

Sustainable Agriculture for California: A Guide to Information

The system of agriculture... if the epithet can be applied to it, which is in use in this part of the United States is as unproductive to the practitioners as it is ruinous to the landholders. Yet it is pertinaciously adhered to. To forsake it; to pursue a course of husbandry which is altogether different and new ... requires resolution, and without a good practical guide may be dangerous.

George Washington, 1783

1991

Steve Mitchell and David A. Bainbridge
Sustainable Agriculture Research and Education Program
Division of Agricultural and Natural Resources Publication #3349
University of California, Davis, CA, 95616

Originally prepared with support from the University of California Sustainable Agriculture Research and Education Program, the Librarians Association of the University of California, the Library of the University of California, Riverside and the Canelo Project.

Excerpts put on the web 2000 by permission of SAREP.

ISBN 1-879906-05-08

Excerpts

- 4.0. Soil management, ecology and fertility
- 4.1. Biofertilizers--general
 - 4.1.1. Biofertilizers--mycorrhizae
 - 4.1.2. Biofertilizers--earthworms and others
- 4.2. Nitrogen fixation and legumes
- 4.3. Green manures and cover crops
 - 4.3.1. Ley farming
- 4.4. Fertilizers and soil amendments--general
 - 4.4.1. Composts
 - 4.4.2. Manures
- 4.5. Soil amendments
- 4.6. Mulches
- 4.7. Soil conservation
 - 4.7.1. New tillage methods (non-conservation tillage)
 - 4.7.2. Conservation tillage
- 4.9. Restoration of degraded farm land
- 5.0. Water management
- 5.1. Improving irrigation

4.0. SOIL MANAGEMENT, ECOLOGY AND FERTILITY

Our most serious problem, perhaps, is that we have become a nation of fantasists. We believe, apparently, in the infinite availability of finite resources. We persist in land-use methods that reduce the potentially infinite power of soil fertility to a finite quantity, which we then proceed to waste as if it were an infinite quantity. Wendell Berry

When people inquire about sustainable agriculture and ask what really distinguishes it from conventional agriculture, farmers doing it, though they might disagree on other things, would probably say that along with making a profit the most important thing is that their soil remain as productive and fertile in coming decades as it is today. This attitude is woven into their approach to agriculture and, in turn, is why proper soil quality management information, based on agroecological and soil conservation principles, is so important in this guide.

Paul, E.A. and Clark, F.E., 1989. Soil Microbiology and Biochemistry. Academic Press.

Molope, M.B. and Page, E.R. 1986. The Contributions of Fungi, Bacteria and Physical Processes in the Development of Aggregate Stability of a Cultivated Soil, in The Role of Microorganisms in a Sustainable Agriculture: selected papers from the second International Conference on Biological Agriculture, Univ. of London, Wye College, Wye, Kent, UK (Lopez-Real, J.M. and Hodges, R.D., eds.) p. 147-163. A B Academic, Berkamsted

Williams, R. and Cooke, G. 1961. Some Effects of Farmyard Manure and of Grass Residues on Soil Structure, Soil Science, 92:30-39.

Harris, R., Chesters, G. and Allen, O. 1966. Dynamics of Soil Aggregation, Advanced Agronomy, 18:107-169.

Shields, L. and Durrel, L. 1964. Algae in Relation to Soil Fertility, Botanical Review, 30:93-128.

Swaby, R. 1962. Effect of Micro-Organisms on Nutrient Availability, Int. Soil Conf. N.Z., p.159-172

Nauta, R.S. 1987. Agricultural Production in the Netherlands by Natural Supply of Nitrogen, Biological Agriculture & Horticulture,4(3):181-201.

Doran, J.W., Fraser, D., Culik, M. and Liebhardt, W. 1987. Influence of Alternative and Conventional Agricultural Management on Soil Microbial Processes and Nitrogen Availability, American Journal of Alternative Agriculture 2(3):99-106.

Burns, R.G. and Davies, J.A. 1986. The Microbiology of Soil Structure, The Role of Microorganisms in a Sustainable Agriculture: selected papers from the second International Conference on Biological Agriculture, Univ. of London, Wye College, Wye, Kent, UK (Lopez-Real, J.M. and Hodges, R.D., eds.) p. 9-27. A B Academic, Berkamsted

Fraser, D.G., Doran, J.W., et al. 1988. Soil Microbial Populations and Activities Under Conventional and Organic Management, *Journal of Environmental Quality*, 17 (4):585-590.

Cooley, J.H. 1985. *Soil Ecology and Management*. International Association for Ecology, Athens, GA. 132pp.

Edwards, C.S., Stinner, B.R., Stinner, D. et al. (eds.), 1988. *Biological Interactions in Soil*. in *Proceedings of a Workshop on interactions between Soil-Inhabiting Invertebrates and Microorganisms in relation to plant growth*. 386p.

Vancura, V. and Kunc, F. (eds.), 1988. *Soil Microbial Associations: control of Structures and Functions*. (Developments in Agricultural and Managed-Forest Ecology series) Elsevier, NY [QR111 .S661 1988--B, QR111 .S66 1988--D/R/SB]

Vancura, V. and Kunc, F. (eds.), 1988. *Interrelationships Between Microorganisms and Plants in Soil*. Developments in Soil Science series no. 18

Daugbjerg, D. Hinge, J., et al. 1988, *Earthworms as Bioindicators of Cultivated Soils*, *Ecological Bulletins*, 39:45-47. Munksgaard International Booksellers and Publisher, Copenhagen K.

Blume, H.P. 1985. *Ecological Guidelines for Soil Management under Intensive Agriculture*, in *Soil Ecology and Management*, J.H. Cooley, ed., p.75-80. International Association for Ecology, Athens, GA.

Foth, H.D. and Ellis, B.G. c1988. *Soil Fertility*. Wiley, NY, 212pp.

Leadley Brown, A. 1978. *Ecology of Soil Organisms*. Heinemann Educational, London [QH541.5.S6 B76--I, QL 110 B812e 1978--LA, QH541.5.S6 L4 1978--R, QH541.5.S6 L4--SB]

Prinsley, R.T. and Swift, M.J. (eds.), 1987. *Amelioration of Soil by Trees: a review of current concepts and practices*. Commonwealth Secretariat, Commonwealth Science Council, London [S596.7 .A43 1987--D/SB]

Foth, H.D. and Ellis, B.G., 1988. *Soil Fertility*. Wiley, NY [S596.7 F681 1988--B, S596.7 F68 1988--R]

Harris, F., ed. 1979. *Fertile Soil Without Chemicals*, Saskatchewan Dept. of Agriculture, University of Regina Extension, Regina, Sask., Canada 131p. [S654 .F34--D, S605.5 F47--SB]

Jenny, H. 1980. *The Soil Resource*, Springer-Verlag, NY 273p. [S592.2 .J46--ALL]

Fuller, W.H. 1975. *Management of Southwestern Desert Soils*. University of Arizona Press, Tucson, AZ 195p. [S599.N65 F84--B/I/R/SB]

Jeffrey, D.W. 1987. *Soil-plant Relationships*, Timber Press, Portland, OR 295p. [QK918 J41--B, QK918 J45--SC, QK901 J43--D]

- Walters, C. ed. 1975. The Albrecht Papers, ACRES USA, Raytown, MO 515p. [S691 .A597--B]
- Russell, E.J. and Wild, A. ed. 1988. Russell's Soil Conditions and Plant Growth, 11th edition. John Wiley and Sons, NY S592.5 R871--B, S591 .R84--D/R]
- Pauli, F.W. 1967. Soil Fertility: A Biodynamical Approach. Adam Hilger Ltd., London, UK 203p. [S591 P327--SD]
- Turner, N. 1951. Fertility Farming. Faber and Faber, London, UK 264p. [S661 T8--Cal Poly]
- Hopkins, D.P. 1948. Chemicals, Humus, and the Soil. Chemical Publishing House, NY 358p [S663 H66--D]
- Fitter, A.H., Atkinson, D., Read, O.J., and Usher, M.B. 1985. Ecological Interactions in Soil, Blackwell Scientific, London, UK 451p. [QH451 .5 S6--B/D/LA/R/SB/SD]
- Mitchell, M.J. and Nakas, J.P., eds. 1986. Microfloral and Faunal Interactions in Natural and Agroecosystems, M. Nijhoff/Dr. W. Junk, Boston, MA 505p. [QH541 .5 .S6 M5--ALL]
- Frissel, M.J., ed. 1978. Cycling of Mineral Nutrients in Agricultural Ecosystems. Developments in Agricultural and Managed-Forest Ecology, 3. Elsevier Scientific Publishing Company, NY 356p. [S589. 7. S96--B/D/I/R/SB]
- Monteith, J. and Webb, C., eds. 1981. Soil Water and Nitrogen in Mediterranean Type Environments, M. Nijhoff/Dr. W. Junk, The Hague 338p.[SB110 .S7--B/I/SB]
- Organic matter in soils influences plant growth in a number of ways. The greatest benefits of organic matter in soil are its water-holding capacity; the manner in which it alters soil structure to improve soil tilth; its high exchange capacity for binding and releasing some mineral nutrients; its presence as a food source for soil microbiota that recycle soil nutrients; and its mineralization to nitrogen, phosphorus, and sulfur. The cycling of mineral nutrients between living organisms and dead organic components of the soil system provides an important reservoir of the elements needed in plant growth.* National Research Council, 1989
- Tate, R.A. 1987. Soil Organic Matter: Biological and Ecological Effects. Wiley, NY 496p. [S592.8 .T38--B/D/I/LA/R/SB/SC]
- SSSA. 1987. Soil Fertility and Organic Matter as Critical Components of Production Systems. Special Publication #19. Soil Science Society of America, Madison, WI 166p. [S590.2 .S625--B/D/R/SB]
- Chen, Y. and Avnimelech, Y. 1986. The Role of Organic Matter in Modern Agriculture, M. Nijhoff/Dr. W. Junk, Boston, MA 306p. [S654. R651--B/D/I/R/SB/SC]
- Sykes, F. 1949. Humus and the Farmer. Rodale Press, Emmaus, PA 392p.

Frimmel, F.H. and Christman, R.F. 1988. Humic Substances and their role in the Environment: report of the Dahlem Workshop on Humic Substances and Their Role in the Environment, March 29-April 3, 1987. (Dahlem Workshop Reports series)(Life Sciences Research Report no. 41) Wiley, NY [QD341.A2 D191 1987--B, QD341.A2 D19 1987--D/R/SB/SC/SD/SF]

Mohan Rao, N. and Shantaram, M.V. 1978. Select Bibliography on Soil Organic Matter Research in India. (UL Bibliographical series no. 45) University of Agricultural Sciences, Bangalore [S633 .C26 1985--D/R/SC, S633 .W47 1985--SB]

Schneider, K. 1988. Soil Organic Matter: impacts on productivity, 1979-April 1988. Quick Bib. 88-76. 36pp.

Stallings, J.H. 1953. Continuous Organic Matter Supply--the key to soil aggregation and biological activity, The Journal of Soil and Water Conservation, v.8:178-184.

Chater, M. and Gasser, J. 1970. Effects of Green Manuring, Farmyard Manure and Straw on the Organic Matter of Soil and of Green Manuring on Available Nitrogen, Journal of Soil Science, v.21:127-137.

Waksman, S. 1936. Humus: origin, chemical composition and importance in nature. Williams and Wilkins Co., Baltimore, MD. 526pp.

Journals of Note:

Biology and Fertility of Soils. Springer International, NY. [QH84.8 .B61--B/D/SB, S590 B56--R]

4.1. BIOFERTILIZERS--GENERAL

The 1973 and 1979 oil crises reminded California's farmers that fossil fuels are nonrenewable, limited resources. The farm sector was affected by shortages of fossil fuels and rapid price increases in nitrogen fertilizers made from fossil fuels. If not as dramatically evident as in 1973 and 1979, the costs of nitrogen from fossil fuels has continued to rise unabated over recent years.

In sustainable agriculture, fossil fuel based fertilizers are seen as one of the major, expensive external inputs that can be reduced or eliminated by skillful management of biological resources. Sustainable practices, while emphasizing the need for increased efficiency and conservation in petro-chemical fertilizer application, often go the next step further by emphasizing on-farm produced, relatively inexpensive nutrient sources produced on the farm. Together these are coming to be known as biofertilizers because they directly or indirectly provide fertile soil conditions through on-farm biological processes. Green manures are perhaps the best known of these. This section covers general treatments of the subject while the next several sections cover specific aspects.

Lopez-Real, J.M. and Hodges, R.D., eds. 1986. The Role of Microorganisms in a Sustainable Agriculture, AB Academic Press, Berkhamsted, UK 246p. [QR51 .I67--D]

Subba Rao, N.S. 1982. Biofertilizers in Agriculture, A. A. Balkema, Rotterdam, The Netherlands 186p [S652 S92--D/SB].

Somani, L.L. 1987. Biofertilizers in Indian Agriculture: an annotated bibliography, 1906-84. Concept Pub. Co., New Delhi [S633.5.I4 S64 1987--B/R]

Gaur, A.C., 1983. Biofertilizers and Crop Productivity, Advances in Soil Science, 1983 (pub. 1985) v.1, p. 127-178. Books and Periodicals Agency, New Delhi.

Tewari, J.P. and Boyetchko, S.M. 1987. The Biological Fertilizers, Agric. For. Bulletin, Alberta Univ Fac Ext., Spring 10(1):33-34.

Bashan, Y. 1986. Alginate Beads as Synthetic Inoculant Carriers for Slow Release of Bacteria that Affect Plant Growth, Applied Environmental Microbiology, May 1986, v.51 (5) p.1089-1098.
moved below

Lynch, J.M. 1986. Rhizosphere Microbiology and Its Manipulation, in The Role of Microorganisms in a Sustainable Agriculture: selected papers from the second International Conference on Biol. Agric. Univ. of London, Wye College, Wye, Kent, UK (Lopez-Real, J.M. and Hodges, R.D., eds.) p. 57-66. A B Academic, Berkamsted.

Bashan, Y. 1986. Alginate Beads as Synthetic Inoculant Carriers for Slow Release of Bacteria that Affect Plant Growth, Applied Environmental Microbiology, 51(5):1089-1098.

4.1.1. BIOFERTILIZERS—MYCORRHIZAL FUNGI

Mycorrhizal fungi can improve crop phosphorus uptake, drought tolerance, and enhance plant growth. Mycorrhizal fungi also provide protection against some types of plant pathogens. Commercial inoculum is now available for many crops and climate zones and shows considerable promise for improving plant growth. Mycorrhizal fungi can be killed or harmed by chemical pest treatment and plants may develop phosphorus deficiency symptoms if the symbiotic mycorrhizal association is affected.

Mycorrhizal fungi are particularly beneficial for perennial plants that will be grown in environments where phosphorus is limited or not readily available to plants. Mycorrhizal fungi can serve as bridges between plants of different species and have been shown to transfer nutrients and carbon. This behavior can be exploited in some intercrops.

Mosse, B. 1986. Mycorrhiza in a Sustainable Agriculture, Biological Agriculture & Horticulture, 1986 3(2/3):191-209.

St-John, T.V. 1985. Mycorrhizae: the other half of the root system, Journal of the California Rare Fruit Growers, 19:61-68.

Hall, I.R. 1985. Increased Pasture Growth after Inoculating Unsterile Soils with Endomycorrhizal Fungi, in Proceedings of the 6th North American Conference on Mycorrhizae, June 1984, Molina, R. ed., p. 227.

Menge, J.A. 1985. Effective Techniques for Field Inoculations, in the Proceedings of the 6th North American Conference on Mycorrhizae: June 1984, Molina, R. ed. p.91.

Crofoot, M.. nd. Symbiont inoculation strategies for the nursery. Permaculture Communications, P.O. Box 101, Davis, CA 95617.

Dehne, H.-W. 1987. VA Mycorrhizae and plant health. p 192. In: Sylvia, D.M., Hung, L.L., and Graham, J.H. eds. Mycorrhizae in the next decade: practical applications and research applications. Institute of Food and Agricultural Sciences, University of Florida, Gainesville, Florida.

Francis, R. and Read, D.J. 1984. Direct transfer of carbon between plants connected by vesicular-arbuscular mycorrhizal mycelium. *Nature* 307:53.

Heap, A.J. and Newman, E.I. 1980. The influence of vesicular-arbuscular mycorrhizas on phosphorus transfer between plants. *New Phytol* 85:173.

Sylvia, D.M., Hung, L.L., and Graham, J.H. eds. 1987. Mycorrhizae in the next decade: practical applications and research applications. Institute of Food and Agricultural Sciences, University of Florida, Gainesville, Florida. pp

Marx, D.H. and Kenney, D.S. 1982. Production of ectomycorrhizal inoculum. pp. 131-146. In: Schenck, N.C. ed. *Methods and Principles of Mycorrhizal Research*. American Phytopathological Society, St. Paul, Minnesota

Menge, J.A. and Timmer, L.W. 1982. Procedures for inoculation of plants with vesicular-arbuscular mycorrhizae in the laboratory, greenhouse, and field. pp. 59-68. In: Schenck, N.C. ed. *Methods and Principles of Mycorrhizal Research*. American Phytopathological Society, St. Paul, Minnesota.

St. John, T.V. 1987. Anti-fertilization proposed to reduce weed growth on restoration sites. *Restoration and Management Notes* 5(2):101-102

Safir, G.R., ed. 1987. *Ecophysiology of VA Mycorrhizal Plants*. CRC Press. Boca Raton, Florida.

Trappe, J. 1977. Selection of fungi for ectomycorrhizal inoculation in nurseries. *Annual Review of Phytopathology* 15:203-222.

Wilhelm, S. 1966. Chemical treatments and inoculum potential of soil. *Annual Review of Phytopathology* 15:203-223.

4.1.2. BIOFERTILIZERS--EARTHWORMS AND OTHERS

Earthworms, though not providing direct symbiotic benefits for crops, enhance soil fertility and structure in so many ways that they belong in this section with the many other organisms which enhance soil fertility.

In arid lands ants replace earthworms as a critical factor in improving soil structure and fertility. Ant mounds are used as a spot fertilizer in several traditional agriculture systems

Earthworms: raising, uses, beneficial aspects, 1988, Quick Bib. 88-77.

Minnich, J. 1977. *The Earthworm Book; how to raise and use earthworms for your farm and garden.* Rodale Press, Emmaus, PA. 372pp.

Doeksen, J. 1959. Earthworms, Manuring and Tillage, *Stikstof?*, 3:17-24.

Satchell, J. and Martin, K. 1981. *A Bibliography of Earthworm Research, Inst. of Terrestrial Ecology, Cumbria, UK* 174p. [QL 391. 04 S38--D].

Barley, K. 1961. The Abundance of Earthworms in Agricultural Land and Their Possible Significance in Agriculture, *Advanc Agronomy*, 13:249-268.

Sharma, N. and Madan, M. 1988. Effects of Various Organic Wastes Alone and with Earthworms on the Total Dry Matter Yield of Wheat and Maize, *Biological Wastes*, 1988, 25(1):33-40

Lee, K.E. 1985. *Earthworms: Their Ecology and Relationships with Soils and Land Use*, Academic Press, Orlando, FL 411p. [QL391. A6 L441--B/D/LA/ R/SB/SC]

Holm-Hansen, O. 1968. Ecology, Physiology and Biochemistry of Blue-Green Algae, *Annual Review of Microbiology*, 22:47-70.

Rodgers, G.A., et al. 1979. Utilization of Blue-Green Algae as Biofertilizers, *Plant and Soil* 52:99-107.

Marathe, K.V. 1972. Role of some blue-green algae in soil aggregation. pp. 328-331. In: Desikachary, T.V. ed. *The taxonomy and biology of blue-green algae: Proceedings of the symposium on the biology of blue-green algae.* University of Madras Press, Madras, India.

Button, M.E. and Noyes, C. 1964. Effect of a Seaweed Extract upon Emergence and Survival of Seedlings of Creeping Red Fescue, *Agron.J.* 56:444-445.

Goldstein, A.H. 1986. Bacterial Solubilization of Mineral Phosphates: historical perspective and future prospects, *American Journal of Alternative Agriculture* 1(2):51-57.

Smith, J.H., Allison, F.E. and Soulides, D.A. 1962. Phosphobacterin as a Soil Inoculant Laboratory, Greenhouse, and Field Evaluation, *USDA Technical Bulletin # 1263*, 22pp.

Cooper, R. 1959. Bacterial Fertilizers in the Soviet Union, *Soils and Fertilizers*, 22:327-333.

Brown, M., Bulingham, S. and Jackson, R. 1964. Studies on *Azotobacter* Species in Soil. III. effects of artificial inoculation on crop yields, *Plant and Soil*, 20:194-214.

Majer, J.D., Walker, T.C., and Berlandier, F. 1987. The importance of ants in degraded soils within Dryandra State Forest. *Mulga Research Center Journal* 9:15-16

The use of the *Azolla-Anaebena* symbioses has been explored for rice production in California. This is a common practice in many areas of the world and was effective in California. Labor costs were considered to be too high for general use--at this time.

Capaya, D.T. 1979. *International Bibliography on Azolla*. International Rice Research Institute, 66pp.

Boussida, S. 1988. N₂-Fixing Cyanobacteria as Nitrogen Biofertilizer--a study with the isolate *Anabaena azollae*, *Symbiosis* 6(1/2):129-138.

Lumpkin, T.A. and Plucknett, D.L. 1980. *Azolla*; botany, physiology, and use as a green manure, *Economic Botany*, 34(2):111-153.

Lumpkin-Kannaiyan, S., Thangaraju, M. and Oblisami, G. 1984. *Azolla*--a potential biofertilizer for rice production, *Developing Plant and Soil Science*, 13:188-201.

Moore, A.W. 1969. *Azolla*: biology and agronomic significance, *Botanical Review*, 35:17-34.

Klingmuller, W. (ed.), 1988. *Azospirillum IV: genetics, physiology, ecology: proceedings of the 4th Bayreuth azospirillum workshop*. Springer-Verlag, Berlin.

Dobereiner, J. and Pedrosa, F.O., c1987. *Nitrogen-Fixing Bacteria in Nonleguminous Crop Plants*. (Brock/Springer Series in Contemporary Bioscience) Science Tech Publishers, Madison, WI [QR113 .D631 1987--B, QR113 .D63 1987--D/R, QW 131 D633n 1987--I]

Bond, G. 1959. Fixation of Nitrogen in Non-Legume Root-Nodule Plants. *Symposia of the Society for Experimental Biology*, #13 p.59-72.

4.2. NITROGEN FIXATION AND LEGUMES

Natural biological nitrogen fixation with the legume-Rhizobium symbiosis has been shown to be highly effective and offers considerable potential for energy conservation. Yet only a few legume species have been evaluated in California and legume based cropping systems have been little studied since the early part of this century. Intercropping nitrogen fixing trees with fruit trees appears to offer many advantages, and an acacia/citrus intercrop has done very well in Australia.

Selecting the appropriate strain or strains of rhizobia can be important. Salt tolerant and salt loving species have been found recently. Nitrogen fixation may take place at considerable depths in some ecosystems. Active nodules have been found at 5-6 m depth.

Allen, O.N. and Allen, E.K. 1981. *The Leguminosae*, University of Wisconsin Press, Madison, Wisconsin 812pp.

Sprent, J.I. 1986. Nitrogen Fixation in a Sustainable Agriculture, *Biological Agriculture & Horticulture*, 1986, 3(2/3):153-165.

Subba Rao, N.S. (ed.), 1984. *Current Developments in Biological Nitrogen Fixation*. Gordon and Breach, NY [QR89.7 .C871 1984--B, QR89.7 .C97 1984--D, QR 70 C976 1984--I, SB651 .C87 1984--R, QR89.7 .C87 1984--SB]

Subba Rao, N.S. (ed.), 1988. *Biological Nitrogen Fixation: recent developments*. Gordon and Breach, NY [QR89.7 .B561 1988--B, QR89.7 .B56 1988--D]

Gallon, J.R. and Chaplin, A.E. 1987. *An Introduction to Nitrogen Fixation*. Cassell, London [QR89.7 .G34 1987--B/D/SC, QU 70 G173i 1987--I]

Postgate, J.R. 1982. *The Fundamentals of Nitrogen Fixation*. Cambridge University Press, London, UK 252p. [QR89.7 P673--B/D/I/LA/R/SB/SC]

Phillips, D.A. and Williams, W.A. 1987. Range-Legume Inoculation and Nitrogen Fixation by Root-Nodule Bacteria, *University of California Agric. Exp. Sta. Bulletin #1842*, 13p.

MacLean, J.T. 1983. *Legumes in Crop Rotations, 1970-1983*. Quick Bib. 25p. [SB203.A12 M321--B]

MacLean, J.T. 1987. *Legumes in Crop Rotations*, Quick Bib. 88-45

Vincent, J.M. ed. 1982. *Nitrogen Fixation in Legumes*. Academic Press, Sydney, Australia 288p.[SB317.L43 N57--B/D/R/SB]

Evans, H.J., Bottomley, P.J., and Newton, W.E. 1985. *Nitrogen Fixation Research Progress*. M. Nijhoff, Dordrecht 731p. [QR89.7 I58--D/R/Sb/SC, QU 70 I61--I/LA]

The estimated value of nitrogen fixed by legumes in the U.S. is \$1.6 billion per year .
National Research Council, 1989

Beck, B.P., Materon, L.A., eds. 1986. *Nitrogen Fixation by Legumes in Mediterranean Agriculture*, M. Nijhoff, Boston, MA 379p. [SB317.L43 N5651--B/D/I/R/SB/SC]

Hermann, F.J. 1953. *A Botanical Synopsis of the Cultivated Clovers (Trifolium)*. (USDA Agricultural Monograph 22). 45pp.

Larson, K.G., et al, 1989. Yield, Dinitrogen Fixation and Above Ground Nitrogen Balance of Irrigated White Lupin in a Mediterranean Climate, *Agronomy Journal*, 81:538-547.

Beadle, N. 1964. Nitrogen Economy in Arid and Semi-Arid Plant Communities. III. the symbiotic nitrogen-fixing organisms. *Proc.Linn.Soc.N.S.W.*, 89:1273-286.

4.3. GREEN MANURES and COVER CROPS

Green manure and cover crops are grown and plowed under to improve soil fertility and structure. They may also be used for grazing and reducing soil erosion. Green manures and cover crops can increase the general level of fertility by fixing nitrogen, mobilizing minerals, and by building up soil organic matter. One of the common benefits of green manures and cover crops is increased infiltration of water.

However there are also some potential disadvantages. Green manure crops may exhaust reduce the supply of soil moisture for the following crop, adversely affect growth through allelopathy or, in some cases, lead to an increase of certain diseases, insects, and nematodes. Attention to choice and timing of green manure and cover crops is important.

Miller, P.R., Graves, W.L., Williams, W.A., Madsen, B.A. 1989. Cover Crops for California Agriculture. UC ANR Publication # 21471, 24pp., \$3.50.

Finch, C.U. and W.C. Sharp. 1981. Cover Crops in California Orchards and Vineyards, USDA Soil Conservation Service Davis, CA pp.

Maclean, J.T. 1987. Green Manures and Cover Crops, 1979- May 1987: 294 citations. Quick Bib. 88-03 [SB294.A12 M34 1987--B]

MacLean, J.T., 1988, Green Manures and Cover Crops, Quick Bib. 89-58.

Pieters, A.J. 1927. Green Manuring Principles and Practice, John Wiley and Sons, NY 356p [S661 .P5--D].

Finch, C.U. 1981. Cover Crops in California Orchards and Vineyards, U.S.D.A. Soil Conservation Service, Davis, CA 25p. [Microfiche .4282--B]

Miller, J.C.M. and Bell, S.M. 1982. Crop Production Using Cover Crops and Sods as Living Mulches, International Plant Protection Institute, Oregon State Univ., Corvallis, OR 123p. [S661 .5 .C7--D, SB284 .C76--B]

Knight, W.E., Hagedorn, C., Watson, V.H. and Friesner, D.L. 1982. Subterranean Clover in the United States, *Advances in Agronomy*, 35:165-191.

Powell, T. 1958. An Encyclopedia of Green Manure Plants, *Organic Gardening and Farming*, Apr. 5(4):86-91.

Rickman, R.W., Rasmussen, P.E., Collins, H.P. and Granatstein, D. 1989. Cover Crop Utilization in the Pacific Northwest, abstract in *Agronomy Abstracts* (1989 Annual Meeting, ASA, CSSA, SSSA, Las Vegas, 10/89), p.292.

Stivers, L.J. and Shennan, C. 1989. Winter Cover Cropping in Processing Tomato Production, abstract in Agronomy Abstracts (1989 Annual Meeting, ASA, CSSA, SSSA, Las Vegas, 10/89), p.254.

Lanini, W.T., et al, 1989. Subclovers as Living Mulches for Managing Weeds in Vegetables, what journal v.43 (6) p.25-27.

Wilkinson, A.E. 1921. Market Garden Cover Crops, Connecticut Agricultural College Extension Bulletin, 35:1-4.

Haylett, D.G. 1961. Green Manuring and Soil Fertility, South African Journal of Agricultural Science, 4(3):363-378.

Smith, N.R. and Humfeldt, H. 1931. The Decomposition of Green Manures Grown on a Soil and Turned Under Compared to the Decomposition of Green Manures Added to a Fallow Soil, Journal of Agricultural Research, USDA, 43 (8):715-731.

United States Agricultural Research Service, Crops Division. 1962. Growing Summer Cover Crops. (USDA Farmers' Bulletin # 2182), 16pp.

Williams, W.A. and Dawson, J.H. 1980. Vetch is an Economical Source of Nitrogen in Rice, California Agriculture, 34(8-9):15-16.

McKee, R. 1946. Crotalaria Culture and Utilization. USDA Farmers' Bulletin # 1980, 17pp.

Miller, M.D., Edwards, R.T. and Williams, W.A. 1973. Soybeans for Forage and Green Manure, Bulletin # 862, California Agricultural Experiment Station, p.60-63.

Anon. 1931. California Agricultural Experiment Station Report, July 1, 1929 to June 30, 1930 [Imperial Valley Station Report - green manure trials], UC Berkeley. 50pp.

Ram, D. and Zwerman, P. 1960. Influence of Management Systems and Cover Crops on Soil Physical Conditions, Agronomy Journal, 52:473-476.

Kamprath, E., Chandler, V. and Krantz, B. 1958. Winter Cover Crops. Their Effects on Corn Yields and Soil Properties, North Carolina Agricultural Experiment Station Technical Bulletin, 129:47.

Miller, D., Bunger, W. and Proebsting, E. 1963. Properties of Soil in Orchards as Influenced by Travel and Cover Crop Management Systems, Agronomy Journal, 55:188-191.

Flocker, W., Vomocil, J. and Vittum, M. 1958, Response of Winter Cover Crops to Soil Compaction, Soil Science Society of America Proceedings, 22:181-184.

Williams, W. and Ririe, D. 1957. Production of Sugar Beets Following Winter Green Manure in California: I. nitrogen nutrition, yield, disease and pest status of sugar beets. Soil Science Society of America Proceedings, 21:88-92.

Williams, W., Doneen, L. and Ririe, D. 1957. Production of Sugar Beets Following Winter Green Manure Cropping in California: II. soil physical conditions and associated crop response. Soil Science Society of America Proceedings, 21:92-94.

Patrick, W., Haddon, C. and Hendrix, J. 1957. The Effect of Longtime Use of Winter Cover Crops on Physical Properties of Commerce Loam. Soil Science Society of America Proceedings, 21:366-368.

Williams, W. 1966. Management of Nonleguminous Green Manures and Crop Residues to Improve the Infiltration Rate of an Irrigated Soil, in Proceedings of the Soil Science Society of America, 30:631-634.

9.30.1.c.1uuHoyt, G.D. and Hargrove, W.H. 1986. Legume Cover Crops for Improving Crop and Soil Management in the Southern United States, HortScience, 21:397-402.

Improvements have already resulted from selecting for crop varieties and naturally occurring Rhizobium strains that fix large amounts of nitrogen. In a 2-year rotation with corn in Minnesota, a new annual cultivar of alfalfa, Nitro ... [fixed] 59 percent more nitrogen than was fixed ... [by] the commonly grown perennial cultivars used as controls in the study. National Research Council, 1989.

Barnes, D., Heichel, G. and Sheaffer, C. 1986. Nitro Alfalfa may Foster New Cropping System. News, Nov. 20. Minnesota Extension Service, St. Paul, Minn.

Skrooch, W. and Shribbs, J. 1986. Orchard Floor Management: an overview, HortScience, 21(3):390-394.

Butler, J. 1986. Grass Interplanting in Horticulture Cropping Systems, HortScience, 21(3):394-397.

Pieters, A.J. and McKee, R. 1938. Use of Cover and Green-Manure Crops. U.S. Dept. of Agriculture, Yearbook of Agriculture, pp. 431-444.

McKee, R. 1947. Summer Crops for Green Manure and Soil Improvement. U.S. Dept. of Agriculture Farmers' Bulletin # 1750, 16pp.

McKee, R. and McNair, A.D. 1931. Winter Legumes for Green Manure in the Cotton Belt. U.S. Dept. of Agriculture Farmers' Bulletin # 1663, pp.1-20.

Jones, L.I. and Ferris, E.B. 1937. Winter Legumes. Mississippi Agricultural Extension bulletin # 85. pp.1-15.

Madison, B.A. 1951. Winter Cover Crops, California Agricultural College Extension Circular # 174. 23pp.

Bell, A.F. 1938. Crop Rotation with Special References to the Principles of Green Manuring, Queensl Ag J. July 50:44-54

Nicholson, A.G. and Wein, H.C. 1983. Screening of Turfgrasses and Clovers for Use as Living Mulches in Sweet Corn and Cabbage , Journal of the American Society for Horticultural Science, 108(6):1071-1076.

Pieters, A.J. 1917. Green Manuring: a review of the American experiment station literature, American Society of Agronomy Journal, April. 9:62-82, 109-126, 162-172.

Chater, M. and Gasser, J.K.R. 1970. Effects of Green Manuring, Farmyard Manure, and Straw on the Organic Matter of Soil and of Green Manuring of Available Nitrogen, The Journal of Soil Science, March 21(1):127-137.

Blake, P.R. 1988. Cover Crops for Erosion Control in Napa County Vineyards, Prodeedings-California Weed Conference. 40:174-178. California Weed Conference Office, Sacramento, CA.

Donaldson, D. 1987. Testing Vine Response to Cover Crops, Prodeedings-California Weed Conference. 1987, 39:27. California Weed Conference Office, Sacramento, CA

Elmore, C.L. 1986. Interdisciplinary Programs in Cover Crops in Tree Fruits and Vines, Prodeedings-California Weed Conference. 1986, 38:171-187. California Weed Conference Office, Sacramento, CA.

Altieri, M.A., Norgaard, R.B., et al. 1987. Cover Cropping and Mulching. in Agroecology: the scientific basis of alternative agriculture by M. Altieri, p.127-137. Westview Press, Boulder, CO.

Altieri, M.A. and Schmidt, L.L., 1985. Cover Crop Manipulation in Northern California Orchards and Vineyards: effects on arthropod communities, Biological Agriculture & Horticulture, 3(1):1-24.

Kennedy, P.B., Dec. 1922. Leguminous Plants as Organic Fertilizers in California Agriculture. California Agricultural Experiment Station Circular # 255, 8pp.

Madson, B.A., Aug. 1916. A Comparison of Annual Cropping, Biennial Cropping, and Green Manures on the Yield of Wheat. California Agricultural Experiment Station , Circular # 270, 14pp.

Kennedy, P.B., Feb. 1923. The Small-Seeded horse Bean *Vicia Faba* var. *Minor*. California Agricultural Experiment Station Circular, # 257, 23pp.

Mertz, W.M. Feb. 1918. Green Manure Crops in Southern California. CES Paper # 46, California Agricultural Experiment Station Bulletin # 292 31pp.

Graves, W.L., Kay, B.L., et al. 1987. Annual Legume Germplasm Exploration and Testing to Improve Range, Pasture and Soils in the Winter-Rainfall California Climate, proceedings of symposium "seed and seedbed ecology of rangeland plants", Frasier, G.W. and Evans, R.A., eds. April 1987 p.188-191. U.S. Dept. of Agriculture, (Washington, D.C.).

Graves, W.L., Williams, W.A., et al. 1987. Berseem Clover is Getting a Second Chance, California Agriculture, Ca. Ag. Exp. Sta. 41(9/10):15-18.

Hofstetter, B. 1988. The New Farm's Cover Crop Guide: 53 legumes, grasses and legume-grass mixes you can use to save soil and money, The New Farm, 10(1):17-22, 27-28, 30-31.

Altieri, M.A. 1985. The Effects of Living Mulches and Weed Cover on the Dynamics of Foliage- and Soil-Arthropod Communities in Three Crop Systems, Crop Protection, June 1985, v.4 (2) p.201-213. Butterworths, Guildford, Eng.

Welker, W.V. Jr. and Glenn, D.M. 1988. Growth Responses of Young Peach Trees and Changes in Soil Characteristics with Sod and Conventional Planting Systems, Journal of the Americal Society of Horticultural Science, Sept. 1988, v. 113 (5) p.652-656. The Society, Alexandria, VA.

Munoz, F. N. and Graves, W. 1987. Legumes for Orchard, Vegetable, and Cereal Cropping Systems, U.C. Cooperative Extension CP488-6/87eo, Bldg. 4, 5555 Overland Ave., San Diego, CA 92123 12p.

McLeod, E. 1982. Feed the Soil, Organic Agriculture Research Institute, Graton, CA 209p. [S661 .M34--B, S661 .M2--D/R/SB]

Schmid, O. and Klay, R. 1981. Green Manuring: Principles and Practice. Woods End Agricultural Institute, Temple, ME 50p. [S661 .S313--B]

4.3.1. LEY FARMING

The introduction of annual legumes and varietal improvements have helped double cereal and animal production in southern Australia since the 1930's. Several million acres of cereal production in comparable climates in California and Baja California would appear well suited for the adoption of ley farming.

The key features of this farming system, also common in Europe, are the use of self-regenerating annual legumes and integration of grazing animals in the rotation. The legume eliminates the need for nitrogen fertilizer by biologically fixing nitrogen from the atmosphere. The grazing animals recycle nitrogen, help manage the legume component, and suppress weeds.

Gibson, T.A., 1987. Legume Ley Farming--a low-cost method of overcoming soil fertility limitations in an upland agricultural system, ACIAR-Proc-Ser. 1987, (18) p. 236-237. Australian Centre for International Agricultural Research, Canberra.

Graves, W.L., et al., 1987. Potential Use of Annual Legumes in a Winter-Rainfall, California-Type Climate for a Cereal-Ley Farming System. in *The Role of Legumes in Conservation Tillage Systems* (J.F. Power, ed.) Soil Conservation Society of America, Ankeny, IA. 11pp.

Heard, A. 1965. The Effect of the Nitrogen Content of Residues from Leys on Amounts of Available Soil Nitrogen and on Yields of Wheat, *Journal of Agricultural Science*, 64:329-334.

Johnston, A.E. 1972. The Effects of Ley and Arable Cropping Systems on the Amounts of Soil Organic Matter in the Rothamsted and Woburn Ley-Arable Experiments, *Rothamsted Experiment Station Report*, 2:131-159.

Heath, G. 1962. The Influence of Ley Management on Earthworm Populations, *Journal of the British Grassland Society*, 17:237-244.

Webber, G., Matz, N., and Williams, G. 1977. Ley Farming in South Australia, Dept. of Agric. and Fisheries, So. Australia, Bull. 15/77, 19p.

Puckridge, D.W. and French, R.J. 1983. The annual legume pasture in cereal-ley farming systems of southern Australia: A review, *Agriculture, Ecosystems and Environment* 9:229-267.

4.4. FERTILIZERS AND SOIL AMENDMENTS--GENERAL

Bassam, N. and Thorman A. 1979. Potentials and Limits of Organic Wastes in Crop Production, *Compost Science/Land Utilization*, 20(6):30-35.

Swanson, C.L.W. 1949. Preparation and Use of Composts, Night Soil, Green Manures, and Unusual Fertilizing Materials in Japan, *Agronomy Journal*, Jul. 1949 41:275-282.

Cihacek, L.J. 1984. Humated ? as Commercial Soil Amendments, *Circular of the New Mexico State University Cooperative Extension Station, Las Cruces, #510*. 12pp.

Severnev, M.M. and Larchenkov, L.V. 1984. The Improvement of Machinery for Chemical Fertilizer Application with the Aim of Achieving a More Even Spread over Agricultural Land, *AGRI/MECH-Rep-Econ-Comm-Eur, United Nations, NY*. (103) 27pp.

Golueke, C.G. and Diaz, L.F. 1989. "Starters"--inoculums and enzymes, *BioCycle*, 30(4):53-57.

Howard, A. and Wad, Y.D. 1931. *The Waste Products of Agriculture*. Oxford. 167pp.

Bunting, A. 1963. Experiments on Organic Manures, 1942-1949, *Journal of Agricultural Science*, 60:121-140.

Warren, R. and Cooke, G. 1958. Concentrated Organic Nitrogen Fertilizers for Vegetables, *Rep. Rothamst. Exp. Sta., v.1957 pp.48-49*.

Ghosh, A., Chibber, R. and Idnani, M. 1956. Composition of Different Types of Bone Meals and Effect of Particle Size on the Available Phosphoric Acid Content, in Proceedings of the National Academy of Science in India, v.25A p.355-359.

Jones, W., Cree, C. and Embleton, T. 1961. Some Effects of Nitrogen Sources and Cultural Practices on Water Intake by Soil in a Washington Navel Orange Orchard and on Fruit Production, Size and Quality. Proceedings of the American Society for Horticultural Science, 77:146-154.

Widdowson, R., Penny, A. and Cooke, G. 1963. Results of an Experiment at Rothamsted Testing Farmyard Manure and N, P and K Fertilizers on Five Arable Crops, Journal of Agricultural Science, 60:347-352.

Garner, H. 1966. Comparisons of Farmyard Manure, Sewage Sludge, and Other Organic Manures Tested on Potatoes and a Succeeding Cereal Crop at Rothamsted, Journal of Agricultural Science, 67:267-280.

Brunner, F. 1958. Organic Irrigation. An introduction to the Gulle system, World Crops, 10:325-328.

Doll, E., Miller, H. and Freeman, J. 1960. Initial and Residual Effects of Rock Phosphate and Superphosphate, Agron.J., 52:247-250.

Debicki, R. and Dechnik, I. c1985. Contemporary Trends in Soil Conditioning: its role in increasing Soil Productivity. in Soil Ecology and Management (J.H. Cooley, ed.), p.113-118. International Association for Ecology, Athens, GA.

Marshall, V.G. 1977. Effects of Manures and Fertilizers on Soil Fauna; a review. Commonwealth Agricultural Bureaux, Farnham Royal. 79pp.

Cramer, C. 1985. The Farmer's Fertilizer Handbook: how to make your own NPK recommendations--and make them pay. Regenerative Agriculture Association, Emmaus, PA. 176pp.

Hagin, J. and Tucker, B. 1982. Fertilization of Dryland and Irrigated Soils. Springer-Verlag, NY 188p. [S633 .H24-B/D/R/SB]

FAO/SIDA Workshop on the Use of Organic Materials for Improving Soil Productivity in the Near East, 1978. Organic Materials and Soil Productivity in the Near East: papers presented at the FAO/SIDA Workshop. (FAO Soils Bulletin # 45) Food and Agriculture Organization of the United Nations, Rome [S591 .F65 #45--D, 76.1 Z-01 #45--LA, S690 .F68 #45, 1978--R, S654 .F23 1978--CSL]

Food and Agriculture Organization of the United Nations, c1978. China, Recycling of Organic Wastes in Agriculture: report on an FAO/UNDP study tour to the People's Republic of Shina. (FAO Soils Bulletin series # 40) Food and Agriculture Organization of the United Nations, Rome, 422pp. [S590 .S695.#40--B, S591 .F65 #40--D, 76.1 Z-01 #40--LA, S590 F68 #40, TD 930 F3--CSL]

Simpson, K. 1986. Fertilizers and Manures (Longman Handbooks in Agriculture series) Longman, NY [S633 .S624 1986--D/SB]

Soil testing and Plant Analysis for Fertilizer Recommendations, 1989, Quick Bib. 89-52

Mortvedt, J.J., Giordano, M., Lindsay, W.L., Dinauer, R.C., Clark, V.S., and Eith, P. eds., 1972 Micronutrients in Agriculture, SSSA, Madison, WI 666p. [S587.5. T7. M5--D/R/SB]

Englestad, O.P., Stelley, M., Dinauer, R.C., Kral, D.M., Buckholz, T.L. 1970. Nutrient Mobility in Soils: Accumulation and Losses, SSSA Sp. Publ. 4, Madison, WI 81p. [S590. S655--D, S591. N87--R/SB]

Parnes, R. 1986. Organic and Inorganic Fertilizers. Woods End Agric. Institute. Mt. Vernon, ME 167p. [S633 .P33--R/SC]

Journals of Note:

Biological Wastes. London. Elsevier Applied Science, c1987- [TD930 .A37--B, TD930 A1 A4--D TD 930. A47--SB]

BIOCYCLE. Emmaus, PA 18098
[S661.A1.C6--B/D/I/LA/R/SB]

4.4.1. COMPOSTS

Golueke, C. G. 1978. Composting: a study of the process and its principles. Rodale Press, Emmaus, PA. 110pp.

Thompson, R. 1979. Composting Brought it All Together, The New Farm, 1(2):42-44, 46-48.

Ministry of Agriculture, 1934. The Manuring of Vegetable Crops, Min.Agric.Bull., v.71 p.63.

Dalzell, H.W. et al. 1987. Soil Management: compost production and use in tropical and subtropical environments (FAO Soils Bulletin # 56) Food and Agriculture Organization of the United Nations, Rome [S591 .S63 1987--B, 76.1 Z-O1 #56--LA, S590 .F68 #56 1987--R, S661 .S65 1987--CSL]

MacLean, J.T. 1988. Composts and Composting of Organic Wastes, January 1979-August 1988: 298 citations. Quick Bib. 89-08 [S661.A12 M321 1988--B]

MacLean, J.T. 1989. Composts and Composting of Organic Wastes, 1989, Quick Bib. 89-59

Davey, C. 1953. Sawdust Composts: their preparation and effect on plant growth. Proc.Soil.Sci.Amer., v.17 p.59-60.

Editors?. 1986. The Biocycle Guide to In-Vessel Composting: evaluating systems, design, operation ...directories. JG Press, Emmaus, PA [TD796.5 .B56 1986--SB]

Fletcher, C.C. 1935. Composts are Good Means of Improving Soil of Small Farms. U.S. Dept. of Agriculture, Yearbook of Agriculture, p.153-156.

Minnich, J., Hunt, M. and The Eds. of Organic Gardening, 1979. The Rodale Guide to Composting. Rodale Press, Emmaus, PA. 405pp.

De Bertoldi, M. et al. (eds.), 1987. Compost: production, quality, and use. Elsevier Applied Science Pub. Co., NY, NY [TD796.5 .C58 1987--D/R/SB/CSL]

General Science Directorate, Commission of the European Community. 1985. Composting of Agricultural and Other Wastes. Elsevier, NY [TD796.5 .C6--D/I, S661 .C65--SB/SC]

On Farm Composting Conference, 1987. Bulletin Distribution Center, Cottage A, Thatcher Way, University of Massachusetts, Amherst, MA 95p.

Seifert, A. 1962. Compost, Faber and Faber, London, UK 124p [S661 S43--CalPoly]

4.4.2. MANURES

Tried and true. Manure provides balanced crop nutrients and organic matter for the soil. It fights soil crusting and enhances soil water retention and structure. On the down side manure can carry weeds and diseases, add unwanted salts, and effect the pH of soils (composting manures, see previous section, usually eliminates or reduces these problems). Availability can be a problem as the value of manure has increased considerably, but \not if you try animal/plant rotations or ley farming can provide the needed materials.

The nutrient value of a manure greatly depends on how it is stored and handled. Nitrogen is easily lost whereas phosphorus and potassium losses usually occur from leaching in open piles. Many of the sources in this section detail proper storage and handling.

Crandall, F.K. and Odland, T.E. 1930. Amount of Manure Necessary for Vegetable Growing. Rhode Island Agricultural Experiment Bulletin # 225, pp. 1-31.

Anderson, M.S. 1957. Farm Manure. in Soil, U.S. Dept of Agriculture, Yearbook of Agriculture, pp. 229-237.

Majumdar, B. and Jang, S. 1963. Comparative Manurial Value of the Excreta of Some Farm Animals, Ann. Biochem., 23(3):91-94.

Black, W. and White, R. 1973. Effects of Nitrogen, Phosphorus, Potassium and Manure Factorially Applied to Potatoes in a Long Term Study, *Canadian Journal of Soil Science*, 53(2):205-211.

Prall, P.A. 1948. A Forgotten By-Product: one ton of poultry droppings equals three tons of farmyard manure, *Poultry World*, 82(20): no pages.

Salter, R.M. and Schollenberger, C.J. 1938. Farm Manure. in U.S. Dept. of Agriculture, *Yearbook of Agriculture*, p.445-461.

Gliemeroth, G. 1963. Residual Effects of Organic Manuring on Structural Conditions and Tilth in Long-Term Trials, *Z. Acker- u. Pt l Bau*, v.116 p.289-300.

Hafez, A.A.R. 1974. Comparative Changes in Soil-Physical Properties Induced by Admixtures of Manures from Various Domestic Animals, *Soil Science*, 118(1):53-59.

Anon?. 1976. Organic Manures, *Bulletin of the Great Britain Ministry of Agriculture Fisheries and Food*, v.210. 78pp.

Sommerfeldt, T.G., Chang, C. and Entz, T. 1988. Long-Term Annual Manure Applications Increase Soil Organic Matter and Nitrogen, and Decrease Carbon to Nitrogen Ratio, *Journal of the Soil Science Society of America*, 52(5):1668-1672.

Thorne, C.E. 1921. *Farm Manures*. Orange-Judd, NY 242p [S633 T5--D]

MacLean, J. 1989. *Poultry Wastes: Uses and Management*. National Agricultural Library, Quick Bib. 89-46.

4.5. SOIL AMENDMENTS

Gilbert, R., Menzies, J. and Griebel, G. 1969. The Influence of Volatiles from Alfalfa upon Growth and Survival of Soil Micro-Organisms, *Phytopathology*, v.59 p.992-995.

Burdick, E. 1965. Commercial Humates for Agriculture and the Fertilizer Industry, *Economic Botany*, v.19 p.152-156.

U. S. Department of Agriculture, 1978. *Improving Soils with Organic Wastes*. Washington, D.C. 157pp.

Halstead, R. and Sowden, F. 1968. Effect of Long-Term Additions of Organic Matter on Crop Yields and Soil Properties, *Canadian Journal of Soil Science*, 48:341-348.

Gilbert, R. and Griebel, G. 1969. Stimulation of Soil Respiration by Volatiles from Alfalfa, in *Proceedings of the Soil Science Society of America*, 33:270-273.

Owens, L.G., Gilbert, R. and Griebel, G. 1968. Identification of Plant Volatiles that Stimulate Microbial Respiration and Growth in Soil, *Microbial Processes*, v.1968 p.3.

Gati, F. 1982. Use of Organic Materials as Soil Amendments, in *Food and Agriculture Organization of the United Nations, Soils Bulletin*, 45:87-105.

Lunt, H. 1955. The Use of Woodchips and Other Wood Fragments as Soil Amendments, *Connecticut Agric. Exp. Sta. Bull.* 593.

Allison, F.E. 1965. Decomposition of Wood and Bark Sawdusts in Soil Nitrogen Requirement, and Effects on Plants, *Technical Bulletin # 1332, USDA Agric. Res. Serv.*

Allison, R. Murphy, R. and Klein, C. 1963. Nitrogen Requirements for the Decomposition of Various Kinds of Finely Ground Woods in Soil, *Soil Science*, 96:187-190.

Warren, R., Cooke, E. and Cooke, G. 1958. Field Experiments on Concentrated Organic Nitrogen Fertilizers, *Journal of Agricultural Science*, 50:273-283.

Mortland, M., Erickson, A. and Davis, J. 1957. Clay Amendments on Sand and Organic Soils, *Michigan Agric. Exp. Sta. Quart. Bull.* pp?

Jackson, J. and Burton, G. 1958. An Evaluation of Granite Meal as a Source of Potassium for Coastal Bermudagrass, *Agronomy Journal*, 50:07-308.

Fussell, G. 1959. Marl: an ancient manure, *Nature*, 183:214-217.

Fragstein, P. von, Pertl, W. and Vogtmann, H. 1986. Silicate Rock Powders: qualitative and quantitative aspects, in *The Importance of Biological Agriculture in a World of diminishing Resources: proceedings of the 5th IFOAM International Scientific Conference and the University of Kassel (Germany), 1984.* p.74-84. Verlagsguppe Witzenhausen: Witzenhausen.

Shainberg, I., Sumner, M.E., et al. 1989. Use of Gypsum on Soils: a review, *Advances in Soil Science*, 9:1-111.

1985, *Western Fertilizer Handbook*. produced by Soil Improvement Committee, California Fertilizer Association, Danville, IL

McAllister, J.C. 1983. *A Practical Guide to Novel Soil Amendments*, Rodale Research Center, Emmaus, PA 124p.

4.6. MULCHES

Research in recent years has highlighted the importance of mulch in enhancing water conservation and soil fertility and structure as well as in protecting against soil erosion. One of the more interesting discoveries has been the influence of the color of the mulch on plant growth and yield.

Davies, J.W. 1975. Mulching Effects on Plant Climates and Yield, Technical Note 136, WMO 388, World Meteorological Organization, Geneva, Switzerland 92p. [S661.5 D3--B; QC851.W6--D; S 596.3 D38--LA]

Jacks, G.V., Brind, W.B., and Smith, R. 1955. Mulching. (Technical Communication #49), Commonwealth Bureau of Soil Science, Harpenden, England. [S590 .C53 #49, 1955--R]

Tukey, R. and Schoff, E. 1963. Influence of Different Mulching Materials Upon the Soil Environment, Proceedings of the American Society of Horticultural Science, 82:68-76.

Shearman, R.C., Steinegger, D.H., et al, 1979. A Comparison of Turfgrass Clippings, Oat Straw, and Alfalfa as Mulching Material for the Garden. Journal of American Horticultural Science, 104(4):461-463.

Bristow, K.L. 1988. The Role of Mulch and Its Architecture in Modifying Soil Temperature, Australian Journal of Soil Research, 26(2):269-280.

Latimer, L. and Percival, G. 1944. Sawdust, Seaweed and Meadow Hay as Mulch for McIntosh Apple Trees. Proc. Amer. Soc.Hort.Sci., 44:49-52.

Brownlee, E.A. 1988. Plastic Mulches, 1979-June 1988: 179 citations. Quick Bib. 89-01.

Fairbourn M.L. and Gardner, H.R. 1972. Vertical mulch effects on soil water storage, Proceedings of the Soil Science Society of America, 36:823-827

Goetz, J. 1987. Color preferences of plants (effect of mulch color on plants), Environment, 29(Dec):23

4.7. SOIL CONSERVATION

Some subjects seem to wax eternal and this is one of them. You can't build up high quality soil unless you manage to keep it on your farm. This isn't always easy. The big push in soil conservation of the 1930s, in the wake of the dust bowl, has subsided between 1940 and 1980 and over the last three decades (many of the older windbreaks planted then have been eliminated or aren't being kept up). Recent interest has increased and valuable new work is being done until recently.

Pimentel, D., Allen, J., et al. 1987. World Agriculture and Soil Erosion, Bioscience, 37(4):277-283.

Lyles, L. 1985. Predicting and Controlling Wind Erosion, Agricultural History, 59(2):p.205-214. University of California Press, Berkeley, CA.

McCalla, T., Army, T. and Whitfield, C. 1962. Stubble-Mulch Farming, Journal of Soil and Water Conservation, 17:204-208.

McCalla, T. 1961, Stubble Mulch Farming, *Advances in Agronomy*, 13:125-196.

Enlow, C.R. 1939. Review and Discussion of Literature Pertinent to Crop Rotation for Erodible Soils. U.S. Dept. of Agriculture, Circular # 559, 51pp. USDA, Washington, D.C.

Domanico, J.L., Madden, P. and Partenheimer, E.J. 1986. Income Effects of Limiting Soil Erosion Under Organic, Conventional, and No-Till Systems in Eastern Pennsylvania, *American Journal of Alternative Agriculture* 1(2):75-82.

Barth, H. and Hermite, P. (eds.), 1987. *Scientific Basis for Soil Protection in the European Community*. Elsevier Applied Science, London.

Reganold, J.R., Elliott, L.R. and Unger, Y.L. 1987. Long-Term Effects of Organic and Conventional Farming on Soil Erosion, *Nature*, 330(6146):370-372.

Weir, W.W. Aug. 1932. *Soil Erosion in California: its prevention and control*, California Agricultural Experiment Station, Bulletin # 538, 45pp.

U.S. Soil Conservation Service, 1954. *A Manual on Conservation of Soil and Water*, USDA (Agriculture Handbook, series # 61) U.S. Govt. Print. Off., Washington [S623 .U48--D]

California Soil Conservation Advisory Committee, 1987. *Conserving the Wealth of the Land: a plan for soil conservation*. (Calif. Dept. of Conservation Publication series # 87-01) The Dept. of Conservation, Office of Land Conservation, Sacramento, CA [KFC396 .C34 1987--HAST, S624.C2 C341 1987--B, C822 C66--SD, C822 .C66--CSL]

Finkel, H.J. 1986. *Semiarid Soil and Water Conservation*. CRC Press, Boca Raton, FL 126pp. [S623 .F481 1986--B, S623 .F48 1986--D/I/R/SB]

Goldman, S.J., Jackson, K., et al? c1986. *Erosion and Sediment Control Handbook*. McGraw-Hill, NY [TC423 .G6451 1986--B/D/I/R/SD, TC 423 G645 1986--LA]

Harding, M.V. 1988. *Erosion Control Effectiveness: comparative studies of alternative mulching techniques*. National Research Council, Transportation Research Board, Washington, D.C. [TA1001.5 P7 1988 # 0244--B]

Moldenhauer, W.C. and Hudson, N.W. (eds.), 1988. *Conservation Farming on Steep Lands*. World Association of Soil and Water Conservation, Soil and Water Conservation Society, Ankeny, IA [S622.2 .C661 1981--B, S622.2 .C66 1988--D]

Lal, R, ed. 1988. *Soil Erosion Research Methods*. Soil and Water Conservation Society Ankeny, IA [S626 S65--B/D/R/SB/SC]

Archer, S.G. 1965. *Soil Conservation*, University of Oklahoma Press, Norman, OK 305p. [S624.A1 A7--D/I/SC/SD]

Bennett, H.H. 1939. Soil Conservation, McGraw Hill, NY 993p. [S623 .B36--B/D/R]

Follett, R.F., Stewart, B.A., and Ballew, I.Y. (eds) 1985. Soil Erosion and Crop Productivity, American Society of Agronomy, CSSA, SSSA, Madison, WI 533p. [S596.7 .S6341--B/SB, S623 .S5737--D/SD]

Hudson, N. 1981. Soil Conservation, Cornell University Press, Ithaca, NY 324p. [S623 .H78--B/D/LA/R]

Soil Conservation Service. 1946. Soil Conservation in California, U.S.D.A., S.C.S., Berkeley, CA 28p. [S624.C2 S6--B]

Hafenrichter, A.L., Schwendiman, J.L., Harris, H.L., MacLauchlan, R.S., and Miller, H.W. 1968. Grasses and Legumes for Soil Conservation in the Pacific Northwest and Great Basin States. Agriculture Handbook 339. USDA, Soil Conservation Service, Washington, DC [S21 A37--R]

4.7.1. NEW TILLAGE METHODS (non-conservation tillage)

Soil compaction, damaged soil structure and soil erosion are all problems that lend themselves to sustainable solutions. These include permanent bed systems, track systems, emphasis on reduced field traffic and multiple operations per pass as well as conservation tillage. Spaders rather than rototillers reduce soil disruption.

Hummel, J.W., Wax, L.M. and Siemens, J.C. 1985. Reduced Tillage Systems: how they compare, Agricultural Engineering, 66(9):18-19.

Wells, K.L., Murdock, L.W. 1988. Contending with Soil Compaction, Soil Science News and Views, Sept. 1988, v.9 (8) 3p. Cooperative Extension Service, University of Kentucky, College of Agriculture, Agronomy Dept. Lexington, KY.

Christensen, L.A. and Norris, P.E. 1983. A Comparison of Tillage Systems for Reducing Soil Erosion and Water Pollution, Agric-Econ-Rep-U-S-Dep-Agric. May 1983 (499) 27pp. The Department, Washington, D.C.

Hakansson, I., Wiklert, O. and Thunholm, B. 1985. Long-Term Effects of Compaction by Farm Machinery on Some Ecologically Important Physical Properties of Soils, in Soil Ecology and Management, J.H. Cooley, ed., p.127-132. International Association for Ecology, Athens, GA.

Taylor, J.H. 1983. Benefits of Permanent Traffic Lanes on a Controlled Traffic Crop Production System, Soil & Tillage Research, 3:385-395.

Mostaghimi, S. et al, 1987. Effects of Tillage System, Crop Residue Level, and Fertilizer Application Technique on Losses of Phosphorus and Pesticides from Agricultural Lands. (Virginia Water Resources Research Center Bulletin series # 157) Virginia Polytechnic Institute and State University, Virginia Water Resources Research Center, Blacksburg, VA [G238 SU2 no..157--B]

Chancellor, W.J. 1977. Compaction of soil by agricultural equipment, U.C. Cooperative Extension Bull. 1881, 63p [TA710.2.C45--SC]

Orzolek, M.D. 1987. Controlled Traffic Cropping Systems for the Management of Soil Compaction. Acta Horticulturae # 210. International Society for Horticultural Science, Wageningen, The Netherlands, 68p.[TA710 .C66--D, S592.3 I56--R]

Journals of Note:

Soil & Tillage Research. Amsterdam. Elsevier Scientific Publ Co. 1980-. [S590 .S48--B, S590 S684--D, S 590. S64--SB]

4.7.2. CONSERVATION TILLAGE

Conservation tillage has some big pluses in regard to can provide many soil conservation benefits. Conservation tillage emphasizes leaving crop residues on the surface to reduce erosion and reducing tillage. Prevalent in the Midwest, it is being adapted to California conditions. It has a potential big minus, however, in regard to maintaining soil and water quality: These benefits can be offset by the adverse impacts of conventional conservation tillage typically substitutes large amounts of herbicides used to replace tillage for weed control.

Sustainable conservation tillage systems are being developed, however. Flame weeding, mowing, efficient herbicide conserving equipment (e.g., wick applicators), the use of living mulches or weed suppressing crops and even the use of weeder geese and grazing by animals and other biological means of control may all start to play bigger roles here.

Although not yet fully modified for California's climate and crops, conservation tillage and its many variants are being more widely used. Over 256,000 acres were in reduced tillage (60%), mulch tillage (24%), no-tillage (16%), ridge tillage (<1%), or strip tillage (<1%) in California in the mid-80's according to the Conservation Tillage Information Center (Study of Tillage Practices, 1985).

MacLean, J.T. 1988. Conservation Tillage (including minimum and no tillage), January 1987-June 1988: 377 citations. Quick Bib. series 88-81. [S604.A12 M33 1988--B]

Bebee, C.N. (ed.), 1986. Conservation Tillage, January 1980-August 1985: citations from Agricola concerning diseases and other environmental considerations. (Bibliographies and Literature of Agriculture series # 51) NAL, Washington, D.C.

Lockeretz, w. 1983. Energy Implications of Conservation Tillage, Journal of Soil and Water Conservation, 38(3):207-211.

Stockwin, W. 1988. No-Till Experiments Pay Off, Western Fruit Grower, 108(5):18-19.

Sand, D. 1986. Resourceful Farming Through Conservation Tillage. Iowa Natural Heritage Foundation, Insurance Exchange Building, Suite 830, 505 Fifth Ave, Des Moines, IA 50309.

Conservation Tillage: a special issue, Journal of Soil and Water Conservation, May-June 1983. 190p.

Rice, R.W. 1983. Fundamentals of No-Till Farming. (Agdex series # 519) American Association for Vocational Instructional Materials, Athens, GA [S604 .R53 1983]

Power, J.F., (ed.), 1987. The Role of Legumes in Conservation Tillage Systems, in proceedings of a national conference, University of Georgia, Athens. Soil Conservation Society of America, Ankeny, IA [SB317.L43 R651 1987--B, SB317.L43 R65 1987--SC].

D'Itri, M. (ed) 1985. A Systems Approach to Conservation Tillage, Lewis Publ., Chelsea, MI 384p.[S604 .S971--B/D/I/R]

Little, C.E. 1987. Green Fields Forever: The Conservation Tillage Revolution in America, Island Pr., Covelo, CA 192p. [S604 .L57--B/D/SB/SC/CSL/SD]

Sprague, M.A. and Triplett, G.B. (eds) 1986. No-tillage and Surface-tillage Agriculture: the Tillage Revolution, John Wiley and Sons, NY 467p. [S604 .N62--B/D/SB/SC]

Phillips, R.E. and Phillips, S.H., 1984. No-tillage Agriculture, Principles and Practices, Van Nostrand Reinhold, NY 306p. [S604 .N6--B/D/R/SB/SC]

Hughes, H.A. 1980. Conservation Farming. John Deere Technical Services, Moline, IL 150p. [S936 .H8--B, S604.5 .H9--D]

Hons, F.M. (ed) 1988. Conservation Tillage in Texas. Texas Ag. Exp. Sta., Research Monograph 15, Texas A&M, College Station, TX 84p.

Logsdon, G. 1984. Erosion's Real Costs--no-till no answer, at least not in the long run, The New Farm, 6(6):38-39, 42

Hinkle, M.K. 1983. Problems with Conservation Tillage, Journal of Soil and Water Conservation, May-June:201-206.

Smyser, S. 1979. The "Other Side" of No-Till, The New Farm, 1(2):78-80.

Journals of note:

Conservation Tillage News. Conservation Tillage Information Center, 2010 Inwood Drive, Executive Park, Fort Wayne, IN 46815

4.9. Restoration of degraded farm land

The long-term harvest from unsustainable production includes a bill that all of us will have to pay for a long time to come: degraded or wasted farm land. Depending on the type of degradation, though, there can be ways to bring back soil fertility, soil organic matter, tillage and to counter problems such as soil salinity.

Ente, P.J. 1985. Soil Reclamation with Special Emphasis on Polders. in *Soil Ecology and Management* (J.H. Cooley, ed.), p.81-88. International Association for Ecology, Athens, GA.

Brown, D., et al, 1986. Reclamation and Vegetative Restoration of Problem Soils and Disturbed Lands. Noyes Data Corp., Park Ridge, NJ (Pollution Technology Review series # 137)[S623 .R361 1986--B, S623 .R36 1986--D/I/R/SB, S 623 R36 1986--LA]

Richards, L.A. (ed.), 1954. *Diagnosis and Improvement of Saline and Alkali Soils*. (U.S. Dept. of Agriculture Agriculture handbook series # 60) U.S. Govt. Print. Off., Washington, D.C.

Bradshaw, A.D. and Chadwick, M.J. 1980. *The Restoration of Land*. University of California Press, Berkeley, CA 317p.[TC605 .B68--B, TC805 .B76--D/I/LA/R/SB/SD]

Haverkamp, M.R., Ganskopp, P.C., Miller, R.F., Sneva, F.A., Marietta, K.L., and Couche, D. 1987. Establishing grasses by imprinting in the Northwestern U.S., in *Proceedings of the Symposium on Seed and Seedbed Ecology of Rangeland Plants*, ed. by Frasier, G.W. and Evans, R.A., USDA/ARS, Tucson, AZ pp.299-308.

Heady, A.F. and Bartolome, J.W. 1976. Desert repaired in Southeastern Oregon: a case study in range management, in *Desertification: Process, Problems, Perspective*, ed. by Paylore, P. and Haney, R.A., Office of Arid Land Studies, University of Arizona, Tucson, AZ pp.107-117.

Jordan, W.R., Gilpin, M.E., and Aber, J.D. 1987. *Restoration Ecology*. Cambridge University Press, NY 342p. [QH541 R456--R]

Khoshoo, T.N. 1987. *Ecodevelopment of Alkaline Land*, National Botanical Research Institute, Lucknow, India 136p.

Leopold, A. 1966. *A Sand County Almanac*, Oxford University Press, NY 269p.

Margolin, M. 1985. *The Earth Manual: How to Work on Wild Land Without Taming It*. Heyday Bks, Berkeley, CA 237p. [QH75 .M36--SC]

Henderson, C.L. 1987. *Landscaping for Wildlife*. Minnesota Documents Division, St. Paul, MN 144p.

Reith, C.C. and Potter, L.D. 1986. *Principles and Methods of Reclamation Science*, University of New Mexico Press, Albuquerque, NM 224p.

Schiechl, H. 1980. Bioengineering for Land Reclamation and Conservation, University Of Alberta Press, Edmonton, Alberta 404p.

Soil and Water Conservation Society. 1988. Vegetative Filter Strips, US Environmental Protection Agency and Soil Conservation Service, Washington, DC 2p.

Wenger, L.E.1941. Reestablishing native grasses by the hay method, Kansas Experiment Station, Circular 208.

Bainbridge, D.A. 1989. The restoration of agricultural lands and dry lands. In J. Berger, ed. Restoring the Earth. Island Press, Covelo, CA

5.0. WATER MANAGEMENT

This state is running out of water. And the water that it has is, in more and more places, becoming of doubtful drinking and agricultural quality. At the same time, both the state and federal government have, in many districts, heavily subsidized irrigation water. This, too, may change. Concern about agricultural water management and conservation is one sustainable agriculture issue that is embraced by all California farmers. More work needs to be done in this area, but the following works are very helpful.

Caswell, M. and Zilberman, D. 1985. The Choices of Irrigation Technologies in California, American Journal of Agricultural Economics, 67(20):224-234.

Umeda, P. 1985. The Use of Vegetation to Reduce the Toxicity of Stormwater Runoff, California Dept. of Transportation, Office of Transportation Laboratory; National Technical Information Service, Springfield, VA.

Letey, J., Roberts, C., Penberth, M., and Vasek, C. 1986. An Agricultural Dilemma: Drainage Water and Toxics Disposal in the San Joaquin Valley, U.C. Agric. and Natr. Res. Spec. Pub. #3319, Berkeley, CA 56p.[G4365 M6-16--B/R/D 1739.C2 A47--D/SC]

Ayers, R.S. and Westcot, D.W. 1985. Water Quality for Agriculture. Food and Agriculture Organization Irrigation and Drainage Paper #29. FAO, Rome, Italy 174p. [TC801 .I715 # 29 D/LA/B]

Boswell, M.J. 1986. Micro-irrigation Design Manual, James Hardie Irrigation, El Cajon, CA, vp.

Stern, P.H. 1979. Small Scale Irrigation: A Manual of Low-Cost Water Technology. Intermediate Technology Publications, Bet Dagan, Israel 152p. [TC805 .S7 D/I/R/SB]

O.T.A. 1983. Water Related Technologies for Sustainable Agriculture in Arid/Semiarid Lands, Office of Technology Assessment, Washington, DC 412p. [S613 .W38--D, docs--B]

Yeomans, P.A. 1981. Water For Every Farm: Using the Keyline Plan, --- Australia 247p. [early edition S616.A8 Y4--D]

Irricab: current annotated bibliography of irrigation. 1976-86 (temp. ceased). International Irrigation Information Center. P.O.B. 49, 50250 Bet Dagan Israel. [Ref S613 I7 R/D/B]. Like Irrigation and Drainage Abstracts, this is a superior abstract journal covering all subjects related to water management and irrigation.

Journals of note:

Agricultural Water Management. c/o Journal Information Center, Elsevier, 52 Vanderbilt Ave, NY, NY 10017 [S494.5.W3.A37--B/R/SB, TD388 A1 A34--D]

5.1. IMPROVING IRRIGATION

The efficiency of conventional irrigation systems can be improved with minor revisions and more careful management. Recent material of interest includes:

Proceedings of the Third International Drip/Trickle Irrigation Congress 1985, (Fresno, CA), Drip/Trickle Irrigation in Action: proceedings. (ASAE Publication series # 10-85) American Society of Agricultural Engineers, St. Joseph, Michigan [S619.T74 I56 1985--B/D/R/SB]

Nakayama, R.S., Bucks, D.A. (eds.), 1986. Trickle Irrigation for Crop Production: design, operation, and management. (Developments in Agricultural Engineering series # 9) Elsevier, NY.

Wildman, W.E., Peacock, W.L., et al. 1988. Soluble Calcium Compounds may Aid Low-Volume Water Application, California Agriculture, 42(6):7-9.

MacLean, J.T. 1987. Drip and Trickle Irrigation 1985-April 1987, 282 citations from AGRICOLA, Quick Bibliography Series # 87-01, updates 85-21,

Richardson, G. 1985. Saving Water from the Ground Up: a pilot study of irrigation scheduling on four California fields. Inform, Inc., NY.

Zekri, M. and Parsons, L.R. 1989. Grapefruit Leaf and Fruit Growth in Response to Drip, Microsprinkler, and overhead Sprinkler Irrigation, J-Am-Soc-Hortic-Sci. 114(1):25-29.

Hanson, B.R., Schwanki, L.J. and Fulton, A. 1988. Uniformity of Low-Energy Precise-Application (LEPA) Irrigation Machines, California Agriculture, 42(5):12-14.

Ley, T.W. 1987. Microsprinkler Design and Management Considerations, Proc-Wash-State-Hortic-Assoc. (83rd):169-175.

Gibson, E.L. 1987. Center Helps Growers Save on Water, Sun-Diamond Grower, 6(4):42-43, 46.

Oster, J.D., Meyer, J.L., et al. 1986. Field Studies of Irrigation Efficiency in the Imperial Valley, Hilgardia, 54(7):1-15.

Sutton, B.G., Strizaker, R.J., et al. c1985. Solar Powered Drip Irrigation for Vegetables, in Drip/Trickle Irrigation in Action: proceedings of the 3rd International Drip/Trickle Irrigation Congress, pp.589-593. American Society of Agricultural Engineers, St. Joseph MI.

Wastewater Irrigation, 1988, Quick Bib. 88-55

Richardson, G. and Mueller-Beilschmidt, P. 1988. Winning with Water: Soil Moisture Monitoring for Efficient Irrigation. Inform Inc., NY 192p. [S619.E34 R531 B/D/CSL]

MacLean, J.T. 1989. Water conserving irrigation. 395 cites. National Agricultural Library Quick Bib. 89-35.

Hanson, B.R. 1987. A systems approach to drainage reduction, California Agriculture, 41(9-10):19-24.

McClintic, D. 1987. Notched-ditch irrigation catches on, The Furrow (Western edition), 92(6):26-27.

Some of the novel alternatives that may be worth a closer look include: closed conduit irrigation, water harvesting, porous capsules, pipe injection, pitcher irrigation, and surge flow irrigation.

Bainbridge, D.A., Steen, A. and B. 1998. Super -efficient irrigation with buried clay pots. USIU Environmental Studies/Canelo Project. 5 p.

Frasier, G.W. and Myers. L.E. 1983. Handbook of Water Harvesting. USDA Agriculture Handbook series # 600 , Agricultural Research Service, Washington, D.C. For sale by Supt. of Docs., U.S. G.P.O. [S21 .A37 #600--D, 44.4 M3-01--LA, QC925.1.U47 1983--SC]

Rawlins, S. L. 1977. Uniform Irrigation with a Closed-conduit Gravity Distribution System, U.S. Salinity Lab. Publication 602, Riverside, CA 12p.

Silva, A. de S., Silva, A. da S., and Gheyi, H.R. 1985. Viability of irrigation by the porous capsule method, Trans. 12th Cong. on Irrig. and Drainage, New Delhi, India pp.753-764.

Sawaf, H.M. 1980. Attempts to improve the supplementary irrigation systems in orchards in some arid zones, in Rainfed Agriculture in the Near East and North Africa, FAO, Rome, Italy 409p.

Bainbridge, D.A. 1989. Pitcher irrigation, Canelo Project, Canelo, AZ 20p.

Sheikh, M.I., Shah, B.H. and Aleem, A. 1984. Effect of Rainwater Harvesting Methods on the Establishment of Tree Species [runoff farming, microcatchments and trenches, Pakistan], For-Ecol-Manage. 8(3/4):257-263.

Boers, T.M. 1983. Economic Evaluation of Water Harvesting in Microcatchments, Water Resources Research, Oct. 1983, v.19 (5) p.1099-1105. American Geophysical Union, Washington.

Oron, D. 1982. Technical and Economic Considerations in the Design of Closed Conduit Irrigation Systems: a case study, *Agricultural Water Management*, 5(1):15-27.

Boers, T.M. and Ben-Asher, J. A 1982. Review of Rainwater Harvesting, *Agricultural Water Management*, 5(2):145-158.

Orev, Y. 1988. Some Agricultural Considerations in the Planning of Runoff Farming, *Desertification Control Bulletin*, (16) p.13-16. United Nations Environment Programme, Nairobi, Kenya.

Sharma, K.D., Pareek, O.P. and Singh, H.P. 1986. Microcatchment Water Harvesting for Raising Jujube orchards in an Arid Climate, *Trans. ASAE* 29(1):112-118.

Murthy, K.N.K., Sharma, K.D. and Vangani, N.S. 1986. Efficient Rainwater Harvesting from Arid Lands of India, in *Soil Conservation in India* (Gupta, R.K. and Khybri, M.L., eds.) p.193-200. Jugal Kishore, Dehra Dun, India.

Zazueta, F.S., Albrechts, E.E. and Stanley, C.D. 1986. Rainwater Harvesting and Irrigation Tailwater Recovery to reduce Water Use for Fruiting Strawberry, *Proceedings of the Soil and Crop Science Society of Florida*, 1986 v.45 p.129-131. The Society, [S.I.].

Sharma, K.D. 1985. Runoff Behaviour of Water Harvesting Microcatchments, *Agricultural Water Management*, 11(2):137-144.

Stringham, G.E. ed. 1988. Surge Flow Irrigation. Research Bulletin 515. Utah Agricultural Experiment Station, Logan UT 92p.

Goldhammer, D.A., Alemi, M.H., and Phene, R.C. 1987. Surge vs. continuous flow irrigation, *California Agriculture*, 41(9-10):29-32.

Smerdon, E.T. and Blair, A.W. 1985. Improving Surge Flow Irrigation Efficiency Based on Analysis of Infiltration and Hydrodynamic Effects. Tech. Report 138. Texas Water Resources Institute, Texas A&M, College Station, TX --p

Bainbridge, D.A. and Virginia, R.A. 1989. Irrigation trials. Systems Ecology Research Group, San Diego State University, 12p.