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IN THE FIELD

Bibliography: Farmer knowledge and management of crop disease

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Abstract. Nearly all contemporary people subsist on cultivated plants, most of which are vulnerable to diseases. Yet, there have been few studies of what traditional people know – and do not know – about crop disease. Agricultural scientists in general are becoming aware of the potential contribution of social scientists and farmers in developing integrated management of crop diseases. The International Potato Center (CIP) has focused on stimulating farmer-scientist collaboration in developing management of late blight, a major fungal disease of potatoes and other plants. Understanding farmers' knowledge of this and other plant diseases is an important element in furthering such collaboration. Although not all agricultural scientists recognize the value of social science, this literature search shows that some agricultural scientists now actively collaborate with farmers, in ways that cross the boundary into social science research. During this search, much of the work we found was written by plant pathologists and entomologists. We found over fifty publications on farmer knowledge of crop disease, and we have annotated the material that we thought most relevant to farmer-scientist collaboration for research of crop diseases, especially late blight.

Key words: Collaborative research, Crop diseases, Farmer knowledge, Integrated disease management, Late blight

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Introduction

In early 1997, International Potato Center (CIP) plant pathologist Rebecca Nelson asked the authors to prepare a bibliography on farmer knowledge of late blight (*Phytophthora infestans* – a major fungal disease of potatoes and other plants) to stimulate further farmer-scientist collaboration in developing integrated management of the disease. We started by writing to about 40 researchers who are active in this area. About half of them responded, and most who did so suggested publications. To keep the bibliography concise, we did not completely annotate it. There are short descriptions for some of the papers that we were most familiar with and which we thought were most relevant to farmer-scientist collaboration on late blight research.

CIP has a well-known social science tradition, associated with the work of Robert Rhoades and others.[1] But agricultural scientists in general are becoming more aware of the potential contribution of social scientists and farmers. Some agricultural scientists are now active in collaborative research with farmers that crosses over the boundary into social science research. It is a positive sign that much of the literature we cite here was written by plant pathologists and entomologists (sometimes working with social scientists).

There is still a lot to be done. Not all agricultural scientists recognize the value of social science perspectives, and as this bibliography shows, much research is still needed on farmer perceptions of crop health problems. Although we tried to focus on farmer knowledge of late blight, there was not enough literature on this important disease to make a bibliography by itself. The only way to make a reasonable bibliography on "late blight" was by including references to research on farmer knowledge of crop disease in general.

There is a vast potential for future research on this

topic. Nearly all contemporary people subsist on cultivated plants, most of which are vulnerable to diseases. Yet, there have been few studies of what traditional people know – and do not know – about crop disease. Human survival depends in part on this knowledge. The authors encourage readers to send relevant citations or publications on farmers' knowledge of plant diseases and other pests.

Bibliography

Awah, E. T. and B. Bakia (1995). *Indigenous Knowledge Systems on Cassava Plant Protection in Cameroon. Proceedings of a Workshop on Indigenous Knowledge Systems in Plant Protection with Special Bias to Cassava in Cameroon, Held at Ekona, Cameroon. 16–17 January, 1995.* Ekona: ESCaPP (Ecologically Sustainable Cassava Plant Protection) Cameroon, 39 pp.

Baral, D. R., N. Timsina, D. Timsina, and P. Bhandari (1997). "Integrating farmer indigenous practices with improved technologies in managing late blight of potato," in *Local R & D, Institutionalizing Innovations in Rootcrop Research and Development* (pp. 51–61). Los Banos, Laguna, Philippines: UPWARD, 222 pp.

Indigenous practices that farmers believe alleviate late blight include: mulching, ridging, hilling up, and using smoke. Farmers have traditional disease forecasting systems based on the on-set of dew, when they begin spraying. Research results show late blight can best be managed by integrating indigenous practices with improved technology.

Bebbington, A. (1991). "Indigenous agricultural knowledge systems, human interests, and critical analysis: reflections on farmer organization in Ecuador," *Agriculture and Human Values* 8(1–2): 14–24.

Some organizations in the Ecuadorian Andes speak of recovering and revalorizing indigenous technologies as a tool for, and a symbol of, resistance to domination by wider society. Others see selective modernization of indigenous agriculture as a necessary strategy to sustain the social and cultural cohesion of the group, even if this implies social changes. Crop protection researchers should take both perspectives into account. The article has some more specific information on crop disease and indigenous perceptions, e.g., in parts of the province of Chimborazo in central Andean Ecuador, some local farmers associate menstruation with late blight.

Bentley, J. W. (1990). "Conocimiento y experimentos espontáneos de campesinos hondureños sobre el Maíz Muerto," *Manejo Integrado de Plagas* 17: 16–26.

A description of what farmers know about maize ear rots, written as a comparison article to del Río's (1991) article on what scientists know about the disease. Farmer knowledge of maize ear rots is more detailed than plant pathologists suspected. Farmers are unaware of the causal agent, but otherwise know essentially the same things that scientists know about this disease: e.g., its relationship with humidity. Farmers' hypotheses about possible control measures (e.g., improving soil fertility, testing new varieties) are similar to scientific hypotheses about controlling ear rots.

Bentley, J. W. (1991). "¿Qué es hielo? Percepciones de los campesinos hondureños sobre enfermedades del frijol y otros cultivos," *Interciencia* 16(3): 131–137.

Farmer perceptions of bean disease in Honduras. Although Honduran farmers have a medium-sized vocabulary for describing bean diseases, nearly all of these terms are synonyms. Farmers are unaware of the causes of various bean diseases, confusing fungal and viral diseases with some kinds of insect damage. About 30 different diseases are all called "*hielo*" (ice) in the local folk taxonomy of disease. Notions of hot and cold are important in local explanations of crop disease.

Bentley, J. W. and W. Melara (1990). "Experimentos por agricultores hondureños." *Ceiba* 31(2): 139–152.

Bentley, J. W. and W. Melara (1991). "Experimenting with Honduran farmer-experimenters," *ODI Agricultural Administration (Research and Extension) Network Newsletter* (June) 24: 31–48.

The article (English and Spanish versions) reports on a 2-year experience by an anthropologist and an agronomist to teach Honduran farmers the information that they lacked about maize ear rots (especially the natural history of the causal agent), give them new varieties to test (Honduran farmers appreciate new varieties to try, whether improved, or local ones from other regions), and then document the research that farmers did with the new varieties and the new information. 13 of the 14 participating farmers planted the new varieties, and one of them designed and conducted an experiment to test how the fungus is transmitted.

Bentley, J. W., G. Rodríguez, and A. González (1993). "Ciencia y pueblo: campesinos hondureños y control natural de plagas," in D. Buckles (ed.), *Gorras y Sombreros: Caminos Hacia la Colaboración Entre Técnicos y Campesinos* (pp. 69–75). México, D.F.: CIMMYT.

Bentley, J. W., G. Rodríguez, and A. González (1994). "Science and people: Honduran campesinos and natural pest control inventions," *Agriculture and Human Values* 11(2–3): 178–182.

This article (Spanish and English versions) describes the Zamorano experience with stimulating farmer invention of new IPM (integrated pest management) technologies. The method includes first learning what people know, what they do not know, and what they

misunderstand. Then teaching them what they do not know, in a way that is consistent with what they do know. New information must be repeated to ensure that people learn it, but it should never be boring. "Redundancy with charm" means that each key point should be reinforced with different methods (slide shows, field experiences, jokes, games, demonstrations, etc.). After receiving the training, some farmers invented new, natural pest control techniques.

Brush, S. (1992). "Ethnoecology, biodiversity, and modernization in Andean potato agriculture," *Journal of Ethnobiology* 12(2): 161–185.

Ethnobiology of insects and crop diseases of the Andes has not been specifically studied. Plant disease taxonomy is the least developed of the folk knowledge systems. Andean farmers gloss late blight and other diseases under the Spanish term *rancha*. Farmers see native potato varieties as culinarily superior, but more susceptible to late blight and other risks.

Castaño, Z. J. (1996). "Epidemiología como base de programas MIP: Tizón tardío de la papa," in *Papas Colombianas con el Mejor Entorno Ambiental* (pp. 210–219). Bogotá: Comunicaciones y Asociados Ltda, 272 pp.

Castaño, Z. J., E. B. Villegas, G. C. Villegas, S. M. Márquez, N. J. C. Pérez, and J. L. Gaviria S. 1996. *Manejo del Tizón Tardío de la Papa.* Manizales, Colombia: Facultad de Ciencias Agropecuarias, Universidad de Caldas, 88 pp.

Literature in Spanish on epidemiology and management of late blight.

Cleveland, D. A. and D. Soleri (1991). *Food from Dryland Gardens*. Tucson: Center for People, Food and Environment.

Written by American anthropologists with a strong agricultural interest. They have worked with the Hopi in Arizona, the Zuni in New Mexico, and with traditional farmers in Pakistan and Burkina Faso. This "how to" book on gardening includes a chapter on managing disease and other pests.

del Río, L. E. (1991). " 'Maíz Muerto' en Honduras provocado por el complejo *Diplodia* y *Fusarium*," *Manejo Integrado de Plagas* 18: 42–53.

This literature review by a plant pathologist on maize ear rots was written as a parallel article to Bentley (1990). In this article, del Río documents the scientific knowledge of maize ear rots, which Bentley compared to Honduran folk knowledge. Both bodies of knowledge were found to be consistent with each other, except that Honduran campesinos did not understand the causal agent of the disease.

Escalada, M. M. and K. L. Heong (1993). "Communication and implementation of change in crop protection," *Crop Protection and Sustainable Agriculture* (pp. 191–207). Chichester: Wiley (Ciba Foundation Symposium 177).

Farmers confuse several rice diseases, calling them all by the same name.

ESCaPP (1994). *Indigenous Knowledge Systems in Cassava Plant Protection. Proceedings of the Expert Meeting on Indigenous Knowledge Systems in Cassava Plant Protection Held at National Root Crop Research Institute Umudike, Abia State, Nigeria. December 6–7, 1994.* ESCaPP Nigeria.

Fairhead, J. (1991). "Methodological notes on exploring indigenous knowledge and management of crop health," *IIED Research Series* 1(4): 29–42.

Farmers' perception of plant disease may be a complex system of disease and health, including notions of causes by floods and hail. Farmers' perceptions of plant disease may be related to their notions of human disease. A study of local knowledge of plant health would be informed by understanding local ideas of human and animal health. Rapid interviews may yield superficial answers ("it's our tradition"), even though people have deeper knowledge. Farmers in Central Africa use notions of hot and cold to describe plant disease, much as Bentley (1991) describes for Central America. Fairhead suggests that the idea is worth more study in other places.

Fonseca, C., R. Labarta, A. Mendoza, J. Landeo, and T. S. Walker (1996). "Economic impact of high-yielding, late-blight-resistant variety Canchán-INIAA in Peru," in T. Walker and C. Crissman (eds.), *Case Studies of the Economic Impact of CIP-Related Technology* (pp. 51–63). Lima: International Potato Center, 157 pp.

Farmers were involved from an early stage in evaluating and multiplying Canchán-INIAA, which is diffusing through the informal seed system. Farmers value its late blight resistance, but earliness, yield potential, culinary qualities, and market acceptance are also important.

Galindo, J. J., G. S. Abawi, and H. D. Thurston (1982). " 'Tapado,' controlling web blight of beans on small farms in Central America," *New York's Food and Life Sciences* 14(3): 21–25.

Galindo, J. J., G. S. Abawi, H. D. Thurston, and G. Gálvez (1983). "Effect of mulching on web blight of beans in Costa Rica," *Phytopathology* 73(4): 610–15.

The role of slash mulch, a traditional system, in controlling disease was not appreciated until Thurston and Galindo started looking at it (see also Thurston et al., 1994). Their studies have helped agricultural scientists see the value of what they formerly regarded as a "backwards" tradition.

Ghimire, S. R., B. K. Dhital, A. Vaidya, T. B. Gurung, and P. M. Pradhanang (1997). "Community management of potato disease in Nepal: from micro experience to macro policy," in *Local R & D, Institutionalizing Innovations in Rootcrop Research and Development* (pp. 138–152). Los Banos, Laguna, Philippines: UPWARD, 222 pp.

Village level farmer committees have been effective in introducing an integrated management program for bacterial wilt, comprising seed multiplication in disease-free areas, rouging of self-sown potatoes, adoption of three year rotations with non-host crops and crop hygiene. Lack of awareness of the disease in neighboring communities could lead to reintroduction through traditional seed exchange systems.

Heong, K. L. and M. M. Escalada (1997). "Perception change in rice pest management: a case study of farmers' evaluation of conflict information," *Journal of Applied Communications* 81(2): 3–17.

Farmers erroneously believe that insecticides are necessary in early stages of rice crop to control leaf-feeding insects. In simple trials, farmers tested a rule of thumb that spraying in the first 30 days after transplanting was not necessary. The experiment changed their perceptions and they no longer believe early spraying is necessary.

Heong, K. L. and N. K. Ho (1987). "Farmers' perceptions of the rice tungro virus problem in the Muda irrigation scheme, Malaysia," in J. Tait and B. Napompeth (eds.), *Management of Pests and Pesticides: Farmers' Perceptions and Practices*. Boulder: Westview Press.

Farmers in Malaysia refer to plants with yellow to brown discolorations as having *penyakit merah* meaning "red disease." They usually cannot differentiate between plants affected by tungro virus and, e.g., iron toxicity. Most farmers recognize that green leafhopper causes tungro but do not appreciate that it is only a vector for the virus. Most farmers use insecticides to control tungro, probably because they see the problem as caused by insects.

Huapaya, F., B. Salas, and L. Lescano (1982). "Ethnophytopathology in Aymara communities of the Titicaca Lakeshore," *Fitopatologia* 17: 8.

Farmers believe that causal agents of crop disease are halos around the sun, phases of the moon, drought, hail, frosts, lightening, excessive humidity, mist, dew, and the use of horse or cow manure. They say that the entry of animals in heat, menstruating or pregnant women, and drunken men can also produce disease. To control leaf diseases, farmers avoid planting in certain phases of the moon, working in the field when the sun has a halo, powder crops with ashes, dampen with water from fish, place branches of *Minthostachys setosa* between plants, and eliminate diseased plants. To control diseases of tubers and grains, farmers select seed carefully, rotate crops, and avoid planting during a full moon.

Jirström, M. (1996). *In the Wake of the Green Revolution: Environmental and Socio-Economic Consequences of Intensive Rice Agriculture – the Problems of Weeds in Muda, Malaysia*. Lund, Sweden: Lund University Press, 273 pp.

An excellent study of knowledge and behavior of weed control among Indonesian rice farmers by a Swedish geographer. Useful for social research methods and for material on herbicides, which could be compared with fungicide use. Also contains an even-handed history of the Green Revolution.

Lazaro, A. A., K. L. Heong, B. Canapi, V. Gapud, and G. W. Norton (1995). *Farmers' Pest Management Knowledge, Attitudes and Practices in San Jose, Philippines: A Baseline Survey*. Report, IPM CRSP, 118 pp.

Malena, C. (1994). *Gender Issues in Integrated Pest Management in African Agriculture*. NRI Socio-Economic Series 5. Chatham, UK: Natural Resources Institute.

Men and women know different things about pests and use different control strategies.

Maître, A. and T. León (1996). "Evaluación participativa de un ensayo con dos variedades de frijol (*Phaseolus vulgaris*) Bajo sistemas de agricultura biológica y convencional," *Geotrópica* 1: 22–29.

Farmers preferred biological methods of controlling disease, although less effective than chemical control, because of cropping arrangement and reduced cost.

Meir, C. J. (1991). *Farmer Perception of Pesticides Used in Crop Production in the Sixaola District of Talamanca, Costa Rica*. Master's Thesis: Imperial College of Science, Technology, and Medicine (University of London).

A study of Costa Rican farmers. Some farmers, usually those who have had contact with CATIE or MAG, are well able to identify the causal agent in pest problems. However, there is also a great deal of confusion both between different stages in the life cycle of certain insect pests and between insect and fungal caused problems.

Mountjoy, D. C. and S. R. Gliessman (1988). "Traditional management of a hillside agroecosystem in Tlaxcala, Mexico: an ecologically based maintenance system," *American Journal of Alternative Agriculture* 3(1): 3–10.

Claim that disease problems are more severe with chemical fertilizers.

Nazarea-Sandoval, V. D. (1995). *Local Knowledge and Agricultural Decision Making in the Philippines: Class, Gender and Resistance*. Ithaca, NY: Cornell University Press.

A study of agricultural knowledge by a Filipino anthropologist. Describes several useful methods for eliciting local knowledge.

Omolo, E. O., J. W. Ssennyonga, A. Ngugi, F. Kiros, and C. Okali (1995). "Community mapping exercises: an evaluation," *ODI Agricultural Administration (Research and Extension) Network*, London. Network Paper 52, 24 pp.

In the area of plant pests and diseases there is already some understanding of the limits of farmer knowledge.

Peñaranda, A. and A. Maître (1994). "La producción de cebolla de rama (*Allium fistulosum*) en Barichara (Santander, Colombia) y la factibilidad de una producción libre de pesticidas," *Memorias de la Primera Reunión de Agroecología y Producción Sostenible en San Gil (Santander, Colombia)*. CIAT. Documento de Trabajo No. 135 (pp. 21–37). Cali: CIAT.

Popper, R., K. Andino, M. Bustamante, B. Hernández, and L. Rodas (1996). "Knowledge and beliefs regarding agricultural pesticides in rural Guatemala," *Environmental Management* 20(2): 241–248.

Farmers used insecticides to combat fungal disease.

Prain, G., F. Uribe, and U. Scheidegger (1992). " 'The friendly potato': farmer selection of potato varieties for multiple uses," in J. L. Moock and R. E. Rhoades (eds.), *Diversity, Farmer Knowledge and Sustainability.* Ithaca, NY: Cornell University Press.

Resistance to late blight and phoma leaf spot (*Phoma andina*) are highly desirable characteristics for farmers when evaluating clones and new varieties of potato. However, farmers refer to late blight and phoma leaf spot with the same term, *rancha*.

Pyndji, M. M. and P. Trutmann (1992). "Managing angular leaf spot on common bean in Africa by supplementing farmer mixtures with resistant varieties," *Plant Disease* 76: 1144–1147.

Röling, N. and E. van de Fliert (1998). "Introducing integrated pest management in rice in Indonesia: a pioneering attempt to facilitate large scale change," in N. Röling and A. Wagemakers (eds.), *Facilitating Sustainable Agriculture*. Cambridge: Cambridge University Press.

Indigenous knowledge about pests and their management is lacking amongst these Green Revolution farmers.

Rubia, E. G., A. A. Lazaro, K. L. Heong, Diah, Nurhasyim, and G. A. Norton (1996). "Farmers' perceptions of the white stem borer *Scirpophaga innotata* (Walker), in Cilamaya, West Java, Indonesia," *Crop Protection* 15(4): 327–333.

Farmers overestimate pest damage and spray at inappropriate moments in insect life cycle.

Rueda, J. L, P. T. Ewell, T. S. Walker, M. Soto, M. Bicamumpaka, and D. Berríos (1996). "Economic impact of high-yielding, late-blight-resistant varieties in the Eastern and Central African Highlands," in T. Walker and C. Crissman (eds.), *Case Studies of the Economic Impact of CIP-Related Technology* (pp. 15–30). Lima: International Potato Center, 157 pp.

Sherwood, S. G. (1995). *Mastering Mystery: Learning to Manage Plant Diseases with Farmers of Honduras and Nicaragua*. MPS project paper. Ithaca, NY: Cornell University Press.

Sherwood, S. G. (1997). "Little things mean a lot: working with Central American farmers to address the mystery of plant disease," *Agriculture and Human Values* 14(2): 181–189.

Sherwood, S. and J. Bentley (1995). "Rural farmers explore causes of plant disease," *ILEIA Newsletter* 11(1): 20–22.

Stephen Sherwood, an American plant pathologist, developed training courses on plant pathology for Central American smallholders. After receiving culturally-sensitive training on the epidemiology, etiology, etc., of crop diseases, Honduran and Nicaraguan smallholder farmers proposed hundreds of new crop disease control methods to test.

Sillitoe, P. (1995). "Ethnoscientific observations on entomology and mycology in the southern Highlands of Papua New Guinea," *Science in New Guinea* 21(1): 3–26.

Report on the Wola of New Guinea by a British anthropologist. The Wola are largely unaware of microorganisms, and only perceive their consequences as diseases. The Wola believe that plant disease is caused by unseen forces, just as people may become ill because of the actions of ancestors' spirits.

Sillitoe, P. (1996). *A Place Against Time: Land and Environment in the Papua New Guinea Highlands*. London: Harwood Academic Publishers, 438 pp.

A biologically and socially sophisticated account of traditional environmental knowledge of the Wola.

Thiele, G., O. Navia, and E. N. Fernández-Northcote (1998). "Análisis económico de la estrategia de control químico del tizón en cultivares susceptibles en Cochabamba, Bolivia," *Fitopatología* 33(3): 176–181.

Farmers lack key knowledge about late blight. They do not understand the invisible development of the fungus within the plant and so usually spray with fungicide when they see symptoms, by which time economic loss is inevitable. Returns to improving farmer management of fungicides are very high.

Thurston, H. D. (1990). "Plant disease management practices of traditional farmers," *Plant Disease* 74(2): 96–102.

Documents extensive knowledge of traditional farmers. Even though they may not know what pathogens are, they often have effective management practices that merit study. Nevertheless traditional practices are a mixture of the "useful and the useless."

Thurston, H. D. (1992). *Sustainable Practices for Plant Disease Management in Traditional Farming Systems*. Boulder: Westview Press.

The most complete overview of traditional farmers' management of crop disease, by an American plant pathologist. Excellent descriptions of traditional practices, organized by technology type. Makes some

judgments regarding the efficacy of certain practices. Required reading for anyone working with traditional farmers and crop disease.

Thurston, H. D. (1994). "Andean potato culture: 5,000 years of experience with sustainable agriculture," in G. W. Zehnder, M. L. Powelson, R. K. Jansson, and K. V. Raman (eds.), *Advances in Potato Pest Biology and Management* (pp. 6–13). St. Paul, MN: American Phytopathology Society Press, 655 pp.

The Incas controlled potato nematodes using rotations with non-host crops and long fallows.

Thurston, H. D. and J. M. Parker (1995). "Raised beds and plant disease management," in D. M. Warren, L. J. Slikkerveer, and D. Brokensha (eds.), *The Cultural Dimension of Development. Indigenous Knowledge Systems* (pp. 140–146). London: Intermediate Technology Publications.

Indigenous practices of planting root and tuber crops in raised beds, mounds, and ridges filter out fungal spores and appear to be a disease management practice.

Thurston, H. D., M. Smith, G. Abawi, and S. Kearl (1994). *Tapado/Mulch: How Farmers Use it and What Researchers Know About it*. Ithaca: CATIE and CIIFAD (Cornell International Institute for Food, Agriculture and Development).

See Galindo et al., 1983.

Trutmann, P. and W. Graf (1993). "The impact of pathogens and arthropod pests on common bean production in Rwanda," *International Journal of Pest Management* 39(3): 328–333.

Trutmann, P. and E. Kayitare (1991). "Disease control and small multiplication plots improve seed quality and small farm dry bean yields in Central Africa," *Journal of Applied Seed Production* 9: 36–40.

Discuss cultural controls for bean diseases.

Trutmann, P. and M. M. Pyndji (1994). "Partial replacement of local common bean mixtures by high yielding angular leaf spot resistant varieties to conserve local genetic diversity while increasing yield," *Annals of Applied Biology* 125: 45–52.

Trutmann, P. and H. D. Thurston (1994). "Disease management and the quest for sustainable systems," *Stressed Ecosystems and Sustainable Agriculture*: 115–128.

Developing more sustainable disease management practices needs the incorporation of basic principles from traditional systems including genetic diversity, flexibility, and cultural controls.

Trutmann, P., K. B. Paul, and D. Cishabayo (1992). "Seed treatments increase yield of farmer varietal field bean mixtures in the central African Highlands through multiple disease and beanfly control," *Crop Protection* 11(5): 458–464.

Side dressings of fungicides on mixes of bean varieties at planting in Rwanda lowered disease and bean fly and increased yields. Became government policy in 1990, but lack of extension, poor training of extension staff, and farmers regarding applications and substitution of the chemicals may detract from the benefits.

Trutmann, P., J. Voss, and J. Fairhead (1993). "Management of common bean diseases by farmers in the Central African Highlands," *International Journal of Pest Management* 39(3): 334–342.

Traditional crop protection strategies are based on microclimate regulation, genetic diversity, and sanitation.

Trutmann, P., J. Voss, and J. Fairhead (1996). "Local knowledge and farmer perceptions of bean diseases in the Central African Highlands," *Agriculture and Human Values* 13(4): 64–74.

Farmers in Central Africa do not perceive plant disease in the same way as plant pathologists. In the case of fungal diseases, they relate symptoms to rain and soil depletion, while virus symptoms are related to varietal traits. Farmers have an evolved concept of plant health related to that of human health. They manage conditions that promote good health rather than treat disease symptoms.

van de Fliert, E., J. Pontius, and N. Röling (1995). "Searching for strategies to replicate a successful extension approach: Training of IPM trainers in Indonesia," *European Journal of Agricultural Education and Extension* 1(4): 41–63.

Farmer field schools improved farmer decision making and knowledge of pests leading to reduced pesticide use.

van Weperen, W., J. Proost, and N. Röling (1998). "Integrated arable farming in the Netherlands," in N. Röling and A. Wagemakers (eds.), *Facilitating Sustainable Agriculture*. Cambridge: Cambridge University Press.

Farmer study groups are helping to improve pest management. Farmers are interested in reducing pesticide use.

Warburton, H., F. L. Palis, and S. Villareal (1997). "Farmers' perceptions of rice tungro disease in the Philippines," in K. L. Heong and M. M. Escalada (eds.), *Pest Management Practices of Rice Farmers in Asia*. IRRI: Los Baños, Philippines.

Farmers' descriptions of disease symptoms usually agree with those of scientists, whilst their perceptions of causes and dissemination differ. They liken tungro to the human diseases of AIDS or cancer. Their belief that tungro could be spread by air, water, and soil is consistent with their perception that it is like germs that attack humans. Farmers are unaware that diseased plants are a source of inoculum for green leafhoppers

and see little urgency in their removal. Farmers know that tungro is connected with insects, although they are not always clear which, and use insecticides for control. Farmers are aware of varietal differences and may be ahead of scientists in selecting for resistance.

Zadoks, J. C. (1982). "Cereal rusts, dogs and stars in antiquity," *Garcia de Orta, Série de Estudos Agronómicos. Revista da Junta de Investigações Científicas do Ultramar, Lisboa* 9(1–2): 13–20.

In ancient Rome, farmers feared rust on wheat, which appeared in April. To avert rust, they organized processions and offered red dogs to the rust *numen* Robigo. The tradition dates from at least 700 BC. Remnants of it survive to this day in Catholic liturgy.

Note

1. R. Rhoades, 1986. "Breaking New Ground: Agricultural Anthropology." In E. Green (ed.), *Practicing Development Anthropology* (pp. 22–66). Boulder: Westview Press.

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