% formic acid. *Fert. Res.*, 23: 37–42.
- Bray, R.M. & Kurtz, L.T.** 1945. Determination of total, organic and available forms of phosphorus in soils. *Soil Sci.*, 59: 39–45
- British Sulphur Corporation Limited.** 1987. *World survey of phosphate deposits*. London. 247 pp.
- Brobst, D.A. & Pratt, W.P.** 1973. *United States mineral resources*. U.S. Geological Survey Professional Paper 820.
- Brundrett, M.C.** 2002. Co-evolution of roots and mycorrhizas of land plants. *New Phyt.*, 154: 275–304.
- Buresh, R.J., Smithson, P. & Hellums, D.T.** 1997. Building soil phosphorus capital in Africa. In R.J. Buresh, P.A. Sanchez & F. Calhoun, eds. *Replenishing soil fertility in Africa*, pp. 111–149. Madison, USA, SSSA Special Publication 51.
- Casanova, E.** 1992. Las rocas fosfóricas naturales y modificadas y su uso potencial en suelos y cultivos de Venezuela. In Palmaven-Imposfos, eds. *Memorias del curso sobre fertilización balanceada*. Valencia, Venezuela. 88 pp.
- Casanova, E.** 1993. Las rocas fosfóricas y su uso agroindustrial en Venezuela. Technical Notes. Palmaven, Venezuela. 124 pp.
- Casanova, E.** 1995. Agronomic evaluation of fertilizers with special reference to natural and modified phosphate rock. *Fert. Res.*, 41: 211–218.
- Casanova, E.** 1998. Suelos y fertilización de forrajes en Venezuela. In R. Tejos, C. Zambrano, L. Mancilla, W. García, M. Camargo, eds. *IV Seminario Manejo y utilización de pastos y forrajes en sistemas de producción animal*, pp. 129–136. Venezuela.
- Casanova, E., ed.** 1998. *Manejo eficiente de los fertilizantes fosfatados con énfasis en rocas fosforicas de aplicación directa. Technical manual*. FAO/OIEA Regional Project of Technical Cooperation in Latin America (ARCAL). Maracay, Venezuela. 91 pp.
- Casanova, E. & Lopez Perez A., eds.** 1991. Alternativas como fertilizantes para los depósitos de fosfato de la América Tropical y Subtropical. *Rev. Fac. Agron. UCV*, Vol. 17, Nos. 1–4.

- Casanova, E., Salas, A.M. & Toro, M.** 1998. Manejo eficiente de los recursos fosfatados con énfasis en rocas fosfóricas de aplicación directa en Venezuela. In E. Casanova, ed. *Manejo eficiente de los fertilizantes fosfatados con énfasis en rocas fosfóricas de aplicación directa*, pp. 75–91. Proyecto ARCAL. Maracay, Venezuela.
- Casanova, E., Salas, A.M. & Toro, M.** 2002a. Evaluating the effectiveness of phosphate fertilizers in some Venezuelan soils. *Nutr. Cycl. Agroecosys.*, 63(1): 13–20.
- Casanova, E., Salas, A.M. & Toro, M.** 2002b. The use of nuclear and related techniques for evaluating the agronomic effectiveness of phosphate fertilizers, in particular rock phosphate in Venezuela. I. Phosphorus uptake, utilization and agronomic effectiveness. In *Assessment of soil P status and management of phosphatic fertilizers to optimize crop production*, pp. 93–100. Vienna, IAEA TECDOC 1272 IAEA. 473 pp.
- Casanova, E., Goitia, R., Pereira, P., Comerma, J. & Aguilar, C.** 1993. Necesidades y perspectivas agronómicas de fertilizantes y enmiendas en Venezuela. *Venesuelos*, 11: 17–23.
- Castellano, M.A. & Molina, R.** 1989. Mycorrhizae. In T.D. Landis, R.W. Tinue, S.E. MacDonald & J.P. Barnett, eds. Biological component: nursery pests and mycorrhizae, Vol. 5. *The container tree nursery manual*, pp 101–167. Agriculture Handbook 674. Washington, DC, USDA.
- Castillo, J., Domínguez, J. & Barreiro, I.** 1998. *Programa de cálculo de estimación de consumos de materias primas en la producción de RPA con roca Riecito y mezclas de ácidos fosfóricos y sulfúrico*. INTEVEP-PEQUIVEN Bulletin. 11p.
- Chalk, P.M., Zapata, F. & Keerthisinghe, G.** 2002. Towards integrated soil, water and nutrient management in cropping systems: the role of nuclear techniques. In IUSS, ed. Soil science: confronting new realities in the 21st century. Transactions 17th World Congress of Soil Science, CD ROM. p. 2164/1–2164–11. Bangkok.
- Chardon, W.J., Menon, R.G. & Chien, S.H.** 1996. Iron oxide-impregnated filter paper (Pi test): a review of its development and methodological research. *Nutr. Cycl. Agroecosys.*, 46: 41–51.
- Chew, K.L.** 1992. Distribution and acceptance of phosphate fertilizers: a Malaysian experience. In A.T. Bachik & A. Bidin, eds. *Proceedings of the workshop on phosphate sources for acid soils in the humid tropics of Asia*, p. 170–176. Kuala Lumpur, Malaysian Society of Soil Science.
- Chien, S.H.** 1977a. Dissolution of phosphate rocks in a flooded acid soil. *Soil Sci. Soc. Am. J.*, 41: 1106–1109.
- Chien, S.H.** 1977b. Thermodynamic considerations on the solubility of phosphate rock. *Soil Sci.*, 123: 117–121.
- Chien, S.H.** 1978. Interpretation of Bray I extractable phosphorus from acid soil treated with phosphate rock. *Soil Sci.*, 144: 34–39.
- Chien, S.H.** 1982. Direct application of phosphate rocks in some tropical soils of South America: a status report. In E. Pushparajah & S.H.A. Hamid, eds. *Phosphorus and potassium in the tropics*, pp. 519–529. Kuala Lumpur, Malaysian Society of Soil Science.
- Chien, S.H.** 1992. Reactions of phosphate rocks with acid soils of the humid tropics. In A.T. Bachik & A. Bidin, eds. *Proceedings of a workshop on phosphate sources for acid soils in the humid tropics of Asia*, pp. 18–29. Kuala Lumpur, Malaysian Society of Soil Science.
- Chien, S.H.** 1993. Solubility assessment for fertilizer containing phosphate rock. *Fert. Res.*, 35: 93–99.
- Chien, S.H.** 1995. Chemical, mineralogical, and solubility characteristics of phosphate rock for direct application. In K. Dahanayke, S.J. Van Kauwenbergh & D.T. Hellums, eds. *Direct application of phosphate rock and appropriate technology fertilizers in Asia: what hinders acceptance and growth*, pp. 49–58. Kandy, Sri Lanka, Institute of Fundamental Studies, and Muscle Shoals, USA, IFDC.

- Chien, S.H.** 1998. Evaluation of Gafsa (Tunisia) and Djebel Onk (Algeria) phosphate rocks and soil testing of phosphate rock for direct application. In A.E. Johnston & J.K. Syers, eds. *Nutrient management for sustainable food production in Asia*, pp. 175–185. Proc. IMPHOS-AARD/CSAR. Wallingford, UK, CAB International.
- Chien, S.H.** 2003. Factors affecting the agronomic effectiveness of phosphate rock: a general review. In S.S.S. Rajan & S.H. Chien, eds. *Direct application of phosphate rock and related technology: latest developments and practical experiences*. Proc. Int. Meeting, Kuala Lumpur, 16–20 July 2001. Muscle Shoals, USA, IFDC. 441 pp.
- Chien, S.H.** 2003. IFDC's evaluation of modified phosphate rock products. In *Proceedings of international meeting on direct application of phosphate rock and related technology: latest developments and practical experiences*. Kuala Lumpur, Malaysian Society of Soil Science, and Muscle Shoals, USA, IFDC.
- Chien, S.H. & Black, C.A.** 1976. Free energy of formation of carbonate apatites in some phosphate rocks. *Soil Sci. Soc. Am. J.*, 40: 234–239.
- Chien, S.H. & Friesen, D.K.** 1992. Phosphate rock for direct application. In F.J. Sikora, ed. *Future directions for agricultural phosphorus research*, pp. 47–52. Bulletin Y-224. Muscle Shoals, USA, Valley Authority.
- Chien, S.H. & Friesen, D.K.** 2000. Phosphate fertilizers and management for sustainable crop production in tropical acid soils. In IAEA, ed. *Management and conservation of tropical acid soils for sustainable crop production*, pp. 73–89. IAEA-TECDOC-1159. Vienna, IAEA.
- Chien, S.H. & Hammond, L.L.** 1978. A comparison of various laboratory methods for predicting the agronomic potential of phosphate rock for direct application. *Soil Sci. Soc. Am. J.*, 42: 1758–1760.
- Chien, S.H. & Hammond, L.L.** 1988. *Agronomic evaluation of partially acidulated phosphate rocks in the tropics: IFDC experience*. IFDC-P-7. Muscle Shoals, USA, IFDC.
- Chien, S.H. & Hammond, L.L.** 1989. Agronomic effectiveness of partially acidulated phosphate rock as influenced by soil phosphorus-fixing capacity. *Plant Soil*, 120: 159–164.
- Chien, S.H. & Menon, R.G.** 1995a. Agronomic evaluation of modified phosphate rock products: IFDC's experience. *Fert. Res.*, 41: 197–209.
- Chien, S.H. & Menon, R.G.** 1995b. Factors affecting the agronomic effectiveness of phosphate rock for direct application. *Fert. Res.*, 41: 227–234.
- Chien, S.H. & Van Kauwenbergh, S.J.** 1992. Chemical and mineralogical characteristics of phosphate rock for direct application. In R.R. Campillo, ed. *First national seminar on phosphate rock in agriculture*, pp 3–31. Serie Carillanca No. 29. Temuco, Chile, Instituto de Investigaciones Agropecuarias.
- Chien, S.H., Clayton, W.R. & McClellan, G.M.** 1980a. Kinetic dissolution of phosphate rocks in soils. *Soil Sci. Soc. Am. J.*, 44: 260–264.
- Chien, S.H., Hammond, L.L. & Leon, L.A.** 1987b. Long term reactions of phosphate rocks with an oxisol in Colombia. *Soil Sci.*, 144: 257–265.
- Chien, S.H., Leon, L.A. & Tejada, H.** 1980b. Dissolution of North Carolina phosphate rock in acid Colombian soils as related to soil properties. *Soil Sci. Soc. Am. J.*, 44: 1267–1271.
- Chien, S.H., Menon, R.G. & Billingham, K.S.** 1996 Phosphorus availability from phosphate rock as enhanced by water-soluble phosphorus. *Soil Sci. Soc. Am. J.*, 60: 1173–1177.
- Chien, S.H., Sale, P.W.G. & Friesen, D.K.** 1990a. A discussion of the methods for comparing the relative effectiveness of phosphate fertilizers varying in solubility. *Fert. Res.*, 24: 149–157.
- Chien, S.H., Sale, P.W.G. & Hammond, L.L.** 1990b. Comparison of effectiveness of various phosphate fertilizer products. In *Proceedings of international symposium on phosphorus requirements for sustainable agriculture in Asia and Oceania*, pp. 143–156. Manila, IRRI.

- Chien, S.H., Adams, F., Khasawneh, F.E. & Henao, J.** 1987a. Effects of combinations of triple superphosphate and a reactive phosphate rock on yield and phosphorus uptake by corn. *Soil Sci. Soc. Am. J.*, 51: 1656–1658.
- Chien, S.H., Singh, U., Van Reuler, H. & Hellums, D.T.** 1999. Phosphate rock decision support systems for sub-Saharan Africa. Special issue on Soil Fertility. *Afr. Fert. Mark.*, 12: 15–22.
- Chien, S.H., Sompongse, D., Henao, J. & Hellums, D.T.** 1987c. Greenhouse evaluation of phosphorus availability from compacted phosphate rocks with urea or with urea and triple superphosphate. *Fert. Res.*, 14: 245–256.
- Comerma, J. & Paredes, R.** 1978. Principales limitaciones y potencial agrícola de las tierras en Venezuela. *Agron. Trop.*, 28: 71–85.
- Cooke, G.W.** 1956. The value of phosphate rock for direct application. *Emp. J. Exp. Ag.*, 24: 295–306.
- Dabin, B.** 1967. *Méthode Olsen modifiée*. Cahiers ORSTOM, Pédologie 5.3.
- Dahanayake, K., Van Kauwenbergh, S.J. and Hellums, D.T., eds.** 1995. *Direct application of phosphate rock and appropriate technology fertilizers in Asia: what hinders acceptance and growth*. Kandy, Sri Lanka, Institute of Fundamental Studies, and Muscle Shoals, USA, IFDC.
- Date, R.A., Grundon, N.J., Rayment, G.E. & Probert, M.E., eds.** 1995. *Plant-soil interactions at low pH: principles and management. developments in plant and soil sciences*. Vol. 64. Dordrecht, The Netherlands, Kluwer Academic Publishers. 822 pp.
- De la Fuente-Martinez, J.M., Ramirez-Rodriguez, V., Cabrera-Ponce, J.L. & Herrera-Estrella, L.** 1997. Aluminum tolerance in transgenic plants by alteration of citrate synthesis. *Science*, 276: 1566–1568.
- Diamond, R.B.** 1979. Views on marketing of phosphate rock for direct application. In IFDC, ed. Seminar on phosphate rock for direct application. Special Publication SP-1. Muscle Shoals, USA, IFDC.
- Dominguez, J. & Barreiro, I.** 1998. *Manual de instrucciones de trabajo para la operación de la planta RPA del complejo petroquímico Morón*. 63 pp.
- Duddridge, J.A., Malibari, A. & Read, D.J.** 1980. Structure and function of mycorrhizal rhizomorphs with special reference to their role in water transport. *Nature*, 287: 834–836.
- Engelstad, O.P. & Hellums, D.T.** 1993. *Water solubility of phosphate fertilizers: agronomic aspects – a literature review*. IFDC Paper Series P-17. Muscle Shoals, USA, IFDC.
- Engelstad, O.P., Jugsujinda, A. & De Datta, S.K.** 1974. Response by flooded rice to phosphate rocks varying in citrate solubility. *Soil Sci. Soc. Am. Proc.*, 38: 524–529.
- Enyong, L.A., Debrah, S.K. & Bationo, A.** 1999. Farmers' perceptions and attitudes towards introduced soil-fertility enhancing technologies in western Africa. *Nutr. Cycl. Agroecosys.*, 53(2): 177–187.
- FAO.** 1984. *Fertilizer and plant nutrition guide*. FAO Fertilizer and Plant Nutrition Bulletin No. 9. Rome.
- FAO.** 1995a. *Integrated plant nutrition systems*, by R. Dudal & R.N. Roy, eds. FAO Fertilizer and Plant Nutrition Bulletin No. 12. Rome.
- FAO.** 1995b. *World agriculture: towards 2010*, by N. Alexandratos, ed. New York, USA, John Wiley & Sons.
- FAO.** 1998. *Guide to efficient plant nutrient management*. Land and Water Development Division, Rome.
- FAO.** 1999. *Fertilizer yearbook 1998*. FAO Statistics Series No. 150. Rome.
- FAO.** 2001a. *Soil and nutrient management in sub-Saharan Africa in support of the Soil Fertility Initiative*. Land and Water Development Division. AGL/MISC/31/01. Rome.

- FAO. 2001b. *Evaluation de l'efficacité agronomique des phosphates naturels pour l'application directe en Afrique de l'Ouest: synthèse des résultats agronomiques expérimentaux*, by G. Bizimungu, R.N. Roy & W. Burgos. Rome. 49 pp.
- FAO. *FAOSTAT statistics database* (available at <http://apps.fao.org>).
- Fardeau, J.C. 1981. *Cinétique de dilution isotopique et phosphore assimilable des sols*. Univ. Paris VI. (Doctoral thesis)
- Fardeau, J.C. 1993. Le phosphore assimilable des sols: sa représentation par un modèle à plusieurs compartiments. *Agronomie*, 13: 317–331.
- Fardeau, J.C. 1996. Dynamics of phosphate in soils: an isotopic outlook. *Fert. Res.*, 45: 91–100.
- Feder, G., Just, R.E. & Zilberman, D. 1985. Adoption of agricultural innovations in developing countries: a survey. *Econ. Dev. Cult. Ch.*, 33: 255–298.
- Fixen, P.E. & Grove, J.H. 1990. Testing soils for phosphorus. In R.L. Westerman, ed. *Soil testing and plant analysis*, pp. 141–180. Book Series No. 3. Madison, USA, Soil Sci. Soc. Am. Inc.
- Flach, E.N., Quak, W. & Van Diest, A. 1987. A comparison of the rock phosphate-mobilising capacities of various crop species. *Trop. Agric.*, 64: 347–352.
- Formoso, M.L.L. 1999. *Workshop on tropical soils*. Rio de Janeiro, Brazil, Brazilian Academy of Sciences. 192 pp.
- Fox, R.L. & Kamprath, E.J. 1970. Phosphorus sorption isotherms for evaluating the phosphate requirements of soils. *Soil Sci. Soc. Am. Proc.*, 34: 902–907.
- Fox, R.L., Saunders, W.M.H. & Rajan, S.S.S. 1986. Phosphorus nutrition of pasture species: phosphorus requirement and root saturation values. *Soil Sci. Soc. Am. J.*, 50: 142–148.
- Frederick, T., Truong, B. & Fayard, F. 1992. *Pre-feasibility study: production of modified phosphate fertilizers using Kodjari phosphate rock, Burkina Faso*. IFDC-CIRAD-TECHNIFERT. 91 pp.
- Frossard, E., Brossard, M., Hedley, M.J. & Metherell, A. 1995. Reactions controlling the cycling of P in soils. In H. Tiessen, ed. *Phosphorus in the global environment*, p. 104–141. New York, USA, John Wiley & Sons.
- Gahoonia, T.S., Claassen, N. & Jungk, A. 1992. Mobilization of phosphate in different soils by ryegrass supplied with ammonium or nitrate. *Plant Soil*, 140: 241–248.
- Gaur, A.C. 1990. *Phosphorus solubilising microorganisms as biofertilisers*. New Delhi, Omega Scientific Publ. 176 pp.
- Gerner, H. & Baanante, C.A. 1995. Economic aspects of phosphate rock application for sustainable agriculture in West Africa. In H. Gerner & A.U. Mokwunye, eds. *Use of phosphate rock for sustainable agriculture in West Africa*, pp. 134–141. Lomé, IFDC Africa.
- Gerner, H. & Mokwunye, A.U., eds. 1995. *Use of phosphate rock for sustainable agriculture in West Africa*, pp. 77–83. Miscellaneous Fertilizer Studies No. 11. Muscle Shoals, USA, IFDC Africa.
- Gillard, P., Sale, P.W.G. & Tennakoon, S.B. 1997. Building an expert system to advise on the use of reactive phosphate rock on Australian pasture. *Aus. J. Exp. Agric.*, 37: 1077–1084.
- Goedert, W.J. 1983. Management of the Cerrado soils of Brazil; a review. *J. Soil Sci.* 34: 405–428.
- Gremillion, L.R. & McClellan, G.H. 1975. Importance of chemical and mineralogical data in evaluating apatitic phosphate ores. Society of Mining Engineers of AIME. *Transactions*. Vol. 270.
- Habib, L., Chien, S.H., Carmona, G. & Henao, J. 1999. Rape response to a Syrian phosphate rock and its mixture with triple superphosphate on a limed alkaline soil. *Com. Soil Sci. Plant Anal.*, 30: 449–456.
- Habib, L., Chien, S.H., Menon, R.G. & Carmona, G. 1998. Modified iron oxide-impregnated paper strip test for soils treated with phosphate fertilizers. *Soil Sci. Soc. Am. J.*, 62: 972–976.

- Halder, A.K., Mishra, A.K., Bhattacharyya, P. & Chakrabartty, P.K.** 1990. Solubilization of rock phosphate by Rhizobium and Bradyrhizobium. *J. Gen. App. Microbiol.*, 36: 81–92.
- Hammond, L.L.** 1977. *Effectiveness of phosphate rocks in Colombian soils as measured by crop response and soil phosphorus levels*. Michigan State University, USA. (Ph.D. thesis)
- Hammond, L.L. & Day, D.P.** 1992. Phosphate rock standardization and product quality. In A.T. Bachik & A. Bidin, eds. *Proceedings of a workshop on phosphate sources for acid soils in the humid tropics of Asia*, pp. 73–89. Kuala Lumpur, Malaysian Society of Soil Science.
- Hammond, L.L. & Leon, L.A.** 1983. Agronomic effectiveness of natural and altered phosphate rocks from Latin America. In IMPHOS, ed. 3rd international congress on phosphorus compounds, pp. 503–518. Brussels.
- Hammond, L.L., Chien, S.H. & Easterwood, G.W.** 1986a. Agronomic effectiveness of Bayovar phosphate rock in soil with induced phosphorus retention. *Soil Sci. Soc. Am. J.*, 50: 1601–1606.
- Hammond, L.L., Chien, S.H. & Mokuwunye, A.U.** 1986b. Agronomic value of unacidulated and partially acidulated phosphate rocks indigenous to the tropics. *Adv. Agron.*, 40: 89–140.
- Hammond, L.L., Chien, S.H., Roy, A.H. & Mokuwunye, A.U.** 1989. Solubility and agronomic effectiveness of partially acidulated phosphate rocks as influenced by their iron and aluminium oxide content. *Fert. Res.*, 19: 93–98
- Harjanto, S.** 1986. *Phosphate deposits in Indonesia*. Workshop on occurrence, exploration and development of fertilizer minerals in the ESCAP region, 26–30 August 1986, Bangkok. pp. 191–197.
- Haynes, R.J.** 1992. Relative ability of a range of crop species to use phosphate rock and monocalcium phosphate as P sources when grown in soil. *J. Sci. Food Agric.*, 74: 1–7.
- He, Z.L., Bian, W. & Zhu, J.** 2002. Screening and identification of microorganisms capable of utilizing phosphate adsorbed by goethite. *Com. Soil Sci. Plant Anal.*, 33: 647–663.
- Hedley, M.J. & Bolan, N.S.** 1997. Developments in some aspects of reactive phosphate rock research and use in New Zealand. *Aus. J. Exp. Agric.*, 37: 861–884.
- Hedley, M.J. & Bolan, N.S.** 2003. Key outputs from reactive phosphate rock research in New Zealand. In S.S.S. Rajan & S.H. Chien, eds. *Direct application of phosphate rock and related technology: latest developments and practical experiences*. Proc. Int. Meeting, Kuala Lumpur, 16–20 July 2001. Muscle Shoals, USA, IFDC. 441 pp.
- Hedley, M.J., Bolan, N.A. & Braithwaite, A.C.** 1988. Single superphosphate-reactive phosphate rock mixtures. 2. The effect of phosphate rock type and denning time on the amounts of acidulated and extractable phosphate. *Fert. Res.*, 16: 179–194.
- Hedley, M.J., Nye, P.H. & White, R.E.** 1983. Plant induced changes in the rhizosphere of rape (*Brassica napus* cv Emerald) seedlings. IV. The effect of rhizosphere phosphorus status on the pH, phosphatase activity and depletion of soil phosphorus fractions in the rhizosphere and on the cation-anion balance in plants. *New Phyt.*, 95: 69–82.
- Heerink, N., Kuyvenhoven, A. & Van Wijk, S.M.** 2001. Economic policy reforms and sustainable land use in LDCs: issues and approaches. In N. Heerink, H. Van Keulen & M. Kuiper, eds. *Economic policy reforms and sustainable land use in LDCs. Recent advances in quantitative analysis*, pp. 1–20. Heidelberg, Germany, Physica Verlag.
- Helleiner, G.K.** 1975. Smallholder decision making: tropical African evidence. In L.G. Reynolds, ed. *Agriculture in development theory*. New Haven, USA, Yale University Press.
- Helling, C.S., Chesters, G. & Corey, R.B.** 1964. Contribution of organic matter and clay to soil cation-exchange capacity as affected by the pH of the saturating solution. *Soil Sci. Soc. Am. Proc.*, 28: 517–520.
- Hellums, D.T.** 1991. *Factors affecting the efficiency of nonconventional phosphorus fertilizers in lowland and upland cropping systems*. Auburn University, Auburn, USA. (Ph.D. thesis)

- Hellums, D.T.** 1992. Role of non-conventional phosphate fertilizers in tropical agriculture: IFDC's research perspective. In J.J. Schultz, ed. *Phosphate fertilizers and the environment*, pp. 89–95. Muscle Shoals, USA, IFDC.
- Hellums, D.T.** 1995a. Phosphorus and its role in crop production in Asia. In K. Dahanayake, S.J. Van Kauwenbergh & D.T. Hellums, eds. *Direct application of phosphate rock and appropriate technology fertilizers in Asia: what hinders acceptance and growth*, pp. 9–14. Kandy, Sri Lanka, Institute of Fundamental Studies, and Muscle Shoals, USA, IFDC.
- Hellums, D.T.** 1995b. Environmental aspects of phosphate fertilizer production and use. In K. Dahanayake, S.J. Van Kauwenbergh & D.T. Hellums, eds. *Direct application of phosphate rock and appropriate technology fertilizers in Asia: what hinders acceptance and growth*, pp. 105–114. Kandy, Sri Lanka, Institute of Fundamental Studies, and Muscle Shoals, USA, IFDC.
- Hellums, D.T., Baanante, C.A. & Chien, S.H.** 1992. Alternative phosphorus fertilizers for the tropics: an agronomic and economic evaluation. In S. Balas, ed. *Proceedings of the tropsoils phosphorus decision support system workshop*, pp. 147–154. Raleigh, USA, Tropical Soils 92–01.
- Hellums, D.T., Chien, S.H. & Touchton, J.T.** 1989. Potential agronomic value of calcium in some phosphate rocks from South America and West Africa. *Soil Sci. Soc. Am. Proc.*, 53: 459–462.
- Helyar, K.R.** 1998. Efficiency of nutrient utilization and sustaining soil fertility with particular reference to phosphorus. *Field Crops Res.*, 56: 187–195.
- Henao, J. & Baanante, C. A.** 1999. *An evaluation of strategies to use indigenous and imported sources of phosphorus to improve soil fertility and land productivity in Mali*. Technical Bulletin IFDC-T-49. Muscle Shoals, USA, IFDC. 75 pp.
- Heng, L.K.** 2000. Modelling, database and the P submodel. In IAEA, ed. *Management and conservation of tropical acid soils for sustainable crop production*, pp. 101–111. IAEA-TECDOC-1159. Vienna, IAEA.
- Heng, L.K.** 2003. Towards developing a decision support system for phosphate rock direct application in agriculture. In *Proceedings of the international meeting on direct application of phosphate rock and related technology: latest developments and practical experiences*. Special Publication. Muscle Shoals, USA, IFDC.
- Hien, V., Kaboré, D., Youl, S. & Löwenberg de Boer, J.** 1997. Stochastic dominance analysis of on-farm trial data: the riskiness of alternative phosphate sources in Burkina Faso. *Ag. Econ.*, 15(3): 213–221.
- Hinsinger, P.** 1998. How do plant roots acquire mineral nutrients? *Adv. Agron.*, 64: 225–265.
- Hinsinger, P. & Gilkes, R.J.** 1995. Root-induced dissolution of phosphate rock in the rhizosphere of lupins grown in alkaline soil. *Aus. J. Soil. Res.*, 33: 477–489.
- Hinsinger, P. & Gilkes, R.J.** 1997. Dissolution of phosphate rock in the rhizosphere of five plant species grown in an acid, P-fixing substrate. *Geoderma*, 75: 231–249.
- Hocking, P.J.** 2001. Organic acids exuded from roots in phosphorus uptake and aluminum tolerance of plants in acid soils. *Adv. Agron.*, 74: 63–93.
- Hocking, P.J., Keerthisinghe, G., Smith, F.W. & Randall, P.J.** 1997. Comparison of the ability of different crop species to access poorly-available soil phosphorus. In T. Ando, K. Fujita, K.H. Matsumoto, S. Mori & J. Sekiya, eds. *Plant nutrition for sustainable food production and agriculture*, pp. 305–308. Dordrecht, The Netherlands, Kluwer Academic Publishers.
- Hocking, P.J., Randall, P., Delhaize, E. & Keerthisinghe, G.** 2000. The role of organic acids exuded from roots in phosphorus nutrition and aluminum tolerance in acidic soils. In IAEA, ed. *Management and conservation of tropical acid soils for sustainable crop production*, pp. 61–73. IAEA-TECDOC-1159. IAEA, Vienna.

- Hoffland, E.** 1992. Quantitative evaluation of the role of organic acid exudation in the mobilization of rock phosphate by rape. *Plant Soil*, 140: 279–289.
- Hoffland, E., Findenegg, G.R. & Nelemans, J.A.** 1989. Solubilization of rock phosphate by rape. II. Local root exudation of organic acids as a response to P-starvation. *Plant Soil*, 113: 161–165.
- Horst, W.J & Waschkies, C.** 1987. Phosphorus nutrition of spring wheat in mixed culture with white lupin. *Z. Pflanz. Bodenk.*, 150: 1–8.
- Howeler, R.H. & Woodruff, C.M.** 1968. Dissolution and availability to plants of rock phosphates of igneous and sedimentary origins. *Soil Sci. Soc. Am. Proc.*, 32: 79–82.
- Hu, H.Q., Li, X.Y., Liu, J.F., Liu, F.L., Xu, L. & Liu, F.** 1997. The effect of direct application of phosphate rock on increasing crop yield and improving properties of red soil. *Nutr. Cycl. Agroecosys.*, 46: 235–239.
- Hulse, J.H.** 1995. *Science, agriculture and food security*. Ottawa, NRC Research Press.
- IAEA.** 2000. *Management and conservation of tropical acid soils for sustainable crop production*. Proceedings of a consultants meeting, 1–3 March 1999. IAEA-TECDOC-1159. Vienna.
- IAEA.** 2002. *Assessment of soil phosphorus status and management of phosphatic fertilizers to optimize crop production*. IAEA-TECDOC-1272. Vienna. (also available on CD ROM)
- IFDC.** 1996. *Pilot plant test to produce granular partially acidulated phosphate rock products by the single step acidulation granulated process using Riecito phosphate rock*. Final Report. Muscle Shoals, USA.
- IFDC.** 2003. *Direct application of phosphate rock and related technology: latest experiences and practical experiences*, S.S.S. Rajan & S.H. Chien, eds. Proc. Int. Meeting, Kuala Lumpur, 16–20 July 2001. Muscle Shoals, USA, International Fertilizer Development Center. 441 pp.
- IFDC-CIRAD-ICRAF-NORAGRIC.** 1996. An assessment of phosphate rock as a capital investment: evidence from Burkina Faso, Madagascar, Zimbabwe. Washington, DC, World Bank. 23 pp.
- Illmer, P. & Scinner, F.** 1995. Solubilization of inorganic calcium phosphates – solubilisation mechanisms. *Soil Biol. Biochem.*, 27: 257–263.
- Illmer, P., Barbato, A. & Scinner, F.** 1995. Solubilization of hardly-soluble $AlPO_4$ with P solubilising microorganisms. *Soil Biol. Biochem.*, 27: 265–270.
- IMPHOS.** 1983. *Third international congress on phosphorus compounds*. Proc. Congress, 4–6 October 1983, Brussels. 656 pp.
- IMPHOS.** 1992. *Fourth international IMPHOS conference*. Proc. Int. Conf., Ghent, Belgium. 758 pp.
- Iretskaya, S.N. & Chien, S.H.** 1999. Comparison of cadmium uptake by five different food grain crops grown on three soils varying in pH. *Com. Soil Sci. Plant Anal.*, 30: 441–448.
- Iretskaya, S.N., Chien, S.H. & Menon, R.G.** 1998. Effect of acidulation of high cadmium containing phosphate rocks on cadmium uptake by upland rice. *Plant Soil*, 201:183–188.
- Ishikawa, S., Wagatsuma, T., Sasaki, R. & Ofei-Manu, P.** 2000. Comparison of the amount of citric and malic acids in Al media of seven plant species and two cultivars each in five plant species. *Soil Sci. Plant Nutr.*, 46: 751–758.
- Jadin, P. & Truong, B.** 1987. Efficacité de deux phosphates naturels tricalciques dans deux sols ferrallitiques acides du Gabon. *Café Cacao Thé*, Vol. XXXI, no. 4: 291–302.
- Jaggi, T.N.** 1986. Potentiality of using ground rock phosphates as phosphatic fertilizers in Indian soils. In G.V. Kothandaraman, T.S. Manickam & K. Natarajan, eds. *Rock phosphate in agriculture*, pp 1–14. Coimbatore, India, Tamil Nadu Agricultural University.
- Jama, B., Swinkels, A. & Buresh, R.J.** 1997. Agronomic and economic evaluations of organic and inorganic phosphorus in western Kenya. *Agron. J.*, 89: 597–604.

- Johnston, A.E & Syers, J.K., eds.** 1996. *Nutrient management for sustainable food production in Asia*. Proc. Int. Conf. IMPHOS-AARD/CSAR. Wallingford, UK, CAB International.
- Johnston, H.W.** 1954a. The solubilization of “insoluble” phosphate. II – A quantitative and comparative study of the action of selected aliphatic acids on tricalcium phosphate. *N. Z. J. Sci. Tech. B.*, 36: 49–55.
- Johnston, H.W.** 1954b. The solubilization of “insoluble” phosphate. III – A quantitative and comparative study of the action of chosen aromatic acids on tricalcium phosphate. *N. Z. J. Sci. Tech. B.*, 36: 281–284.
- Johnstone, P.D. & Sinclair, A.G.** 1991. Replication requirements in field experiments for comparing phosphate fertilizers. *Fert. Res.*, 29: 329–333.
- Jones, D.L.** 1998. Organic acids in the rhizosphere – a critical review. *Plant Soil*, 205: 25–44.
- Jones, M.D., Duraqll, D.M. & Tinker, P.B.** 1998. A comparison of arbuscular and ectomycorrhizal *Eucalyptus coccifera*: growth response, phosphorus uptake efficiency, and external hyphal production. *New Phyt.*, 140: 125–134.
- Kamh, M., Horst, W.J., Amer, F., Mostafa, H. & Maier, P.** 1999. Mobilization of soil and fertilizer phosphate by cover crops. *Plant Soil*, 211: 19–27.
- Kamprath, E.J.** 1970. Exchangeable aluminum as a criterion for liming leached mineral soils. *Soil. Sci. Soc. Am. Proc.*, 34: 252–254.
- Kanabo, I. & Gilkes, R.J.** 1987. The role of soil pH in the dissolution of phosphate rock fertilizers. *Fert. Res.*, 12: 165–174.
- Keerthisinghe, G., Zapata, F., Chalk, P.M. & Hocking, P.** 2001. Integrated approach for improved P nutrition of plants in tropical acid soils. In W.J. Horst, M.K. Schenk, A. Bürkert, N. Classen, H. Flessa, W.B. Frommer, H. Goldbach, H.W. Olf, V. Römheld, B. Sattelmacher, U. Schmidhalter, S. Schubert, N. v. Wiren & L. Wittenmayer, eds. *Food security and sustainability of agro-ecosystems through basic and applied research*, pp. 974–975. Proceedings of the XIV International Plant Nutrition Colloquium. Dordrecht, The Netherlands, Kluwer Academic Publishers.
- Khasawneh, F.E. & Doll, E.C.** 1978. The use of phosphate rock for direct application to soils. *Adv. Agron.*, 30: 159–206
- Kirk, G.J.D. & Nye, P.H.** 1985a. The dissolution and dispersion of dicalcium phosphate dihydrate in soils. I. A predictive model for a planar source. *J. Soil Sci.*, 36: 445–459.
- Kirk, G.J.D. & Nye, P.H.** 1985b. The dissolution and dispersion of dicalcium phosphate dihydrate in soils. II. Experimental evaluation of the model. *J. Soil Sci.*, 36: 461–468.
- Kirk, G.J.D. & Nye, P.H.** 1986. The dissolution and dispersion of dicalcium phosphate dihydrate in soils. III. A predictive model for regularly distributed particles. *J. Soil Sci.*, 37: 511–524.
- Kittams, H.A. & Attoe, O.J.** 1965. Availability of phosphorus in rock phosphate-sulphur fusions. *Agron. J.*, 57: 331–334
- Klockner Industrie Anlagen GMBH.** 1968. Etude économique et technique en vue de l’exploitation d’un gisement de phosphates dans la région de Bourem, Mali. Bamako, Dir. Nat. Geol. Mines. 63 pp.
- Kpomblekou, K. & Tabatabai, M.A.** 1994a. Effect of organic acids on release of phosphorus from phosphate rocks. *J. Soil Sci.*, 158: 442–453.
- Kpomblekou, K. & Tabatabai, M.A.** 1994b. Metal content of phosphate rocks. *Com. Soil Sci. Soc. Plant Anal.*, 25: 2871–2882.
- Kpomblekou, K., Chien, S.H., Henao, J. & Hill, W.A.** 1991. Greenhouse evaluation of phosphate fertilizers produced from Togo phosphate rock. *Com. Soil Sci. Plant Anal.*, 22: 63–73.
- Kucey, R.M.N., Janzen, H.H. & Leggett, M.E.** 1989. Microbially mediated increases in plant-available phosphorus. *Adv. Agron.*, 42: 199–228.

- Kuyvenhoven, A., Becht, J.A. & Ruben, R.** 1998a. Critères économiques d'un investissement public dans l'amélioration du sol en Afrique de l'Ouest: prévisions d'utilisations du phosphate naturel pour l'amélioration de la fertilité du sol. In H. Breman & K. Sissoko, eds. *Intensification agricole du Sahel*, pp. 895–916. Paris, Karthala.
- Kuyvenhoven, A., Becht, J.A. & Ruben, R.** 1998b. Financial and economic evaluation of phosphate rock use to enhance soil fertility in West Africa: is there a role for government? In G.A.A. Wossink, G.C. Van Kooten & G.H. Peters, eds. *Economics of agro-chemicals*, pp. 249–261. Aldershot, UK, Ashgate.
- Kuyvenhoven, A., Ruben, R. & Kruseman, G.** 1998c. Technology, market policies and institutional reform for sustainable land use in southern Mali. *Ag. Econ.*, 19: 53–62.
- Lal, R.** 1990. Tropical soils: distribution, properties and management. *Res. Man. Opt.*, 7: 39–52.
- Lal, R.** 1999. Soil management and restoration for C sequestration to mitigate the accelerated greenhouse effect. *Prog. Env. Sci.*, 1: 307–326.
- Lal, R.** 2000. Soil management in the developing countries. *Soil Sci.*, 165(1): 57–72.
- Lange Ness, R. & Vlek, P.L.G.** 2000. Mechanism of calcium and phosphate release from hydroxy-apatite by mycorrhizal hyphae. *Soil Sci. Soc. Am. J.*, 64: 949–955.
- Larsen, S.** 1952. The use of ³²P in studies of the uptake of phosphorus by plants. *Plant Soil*, 4: 1–10.
- Ledgard, S.F., Thorrold, B.S., Sinclair, A.G., Rajan, S.S.S. & Edmeades, E.C.** 1992. Summary of MAF field trials with 'Longlife' phosphatic fertilizers. *Proc. N. Z. Grass. Ass.*, 54: 35–40.
- Lehr, J.R. & McClellan, G.H.** 1972. *A revised laboratory reactivity scale for evaluating phosphate rocks for direct application*. Bulletin Y-43. Muscle Shoals, USA, Tennessee Valley Authority.
- Lenglen, M.** 1935. *La question de l'emploi direct des phosphates minéraux naturels*. Paris, Syndicat National des Engrais Chimiques. 46 p.
- Leon, L.A., Fenster, W.E. & Hammond, L.L.** 1986. Agronomic potential of eleven phosphate rocks from Brazil, Colombia, Peru, and Venezuela. *Soil Sc. Soc. Am. J.*, 50(3): 798–802.
- Ling, A.H., Harding, P.E. & Ranganathan, V.** 1990. Phosphorus requirements and management of tea, coffee and cocoa. In IRRI, ed. *Phosphorus requirements for sustainable agriculture in Asia and Oceania*, pp. 383–398. Manila, IRRI.
- Loganathan, P., Hedley, M.J. & Bretherton, M.R.** 1994. The agronomic value of co-granulated Christmas Island grade C phosphate rock and elemental sulphur. *Fert. Res.*, 39: 229–237.
- Lompo, F., Sedogo, M.P. & Hien, V.** 1995. Agronomic impact of Burkina phosphate and dolomite limestone. In H. Gerner & A.U. Mkwunye, eds. *Use of phosphate rock for sustainable agriculture in West Africa*, pp. 54–66. Miscellaneous Fertilizer Studies No. 11. Muscle Shoals, USA, IFDC Africa.
- Lopes, A.** 1998. The use of phosphate rocks to build up soil P and increase food production in acid soils: the Brazilian experience. In A.E. Johnston & J.K. Syers, eds. *Nutrient management for sustainable food production in Asia*, pp. 121–132. Proc. IMPHOS-AARD/CSAR. Wallingford, UK, CAB International.
- Mackay, A.D. & Syers, J.K.** 1986. Effect of phosphate, calcium, and pH on the dissolution of a phosphate rock in soil. *Fert. Res.*, 10: 175–184.
- Mackay, A.D., Syers, J.K. & Gregg, P.E.H.** 1984. Ability of chemical extraction procedures to assess the agronomic effectiveness of phosphate rock materials. *N. Z. J. Agric. Res.*, 27: 219–230.
- Maene, L.M.** 2003. Direct application of phosphate rock: a global perspective of the past, present, and future. In S.S.S. Rajan & S.H. Chien, eds. *Direct application of phosphate rock and related technology: latest developments and practical experiences*. Proc. Int. Meeting, Kuala Lumpur, 16–20 July 2001. Muscle Shoals, USA, IFDC. 441 pp.

- Mahimairaja, S., Bolan, N.S. & Hedley, M.J.** 1995. Dissolution of phosphate rock during the composting of poultry manure: an incubation experiment. *Fert. Res.*, 40: 93–104.
- Malaysian Standard.** 1998. *Specification for ground phosphate rock, agricultural grade (second revision), MS46: 1998*. Selangor DE, Malaysia, Department of Standards.
- Manickam, T.S.** 1993. Organics in soil fertility and productivity management. In P.K. Thampan, ed. *Organics in soil health and crop production*, pp. 87–104. Cochin, India, Peekay Tree Crops Developments Foundation.
- Manjunath, A. & Habte, M.** 1992. External and internal P requirements of plant species differing in their mycorrhizal dependency. *A. Soil Res. Rehab.* 6: 271–284.
- Marschner, H.** 1993. *Mineral nutrition of higher plants*. London, Academic Press Ltd., Harcourt Brace & Co. Publishers.
- Matthews, R., Stephens, W., Hess, T., Middleton, T. & Graves, A.** 2002. Applications of crop/soil simulation models in tropical agricultural systems. *Adv. Agron.*, 76: 31–124.
- McClellan, G.H.** 1980. Mineralogy of carbonate fluorapatites. *J. Geol. Soc.*, 6: 675–681.
- McClellan, G.H. & Gremillion, L.R.** 1980. Evaluation of phosphatic raw materials. In F.E. Khasawneh, ed. *The role of phosphorus in agriculture*, pp. 43–80. Madison, USA, ASA-SSSA.
- McClellan, G.H. & Lehr, J.R.** 1969. Crystal chemical investigation of natural apatites. *Am. Min.*, 54: 1374–1391.
- McClellan, G.H. & Notholt, A.F.G.** 1986. Phosphate deposits of tropical sub-Saharan Africa. In A.E. Mokwunye & P.L.G. Vlek, eds. *Management of nitrogen and phosphorus fertilizers in sub-Saharan Africa*, pp. 173–224. Developments in Plant and Soil Sciences 24. Dordrecht, The Netherlands, Kluwer Academic Publishers.
- McClellan, G.H. & Van Kauwenbergh, S.J.** 1990a. Mineralogy of sedimentary apatites. In A.J.G. Notholt & I. Jarvis, eds. *Phosphorite research and development*. Geological Society Special Publication 52: 23–31.
- McClellan, G.H. & Van Kauwenbergh, S.J.** 1990b. Relationship of mineralogy to sedimentary phosphate rock reactivity. In A.T. Bachik & A. Bidin, eds. *Proceedings of the workshop on phosphate sources for acid soils in the humid tropics of Asia*, pp. 1–17. Kuala Lumpur, Malaysian Society of Soil Science.
- McClellan, G.H. & Van Kauwenbergh, S.J.** 1991. Mineralogical and chemical variation of francolites with geological time. *J. Geol. Soc.*, 148: 809–812.
- McConnell, D.** 1938. A structural investigation of the isomorphism of the apatite group. *Am. Min.*, 54: 1379–1391.
- McLaughlin, M.J., Simpson, P., Fleming, F., Stevens, D.P., Cozens, G. & Smart, M.K.** 1997. Effect of fertilizer type on cadmium and fluorine concentrations in clover herbage. *Aus. J. Exp. Ag.*, 37: 1019–1026.
- McLay, C.D., Rajan, S.S.S. & Liu, Q.** 2000. Agronomic effectiveness of partially acidulated phosphate rock fertilizers in an allophonic soil at near-neutral pH. *Com. Soil Sci. Plant Anal.*, 31: 423–435.
- Menge, J.A., Lembright, H. & Johnson, E.L.V.** 1977. Utilization of mycorrhizal fungi in citrus nurseries. *Proc. Int. Soc. Cit.*, 1: 129–132.
- Menon, R.G. & Chien, S.H.** 1990. Phosphorus availability to maize from partially acidulated phosphate rocks and phosphate rocks compacted with triple superphosphate. *Plant Soil*, 127: 123–128.
- Menon, R.G. & Chien, S.H.** 1995. Soil testing for available phosphorus in soils where phosphate rock-based fertilizers are used. *Fert. Res.*, 41: 179–181.

- Menon, R.G. & Chien, S.H.** 1996. *Compaction of phosphate rocks with soluble phosphates – an alternative technology to partial acidulation of phosphate rocks with low reactivity: IFDC's experience*. IFDC-T-44. Muscle Shoals, USA, IFDC.
- Menon, R.G., Chien, S.H. & Chardon, W.J.** 1997. Iron oxide-impregnated filter paper (P_i test): II. A review of its application. *Nut. Cyc. Agroecosys.*, 47: 7–18.
- Menon, R.G., Chien, S.H. & Hammond, L.L.** 1989a. The P_i soil phosphorus test: a new approach to testing for soil phosphorus. IFDC Reference Manual R-7. Muscle Shoals, USA, IFDC.
- Menon, R.G., Chien, S.H. & Hammond, L.L.** 1990. Development and evaluation of the P_i soil test for plant-available phosphorus. *Com. Soil Sci. Plant Anal.*, 21: 1131–1150.
- Menon, R.G., Hammond, L.L. & Sissingh, H.A.** 1989b. Determination of plant-available phosphorus by the iron hydroxide-impregnated paper (P_i) soil test. *Soil Sci. Soc. Am. J.*, 53: 110–115.
- Metherell, A.K. & Perrott, K.W.** 2003. An integrated decision support package for evaluation of reactive phosphate rock fertilizer strategies for grazed pasture. In S.S.S. Rajan & S.H. Chien, eds. *Direct application of phosphate rock and related technology: latest developments and practical experiences*. Proc. Int. Meeting, Kuala Lumpur, 16–20 July 2001. Muscle Shoals, USA, IFDC. 441 pp.
- Mew, M.** 2000. Phosphate rock. In *Metals and mineral annual review*, pp. 110–122. London, The Mining Journal Ltd.
- Mishra, B.** 1975. Report on investigations on the utilization of Mussoorie rock phosphate for direct application to field crops. In PPCL, ed. *Mussoorie-phos, a phosphate fertilizer for direct application*. Dehradun, India, PPCL. 34 pp.
- Mishra, M.M. & Bangar, K.C.** 1986. Rock phosphate composting: transformation of phosphorus forms and mechanisms of solubilization. *Bio. Ag. Hort.*, 3: 331–340.
- Miyasaka, C. & Habte, M.** 2001. Plant mechanisms and mycorrhizal symbioses to increase phosphorus uptake efficiency. *Com. Soil Sci. Plant Anal.*, 32: 1101–1147.
- Moghimi, A. & Tate, M.E.** 1978. Does 2-Ketogluconate chelate calcium in the pH range 2.4–6.4? *Soil Biol. Biochem.*, 10: 289–292.
- Mokwunye, A.E. & Vlek, P.L.G., eds.** 1986. *Management of nitrogen and phosphorus fertilizers in sub-Saharan Africa*, pp. 173–224. Developments in Plant and Soil Sciences 24. Dordrecht, The Netherlands, Kluwer Academic Publishers.
- Montange, D. & Zapata, F.** 2002. Standard characterization of soils employed in the FAO/IAEA phosphate project. In IAEA, ed. *Assessment of soil phosphorus status and management of phosphatic fertilizers to optimise crop production*, pp. 24–43. IAEA TECDOC 1272. Vienna, IAEA. 473 pp.
- Montenegro, A. & Zapata, F.** 2002. Rape genotypic differences in P uptake and utilization from phosphate rocks in an andisol of Chile. *Nut. Cyc. Agroecosys.*, 63(1): 27–33.
- Moorby, H., White, R. & Nye, P.** 1988. The influence of phosphate nutrition on H ion efflux from the roots of young rape plants. *Plant Soil*, 105: 247–256.
- Morel, C. & Fardeau, J.C.** 1989. Native soil and fresh fertilizer phosphorus uptake as affected by rate of application and P fertilizers. *Plant Soil*, 115: 123–128.
- Mortvedt, J.J. & Sikora, F.J.** 1992. Heavy metal, radionuclides, and fluorides in phosphorus fertilizers. In F.J. Sikora, ed. *Future directions for agricultural phosphorus research*, pp. 69–73. TVA Bulletin Y-224. Muscle Shoals, USA.
- Mosse, B., Stribley, D.P. & Le Tacon, F.** 1981. Ecology of mycorrhizae and mycorrhizal fungi. *Adv. Micro. Ecol.*, 5: 137–210.
- Mostara, M.R. & Datta, N.P.** 1971. Rock phosphate as a fertilizer for direct application in acid soils. *J. Ind. Soil Sci.*, 19: 107–113.

- Mugwira, L., Nyamangara, J. & Hikwa, D.** 2002. Effect of manure and fertilizer on maize at a research station and in a smallholder (peasant) area of Zimbabwe. *Plant Soil*, 33: 379–402.
- Murdoch, C.L., Jacobs, J.A. & Gerdemann, J.W.** 1967. Utilization of phosphorus sources of different availability by mycorrhizal and non-mycorrhizal maize. *Plant Soil*, 27: 329–338.
- Nakamaru, Y., Nanzyo, M. & Yamasaki, S.** 2000. Utilization of apatite in fresh volcanic ash by pigeonpea and chickpea. *Soil Sci. Plant Nut.*, 46: 591–600.
- Nelson, W.L., Mehlich, A. & Winters, E.** 1953. The development, evaluation, and use of soil tests for phosphorus availability. *Agron. J.*, 4: 153–158.
- Netherlands Economic Institute (NEI).** 1998. *Opérationnalisation d'un programme d'utilisation du Burkina phosphate*. Restricted circulation. Rotterdam, The Netherlands.
- Nordengren, S.** 1957. New theories of phosphate reactions in the soil. *Fert. Feed. Stuffs J.*, 47: 344–353
- Notholt, A.J.G., Sheldon, R.P. & Davidson, D.F., eds.** 1989. *Phosphate deposits of the world, Vol. 2: phosphate rock resources*. Cambridge, UK, University Press Cambridge.
- Official Journal of the European Communities.** 1976. No. L24, 30.1.76, p.29.
- Oldeman, L.R.** 1994. The global extent of soil degradation. In D.J. Greenland & I. Szabolcs, eds. *Soil resilience and sustainable land use*, pp. 99–118. Wallingford, UK, CAB International.
- Olsen, S.R., Cole, C.V., Watanabe, F.S. & Dean, L.A.** 1953. *Estimation of available phosphorus in soils by extraction with sodium bicarbonate*. USDA Circ. 939.
- Ortas, I., Harris, P.J. & Rowell, D.L.** 1996. Enhanced uptake of phosphorus by mycorrhizal sorghum plants as influenced by forms of nitrogen. *Plant Soil*, 184: 255–264.
- Ortas, I., Ortakci, D. & Kaya, Z.** 2002. Various mycorrhizal fungi propagated on different hosts have different effect on citrus growth and nutrient uptake. *Com. Soil Sci. Plant Anal.*, 33: 259–272.
- Owusu-Bennoah, E., Zapata, F. & Fardeau, J.C.** 2002. Comparison of greenhouse and P isotopic laboratory methods for evaluating the agronomic effectiveness of natural and modified rock phosphates in some acid soils of Ghana. *Nut. Cyc. Agroecosys.*, 63(1): 1–12.
- Pairunan, A.K., Robson, A.D. & Abbott, L.K.** 1980. The effectiveness of vesicular-arbuscular mycorrhizae in increasing growth and phosphorus uptake of subterranean clover from phosphorus sources of different solubilities. *New Phyt.*, 84: 327–338.
- Palaniappan, S.P. & Natarajan, K.** 1993. Practical aspects of organic matter maintenance in soil. In P.K. Thampan, ed. *Organics in soil health and crop production*, pp. 24–41. Cochin, India, Peekay Tree Crops Development Foundation.
- Pearson, R.W.** 1975. *Soil acidity and liming in the humid tropics*. Cornell International Agriculture Bulletin 30. Ithaca, New York, Cornell University. 66 pp.
- Perrott, K.** 2003. Direct application of phosphate rocks to pastoral soils – phosphate rock reactivity and the influence of soil and climatic factors. In S.S.S. Rajan & S.H. Chien, eds. *Direct application of phosphate rock and related technology: latest developments and practical experiences*. Proc. Int. Meeting, Kuala Lumpur, 16–20 July 2001. Muscle Shoals, USA, IFDC. 441 pp.
- Perrott, K.W. & Wise, R.G.** 2000. Determination of residual reactive phosphate rock in soil. *Com. Soil Sci. Plant Anal.*, 31: 1809–1824.
- Perrott, K.W., Saggat, S. & Menon, R.G.** 1993. Evaluation of soil phosphate status where phosphate rock based fertilizers have been used. *Fert. Res.*, 35: 67–82.
- Perrott, K.W., Kerr, B.E., Watkinson, J.H. & Waller, J.E.** 1996. Phosphorus status of pastoral soils where reactive phosphate rock fertilizers have been used. *Proc. N. Z. Grass Ass.*, 57: 133–137.

- Pessarakli, M., ed.** 1999. Handbook of plant and crop stress. New York, USA, Marcel Dekker Inc. 1254 pp.
- Pohlman, A.A. & McColl, G.J.** 1986. Kinetics of metal dissolution from forest soils by organic acids. *J. Env. Qual.*, 15: 86–92.
- Poojari, B.T., Krishnappa, K.M., Sharma, K.M.S., Jayakumar, B.V. & Panchaksharaiah, S.** 1988. Efficiency of rock phosphate as a source of phosphorus in rice-groundnut cropping system in coastal Karnataka. In *Seminar proceedings on the use of rock phosphate in west coast soils*, pp. 58–63. Bangalore, India, University of Agricultural Sciences.
- Pushparajah, E., Cnah, F. & Magat, S.S.** 1990. Phosphorus requirements and management of oil palm, coconut and rubber. In IRRI, ed. *Phosphorus requirements for sustainable agriculture in Asia and Oceania*, pp. 399–425. Manila, IRRI.
- Pyrites, Phosphates and Chemicals Ltd. (PPCL).** 1980. *Mussoorie phosphorite as straight phosphatic fertilizer*. Dehradun, India.
- Pyrites, Phosphates and Chemicals Ltd. (PPCL).** 1982. *Mussoorie-phos, a phosphate fertilizer for direct application*. Mussoorie Phosphorite Project. Dehradun, India.
- Pyrites, Phosphates and Chemicals Ltd. (PPCL).** 1983. *Research on Mussoorie phosphate rock*. Technical Bulletin No. 1. New Delhi.
- Quin, B.F. & Scott, P.** 2003. Development of the market for direct application phosphate rock – a perspective based on experience in New Zealand and Scotland. In S.S.S. Rajan & S.H. Chien, eds. *Direct application of phosphate rock and related technology: latest developments and practical experiences*. Proc. Int. Meeting, Kuala Lumpur, 16–20 July 2001. Muscle Shoals, USA, IFDC. 441 pp.
- Rajan S.S.S.** 1973. Phosphorus adsorption characteristics of Hawaiian soils and their relationships to equilibrium concentrations required for maximum growth of millet. *Plant Soil*, 39: 519–532
- Rajan, S.S.S.** 1982a Availability to plants of phosphate from “biosupers” and partially acidulated phosphate rock. *N. Z. J. Ag. Res.*, 25: 355–361.
- Rajan, S.S.S.** 1982b. Influence of phosphate rock reactivity and granule size on the effectiveness of ‘biosuper’. *Fert. Res.*, 3: 3–12.
- Rajan, S.S.S.** 1983. Effect of sulphur content of phosphate rock/sulphur granules on the availability of phosphate to plants. *Fert. Res.*, 4: 287–296.
- Rajan, S.S.S.** 1987. Phosphate rock and phosphate rock/sulphur granules as phosphate fertilizers and their dissolution in soil. *Fert. Res.*, 11: 43–60.
- Rajan, S.S.S.** 2002. Comparison of phosphate fertilizers for pasture and their effect on soil solution phosphate. *Com. Soil Sci. Plant Anal.*, 33: 2227–2245.
- Rajan, S.S.S. & Ghani, A.** 1997. Differential influence of soil pH on the availability of partially sulphuric and phosphoric acidulated phosphate rocks. II. Chemical and scanning electron microscopic studies. *Nut. Cyc. Agroecosys.*, 48: 171–178.
- Rajan, S.S.S. & Marwaha, B.C.** 1993. Use of partially acidulated phosphate rocks as phosphate fertilisers. *Fert. Res.*, 35: 47–59.
- Rajan, S.S.S. & Watkinson, J.H.** 1992. Unacidulated and partially acidulated phosphate rock: agronomic effectiveness and the rates of dissolution of phosphate rock. *Fert. Res.*, 33: 267–277.
- Rajan, S.S.S., Watkinson, J.H. & Sinclair, A.G.** 1996. Phosphate rock for direct application to soils. *Ad. Agron.*, 57: 78–159.
- Rajan, S.S.S., Brown, M.W., Boyes, M.K. & Upsdell, M.P.** 1992. Extractable phosphorus to predict agronomic effectiveness of ground and unground phosphate rocks. *Fert. Res.*, 32: 291–302.

- Rajan, S.S.S., Fox, R.L., Saunders, W.M.H. & Upsdell, M.P.** 1991a. Influence of pH, time and rate of application on phosphate rock dissolution and availability to pastures. I. Agronomic benefits. *Fert. Res.*, 28: 85–93.
- Rajan, S.S.S., Fox, R.L., Saunders, W.M.H. & Upsdell, M.P.** 1991b. Influence of pH, time and rate of application on phosphate rock dissolution and availability to pastures. II. Soil chemical studies. *Fert. Res.*, 28: 95–101.
- Rao, I.M., Friesen, D.K. & Osaki, M.** 1999. Plant adaptation to phosphorus-limited tropical soils. In M. Pessarakli, ed. *Handbook of plant and crop stress*, pp. 61–96. New York, USA, Marcel Dekker Inc.
- Ratkowsky, D.A., Tennakoon, S.B., Sale, P.W.G. & Simpson, P.G.** 1997. The use of substitution values for characterizing fertilizer performance. *Aus. J. Exp. Ag.* 37: 913–920.
- Ratsimbazafy, J.R.** 1975. *Reconnaissance préliminaire des dépôts phosphatés des Iles Barren*. Doc. A.2223. Tananarive, Madagascar, Service Géologique de Madagascar.
- Rauniyar, G.P. & Goode, F.M.** 1992. Technology adoption on small farms. *World Dev.*, 20(2): 275–282.
- RELARF.** 1996. *Resúmenes de comunicaciones orales*. IV Reunión de la Red Latinoamericana de Roca Fosfórica, 3–5 julio 1996. Havana.
- Robinson, J.S. & Syers, J.K.** 1991. Effects of solution calcium concentration and calcium sink size on the dissolution of Gafsa phosphate rock in soils. *J. Soil Sci.*, 42: 389–397.
- Robinson, J.S., Syers, J.K. & Bolan, N.S.** 1992. Importance of proton supply and calcium-sink size in the dissolution of phosphate rock materials of different reactivity in soil. *J. Soil Sci.*, 43: 447–459.
- Rodríguez, R. & Herrera, J.** 2002. Field evaluation of partially acidulated phosphate rocks in a ferralsol from Cuba. *Nut. Cyc. Agroecosys.*, 63(1): 43–48.
- Rogers, E.M.** 1983. *Diffusion of innovations*. New York, USA, The Free Press.
- Rogers, H.T., Pearson, R.W. & Ensminger, L.E.** 1953. *Soil and fertilizer phosphorus in plant nutrition*. New York, USA, Academic Press.
- Rong, M.** 1995. Phosphate rocks and fertilizers in China. In K. Dahanayake, S.J. Van Kauwenbergh & D.T. Hellums, eds. *Direct application of phosphate rock and appropriate technology fertilizers in Asia – what hinders acceptance and growth*, pp. 187–189. Kandy, Sri Lanka, Institute of Fundamental Studies, and Muscle Shoals, USA, IFDC.
- Saggar, S., Hedley, M.J. & White, R.E.** 1990. A simplified resin membrane technique for extracting phosphorus from soils. *Fert. Res.*, 24: 173–180.
- Saggar, S., Hedley, M.J. & White, R.E.** 1992a. Development and evaluation of an improved soil test for phosphorus: 1. The influence of phosphorus fertilizer solubility and soil properties on the extractability of soil P. *Fert. Res.*, 33: 81–91.
- Saggar, S., Hedley, M.J., White, R.E., Gregg, P.E., Perrott, K.W. & Comforth, I.S.** 1992b. Development and evaluation of an improved soil test for phosphorus: 2. Comparing of the Olsen and mixed cation-anion exchange resin tests for predicting the yield of ryegrass grown in pots. *Fert. Res.*, 33: 135–144.
- Sale, P.W.G. & Mokwunye, A.U.** 1993. Use of phosphate rocks in the tropics. *Fert. Res.*, 35: 33–45.
- Sale, P.W.G., Simpson, P.G., Anderson, C.A. & Muir, L.L., eds.** 1997a. The role of reactive phosphate rocks fertilizers for pastures in Australia. *Aus. J. Exp. Ag.*, 37: 845–1023. Reprint: Melbourne, Australia, CSIRO Publishing.
- Sale, P.W.G., Simpson, P.G., Lewis, D.C., Gilkes, R.J., Bolland, M.D.A., Ratkowsky, D.A., Gilbert, M.A., Garden, D.L., Cayley, J.W.D. & Johnson, D.** 1997b. The agronomic effectiveness of reactive phosphate rocks: 1. Effect of the pasture environment. *Aus. J. Exp. Ag.*, 8: 921–936.

- Sanchez, P.A. & Buol, S.W.** 1975. Soils of the tropics and the world food crisis. *Science*, 188: 598–603.
- Sanchez, P.A. & Salinas, J.G.** 1981. Low-input technology for managing oxisols and ultisols in tropical America. *Adv. Agron.*, 34: 280–398.
- Sari, N., Ortas, I. & Yetisir, H.** 2002. Effect of mycorrhiza inoculation on plant growth, yield, and phosphorus uptake in garlic under field conditions. *Com. Soil Sci. Plant Anal.*, 33: 2189–2201.
- Schnitzer, M. & Skinner, S.I.M.** 1969. Free radicals in soil humic compounds. *Soil. Sci.*, 108: 383–388.
- Schultz, J.** 1986. Sulphuric acid-based partially acidulated phosphate rock: its production cost and use. IFDC-T-31. Muscle Shoals, USA, IFDC.
- Secilia, J. & Bagyaraj, D.J.** 1992. Selection of efficient vesicular-arbuscular mycorrhizal fungi for wetland rice (*Oryza sativa* L). *Bio. Fert. Soils*, 13: 108–111.
- Sery, A. & Greaves, G.N.** 1996. Chemical state of Cd in apatite phosphate ore as determined by EXAFS spectroscopy. *Am. Min.*, 81: 864–873.
- Shapiro, B.I. & Sanders, J.H.** 1998. Fertilizer use in semi-arid West Africa: profitability and supporting policy. *Ag. Sys.*, 56(4): 467–482.
- Sheldon, R.P.** 1987. Industrial minerals, with emphasis on phosphate rock. In D.J. McLaren & B.J. Skinner, eds. *Resources and world development*, pp. 347–361. New York, USA, John Wiley & Son Limited.
- Siddique, M., Ghonsikar, C.P. & Malewar, G.U.** 1986. Studies on the use of Mussoorie rock phosphate in combination with some indigenous solubilising materials on calcareous soil. In G.V. Kothandaraman, T.S. Manickam & K. Natarajan, eds. *Rock phosphate in agriculture*, pp. 142–149. Coimbatore, India, Tamil Nadu Agricultural University.
- Sikora, F.J.** 2002. Evaluating and quantifying the liming potential of phosphate rocks. *Nut. Cyc. Agroecosys.*, 63(1): 59–67.
- Silverman, S.R., Fuyat, R.K. & Weiser, J.D.** 1952. *Quantitative determination of calcite associated with carbonate-bearing apatites*, pp. 211–222. US Geological Survey.
- Simpson, P.G.** 1997. *Reactive phosphate rocks: their potential role as P fertilizer for Australian pastures*. Technical Bulletin. Melbourne, Australia, La Trobe University.
- Sinclair, A.G., Shannon, P.W. & Risk, W.H.** 1990. Sechura phosphate rock supplies plant-available molybdenum for pastures. *N. Z. J. Ag. Res.*, 33: 499–502.
- Sinclair, A.G., Johnstone, P.D., Smith, L.C., O'Connor, M.B. & Nguyen, L.** 1993a. Comparison of six phosphate rocks and single superphosphate as phosphate fertilizers for clover-based pasture. *N. Z. J. Ag. Sci.*, 41: 415–420.
- Sinclair, A.G., Johnstone, P.D., Smith, L.C., O'Connor, M.B. & Nguyen, L.** 1993b. Agronomy, modelling and economics of reactive phosphate rocks as slow-release phosphate fertilizers for grasslands. *Fert. Res.*, 36: 229–238.
- Sinclair, A.G., Johnstone, P.D., Smith, L.C., Risk, W.H., O'Connor, M.B., Roberts, A.H., Morton, J.D., Nguyen, L. & Shannon, P.W.** 1993c. Effect of reactive phosphate rock on the pH of soil under pasture. *N. Z. J. Agric. Res.*, 36: 381–384.
- Singaram, P., Rajan, S.S.S. & Kothandaraman, G.V.** 1995. Phosphate rock and a phosphate rock/superphosphate mixture as fertilizers for crops grown on a calcareous soil. *Com. Soil Sci. Plant Anal.*, 26: 1571–1583.
- Singh, C.P. & Amberger, A.** 1990. Humic substances in straw compost with rock phosphate. *Bio. Wastes*, 31: 165–174.

- Singh, C.P. & Amberger, A.** 1991. Solubilization and availability of phosphorus during decomposition of rock phosphate enriched straw and urine. *Bio. Ag. Hort.*, 7: 261–269.
- Singh, S. & Kapoor, K.K.** 1999. Inoculation with phosphate-solubilising microorganisms and a vesicular-arbuscular mycorrhizal fungus improves dry matter yield and nutrient uptake by wheat grown in a sandy soil. *Bio. Fert. Soils*, 28: 139–144.
- Singh, U., Wilkens, P.W., Henao, J., Chien, S.H., Hellums, D.T. & Hammond, L.L.** 2003. An expert system for estimating agronomic effectiveness of freshly applied phosphate rock. In *Direct application of phosphate rock and related appropriate technology – latest developments and practical experiences*. Special publication. Muscle Shoals, USA, IFDC.
- Sissoko, K.** 1998. *Et demain l'agriculture? Options techniques et mesures politiques pour un développement agricole durable en Afrique subsaharienne*. Documents sur la gestion des ressources tropicales. Wageningen, The Netherlands, Wageningen University.
- Smith, F.W. & Grava, J.** 1958. Availability of phosphorus contained in phosphatic shale compared to that contained in monocalcium phosphate and raw rock phosphate. *Soil Sci.*, 86: 313–318.
- Smith, F.W., Ellis, B.G. & Grava, J.** 1957. Use of acid-fluoride solutions for the extraction of available phosphorus in calcareous soils and in soils to which rock phosphate has been added. *Soil Sci. Soc. Am. Proc.*, 21: 400–404.
- Sprague, R.H. Jr & Carlson, E.H.** 1982. *Building effective decision support systems*. Englewood Cliffs, USA, Prentice-Hall Inc.
- Sri Adiningsih, J. & Nassir, A.** 2001. *The potential for improving crop production on upland acid soils in Asia through the use of appropriate phosphate rocks*. Proceedings of the World Fertilizer Congress: Fertilization in the Third Millennium: Fertilizer, Food Security and Environmental Protection, 3–9 August 2001, Beijing.
- Srinivasan, T.N.** 1994. Foreign trade policies and India's development. In *Agriculture and trade in China and India*, p. 177. San Francisco, USA, International Centre for Economic Growth, ICS Press.
- Stevenson, F.J.** 1967. Organic acids in soil. In D.A. McLaren & G.H. Peterson, eds. *Soil biochemistry*, pp. 119–146. New York, USA, Marcel Dekker Inc.
- Stowasser, W.F.** 1991. Phosphate rock – analysis of the phosphate rock situation in the United States: 1990–2040. *Eng. Min. J.*, 192(9): 16CC–16II.
- Subba Rao, N.S.** 1982a. Biofertilizers. In N.S. Subba Rao, ed. *Advances in agricultural microbiology*, pp. 219–242. Oxford and IBH, UK, Mohan Prilani, and New Delhi, Butterworth and Co.
- Subba Rao, N.S.** 1982b Utilization of farm wastes and residues in agriculture. In N.S. Subba Rao, ed. *Advances in agricultural microbiology*, pp. 509–522. Oxford and IBH, UK, Mohan Prilani, and New Delhi, Butterworth and Co.
- Swaby, R.J.** 1975. Biosuper – biological superphosphate. In K.D. McLachlan, ed. *Sulphur in Australasian agriculture*, pp. 213–220. Sydney, Australia, Sydney University Press.
- Sylvia, D.M.** 1992. Demonstration and mechanism of improved phosphorus uptake by vesicular-arbuscular mycorrhizal fungi. In F.J. Sikora, ed. *Future directions for agricultural phosphorus research*, pp. 31–34. Muscle Shoals, USA, National Fertilizer and Environmental Research Centre, TVA.
- Tandon, H.L.S.** 1987. *Phosphorus: research and agricultural production in India*. Fertilizer Development and Consultation Organization. New Delhi, Greater Kailash 1.
- Tandon, H.L.S.** 1991. *Sulphur research and agricultural production in India*. Washington, DC, The Sulphur Institute. 88 pp.
- Teboh, J.F.** 1995. Phosphate rock as a soil amendment: who should bear the cost? In H. Gerner & A.U. Mokwunye, eds. *Use of phosphate rock for sustainable agriculture in West Africa*, pp. 142–149. Lomé, IFDC Africa.

- Toro, M., Azcon, R. & Barea, J.M.** 1997. Improvement of arbuscular mycorrhiza development by inoculation of soil with phosphate-solubilising rhizobacteria to improve rock phosphate bioavailability (^{32}P) and nutrient cycling. *App. Env. Microbiol.*, 63: 4408–4412.
- Truong, B.** 1986. *Synthèse des résultats des essais phosphates du Togo, bruts et partiellement attaqués, de 1983 à 1985*. Rapport de mission d'appui à la Direction de la Recherche Agronomique, Lomé. 22 pp.
- Truong, B. & Cisse, L.** 1985. Appréciation de la valeur fertilisante des phosphates de Matam (Sénégal). *Agron. Trop.*, 40(3): 230–238.
- Truong, B. & Fayard, C.** 1987. *Proposition d'une filière d'engrais au Burkina Faso à base de phosphates naturels de Kodjari, partiellement solubilisés*. Etude de faisabilité pour le Ministère de l'Agriculture et de l'Élevage (Burkina Faso) et du Ministère de la Coopération (France). 90 pp.
- Truong, B. & Fayard, C.** 1988. *Proposition d'une approche raisonnée pour la valorisation des phosphates naturels du Vénézuéla*. Rapport CIRAD-TECHNIFERT. 83 pp.
- Truong, B. & Fayard, C.** 1993. *Etude de prefaisabilité pour une production d'engrais au Mali à partir des phosphates de Tilemsi*. Rapport CIRAD-TECHNIFERT. Montpellier, France. 127 pp.
- Truong, B. & Fayard, C.** 1995. Small-scale fertilizer production units using raw and partially solubilized phosphate. In H. Gerner & A.U. Mokwunye, eds. *Use of phosphate rock for sustainable agriculture in West Africa*, pp. 181–198. Miscellaneous Fertilizer Studies No. 11. Muscle Shoals, Alabama, USA, IFDC Africa.
- Truong, B. & Montange, D.** 1998. The African experience with phosphate rock, including Djebel Onk, and case studies in Brazil and Vietnam. In A.E. Johnston & J.K. Syers, eds. *Nutrient management for sustainable food production in Asia*, pp. 133–148. Proc. IMPHOS-AARD/CSAR. Wallingford, UK, CAB International.
- Truong, B. & Pichot, J.** 1976. Influence du phosphore des graines de la plante test sur la détermination du phosphore isotopiquement diluable (valeur L). *Agron. Trop.*, 31(11): 379–386.
- Truong, B. & Zapata, F.** 2002. Standard characterization of phosphate rock samples from the FAO/IAEA phosphate project. In IAEA, ed. *Assessment of soil phosphorus status and management of phosphatic fertilizers to optimise crop production*, pp. 9–23. IAEA TECDOC. 1272. Vienna, IAEA. 473 pp.
- Truong, B., Pichot, J. & Beunard, P.** 1978. Caractérisation et comparaison des phosphates naturels tricalciques d'Afrique de l'Ouest en vue de leur utilisation directe en agriculture. *Agron. Trop.*, 33: 136–145.
- Truong, B., Beunard, P., Diekola, K. & Pichot, J.** 1982. Caractérisation et comparaison des phosphates naturels de Madagascar en vue de leur utilisation en agriculture. *Agron. Trop.*, 37(1): 9–16.
- U.S. Bureau of Mines & U.S. Geological Survey.** 1981. *Principles of a resource/reserve classification for minerals*. U.S. Geological Survey Circular 831.
- U.S. Bureau of Mines.** 2001. *Mineral commodity summaries (1981–2001), phosphate rock*. Washington, DC, U.S. Department of the Interior.
- U.S. Geological Survey.** 1982. *Sedimentary phosphate resource classification system of the U.S. Bureau of Mines and the U.S. Geological Survey*. U.S. Geological Survey Circular 882.
- United Nations Environment Programme (UNEP).** 2000. *Global environment outlook 2000*. London, Earthscan Publications Ltd.
- United Nations Industrial Development Organization (UNIDO) & IFDC.** 1998. *Fertilizer manual*. Dordrecht, The Netherlands, Kluwer Academic Publishers. 615 pp.
- Valencia, I., Pieri, C. & Hellums, D.T.** 1994. Rock phosphate as a capital investment in natural resource management. In ISSS and MSSS, eds. *Trans. 15th World Congress Soil Science, Commission VI Symposia, Vol. 7a: 227–233*. Acapulco, Mexico.

- Van der Paauw, F.** 1971. Effective water extraction method for the determination of plant available soil phosphorus. *Plant Soil*, 34: 467–481.
- Van der Zee, S.E.A.T., Fokking, L.G.J. & Van Riemdijk, W.H.** 1987. A new technique for assessment of reversibly adsorbed phosphate. *Soil Sci. Soc. Am. J.*, 51: 599–604.
- Van Kauwenbergh, S.J.** 1995. Mineralogy and characterization of phosphate rock. In K. Dahanayake, S.J. Van Kauwenbergh & D.T. Hellums, eds. *Direct application of phosphate rock and appropriate technology fertilizers in Asia – what hinders acceptance and growth*, pp. 29–47. Kandy, Sri Lanka, Institute of Fundamental Studies.
- Van Kauwenbergh, S.J.** 1997. *Cadmium and other minor elements in world resources of phosphate rock*. Proceedings No. 400. London, The Fertilizer Society.
- Van Kauwenbergh, S.J.** 2003. Overview of world phosphate rock production. In S.S.S. Rajan & S.H. Chien, eds. *Direct application of phosphate rock and related technology: latest developments and practical experiences*. Proc. Int. Meeting, Kuala Lumpur, 16–20 July 2001. Muscle Shoals, USA, IFDC. 441 pp.
- Van Kauwenbergh, S.J. & Hellums, D.T.** 1995. Direct application phosphate rock: a contemporary snapshot. *Phos. Pot.*, 200: 27–37.
- Van Kauwenbergh, S.J. & McClellan, G.H.** 1990a. Mineralogy of sedimentary apatites and the relationship to phosphate rock reactivity. In Proc. National Workshop on Fertilizer Efficiency, Cisarua, Indonesia. 29 pp.
- Van Kauwenbergh, S.J. & McClellan, G.H.** 1990b. Comparative geology and mineralogy of the southeastern United States and Togo phosphorites. In A.J.G. Notholt & I. Jarvis, eds. *Phosphorite research and development*, pp. 139–155. Geological Society Special Publication No. 52.
- Vanlauwe, B., Nwoke, O.C., Diels, J., Sanginga, N., Carsky, R.J., Deckers, J. & Merckx, R.** 2000. Utilization of rock phosphate by crops on a representative sequence in Northern Guinea savanna zone of Nigeria: response by *Mucuna pruriens*, *Lablab purpureus* and maize. *Soil Bio. Bioch.*, 32: 2063–2077.
- Verma, L.N.** 1993. Biofertiliser in agriculture. In P.K. Thampan, ed. *Organics in soil health and crop production*, pp. 152–183. Cochin, India, Peekay Tree Crops Development Foundation.
- Von Uexkull, H.R. & Mutert, E.** 1995. Global extent, development and economic impact of acid soils. In R.A. Date, N.J. Grundon, G.E. Rayment & M.E. Probert, eds. *Plant-soil interactions at low pH: principles and management*. Development in Plant and Soil Sciences 64. Dordrecht, The Netherlands, Kluwer Academic Publishers. p 5–19.
- Wani, S.P. & Lee, K.K.** 1992. Role of biofertilisers in upland crop production. In H.L.S. Tandon, ed. *Fertilisers, organic manures, recyclable wastes and biofertilisers*, pp. 91–112. New Delhi, Fertiliser Development and Consultation Organization.
- Watkinson, J.H.** 1994a. Modelling the dissolution of reactive phosphate rock in New Zealand pastoral soils. *Aus. J. Soil Res.*, 32: 739–53.
- Watkinson, J.H.** 1994b. A test for phosphate rock reactivity in which solubility and size are combined in a dissolution rate function. *Fert. Res.*, 39: 205–215.
- Weil, R.R.** 2000. Soil and plant influence on crop response to two African phosphate rocks. *Agron. J.*, 92: 1167–1175.
- Weil, S., Gregg, P.E.H. & Bolan, N.S.** 1994. Influence of soil moisture on the dissolution of reactive phosphate rocks. In L.D. Currie & P. Loganathan, eds. *The efficient use of fertilizers in a changing environment: reconciling productivity and sustainability*, pp. 75–81. Occasional Report No. 7. Palmerston North, New Zealand, Fertilizer and Lime Research Centre, Massey University.
- World Bank.** 1994. *Feasibility of phosphate rock as a capital investment in sub-Saharan Africa: issues and opportunities*. Washington, DC.

- World Bank.** 1997. *PR Initiative case studies: synthesis report. An assessment of phosphate rock as a capital investment: evidence from Burkina Faso, Madagascar, and Zimbabwe.* IFDC/CIRAD/ICARF/NORAGRIC. Washington, DC.
- Yost, R.S., Naderman, G.C., Kamprath, E.J. & Lobata, E.** 1982. Availability of rock phosphate as measured by an acid-tolerant pasture grass and extractable phosphorus. *Agron. J.*, 74: 462–46.
- Young, C.** 1990. Effect of phosphorus-solubilizing bacteria and vesicular-arbuscular mycorrhizal fungi on the growth of tree species in sub-tropical-tropical soils. *Soil Sci. Plant Nut.*, 36: 225–231.
- Yusdar, H. & Hanafi, M.** 2003. Use of phosphate rock for perennial and annual crops cultivation in Malaysia: a review. In S.S.S. Rajan & S.H. Chien, eds. *Direct application of phosphate rock and related technology: latest developments and practical experiences.* Proc. Int. Meeting, Kuala Lumpur, 16–20 July 2001. Muscle Shoals, USA, IFDC. 441 pp.
- Zapata, F.** 2000. Evaluating the agronomic effectiveness of phosphate rocks using nuclear and related techniques: results from a past FAO/IAEA Coordinated Research Project. In IAEA, ed. *Management and conservation of tropical acid soils for sustainable crop production*, pp. 91–100. IAEA-TECDOC-1159. Vienna, IAEA.
- Zapata, F.** 2003. FAO/IAEA research activities on direct application of phosphate rocks for sustainable crop production. In S.S.S. Rajan & S.H. Chien, eds. *Direct application of phosphate rock and related technology: latest developments and practical experiences.* Proc. Int. Meeting, Kuala Lumpur, 16–20 July 2001. Muscle Shoals, USA, IFDC. 441 pp.
- Zapata, F., ed.** 1995. Evaluation of the agronomic effectiveness of phosphate fertilizers through the use of nuclear and related techniques. Special issue. *Fert. Res.*, 41: 167–242.
- Zapata, F., ed.** 2002. Utilisation of phosphate rocks to improve soil status for sustainable crop production in acid soils. Special issue. *Nut. Cyc. Agroecosys.*, 63(1):1–98.
- Zapata, F. & Axmann, H.** 1995. ³²P isotopic techniques for evaluating the agronomic effectiveness of rock phosphate materials. *Fert. Res.*, 41: 189–195.
- Zapata, F. & Zaharah, A.R.** 2002. Phosphorus availability from phosphate rock and sewage sludge as influenced by the addition of water-soluble phosphate fertilizer. *Nut. Cyc. Agroecosys.*, 63(1): 43–48.
- Zapata, F., Axmann, H. & Braun, H.** 1986. Agronomic evaluation of rock phosphate materials by means of radioisotope techniques. In ISSS & BG, eds. *Trans. 13th Int. Cong. Soil Sci.*, Vol. III: 1012–1013. Hamburg, Germany.
- Zapata, F., Casanova, E., Salas, A.M. & Pino, I.** 1994. Dynamics of phosphorus in soils and phosphate fertilizer management in different cropping systems through the use of isotopic techniques. In ISSS & MSSS, eds. *Trans. 15th World Congress Soil Sci., Commission IV Symposia*, Vol. 5a: 451–466. Acapulco, Mexico.
- Zapata, F., Pino, I., Baherle, P. & Parada, A.M.** 1996. Estudio comparativo de la eficiencia de uso y absorcion de fosforo a partir de fertilizantes fosforicos por genotipos de trigo. *Terra*, 14: 325–330.

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