APPLICATION OF
MICROCLIMATE MANAGEMENT AND
MANIPULATION TECHNIQUES IN LOW EXTERNAL
INPUT AGRICULTURE

by

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(Report of the CAGM-IX Joint Rapporteurs on Microclimate
Management and Manipulation Techniques in Low
External Input Agriculture)

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1. GENERAL INTRODUCTION (C.J. Stigter)

When the Working Group on Microclimate Management and Manipulation in Traditional Farming, proposed in the (draft) CAGM Report (Stigter, 1988) as a first alternative to nominate for the ninth intersessional period a rapporteur to monitor and stimulate progress on the subject, it had in mind that continued function of the Working Group was most important of all. When the terms of reference for such a rapporteurship were drawn, this awareness function again was the main guiding principle. It was generally felt, during the ninth CAGM session, that the performance of such a function should preferably be shared by a few people well acquainted with the subject.

In the meeting of the Advisory Working Group immediately after the session in Madrid, the USSR proposed that I should coordinate the work of the four experts proposed from China, the Netherlands, the USA and the USSR (see Appendix I) and it was decided accordingly. Contrary to Working Groups, each member of a group of joint rapporteurs has his own individual responsibility with respect to all terms of reference (see Appendix II) and no distribution of tasks was proposed other than the annotations of the earlier published Bibliography and the contacting of earlier contributors to be done by those who collected these items. In the joint report the different contributions therefore remain separated for obvious reasons. However, the editing was most logical when following the sequence of the terms of reference. Some of the joint rapporteurs preferred to contribute to only one or two of those terms of reference and this is covered by the separation of the contributions as well.

With respect to the interpretation of the term "Traditional Techniques" as used in the terms of reference (a) and (b), it should be noted that it broadened somewhat in the course of the existence of the former Working Group and this group of rapporteurs. In this report we therefore cover in principle all present micrometeorological and microclimatological aspects of management and manipulation techniques applied in systems in which some important traditional aspects have been kept, such as for example in farming systems based on agroforestry and (other) intercropping practices or in older agricultural techniques from temperate regions. This latter category is the reason why the contribution of Dr. Karing fits in nicely in Chapter 4 and the contribution of Dr. Wilken to Chapter 2 contains some older WMD and non-WMD publications that were deliberately left out in 1986.

Management/manipulation/modification of microclimate means in this report (Stigter and Darnhofer, 1989):

"Decreasing or increasing the exposure of surfaces, either the actual soil surface or the more composite surfaces including above surface living and dead material, to radiation,
precipitation and wind and/or changing the original properties of (composite) surfaces, resulting in an alteration of the impact of these large scale weather elements."

It was proposed to use in this report, less loosely than in Stigter (1988), "modification" of microclimate in the sense of an inadvertent change in surface exposure or surface properties as a consequence of human action. "Manipulation" then expresses deliberate actions to alter particular severe aspects of the microclimate and "management" reflects the results of preservation of desirable characteristics of the microclimate (Stigter and Darnhofer, 1989).

It was decided that the system of information labelling as developed by the coordinator and adopted by the former Working Group would as far as possible be kept (see Appendix III).

Abbreviations used may be found in Appendix IV, where also the addresses of some mentioned institutes have been reproduced. Other useful addresses may be found in section 2.3.

It is recommended from the output collected in this report that the subject be continued as part of future CAgM Working Group and Rapporteur assignments, now that it has been recognized and established over the past decade as an important field of work. In the draft proposals for such Working Groups and Rapporteurs as established by the Advisory Working Group in May 1990 (WMO, 1990), there is ample scope for such continuation. The selected intersessional priority subject of "Agrometeorology in support of sustainable agriculture" and the way our fields of interest occur in the WMO Third Long-term Plan warrant sufficient attention to our subject in the near future.

In the following chapters the introductions were written by the coordinating editor.

Literature


2. PUBLISHED CASE STUDIES AND PLANNED AND ONGOING PROJECTS

2.1 Introduction

One of the most important conclusions to be drawn from the past five years of work in comparison to the period 1980 - 1985 is that our awareness function had to change considerably in character compared to that of the former Working Group. Microclimate management and manipulation and inadvertent (micro)climate modification are visibly back on the stage of fields of research with acknowledged importance. Although the annotated bibliography for the period 1960 - 1985 in chapter 3 shows that these subjects have never been off stage, it is only more recently that they got again the visible recognition they deserve. It is also no longer necessary to time and again defend particular research attention to traditional techniques and practices. Between Brookesha et al. (1980) and Warren et al. (1990) the world of tropical agricultural research has changed in this respect. [The next decade should see an equal change in the view of administrative decision and policy makers for and in rural areas!!] Two main reasons are to be indicated for these reevaluations.

Firstly, in the world of modern intensive highly mechanized agricultural production, the observed cumulative environmental consequences of large amounts of inputs in the form of artificial fertilizers, herbicides, pesticides and fuel consumption have strongly contributed to calls for lower inputs. Such attempts range from no/lowlow till operations and attempts to develop systems with less other inputs, whether by a more economical use of such inputs and a change of the definition of optimal yields or in biotechnological attempts to change the needs for such inputs, to a complete change to organic farming. With lower inputs and more economical methods of their applications, microclimatic conditions will have more influence on yields. When more biological, physical and integrated methods of crop and soil protection are applied, more microclimate conditions have to be involved, also in yield forecasting. When more environmental protection problems are considered, more (micro)climatic aspects are implied.

Secondly, in tropical and subtropical agriculture the rate at which all forms of multiple cropping, but especially intercropping, from simple mixed cropping to complex homegardens, have gained interest in agricultural research, has considerably increased outside the original circles of Volunteer/NGO work where this awareness was originally most strongly developed operationally (e.g. GRET, 1982; Steiner, 1982; Carls, 1982-1987; Dupriez and de Leener, 1983; 1987). Although important initial review contributions appeared earlier (e.g. Papendick et al., 1976; Willey, 1979a; 1979b; Mead and Willey, 1980; Beets,
1982) this is shown by the more recent literature on these subjects (e.g. Noman et al., 1984; ILEIA, 1985 - 1990; Palaniappan, 1985; Wilely, 1985; Wilely et al., 1986; Baldy, 1986; Francis, 1986; 1986b; Baldy et al., 1987; Baumer, 1987; Harrison, 1987; Ofori and Stern, 1987; Steppler and Nair, 1987; Wilken, 1987; AGRECOL/ILEIA, 1988; Dommen, 1988; Rocheleau et al., 1988; Reifsnyder and Darnhofer, 1989; Stigter and Baldy, 1989; Vandermeer, 1989; Kang et al., 1990).

The main reason for this stronger recognition of the value of traditional practices and the potential for their modification, improvement and dissemination in agricultural research has been the increasing awareness of the impact of environmental degradation on the natural resource basis of tropical countries and the role that such techniques will have to play in the development of more sustainable agricultural production systems in these countries, especially in the poorer regions. Again necessarily low inputs - be it here mainly due to lack of such inputs and/or their economic non-feasibility - , biological and physical crop and soil protection needs, in the widest meaning of the word protection, and other related environmental issues, like large scale climatic variability, deforestation, erosion, desertification, aridification, floods and other environmental disasters and calamities, determine the increased interest in yield performance of low external input or low resource multiple cropping systems and the related (micro)climatic aspects.

Answers to my recently renewed correspondence on the detection of new case studies from earlier respondents and oral information obtained on the spot during my travel for the TTMI-project, have indicated that some International Agricultural Research Institutes (notably CIP, ICRAF, ICRISAT and IITA) have continued and often increased their leading work into the above mentioned directions, with an ever growing interest for on-farm research and sustainable production systems, while others (notably CIAT, ICARDA, ICIPE, ILCA and IRRI) indicated that they were now planning more work in these directions. From answers from outside these institutes one gets the impression that what is particularly lacking in National Agricultural Research Institutes are long term research policies.

The main reasons for such absence of long term policies in the industrialized world appear to be short term research funding in general, increasing reliance on research funding from outside these National Institutes, high turnover rates of staff members, with differing fields of interest and capacities, and a strong inclination for trendiness in research subjects. In the developing world these reasons apply a fortiori, with a strong tendency of more senior staff members to join International Institutes or other more rewarding enterprises, while junior ones mis yet the skills, the infrastructure, the opportunities, the decision power and increasingly the incentives to launch any long
term strategies. Here also the link with intermediate organizations and farmers to get any results validated and applied is virtually lacking. This explains the extremely low rate of return on my renewed correspondence with National Institutes earlier engaged in some applied work in our fields of interest and the even increased scatter of research (project) results in these fields throughout the different means of publication. Moreover, these results remain unvalidated and don't reach the stage of operationality under the conditions of intended users (e.g. Stigter and Weber, 1989).

The above observations have two consequences. Firstly, they indicate the remedies towards more systematic efforts in the field of application of microclimate management and manipulation techniques in low external input agriculture. On my question in a recent mini-symposium "Beyond the Green Revolution" in Wageningen (The Netherlands), whether National Agricultural Research Institutes in the developing world are sufficiently equipped to take over part of the research tasks of the International Institutes, especially those related to the on-farm research and extension tasks, the Director of CIMMYT answered that this would remain for a long time to come one of the (hitherto too much neglected, see Jahnke et al., 1987) fostering tasks of the International Institutes, while the Director of ISNAR indicated that for example in Africa the National Institutes even lack the most basic infrastructure and human capacity to carry out such tasks. Without strong inputs from international multilateral and bilateral aid towards National Agricultural Research, with respect to capacity generation and training, in well selected fields of agricultural research, among which certainly ours, and without a better management of this aid, no improvements may be expected.

Secondly, the consequence for our tasks as rapporteurs became indeed a largely different approach. The old function of case study awareness of what was going on in our fields of interest only still held in such cases as China, from where hitherto little information had been collected (compare also Agrometeorological Society of China, 1989) and a few cases reported through tear out sheets provided in Stigter, 1988. It became a new function to identify periodically occurring publications, in which attempts are made to review (project) work on multiple cropping and other potentially more sustainable cropping systems (and on the farming systems employing such cropping systems). This overcame the difficulties of the wide scattering now generally realized and of the appreciably increased amount of work with a microclimatic component, also illustrated by the Chinese work.

The very few cases reported through the tear out sheets, provided with the CAgM-Report No. 25 over the past two years, confirm the inconsistency of research and the relatively small group of
researchers outside the International Agricultural Research Institutes that reacted to this CAgM-report, which may have had little dissemination among those most involved in the National Agricultural Research Institutes in the developing world.

The reporting tasks are covered below. As before, the material covers also the micrometeorological basis for understanding traditional techniques of microclimate management and manipulation. It covers as well the field of quantitative approaches in general (e.g. Anderson and Ingram, 1989) and appropriate instrumentation in particular, that fortunately is now also more and more recognized as indispensable to obtain operational results (Stigter and Darmhofer, 1989). Matthews et al. (private communication, 1990; paper to appear soon in Agric. For. Meteorol.) from ICRISAT recently concluded that in all multiple cropping research, measurements of the microclimate are indispensable. What remains is the need for an integrated agrometeorology of multiple cropping (Stigter and Baldy, 1989; Baldy and Stigter, 1991).

Literature


[English translation appeared from the same source in 1990]
Beets, W.C., 1982. Multiple cropping and tropical farming systems. Gower and Westview Press, Aldershot (UK) and Boulder (CO, USA).


Steiner, K.G., 1982. Intercropping in tropical smallholder agriculture with special reference to West Africa. GTZ (no. 179), Eschborn (Germany). [In 1985 a French translation: "Cultures associées dans les petites exploitations agricoles tropicales en particulier en Afrique de l'Ouest" became available from the same publishers.]


2.2 Case Studies, books and other literature from China (Wanlong Chen)

2.2.a. Case Studies and related literature

Case studies

A.1

The influence of slope on the sunniness
Address: Prof. B. Fuh, Department of Meteorology, Nanjing University, Nanjing, Jiangsu Province, China

A2 + B21 + C3

The study of mulching effects using plastic films in different colours on vegetables
Address: M. Zhane, Hebel Agricultural University, Baoding, Hebel Province, China.

A2 + C3 + F2

An analysis on microclimate environment and its formative cause of rice seeding fields using plastic covers.
Reported in: 1966, Journal of Jiangsu Agriculture Science and Technique
Address: T. Zhou, Tianjing Meteorological Bureau, Tianjing, Hebel Province, China
W. Chen, Nanjing Meteorological Institute, Nanjing, Jiangsu Province, China

A2 + C3 + F2

Studies on adaptability and yield of strawberry cultivars in sunlight greenhouse
Reported in: 1988, Journal of Shenyang
Address: M. Deng, et al., Shenyang Agricultural University, Shenyang, Liaoning Province, China

A2 + C3 + F2

Studies on protected cultivation using covers of plastic for maize
Address: D.Hu, Z.LI and G.Hu, North-Eastern Agricultural college, Harbing, Heilongjiang Province, China

A2 + F2 + L2

A study on microclimatic effects on vegetable covered by plastic films
Reported in: 1990
Address: W. Feng, Northeast Agricultural college, Harbing, Heilongjiang Province, China
A2 + G1 + L2
A preliminary investigation of micrometeorological effect of the artificial wind barriers used in North China
Address: K. Yen and Y. Jen, Beining University, Beijing, China

A3 + G1
The investigation of the heat balance in the field inside the windbreak (Part II)
Reported in: 1987, Acta Agriculturae Universitatis Pekinensis
Address: H. Zhou, et al., Beijing Agricultural University, Beijing, China

A3 + G1 + L2
The crop yield and quality under the protect of the Shelter-belt network
reported in: 1988, Acta Agriculturae Universitatis Pekinensis
Address: G. Zu, et al., Beijing Agricultural University, Beijing, China

E + H
Studies on climate-ecological adaptation of relay cropping in China
Reported in: 1987, Acta Agriculturae Universitatis Pekinensis
Address: Prof. X. Han, et al., Beining Agricultural University, Beijing, China

G1 + L2
A study on wind prevention characteristic of conifer shelterbelts
Reported in: 1981, Journal of Northeast forestry Institute
Address: J. Zhu, et al., Institute of Forestry and Soil Science, Shenyang, Liaoning Province, China

01
A study on the equilibrium of forest influences on environment
Address: Y. Wang, Northeast Forestry Institute, Harbin, Heilongjiang Province, China
Related Literature

Fang, C and Gao, R., 1988
Energy balance and evapotranspiration observation in a Chinese pine plantation
J. Beijing Forestry University, 10(2), pp. 31-37

Fuh, B., 1962
The influence of slope orientation on the microclimate,
Acta Meteorological Sinica, 32(1), pp. 71-86

Chen, F., 1980
A microneternomerological study on the thermal effect of soil mulching
Acta Geographica Sinica, 35(1), pp. 68-75

Dou, V., 1988
A theoretical study of erosion control on terrace land
Journal of Northwest University, 18(2), missing pages

Hu, L. and Yang, Z., 1986
Photosynthesis and yield formation of different population structures in ramin
Part I: Construction of population and properties of photosynthesis
J. Huazhong Agric. U. 5(1), pp. 45-52

Pu, P., 1982
Microclimate characteristics of hotbeds in winter months
J. Nanjing Institute of Meteorology, No. 1, pp. 91-102

Qu, W., et al., 1988
Water consumption of wheat and the change of soil moisture of water field in Hui-lu-ong-gang Area
Acta Agricultural Universitatis Pekinensis, 14(2), pp. 167-176

Weng, D., et al., 1979
Radiation distributions in canopies
J. Nanjing Institute of Meteorology, No. 2, pp. 160-168

Weng, D., et al., 1980
A preliminary study on radiation balance in crop-fields
J. Nanjing Institute of Meteorology No. 2, pp. 149-157
Weng, D., et al., 1982
A theoretical study on sunshine duration in crop-fields
Scientia Meteorology Sinica, No. 1, 2, pp. 73-83

Wu, N. and Zhang, T., 1987
Relationships between water consumption for wheat field and winter wheat
J. Academy of Meteorological Science, SMA, China, 1(2), pp. 182-188

Xu, Z., et al., 1988
Study on radiation balance inside network of shelter belt in the field
Acta Agricultural Universitatis Pekinensis, 14(2), pp. 177-184

Yan, S., 1979
Effects by pressure soil on protected freezing damage for wheat in winter
J. Tibet Agriculture Science and Technique, No. 4, pp. 30-31

Zhou, M., 1987
Crop water requirements in relation to irrigated agriculture and climate change
J. Jiangsu Agricultural College, 8(1), pp. 13-20

2.2.b Books

Institute of Geographical Science, Chinese Academy of Science, 1976
(A, F, I)
Soil mulching and its application for agriculture
Science Publishing House, Beijing, China

Microclimatology and Crop Field Microclimate
Agriculture Publishing House, Beijing, China

Cultivation Techniques with Plastic Film Cover (in Chinese)
Inner Mongolia People Press, China
2.2.c Other literature (chronologically)

Liu, J., 1981
Theory of preventing low temperature transpiration inhibitor and its application
Scientia Agric. Sinica. (China), No. 2: pp. 73-79

Chen, Q., 1982
Environmental effects of plastic film for cotton field covering
Scientia Agric. Sinica. (China), No. 41, pp. 43-50

Tang, L., et al., 1984
The mulching effect of silver reflex film for ground-covering in apple orchard
Scientia Agric. Sinica. (China), No. 5: pp. 25-29

Li, Q., 1988
Production trail of tomato for overwintering using plastic film in sunlight greenhouse
Liaoning Agric. Sci. No. 5: pp. 50-51

Liang, Y., et al., 1988
Study on the film-covered cultivation of sorghum in high elevation of cold zone
Liaoning Agric. Sci. No. 2: pp. 43-44

Liu, B., et al., 1988
Study of microclimate of citrus orchard in shelter belts

Liu, X. and Ge, X., 1988
The effect of soil temperature and nutritive area on the growth and quality of tomato seedling

Wang, R., et al., 1988
Irrigation techniques using plastics soft tube for plastics tent of cover-film cultivation in cucumber
Liaoning Agric. Sci. No. 5: pp. 33-35

Yun, J., 1988
A cultivation technique leading to high yield of the green pepper cultivated in the plastic shed in Hubei area
J. Inner Mongolia College of Agriculture and Animal Husbandry. No. 2: pp. 46-49

Zhang, Z., et al., 1988
Analysis of temperature-light responses on sunlight greenhouse of "anshan" (i.e. "saddle mountain") type
Liaoning Agric. Sci. No. 4: pp. 22-25
He, P., 1989
Studies on effects of light regime on absorption spectrum and fluorescence spectrum of chloroplast and needle of Chinese pine (Pinus tabulaeformis Carr) seedling

Li, YI., et al., 1989
A preliminary study on the effects of different storage methods for keeping chewing cane under ambient temperature
J. Guangxi Agricultural College, 8(2): pp. 82-85

Ni, S., Zhou, Y. and Wei, P., 1989
Studies on the paulownia’s silviculture covered with plastic film on saline soil

Pang, H., 1989
Effect on stubble mulch tillage to soil in rainfed areas
J. Laiyang Agricultural college, 6(3): pp. 17-22

Song, P., et al., 1989
Meteorological effects of sunlight greenhouse without heating and vegetable production in winter in north Liaoning Province
Liaoning Agric. Sci. No. 1: pp. 29-33

Tang, X. and Ling, L., 1989
A preliminary report about the effect of light quality on radish when culturing under the coloured film
J. Talim U. of Agric. Reclamation. No. 1: pp. 36-40

Tang, Y., et al., 1989
Improvement of the illumination of geothermal greenhouse by utilizing aluminum-plated silvery plastic film
Liaoning Agric. Sci. No. 2: pp. 45-47

Wang, S. and Xu, S., 1989
Effect of straw mulch in wheat field and preliminary study of water economization
Agric. Res. in the Arid Areas. No. 2: pp. 7-15

Wang, S., et al., 1989
Studies on unmolding plastic sheet covered cultivation of taro.
J. Liaoning Agric. College. 6(2): pp. 43-47

Wang, S., et al., 1989
The soil energy balance covered with film and the effect of it on soil heat regime
Wang, Z. and Wang, Y., 1989
Preliminary studies on protection benefit and structural
characteristic of agri-silviculture
Shanxi Forest Science and Technology, No. 2, pp. 23-27

Wu, D., et al., 1989
Preliminary report on experiment of plastic film cultivation of corn
at Weining Country of Guizhou
J. Guizhou Agric. Sci. No. 4: pp. 23-30

Yang, B., et al., 1989
A study on the improvement of the qualities of apples and grapes
covered with silver plastic film
Agric. Meteorol. (China), 10(1): pp. 29-32

You, X., 1989
Forest protection and farmland development in ancient China
Acta Agriculturae Universitatis Zhejiangensis, 15(3): pp. 223-228

Zhang, J., et al., 1989
Effect of yield increased by pressing-down wheat at seedling stage
J. Guizhou Agric. Sci. No. 4: pp. 43-48

Zhang, Z., et al., 1989
Influence of ground coat cover on the growth and development of potato
J. Laiyang Agricultural College, 6(4): pp. 17-22

Zhou, G., et al., 1989
Study on the meteorological effects of slopping field shelter-belts

Dai, Yi., 1990
Effect of straw mulching upon orchards in hilly sloping lands
Agricultural Research in the Arid Areas, No. 1, pp. 41-48

Liang, Y., et al., 1990
A study of the mechanism of maize cultivated with plastic film cover
for water storage moisture preservation
Agricultural Research in the Arid Areas, No. 1, pp. 27-32

Pu, J. and Huang, Z., 1990
Experiment of optimum irrigation norm for spring wheat crop in the
Arid Gansu Province
Agricultural Research in the Arid Areas, No. 1, pp. 49-58

Tang, T. and Mo, F., 1990
Preliminary report on irrigation experiment of maize
J. Guizhou Agricultural Science, No. 2, pp. 10-12
Zhang, D. and Lou, C., 1990
Studties of three principal training systems of grapevine on canopy
microclimate and water relations in Beijing Area
Scientia Agricultura Sinica (China), 23(2), pp. 73-82

Zhu, L., et al., 1990
Experiments of irrigation on plastic sheet used to cover
border-planting and furrow-planting cotton
Xinjiang Agricultural Sciences, No. 2, pp. 62-63
2.3 Periodicals and (annotated) Bibliographies containing information on aspects of the fields of study (C.J. Stigter and G.C. Wilken)

ILEIA-Newsletter (for low external input and sustainable agriculture), published by the Information Centre for Low-External-Input and Sustainable Agriculture.

The word sustainable is a relatively new addition to the name of this extremely informative newsletter, the best in our field of interest. It is published since 1985 in four issues annually and its sixth volume has started to appear. It gives practical articles on methods of sustainable agriculture and strategies on how to introduce these methods in agricultural development, agroecosystems, indigenous knowledge, new publications, networking, thematic issues. In 1987 the third issue was on "Microclimate Management" and three contributions came from the TITI-project (see section 3.5). The first issue in 1990 was on "Local knowledge endures and grows". Interesting recurrent sections are: TOP 5, in which a scientist well known in one of the fields of low external input agriculture gives the 5 publications he values most in his current work, "NEW IN PRINT", "SOURCES", in which suggested important books and publications are shortly annotated, "NETWORKING", in which associations and organizations in this field are presented with their activities and addresses, "WANTED", where questions may be asked, and ILEIA NEWS. Of course this journal has exactly the awareness function necessary to find some paths in the streams of literature. Traditional farmers are the focus and those interested to follow the growing appreciation of the merger between indigenous knowledge and modern science, in the context of participatory research for solving rural development problems, should follow this Newsletter closely.

Address: ILEIA, P.O. Box 64, NL-3830 AB Leusden, The Netherlands.

Towards Sustainable Agriculture, Part One: Abstracts, Periodicals, Organizations.

Again a publication that at the same time saves and gives a lot of work. In the first part 45 books on sustainable agriculture are abstracted with some overlap with material used by the former Working Group in CAGM 25. In a matrix it is also made immediately visible which most important subjects of a list of 33 are covered in these books. For our work the eight entries "environment" (1), "agro-ecosystem approach" (2), "low external input agriculture" (3), "indigenous knowledge" (4), "agroforestry" (5), "pest
management” (6), “soil conservation” (7) and “water management” (8) are most important. With the same entries, 31 periodicals have been listed. With the above numbering applied, the following are of importance for our work:

ABSTRECO (3), English
(Abstract Bulletin on Sustainable Agriculture)
Gives abstracts of documents available at the Agricultural University of Wageningen, the Netherlands, on sustainable agriculture in temperate as well as tropical countries.
Address: Haarweg 333, NL-6709 RZ Wageningen, The Netherlands

AGROFORESTRY SYSTEMS (4.5), English
An international journal in cooperation with ICRAF
An international, multidisciplinary journal publishing research on the various aspects of agroforestry.
Address: Martinus Nijhoff Publishers, P.O. Box 163, NL-3300 AA Dordrecht, the Netherlands.

ALTERNATIVES AGRICOLES (3), French
Issued by GEYSER, Groupe d’Etudes et de Services pour l’Economie des Resources
Abstracts of documents and information on alternative agriculture for temperate and tropical regions.
Address: Vacquieres, 34270 St. Mathieu de Treviers, France.

APPROPRIATE TECHNOLOGY (3), English
Intermediate Technology Publications Ltd.
Appropriate technology in agriculture, small industries, housing, health, etc. Ritchly illustrated.
Address: 103/105 Southampton Row, London WC1B 4HH, UK

AT-SOURCE (3), English and French Editions
A quarterly for technology and development
Practical information on agriculture, technical and health related topics, including their social implications in Third World situations.

Address: P.O. Box 41, 6700 AA Wageningen, The Netherlands.

BOS NiEuWsLETTER (4, 5), English Foundation for Dutch Forestry Development Cooperation

Information on tropical forestry and agroforestry, practical experiences, short descriptions of projects, new publications etc.

Address: P.O.Box 23, 6700 AA Wageningen, The Netherlands.

CATER INFORMATIVO (3, 4), Spanish Centro Andino de Tecnologia Rural de la Universidad Nacional de Loja

Presentation of practical and scientific research of the Centre on Andean Agriculture.

Address: CATER Unidad de Comunicacion, Casilla 399, Loja, Ecuador.

COMMUNAUTES AFRICAINES (3), French Communautés Africaines

Practical articles on technology, food processing, agriculture, health and education for villagers, illustrated with practical drawings.

Address: B.P. 5946, Douala-Akwa, Cameroun.

CONSTRUIRE ENSEMBLE (3. 5), French Le Bulletin du Centre d'Etudes Economiques and Sociales d'Afrique Occidentale (CEGAO)

Articles directed on integral development in self-responsibility, education, participation, agriculture, forestry, technology, management for self-help groups.

Address: B.P. 30, Bobo-Dioulasso, Burkina Faso
ECHO DEVELOPMENT NOTES (3), English
ECHO Inc.

Very practical applied information for people working with small farmers in Third World countries.

Address: 17430 Durrance Road, North Fort Myers, FL 33917 USA.

ECOFORUM (1, 3, 4, 6), English, French, Spanish Editions.
Environmental Liaison Centre (ELC)

ECOFORUM functions as networking instrument for NGO's around the world to share information and strategies relating to environment and sustainable development issues.

Address: P.O. Box 72461, Nairobi, Kenya.

ENTWICKLUNG UND LANDLICHER RAUM (3) German, English
Beitrage zur Internationalen Zusammenarbeit

Articles on rural development and agriculture in Third World countries, research, projects, thematic issues.

Address: DLG-Verlag, Ruesterstrasse 13, D-6000 Frankfurt am Main, F.R. Germany.

FARMING FOR DEVELOPMENT (3), English and French.
International Federation for Agricultural Producers (IFAP)
Bulletin serving farmer's organizations

Articles on News of IFAP, Farmer's Organizations, International Research and Development, Co-operatives, Projects, Training and Extension, Practical Farming, Commodities, Women in Agriculture, International or Regional Information Centres on Appropriate Technologies and Agriculture for Small Farms in Third World Countries.

Address: IFAP, 21 Rue Chaptal, 75009 Paris, France

GATE (3), English
questions, answers, information. German Appropriate Technology Exchange
Articles on appropriate technology and agriculture in Third World countries, research, new developments, projects, publications.

Address: GATE, P.O. Box 5180, Dag-Hammarskjold-Weg 1, D-6236 Eschborn, F.R. Germany.

IIED Perspectives (1), English
The Bulletin of the International Institute for Environment and Development-Earthscan

A bulletin on environment and development, policy, information, activities, organizations.

Address: 3 Endseleigh Street, London WC1H ODD, UK

International Agricultural Development (3), English

Forum for debate on agricultural issues in the developing world.
Channel through which people can talk to each other.

Address: John Madeley, 19, Woodford Close, Caversham, Reading, Berks., RG4 7HN, UK

IRED Forum (3), English, French, Spanish
IRED-Development Innovations and Networks

Information on what different groups and networks are doing, references to interesting technologies, tools, methods and documents for action.

Address: 3, rue de Varemb, Case 116, 1211 Geneve 20, Switzerland. May also be obtained from IRED regional offices.

MINKA (3, 4), Spanish

a favor de una autentica ciencia campesina.

Practical articles on rural development, traditional and improved agriculture, technology and health and on cultural integration in the Andes, very well illustrated.

Address: Grupo Talpuy, Apartado 222, Avenida Centenario 589, San Carlos, Huancayo, Peru.
PANOSCOPE (1), English  
The PANOS Institute  

Articles on environment and sustainable development in Third World countries, opinions, policy, regional news, NGO news, publications.  

Address: 8 Alfred Place, London WC1E 7EB, UK.  

Permaculture Nambour Newsletter (3), English  
Permaculture Nambour Inc.  

Practical articles on permaculture, sustainable agriculture for subtropical regions.  

Address: P.O. Box 650, Nambour, QLD 4560, Australia.  

RESEAUX (3), French  
technologie et developpement, bulletin du GRET.  

Short reports and a lot of information on new and old technologies, books and organizations concerning appropriate technology, agriculture, health, construction, etc.  

Address: Groupe de Recherche et d'Echanges Technologiques, Reseaux, Technologie et Developpement, 213 rue La Fayette, 75010 Paris, France.  

SPORE (3, 4), English, French  
Technical Center for Agricultural and Rural Cooperation  

International bulletin for the dissemination of scientific and technical information on agriculture and rural development to ACP countries, policy, opinion, research, new developments, publications, activities.  

Address: CTA, P.O. Box 380, 6700 AJ Wageningen, The Netherlands.  

Sustainable Agriculture Newsletter (3), English  
International Development Research Centre  

Thematic issues on technical aspects of sustainable agriculture in the South-East and East Asia region.
Address: IDRC, Regional Office for South-East and East Asia,
Tanglin P.O. Box 101, Singapore 9124, Republic of
Singapore.

The Small Farm Newsletter (3), English
The Small Farm Newsletter Network

Exchange of practical experiences with sustainable agriculture
for small farms in Thailand.

Address: CUSO, 17 Phaholyothin-Golf Village, Phaholyothin Road,
Bangkhen, Bangkok 10900, Thailand.

TRANET (3), English
Transnational Network for Appropriate/Alternative Technologies

Short informative notes on developments in appropriate
technologies and agriculture.

Address: TRANET, Box 567, Rangeley, ME 04970, USA

The same first part of AGRECOL/ILEIA, 1988 gives a description,
with addresses, of 34 Information Centres and 5 International
Networks in the same fields as indicated above.

AGRECOL/ILEIA, 1988. Towards Sustainable Agriculture, Part Two:
Bibliography.

A list of 254 books dealing with aspects of sustainable
agriculture.

Research in Agroforestry. Volumes 1 and 2.

Transformation of the ICRAF Newsletter into an Agroforestry
Magazine.

Address: ICRAF, P.O. Box 30677, Nairobi, Kenya.

A newsletter that shows once more that taking indigenous knowledge serious has become a scientific discipline of its own and its news justifies its existence. A must for all interested in traditional knowledge and its merging with modern science, social, economic and technical aspects alike.

Address: 318B Curtiss Hall, Iowa State University, Ames, Iowa 50011.


Supplies information on current episodes of drought and its impacts; timely reports of response, mitigation, and planning actions of governments and international organizations (successes and failures); recent research results and new technologies that may advance the science of drought planning and management; recent publications; conference reports and news of forthcoming meetings; and editorials. A lot on the Third World.

Address: Center for Agricultural Meteorology and Climatology, 236 L.W. Chase Hall, University of Nebraska-Lincoln, Lincoln, NE 68583-0728, USA.

Natural Resources Institute Bulletin


Address: NRI, Central Avenue, Chatham Maritime, Kent ME4 4TB, England.

The Network is concerned with the generation and dissemination of new technology, particularly for the more difficult farming areas. Its focus is on organization and management issues in technology development and on the links between research, extension and farmers themselves. Within this area, it provides a forum for exchange of ideas and experiences among practitioners in developing countries, and between North and South.

Address: AA Research and Extension Network, Overseas Development Institute, Regent’s College, Regent’s Park, Inner Circle, London NW1 4NS, England.

Worldwatch Papers (nearly 100 papers appeared so far) and State of the World (annually 1984 - ).

The Worldwatch Institute is an independent, nonprofit research organization, created to analyze and to focus attention on global problems, funded by private foundations and UN Organizations. Worldwatch papers are written for a worldwide audience of decision makers, scholars, and the general public. State of the World is an annual report on progress toward sustainable society.

Address: Worldwatch Institute, 1776 Massachusetts Avenue, N.W., Washington, D.C. 20036 USA.

Finally for this section, a list of additional scientific journals and series has been composed in which we found more than occasionally papers on our subjects:

Abstracts on Sustainable Agriculture, Vol. 1 (1988) -
[J. Cals compiler, GTZ, Eschborn]
(Continuation of Abstracts on Intercropping, see above)

(Continuation of Tropical Abstracts, Vol. 1 (1946) - Vol. 29 (1974))

Advances in Agronomy, Vol 1 (1949) -
[Academic Press, New York etc.]


Agricultural (and Forest) Meteorology, Vol. 1 (1964) - [Elsevier, Amsterdam]
(Addition of (and Forest) since 1985)


Agronomy Journal, Vol. 1 (1907) - [American Society of Agronomy, Madison]

Annual Reports
[Under this heading we want to mention for our subjects those of CIP, ICRAF, ICRISAT, IITA, ILCA and ISNAR]
(See also "Publications of the International Agricultural Research and Development Centers", of which the first part was issued by IRRI in 1985. See also Appendix IV)

Biological Agriculture and Horticulture, Vol 1 (1983) - [AB Academic Publishers, Berkhamsted]

Experimental Agriculture, Vol 1 (1965) - [Cambridge University Press, New York]

FAO Papers and FAO Reports
[Many Paper and Report Series; Information to be obtained from the Publication Division, FAO, Via delle Terme de Caracalla, 00100 Rome, Italy]

Field Crop Abstracts, Vol. 1 (1948) - [Commonwealth Agricultural Bureaux, Farnham Royal]

Field Crops Research, Vol 1 (1978) - [Elsevier, Amsterdam]
Forestry Abstracts, Vol 1 (1939) -
[Commonwealth Agricultural Bureaux, Farnham Royal]

Fruits, Vol 1 (1946) -
[IRFA, Paris]

The Geographical Review, Vol 1 (1910) -
[The American Geographical Society of New York, New York]

Journal of Agricultural Science, Vol 1 (1905) -
[Cambridge University Press, New York]

Journal of Arid Environments, Vol 1 (1978) -
[Academic Press (London), London]

Journal of Applied Ecology, Vol 1 (1964) -
[Blackwell Scientific, Oxford]

Quarterly Journal of International Agriculture, Vol 1 (1961) -
[DLG Verlag, Frankfurt (Main)]

Science, Vol 1 (1926) -
[American Association for the Advancement of Science, Washington]

Tropical Agriculture, Vol 1 (1924) -
[Butterworth, Guildford]

WMO, Technical Notes Series, Technical Publications Series and CAgM-Reports Series
[Information from WMO, P.O. Box 2300, CH-1211 Geneva 2]
2.4 Case studies from tear out sheets (C.J. Stigter)

Two examples have been received. However, one was on the manipulation of solar radiation for microclimate changes inside a greenhouse with different covers, in order to create appropriate environmental conditions for the development and study of coffee diseases. This example from El Salvador, contributed by the Meteorological and Hydrological Service, in collaboration with the Salvadorian Coffee Research Institute, does not have any traditional aspects left.

The second sending came from Youn-chang Park, Director of the International Cooperation Division, Korea Meteorological Service, in Seoul. It contains one case study and two examples of references. The case study is on the Effect of Ridging System and Planting Depth on Growth, Yield and Labour-Saving in PE film Mulched Crop of Potato. Authors are Kim, Sung-yeul; Ryu, Dun-ha and Hahn, Byung-hee of the Rural Development Administration at 209 Seudon-dong, Suwon-shi, Kyonggi-do, Korea. The following abstract of the work was given:

"To investigate the effects of ridging system and planting depth on the growth, yield and labour-saving in spring crop potato under PE film mulching, two ridging methods and two planting depths were tested. Shallow planting (5 - 7 cm) accelerated the emergence by one week compared to deeper planting (12 - 15 cm). In the two-rows-planting plot, emergence was three days earlier than one-row-planting. Plant growth showed similar tendency till the emergence of sprouts. One-row-planting showed greater changes of diurnal soil temperature and lower minimum soil temperature than that of two-rows-planting. Yield performance in response to ridging systems and planting depths was not significantly different, while the greened tubers were increased with 10-14% at the shallow planting. The labour saving was greatest at the deep planting with two-rows due to the unnessesity of hilling."

This is an example where new, medium input technology is tried out to save on now scarce labour but taking microclimatic conditions of the traditional as well as of the developed system into account.

The two references sent were:


3. SELECTIVELY ANNOTATED BIBLIOGRAPHIES

3.1 Introduction

In the former Working Group report (Stigter, 1988) in Appendix VIc a hundred references were collected by the present author for "A selectively annotated bibliography on aspects of traditional techniques of microclimate management and manipulation or on a micrometeorological basis for understanding such techniques". The 79 non-Russian items in that bibliography have been elaborately annotated, selectively on the aspects of microclimate management, manipulation and modification, for the present report and are given below in 3.2.

Additions to this annotated bibliography, including also the period after 1985, have been contributed by three of the joint rapporteurs. They contain 44, 6 and 53 items respectively. More details on these publications may be obtained from the authors, where necessary. The only sparsely annotated bibliography by Prof. Wilken is partly an addition to the original one of the former Working Group and partly an extension beyond 1985. [See also my remarks on the widened scope of the word "traditional" in Chapter 1.] The items by Dr. Karing were sent with his contribution to chapter 4. The second annotated bibliography by the coordinator covers the period beyond 1985 through the work of his project "Traditional Techniques of Microclimate Improvement (TTMI)", core funded by the Netherlands Government (DGIS/DPO/OT). The items I collected on work performed by others are covered in the literature lists of these project publications and many details of that work are covered by their contents. It is believed to be a valuable method of reporting on progress in our fields of interest, as the TTMI-project so far remained to our best knowledge the only project of its kind (confirmed by Wilken, 1987) and therefore the only project covering many aspects of the subject of this rapporteurship, as also demonstrated by its contribution to Chapter 4.

Literature


3.2 ASPECTS OF TRADITIONAL TECHNIQUES OF MICROCLIMATE MANAGEMENT AND MANIPULATION

OR

A MICROMETEOROLOGICAL BASIS FOR UNDERSTANDING SUCH TECHNIQUES

A SELECTIVELY ANNOTATED BIBLIOGRAPHY (1960 - 1985)

Compiled by C.J. Stigter

Based on Appendix VI c of CAgM Report No. 25 (WMO/TD-No. 228) "Microclimate Management and Manipulation in Traditional Farming" WMO, Geneva, 1988 by C.J. Stigter
One of the earliest studies of African agriculture with ears and eyes for the African subsistence and semi-subsistence farmer and their traditional knowledge and for concepts of sustainable agriculture and location-specific research on environment specific adapted production techniques. It states that the story of the many and continuing attempts to improve and develop African land use is by no means one of unrelieved failure but rather of partial and limited success which is disappointing in relation to the effort, the early hopes and expectations, and the magnitude of the problems. Concepts like "carrying capacity" and "normal surplus" owe much to this author, who also demonstrated the tribe (so location) specificness of much (especially more recent) traditional African knowledge and the need of studying carefully not only the land itself but the (changing) agricultural practices of its inhabitants. For our purposes the first half of the book, especially chapters 5 till 15 inclusive are most important. Traditional practices with microclimatic consequences that are dealt with are: making high (over 75 cm) mounds of different kind, composition and shape (for reasons of fertility maintenance, moisture conservation and temperature manipulation) for planting crops; the use of surface mulching for several reasons; hedge enclosure (among other things for wind protection); erosion protection on steep slopes by terraces, ridging, ground cover (including interplanting techniques) and mulching (including cut and transported grass) and by such famous but laborious systems as that of the "banks and pits" of the Matengo (Tanzania); agroforestry for all kinds of reasons, including the use of trees in the Wakara (Tanzania) and Hill pagans (Cameroon) systems and bush trees in the Makonde (Tanzania) thickets and use of the tropical rain forest (margins), such as in shading cocoa. The whole book is full of examples where African farmers "have not merely adapted their system to the environment" but "have adapted the environment to meet their needs."

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Radiation and microclimate relationships in multiple cropping systems. In: R.I. Papendick et al. (Eds.), Multiple cropping. Madison: American Society of Agronomists.

Although the title promises emphasis on multiple cropping, most of this paper deals with reviewing basic radiation processes in monocultural systems because "Understanding crop ecology of monocultures has not been rapid; understanding the crop ecology of polycultures has begun but the permutations and combinations
are numerous (...). General attention is given to radiation sources and source distributions, to radiation quantity, photosynthesis and the energy balance in crops and to radiation quality and fluctuations in crops. This information is then applied to aspects of photosynthesis and yield in sequential cropping systems and intercropping systems. It is shown that although sequential crops will yield more per year than a single annual short-term crop, there will be a significant loss of yield potential during the period between the harvest of one crop and the establishment of ground cover by a sequential crop. This makes yield potential for continuous one-year crops larger than for sequential ones in the same period and methods have to be sought to utilize more efficiently the radiant energy available in sequential cropping systems, for example by more overlapping forms of (so called relay) cropping, which lay inbetween sequential cropping and full intercropping. In intercropped systems shading will influence the quantity and the quality of radiation reaching shorter plants, affecting such phenomena as morphogenesis and (obviously) photosynthesis. Therefore shade tolerance to both shifts in radiation spectral quality and radiation quantity should be considered in choices of crops for intercropped systems. There are 61 references.


Alternative agriculture is defined here as "any approach to farming that attempts to provide sustained yields through the use of ecologically sound management technologies". This tends to refocus the emphasis in agricultural research away from disciplinary and commodity concerns and towards complex interactions among and between people, crops, soil, livestock, etc. It appears that where tropical small farmers have been confined to farming low quality, marginal soils with little capital or institutional support, their systems provide valuable information for the development of yield-sustaining systems. Many of these are polyculture or other multiple cropping systems. As techniques that influence the microclimate, the following traditional examples may be found scattered throughout the book: alley cropping and other agroforestry; different kinds of mulches on and near the original interface, including stubble mulches and live mulches; different kinds of efficient light use through shading in two- or multi-storey canopy structures with or without trees; mounding in different forms; various kinds of soil erosion prevention methods, including minimum- and non-tillage, strip cropping and cover crops; the use of windbreaks and shelterbelts and their multiple functions. A lot of attention is paid to changing conditions for proliferation of pests, including weeds,
and diseases with forms of biological control, where microclimate conditions play an important role. There are 16 pages of references.


Of the eleven chapters, two are particularly relevant to our subject: the one on alleviating plant water stress and even more so the one on alleviating temperature stress. Plant water stress is alleviated by decreasing the evaporative demand, increasing the wetting of soil by rainfall or irrigation, and increasing the storage and availability of soil water to plants. Root zone modification is therefore beneficial if it increases water storage and root development in the profile or alleviates such problem conditions as poor drainage or high salinity. Profile modification should aim at changing soil water storage, primarily through changing water infiltration and the hydraulic conductivity—thus improving on conditions that limit water movement—and through changing water holding capacity. It also should aim at improving penetration and proliferation of plant roots. Unless a recognizable problem exists that profile modification can correct, there is little chance that it will be worthwhile on a large scale and with high intensity of treatment. [This last statement is typical for a capital intensive, high technology, low labour input agriculture and does not apply to our kinds of work. CJS.] Thermal aspects of soil can be modified by changing reflection, thermal properties, surface heat losses and shape, slope and orientation of the soil surface. Very often more than one of these factors are involved simultaneously in soil temperature management, manipulation and modification. High small scale heterogeneity is characteristic for soil properties near the surface. Under soil temperature modification this chapter deals particularly with: mulching, especially with plant residues on the surface; tillage, from the point of view of changing surface roughness and soil properties and water relations in the tilled layer, of using beds and ridges and changing compaction; irrigation and drainage; crop canopy effects. Simulations are available to project soil temperature effects of these treatments, but too few data sets are available for a comprehensive evaluation of such projections. The two chapters dealt with have 91 and 209 references respectively.
BALDY, C., 1963

One of the earliest attempts to classify mixed or intercroppings and to review climatic, soil and biotic factors that have beneficial or harmful effects on their yields, with emphasis on improved water use efficiency and related photosynthetic efficiency, illustrated with many case studies. Homogeneous (relatively small height differences and identical cropping periods), heterogeneous (large height and cropping period differences, with a dominant and a dominated crop, like in most agroforestry) and two- or multi-storey intercrops in cases are distinguished. Before water use efficiency of such intercrops are dealt with, the solar/thermal complex is highlighted, with emphasis on heterogeneous and oasis conditions: effects of quantity and spectral quality change of radiation with depth into the dominant canopies and temperature effects. Also different soil aspects: structure and fertility, soil conservation and erosion prevention, are discussed from the intercropping point of view, as well as specific interactions of the intercrop components: microclimate, roots and related chemical and biological (competition!) interactions. In the section on water and intercrops the following main aspects are discussed in detail: availability of soil water; soil volume exploited by roots and desiccation rate; evapotranspiration; (complementary) irrigation. In a synthesis positive and negative aspects of intercropping are finally reviewed and microclimatic aspects are particularly found at the positive side. In this early synthetic review, made more than 25 years ago, more systematic studies are demanded. [And it is only very recently that some of these have indeed been initiated. CJS.]

BALDY, C., 1985
Contribution à l'étude des applications de la bioclimato-météorologie végétale à l'agrométéorologie des zones arides et semi-arides en climats méditerranéen et tropical. These de Docteur es-Sciences. Aix-Marseille: Université de Droit, d'Economie et des Sciences d'Aix-Marseille.

Thirty years of research activities of the author in bioclimatology and agrometeorology in Mediterranean and Soudan-Sahelian arid and semi-arid areas are reviewed here. In the first half of this work most attention is given to water relations of different crops in different countries, including rare work on North African oases. For our purpose the third part of this thesis is most important, starting to make the step from bioclimatology towards agrometeorology and resuming with more recent literature a synthesis on intercroppings the author
started 25 years ago, especially from the point of view of competition, positively as well as negatively. Cover crops get a very important place. Competition for water and root space and their consequences for evapotranspiration of intercrops gets also a lot of attention again. Influence of trees (in deforestation and afforestation, in irregular belts, in small clusters or scattered) on air movement may be added to the list of subjects one doesn’t read much about elsewhere and well treated here. Also the quality change of light within a dominant crop is emphasized and quantified with case studies. It is concluded that more detailed knowledge is needed on critical periods of water needs of crops and intercrops to use (irrigation) water more efficiently in (semi-) arid areas. In the conclusion of his synthesis the author indicates that his main aim in all of his research has always been to reduce production risks for the farmers concerned.

Modification of the aerial environment of plants.

Although the introduction of this unique monograph acknowledges that the ability to modify the environment of the biosphere has been developed over centuries, there is nowhere actual acknowledgement of traditional farming in this respect. Food crops in the tropics are anyway not getting much attention in this book, but its value must be sought in a review of modification techniques in high external input commercial agriculture and in a contribution to the understanding of processes involved when we want to modify the aerial environment. The latter fundamental task takes more than half of the book in the first three sections. As section 4 deals largely with high technology environmental modification for cold and frost protection and section 7 on future trends ignores low external input potentials even completely, with the exception of the very last chapter, the most important sections for our purposes are those on environmental modification for alleviating heat and moisture stress (5) and on environmental modification for controlling phenological development (6), together seven chapters in less than 100 pages. Of albedo increase, reduction of advected heat and increasing latent energy transfer as methods to diminish heat stress, the last one is in the first chapter called most promising, but strange enough shading is not mentioned. This is made good in a chapter on miscellaneous techniques for alleviating heat and moisture stress, where shading is well treated next to site selection and again albedo modification (including row crops). Special chapters discuss in detail
sprinkling for heat stress reduction and windbreaks for reducing moisture stress. In a chapter on physical principles involved in controlling phenological development, temperature responses (from chill units to heat units) and light responses are discussed. A special chapter deals with sprinklers for micro-climate cooling of bud development and the last chapter (miscellaneous techniques) serves us best by dealing with the effects of windbreaks, shading, spacing, sprinkling, painting and mulching (together with antitranspirants, growth regulators and CO2 enrichment) on phenological development. On the last page of this monograph it is concluded that improved methods of control of temperature are needed and that procedures for energy efficient field control of environmental parameters other than temperature need to receive more attention.

BEETS, W.C., 1982 [A, G, L, O, R]
Multiple cropping and tropical farming systems.

One of the earliest reviews of relevant research and development strategies for integrated multiple cropping systems throughout the tropical world. It treats aspects of the history (tradition!), agronomy, crop husbandry, management, economics, social conditions and planning and design of those multiple cropping systems which are presently practised or feasible. Introductions on the productivity, constraints and rationale of multiple cropping systems are followed among others by discussions on agro-technical characteristics, on plant interrelationships and competition, on agro-ecological, biological and plant physical aspects and on selection and design of multiple cropping systems. Microclimatic aspects are first discussed in the description of the different systems, especially in multi-storey cropping and systems with annual windbreaks. It comes back in positive aspects of competition and in competition for light and gets its own section in chapter 7 on agroecology, biology and physics of multiple cropping systems, with emphasis on availability of (again) light and moisture. Shade and shelter, including mulching, are dealt with. Already in the introduction, under agronomic or crop husbandry techniques that require little capital investments, using already available crop species, changing the microclimate is explicitly mentioned as a way to augment significantly the yield of individual crops and the total output of a given land area. In the last chapter a frame work for cropping systems research is given. It considers as a first step in the design of new systems the quantitative assessment of the physical and biological environment of the region. Concurrently the farmer’s present environment (in the widest sense) should be understood by an interdisciplinary approach through detailed quantification. Subsequently it considers further design aspects,
on-station trials, on-farm validation and use, and the support conditions needed in such exercises. Finally it reviews the (limited) research on multiple cropping systems in Taiwan, the Philippines, India, Africa and Tropical America. Under technical research needed in the future the book mentions measurement of differences in the microclimate induced by certain actions of components of crop associations and learning how to manipulate these to best advantage.


The value of this book is in first instance in the thorough introduction it gives to the thinking on large (global) scale energy and mass balances at the earth surface, and their long term changes, in the Soviet Union and the reconciliation with identical work in the Western world. For our purpose two chapters are of main interest, the one on the thermal regime of living organisms and the (last) one on man and climate. In the first it is argued that poikilothermal as well as (especially small) homiothermal animals use microclimatic features of the landscape to optimize their body temperature. Data are shown to explain the effect of microclimate on vegetation cover under conditions of rugged relief. In general the text applies basic exchange equations to approach and approximate surface temperatures of animals and man and within vegetation. In the last chapter one reads first an (early) warning on the impact of man’s activities such as destruction of (wooden) vegetation on local climate. Climate modification activities dealt with at length quantitatively are management of water in irrigation, in drainage and with storage reservoirs and management of vegetation cover. In the latter case especially the effects of forest belts on micro- and mesoclimate are extensively reviewed. Atmospheric pollution and anthropogenetic climatic change are only shortly mentioned (under "undirected changes") but one should realize that this book is already 20 years old. It already announces climatic change due to human activities in the next century as "inevitable". It might only be a bit too optimistic in its belief in the potential for large scale climatic management by man.
DARNHOFER, T., 1983
Micromalnic effects and design considerations of shelterbelts. In: D.A. Hoekstra and F.M. Kuguru (Eds.), Agroforestry systems for small-scale farmers. Nairobi: ICRAF.

This paper considers shelterbelts as a feature of an agroforestry land-use system. It reviews shortly micromalnic effects of shelterbelts with respect to their aerodynamics, shading and modifications of temperature, precipitation (from rainfall to dew) and evaporation, as well as shelterbelt effects on yields and (wind and water) erosion. Subsequently it deals with shelterbelt patterns (arrays of rows and networks) and with shelterbelt design, from which it is concluded that there is no substitute for a thorough site-specific design effort at each individual site. In the latter case physical features as climate, topography, soils and hydrology have to be considered as well as ecological features of human settlements, livestock and agricultural crops to be protected. In planting of shelterbelts decisions have to be made on pattern, tree species and spacing of trees. Main factors that influence such decisions are reviewed and management aspects involved are mentioned. It is concluded that agroforestry principles and methodology should be applied to any problems concerning artificial protection against wind and that accordingly the request for a shelterbelt design should only be the result of a problem-oriented diagnostic approach to the specific land use system. This asks for a multidisciplinary approach from preliminary diagnosis to the evaluation of an implemented system of one or more shelterbelts.

DAVIES, J.W., 1975
Mulching effects on plant climate and yield. WMO No. 388 (Technical Note No. 136) Geneva: WMO.

A classic in the science of mulching, in the form of an annotated review of the main literature that appeared on the subject in the fifties and the sixties. Next to a "review of reviews" there are reviews on the effects of mulching on temperature, soil moisture, erosion and soil physics, pests and diseases, growth and yield of plants and weed suppression. In the reviews there are six subdivisions by crop: no specific crop; temperate tree fruits; temperate horticulture, soft fruit, vegetables and flowers; forestry; grasses and cereals; tropical and subtropical crops. Within each of these organic, non-organic and mixed mulch comparisons are distinguished where feasible. A starting point for every scientist interested in mulching as management technique and manipulation practice. It shows the need for a comparable bibliography of the literature of the seventies and the eighties, especially because of the increasing interest in
mulching in tropical low external input agriculture. Each subdivision has its own references, which may overlap.


Attempts to exercise some additional influence over the soil climate of a given site are perhaps as old as agriculture itself. Mulching is perhaps our most effective means of attempting such control. After such initial statements, this short paper deals with stubble mulching, colour of the surface, straw mulches, sawdust mulches, plastic mulches, black films, coloured films, water filled bags, foam or emulsion mulches, frost penetration and protection, air temperatures above a mulch, seasonal effects and direct comparisons between organic and non-organic mulches. From his review the author has to conclude that, although that is not per se necessary to show yield increases, no direct relationship has emerged between temperature changes and the type, depth or colour of the mulch used. [This is certainly mainly due to the non-physical approach of most work CJS.] There is finally the caution that few writers have made an economical appraisal of mulching and that the costs of materials, labour and maintenance are not always justified.

EDDY, A., 1983 [A, I, D, R]

Examples of the beneficial uses of climatic data and information, directed at stimulating interest in the better operational use of climatic data which would result in short-term economic payoff. It is among other things stated that man, through his own cultural practices, can effect climatic variability to a significant extent. The use of shade and wind protection or air movement enhancement are discussed with respect to animal production. An example of fitting millet crops to the seasonal availability of water is shown. "Eco-farming" is dealt with, especially as an anti-erosion measure.
EIMERN, J. VAN, ET AL., 1964

Windbreaks and shelterbelts. WMO No. 147 TP 70 (Technical Note No. 59). Geneva: WMO.

Another WMO classic, still used by everyone interested in the science of wind protection. It deals with the effects of shelterbelts and windbreaks on aerial microclimate, soil climate, soil erosion, plants and animals. Reduced surface wind speed is their main effect, mainly independent of wind speed itself and proportional to belt height in dependence of belt permeability, which in turn is determined by belt geometry and composition. Very frequently a rectangular network of shelterbelts gives the best wind reduction because of variation in wind direction. Smaller effects on other environmental parameters, mostly of importance near critical values of the parameter concerned, are treated. Considerable (of course wind determined) influence is noticed near shelterbelts on precipitation distribution, including snow, and evapotranspiration. The latter is considered as being frequently the main purpose of shelterbelts in cases where physical damage has not to be alleviated. Better water supply, together with positive temperature effects, are considered to be the main reasons for increase in quantity and quality of yields behind belts, with the best results in temperate areas being obtained with the more horticultural types of crops. Other topics dealt with are: shelterbelt design, planting, care and maintenance of shelterbelts, wind flow through gaps and at ends, problems in hilly areas, the influence of forests on winds, the complex problem of soil erosion control and protection for farm animals, farm buildings and pastures. All these and many more smaller subjects are illustrated with case studies from one of the most comprehensive literature studies that exist on the subject. In 20 pages more than a thousand references are given and this makes the study the absolute starting point of any work on wind modification by breaks and belts.

FOURNIER D’ALBE, E.M., 1958


With only ten exceptions, among which one from 1751 on dew, the 139 references of this paper are from the interesting first decade after the second world war. Although Geiger’s book on the climate near the ground (see below) had appeared, this was certainly the first publication that put so much emphasis on the natural influences (vegetation, plants, animals and the microclimate) to understand artificial (management, manipulation) influences on microclimate, with an emphasis on water as this was
indicated to be the single most important factor in the arid zones for which the review was meant to be. Weather modification through cloud seeding, from which field of work the author came, was included in microclimate modification as influencing part of the water balance near the earth surface. But all other factors near the surface are discussed as well, with physical explanations as far as our knowledge had come at the time. The paper ends with stating that the full potentialities of techniques as shading and wind breaks/shelterbelts remain to be explored and that the challenge remains to the experimental climatologist of how to control the elements of the microclimate in arid zones, given the abundance of sunlight available.

FUCHS, M., 1972

Almost two decades back it is observed in this paper that in contrast with the great efforts invested in the physical and chemical improvement of soil environments, it seems that insufficient attention has been devoted to the controlled transformation of the radiation climate. Most of the techniques used are based on traditional (empirical) knowledge rather than on physical theory. The paper then starts to discuss the limitations of the simple extinction coefficient approach in radiation interaction with crops and some recent attempts to improve this theory. It then reviews the early attempts of using the modification of reflectivity and transmissivity of leaves and the reflection of the soil to control the radiation climate. The largest part of the paper is then used to develop a macroscopic mathematical theory to understand the consequences and results of such modifications while avoiding the limitations of the extinction coefficient theory and neglecting the detailed pattern of solar radiation absorption in the canopy profile. From the results of this mathematical approach the most important conclusion is that increase of soil reflection can reduce total radiation absorption but at the same time increase the absorption of solar radiation by the (lower) canopy. The relative effects are expected to be highest on light colored soils and at high solar elevations.

This paper tries to apply theory of transport processes to what happens in the environment of arid-land vegetation. Very few studies of the transport processes in the atmospheric surface layer have been carried out specifically to elucidate the relationship between the arid vegetation and its environment. Nonetheless theories based on information gathered chiefly in agricultural land can be applied to most arid vegetation. The microenvironment of a leaf or a fruit is adequately understood by applying the relations between the dimensionless numbers developed in general transport theories. Numerical values of the transfer coefficients, used to predict the shearing stress, mass and heat flux of plant organs, may require some adjustment to account for the mutual sheltering effect and the turbulence of the atmosphere. The description of the momentum transport may readily be obtained from wind-speed data using a roughness length and a correction accounting for the thermal stratification of the air. The choice of a particular diabatic correction is not very critical since most of the formulations do not differ by more than a few percentage points. The flux profile relationships for sensible heat transport and evaporation are not as well documented. It appears that many of the conflicting reports originate in misconceptions about the differences in the transport processes of momentum, heat and mass at the sources or sinks of these quantities. Nonetheless, some of the information available provides a good basis for modeling the basic exchange processes between the arid vegetation and its atmospheric environment. There are 42 references.


The first edition of this book was in 1927 and it was certainly the first that discussed basic microclimatology together with the way it was and could be applied, especially in the area of forestry, where its contributions were absolutely unique. In 1961, with its more than 1200 references, it had become a handbook on its own from which very many (especially European) meteorology students learnt the essentials of climatology "close to the ground". The first four chapters remain a thorough explanatory as well as quantitative introduction to the energy balance at the earth surface and to what happens in the boundary
layers near bare soil, including the upper soil layers. Given that the last chapter (9, by Hofmann) is on measurements and the largest one on meso- and topoclimatology (7), the three most important chapters for our purposes are the one on the boundary layer near vegetated surfaces (5), the still unique one on forest meteorology and climatology (6) and the one on the relationship between man and animal and the microclimate (8). Thoroughly quantitative illustrations are the real power of this book in getting details of the microclimate understood. Even the early microclimatological work in the tropics, of Ramdas and collaborators in Pune, India, and of course the tremendous quantity of important Japanese work in agro-microclimatology are illustrated widely. A book to use when making lecture notes and syllabi. Early work on almost every subject in natural vegetation, crop and forest microclimate may be found here. Of course there is more microclimate management than manipulation in all but the last chapter. As a tropical researcher one may nevertheless envy the details that have been known for so long on temperate microclimatology and one would wish that the capacity existed to do such detailed small scale agroclimatological work presently in tropical farming systems.

GERBER, J.F., J.D. MARTSOLF AND J.F. BARTHOLOMIC, 1974


Attempt to ask attention for the microclimate of trees and vines and certain aspects of its management and manipulation. The climate of trees and vines is different from fields, meadows and agronomic crops. These differences may be tied to the evolution of trees and vines, or they may be a peculiar result of man's culture. Knowledge of the climate of trees and vines may be of assistance to the horticulturist and any other small scale farmer in climate modification (management and manipulation). Trees and vines can be identified by their physical shape and texture. They have fewer stems and larger boles than most plants. They are perennials, so shape and texture persist, but change with the season in temperate zones as leaves are lost. Such physiological-climatic related response has evolutionarily adapted the plant to the climate. They may be deciduous or evergreens. Special attention in this paper is given to the climate of trees and vines in the day time, the thermal effects of solar radiation, the climate of defoliated trees and vines, frost and freeze protection, irrigation with sprinklers to moderate heat stress and other cultural and managerial practices. There are 43 references.
Shelter has rarely been given sufficient consideration when examining the relationships of plants with their environment. In this book very scattered material has been brought together on shelter effects in terms of both plant physiology and crop microclimatology. It reviews air flow theories, instruments and equipment as relevant to quantification and control of wind indoors and in the field. It looks at response to wind of single leaves and whole plants, of course including trees, and in doing so throws doubts on the earlier more simplistic explanations of reduced evaporation stress and improved soil moisture conditions as the main causes of shelter effects on crop growth and development. Especially the causes and consequences of primary (that is mechanical stress) wind injury are getting full attention here in an integrated way for the first time. In another chapter air movement in and around crops, from determining the exchange of mass, heat and momentum till its role at the small scale in particle take off and dispersal, as well as at the large scale in lodging, are dealt with, boiling down to the consequences of shelter in physiology and yields of sheltered crops. Ecology of mountain and coastal vegetation, where winds play such a dominant role, form the last chapter.

These proceedings of a Symposium of the British Ecological Society in 1979 contains 23 chapters of which more than half has been written by well known British and a few foreign ecologists/plant and crop micrometeorologists. Although most chapters are after understanding of basic phenomena and concepts, subjects like adaptation of plants to their environment and inter-specific relations in plant communities bear quite some interesting connections to microclimate of complex composite crops. As stated in the concluding remarks, the distinguishing concepts of ecology are those of population and community and, so far as plants are concerned, the main effects of neighbours are to modify the climatic and soil environments. It is suggested, from the difficulties to understand at the physiological level all the relationships between individuals in (composite) communities, that for example perhaps the simplest entry to the study of the physiology of species in layered communities, in relation to the gradients of microclimate, is initially through investigation of the physiological ecology of the (woodland) ground flora. It also becomes clear from this volume that micrometeorology and microclimatology have a role to play in the
more abundantly wanted studies of the negative influence of industrial pollution on the agricultural environment. Another important note made is that on the needed attention for sampling approaches in complex communities, which indeed makes research live so difficult in the inhomogeneous intercrops of the tropics and necessitates the determination of large scale ecosystem parameters along at least two independent lines of quantification.

GRACE, J. (ED.), 1985

Much new work on the biological response of organisms to shelter has accumulated since the late sixties, forcing us to re-evaluate the role of shelter in evaporation and growth. New factors that came into the picture are abrasion of leaf surfaces and the influence of mechanical action per se on plant development. Also cold and heat stress and the needed shelter for animals became better known. In this small booklet, papers at a 1983 sub-meeting in Hull of the Society for Experimental Biology, of working scientists interested in shelter and its effects, have been collected. Next to rather some useful state of the art theoretical review papers, which are eight in total, four more practical papers are on shelter for animals in hot countries (by R.M. Gatenby), on some effects of shelter on the yield and water use of tea in East Africa (by M.K.V. Carr), on the effect of climate (particularly wind) on extensive sheep farming in the Falkland Islands (by J.H. McAdam) and on wind protection in traditional microclimate management and manipulation in East Africa (by C.J. Stigter). The last mentioned paper is annotated separately below.

GROLLEAUD, M., 1985
Granary styles as a reflection of culture and climate. CERES, FAO Review 18 (106): 4-5.

Short paper on local granaries. One can say that the gamut of plant material granaries is infinite. It is, however, possible to classify them according to dry and wet regions, plains, forests and high plateaux, because it depends among other things on climate. Good preservation of harvests and seeds being their major function, the first condition is that grain or ears be sufficiently dry (less than 13 percent humidity is mentioned). The plant-material granary allows heat and wind to penetrate, which keeps the grain dry and moderates the temperatures of the
stock. In wet zones, greater ventilation is necessary, which is why the shelters are often up on pilings and open, or contain many doors and windows. These granaries have their place in an ecological microsystem and physical losses are small (lower than 5% is mentioned for the Sahel).

GUYOT, G., 1963

With its 127 references this is meant to be a summarizing bibliography and at the same time a review of the state of the art (of now more than 25 years ago) of the knowledge on the multiple and sometimes contradictory effects of windbreaks. It distinguishes the influence of windbreaks on the wind itself, on microclimatic factors like evapotranspiration, air temperature, air humidity, radiation balance and CO₂-content of the air, on the soil (erosion, climate, physical properties). It also deals with hydrological influences of windbreaks (on rainfall distribution, run off and groundwater) and their influence on yields. With one publication from Belgian Congo and some from Israel, results under more tropical conditions are rather absent, as could be expected, but the many results from the Russian stepp regions compensate this somewhat. For our purposes section 5 on the yield influences is most interesting. Here disadvantages and advantages of windbreaks are distinguished. As negative factors for the wind protected crops, of course depending on the location and sometimes the orientation of windbreaks, are mentioned: shading of part of the protected crops, root competition between break and crop, higher springtime night frost risks, higher maximum temperatures and higher humidities, increase of harmful bird and insect populations and competition for space. As positive factors are mentioned: protection from mechanical damage, soil water conservation and water use efficiency increase by evapotranspiration changes, from which changes in other parameters (temperature, humidity, soil temperature and other physico-chemical factors) are partially derived as well, and finally increase in photosynthesis by longer stomatal opening. In cases where wind breaks increase both evaporation and temperature, such as with cereals in hot rain fed dry tropical areas, yield effects may be negative. In the other cases the yield increases differ with distance from the belt, with generally the highest increase where wind and evaporation are at their minimum. The most spectacular results have been reported with multiple belts in relatively dry climates with shallow rooting plants, such as in prairies. In the Russian steppes yield improvements of 100% with prairies have been reported.
The French landscape named "bocage", especially found in Brittany, consists of a network of living hedges as windbreaks, ameliorating climate for the grasslands and low crops grown between them. When mechanized agriculture became more and more important, reparation took place on a large scale and the network was in many cases thinned or even suppressed. This study gives the theoretical and experimental approach to a comparison of microclimates in an area where such suppressions did take place and one where reparation had not yet occurred and the bushed gently sloping hills had not yet been modified. It was the first research of its kind to assess the consequences of an agricultural management decision, away from the traditional landscape, at such a scale. After a chapter on the experimental and sampling set-up, a theoretical chapter deals with meso- and microclimatic modifications that depend on a large scale roughness of a region and a synthesizing chapter concludes on the climatic results. It is the wind and consequently the aerodynamic contribution in the evaporation that are modified most obviously by denuding the landscape from its hedges. Only directions of changes could be indicated, as generalization is not possible because of site specificity of the absolute values obtained. It could nevertheless be observed that also wind speed not influenced by individual hedges was still in the order of 40% lower than in a not hedged area, due to the roughness increase of the landscape. In the second half of the publication mainly the consequences for the vegetation and the agricultural production are discussed. It appears as if the differences in soil conditions and agronomic practices, changes in the farming systems and interannual climatic differences are often more important from the point of view of agricultural production than the suppression of hedges in this area of sufficient rainfall, with the exception of grassland that may be expected to do better with the hedges remaining. It also follows from the last parts of this study that the French farmers anyway do what suits them and, forced by their deteriorating economic conditions, have no considerations for ecology or landscape.

GUYOT, G., 1980


Relatively short (12 pages) but detailed paper on essentials of soil erosion caused by wind and some of the measures taken to reduce it. After the physical mechanisms on the scale of particles and on the resulting total transport scale have been treated, general principles of wind erosion reduction are dealt
with. After which there is special attention for management of vegetative soil cover, selection of cultural practices, application of mulching and the use of wind breaks in the fight for erosion control. In the conclusions the American wind erosion equation for the on-farm quantification of soil loss is explained. It is suggested that application of this equation elsewhere would contribute to reduction of wind erosion.


Paper of 24 pages dealing with cultural practices to influence the microclimate in the context of pest management. After a description of the daily and seasonal microclimate of crop canopies, in dependence of canopy morphology and macroclimate, the question is asked to what extent the microclimate is modified (altered non-purposely) by certain cultural practices or may be managed and manipulated purposely. The following options are treated: irrigation, row spacing and direction, canopy effects on soil temperature, mulches and windbreaks. The paper ends with an evaluation of the effect of management on the microclimate and concludes that further research is needed on the role of management factors in the microclimate for perennial crops, irrigation practices and schedules in all climates, and modification of canopy energy exchange via pruning or trellising. There are 56 references.

HENRICKSEN, B.L. AND J.W. DURKIN, 1985 [R]

Over the last thirty years, four major drought periods and associated famines of varying degrees have been recorded in Ethiopia. In this paper, a moisture availability model developed by FAO is used to estimate the periods since 1953 when there has been sufficient moisture available for satisfactory crop growth at four different locations in Ethiopia. The preliminary results of an analysis using existing meteorological data show that short lengths of growing periods correlate well with the recorded incidence of drought and famine in the country. If the short rains fail, most land preparation can only begin after the start of the main rains, and this preparation time cuts into the period available for crop growth. Historically, severe famine periods have been associated with a sequence of 2 or more years in which
the short rains failed and the resulting main-season growing periods were either marginal or so short that crop failure was inevitable. To what extent other factors such as disruption of traditional supply routes and cultivation patterns, due to civil unrest, contributed to the rapid onset and severity of the current famine is unknown. Over the longer term, fundamental changes will need to be made to existing production systems; land use will have to be rationalised so that erosion prone soils are conserved. Better adapted, rapidly maturing crop cultivars should be sought. Alternative cultivation systems which conserve soil moisture and/or runoff water should be investigated, extending the growing period. A combination with some external inputs is recommended.

HEWITT, K. (ED.), 1983

D, G, L, R, S


The first part of this book is preoccupied with the interpretation of major disasters, but based on the criticism that the present concepts of disaster fail to recognize how the roots and occurrence of contemporary disasters depend upon the way "normal everyday life turns out to have become abnormal, in a way that affects us all". Since it is the institutional and structural order that is at fault, disaster research and relief should formulate models and strategies which challenge this order. These should be based on the preservation and reinforcement of a wealth of indigenous responses and involve a minimum of external intervention. The above is illustrated with examples from New Guinea and Botswana/Namibia, the UK and the USA (!) and the Sahel. The latter study concludes that ecology can only be a political science. In the second part, the emphasis is on case studies of climatic hazards in agricultural communities, agricultural development and food security. It is shown that command over natural resources influences severity of consequences of and response to natural disasters in agricultural communities. People forced to migrate to other agricultural areas or subjected to change of their conditions from outside are again more vulnerable in their new conditions. We have to look closely at the interdependence between the conditions of agricultural development and the meaning of natural hazards in food security. This is illustrated by case studies from Belize (in which a few interesting microclimate management and manipulation examples but also a few biases towards traditional knowledge), settlements of the Paraguayan Chaco, wheat yields and trade in the Soviet Union (be it unintentionally) and Canada and development problems in the Indo-Pakistan subcontinent as a whole. In the final section revised conceptions of natural hazards and disaster are attempted, based on the above conclusions.
HILLEL, D. (ED.), 1972

Optimizing the soil physical environment toward greater crop yields. New York: Academic Press.

The most important chapter of this book for our purposes, by Fuchs, was already dealt with above. Again for our purposes one also finds some information on control of soil water, including management by bringing previously unproductive land into production by taking away other limitations than water (including chemical means and physical means like barriers in too quickly draining sandy soil and the use of soil conditioners), management through fallow periods, tillage, run off reduction and soil storage increase (including increase of organic matter content and chemical means) and of course through irrigation and drainage. It is indicated that the conventional phytotron is wholly inadequate for study of environmental management and modification and that the field environment may be uncontrollable but still preferable for such studies. There is also attention for controlling (crop and field) water use efficiency, including by manipulating soil moisture content, potential and supply method, fertilization, soil aeration and atmospheric composition (H2O, CO2). Restricting water losses directly from the soil by the use of a surface mulch gets some separate attention in a short chapter on water utilization by a dryland row crop. Referring to Fuchs' paper, the editor states in his own contribution that control of climate and other environmental factors above the ground is difficult in the open field, but perhaps not impossible. This bibliography shows that this statement is true, and already for ages!

HOYNINGEN-HUENE, J. VON, 1980


This dissertation is about water use efficiency of irrigated crops in temperate climate and under arid conditions. The thesis shows the importance of the various micrometeorological processes within this problem field and shows the crucial role of the energy balance of parts and the whole of the irrigated crop. Radiation and advectively received heat appear to be the most important factors to understand the differences between temperate and arid climate results, especially on the small tropical fields in a dry oasis condition where the latter factor becomes of the same order of magnitude as the former in evaporation calculations. However, on small irrigated fields in more humid conditions the advection is in dry years an important factor as well. Soil heat flow hardly plays any role in this respect. Too high leaf temperatures as a consequence of limitation of leaf
transpiration can only be modified by increased heat transport away from the leaves or decrease of the energy flow towards the leaves. Increase of air movement has in most cases only a positive effect on increasing heat exchange of an evaporating crop when the temperature of the leaves is below that of the air. Less advection may be obtained from wind protection measures and laying small fields together to reduce the oasis effect, and less radiation load may of course be obtained from shading from intercropping techniques. The energy balance model developed makes the above also clear quantitatively and moreover explains more difficult phenomena as why sprinkling has in cases of heat stress often not been successful, and led to increases of leaf temperatures and to yield depressions, and why morphological and stand structural/composition parameters (and other agronomic measures) will play a role as well in the manipulation of crop temperatures to increase water use efficiency. Only better plant physiological knowledge may still fundamentally increase success of biophysical research and of models of water use efficiency.


In this third part of a publication on the climate of Al Hassa, one of the largest oases in the world and the largest of Saudi Arabia (the first two are on macroclimate and mesoclimate of the same 8000 ha area), microclimate is considered for agricultural purposes. In the first section energy and water balances of an irrigated maize crop are reported on under extremely dry microclimatic conditions, where especially extreme advection effects are considered which are at work quite deeply into the oasis and contribute heavily towards actual evapotranspiration values up till 1 mm/hr and 9 mm/day. It is stated that water under these extreme conditions does not only play an important role in carrying nutrients and keeping stomata open but also in keeping leaf temperatures near optimal for plant physiological processes in photosynthesis/respiration. This advective heat load of the oasis effect may be minimized by bringing the irrigated areas together and using wind protection at the wind-facing sides. In the second section such wind protection of an alfalfa crop by dry palm leaves, which are in use for such purposes in oases already for millennia, is reported on with respect to water use efficiency. Contrary to most other wind protection results, these windbreaks change their permeability with wind speed and
therefore also their protection capacity appears to be somewhat wind speed dependent. High wind speeds give lower wind reduction close to the break but higher protection beyond about four times their height. An influence of crop stage on the wind protection pattern was also found. On the average overall water use efficiency was increased in the period of investigation from 10% in "winter" till 30% in the two hottest (but clearly below long term average) summer months behind the wind breaks. It was extrapolated that increases in the latter months may be expected to become as high as 80 - 100% under the most extreme conditions regularly found.


Apart from the paper of Jackson, singled out for separate annotation below, these very interesting proceedings of an early (1981) consultative meeting, for our purpose mainly show two things: a relatively small presence of particular quantitative microclimatic aspects in the scientific thinking on agroforestry, about a decade ago, and at the same time a high scope for the increase of considering such aspects in the management and design of agroforestry systems, especially for the low external input farmers. From the 34 collected papers and four group reports it follows how traditional farmers use agroforestry systems all over the world, from single trees scattered through their fields to the multi-storey compositions of their homegardens compounds. Occasionally examples of microclimate management and manipulation are nevertheless given. Management of shade, as in nurseries, coffee, cacao, tea, cowpea, with coconut palms, Acacia albida, Tamarix, bananas and fruit trees and climbing plants as well as some general aspects are mentioned in different papers. With respect to windbreaks/shelterbelts, there are appreciably less specific examples. In fact only Eucalypts and Tamarix are mentioned for this purpose but the latter is not recommended. At three places short general comments on windbreaks in agroforestry are made and mainly improved water relations are mentioned as the reason for application, among other cases in strip cropping, and only in one case strong winds and wind erosion. (Live) mulching is mentioned largely in general, and only in two cases is there a specific example, in both cases related to nutritional aspects of Leucaena leaf mulches. Wind and water erosion are only occasionally mentioned and only "surface modification" in different forms gets the attention it deserves, but apart from irrigation not in a form that leaves much to expect from microclimate modification, that itself is only explicitly mentioned in the report of the first Working Group with respect to the effects of overstorey, especially again in relation to light intensity.
Climate, water and agriculture in the tropics. London: Longman.

The book examines characteristics of tropical rainfall and evaporation, together with their implications, especially related to agriculture, land use and aspects such as soil erosion and irrigation. After an introduction three separate chapters deal with origins of precipitation, rainfall seasonality and with variability and other rainfall characteristics, after which evaporation gets its own chapter. In the second part, after a general review on water and plants, their tropical situation, with special attention to water-yield relationships of different crops, culminates in that of water and agriculture in the tropics. Finally, human impact on the hydrological cycle and related climate modification is treated at the meso/macro scale with quite elaborate examples. For our purpose especially mulching, tillage/ridging and soil erosion/conservation are widely treated subjects next to irrigation and fitting cropping periods to the seasons (water regimes). Also dew management gets some attention. With its second edition after 12 years it has proven its value for a range of students and researchers in the tropics already, especially because of its cross-disciplinarity, and will continue to do so, with now added and expanded sections such as on El Nino, variability of rainfall, drought, climatic classification, human impact on the hydrological cycle and conclusions. In this last new concluding chapter, on problems and priorities, it is among other things concluded that research in the tropics needs adapted approaches in many ways, including different instrumental, experimental, educative/training, target and comparative approaches. And also the traditional systems and knowledge are explicitly recommended for detailed study, with the final imperative not to divorce the political, economic and social realities from the physical ones.

JACKSON, J.E., 1983 [A, B]
Light climate and crop-tree mixtures. In: P.A. Huxley (Ed.),
Plant research and agroforestry. Nairobi: ICRAF.

This is a quantitative attempt to understand light/radiation interception, transmission and distribution within discontinuous and multi-storey canopies by a relatively simple but for a first approximation adequate, quantitative approach. It is an attempt to continue where the paper by Allen et al. (1976) stopped. Mathematically a Beer’s law approach is selected for extinction of light passing through a tree canopy, with a constant extinction coefficient defended by the fact that in trees a very similar arrangements of (branch induced clustering of) leaves is presented to light throughout the day, and with leaf area index replaced by the tree leaf area per unit of ground surface which
it potentially shades. In this way rather simple expressions indicate the light that reaches the upper surface of a ground-cover crop after transmission through the tree canopy and the radiant energy actually intercepted by the two crops. Comparably simple expressions are given for the leaf area and the volume of a canopy in the upper zone of a discontinuous canopy, within which irradiance on a horizontal surface is at or above a prefixed value. These are important quantities in determination of efficient photosynthesis. Measurement of the necessary parameters also get attention. With these expressions the consequences of management and manipulation decisions can be considered quantitatively. On the basis of the above, the paper therefore ends with considering the physiological implications of the ecosystem light climate and the use to which this knowledge can be put with regard to the choice of mixed tree and ground crop systems and to their subsequent management. It discusses increasing and optimisation of (components of) cropping system light interception and their light requirements, with attention to changes in light quality and horizontal aspects of discontinuous canopies.

KANG, B.T., G.F. WILSON AND T.L. LAWSAN, 1984
Alley cropping: a stable alternative to shifting cultivation. Ibadan: IIITA.

One of the challenges presented to the International Institute of Tropical Agriculture from its beginning has been to develop alternatives to the centuries-old shifting cultivation and bush fallow production systems predominant in tropical regions. The fragile tropical soils do not respond well to temperate climate farming methods based on the use of heavy machinery and expensive agrochemicals, which often leave the land in poorer condition than does a heavily used bush fallow system. Alley cropping has been developed in an attempt to incorporate the good features of bush fallow into a low-input continuously productive stable alternative farming system. It retains the basic principles and components of traditional agriculture while introducing important improvements. Biological recycling of nutrients and soil conservation, suppression of weeds and rapid production of by-products such as stakes and firewood are major advantages of alley cropping. In other conditions alley farming offers a means of combining crops and/or livestock with firewood production in areas where the latter has become scarce. Leuceana is the tree that has been incorporated in all the developed alley cropping systems reported on in this publication. Of our microclimate subjects explicitly the following are mentioned: use of mulch for plant nutritional and weed suppressive purposes, provision of bush/tree shade for weed suppression, providing favourable soil
climatological conditions for soil macro- and microorganisms and providing soil erosion protection (when contour planted). The little booklet includes further details on Tree and Shrub Species and their establishment, on alley widths, pruning, staking for vine support, tillage for root trimming, weed control, biomass production and nutrient recycling, effects on soil properties, crop performance and fodder.

KAY, M.G., W. STEPHEN AND M.K.V. CARR, 1985
The prospects for small scale irrigation in sub-Saharan Africa. Qutl. Agric. 14: 115 - 122.

This paper is about irrigation practiced by individual farmers in sub-Saharan Africa, usually on a small scale, under their own responsibility, usually at low cost with little or no government support and using technology they can understand and manage easily themselves. A physical classification of small scale irrigation, its relative importance in agricultural regions and such agricultural regions of Africa are reviewed in respectively two one page tables and one map. The first of these contains traditional methods with geographical examples. A classification based solely on climate tends to be too simplistic, as the traditional agricultural background of the local people will greatly influence the success of irrigation. The valuable role of Non Governmental Organizations (NGO's) in irrigation, by mobilizing and involving participants in the development of small scale schemes much more successfully than governments, is highlighted. Six crucial issues for small-scale irrigation to succeed in Africa are distinguished. For our purpose the most important ones are: that any system set up to respond to farmer demand is more likely to succeed than one which is imposed, however well meaning this might be, and that each country/region needs a group of people with experience and the special skills needed for this type of work to provide assistance in the design, construction, and implementation of schemes; to assess the potential for small scale irrigation; and to train people and organise farmer training in the use and maintenance of schemes.

KLEE, G.A. (ED.), 1980
World systems of traditional resource management. London: Winston & Sons and Edward Arnold.

One introductory and one closing chapter parentheses nine regional ones (on Africa, The Middle East, South Asia, East Asia, The Soviet Union, Europe, North America, Latin America and Oceania), which each have the same characteristic sub-division of
an introductory section and sections on (i) The resource base, (ii) Evolution of a tradition, (iii) Existing traditional resource-using systems, (iv) Region in transition and (v) Concluding regional assessment. The book is of major interest to us because it is one of the very few examples that, even at several places, explicitly picked up the challenge that was formed by the paper of Wilken (1972) on identifying traditional microclimate management and modification. This is not the case in the paper on Africa, where only the use of mulches, shade, irrigation, erosion control and the use of wind and solar energy for several purposes are mentioned in an essentially ethnoscientific approach. In the paper on the Middle East water control is the main subject with emphasis on the danger of socially unadapted "modern" approaches. However, the chapter on South Asia has a sub-section and a table on Microclimate Management, including examples of shading, surface geometry management, tillage systems, mulches and wind management, indicating the land type, the resource complex/crop and the locations where these techniques are practised. In comparable tables on soil, water, space and plant/vegetation management, many of these and related aspects return in the same descriptive way. The most salient feature of the chapter on East Asia is the high valuing of the low external input peasant-gardening resource systems, based on sound ecological principles but nevertheless in a condition of unstable equilibrium with its environment because of the massive submission of all other resource systems to the needs of agriculture. However, it is stated that through an untutored understanding of the basic ecological principles at work, the farmers of the peasant-garden system were able to combat a great many of these problems, partly through the judicious imitation of natural ecosystems in such practices as intercropping, multiple-cropping, (......)and partly through additional inputs of labor directly applied to combating the environmental damage. This book is rich in tables and one of them mentions here as important examples for our purpose the temperature control in nursery beds (including blackening for warming), straw mulching, ridging and water conservation and erosion prevention. Japan is mentioned as an example where the rich traditional knowledge is getting lost for ever. In the chapter on Latin America, microclimate management figures explicitly again in a sub-section and a table as being found widespread. This includes mulching, temperature control, dew inducement, shading, wind breaking, reduction of evapotranspiration, reduction of rain impact, and infiltration control, as well as the means of water and space control, crop scheduling, multiple cropping functions, multi-layering functions and ridging/mounding/pitting. It is our task as scientists, this paper says, to seek out the "essence of palaeotechnic permanence" and apply it to our use of the earth's resources. In the paper on Oceania, sunken gardens and pits, pot cultivation, swidden agriculture and other traditional soil and water conservation practices are mentioned that have microclimatic implications.
Explicitly only mulching, mounding, soil erosion controls with trees and shelterbelts are explicitly mentioned, also in the interesting table on lapsed or dying-out attitudes and practices that might be revived, reinforced or modified. It is finally worth mentioning that in the chapter on North America, microclimate management by Southwest Indian horticulture and by Atlantic subsistence farmers of Canada are explicitly mentioned.

LAL, R., 1984

With its far over 300 references this is a real review on tropical soil erosion, especially on basic research information of the last 15 years and its consequences. Its most striking opening statement is that our ability to prevent soil erosion on tropical lands is hardly better than that of the stone-technology slash-and-burn agriculture of the Mayan civilisation. For our purposes the paper becomes most interesting in the last three chapters, where soil surface management for erosion control, runoff management and research and development priorities are treated. Soil surface management techniques that have an important influence on soil erosion include seedbed preparation, crop residue use, weed control and some husbandry measures. In this chapter residue mulching gets dealt with intensively, together with cover crops, in situ mulch and no-till for soil erosion reduction. Examples are geographically well distributed and good quantitative examples are given, such as regression equations relating soil erosion with slope for different mulch rates, effects of mulch rate on soil physical properties and the effect of different tillage practices on runoff and soil erosion. A list of some 20 cover crops (grasses and legumes) used for soil and water conservation in the tropics is also tabulated. On runoff management, the paper discusses terraces, diversion banks and contour ridges and quantifies with examples among others reduction of soil erosion losses from various of such conservation techniques and effects of mulch, tillage and strip cropping on runoff and soil erosion. The paper concludes that the topics of priority research must bear on practical problems. Basic data collection must have first priority. Suggested priority research subjects are in the field of Erosion rates, Erosivity, Erodability, Steep land management, Soil erosion/productivity relationships, Soil degradation, Methodology and Conservation-effective farming systems. On this last subject it is concluded that ground cover by mulch, cover crops, no-till, vegetative cover and mixed cropping have shown to be important in erosion control on tropical arable land.

In this short paper on the history of North American research on wind erosion, it is indicated that before 1930, when people became aware of large scale erosion dangers in the Great Plains, dust storms did exist as well. As far back as 1790, hedges were mentioned to prevent erosion and such barriers and the use of grasses and other vegetation, crops, stubble and inert materials as well as wind stripcropping, manipulating organic matter and water content in the top soil and leaving the ground uneven can ploughing and seeding have a long history as wind erosion control practices. Many of these methods that were so early identified as useful in wind erosion prevention in the USA may play an important role at present as well. Much less was known on the "how" and the "how much" of control principles and practices when the problem became larger in scale. That is why the goal of erosion researchers in the USA in the thirties has been quantification of the need for protection and the means to provide it, leading after the second world war to a national wind erosion project, that after 1967 reduced in importance but had in the meantime been seconded by another small research project since the new wind erosion problems of the fifties. In the sixties and seventies the following aspects were studied in the USA: wind climatology, influence of wind barriers, aerodynamic forces, effects of surface roughness, residue conservation (tillage), soil stabilizers, plant tolerance, abrasion, surface soil aggregation and erosion tolerance and soil renewal. Quantification attempts in the sixties gave rise to the establishment of the soil erosion equation that relates potential average annual soil loss to a soil erodibility index, a soil ridge roughness factor, a climatic factor, the unsheltered (weighted) travel distance of the wind across a field and an equivalent vegetative cover. Renewed interest in wind erosion in the late seventies and early eighties incorporated the wind erosion equation in a model that projects the long-term effects of erosion on soil productivity.


A one page (very small lettered!) summary of research results, especially on the influence of earliness of potato clones on lower yields. Most of the results and discussion indicate yield advantage of late cultivars. But lower yielding, early clones may for example be preferred if a short growing season is required to
allow potatoes to fit into the local cropping system or when the producer wants a quick food supply for himself. Closer spacing in early potato clones can compensate for their lower bulking rates. It is concluded that the practical manipulation of genotype/environment interactions, especially seed tuber production and storage environments, and the search for improved efficiency of conversion of intercepted radiation to dry matter under high temperatures both deserve further study.


Again such a one page summary. A complementary approach to breeding attempts for higher tolerance of potato clones to high temperatures is to modify the aerial and edaphic environment to favour growth of potato. Here the use of shade is discussed. Rather costly artificial shade enables precise regulation of the quality of shade but natural shade by companion crops, although less easily regulated, would be more easily available in the tropics and subtropics, where intercropping is already a widespread practice. It is known that continuous heavy shade lowers potato yields appreciably and dense shade during certain critical periods reduces yields also but less. The present experiments were set up to investigate the influence of sparse shade spread over the whole potato crop cycle or of a denser shade applied from planting for a short period of time, because both may be effective in reducing soil and air temperature and conserve soil moisture, especially during the emergence period. Almost all shade treatments when applied from planting hastened crop emergence, due to temperature reduction, the importance of which was confirmed by experiments with shade for different periods of the day at the hotter place. During the wet season E/W shade rows were better and during the dry season soil moisture was conserved. This latter factor also applied to yield improvement by continuous sparse shade apart from the cloudy rainy season, where rotting even decreased yield. Allover, the results indicate that shading can modify the environment to the extent that potatoes can be grown in hot climates where excess of soil water is not a problem. Also, intercropped potatoes are expected to have less insect and pest damage. Vast areas of natural forest, cultivated areas with coconuts, tall fruit crops and intercrop systems with e.g. maize, sorghum, pigeon pea, could be exploited to expand potato cultivation to the hot tropics.
A rich source of successful use of topoclimatic and of the potential for microclimate management and manipulation is the Japanese post-war literature in agricultural meteorology from before glasshouses took over there. This concerns the period roughly from 1945 - 1970 and successes were largely due to the high labour input available and spent and the interdisciplinarity of the research concerned that started from agricultural physics. This literature became much better accessible through the appearance of this book. For our purpose the first half of the book only contains an agroclimatological determination of a suitable cultivation period and some scattered remarks on management of temperature and wind and shading effects. However, chapter 5 on meteorological hazards very thoroughly deals with the research on effects and consequences of damaging weather conditions from which protection is needed and already brings more examples of protection measures, especially from different effects of strong winds treated such as waving, vibrating, fruit dropping, bending, defoliation, lodging, breaking, withering, dehydration, salt particle deposition, chilling and soil erosion. Measures against chilling low temperatures in rice growing are also extensively dealt with. Of course manipulating water is one of the most important factors in these measures as far as rice growing is concerned. Measures against drought and especially frost and hail damage are also treated here. The next richest source for our purpose is the section on modification of local climate and microclimate of the last chapter (7) on weather and climate modification. It deals with counterplans for cold weather, modification of wind and counterplans for invasion fog. Under the first counterplans, warming of irrigation water, artificial thawing and frost prevention get separate treatment. Under the second, especially work on soil topography and shelterbelt design is reviewed. Under the third, fog prevention forests appear to be most important. It is concluded that the progress in agricultural meteorology has greatly contributed to developing techniques for amelioration of microclimate near the ground and that basic research in understanding micrometeorological processes near the ground, as extensively dealt with in the first part of this book (in chapter 3 in particular), will continue to provide improvements for existing practical methods. Such a conclusion from this source should be taken extremely serious by those who have been reluctant to give microclimate management and manipulation a place in the scala of attempts to improve crop growing by controlling the environment.
In the post-war period, especially after 1950, a deliberate effort has been made to achieve a better balance between weather and soil studies in the study of vegetation in relation to its environment, in which soil conditions had been privileged for a long time. Stimulus for this work comes from, among others, (tropical) ecologists concerned with changes in the microclimate that occur when the equilibrium of an ecosystem is disturbed. The two volumes have been prepared to take stock of current knowledge and to ask whether ecological science is getting the full benefit from all the information now available about physical processes and mechanisms in plant communities. The first volume, as the introductory chapter states, deals with the main contributions of micrometeorology to ecology in terms of a matrix where mechanisms, processes and states are used against air, plants and soil. This leads to review chapters on radiative transfer in plant communities, momentum, mass and heat exchange of plant communities, the hydrological cycle in vegetation, the movement of particles in plant communities, micrometeorological models and instruments and their exposure. In the first part of the second volume chapters on relatively heavily studied crops like temperate cereals, maize and rice, sugar beet and potatoes, sunflower and finally cotton show (and occasionally state in their conclusive chapters) that much is known on (consequences of) radiation characteristics, less on (consequences of) detailed heat and water balances, appreciably less on (consequences of) momentum balances and carbon dioxide balances, overall enough to try to use some of it in relatively simple but economically useful attempts of crop climate management and manipulation, but that a synthesizing attempt for that purpose is far from possible. Only in either a modelling approach, like in the chapter on townsville style, or in controlling certain confined aspects (frost, solar radiation) of the microclimate, like in the chapter on citrus orchards, such simple but useful attempts are actually exemplified. The chapter on coniferous forests is one of the earliest attempts to apply in detail the same approach as for the well studied crops. In less detail, because less is known, the same is done for deciduous forests. And still more limited in scope but rather unique is the micrometeorological work reported on tropical rain forest. The last three chapters, on swamps, grassland and tundras show how micrometeorological concepts can be applied to whole ecosystems. It is important for our purposes that the following ecological topics are listed in which the potential contributions of micrometeorology have still to be realized: "measurements of states outside the temperate climates in which most micrometeorological groups have hitherto worked", "measurements of process rates over a whole growing season", "the description of plant communities as 2- or 3-dimensional systems: in particular, the application of micrometeorology to row crops".
and to systems of inter-cropping which are an integral part of traditional farming practice in many tropical areas; the micrometeorology of isolated trees or small groups of trees valuable for amenity or shelter; the measurement and specification of root systems", "analysis of the relation between weather and disease in terms of mechanisms, processes and states (including dispersal)", "the measurement of atmospheric pollutants in plant environments".


Many early growing methods, being a mixture of folklore, superstition and fact, have been passed down to recent times. This paper deals with factors to consider in developing ways to modify the plant microclimate and microclimate modification techniques for vegetable crops in the open field. Research on microclimate modification appears to be a promising field that will pay handsome dividends. Environmental influences of modifying techniques on plants are categorized as inductive (such as cold treatment of seedlings to increase flowering and fruiting), progressive (such as mulching to warm soils) and protective (such as wind breaks and row covers). A figure on microclimate modifying techniques distinguishes shading, row covers, plant spacing, windbreaks, heaters, sprinkler irrigation, row orientation, CO2 enrichment, foam, bed shape, mulching, light reflection (at the soil surface), seedling environments, drip irrigation, cultivation and thermal water, which are all shortly or more intensively dealt with. The more intensive ones are treated with examples under the headings: seed and seedling environs, mulching, row covers, irrigation, plant and row orientation, light regulation and CO2 enrichment, all of course for vegetables. The fact that this is a review is illuminated by the 105 references. It is concluded that the development of many of these techniques occurred through trial and error, often in a piecemeal manner and without a systematic approach to the total ecosystem. With abundant findings in plant physiology and the development of sound principles of micrometeorology, the horticulturist has unique opportunities to develop an integrated plan for making the (outdoor) vegetable ecosystem highly productive. It is clear that also the tropical small farm ecologist may profit from this approach, especially from the low external input techniques.

Temperature data from mulched soils in young tea in Kericho (Kenya) show that a ratio of diurnal temperature fluctuations relative to bare soil, as earlier derived and used by Stigter, may be successfully used in thermally homogeneous soil to rate the thermal efficiency of dry and living grass mulches. The use of such ratios appears to be much more accurate than using average temperatures in assessing these thermal mulching effects. Of the grass mulches used for erosion prevention in the new tea plantations, *Eragrostis curvula* appeared to be thermally least efficient. This was an advantage in the prevention of thermally induced shallow root growth and subsequent drought problems of young tea plants in this relatively cold area. Diurnal temperature patterns at only one depth appeared sufficient for the comparisons of different mulches and the data also allowed the comparison of different decomposition rates among mulches and in dry and wet seasons, which can lead to advisories on mulching frequencies and amounts to be applied. Mathematically defined apparent reflectivities can be used to understand the thermal consequences of mulches from the heat balance point of view, and the influence of other factors like actual mulch albedo and mild shade from bushes can this way be understood as well and separated from the main effects.


In this book among other things the ancient traditional tropical multiple cropping systems are summarized from a regional perspective never attempted before. Above and below respectively two papers, by Allen et al. and by Radke and Hagstrom were separately annotated. Between an introductory chapter on the importance of multiple cropping in increasing world food supplies and an economical chapter on multiple cropping systems, we further find chapters on such systems in Tropical Asia, America and Africa, the Eastern and Western United States and some countries of the Middle East, chapters on plant interactions, adapting species (for forage mixtures) and varieties in and for such systems and chapters on land preparation and seedling establishment practices, soil fertility management, integrated pest management, water and wind erosion control aspects and machinery adaptations in and of such multiple cropping systems. In the final review chapter on appraisal of present knowledge and future needs, it is stated that most authors agree that improving
the productivity of the more complex intercropping systems, rather than attempting to replace them with capital- and energy-intensive technology, is the appropriate research strategy. Much can be gained by studying the techniques developed in the tropics and improving them at their place of origin. Competition should be more thoroughly studied. Pest management advantages appear well established. Researchers are following the farmer's innovations more than supplying new information. There is a need for a completely different breeding strategy for intercropped systems. The largest knowledge gap, by far, is what happens below the ground. A better use of available human and animal labour in labour-intensive and capital-short farming situations may be most advantageous.


This is next to the paper of Allen et al. (1976) the second paper selected for separate annotation from the above early book on intercropping. Although it does not contain a single example from the tropics, it is a valuable review of examples of a particular technique. The two main effects of interplanting a short and a tall crop are light interception (shading) and wind protection, the latter systems called intercrop wind barriers. This paper discusses the wind-sheltering effects and related parameters, including plant response, plant-water relations, microclimate, wind structure and turbulence. There are three reasons for their use in the USA: to control wind erosion; to harvest snow for soil water recharge and to alter crop response. Distances between wind barriers appear to be between ten and fifteen times the sheltering crop. Sheltered plants in the USA usually grow taller, produce more dry matter and larger leaves, exhibit lower stomatal resistance and yield more, especially when irrigated, and usually of higher quality. For the microclimate behind barriers the usual picture is given. However, under dryland conditions sheltered and unsheltered crops don't differ very much in accumulated evapotranspiration and soil moisture when longer periods are considered, be it that plant water relations and water use efficiency are better for the sheltered crops. With low porosities wind speed and turbulence peak between barriers because porous barriers, especially those made up of crops, break the larger eddies into smaller ones, decrease wind velocities and reduce the amount of energy more at lower than at higher frequencies, which is all beneficial to growth. Strip interplanting often offers more flexibility than permanent breaks and may also be used additionally between permanent ones.
ROSENBERG, N.J., 1967
The influence and implication of windbreaks on agriculture in dry regions. In: Ground level climatology, American Agricultural Society.

The author has noted that at least a part of the documented disagreement on the nature and magnitude of shelter effects may be due to the fact that sensors are often improperly exposed. The paper is on shelter results within four-sided shelters of two tiers of snow fence and between parallel rows of snow fence and barriers composed of two rows of corn. From the literature and own results it is concluded that the value of windbreaks on dry land in subhumid and semiarid regions is largely due to the favourable distribution of soil moisture and favourable influence on the internal water regime of sheltered plants. Increased temperatures during early growth are also important in some cases. In semiarid windswept irrigated regions windbreaks reduce evaporative demand and plant water stress and increase photosynthesis efficiency and again water use efficiency. Effects on CO2 supply to sheltered crops are questionable. Tree planting should not be excluded from consideration as a means of improving plant growth in arid regions. Tall plants might also serve well as windbreaks in arid regions and be included in the irrigation rotation. The vast majority of reports, including this one, indicate beneficial yield effects due to windbreaks. In summary, windbreaks are among the most practical means of beneficially modifying climate in agricultural regions.

ROSENBERG, N.J., B.L. BLAD AND D.B. VERMA, 1983 (2nd ED.), 1983

With its twelve chapters: on the radiation balance; soil heat flux and soil temperature; air temperature and sensible heat transfer; wind and turbulent transfer; atmospheric humidity and dew; modification of the soil temperature and moisture regimes; evaporation and evapotranspiration; field photosynthesis, respiration and the carbon balance; windbreaks and shelter effects; frost and frost control; water use efficiency in crop production; new approaches; and human and animal biometeorology, this is a textbook closest to our aims of understanding modification practice and potential. Especially microclimatic influences of different mulches and shelters and the manipulation of evaporation and frost climate are quantitatively dealt with. For our purposes shelter from wind and frost protection are most impressively dealt with. On the first it summarizes that the literature of shelter effect is reasonably consistent in its conclusions that: shelter alters microclimate; shelter reduces potential evapotranspiration; shelter reduces actual
evapotranspiration; shelter improves internal water relations, for example greater internal water potential, lower stomatal resistance; shelter provides improved opportunity for photosynthesis; shelter generally increases yield. On the one hand these benefits may be most dramatic in dry years or when moisture shortages are critical, but on the other hand the literature also suggests that benefits in terms of actual yields may be more consequential under irrigation than on dry lands. Scattered trees as shelter have not been dealt with. As methods of frost protection are treated: site selection; radiation interception; thermal insulation; air mixing; direct air and plant heating; application of water; chilling to prolong dormancy and soil manipulation. The book is full of very relevant tropical and other Third World examples from the experience of the authors and many other sources.

SAVAGE, M.J., 1980

With its 112 references, this is a true review of an important practice in an important ecosystem. Prior to 1930, fire was generally considered destructive to ecosystems, but more recent critical evaluation has indicated its positive role in the management of forests, shrublands and agricultural systems. Fire may be regarded as a natural ecological factor producing and maintaining grasslands in those regions hot and dry enough to give good seasonal burns with enough biomass to support them. It is the response of vegetation to climate that determines what will finally dominate. In this paper soil temperature, net radiation, air temperature, windspeed, leaf temperature, evaporation, leaf and soil water potential and fire temperatures are each discussed in turn in relation to fire and the fire regime. Soil temperature has unfortunately been a neglected parameter but its increase appears to have frequently a more marked effect on growth in grasses than does air temperature. The sections on soil temperature and (also increasing) net radiation end with a list of research priorities. Following burning, the surface windspeed is significantly altered, especially affecting transpiration rate, which will also be larger in burnt plants due to the two earlier mentioned increasing factors of soil temperature and net radiation. Leaf temperatures of burned plants will therefore be lower compared to unburned ones. During years with below average rainfall burning has no beneficial effect on soil water status and for some species in years with above average rainfall the effect of resulting soil water status on growth was in fact detrimental. Total knowledge remains fragmentary and only an integrated multidisciplinary study could improve on this situation.
B. VAN MEURS, I. PIGGIN, A. USSHER AND A. WU, 1975

This is a review of theory and appearance of some important micrometeorological factors playing a role in shaping the environment of crops, detailed from a series of particular experiments at one site. It deals successively with micrometeorological profiles in the air above plants, canopy waves as an aspect of momentum transfer to crops, the albedo of cereal canopies, radiation under a plant canopy, energy distribution within a plant layer and micro-climatology: diurnal and synoptic variations in micrometeorological parameters. There are reviewing and original elements in this paper. Its main contribution lays in the original application of considerations derived from more extensive and elaborate experiments, in carefully selected ideal surroundings and under steady conditions, to relatively limited and simple micrometeorological measurements made at a particular site. The originality is largely in the micrometric procedure of incorporating "synoptic" variations in occurring diurnal changes to map, table and explain the field results obtained over a longer period and the illustration of this concept of micro-climatological representation. The paper is only occasionally referring to microclimate modification implications, especially towards the end, where certain obtained features are related to particularities of the site concerned.

SCHWERDTFEGER, P., 1976 [B, I, L]
Physical principles of micrometeorological measurements. Amsterdam: Elsevier.

This book has been designed to emphasize the physical basis of precise meteorological measurements, particularly those necessary in the determination of those processes relevant to the behaviour of the atmosphere near the surface of the earth. The six parts are on (i) air temperature and sensible heat transfer; (ii) solar and terrestrial radiation; (iii) air and water vapour pressure; (iv) wind velocity and turbulent transfer; (v) ground temperature and heat conduction; (vi) electrical analogue modelling of thermal processes. Scattered through the book there are 32 experiments, accompanied by brief outlines of theory and designed to familiarize students with physical principles of measurements. Very many of these experiments are laboratory ones. However, the set up creates a desire for a comparable set of experiments fully outdoors. The major reason for inclusion in this bibliography are the facts that it is this kind of equipment that forms the basis
for measurements in the (managed and modified) agricultural environment and that the book shows the many sides of such quantification approaches as well as a proper didactical approach to the teaching of micrometeorological measurements. There are hardly any references.

SMITH, L.P., 1975

An unconventional and inspiring treatise on agricultural meteorology and the state of its science and art by an experienced agrometeorologist. The meaning, the materials, the modes and the market-place of agricultural meteorology form the contents of this book. In the first chapter for our purpose long-term and short-term modifications of plant and animal climate are distinguished as well as combating adverse effects of weather, avoidable and unavoidable dangers and decision making and strategy of land use, which come back at the end of the second chapter. The modes chapters are dealing separately with plants, animals, soils, techniques and hazards. Separate sections deal for our purposes with mulches, irrigation, shelter, housing, storage, shade, transport, weather forecasts for agriculture, frost, forest and bush fires and meteorological hazards, in this sequence. The book is far from a literature review. It is a conceptual review as integrated in the experience of the author, here and there exemplified with (largely non-tropical) examples. One would wish that someone would take the trouble to make a comparable conceptual approach to tropical agricultural meteorology but with the inclusion of a thorough bibliography of tropical examples. In that case this book should be the starting point from the concepts point of view. An annotated list of technical notes on subjects of agricultural meteorology published by the WMO, of which some are at present reprinted or updated, is given in an Appendix.

STIGTER, C.J., 1982

A report on the newspaper contest organized in Tanzania in November 1980 to collect examples on traditional techniques of microclimate management and manipulation. Reasons behind the contest are discussed, data on the response are reviewed and a derived classification of examples is given. Letters to the first five prize winners are reproduced, reviewing their contributions.
Examples provided by the eight consolation prize winners are also mentioned, giving an impression of the useful contents of the generous response received.

STIGTER, C.J., 1984 (2x)  

Microclimate management and manipulation are among the methods which have traditionally been employed on small plots in low-input agriculture. These papers, each with a different emphasis, report on the methods smallholders employ to shade soil, seedlings, plants and crops to protect them from environmental stresses and to improve their yield capacity. Natural and artificial shading are discussed, both in the form of open shades and mulches, as well as other means of covering. Consequences of shading and shade reduction are reviewed from the point of view of modifying terms of the energy balance of surfaces. Other consequences of shading techniques and other manipulations providing shade as a side effect are considered. Some specific examples collected from Tanzanian practice are described as evidence of today's use of shading methods in traditional farming. It is concluded that we can learn a lot from small farmers in this respect but that the science of micrometeorology could assist in improving efficiency and labour requirements of traditionally employed techniques, as well as in their wider dissemination in the farmer community.

STIGTER, C.J., 1984 (2x)  

These papers, each with a different emphasis, review the use and the effects of mulching and specifically consider mulching as employed in smallholder farming in Tanzania, using general and specific examples of environmental management which were obtained from a public contest. It is shown from the same information that today's mulch use contains important indigenous components. Specific examples show the ingenuity of the local practices and the vast extent of empirical knowledge. However, it appears that quantitative information on existing practices in traditional farming is almost lacking. It is concluded that
micrometeorological research into traditional methods of soil and aerial climate management would be of considerable value in improving and disseminating these techniques in low-input agriculture. There are 25 and 12 references respectively.


Stigter's ratio of diurnal sub-surface temperature fluctuations was used to rate the thermal efficiency of two traditional applications of the same grass mulch on a thermally homogeneous soil in Tanzania. The very dry mulch applied under dry conditions showed a very high efficiency. Using a model of solar radiation transmission by grass mulches, recently developed by Stigter and Kainkwa, the shading and insulation properties of the two mulch applications could be separated, their contributions quantified and the trend of the ratios of the latter explained. Mulch surface temperatures, remotely sensed by infrared thermometry improved by Stigter et al. earlier, could be explained to be very close around the warmest part of the day for the two different applications. These results suggest that such surface temperatures are not very representative for sub-soil temperatures when not the whole diurnal temperature pattern is available in full detail. The paper shows the high sensitivity of Stigter's ratio and the related apparent reflectivity parameter for the quantification of thermal efficiency of mulching material from diurnal temperature patterns at only one depth relative to bare soil.


Monthly averaged diurnal temperature patterns were used to quantify the thermal homogeneity of soil on which young tea is grown under different, mulch treatments in Kericho (Kenya). A theory relating reflection coefficients of homogeneous soils to temperature fluctuations at different depths, developed earlier by Stigter and collaborators in Tanzania, was successfully used in a comparison of diurnal variations. It was shown that the tea canopy acts only as an additional shade. The theory on thermal mulch effects remained valid for growing tea if a simple shade correction was made on average diurnal temperature fluctuations. An effect of compaction of bare soil, explaining a sudden change
in the damping depth parameter used to show thermal homogeneity, was reported to be most likely due to a severe hail storm.


From energy balance considerations at the surface, relationships have been derived between near-interface soil and air temperature patterns and the albedos and temperature patterns of the interface under low evaporation conditions of bare soils. Simple theoretical approximations of these relationships were established for nearly identical soil conditions with different albedos. A demonstration experiment, developed for educational purposes at University level in Tanzania, is discussed which proved that the derived theory is also valid at the surface of plastic-covered dry soils with different albedos. Field temperature patterns for bare and black plastic covered relatively dry soil in Kericho (Kenya) at a depth of 7.5 cm are shown to be also in good agreement with the derived theory. The relationships derived are an important step in establishing a simple operational method for quantification of the thermal efficiency of mulching materials.

STIGTER, C.J., 1985 (2x) ["ALL"]

Based on a newspaper contest and related literature research a review is given of practices by which traditional Tanzanian farmers manage and modify the microclimate of their crops and agricultural products. The synopsis, in its awareness function, only provides a brief summary of the Special Report. The latter, after an introduction, deals with classification problems first. Subsequently it treats the following least known (from the micrometeorological point of view) subjects: shading, mulching, wind protection and modification at/of the surface. It also distinguishes better known subjects: drying, storage, rain and hail impact. It is concluded that the combination of the ethnoscientific approach with high level quantitative scientific research in tropical agrometeorology, which should be fostered in
scientific and educational cooperation projects, will bring farming systems research beyond the descriptive phases and will this way contribute toward tropical agricultural development. The report has 42 references.

STIGTER, C.J., 1985
Physics of mulching, with particular emphasis on grass mulches.
Proceedings of the International Colloquium on Energy Flux at the Soil/Atmosphere Interface. Trieste: ICTP.

Mulch is best defined, in line with traditional concepts, as a shallow layer established naturally or artificially at the soil/air interface, with properties differing from the original unmodified soil surface layer. This paper reviews the physics of the modification of temperature fluctuations in mulched soils and how an operational method was derived from this theory to easily quantify the thermal efficiency of dry grass mulches. The different steps of this operational method are shown and it is demonstrated that once the damping depth of a soil is known, fluctuations at one depth, between 5 and 20 cm, suffice to determine the thermal efficiency of a certain mulch if compared with bare soil. A correction for additional shade on bare soil could be made as well. Values for thermal efficiency are given in a comparison of one live mulch and three dry grasses.

STIGTER, C.J., 1985

When wind meets natural or man-made obstacles, type (morphology, flexibility, composition or construction) and spacing of such obstacles as roughness elements determine the character and evolution of the resulting local wind field. It is here that ingenuity to prevent mechanical damage to soils and plants by farmer’s management and manipulation comes in. Judging from the existing literature, protection against primary wind injury (damage due to direct mechanical stress) must have been widespread since antiquity. Given examples confirm for East Africa that wind protection is a long-standing indigenous practice. Such examples come from protection against wind erosion by wind speed reducing measures, including the use of cover crops, from the use of scattered trees as a wind speed reducing protective measure in intercropping, including the spread of wind
born insects, and from nursing of individual plants and young trees. It is concluded that coordinated efforts between Western and Third World scientists may foster efficiency of such indigenous practices and their dissemination. There are 31 references.

STIGTER, C.J., 1985

This paper deals again with some microclimate management and manipulation practices on which not much is known with respect to their performance and use in traditional farming, summarized under the heading of modification of surface properties. The latter is defined as decreasing or increasing exposure of surfaces to the atmosphere or modifying directly their original properties to change the environmental impact on these surfaces. Emphasis is given to direct modification of surface properties. Some earlier examples of shading, mulching, wind protection and drying are viewed from this new angle of surface modification. Then less known examples from the stimulation of drying and ripening, prevention of sun scorch, heat stress and strong evaporation, management and manipulation of dew and a few others are mentioned. It is concluded that based on the quantitative study of such phenomena, local scientists have to provide relevant knowledge to the extension services in the form of weather advisories, which work should be nationally and internationally stimulated and supported.

STIGTER, C.J., 1985
Research methodology to quantify and understand the modification of the energy flux at soil/atmosphere interfaces. Proceedings of the International Colloquium on Energy Flux at the Soil/Atmosphere Interface. Trieste: ICTP.

After an introduction on the use of agricultural physics for development purposes, external and internal criteria are developed for tackling derived agricultural physics problems for solving agricultural problems of small farmers in the tropics. In this derivation of a feasible approach, a schematic outline of a methodology of problem oriented research in environmental physics and a positive feedback system between different research types, as earlier developed by the author, are used. Subsequently ten basic energy fluxes in ecosystems are distinguished and their
management, manipulation and modification are dealt with in
general terms and through examples. Using an earlier
classification of such examples as published by the same author,
separate attention is paid to what happens to wind, rain (drops
and water) and hail kinetic energy at the soil surface under
different conditions and to influencing the surface energy
balance by management, manipulation and modification as practised
by traditional small farmers, whose main input is their own
labour to influence the environment.

STIGTER, C.J. AND A. WEISS, 1986

In quest of tropical micrometeorology for on-farm weather
advisories. Guest Editorial in: Agric. For. Meteorol. 36:
289 - 296.

This paper marks the birth of the Traditional Techniques of
Microclimate Improvement Project in 1985, for which it is the
first attempt at the international level to word the rationale.
The editorial starts from the observation that the current world
economic conditions look grim enough to foretell that low-input
agriculture will dominate, for a long time to come, a major part
of the third world production by small farmers. In this paper for
the first time the distinction is made between weather
forecasting for agriculture, agrometeorological forecasting and
weather advisories. The latter may be defined as a production
advisory regarding use or manipulation of meteorological
conditions, in or close to the space occupied by crops and
animals or their products, to increase quantity and quality of
crops, animals and yields and their protection as well as that of
the production environment. It is stated that if the latter
become operational they will be the most powerful tool to meet
the needs of low-input agriculture. Problems faced with this
approach are outlined. Subsequently the contribution
micrometeorology can provide is highlighted. Discussing the
implications of such a contribution it is stated that in the
training of tropical scientists in experimental agriculture,
education in agricultural meteorology should be fostered. Such
agricultural meteorology should also be part of aid programmes
with educational and research components and of scientific and
technical cooperation projects with third world institutes. The
agro-ecology of tropical crop space management is in need of a
larger micrometeorological component: as our contribution to face
the challenges of the present food and development crisis. The
categorization on which our bibliography is based, distinguishing
15 classes of manipulation of radiation, 16 classes of
manipulation of heat and/or moisture flow, 12 classes of
manipulation of mechanical impact of wind, rain and/or hail and
two general examples is published here for the first time
internationally.
STOUTJESDIJK, Ph., 1977 AND 1980

In the earliest paper surface temperatures in a temperate and a desert climate are compared to illustrate the fact that microclimate is realized directly by prevailing vegetation and landscape structure, which themselves are features determined by macroclimate, forming an indirect effect on microclimate. The range of air/surface temperature differences, determined by infrared thermometry, in temperate climate goes from minus 10 degrees for the characteristic climate for "open shade" to plus 60 degrees for a sheltered ant hill facing the sun at a summer day. Detailed quantitative energy balances illustrate these extreme examples. The absolute extremes are not higher in the desert but they occur much more frequently. In the second paper a review is given, ultimately collected into one graph, of excesses of temperature and saturation deficit at 1 cm above the ground in different types of vegetation and at the surface as compared with the air at 1.5 m near assumed standard conditions, on a bright summer day in a temperate climate. Again the "open shade" is the minimum, the maximum is formed by pine litter with an excess of 40 degrees and more than 15 kPa (for the saturation deficit). In the picture cool dry, cool humid, warm humid and dry warm quadrants of the air at 1 cm are distinguished.

STURROCK, J.W., 1975

After a general introduction, this review paper on wind shelter deals with a large range of issues: air flow and the nature of shelterbelts; shelter microclimate; the nature of crop responses; mechanical damage; crop yields; crop quality; diseases and pests; crop pollination; planning shelter; management and other wind control measures. Next to the well known reviewing picture of Nageli, also his less well known work on staggered barriers is used. Next to examples of well known influences on crop temperatures and humidities, also less well known influences on turbulent exchange coefficients are used to complete the picture. These contribute to conclude that especially effectiveness of shelter-belts has not been sufficiently investigated, among other things with respect to protection against advection. Next to well known examples of influences of shelter on soil moisture and related plant development and water status, also less well known influences on root systems are reviewed and the combination is
used to reconcile opinions on the effects of wind breaks under dry and under irrigated conditions. Next to well known results on yield increases, a variety of less well known examples is collected relating to very different types of windbreaks and climates. There seems little doubt that shelter benefits a considerable number of crops, but it remains to be shown how economic these increases are under general farming conditions. Where surveys have been made of existing shelter, they have invariably revealed many deficiencies with respect to planning, maintenance, weed control, porosity, choice of species, timber potential, effective replacement policy and negative influences on disease, pest and livestock damage. It must be concluded that in the majority of cases the value of existing shelter is considerably less than its potential worth, including the multi-purpose use of shelter crops/trees. Next to well known developments needed, as an interesting less known "new" development, grazing forests and arable forests with widely spaced trees [so what is traditional agroforestry in Africa. CJS.] are mentioned. It is concluded that the provision of effective permanent shelter will, in general, be the most effective way of avoiding damage and growth restriction by wind.


This paper covers largely progress in shelter research and shelter implementation in the period 1963 - 1971, with special reference to the control of wind in crop production. The first part is on environmental and biological aspects of wind protection, the second on practical aspects of providing shelter. The first part is largely making the same main points as the publication of the same author annotated above. The second part is more elaborate for our purposes. We emphasize the additions here. Under general considerations it starts with assessment of shelter need through exposure assessment under different conditions. Maximum land requirements of trees for wind protection appear to run from 1% of the better arable lands to 10% in areas with severe soil erosion and between 15 and 20% where timber contributes to the economy of the region. With uniform high efficiency of belts, 2-3% of land with trees would give about 20% overall wind speed reduction but with the inevitable variation in efficiency the land area will normally double. Farmers and their advisors often lack knowledge about trees and easily doubt their economic worth. Under species, management and economics, added aspects are on ideal species properties, literature on actual species used, on establishment and design indications, and on economic aspects. It is concluded
that in spite of all efforts already made, it is not yet possible to even begin to quantify — and therefore predict — the effect of shelter on crop yield, crop quality, soil erosion and so on. A major hindrance to progress in extension is the lack of information on field yields and therefore the virtual absence of reliable figures on the economics of shelter. New systems of integrating trees into farms may challenge existing concepts of shelter, for example under pastoral conditions.


One of the few papers existing on basic features of microclimate management and manipulation. It deals with the matter from the point of view of simple energy balance modifications, with emphasis on illustrations for conditions of horticulture. Radiation balances and heat balances are separately dealt with. Dew and frost formation are indicated to illustrate our understanding of radiation exchanges. Prediction of temperatures of leaves illustrate our understanding of heat exchanges. Examples given on influencing the radiation balance are the use of colored or reflective mulches, painting tree trunks white to cool them, using (reduction of) shade. Examples of influencing heat exchange come from wind modification: breaks increase temperatures of sunlit organs and wind machines increase temperatures of exposed leaves at night; plant population and planting pattern as well as pruning influence air movement, so mixing within and above the canopy and also the participation of any thermal convection effects, which are only important at very low wind speeds, in shaping the environment. The modification of the latent heat exchange is illustrated among other examples again by the use of wind shelter, now to influence plant water balance, and by wetting dry hot surfaces of sandy soil to lower the temperature and prevent tuber and seedling damages and of course by more common forms of irrigation. Subsequently heat flow into a substrate and the related subject of heat sharing are discussed with simple mathematics, introducing the concept of thermal admittance and highlighting the resulting surface temperature. This approach facilitates the understanding of the influence of any soil (surface) property or modification on what happens at and near the surface concerned, in relation to the thermal properties of the two media meeting. This makes manipulations at and near the soil surface one of the better quantitatively understood microclimate modification subjects, as follows from the relatively abundant examples given here on these aspects. Best examples are mulchings of all kinds, applying the widest definition to the concept of mulching, which includes wetting, draining, loosening and compaction. But the concept of
thermal admittance of the atmosphere and objects in the air also helps to understand earlier conclusions on frost prevention by irrigation, heating and blowers.


Conservation tillage systems are systems of managing crop residue on the soil surface with minimum or no tillage. Other names are stubble mulching, ecofallow, limited/reduced/minimum tillage, no-tillage and direct drill. Leaving crop residues serves water and wind erosion control, conservation of soil and water and reduction of energy use. The review is limited to the salient points that have been researched over the last twenty years and is limited to the United States. For our purposes general remarks in the sections on seed bed preparation and crop seeding, control of wind erosion, control of water erosion, weed control with tillage and the three sections on soil temperature and the same number on soil structure and other physical properties are of most importance. On wind erosion, after a general introduction the wind erosion equation is dealt with. Tillage has a direct bearing on the factors I, soil erodibility; K, soil surface roughness and V, equivalent quantity of vegetative cover. Surface residue influences V, tillage proper influences mainly I and K. Partial (de)coverage of a field would influence L, equivalent width of field (maximum unsheltered distance across the field along the prevailing wind erosion direction). Kind, amount, texture, height and orientation of surface residue all influence wind erosion. Tillage operations that minimize soil pulverization and smoothing are effective for maintaining K and keeping clodiness for maintaining I. Examples are given from the USA. A comparable approach is followed in the chapter on water erosion, using the influence of residue and tillage effects on the Universal Soil Loss Equation. The section on soil temperature deals with the effects of surface residue: changing the radiation balance accompanied with an insulation effect, and with residue factors involved in these effects: residue age (decoloration; decomposition), color, geometry, distribution and amount. Again some examples. Finally its biological effects on crops are dealt with. After dealing with soil aggregation, porosity and density as affected by tillage, other soil physical factors dealt with as influenced by tillage operations are soil texture, crusting, hydraulic conductivity and water storage capacity. Tillage reduction in the USA can’t be considered without the rapid technological advances in the use of herbicides. It is estimated to serve from 5 to 15 cm of additional water to rain-fed agriculture. Only more interdisciplinary knowledge will advance this field of soil science.
WAGGONER, P.E. (ED.), 1965

Of the twelve chapters of this landmark monograph, although many chapters have gained a long standing reputation as reviews, for our purposes the ones on soil microclimate, its creation and modification; on protection from the cold; on response of animals to heat; on transport of soil and snow by wind and on forecasts and decisions are the most important ones. In the first it is shown convincingly that the mathematical approach of soil temperature can lead to a better understanding of what factors play key roles in determining soil thermal microclimate and of what happens when the soil conditions are modified. In the second the same approach is successfully applied, in two separate sections, to frost protection of plants with sprinkler irrigation, applying a nocturnal energy balance approach to leaves and spherically shaped objects, and with wind machines and heaters, applying an energy balance to a whole orchard layer. In the chapter on animals again the gains and losses of heat are used to describe the environment. In the end, knowledge of the animal's adaptability and its requirements are combined with an engineering ability to build shelters. Physical considerations on the surface wind and the mechanics of soil and snow transportation are preceding the principles of soil erosion control. All devices to that end of control are designed to (i) take up force of the wind leaving little, if any, to be taken by the erodible particles and (ii) trap any eroded snow or soil particles on the lee or among surface roughness elements or barriers, thereby reducing avalanching and intensity of erosion and preventing erosion from spreading. In the final chapter, theory of decisions and farm management theory are connected with the weather via relations between weather, alternatives and consequences. Examples are given of so called decision matrices. It is concluded that tradition and technical assistance have assisted farmers to face complex decisions. Practices that do not fit the climate and economy of an area generally are sooner or later abandoned, and practices that do fit become part of the culture. Technical help in making decisions is generated in economical development from within the society.

WEISS, A. (ED.), 1981
Computer techniques and meteorological data applied to problems of agriculture and forestry: A Workshop. Anaheim: National Science Foundation.

Mostly the use of (near) real-time weather data for agricultural management purposes are discussed in these proceedings because here the computer plays its most immediate role for planning
purposes. Moreover, very often the farmer is supposed to have immediate access to modern communication means to participate in or gain from the information dissemination systems discussed. The low external input (tropical) farmer will therefore not find much he may be able to use. A paper on the potential of modern weather data technology for relevant agrometeorology in developing countries (by Stigter) states that the aim must be to benefit production and producers. As a condition to that aim it starts with identification of the most striking differences in social production conditions between farmers in the developed and most of the developing world. From the bottom upwards local conditions for application, transfer and development of relevant agrometeorological knowledge to small scale tropical farmers are discussed. Computers are concluded to play for the time being a role in generation of needed information only. Honest extension services are mentioned as a "conditio sine qua non" for serving the low-income farmers. On agricultural weather advisories it is stated elsewhere in this volume that even in the USA management-oriented ones are generally not available to farmers and that advisories currently available have little practical utility and therefore are not often incorporated into the management decision making process. It is concluded that spatial and temporal specificity of optimum management practices, a result of variations in the above and below ground environment of crops, different species and cultivar responses to environmental stimuli, and changes in crop sensitivity with stage of development or age, necessitate management practices dependent on precise and quantitative knowledge of existing environmental conditions. A general conclusion of the book may be summarized in the statement that operational agricultural weather and climate information is not efficiently communicated to users in the USA and almost non-existent in the developing world.

WILKEN, G.C., 1972

The only "classic" in the field this bibliography wants to cover and the main starting point and source of inspiration of the only international project existing on "Traditional Techniques of Microclimate Improvement". [See the work of Stigter and associates above and elsewhere in this Joint Rapporteurs Report.CJS.] Traditional farmers are defined as those cultivators of all ages and places whose knowledge and methods are derived from individual and social experience and who use only locally available energy and materials for environmental management. The paper relies on field reports in its identification of farmers’ reasons for using particular management practices and wants to produce sufficient evidence to justify the nomination of
(micro)climate to that group of environmental factors over which traditional farmers exercise significant control. Two aspects of field microclimate are distinguished: preservation of desirable characteristics and generation of these characteristics within the crop zone. In a section on shortwave and longwave radiation, examples of shade management, the manipulation of albedos, surface geometry and longwave transfers are separately dealt with. In a section on heat and moisture this applies to tillage systems, surface mulches and dew. Sections on wind, rain and hail and on maintaining microclimates close this valuable paper. In foot notes the widely scattered existing literature on basic concepts and examples is very adequately covered. The paper nevertheless concludes that its coverage is less than comprehensive, and for good reason. Crop climate management is so widespread and assumes so many forms that a complete catalogue of practices would fill volumes. Nor can extensive quantitative evaluation be attempted, since neither field nor laboratory research has produced much data on the results achieved by traditional methods. [This reasoning was taken over when establishing the CAGM Working Group on Microclimate Management and Manipulation in Traditional Farming in 1982 and its continuation in the present group of Joint Rapporteurs in 1986. CJS.] The paper concludes that traditional farmers the world over employ an impressive array of climate-ameliorating techniques. But information on these practices comes mostly from scattered field observations, with few indications of the results achieved. Measurement of radiation, heat, and moisture fluxes under a variety of crop and field conditions are sorely needed to determine the effectiveness and extent of these climate-control measures. Only after basic data of this kind are available can we go on to such larger questions as how crop limits, growing seasons, and production are (in general) affected by these practices.


This book on the humid tropics agricultural environment differs from others in its immediate association and coupling of basic concepts with actual agricultural conditions and problems at a thorough introductory level. When it discusses moisture, light and temperature, it discusses mainly their use and limitations in tropical crops and illustrates this immediately with actual (especially cash) crop examples. It therefore gets a substantial interdisciplinary character at the lowest possible level of integration without forgetting the principalities of basic concepts neither techniques to quantify the parameters concerned. The balance for these three chapters on soil/plant/atmosphere
interrelated factors regarding light, water and heat is formed by an equal number on tropical soils, organic matter and soil fertility and the rice soil environment. For our particular purposes shorty attention is asked for (supplementary) irrigation, plant spacing, intercropping, shading, leaching and erosion losses in tropical soils, soil conservation in agriculture and finally cultural methods in the rice environment. A modern textbook with the aim of advancing understanding, first approximation quantification, interdisciplinarity, and the feeling that the use of knowledge on the agricultural environment contributes to its optimum use, its protection and conservation. The arid tropics deserve an equally important introductional textbook with the same approach.


In this paper a broader view than commonly met in literature on agriculture in the tropics is taken by including in soil conservation methodology all methods of cultivation that help to maintain the soil in a productive state. Soil conservation is defined as the maintenance or improvement of the productivity and stability of the soil through systems of land use and land management involving appropriate agricultural techniques. In contemporary soil conservation methods in subsistence systems in Papua New Guinea therefore erosion control, fertility control, water control and temperature control are distinguished. Two other sections review (i) evidence for past cultivation practices, their environmental impact, and the ways in which past practices have been modified for new crops and different environments and (ii) the effectiveness of traditional soil conservation in controlling environmental degradation, both now and in the past. Because traditional soil conservation is no longer effective in some areas in controlling soil degradation, the final section suggests ways in which present soil management can be modified or improved for contemporary agricultural production and identifies some research priorities. It is concluded that a soil conservation strategy based on traditional knowledge supplemented by adaptable practices from elsewhere is needed. But the effectiveness of traditional techniques as well as of techniques developed elsewhere are little known and even the rate of actual soil erosion and fertility decline needs quantification for such and for improvement purposes. It is extremely difficult to transfer techniques within the country or to introduce new ones without an extensive environmental
education programme, and initially only modest changes should be attempted.


In an investigation in a Kenyan arabica coffee plantation, the frequency and duration of the micrometeorological conditions necessary for the germination of conidia of Colletotrichum coffeaeum (Coffee berry disease) were evaluated on coffee twigs of different aspects and exposures. The detailed results, in this example to consider the possibility of manipulating the microclimate by pruning to influence disease proneness, indicate that dewfall was nowhere sufficient to lead to any appreciable persistence of the micro-climate necessary for effective germination. Rainfall was necessary both for effective spore germination and for spore dispersal through water splash. East-facing branches appeared (be it not statistically significantly) slightly more disease-prone than west-facing ones because of the more rapid warming of their water films under the influence of the early morning insolation. From the results obtained no weather advisories on pruning operations could be derived. What needs to be investigated is among other things the cumulative effect of potential spore germination periods interrupted by heat or cold. A condition for this kind of work is that the microclimatic requirements for completion of the life cycle of the pathogen are well known. A better result would have been obtained from the point of view of operational results if different pruning operations had induced different microclimates prior to the investigations. The site-specific nature of this kind of research is emphasized. However, of particular importance is the experimental approach with the collection of a wealth of relevant non-routine micrometeorological data with instrumentation that was suitable for African field conditions if proper attention was given to its functioning, maintenance and calibration.


In the time UNESCO was playing a major role in funding and coordinating arid zone research, its series on (problems of the)
arid zone research was laying the foundation for renewed scientific interest in the relations between extreme climate and protection of the agricultural environment in relation to development issues. With its more than 250 references this paper plays that role with respect to microclimatic issues, including topoclimate. The report wants to serve as a basis for planning of research and application of science in the arid zone in the near future with respect to microclimate and its relation with plant, animal and human life. After a general introduction and one on organization of current research and investigation, the present state of knowledge is presented. For our purposes (sub-)sections on irrigation, soil temperature, mulch, shelterbelts and windbreaks, dew and fog, the use of micrometeorological data in applied entomology and plant pathology and finally some remarks on microclimatology in relation to man and domestic animals are most important. A large section on future work and outstanding problems, written now thirty years ago, makes interesting reading. In general the more fundamental microclimatic studies are mentioned for promotion but in the section on microclimatic measurements in relation to plant pests and diseases many more particular problems are discussed, including quite some with manipulation and management aspects. The most interesting recommendation is on promoting the publication of monographs in microclimatology as a quantitative rational assessment of often conflicting data based upon the laws of physics and if possible physiology, to provide arid land civil engineers and agronomists with the information required for the planning and the lay out of a new project on land reform: irrigation, windbreaks, etc.. Shelterbelts, mulch and dew are mentioned as ripe for reassessment using the physical approach, based on the example of evaporation. In the discussion interesting brief reviews are given on microclimatic studies in Pakistan and India. In particular the latter, given by Dr. Ramdas, are very specific with respect to microclimate management and manipulation issues studied there since 1932: treating the soil with black and white powder to influence soil temperature; effects of sprinkling on vegetation surface temperature; effects of windbreaks; effects of shading; effects of evaporation suppressants. In a short concluding report to the advisory committee on arid zone research, by Dr. Ramdas, at the end of the paper and based on its contents, it is stated that the developments of methods of conservation and most economic use of the scanty water resources in the arid zone for maximizing food production, and techniques for assessing the factors controlling the water balance at the ground, assume a very special importance. Care is necessary to ensure that in microclimatic researches the experimental techniques are adequate for the particular purposes in view, it being equally essential to avoid oversimplification of techniques on the one hand as much as over-instrumentation on the other.
When this book first appeared in 1963, it did not have a predecessor of its kind. Although heavily biased to temperature variations in soil, it applied the physical method to a variety of subjects in essential difference with the application of mathematical statistics. Contrary to the latter this physical method changes the empirical character of design and interpretation of experiments. Much that has appeared since makes the contents of this book now part of common knowledge, but the introduction on the physical method remains worth rereading by old and new generations of agricultural scientists, particularly in the tropics. References to management of soil microclimatic issues are made, in the section on tilth and soil temperature, and on the optimum depth of a water table in drainage, in this introductional chapter. We also find such remarks at the end of the chapter on general temperature variations in a homogeneous soil where penetration of frost and thawing are discussed, and scattered through the chapter on sinusoidal temperature variations in a layered soil, where tilled soils and other types of top layers are discussed. Other minor references to microclimate manipulation are found towards the end of the chapter on turbulent transport in air and of course in the chapter on the glasshouse (greenhouse) climate. But the main present quality of this book remains the way it showed towards applying the physical method to quantify and understand the complicated actual agricultural environment.
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nighttime radiation.

Use of natural and planted trees to create favorable crop microclimates


Chapter 11 reviews traditional micro-climate management.


Creating partial forest micro-climates to protect and benefit crop plants.


Arapaho woven fence windbreaks.

OTHER REGIONS


Review of indigenous Maori practices to achieve production in cool climates of New Zealand. Include surface modification, stone walls, windbreaks.


Unfelled trees in swidden plots provide partial shade; reduce evaporation; encourage ligneous reforestation.


New Guinea windbreaks; Polynesian shading; Bahiti (East African) evaporation control; Chinese nitrogen fixation; moisture control.


Heating walls in France.


Banana stands create microclimates invaluable for reforestation.


Trees left in swidden fields; mounding; planting in holes for shade; mulching.


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MORE GENERAL WORKS

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3.4 ANNOTATIONS (P.H. Karing)


A scheme of agroclimatic regionalization of the desert areas of Central Asia for solving problems of vegetative reclamation of pastures is presented. On the example of the Central Karakum methodological possibilities for differential estimation of agrometeorological conditions by relief elements of a complex consisting of ridges and takyrs are suggested. The principle of flexible yearly planning of the amount of vegetative reclamation work with a consideration of weather conditions is substantiated.


A general approach to the problem of making economic decisions for climatologically nonuniform areas is presented. The concept of undifferentiated, differentiated and partly differentiated strategies of economic planning is introduced. A method of assessing their economic efficiency with allowance for the spatial distribution of a varying climate factor is proposed. The choice of an optimal and an
economically warranted degree of regionalization of nonuniform areas is discussed. Some theoretical models are considered. The results from numerical experiments for real spatially nonuniform areas are reported.

3. Каринги П.Х. Эффективность регулирования микроклимата и климата почвы под посевами ячменя. (Karing, P. The efficiency of manipulating microclimate and the climate of soils sown to barley) Труды ВНИИСХМ, 1928, вып. 23. С. 59-70.

Agroclimatic estimated of the efficiency of regulating the water regime on barley fields in different localities are presented. Calculations have been made on the basis of an applied mathematical model of the productive process of spring barley. It has been ascertained that on concrete fields the economic efficiency of manipulating microclimate and soil climate is determined by the level of land cultivation culture on the farm studied and the doses of mineral fertilizers applied.

1. Каринги П. Оценка биоклиматического потенциала производства ячменя в разных микроклиматических условиях. (Karing, P. An estimate of the bioclimatic potential of barley sowing in different microclimatic conditions) Ученые записки Тартуского государственного университета. Структура и ландшафтно-экологический режим геосистем. Труды по географии. Тарту, 1955, вып. 208. С. 3-17.

The reshaping of natural landscapes as a result of human economic activities and the rational use of resources require the exploration of the potential possibilities of every natural complex. On the territory of the Estonian SSR yields depend to a large extent on the microclimatic condi-
tions prevailing on the field. To estimate the bioclimatic potential of barley growing the following indices are used: potential yield \((Y)\), the yield guaranteed by climatic resources \((Y_g)\), optimal water supply \((E_o)\), and the demand of nitrogen \((N)\), phosphorus \((P)\) and potassium \((K)\). For calculating these indices an applied mathematical model of the formation of barley yield considering microclimatic differences has been worked out. The calculation results show that in Estonia the basic factors forming the bioclimatic potential of barley crops are relief, soil and land reclamation.


The book analyzes the role of two main agrometeorological factors - temperature and aerodynamics. The book deals also with methods of affecting these factors. Mathematical models describing the heat and aerodynamic regime under reclamation measures are given. The book contains practical recommendations for fighting such unfavourable phenomena as wind erosion and frost injury of agricultural plants. Much attention is paid to algorithms necessary for the realization of measures for computerized control of field microclimate.


Assessment of the agroclimatic resources of desert and
semidesert pastures of Uzbekistan for solving problems of vegetative reclamation is discussed. The dynamics of the productivity of natural pastures and those where vegetative reclamation has been used is discussed, and the share of different plants in the total yield of phytocenosis depending on weather conditions is ascertained.

The effect of vegetative reclamation measures on landscape structure is studied, and some recommendations are presented for vegetative reclamation with a consideration of soil and geobotanical conditions on the territory concerned.
3.5 CASE STUDIES OF MICROCLIMATE IMPROVEMENT AND PROTECTION OF THE
(LARGELY AFRICAN) AGRICULTURAL ENVIRONMENT AND OF THEIR
QUANTIFICATION: AN ANNOTATED BIBLIOGRAPHY OF PAPERS ON TTMI-I
WORK APPEARED OR ACCEPTED BETWEEN LATE 1985 AND EARLY 1990

[Closed by March 31st 1990; Internal reports, book reviews and
news items excluded]

By C.J. Stigter, TTMI Project supervisor

Research methodology to quantify and understand the modification
of the energy flux at soil/atmosphere interfaces.
In: Proceedings of the International Colloquium on Energy Flux at
the Soil/Atmosphere Interface, Trieste, Italy. ICTP, Trieste.

This is one of two review papers forming the bridge between the
work performed in the DAP-Project at the University of Dar es
Salaam (1976 - 1984) and the TTMI-Project. It discusses external
and internal criteria for tackling agricultural physics research
problems. It distinguishes 10 basic energy fluxes in ecosystems.
It deals with examples of energy flux modifications in
traditional farming and especially distinguishes between
modification of wind, rain (drops and water) and hail kinetic
energy and modifying the surface energy balance.

Physics of mulching, with particular emphasis on grass mulches.
In: Proceedings of the International Colloquium on Energy Flux at
the Soil/Atmosphere Interface, Trieste, Italy. ICTP, Trieste.

This is the second review paper bridging the DAP-Project and the
TTMI-Project. It reviews the mathematical approach developed to
simplify the determination of thermal efficiency of grass mulches
and exemplifies its use with measurements in Kenya and Tanzania.
It also shows solar radiation extinction in such grasses. It
finally indicates how weather advisories may be obtained from
such results.

[The two papers annotated above and the first one annotated below
are the only ones that also occur, but annotated differently,
among the 79 publications in the selectively annotated
bibliography (1960 - 1985), based on Appendix VI c of CAGM Report
No. 25 (WMO/TD-No. 228) prepared also for WMO (CAGM).]
In quest of tropical micrometeorology for on-farm weather advisories.  

This is the first international presentation outside the circles of the Tanzanian National Agrometeorological Committee, CAgM (WMO) and ICTP (Trieste), for which circles it was originally developed, of a new categorization of examples of manipulation of microclimate. This categorization includes examples from tropical agrometeorology. This guest editorial also defines weather advisories of which it believes that it will be the most powerful tool to meet the needs of low-input agriculture if this approach is made operational. It concludes that the agro-ecology of tropical crop space management is in need of a larger micrometeorological input as our contribution to face the challenges of the present food and development crises.

Microclimate Management and Manipulation in Traditional Farming.  
Final Working Group Report submitted to the Ninth Session (Madrid).  
Commission for Agricultural Meteorology, WMO (Geneva), 74 pp.  

This report formed the basis for the CAgM Report No. 25, issued as WMO/TD-No.228 in English (1988), French (1989) and Spanish (1990). Its text was proposed by the Chairman of the Working Group, who chaired the group on behalf of the United Republic of Tanzania, and determined during a Working Group meeting in Geneva by the members of the Group. It was presented in Madrid in November 1986 to be approved by CAgM. Members in the Group were from three countries: FRG; USSR; Tanzania and represented three international Organizations/Institutes: FAO; ICRAF and IITA. The contents are reviewed in C.J. Stigter (1988).

Experimental studies of performance of wind barriers in irrigated crops in Guanacaste Region (Costa Rica).  

The most important information this WMO consultancy mission report gives are design criteria for experimental studies of multiple tree wind barriers to be established against strong winds in planned irrigated food and cash crop agriculture in the
dry season in Guanacaste Region, Costa Rica. It recommends location specific studies of such shelterbelts and of various forms of strip cropping in an attempt to determine the feasibility of large scale projects of this kind.

Wind protection and its aims: background and recommendations; and
What's new in wind protection?
Texts of lectures given in August at the Estacion Experimental Enrique Jimenez Nunez, Taboga, Guanacaste region and the Instituto Meteorologico Nacional, San Jose respectively, in Costa Rica.
Taken up in Appendix III of the consultancy mission report to WMO, pp. 16 - 33.

The lectures contain the results of the study of the agrometeorological literature from which design criteria could be derived for experimental studies of multiple tree wind barriers to be established against strong winds in planned irrigated food and cash crop agriculture in the dry season in Guanacaste Region, Costa Rica.

Traditional knowledge on microclimate modification: an ethnoscienctific approach in Tanzania.

A story, exclusively for those interested in that country, of the outcome of the newspaper contest held earlier in Tanzania on microclimate management and modification in traditional farming in Tanzania. Also a look into the future of such work in East Africa.


A first review, for a wider specialized agricultural audience, of the TTMI-Project rationale and the background that created its approach. It makes use of the results of the surveys of traditional methods made locally in Tanzania and internationally by a Working Group of CAgM (WMO). It also reviews the case studies we had just embarked on in Kenya, Tanzania and Sudan. It reviews conditions for success in this kind of undertakings as
far as it concerns the possible application of results by the low external input farmers aimed at.


This paper reports on a laboratory experiment that for the first time proved by experimental simulation the existence of thermal convection currents in bulk stored maize grain. It also indicates the difficulties obtained, especially in simulating the related moisture transport. It finally informs about a new tracer gas (SF6) method used for the detection of the convection currents in the grain.


A Working Group Report of an afternoon discussion between participants that opted for this subject during the ICRAF/WMO/UNEP International Workshop in Nairobi in February 1987. It is one of the first international recognitions of the importance of microclimate management and manipulation in tropical multiple cropping systems including trees.


The introductory paper of a Newsletter issue on Microclimate Management that I helped compose for the Information center for Low External Input Agriculture (ILEIA). It distinguishes three types of traditional practices: those still successfully in use, but often very locally; those still in use but which no longer meet the increased pressure of changing land use and of other socio-economic changes; and those relatively recently abandoned for various reasons.
Traditional Techniques of Microclimate Improvement: The TTMI Project.
ILEIA Newsletter 3(3): 7 - 8.

A review paper on the TTMI-project and the up to date state of affairs in the case studies we embarked on. It also reviews the international attention obtained and the future of the subject within the CAGM (WMO) with the freshly established Group of Four Joint Rapporteurs.

Mulching with organic materials: knowledge is power.
ILEIA Newsletter 3(3): 10 - 11.

A review paper on mulching as an example of a traditional technique of microclimate management and manipulation. The examples are drawn from the work in Kenya and Tanzania by Othieno, Stigter and collaborators on on-surface dry grasses in young tea and in the open and from the work more recently done by Coulson, Stigter and the TTMI-team in Kenya on alley cropping in a semi-arid area, where tree prunings are incorporated into the topsoil.

Conclusions and Recommendations.

In these conclusions and recommendations an attempt was made by those responsible for initially formulating them for the last session of the Symposium to reconcile the many deviating experiences and statements of the earlier days. By considering the temperate and the tropical countries separately and by distinguishing in both between large(r) and small(er) scale farmers, the information streams from and to those organizations collecting and issuing agrometeorological information and from and to different categories of researchers, farmers and extension people, serving or being part of the differentiated farming communities, could be visualized. It was possible to show this way the sources of earlier detected differences in problems and approaches, both scientifically as well as operationally.
Agrometeorology of the Potato Crop.
Proceedings of a WMO/KNMI/ICP/ISHS Symposium, Wageningen, The
Netherlands. Acta Horticulturae, Number 214, Special issue co-
published by ISHS and WMO, 201 pp.

Proceedings edited on behalf of the organizing committee by the
Chief, Division of Agrometeorology of the World Climate Programme
(WMO, Geneva) and the Vice-president of the Commission for
Agricultural Meteorology (WMO, Geneva).

What information can small-scale farmers use?
In: ISAPAM/J.R. Milford (Ed.), Applicability of agricultural
physics and meteorology in Africa, Proceedings of an ICTP/ISAPAM
Workshop, Addis Ababa University, Addis Ababa. ICTP, Trieste.

Distinguishing (i) Weather forecasting for agriculture; (ii)
Agricultural forecasting and (iii) Weather advisories as ways in
which meteorology and agriculture operationally meet, the last
one is claimed to be most powerful in contributing to solutions
of problems of African agriculture as long as they are obtained
in combining managerial skills of the small farmer with the
quantitative knowledge and understanding that may be gained from
scientific experiments.

Environmental measurements in Africa.
In: ISAPAM/J.R. Milford (Ed.), Applicability of agricultural
physics and meteorology in Africa, Proceedings of an ICTP/ISAPAM
Workshop, Addis Ababa University, Addis Ababa. ICTP, Trieste.

This second Workshop paper deals with conditions of the use of
instrumentation in Africa, especially of course in agricultural
physics and meteorology. It is discussed what University training
may contribute in improving the situation. Examples of the
authors experience have been added to illustrate both conditions
and possible remedies. An Appendix contains recommendations on
data collection from an ICRAF Workshop of which two papers have
been annotated below (Reifsnyder and Darnhofer, 1989). In this
paper also parts of the one of Coulson and Stigter (1988)
annotated below have been used to illustrate what we mean with
appropriate instrumentation.
Appropriateness of instrumentation for agro-ecological research in low-income developing countries.

This paper in the Forum section of a new journal tried to raise attention to the instrumental problems of agro-ecological research in countries that need that research most in assessing the potential for sustainable agricultural development. The existing situation as experienced by the authors in their many years in Africa is discussed and an idea of appropriate instrumentation is rising from treating general and specific examples. Special attention is paid to problems and potential of aid programmes and projects in this context.

Microclimate management and manipulation in agroforestry.
Agricultural University, Wageningen.

Starting from surprisingly applicable recommendations in a publication on climate and economic development of thirty years ago, a research and development framework and some points of departure are defined for dealing with microclimate management and manipulation in agroforestry. Sections on shading, mulching and wind protection each have subsections on traditional knowledge, on their effects and on operational(ity) and transfer of techniques. In an Appendix Stigter, Pietrowitz and Reifsnnyder (1987), annotated above, has partly been reproduced.

Microclimate Management and Manipulation in Traditional Farming.
[French translation available; Spanish translation in preparation]

This is the edited and amended version of Stigter et al., 1986. It has given the research field of microclimate management and manipulation back the place it started to loose in the sixties and had definitely lost in the seventies, due to the rise of glass house agriculture in Western and Japanese agriculture and the more abundant use of fertilizers in horticulture. It is therefore not surprising that it is largely geared to tropical agrometeorology, making use among other sources of answers to a worldwide questionnaire and of material provided by some national and international resource persons. In its state of the art
review it makes use of the earlier identified subjects in need of major attention: shading; mulching; wind protection; surface modification; drying; impact of rain and hail. The ideas worded in the first four of its six recommendations, adopted in 1986 by the CAgM at its ninth session in Madrid, have formed the basis of the present TTMI-Project. The discussion its author delivered to WMO in 1982 (after having initiated the subject within WMO in 1980 as member of another Working Group) and on which the establishment of a CAgM Working Group was based, is reprinted in the Appendices. These Appendices also contain published as well as planned and ongoing case studies, with their literature references, and 100 references for a selectively annotated bibliography. It finally provides tear-out sheets for sending examples of other case studies and references for bibliographies.

C.J. Stigter, 1988
CASAM (Pune, India) and FAO (with ICAR, WMO and UNDP), Rome, 103 pp.
Consultancy report that tries to investigate how much of the TTMI-approach may be used under the conditions of Indian Universities. It also gives detailed suggestions for approaches in local M.Sc.-research, in the fields of hydrometeorology and soil physics, based on the TTMI-philosophy.

Meteorology and Agriculture, where do they meet?
Techniques of microclimate improvement: a Ph.D.-research approach in Africa (Abstract only) and
Quantification of the tropical agricultural environment, why and how?
Texts of three seminars given in September at the Centre of Advanced Studies in Agricultural Meteorology (CASAM), Pune, India (first and last) and at the Indian Meteorological Department (IMD), Division of Agricultural Meteorology, Pune, India.
CASAM (Pune, India) and FAO (with ICAR, WMO and UNDP), Rome, 77-89. Literature on pages 90-97.
Texts of three seminars in which the basic philosophy and rationale of TTMI are explained and illustrated with (largely African) examples. The advantages operational weather advisories have and the role quantification of the tropical agricultural environment may play, yes has to play, in its protection are highlighted.


An example that carries the message that interpretations of primary measured data may become completely different when such data have been obtained independently with different equipment, due to the fact that some of that equipment is improperly used in the field under demanding tropical conditions. It becomes even worse when data are derived from such primary measurements. In the case of leaf temperatures, well tested infra red thermometers have to be preferred above observations made with pyrometers and air temperatures made with thermohygrometers above those available from CO2 measuring equipment.


The arguments on instrument appropriateness in the tropics earlier used by the authors in general are reviewed and exemplified. Bottlenecks are identified. Attention is given to the importance of "hands on" experience in the tropical situation. A table reviews the ideas and the approaches proposed to deliver countervailing power to get the actual problems not further out of hand. It is surprising to note that only few papers in this Workshop dealt with quantification. This shows the needs for more quantitative research in agroforestry to make the recommendations in different farming systems much more operational than they can be today.
Climate.

Minimum requirements for meteorological data collection in Tropical Soil Biology and Fertility (TSBF) studies and in TSBF Programme Centres as well as possible additional meteorological observations have been defined here. It is the first place where internationally also shaded Piches have been recommended for replacing routinely the aerodynamic term in the Penman equation in the tropics.

Quantification of microclimate near the soil surface.

Against all odds of the abundantly found ideas in circles of tropical biologists and soil scientists that microclimate management and manipulation have not contributed much to shaping the agricultural environment of small farmers, we were invited to write this review as evidence of the opposite reality. In this handbook chapter therefore simple quantification methodology to establish the need and results of such interventions is reviewed. In this paper we have also proposed to sharpen the vocabulary in the sense that "modification" of microclimate could best be used in the sense of an inadvertent change in surface exposure or surface properties as a consequence of human action. "Manipulation" then expresses deliberate actions to alter particular severe aspects of the microclimate and "management" reflects the result of preservation of desirable characteristics of the microclimate.

Crop protection from very strong winds: recommendations in a Costa Rican agroforestry case study.

This is an attempt to review what the agrometeorological literature provides as assistance in designing shelterbelts for protection of agricultural crops from (in this case study mainly) mechanical damage from strong winds, including multiple belts. It
discusses in different sections general physical features and such combinations as "shape, composition and height", "length, width and direction" and "distance, number and permeability". There is a separate section on measurements and observations. In a table of recommendations on windbreaks for crop protection three kinds are considered: rows/strips; wider belts; scattered trees and bushes.

The Project "Traditional Techniques of Microclimate Improvement" (TTMI-Project) and the "Groningen Criteria".
Invited paper in: "Reply of the Netherlands research community to the letter written by the Organizing Committee of the Conference". Pre-conference paper for: Conference on Development related Research; the Role of the Netherlands, Groningen, 29-31 March, RAWOD/NUFFIC/RUG, contribution 13, 9 pp.

This paper applies the criteria of the Organizing Committee (of which the author was a member himself for more than two years) to the realities of four years of the TTMI-Project. Subsequently it reviews the preliminary results of the TTMI Ph.D. case studies for the first time in a handy format, including shortly the likely weather advisories springing from these results.

C.J. Stigter, 1989
Agricultural production meteorology for India: a TTMI-like set up of a Ph.D.-Programme at CASAM.
CASAM (Pune, India) and FAO (with ICAR, WMO and UNDP), Roma, 64 pp.

In this second consultancy report to CASAM, a Ph.D.-programme set up has been developed, including a proposal for a staff development "thesis alone" Ph.D.-programme. The latter is, for reasons of Indian University logistics, following partly the sandwich model and partly the TTMI-model (which we now have nicknamed the "picknick" model). For a future regular local Ph.D.-programme ten course proposals have been identified, their outlines have been developed and together with a literature base related to each course they are given in this report. The Ph.D.-research contents have to be further developed following TTMI approaches.
Errors in routine humidity data from Tanzanian stations and their
consequences.
In: Proceedings of the Fourth Technical Conference on Instruments
and Methods of Observation (TECMO IV), Instruments and Observing

A simple statistical approach of one year of routine humidity
data of 17 Tanzanian stations shows that thermohygrometer results
are far superior to unventilated dry and wet bulb thermometry in
routine humidity determinations under Tanzanian conditions of
meteorological observations. Reasons for the failures are given
and consequences, especially for evaporation calculations, are
reviewed quantitatively. It is proposed to abandon such dry and
wet bulb thermometry for routine tropical work. It is suggested
that in Penman calculations of reference crop evaporation and of
open water evaporation, correlated shaded Piche measurements
could replace the aerodynamic term.

The National Radiation Measurement and Calibration Centre in Dar
es Salaam, Tanzania: an appraisal of the early work.
In: Proceedings of the Fourth Technical Conference on Instruments
and Methods of Observation (TECMO IV), Instruments and Observing

From 1976 to 1981 the first radiation measurements on the roof of
the Physics Department of the University of Dar es Salaam were
growing slowly into a full measuring programme at the National
Radiation Measurement and Calibration Station jointly run by
the University and the National Directorate of Meteorology at
that same roof. The paper reviews this work on which the senior
author published earlier with eight local co-authors, his M.Sc.-
and Ph.D.-students, on a large range of radiation subjects. There
is a clear trend from routine radiation instruments towards more
agricultural production related subjects, such as photosynthetic
radiation, solar radiation extinction in grass mulches and long
wave radiation for reference crops.

Ahmed A. Ibrahim, C.J. Stigter, Ali M. Adeeb, Hussein S. Adam and
Development and validation of a shaded Piche evaporimeter for the
tropics to replace humidity and wind speed data in the
aerodynamic term of the Penman equation.
In: Proceedings of the Fourth Technical Conference on Instruments
and Methods of Observation (TECMO IV), Instruments and Observing
This is the first full account of the results obtained in Wad Medani, Sudan, to correlate evaporation of a shaded Piche with the aerodynamic term of the Penman equation. The development of a round axisymmetrical shade for a Piche used outside the Stevenson screen was an important first step. Subsequently the results showed that in our case three different periods of the year should be distinguished for the best correlations: the rainy season, the dry season and a transitional one. The correlations so obtained for Piche evaporation between 12 and 37 mm/day (and aerodynamic terms between 2 and 7 mm/day) were not very different from those obtained earlier in Tanzania for Piche values below 6 mm (and aerodynamic terms below 2 mm).

Users' needs for quantification in tropical agrometeorology: some case studies.

The need for quantification of the tropical agricultural environment with equipment properly tried out under such conditions and matched/adapted to these conditions is illustrated in this paper with case studies from the following areas: shade & radiation interception; surface temperatures; wind induced sand movement and soil moisture under dry conditions. In all cases particular errors were detected in commercially or otherwise available equipment, under the tropical conditions concerned, that had to be attended to for the obtaining of sensible results. Often the data obtained were otherwise inexplicable or led to essentially wrong conclusions.

Routine and research information for agricultural purposes from African Meteorological Services: A Dilemma of Truth and Use.

Starting from the text of a recent review by the author of the Second WMO Long-Term Plan as far as it considers agricultural meteorology, a serious gap is noted between WMO planning, projects and time line charts at one end and African realities of National Meteorological Services and Stations as far as services to agricultural production and agricultural research are concerned at the other. It is even concluded that the gap is at present widening. It is nevertheless suggested that solutions are
available in that same Long-Term Plan, if national governments and international funding organizations would take agricultural meteorology more serious in their financing.


In this paper the aims of the TTMI-Project are reviewed after serious support errors have been identified from the side of International Agricultural Research Institutes towards National ones. Subsequently a short description is given of past, present and planned sub-projects in the three present project countries: Kenya, Sudan and Tanzania. It is concluded from the TTMI-Project results that the triptych combination of local interdisciplinary applied research, local research training and development of weather advisories for low resource agriculture is a suitable model to foster operational extension oriented research at National Agricultural Research Institutes in Africa.


This is an extension of the paper presented in Brussels by Stigter et al. (1989), on users’ needs of quantification in tropical agrometeorology. It is concluded that quantification in tropical agrometeorology in on-station work closely representing on-farm conditions and in actual on-farm situations asks for special attention for the needs of users of equipment, without losing sight of the research problems to be tackled and the advisories to be given.
Agrometeorology of multiple cropping systems: biomass management and the low external input African farmer.

Different forms of multiple cropping are first defined in this paper that shows some trends in the book that Baldy and Stigter are preparing. After an explanation on the limiting factor approach and competition in crop space, examples of multiple cropping systems are given to illustrate their biomass management. In this approach four types of systems are distinguished after their intimacy of system components and their "activity" in "service conditions" between components. The ethnoscientific approach is explained and necessities are shown for transformation of farming systems towards more intensive sustainable cropping with slowly increasing external inputs and labour efficiencies.

An integrated quantification approach of agroforestry interventions: a Kenyan alley cropping case study.

The quantification of alley cropping in semi-arid Machakos District (Kenya) is described in which simultaneous measurements of the cropping system's physical and biological parameters are made (while additional simultaneous chemical measurements were made by others). The major benefits of this type of approach in our case are: the appropriate training of local research scientists; a fuller understanding of the biological potential and sustainability of alley cropping under semi-arid conditions; and the design and development of appropriate methodologies and equipment for agro-ecological research.

Evaporation from Sennar reservoir.
This paper presents the preliminary research results on the comparisons made in evaporation calculations near Lake Sennar, using data of a station established on the lake, a station established at the shore and the inland regular meteorological observational station using the Penman equation, the directly measured radiation being taken to be equal at those stations. Also several other methods are compared with the Penman results and in the search for a minimum meteorological input approach particularly that of Stewart & Rouse appears superior to the others when the Penman calculation is taken to be appropriate for this case of a shallow lake. The replacement of the aerodynamic term in the Penman equation by correlated data of shaded Piches appears also successful. The evaporation calculated in our way appears surprisingly lower than the simple formula presently in use suggests.

Economic considerations of alley cropping for food production in semi-arid areas.

It follows from the experience with the alley cropping system of maize between Cassia siamea studied in semi-arid Machakos (Kenya) that it is economically not successful in the long run, unless it is highly protective against water erosion. This is due to too high competition between crop and tree, especially in seasons with below average rainfall. But also the gain in yield per hectare in the best seasons hardly offsets the yield reduction due to area loss for the maize that is replaced by trees. The competition appears due to shallow rooting of the Cassia, which might have been induced by the pruning regime applied. The cost of providing a good manpower base for agroforestry research is underestimated and the long term implications are not fully understood.

Meteorological hazards and the low external input farmer: some case studies.
The TTMI subprojects are dealt with as based on protection of the agricultural environment from a meteorological hazard such as soil erosion by water and wind, crop damage from strong winds (mechanical and heat advective) and wind born sand and from strong radiation and drought. Many sub-projects have an agroforestry component. In an Appendix six other cases are summarized which did not get funded in West Africa, due to the initial failure of funding organizations to understand two things: the importance of multiple cropping micrometeorology in combatting the on-farm damaging effects of meteorological hazards in low external input agricultural production and the advantages of the network approach we advocate.


The starting point of the TTMI-Project research is the actual situation in African National Research Institutes, including Universities, with deficient financial resources and a limited and vulnerable equipment infrastructure and with only a small experienced senior staff. It appears that local Ph.D.-research and supportive local M.Sc.-research are extremely effective and efficient tools to get local research in Africa moving. In agricultural research, problems to be tackled should be selected together with extension agents and farmers from their immediate environment.


Classification of climate, phenomena relevant to agricultural meteorology (collected after the parameters temperature, wind, evaporation, dew and precipitation) and data collection remained the main sections of this chapter in the successful Elsevier compendium that recently got its third now revised edition.
Studies of sustainable crop yield improvement through an agroforestry intervention, involving postgraduate training, methodology and appropriate equipment development, the collection of data and generation of weather advisories through a multi-disciplinary integrated approach.

This paper, of which the title itself is almost an annotation, reviews the interdisciplinary approach and results of the Ph.D.-work and some supportive M.Sc.-undertakings in the alley cropping research in semi-arid Machakos (Kenya). It puts emphasis on the competitiveness aspects of the alley cropping set up in different rainy seasons and also exploits for the first time the most recent results of the season with the accidentally sown maize hybrid and the revealing season with the normal Katumani B composite maize after this accident.

Tropical grey literature: no place to go?

Compared to the average research paper, even good tropical research papers often have specific deficiencies, not in quality but in content as to kind and quantity of data that can be presented. Inspired by a recent "Current Comments" of Eugene Garfield in "Current Contents" and by experience with the way tropical papers are received by the regular international journals, this letter makes a plea for the original "grey literature" synopsis that started six years ago in the Neth. J. Agric. Sc. but has changed in character since. If an appreciable number of scientific and technical journals in relevant fields would carry such a clearly distinguishable synopsis section, devoted to what happens in the Third World, everybody involved would stand to gain.

Transfer of indigenous knowledge and protection of the agricultural environment: a project strategy in Eastern Africa with National Agricultural Research Institutes.
The cornerstones and the strategy of the TTMI-project are shortly described before transfer of Indigenous Technical Knowledge (ITK) is discussed from the cultural point of view. It is argued that not only the cultural dimensions but also the technical dimensions of the transfer of ITK and ITK principles are problematic in the development context, unless the ethnoscientific approach is taken as it was pictured in books like Brokensha et al. (1980). However, a warning for simplification is given. With this background the four almost terminated TTMI sub-projects are discussed from the point of view of transfer and use of ITK and ITK principles. It is concluded that, on such a wide ITK basis, our project strategy as outlined and exemplified in this paper has contributed to the solution of problems locally felt as environmental protection priorities to be tackled, but of course within today's power limits of National Agricultural Research.

Kees de Wit at the Department of Physics and Meteorology. In: Theoretical Production Ecology, Hindsights and Perspectives, Proceedings of a Symposium to memorize the retirement of Prof. Dr. C.T. de Wit, PUDCC, Wageningen, in print.

Going back to the late forties/early fifties we find Kees de Wit working, in the post-war reconstruction period of the Department of Physics and Meteorology by the physicist Prof. W.R. van Wijk, on his Ph.D.-thesis "A physical theory on placement of fertilizers". It is surprising but very symptomatic for the approach of Van Wijk that, in a period in which the word "interdisciplinarity" was not yet part of our jargon, this work could be done at such a Department. Historically it appears that we have to do with a real school of thinking, which must have influenced de Wit, and not only him, very much. This approach may be summarized as bringing the physics way of thinking into agricultural research, showing the power of the cause and effect relationship thinking beyond the extremely useful but after all more limited, because empirical, statistical approach.

Precautions in using Piche evaporimeters.
Accepted to appear in publication to honour Prof. Jaap Schenk.

From measurements in a Stevenson screen in Tanzania, the Piche evaporimeter is confirmed to be a very suitable and convenient replacement for the aerodynamic term in Penman's evaporation equation. In reporting on the measurements, precautions to be taken for consistent results are derived. It is concluded that
the use of shaded Piches is recommendable for tropical conditions.

Air convection currents in metal silos storing maize grain.
Tropical Science, in print.

In addition to a review of the measurement results of the thesis work of Dr. Uiso, supervised by the two other authors, the consequences of our proof of the existence of the measured convection currents are discussed. Moreover, a new calculation method, derived by the senior author and associates in Korea, is reported to be able to confirm to a very good approximation the amount of moisture we measured as transferred by these currents from the bulk of the grain towards the top grain region. This shows that the simple model we derived explains moisture migration in the maize silos to a large extent.

Detection, causes and consequences of convection currents in bulk stored grain. A synopsis.

This synopsis is a review of the thesis results of Dr. Uiso. In this work for the first time hypothesised convection currents have been shown in situ to exist. This was done in a simulation experiment with columns of maize grain at different temperatures in London as well as in the silos with maize grain in an upland tropical climate in Njombe, Tanzania. For both experiments an SF6 tracer method was developed and skillfully used to show the existence of the ultra low air flows. In the silo these results were supported by those of two other methods using pressure transducers and moving soap bubbles in a glass tube respectively. It appears that the head space may play a very crucial role in measures to reduce the consequences of moisture migration in bulk stored grain in metal silos in the tropics.

Evaporation calculations for Lake Sennar (Sudan): a search for a meteorological minimum input approach for shallow lakes. A synopsis.
This synopsis reviews the M.Sc.-thesis work of Mr. Abdulai (Ghana), who got his degree at the University of Wageningen with distinction, supervised by Dr. Adeeb in the period he was in Sudan, where he collaborated with TTMI Ph.D.-candidate Ibrahim, M.Sc., and supervised in Wageningen by the second author, who with Dr. Adeeb and Dr. Adam supervises the Ph.D.-work in Sudan. In the paper of Ibrahim et al. (1989) on the Sennar reservoir evaporation the experimental approach has been indicated. This thesis proofs with the Wad Medani data, but now for open water evaporation, that Piche data may replace the aerodynamic term in the Penman equation. Piche evaporation is also the only meteorological parameter that correlates well between the three stations. After a search for potential low input approaches and a selection of the most promising ones, it compares Penman calculation results with the approaches of Kohler et al., Priestley & Taylor, de Bruin and finally Stewart & Rouse. The last one appears most promising.

On some experience within the TTMI-Project [Along lines suggested by Jon Moris, 1988]
ODI Agricultural Administration (Research and Extension) Network Newsletter, in print.

Such approaches as the TTMI ones were recently independently advocated by Harrison in his 1987 book on the Greening of Africa and Moris in a 1988 ODI AA (R & E) Network Newsletter. In short we also have been looking for and working on what John Moris called "options for science based interventions in African agriculture". Exactly because of his conclusion that there are relatively few examples of direct transfer of animal and plant production technologies which have worked well in Africa (when they came from outside Africa, KS), we selected the option of attention for (transfer of) African ITK and ITK principles, which have at least been shown to work somewhere under African constraints and conditions. This ethnoscientific approach is essentially different from the Western conventional breeding and husbandry (and recent biotechnology) approach and started for example to take all forms of intercropping and local experiments by farmers serious. Again essentially because of the same conclusion of Moris, which I drew from my Tanzanian experience of nine years, that the main weaknesses in African research are (i) very low institutional productivity and (ii) a local paucity of ideas what might be done (and not only for NGO's, which is a more recent but fruitful idea, KS), we wanted to establish a costeffective modest scale project to show that the TTMI-ideas could increase relevant applied research productivity drastically. This is further adstrucked with our experiences.
C.J. Stigter, 1990
Aspects of traditional techniques of microclimate management and manipulation on a micrometeorological basis for understanding such techniques: a selectively annotated bibliography (1960-1985).
First Report to the Commission for Agricultural Meteorology, WMO, as one of four joint Rapporteurs on Application of Microclimate Management and Manipulation Techniques in Low External Input Agriculture, submitted.

These 56 pages of annotations on 79 relevant publications are based on all non-Russian language references collected by the same author in Appendix VI c of the 1988 CAgM Report No. 25 (WMO/TD-No. 228) for this purpose. This CAgM report was already annotated above.
4. RESULTS OBTAINED IN TESTING AND VALIDATING OPERATIONAL TECHNIQUES AND DOCUMENTATION OF THOSE THAT HAVE BEEN SUCCESSFUL LOCALLY

4.1 Introduction

Given the fact with which the introduction to Chapter 3 was closed, that to the best of our knowledge the TIM1-Project is the only actually operating project that exclusively deals with the subject of this report, it was to be expected that little could be found in the form of explicit documentation on operational techniques that have been shown to be successful locally after having been tested and validated in farmer’s fields or under equivalent conditions.

The reasons for this lack of documentation are rather obvious and have partly been hinted at already in the introduction to chapter 2. Let us take agroforestry systems as an example, as most scientific literature has certainly appeared on such cropping/farming systems, with and without microclimatic aspects, largely due to the stimulating role of the International Agricultural Research Institutes, with ICRAF in a leading role, followed by ICRISAT and IITA. It follows also from the TIM1-project experience that very many traditional practices in our fields of interest have an agroforestry component. We borrow from two papers published at the event of the 10th anniversary of ICRAF. Von Maydell (1987) ends his editorial on international research in agroforestry as follows:

"It is indispensable to benefit from the wisdom and deep-rooted, site specific experience of rural people, cultivating their lands according to well-established traditional rules, but it is likewise indispensable to be ahead of other land uses in order to become or remain competitive. Agroforestry research will thus have to be diversified and to expand into hitherto less considered fields of technical and social science. This will require increasingly higher skills for interdisciplinary work and utmost standards of quality. If such research is carried out by specialists at international levels, there will be the danger of isolating the scientist’s progress from the grassroots practice. (......) In other words, applied research, however dynamic and progressive, will have to make sure that its results will be transferable and at a given time applicable by those for whom they have been developed. The "primitive" farmer’s family will be expected to verify what research teams and computers have designed. This is essential for future evaluation [what we have called: testing and validation. CJS] of agroforestry progress. Evaluation, after diagnosis and design, should form a focal research topic for the future. (......). International research in agroforestry should, therefore, not only be propagated and further developed in a horizontal dimension, i.e. initiating
world-wide cooperation, but also in a vertical dimension, i.e. from top scientists and "high-tech" institutions to the people working with their fields, forests and livestock. This depends on the results of their labour and on many risks, and more than often they were left alone if national or regional programmes did not meet previous expectations or did not correspond with political developments. (......).

Lundgren (1987), talking about the future of the "environment" in which ICRAF will have to work in the early nineties, among other things concludes:

"(......)

- there will be a very rapid increase in terms of technology results coming out of research and development projects; (......);

- one area where the coming three to five years will probably not see any major breakthrough is on the institutional side; the full realization of the potential of agroforestry can eventually only be achieved through an integrated institutional approach (forestry, agriculture, livestock, social sciences, etc.) at all levels - planning, funding, implementation and extension; most of the programmes mentioned in the paragraph above are mono-disciplinary (forestry or agriculture) in approach;

- in view of the two previous statements, there will be a rapidly increasing number of promising technologies produced through research and local, and often externally funded, development projects, but a continued inability by national institutions and donor agencies alike to get these technologies out to farmers and land users through conventional extension channels (which are invariably mono-disciplinary);

(......)"

If this is the conclusion in the most advanced field of research on traditional tropical cropping and farming systems, in which field of agroforestry our microclimatic work has an important role to play (e.g. Stigter, 1988; Reifsnyder and Darnhofer, 1989), it explains sufficiently the lack of documentation on tested and validated operational techniques or even on attempts to test microclimatic aspects of traditional techniques in on-farm or equivalent conditions. Further explanations of this kind and future remedies to which we may contribute have for example been forwarded by Nair (1983) and Moris (1988). We therefore have only two contributions under this chapter.
The first contribution, by Dr. Karing, reviews the experience in the USSR, under what we would consider medium external input conditions in the developing world. Interesting aspects are in particular the high use that is made of scientific methods of analysis and of instrumentation and other methods of observation to quantify the environment concerned and to derive decision power from such quantifications. It is indicated that a new task has been taken up by microclimatologists in the USSR, in working out methods for using information on microclimate in rendering day-to-day agrometeorological services to agriculture (see Chapter 5.). It is observed that measures of microclimate manipulation should always be planned together with improving production conditions on the farm. The contribution ends with a case study on microclimatic considerations in determining amounts of nitrogen to be applied in summer. This contribution is an interesting addition to some of the agrometeorological information that became recently available from the USSR as well (Gringof and Kozinets, 1986; 1988).

The second contribution reviews in a very short form the experience of the ITMI-Project over the first four years of its existence, 1985 - 1989. It indicates the results of its four subprogrammes on respectively an alley cropping system (Kenya), a shelterbelt system to prevent sand encroachment (Sudan), two wind protection systems of respectively shade trees in coffee and a savanna woodland edge (both Tanzania) and water waste protection in an irrigation system (Sudan). It also shows the contexts in which the results were obtained. This material will in a somewhat modified form be published in Warren et al. (1990).

Literature


4.2 APPLICATION OF MICROCLIMATE MANAGEMENT AND MANIPULATION TECHNIQUES
IN LOW EXTERNAL INPUT AGRICULTURE (P.H. Karing)

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Regional agrometeorological research efforts are closely connected with microclimate management. Each region grows its own set of crops, which is harmony with the specifics of agriculture in the region, and is adapted to the peculiarities of the climate and soils. Within the region microclimatic conditions may considerably differ from those optimal for crops grown in the region. Conditions vary within short distances due to physical characteristics of the surface. Besides, different landscape types react to changes in weather in different ways in concrete years. For instance, on dry and warm plots the damage caused by drought is serious; in wet years, on the contrary, the unfavourable effect of superfluous humidity is mitigated on such plots, and the crops do not suffer seriously from unfavourable conditions. The microclimate of wet and cold plots softens the adverse effect of drought, and strengthens that of excess moisture during cold and wet years.

In his economic activities man makes widespread use of the possibilities offered by microclimate, and simultaneously, applies various manipulation techniques to regulate microclimate. Until recently microclimate has mainly been affected without considering the concrete tasks of agricultural production. It has been assumed that any improvement of the microclimate will have a favourable effect on economic activities (Кургенер, Услова, 1988). However, at the present stage the microclimate management and manipulation techniques should be directly connected with the tasks and methods of land cultivation.
I. METHODS OF ASSESSING MICROCLIMATIC VARIABILITY OF CLIMATE CHARACTERISTICS

Microclimatic differences are especially notable in areas located between observation points of a hydrometeorological network and having different landscape conditions. The lack of regular microclimatic observations in observation networks makes it necessary to develop and apply special methods for gathering, storing and processing microclimatic information.

In the Soviet Union an important trend of research in the field of microclimatology has been the assessment of physical regularities of the formation of microclimate, development of new indicators and quantitative characteristics (Микроклимат СССР, 1967; Романова, 1977; Адаменко, 1979; Романова и др. 1983; Мишенко, 1984; etc.). The basic method of acquiring information on the microclimate in different natural zones of the Soviet Union has been experimental, i.e. field observations have been carried out (Микроклимат холмистого рельефа, 1963; Романова, 1977; etc.). The methods and recommendations for investigating microclimate for the needs of agricultural production are discussed in detail in (Руководство..., 1979).

Of great interest are approaches to processing experimental findings in investigating the phytoclimate of forests (Раuner, 1972; Выхристюк, 1977). The authors suggest comprehensive methods for measuring heat balance. The authors require that simultaneous observations be carried out at
least on two plots with different vegetation. The set of observation includes actinometric, gradient, water balance and phytometric ones.

An important element of microclimatic studies for agriculture is research into the effect of microclimate on the vital processes of plants and yield of crops. For studying these problems on the example of perennial grasses in different localities under microclimatic conditions regulated by land reclamation and land cultivation techniques comprehensive methods and a programme of studies have been suggested (Карпин, Мягальный, Лийв, 1977). The programme involves the following measurements:

1. Radiation balance and its constituents.
2. Elements of water balance.
4. Biometric measurements.

The value of the elements of heat balance was found by calculations based on the measurements of radiation balance, evaporation and the registration of meteorological elements. The sum totals of photosynthetically active radiation were also calculated. Observations of meteorological elements consisted of (1) registration of background characteristics (at the height of 2 m), and (2) microclimatic observations.

The complex of biometric measurements includes the assessment of a whole crop and an individual plant. A crop as a whole is characterised by its total biomass and individual organs (leaves, stalks, roots, etc.), the area of leaves, the density of stand; on their basis the indicators of the photosynthetic activity of the crop were calculated. The same characteristics were ascertained also for an indi-
individual plant, in addition the linear size of the plant and its organs were measured every other day.

After a scientific analysis and generalization of experimental materials generalized tables of the microclimatic variability of the elements of climate are compiled. Such tables have been compiled for all major natural zones of the Soviet Union (Гольцберг, 1961; Микроклимат СССР, 1967; Романова, 1977; Мищенко, 1984; Романова, Масакова, Береснева, 1988; et al.). On the basis of these tables and the physico-geographical character of the given locality it is in principle possible to give a very general survey of the microclimate of any locality without conducting special observations.

In solving practical problems on concrete plots of land general microclimatic estimates are often insufficient. Data which involve all peculiarities of the surface in the given place are needed. Microclimatic variability of the elements of climate requires regional concretization.

Numerous examples of regional concretization of the regularities of microclimate could be cited.

In the Non-Chernozém Zone of the Soviet Union agrometeorological conditions prevailing in spring are of special importance for agriculture. For specifying the characteristics of the microclimate in Estonia during this period the following set of observations was used (Пыжлик, 1965):

1. Disappearance of the snow cover.
2. Thawing of the soil.
3. Drying of the soil.
4. Warming of the soil in the arable layer.
5. Minimum air temperature.
6. Maximum air temperature.

For characterizing the microclimate during the whole vegetation period the complex of observations is expanded. Since 1968 microclimatic research has been carried out by the Estonian Hydrometeorological Board and the Estonian Agrometeorological Laboratory of the All-Union Scientific Research Institute of Agricultural Meteorology. The initiator of such research was the Ministry of Agriculture of the Estonian SSR. The aim of the research is to provide agriculture with microclimatic data in the form of microclimatic maps, tables and descriptions of agrometeorological indicators. In addition to the above-mentioned characteristics, observations of the soil moisture and biometric characteristics of the condition of crops are carried out for the spring period.

The observation network consists of a number of stationary observation points (a meteorological station or an agrometeorological post, conducting observations according to a specific programme), an episodic network which includes seasonal observation posts, and expeditious observations. The tasks of expeditious research include investigation of microclimate en route, estimates of the state of crops, and various specific tasks (ascertaining of agrophysical characteristics of soils, parameters of photosynthetic activity of crops, etc.).

By now microclimatic maps of frost hazard and thermal resources have been compiled for a territory of over 40 thousand hectares. Numerous farms have been provided with handbooks of agroclimatic and microclimatic characteristics of agricultural lands on the territory of the given farm,
and also collections of data on meteorology (Faydenn, 1980). Microclimate is of special importance when thermophytic crops are cultivated. Peculiarities of microclimate should be considered first of all for making decisions about the location of vineyards and orchards to protect them from frost (Мищенко, 1986).

In the Moldavian SSR a long-term programme and methods of carrying out a microclimatic experiment (Мищенко, 1985) have been suggested for the regionalization of agroclimatic resources with an evaluation of the significance of microclimate. In principle these methods differ from the above-mentioned ones (Микроклимат СССР, 1967; Романова, 1977) as (1) microclimatic observations should be carried out by stationary observation posts, (2) during the whole year, (3) simultaneously on several observation grounds, (4) microclimatic observations are to be carried out together with agrometeorological evaluation of the state of crops (phenology, yield, etc.).

The complex of microclimatic and agrometeorological observations involves a standard programme of several specialized stations of a hydrometeorological network - actinometric, heat balance, meteorological and agrometeorological. A typical scheme of a microclimatic experiment on a complicated relief envisages that a set of observations consisting of (1) stationary microclimatic grounds, (2) stationary micropoints on the upper and lower parts of slopes and on different soils, (3) itinerary micropoints be present on each testing ground.

The realization of such a widescale microclimatic experiment is a new possibility of operative agrometeorological
provision of agriculture (Мищенко, 1985).

A new task of microclimatology consists in working out methods for using information on microclimate in rendering day-to-day agrometeorological services to agriculture. The Estonian Agrometeorological Laboratory of the All-Union Scientific Research Institute of Agricultural Meteorology carries out research into experimental methods of gathering microclimatic information. The actual work is done by an expedition team operating full-time. Expeditions are arranged in order to get additional information on the microclimate of agricultural lands, phytometric parameters of crops in different locations, agrohydrological characteristics of soils, etc. An important element of this research is the gathering of information for estimating changes in microclimate caused by human activities and the efficiency of using materials about microclimate in production.
II. AGROCLIMATIC ESTIMATION OF MICROCLIMATIC RESOURCES

An important component of agroclimatic estimation of small sections of territory is the consideration of microclimatic variability of the elements of climate. For this purpose background values of the characteristics of the climate under study are ascertained on the basis of data provided by the stations and posts of the hydrometeorological network. For concrete places the background information is specified with the help of the system of microclimatic characteristics, which can easily be presented in the form of generalized tables of microclimatic variability. To go over from calculations for a concrete point to a whole area maps of physical-geographical characteristics of the locality are used (i.e., maps of the exposition and steepness of slopes, relief form, characteristics of soils, vegetation, etc. are used). Microclimatic maps give a detailed survey of microclimatic resources.

The basic principles and methods of largescale microclimatic mapping have been worked out by G.T. Selyaninov (Селянинов, 1938, 1958), and specified by S.A. Sapozhnikov (Сапожников, 1938, 1960), I.A. Golzberg (Гольцберг 1961, 1988, 1967), E.N. Romanova (Романова, 1983), Z.I. Mishchenko (Мищенко, 1984). The experience of mass production of maps and working out agrometeorological recommendations on their basis has shown that (1) manual compilation of microclimatic maps is highly labour-consuming, and (2) in practice the information required for making economic decisions need not
always be very detailed. For example, in a hilly area notable differences in the characteristics of heat and water provision may occur within the boundaries of one field on plots similar as to their microclimate located on the tops, slopes and feet of hills. In practice it is not rational to use different land cultivation techniques here or apply land reclamation measures. Rather general assessment of microclimate is needed within the boundaries of such territorial units.

To solve these tasks a method for line-printer mapping of microclimate and for analyzing these maps with the help of an alphanumerical computer АШПУ ЭВМ (Карин, 1973; Карин, 1980), and a method for territorial assessment of microclimate have been worked out.

The initial information required for compiling maps and analyzing the peculiarities of the territorial pattern of microclimates as well as in manual microclimatic mapping is meteorological information provided by the network of hydro-meteorological stations for characterizing the general climatic background, tables of microclimatic variability of climatic elements and maps depicting the characteristics of the underlying surface.

On the basis of a map of the characteristicas of the surface a list of microclimate-forming factors in the given locality is drawn up. Here we refer by microclimate-forming factors to elements of landscape which bring forth deviations from the general climatic background at least with regard to one element of climate. The list is compiled on the basis of generalized tables of microclimatic variability of the elements of climate. By now systems of tables of
miroclimatic variability of radiation characteristics, various thermal characteristics of the air and soil, wind speed, soil moisture, evaporation, etc. have been compiled for the main natural zones of the territory of the Soviet Union. These tables show the dependence of the above-mentioned elements of climate on the steepness, orientation and part of the slopes, mechanical composition of soil, land reclamation, vegetation, etc.

The information on microclimate-forming factors is input into the computer with the help of a system of reference points as the type of computers widely used today cannot directly accept two-dimensional cartographic information. The system of reference points is constructed so that the distance between the points on the map is determined in strict accordance with the possibilities of the computer (Apple). The boundaries between the contours can be fixed and the maps printed by the computer as shown in (Monmonier, 1975).

If we write all the reference points in one row according to the given rule, it will be possible to compile a matrix of geographical data (F) of the territory studied as follows:

\[
F = \begin{bmatrix}
  x_{11} & x_{12} & \cdots & x_{1n} \\
  x_{21} & x_{22} & \cdots & x_{2n} \\
  \cdots & \cdots & \cdots & \cdots \\
  x_{m1} & x_{m2} & \cdots & x_{mn}
\end{bmatrix}
\]

where \( x_{mn} \) — characteristics of the studied phenomena \( x_m \) in a given point \( n \) of the territory under study.
a given point \( n \) of the territory under study.

One row of the matrix \( B \) characterizes the territorial distribution of the characteristics of the phenomena, one column gives information on the variability of various indicators in a certain point.

In order to make qualitative estimates of the peculiarities of the territorial distribution of the elements of climate on microclimatic maps, a set of territorial characteristics was used. The set includes the following characteristics:

1. The number of gradations on the map of the phenomenon studied \( (A) \).

2. Weighted average value \( A \) over the area of the plot studied.

3. The percentage of the areas having the same value of the state of the phenomenon.

4. Entropy \( H \) of the phenomenon \( A \) found using the following formula:

\[
H(A) = -\sum_i p(a_i) \log_2 p(a_i), \quad (1)
\]

where \( H(A) \) - entropy of the phenomenon \( A \),

\( p(a_i) \) - the probability of the state \( i \) of the phenomenon \( A \).

5. The uniformity coefficient

\[
\phi = \frac{H(A)}{\sum_i p(a_i) \log_2 p(a_i)}, \quad (2)
\]
where $H(A)_{p}$ is entropy of the phenomenon A in case of its equal-probability state i.e.,

$$p(a_0) = p(a_1) = p(a_2) = \ldots = \frac{A}{C}.$$  

Depending on the concrete task also other characteristics showing interrelationships between areas with different states of the phenomenon A as well as linear dimensions of the areas may be applied (Kaušila, 1981).

For calculating characteristics of the spatial distribution according to the formulas (1) and (2), the number of the elements in one row of the matrix B to I is normalized so that the ratio of the number of the rectangles corresponding to the gradations of the indicator to the total area of the territory studied would be equivalent to the probability.

Microclimatic research is highly important on agricultural land with a variegated relief and great variability of soils. A good example here is the hilly area in South-East Estonia. Expeditious investigations carried out in this region have enabled to concretize regionally the tables of microclimatic variability of the influx of solar radiation, air and soil temperature and moisture. Relying on the data of the nearest meteorological station on the climatic background, landscape maps and tables of microclimatic variability, microclimatic maps of the above-listed elements of climate and their complexes have been compiled. The maps show that on agricultural lands with a broken relief and highly diverse soils a large number of different types of microclimates (sometimes over 20-30) occur. An analysis of
the territorial characteristics allowed us to draw the conclusion that regardless of the large number of possible types of microclimate under certain physico-geographical conditions, only three or four of them are predominant. To solve practical problems in agriculture the predominant types of microclimate should be considered first (Карпин, 1974). These results are in good agreement with theoretical estimates of the potential efficiency of the spatial differentiation of the solutions concerning land cultivation techniques. It has been proved that in the majority of cases there is no necessity for differentiations on the basis of all gradations of the variegating spatial factor, economically it is rational to consider 3-4 gradations of the variegating parameter (Жуковский, Закарян, Саюн, 1986).
III. THE EFFICIENCY OF MICROCLIMATIC MANIPULATION IN CASE OF DIFFERENT LEVELS OF LAND CULTIVATION CULTURE

The yields of agricultural crops on a certain field depend on the socio-economic factors of the given farm and the soil and climatic factors of the field concerned.

For studying the advisability of microclimate manipulation on concrete farms and also for quantitative estimation of its efficiency under different landscape conditions, the concept of relative yielding capacity $Y_i$ has been suggested by the author (Kapner, 1988). The value of $Y_i$ is found by the following equation:

$$ Y_i = \frac{Y_{pi}}{Y_m}, \quad (3) $$

where $Y_{pi}$ - the yielding capacity of the crop under the natural regime of climatic factors,

$Y_m$ - the yielding capacity of the crop under an optimal regime of the manipulatable climatic factors and under the natural regime of the factors not manipulatable by man.

Formula (3) can be written as

$$ Y_{pi} = Y_m \cdot Y_i, \quad (4) $$

The efficiency of optimizing the yield capacity factors reflected by an increase in the yield $Y_i$ of the crop studied is calculated as follows:
\[ \Delta Y_i = Y_m - Y_{pi}, \]  
(5)

or, using also formula (4):

\[ \Delta Y_i = Y_m (1 - Y_i), \]  
(6)

The yielding capacity \( Y_{pi} \) can be calculated on the basis of the following formula (Карин, Еарчева, Тооминг, 1987):

\[ Y_{pi} = Y_e \sum_{i=1}^{n} F_i(K_i), \]  
(7)

where \( Y_e \) — maximum estimated yielding capacity with a consideration of the socio-economic factors of the farm under study,

\( F_i(K_i) \) — function showing the effect of the natural factor \( K_i \) on the yielding capacity.

In the calculations the effect of photosynthetically active radiation (PhAR), air temperature and moisture conditions on the yielding capacity are taken into account.

Provided all socio-economic and natural factors affecting yielding capacity are optimized, the crop's yielding capacity will become equal to its potential one which is determined by the influx of PhAR and the biological peculiarities of the crop studied (Тооминг, 1977). The potential yielding capacity is calculated with the help of the formula

\[ Y_n = k_0 \int_{0}^{n} \eta_n(t) \alpha(t) dt, \]  
(8)

where \( \eta_n \) — potential efficiency coefficient of the crop.
\( Q_f \) - photosynthetically active radiation,
\( q \) - fuel value of plants,
\( T_o \) - length of the vegetation period or its part,
\( K_o \) - coefficient of the economic effectiveness of the yield.

The temperature factor \( K_T \) is determined by the following formula after (Дмитренко, 1976):

\[
K_T = e^{-a \left( \frac{T_k - T_{opt}}{10} \right)^2}
\]

(9)

where \( T_k \) - average daily air temperature measured at meteorological stations,

\[
a = \begin{cases} 
+1 & \text{if } T_k < T_{opt}, \\
+2 & \text{if } T_k > T_{opt}.
\end{cases}
\]

On concrete fields the air temperature may differ from due to the effect of the relief, water bodies forests and other microclimate-forming factors. In such cases the values of \( T_k \) are applied as background characteristics, and the microclimatic variability of the temperature as temperature correction \( \Delta T_k \). When the correction of microclimate was taken into account in calculating \( K_T \) the following formula was obtained:

\[
K_T = e^{-a \left( \frac{T_k + \Delta T_k - T_{opt}}{10} \right)^2}
\]

(10)
On the basis of formulas (7) and (10) the yielding capacity \( Y_m \) is determined according to the following formula:

\[
Y_m = Y_e \left[ 1 + \frac{a \left( T_{kk} + \Delta T_{kk} - T_{opt} \right)^2}{\Theta} \right]
\]

(11)

The moisture conditions of the fields sown to barley are characterized by relative evaporation

\[
K_{ww} = \frac{E}{E_o}
\]

(12)

where \( E \) — evapotranspiration of vegetation,

\( E_o \) — optimum water consumption.

The yields of agricultural crops can be raised by means of optimizing the soil climate only if the demand on the plants in mineral nutrients is satisfied. The quantities of \( N_o \), \( P_o \) and \( K_o \) required for obtaining good barley yields were calculated on the basis of the following formulas:

\[
N_o = C_N Y_m
\]

(13)

\[
P_o = C_P Y_m
\]

(14)

\[
K_o = C_K Y_m
\]

(15)

where \( C_N \), \( C_P \) and \( C_K \) are respectively the nitrogen, phosphorus and potassium contents in a unit of the barley crop.

The average coefficients used for the territory of the
Estonian SSR in our calculations were $C_n = 23.8$, $C_p = 8.4$, and $C_k = 20.4$.

The reduction of yields due to insufficiency of nutrients in the soil was taken into consideration by means of the following functions (Карпинг, Барчева, Торминг, 1987):

$$
K_n = e^{-\left(\frac{N_n + \Delta N}{N_o} - 1\right)^2}
$$

$$
K_p = e^{-\left(\frac{P_n + \Delta P}{P_o} - 1\right)^2}
$$

$$
K_k = e^{-\left(\frac{K_n + \Delta K}{K_o} - 1\right)^2}
$$

where $K_n$, $K_p$, $K_k$ - coefficients of the yield loss due to the shortage of nitrogen, phosphorus and potassium, respectively, $N_n$, $P_n$, $K_n$ - nitrogen, phosphorus and potassium reserves in the soil, $\Delta N$, $\Delta P$, $\Delta K$ - doses of nitrogen, phosphorus and potassium fertilizers applied.

The required norms of irrigation under the conditions of insufficient moisture were calculated with the equation

$$
\Delta E = E - E_o.
$$
As an example calculations were made to estimate the efficiency of manipulating microclimate by means of optimizing the water regime of the soil on the territory of one state farm situated in a hilly area in the Estonian SSR. In recent years the maximum yield of barley has amounted to 3.8 tons/ha on this farm.

On the basis of an analysis of soil and microclimate maps of this farm production types for cultivating barley were suggested for localities with different microclimates and soil climates. Tops of hills, their northern and southern slopes, lowlands and flat areas were distinguished. On slopes, the upper, middle and lower parts and feet were distinguished, on lowlands with drained loams and those suffering from temporary superfluous moisture were distinguished. On flat areas the climatic peculiarities of the plots not far from one another were discriminated on the basis of the distribution of loams and sandy loams.

The potential yielding capacity of barley is $Y_n = 9.3$ tons/ha on a plot in a flat area, on northern slopes of hills it is 8.7 tons/ha, reaching on southern slopes 9.5 tons/ha. The effect of atmospheric temperature is the most notable in May and June. On the hilltops and upper parts of slopes the air temperature is close to optimal for barley, in other places the yields are up to 7 per cent lower due to low air temperature.

The greatest variation in barley crops in hilly areas is caused by moisture conditions. Both plots suffering from superfluous moisture and insufficient moisture are found in such areas. The greatest losses of yields — up to 60 per cent — occur at the feet of northern slopes due to super-
fluous moisture. Favourable moisture conditions prevail on lower parts of southern slopes and in flat areas with loamy soils. The combined effect of the microclimatic variability of photosynthetically active radiation and atmospheric temperature brings about a 7 per cent loss of yields on lowlands and a 10-15 per cent loss on northern slopes. The effect of the whole complex of the climatic factors studied here causes up to 50 per cent loss of yields on lower parts of northern slopes. The most favourable conditions are enjoyed by plots located on lower parts of southern slopes where yields vary due to climatic factors not more than 1 per cent.

Agroclimatic indicators of the efficiency of manipulating microclimate and soil climate were calculated with the absolute maximum yielding capacity on the farm during the period studied, $Y_e = 3.8$ tons/ha, serving as the indicator of the barley yields in case socio-economic factors are provided. The results are presented in Table 1.

In practice microclimate management is accomplished by means of regulating the water regime of the soil. Light and thermal resources of the air are practically unmanageable on agricultural fields. Therefore in Table 1 the values of $Y_m$ were determined on the basis of data on PhAR and air temperature, while for calculating those of $Y_{pi}$ all climatic factors studied were considered. Table 1 shows that the efficiency of manipulating microclimate varied greatly in different localities. Provided the development level of productive forces prevailing on the state farm presently remains stable, optimization of the water regime of the soil will raise the barley yield by 1.4 tons/ha as the maximum.
Both irrigation and drainage are needed. Their maximum efficiencies differ little in hilly areas. With the raising level of land cultivation culture the efficiency of microclimate manipulation increases. Table 1 shows that in case of a 9.3 tons/ha yielding capacity under average yearly climatic conditions the efficiency of regulating the water regime can be expressed as an increase in the yield surpassing 3 tons/ha.

Table 1 also shows calculation results at the level of $Y_e = 1.0$ ton/ha. At such a level of agricultural production the efficiency of manipulating microclimate and soil climate is very low -0.5 ton/ha or lower.

To get barley yields of 3.8 tons/ha only 199.8 kg/ha of mineral fertilizers, among them 90.4 kg/ha nitrogenous ones are needed. To get 9.3 tons/ha the amount of complete fertilizers required is 489.1 kg/ha of which 221.3 kg/ha should be nitrogenous fertilizers.

Optimization of water regime in case of estimated yields of 3.8 tons/ha increases the demand for complete fertilizers as a maximum to 68.3 kg/ha (30.9 kg/ha nitrogenous, 10.9 kg/ha potassic and 26.5 kg/ha phosphorus). If the estimated yield is 9.3 tons/ha the potential demand for complete fertilizers may amount to 173.5 kg/ha, among it up to 78.5 kg/ha of nitrogenous, 27.7 kg/ha potassic and 67.3 kg/ha phosphorus fertilizers.

It is advisable to arrange all plots into groups on the basis of relative variability of barley yields due to microclimate and soil climate. Group I might include plots with relative variability of yields up to 10 per cent, i.e. lower parts of the southern slopes, drained loams in low-
lands and old arable lands in flat places. Group II should then include upper and middle parts of northern slopes and sandy loams in flat areas where the yields vary from 11 to 20 per cent. Group III would include feet of southern slopes and temporarily excessively wet and drained sandy loams in lowlands where yields vary from 21 to 30 per cent. Group IV is for plots where yields fluctuate over 31 per cent—hilltops, lower parts of northern slopes and middle parts of southern slopes.

Figure 1 gives a survey of the efficiency of nitrogenous fertilizers in the above-described four locational groups for 9.3 tons/ha and 3.8 tons/ha yields. It can be seen that the efficiency of fertilizers depends notably on the level of yields. If the yield level is below 3.8 tons/ha, the efficiency of each additional kilogramme of nitrogen does not practically depend on the peculiarities of microclimate up to 60 kg/ha. If the yields are 9.3 tons/ha, such fertilizer dose will be up to 100 kg/ha. If fertilizer doses are increased to the amount demanded by plants, the efficiency of each kilogramme is almost nil. Further increase in fertilizer doses will have a negative effect on yields.

As the above-presented material shows that the efficiency of microclimate manipulation depends notably on the level of land cultivation on the given farm, and the doses of mineral fertilizers applied. The higher the production level, the higher also the efficiency of microclimate management. Measures of microclimate manipulation should always be planned together with improving production conditions on the farm.
<table>
<thead>
<tr>
<th>Position</th>
<th>ΔE</th>
<th>$\bar{Y}_e =3.8 \text{ tons/ha}$</th>
<th>$\bar{Y}_e =9.3 \text{ tons/ha}$</th>
<th>$\bar{Y}_e =1.0 \text{ tons/ha}$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>$Y_m$</td>
<td>$Y_{pi}$</td>
<td>$\Delta Y$</td>
</tr>
<tr>
<td>1. Hilltop</td>
<td>59</td>
<td>3.8</td>
<td>2.5</td>
<td>1.3</td>
</tr>
<tr>
<td>2. Northern slope</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>upper part</td>
<td>0</td>
<td>3.4</td>
<td>3.4</td>
<td>0</td>
</tr>
<tr>
<td>middle part</td>
<td>0</td>
<td>3.3</td>
<td>3.3</td>
<td>0</td>
</tr>
<tr>
<td>lower part</td>
<td>-46</td>
<td>3.3</td>
<td>2.4</td>
<td>0.9</td>
</tr>
<tr>
<td>foot</td>
<td>-71</td>
<td>3.2</td>
<td>1.8</td>
<td>1.4</td>
</tr>
<tr>
<td>3. Southern slope</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>upper part</td>
<td>57</td>
<td>3.8</td>
<td>2.5</td>
<td>1.3</td>
</tr>
<tr>
<td>middle part</td>
<td>49</td>
<td>3.8</td>
<td>2.7</td>
<td>1.1</td>
</tr>
<tr>
<td>lower part</td>
<td>0</td>
<td>3.8</td>
<td>3.8</td>
<td>0</td>
</tr>
<tr>
<td>foot</td>
<td>-39</td>
<td>3.7</td>
<td>2.8</td>
<td>0.9</td>
</tr>
<tr>
<td>4. Lowland temporary</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>excessive moisture</td>
<td>-30</td>
<td>3.5</td>
<td>2.9</td>
<td>0.6</td>
</tr>
<tr>
<td>drained loams</td>
<td>25</td>
<td>3.5</td>
<td>3.0</td>
<td>0.5</td>
</tr>
<tr>
<td>drained sandy loams</td>
<td>0</td>
<td>3.5</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>5. Hat area</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>loams</td>
<td>17</td>
<td>1.7</td>
<td>3.3</td>
<td>0.4</td>
</tr>
<tr>
<td>sandy loams</td>
<td>0</td>
<td>3.7</td>
<td>3.7</td>
<td>0</td>
</tr>
</tbody>
</table>
Fig. 1. The efficiency of nitrogenous fertilizers under various conditions of microclimate and soil climate in the Estonian SSR in case of estimated yields of 93 tons/ha (a) and 3,8 tons/ha (b).  
1, 2, 3, 4 – numbers of locational groups,  
5 – background indicator.
IV. CONSIDERATION OF MICROCLIMATE IN DETERMINING THE NORMS OF NITROGEN APPLICATION IN SUMMER

The efficiency of applying mineral fertilizers, especially nitrogenous ones, varies notably from year to year depending on weather conditions. The most notable influence on the efficiency of nitrogen is exerted by moisture conditions, this is apparent already in case small doses of nitrogen are applied. With increasing doses of nitrogenous fertilizers the dependence of the efficiency on moisture conditions rises (Федосеев, 1979).

An important role in the system of yields management is played by summer fertilization with nitrogen.

The microclimate of different localities of growing agricultural crops may be taken into consideration using the methods suggested in "Способ определения норм летних азотных подкормок" (Варчева, Карпин, Тооминг, 1988).

In accordance with these methods the norms of summer fertilization with nitrogen are calculated taking into account the agrometeorological conditions during the period of maximum growth in the area of leaves. The size of leaves' surface may be calculated either on the basis of the area of leaves' surface, or the weight of the dry biomass of the leaves. A promising method of determining a continuous curve of the growth in the area of leaves is presented in "Способ оценки состояния посевов сельскохозяйственных культур" (Тамметс, Тооминг, 1986). According to this method the changes in the area of leaves are found on the basis of
changes in the transmission coefficient, i.e. total solar radiation above and inside the crop is measured with a pyrheliometer connected to a recorder. During the period of intensive growth of leaf surface the sum of precipitations, the sum of radiation balance and moisture content in the root layer at the beginning and end of the period are measured, and then the norm of summer fertilization is fixed.
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4.3 APPLICATION OF TRADITIONAL KNOWLEDGE AND PROTECTION OF THE AGRICULTURAL ENVIRONMENT: THE TTMI-PROJECT EXPERIENCE (C.J. Stigter)

INTRODUCTION

In their recent impact study of agricultural research in tropical Africa, Jahnke et al. (1987) state that any beneficial role of International Agricultural Research (IAR) relates to the reorientation of National Agricultural Research (NAR), the enhancement of scientific capital (including human capital) and the systematic elaboration of promising research areas in view of a slow but sure progress in agricultural productions. Obviously, the strength of NAR is the crucial problem for IAR success in tropical Africa, they add, and despite severe shortcomings of NAR and its even negative effect on IAR impact there, no substitute for NAR exists. For the fairness of argument it should be added to this latter statement that certainly until today IAR has had negative effects on African NAR as well. High priority should therefore be given to strengthening and improving appropriately the performance of African NAR (Jahnke et al., 1987; Stigter and Weber, 1989).

This priority is one cornerstone of the rationale of the project Traditional Techniques of Microclimate Improvement (TTMI), that started officially in 1985 after a successful trial of its approach in the early eighties at the University of Dar es Salaam, Tanzania. Another cornerstone is the belief in the content of McCall’s (1987) statement used as motto for this paper, with the explicit addition that also those scientists participating from within Africa in NAR are or have become outsiders in this respect. A third cornerstone is the conclusion drawn from national (Stigter, 1985) and international (Stigter, 1988a) surveys that many traditional environmental management and manipulation techniques, especially those developed in harsh and marginal environments or under increasing intensity of land use, are highly protective with respect to the agricultural environment. A last cornerstone to be mentioned is the conviction that outsider scientists can contribute to the obtainment of a better understanding of Indigenous Technical Knowledge (ITK) - and in that way to a more relevant assessment of its transferability - mainly by seriously studying and appropriately quantifying the endangered tropical agricultural environment of traditional farming in order to reveal hidden parts of the cause and effect relationships (Howes, 1980; Stigter and Darnhofer, 1989; Stigter et al., 1989a).

PROJECT STRATEGY

In short, the TTMI-Project, internationally backstopped from The Netherlands, works with local Ph.D.-candidates, which are either junior staff members of local Universities or of other local NAR Institutes, supervised by teams of (mainly local) co-supervisors. The students do their thesis on a jointly identified local
problem of low external input farmers that involves the understanding and subsequent use of traditional ITK of microclimate management and manipulation such as mulching, shading, wind protection and other surface modification techniques. Such ITK or ITK principles may have been developed in the area concerned or been proposed for transfer from experience obtained elsewhere. The ultimate aim of all Ph.D.-research is to develop a weather advisory (Stigter and Weiss, 1986), which may be defined as a production advisory regarding use or manipulation of meteorological conditions, in or close to the space occupied by crops and animals or their products, to increase quantity and quality of crops, animals and yields and their protection as well as that of the production environment.

The background ideas of ITM, its first steps, the difficulties met and some early results have been well documented (e.g. Stigter, 1987a; 1987b; 1989; Stigter et al., 1987a; 1987b; 1989b; 1989c; 1989d). Such approaches as ours were recently independently advocated by Harrison (1987) and Moris (1988). In this paper we want to discuss to what extent actual transfer of ITK and ITK principles is possible with respect to protection of the agricultural environment in Africa, which transfer has been and will remain the ultimate aim of the TTMI-Project.

TRANSFER OF INDIGENOUS TECHNICAL KNOWLEDGE

One of the outcomes of our surveys on traditional techniques confirmed earlier findings (e.g. Allan, 1965) that ITK in East Africa was extremely local and transfer apparently very limited (Stigter, 1988a). East Africa is primarily an agrico-pastoral society. And if aesthetics are culturally based, Kamera and Mwakasaka (1981) state, then East African creative and critical lore must derive from the socio-cultural milieu in which indigenous East Africans move and have their being. Going once more over their East African folktales, it struck me that "knowledge" is most often dealt with in the taboo sphere. In the Pare tale called "Wisdom" this is strongest worded. "Know how to keep your secrets. Even if you have a friend dearer than yourself, even if you have a wife you love more than your life, keep your secrets from them", an old man advises after having been asked for some words of wisdom. And when the man who was told like this violates this rule, he looses all his wealth, which he had wanted to trade for wisdom. And the tale "Morile", coming from the Chagga's, from whose environmental management experience on the slopes of the Kilimanjaro so much may be learnt (Ok'ting'ati, 1984; Fernandes et al., 1984; Maro, 1988), ends with the tragic words of the disappearing Morile: "Mother, I told you; Mother I warned you: Don't feed me on taboos", where he meant that his mother should not have broken the food taboos of somebody else. Whether this is at least part of the explanation
for the highly location specific environmental management and manipulation ITK in agricultural undertakings and the apparent lack of its transfer can only be speculated upon, but the highly tribal specificness of the knowledge that we collected in Tanzania of course points into the same direction. [Also compare Brokensha et al., 1980 and Harrison, 1987 for this tribal specificness of ITK].

Whatever the truth, differences in success to survive high population pressures and the problems harsh environments pose are mainly due to the fact that the skill and diligence with which local groups in Africa apply themselves to the task of farming are the immediate determinants of the level of agricultural output and its growth (Anthony et al., 1979). Knowing that population pressure will keep growing for quite some time and that this and other factors severely endanger the agricultural environment, we should among other things assist in transferring, adapting, validating and improving the essentials of what were locally shown to be the most promising techniques. Kusum Nair (1983) states that the capacity to provide backup research to support and maintain high levels of productivity of improved practices and plant varieties that are available is very limited in Africa and that in fact even the methodology for tailoring technical packages to fit location-specific requirements has yet to be developed. This is particularly true when technical packages would be introduced from beyond Africa (World Bank, 1981; OTA, 1984; Elfring, 1985, Wolf, 1986). However, already a decade ago papers of Brokensha and Riley (1980), Richards (1980), Belshaw (1980), Knight (1980), Howes and Chambers (1980), Howes (1980) and Warren (1980), to mention those most important with respect to the agricultural environment in Brokensha et al. (1980), clearly demonstrated that only the ethnoscientific approach was a way out of this dilemma and the more so in the present conditions of rapid change. However, this publication also showed that actual information was still widely scattered and in fact relatively little used in rural development projects and programmes for low-input farmers. On the other hand it provided a so consistent picture of the value of ITK and the potential of its use, that was so completely different from what was hitherto generally persistent, that the main question virtually remained: "where do we go from here in practice?".

Proposals as in the paper of Howes and Chambers (1980) were setting the trends. Work as that of Richards (1985) and Chambers and Bhildyal (1985) started to provide the necessary details. Developments as exemplified by the appearance of the ILEIA Newsletter (1985 - 1989) showed that winds of change were starting to blow. Also more recently McCall (1987) concluded from his own review for East Africa that the articulation of ITK has started to show to be able to act both as the means and the end in promoting rural people's participation as a condition in local development. An East African bibliography on ITK of the same
author (McCall, 1988) forms strong shoulders to stand on in any attempt of studying ITK and its principles and in considering it for transfer within or toward a region in East Africa.

However, there remains a long way to go and overoptimism might be dangerous. Paul Harrison (1987), in his optimistic but inspiring chapter on "The secrets of success" also takes participation as the key and states that none of the successful projects he selected to describe involves any increase in exposure to climatic risk. Indeed, many of them reduce risks and protect farmers and their crops and animals against the vagaries of the climate, he states. However, based on his earlier assessment that agroforestry is arguably the single most important discipline for the future of sustainable development in Africa, compared to our TIMI experience he starts to simplify matters by noting that the basic principles of alley cropping are so straightforward they can be put across in six simple drawings with one-sentence captions. We will proof below that this is unfortunately not true.

With this warning for simplification as a background it may make most sense to use the remainder of this paper to discuss the difficulties we meet in our project strategy, which was explicitly based on developments in the early eighties and which has seriously tried to contribute to the transfer and use of ITK and ITK principles, in some well defined priority areas of microclimate management and manipulation.

SOME EXAMPLES WITH SUCCESS AND FAILURE

Alley cropping

We read about the successes obtained with alley cropping, as an alternative to shifting cultivation and other systems now endangering the agricultural environment, based on indigenous knowledge of combining crops and trees, especially in the sub-humid conditions of West-Africa by IITA (e.g. Kang et al., 1984). Therefore we joined the Dryland Agroforestry Research (DAR) Project set up by several Kenyan NAR Institutes, advised by the Agroforestry IAR Institute ICRAF, at Machakos, 70 km East of Nairobi, that studied on-station an alley cropping system of composite maize, being the local staple, grown between *Cassia siamea* trees. After a participation of seven seasons (maize can be planted twice a year in this area) our conclusion must be (Coulson et al., 1989; Mungai et al., 1989; Stigter et al., 1989d) that this particular system should not be advised to farmers. Only in about average and especially in above average rainfall seasons, the maize between the trees, of which prunings are used as mulches to sustain soil fertility, yields appreciably better. However, in below average rainfall seasons, when the
conditions for the obtainment of reasonable yields are most
difficult, the trees compete too much and the maize yields
between the Cassia become even less than on the unmulched soil
without the trees. Without going in too much detail, the
conclusion must be that it was wise not to have trials of this
system on-farm as the risk was too high. Apparently we don't
understand alley cropping under semi-arid conditions sufficiently
for the right choices yet to be made. But what to do now? As in
all applied scientific research there are quite some options.
Have we made the wrong choice? Do we continue the maize/Cassia
system in other management options? Would the system have been
more beneficial, because more protective, under higher rainfall
run-off conditions in the plots without trees? Do we try other
systems? Can the farmer wait for us? Or did we only contribute
just one more stone to the ivory tower (Knight, 1980)? In all
modesty we would like to conclude that, given all the small
pieces of relevant knowledge we have collected over these four
years, we should continue this on-station work, especially to
learn how we can design systems of trees and crops that take
their water and nutrients from different horizons, so compete
less. Also we have to look closer to the long term sustainability
of yield aspects of these systems (Moris, 1988). But we have also
to conclude with Nair (1983) that development of "effective
technical packages" for each region and each farming system could
take not a few years but decades, even though we based ourselves
on transfer of ITK principles. Again Harrison (1987) might be too
optimistic here in stating that given modest extra resources and
guidance, spread through nationwide networks of advice and
supply, African farmers will be capable of rapid advances that
could transform Africa's food outlook within a decade.

Shelterbelts

At the regional University of Gezira in Wad Medani, Central
Sudan, my local co-supervisors and one of the local Ph.D.-
candidates identified an urgent desertification problem in the
North Western part of the Gezira, part of a huge one million
hectares gravity irrigated (so low external input) water
management scheme that derives its water from the Blue Nile. We
decided to take up the challenge to understand how a shelterbelt
of irrigated Eucalyptus, established by the national Forest
Department and FAO over five kilometers and 200-500 wide,
succeeded to keep the sand out of the canals and fields. The
ultimate aim would be to give indications on design criteria and
to get the farmers interested by paying special attention to the
arguments they normally use against the large scale introduction
of trees in the Gezira. After four years we have largely
understood the mechanisms by quantifying wind fields and sand
transport in front of and within the belt edge, although we are
still surprised by the survival power of the trees in the front
lines, after deposition of two meters of sand (Stigter et al., 1989a; 1989b; 1989d). The use of trees for this purpose of keeping sand out of irrigation schemes appears to be traditional in Egypt, where it has been developed by the farmers themselves and therefore not much written evidence of such establishments could be detected, but an Egyptian consultant of one of our local funders confirmed their existence (M.H. El-Lakany, personal communication, 1986). Our Ph.D.-candidate at present participates successfully in the attempts of the local Forest Authorities to plan, together with the tenants, more of these belts and other tree plantings within the scheme, after a series of objections had been demonstrated to apply less to our trees as long as they get their minimum share of irrigation water (A. El-Tayeb Mohamed, personal communication, 1989). Also the visibly encroaching sands in the area have certainly contributed to convince farmers that something should be done. Their need for wood products and the general scarcity of fire wood and poles are other arguments that count. Again, as in the first example, transfer of ITK principles more than of well articulated ITK per se took place, be it with appreciable more success in this case. One could argue that the urgency of the problem of protecting their agricultural environment more than the applicability of ITK principles has caused the change of mind among the tenants. But certainly their participation in the arguments about the disadvantages and advantages of trees in the Gezira, has plaid an important role as well as the fact that those scientists/administrators involved wanted to listen to and to investigate on their objections.

Trees and again trees

It is certainly not accidental that another two TITMI sub-projects, both tackled by the same Tanzanian Ph.D.-candidate, use again ITK on trees, now in a scattered pattern, as point of departure. Trees have many protective functions in the agricultural environment (Stigter, 1988b). These two sub-projects are on wind protection. The first one has been designed to obtain basic information in an actual tropical savannah woodlot edge condition on wind reduction of scattered trees with a density that a crop could easily be grown between them. This work was taken up because of the almost complete absence of any quantification of this method of wind protection, that from our surveys appeared to be an excellent example of African ITK (Stigter, 1984). This was an example selected to show the strength of ITK, at the same time obtaining highly useful information as countervailing power to the cutting of trees in the Sahelian and other parts of Africa that increasingly suffer from wind erosion problems (Baldy, 1986; Baumer, 1987). The measured wind reductions at two heights within the tree space, in the order of 50% over less than 100 m of trees, are indeed
impressive (R.M.R. Kainkwa, personal communication, 1989). The second project was based on straight local ITK. The Director of the Agricultural (formerly Coffee) Research Station in Lynamungu near Moshi in Kilimanjaro Region (North Tanzania) had pointed out to us that local farmers don't want to follow the extension advice to cut shade trees above their coffee, because they believe in their wind protection function for the coffee bushes (D.L. Kesso, personal communication, 1986). Several years of experiments have shown the farmers to be right. The umbrella type of trees appear to offer protection against occasional but devastating high vertical winds just before and during violent showers. The horizontal winds that we quantified were slightly increased by a tunneling effect, but high horizontal winds do not occur in most of this area, contrary to the region where the first experiment was carried out (R.M.R. Kainkwa, personal communication, 1989). In the shade trees above coffee example one can not talk about transfer of ITK, because the example is rather location specific. But the value of local ITK was once more demonstrated and could be used as a countervailing power. In the savannah woodlot edge case, quantitative knowledge about important ITK is now available for transfer and has already drawn attention from within West Africa.

An example of farmer induced change

The last of our first four ITK inspired TTMI Ph.D.-studies nearing completion is again one in the Gezira, Central Sudan, but of a very different nature, again identified for study by local co-supervisors in the TTMI-Project. Traditional tenants in the Gezira scheme have over the past years, especially since independence, slowly abandoned their traditional labour intensive ways of irrigation "angaya by angaya", as you find it still applied directly along the borders of the Nile (Mohammed and Tiffen, 1986). The main reasons appear to be economical in nature, with respect to paid labour for such management. These days water is applied continuously in daytime, and sometimes illegally at night, leaving standing water on the soil for some longer time, applying in general more water per unit of time and land and causing some soil erosion near outlet pipes. It is the feeling of the administration and some intervening international organizations in structural adjustment programmes that water is wasted this way. But nobody actually can forward anything to support or disproof these arguments. We are therefore trying on-farm, with the immediate participation of local tenants, to compare water use efficiency of sorghum and groundnut under the former traditional labour intensive and the present unattended "laissez faire" modes of irrigation. The preliminary trend of the results points towards an appreciably higher water use efficiency of the traditional mode of irrigation but some more yield in the present irrigation mode and a host of other factors, such as
intercrop yields, being as important as the method of irrigation (A.A. Ibrahim, personal communication, 1989). The soil erosion concerned appears minimal but there is some more risk of crop failures in the unattended mode. We also attempt to compare remaining "wastage of water" with other losses from the canals, when the water is on its way over hundred and more kilometers, and from lake Sennar, that supplies the system. In the latter investigation we surprisingly could prove that the present calculations of evaporation of lake Sennar are much too high, which result could have appreciable consequences for the distribution of Nile water between Egypt and Sudan (Ibrahim et al., 1989; Abdulai et al., 1989). In this example it was particularly the participation of local tenants in the evaluation of the change from traditional ITK to modern ITK that made all the difference, be it that they insisted on being compensated for lost yields in applying their traditional methods again (!).

FINAL REMARKS

The above examples prove the variety of ways in which ITK and transfer of ITK and its principles come into the picture in our different sub-projects in the three East African countries concerned. This is confirmed by our numerous more recent attempts to mount new sub-projects on the same footing (Stigter et al., 1989d). This first and foremost proofs the enormous variation in (kind of) problems of the agricultural environment locally identified as priorities for study at the Ph.D.- and supportive M.Sc.-level. It also shows the necessity for interdisciplinarity of any attempt to contribute to the solution of such problems. Our work confirms many of the problems that occur in the earlier inventories in Brokensha et al. (1980) but has gone already a long way in obtaining new credit for the ethnoscientific approach by just throwing itself into the water and being forced to swim. Rereading such procedures as brought forward by Belshaw (1980) for participatory research, we get the strong impression that such rules may fit better relatively simple interventions such as the introduction of a new variety or farm implement, where by all standards anyway most of the experience has been obtained (e.g. Jahnke et al., 1987), but are less rigorously applicable to the environmental issues we work on. We nevertheless conclude (compare Morris, 1988, for an identical reasoning) that our less strict project strategy as outlined and exemplified above has contributed, using ITK and/or ITK principles, to the solution of problems. Problems that were locally felt, by the farmers as well as the scientists concerned, as agricultural environment protection priorities to be tackled, of course within the power limits of NAR. What else can we want for the future in IAR than getting ever closer to the best problem identifications and the best solutions with ever more powerful NAR that put an ever growing confidence in ITK?
ACKNOWLEDGEMENTS

Co-supervisors, Ph.D.-candidates and supportive M.Sc.-students, local authorities and not the least local farmers and tenants are thankfully acknowledged for sharing so many of their ideas among each other and with me over the past more than four years of the TTMI-Project. The Netherlands Ministry of Foreign Affairs, DGIS/DPO/OT, is acknowledged as the core funder of the TTMI research.

REFERENCES

Howes, M., 1980. The uses of indigenous technical knowledge in development. In: D. Brokensha et al. (Eds.), see above.


Stigter, C.J., 1989. The Project "Traditional Techniques of Microclimate Improvement" (TTHI-Project) and the "Groningen Criteria". Invited paper in: "Reply of the Netherlands research community to the letter written by the Organizing Committee of the Conference". Pre-conference paper for: "Conference on development related research; the role of The Netherlands". Groningen: University of Groningen.


5. ACTUAL ATTEMPTS OR DETECTED POSSIBILITIES TO INITIATE OR STRENGTHEN OPERATIONAL WEATHER ADVISORY SERVICES FOR LOW EXTERNAL INPUT AGRICULTURE BASED ON SUCCESSFUL TECHNIQUES (C.J. Stigter)

From what we have argued and reported above, it is clear that least results have to be expected under this heading, especially from the developing world, with the exception of some pilot projects running with WMO assistance (see below). The example given by Karing in his contribution in Chapter 4 applies to medium level farm inputs, at least when measured with yardsticks from the developing world, and a rather sophisticated input of data. Of course, the in the industrialized world still increasing importance of crop protection, with the changes to be expected in its emphases as described in the introduction to Chapter 2, as well as the new challenges of increasing environmental pollution and supposed climatic change, will only lead in a more distant future to operational technology with microclimatic implications. As we argued over the past decade, most of microclimate management and manipulation based weather advisories would be especially beneficial in farming systems with low flexibility, that have only little opportunity to react fastly to information from any forecastings, and in all cases where permanent changes in cropping patterns are feasible or necessary (Stigter, 1990).

Our findings in this respect are confirmed by the recent meeting on Economic and Social Benefits of Meteorological and Hydrological Services (WMO, 1990a). From these proceedings one observes that presently existing meteorological services deal mostly with weather forecasts, increasingly related to more or less sophisticated forms of yield forecasting/early warning systems, and have most often little to do with our weather advisories. From the same proceedings it may be concluded that such observations also apply to China (confirmed by Huajie and Chenggang, 1989), Viet Nam, India (although Raman makes a plea here for some reorientation into our direction for several purposes and Mavi mentions a few very promising examples from initiatives at Punjab Agricultural University) and in fact the whole of RA-II (Asia) and RA-V (Southwest Pacific), with exception of some cases of decisions on measures such as afforestation, shelterbelts and projects to conserve water. The same appears to apply again to Zimbabwe (with the exception of small scale irrigation), Ethiopia (with the exception of specific soil moisture conservation practice, increasing the length of growing period, and again small scale supplementary irrigation) and in fact to Africa as a whole. Minimum user oriented services proposed for that continent do not contain anything in our direction, but fortunately a shift from aviation meteorology towards agrometeorology is experienced everywhere in the region.
Hope, however, arises indeed from the still small scale pilot project approach in Mali, as reported in these proceedings by Konare. Important recent conclusions for our study are that

-Agrometeorological assistance of this type tends to produce better results in a more varied climate;

and

-Agrometeorological assistance produces higher yield increases on non-fertilized land than on fertilized land.

At present the microclimate related advice in such projects is still simple, related mainly to soil preparation, sowing date and planting density and in some cases to the cropping system as a whole. Crop security is more influenced in many cases than average yield in good years. But once such pilot projects are getting larger scale, also the packages of information may be refined through the established contacts between farmer communities and extension. It appears advisable that in the local research microclimate management and manipulation get more attention soon, as this will increase the available options for weather advisories.

The few examples from Africa and Asia indicated above and the experience within the TTMI-Project point towards the necessity of a particular approach in the direction of establishing and strengthening operational weather advisory services. This approach should be a problem by problem one, with the often very local problems in first instance sorted out and defined by National Research Institutes, together with intermediate and final users of solutions to such problems, and then tackled by the same, including Universities and Research Departments of National Meteorological Services. Once a solution appears at hand, or was already tried by any extension or farming organization, again these same Institutes should be involved in the scientific aspects of on-farm testing and validation. Only with such results at hand one may design a larger scale pilot project for an operational service of such specific problem oriented weather advisories within the National Meteorological Services. This approach is fully in line with the one that Kassar and Stigter (1988) designed to connect the projects carried out in the second WMO Long Term Plan for Agrometeorology (see also Appendix III of WMO, 1990b).
Literature


6. POTENTIAL CONTRIBUTIONS TO CARS-FOOD

6.1 Introduction

It is most revealing to study CagM Report No. 37, CARS-FOOD, Part II, issued by WMO as TD-No. 347 in March 1990. In the session of the former Working Group, it was already observed how minor the contributions from the tropics were to the 1984 CARS-FOOD, Part I, issue. The number of contributions from the developing world in CARS-FOOD, Part II, is only 2 on a total of 35. They are both from Chile, one on agroclimatic mapping and one on phenology and temperature for vine, and they are both validations, for transfer and adaptation to local conditions, of an existing methodology. There is no microclimatology involved, which "miscellaneous" keyword is anyway used only once in an example of temperature requirements of crops/fruit in Hungary (with under the constraints: "useful only for macrofield")! Microclimate management and manipulation may be back on stage, operational methods are indeed scarce (compare Chapters 4 and 5).

If the 33 non-tropical examples in CARS-FOOD II are categorized, with a bit of simplification, into a few "classes", nine are based on simple heat/temperature balances, seven on simple water balances, six on simple crop protection methods to forecast pests and diseases and eleven on forecasting simple aspects of growth, development and yield of crops. If we try, with a lot of good will, to determine which methods might be transferable to tropical regions for testing and validation there, we count eight (or about 25%) of the 33 cases developed in temperate or subtropical regions. As might be expected, of these eight more or less transferable examples, there are five based on heat/temperature balances, one from Israel and four from the USSR. Two from Cyprus have to do with water balance methods and only one, from Hungary, falls in the crop yield forecasting category.

No contributions were received under this heading from other co-rapporteurs. In 6.2 we therefore have only those examples that follow from the annotated bibliographies of sections 3.2 and 3.5 of this report.
6.2 Some examples (C.J. Stigter)

It was attempted to screen the items of the annotated bibliographies of 3.2 and 3.5 for information of the kind that could fit CARS-FOOD, but only in our fields of microclimate management and manipulation and with respect to methods that are or could easily be made operational in the developing world and still contain traditional elements or can easily be absorbed because of persisting traditional knowledge.

In line with earlier indications in this report, we included appropriate instrumentation and quantification methods for use in the development, testing and validation of such methods, like this has been done in the existing CARS-FOOD collections, because only methods on which quantitative results exist may occur in such collections. We have in this selection taken note of the remarks, in the CARS-FOOD II publication, on which techniques and methods should be included.

Many publications in the bibliography of section 3.2 contain references in which techniques and methodology are described that would very likely fit CARS-FOOD, because this bibliography contains mainly review and reference books and publications. However, an awareness function towards such information could not be our task. Moreover, these were almost only techniques and methods that possibly could be transferred from temperate regions after modification, testing and validation. There were rarely any with which results were obtained in developing countries. An exception to this rule is formed by information in the books by Jackson (1989), Lal (1984), Mihara (1975), Rosenberg et al. (1983), Smith (1975) and Williams and Joseph (1970). However, it has also to be concluded that one is left with the impression that many more techniques and methods exist than are actually reported on in CARS-FOOD. This means that members of CAgM fulfill their awareness function insufficiently. As shown below, the coordinating author shares such a blame with respect to his own work. In the meantime he has contributed three items mentioned below.

Perhaps it should be suggested that entries could be stimulated through a consultancy action, inviting potential contributors after identification of the techniques and methods they developed. For tropical regions one should insist that more relevant techniques and methods will be developed, tested and validated in local problems oriented research.

The following publications of section 3.2 are containing material that would directly fit CARS-FOOD:
Henricksen and Durkin, 1985.

A moisture availability model developed by FAO and used in Ethiopia.

Jackson, 1983.

Relatively simple but for a first approximation adequate quantitative approach to understand light/radiation interception, transmission and distribution within discontinuous and multi-storey canopies.


Method to simply quantify the thermal efficiency of (grass) mulches from a comparison of diurnal temperature dynamics at one depth under a bare and an identical mulch covered soil.

Lyles, 1985; Unger and McCalla, 1981.

The wind erosion equation as developed in the USA. The quantitative information needed is not easily obtained under tropical conditions and much work will be needed to adapt, test and validate such equations for the tropics.

From the section 3.5 to the above may still be added the following papers containing suitable references:

Stigter and Darnhofer (1989) for reviewing simple but appropriate methods which are suitable to quantify the microclimate in the tropics; Stigter, Jiwaji, Kainkwa, Juma, Musabilha, Mabuba and Waryoba (1989) for reviewing results on trials with radiation equipment in the tropics; EUROCONSULT (with Stigter and Wartena, 1989) for reviewing some climatological methods suitable for an Agricultural Compendium for Rural Development in the Tropics and Subtropics.

Actual CARS-FOOD information from this section 3.5 is found in:

Stigter, Darnhofer and Herrera S., 1989.

Recommendations on design of windbreaks for crop protection: rows/strips; wider belts; scattered trees and bushes.

Development, testing and validation of a shaded Piche evaporimeter to replace the aerodynamic term in the Penman equation.

For the CARS-FOOD entry proposals from the work of Stigter and associates mentioned above, see Appendix V.
Rapporteurs on the Application of Microclimate Management and Manipulation Techniques in Low External Input Agriculture

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Res. 3 (CAgM-IX) - RAPPORTEUR ON THE APPLICATION OF MICROCLIMATE MANAGEMENT AND MANIPULATION TECHNIQUES IN LOW EXTERNAL INPUT AGRICULTURE

THE COMMISSION FOR AGRICULTURAL METEOROLOGY,

NOTING:

(1) The final report of the CAgM-VIII Working Group on Microclimate Management and Manipulation in Traditional Farming,

(2) Recommendation 3 (CAgM-VIII) - Microclimate Management and Manipulation in Traditional Farming,

RECOGNIZING:

(1) That assistance is needed with the transfer of results of research on microclimate management and manipulation techniques and with the transfer of the results of attempts to test and validate operational techniques locally,

(2) That attempts to initiate or strengthen operational weather advisory services based on such techniques should be monitored and the results transferred;

DECIDES:

(1) To appoint a Rapporteur on Application of Microclimate Management and Manipulation Techniques in Low External Input Agriculture, with the following terms of reference:

(a) To continue the search for published case studies and planned and ongoing projects on traditional techniques employed for microclimate management and manipulation;

(b) To complete a selectively annotated bibliography on aspects of traditional techniques of microclimate management and manipulation and on a micrometeorological basis for understanding such techniques;

(c) To collect results obtained in testing and validating operational techniques and to document those techniques shown to have been successful locally;

(d) To collect information on actual attempts or detected possibilities to initiate or strengthen operational weather advisory services for low external input agriculture based on such successful techniques;

(e) To identify potential contributions to CARS-Food;

(f) To submit annually information on progress of activities and a final report on the above to the president of CAgM not later than six months before the next session of CAgM;
CATALOGIZATION OF EXAMPLES OF MANIPULATION OF MICROCLIMATE

I. Manipulation of radiation (15 classes) by (A, B, C, D)

1. using natural means
2. using mulch (artificial)
3. using artificial means other than mulch

A Shading
   1. reflectivity
     i. use of colour or other surface change
     ii. use of geometry change
     iii. use of stony structures
   2. absorption

B Increase) or ) of surface Decrease)

C Cover for radiation loss at night
   1. using natural means
   2. using mulch (artificial)
   3. using artificial means other than mulch

D Using solar radiation for
   1. field drying... i. in the field of growth
   ii. elsewhere before storage
   2. keeping products dry in storage
II. Manipulation of heat and/or moisture flow (16 classes) by (E, F, G, H, I, J, K)

E (Non)Tillage

1. by natural means

F Mulching

2. by artificial means

1. Using wind breaks

G

2. Using other shelter (storage)

H Protection for ripening purposes

I Influencing flow processes by changing conditions at or on the surface

1. solar radiation)
   i. field drying in the field of growth
   for ii. field drying elsewhere before storage
   2. other means ) iii. keeping products dry (and pest free) in storage

J Using air warmed by

1. Increase of )

K Dew

2. Use of ) natural dew fall

3. Protection against)
III. Manipulation of mechanical impact of wind, rain and/or hail (12 classes) by (L, M, O, P, Q)

L  Change of
   1. direction)
   2. speed    ) of wind and air flow by
   i. wind breaks
   ii. other shelter

M  Planting in lower places or pits or where deep rooting is possible

N  Improving soil conditions by natural deposits

O  Protection from soil erosion by
   1. wind
   2. rain and hail

P  Protection of crops and produce against impact by
   1. rain
   2. hail
   3. wind

Q  Use of wind for winnowing

IV. Two general examples (R, S)
R  Fitting cropping periods to the seasons
S  Making use of superhuman intervention
ABBREVIATIONS USED AND ADDRESSES

International Agricultural Research and Development Centers (IARC's)

Most of the IARC's are starting to recognize that sustainable agriculture is a valuable approach to agricultural development and are making it as one of the main focus points of their programmes. IARC's are major publishers of books, periodicals, slide sets, films and other educational materials on agricultural science and technology for developing countries. Information on these publications can be obtained directly from the IARC's (see addresses).

A catalog of the publications of the IARC's is published by:


CIAT / CIP / CIMMYT / IBPGR / ICARDA / ICIRSAT / IFPRI / IITA / ILCA / ILRAD / IRRI / ISNAR / AVRDC / CIPE / ICIMOD / ICLARM / ICRAF / INTSOY / WINROCK / BOSTID / GTZ
Utility: catalog, abstracts, prices, ordering instructions.
A second part of this catalog with new publications is also available from IRRI.

Some of these IARC's are:

CIAT, Centro Internacional de Agricultura Tropical.
Apartado Aereo 6713, Cali, Colombia.
Tel. 689343. Telex 05769 CIAT CO.
Research on Phaseolus beans, Cassava, Rice. Tropical pastures.

CIMMYT, Centro Internacional de Mejoramiento de Maize y Trigo
Lourdes 40, Mexico 6, D.F., Mexico, Tel. (905) 565-4355. Telex 383-177203 CIMTME
Research on Wheat, Maize, Triticale barley.

CIP, Centro Internacional de la Papa.
Apartado 5669, Lima, Peru, Tel. 350266, Telex 25672 PE.
Research on Potato.

ICARDA, International Center for Agricultural Research in the Dry Areas.
P.O. Box 114/5055, Aleppo, Syria. Tele. 50465/51260. Telex 924-331206.

Patancheru, P. O., Andhra Pradesh 502324, India, Tel. 262251, Telex 0125-203 and 0155-366.
Research on Farming Systems (Semi-arid tropics), Sorghum, Pigeonpea, Groundnuts, Millet, Chickpea.

IITA, International Institute of Tropical Agriculture.
P.O. Box 5320, Oyo Road, Ibadan, Nigeria, Tel. 413440, Telex 31417 TROPIB
Research on Farming Systems (Africa), Rice, Maize, Cassava, Cocoma, Cowpea, Yam, Sweet potato, Soybean.

ILCA, International Livestock Centre for Africa.
P.O. Box 5689, Addis Ababa, Ethiopia, Tel. 180215/182229/182455. Telex 21207 ILCA ADDIS.
Research on Livestock production systems in Africa

IRRI, International Rice Research Institute.
P.O. Box 933, Manila, Philippines. Tel. 884669, Telex (ITT) 45365 RICE INST PM.
Research on Rice

WARDA, West Africa Rice Development Association.
P.O. Box 1019, Monrovia, Liberia. Tel. 221466/221963, Telex 937-4333.
Research on Rice.

CATIE, Centro Agronómico Tropical de Investigation.
Turrialba, Costa Rica.
Research on Tropical agriculture and Agroforestry.

ICPE, International Center of Insect Physiology Ecology.
P. O. Box 30772, Nairobi, Kenya.
Research on Insect pests.

P. O. Box 30677, Nairobi, Kenya, Tel. (254-2) 521450, Telex 22048.
Research on Agroforestry.

NFTA, Nitrogen Fixing Tree Association.
P. O. Box 680, Waimanalo, Hawaii 96795 USA.
Research on Nitrogen fixing trees.

FAO, Food and Agriculture Organization of the United Nations.
VIA delle Terme di Caracalla, 00100 Rome, Italy. Tel. 39 6.5797321, Telex 610181 foodagri.
Tropical agriculture, policy, research, projects.
Documents can be ordered from the national FAO Sales Agent or directly from FAO Distribution and Sales Section.

BOSTID, Board on Science and Technology for International Development.
2101 Constitution Avenue, Washington, D.C. 20418, USA.
Publications of the National Academy of Sciences can be requested by Third World organizations free of charge. Individuals and organizations from industrialized countries have to order from local sales agents like TOOL, SKAT, I.T. Publications (9 King Street, London WC2E 8H, England) or Winrock International (1611 North Kent Street, Arlington, VA 22209, USA).
Proposed entry for CARS-FOOD (III), Nr. 1

1. OBJECT OF METHOD

1.1 Objective/title

Method to simply quantify the thermal efficiency of (grass) mulches from a comparison of diurnal temperature dynamics at one depth under a bare and an identical mulch covered soil.

1.2 Key words Energy balance Mulching Temperature (from the list)

Microclimate

1.3 Other potential key words

Thermal efficiency Stigter’s ratio

2. DESCRIPTION OF METHOD

2.1 Output (expected results and accuracy)

Thermal efficiency of mulches, expressed as a ratio of simultaneous temperature differences with the average at a selected depth (usually between 5 and 10 cm) under bare and mulched soil.

2.2 Description

The influence of the state of mulches (thickness, density, moisture status, decomposition) on their thermal efficiency can be expressed and followed this way. Mulches can be compared this way. Decisions on replacement or addition of mulch material can be made this way.
2.3 Input data

Diurnal temperature patterns at one selected depth below a bare soil and an identical mulched soil. If homogeneity of the soil has to be checked from its damping depths, measurements of the diurnal temperature patterns have to be made at two depths (for example one between 5 and 7.5 and one between 10 and 15 cm, with a vertical distance between them of between 5 and 10 cm).

2.4 Operational requirements (including computer requirements)

Between hourly and three-hourly temperature observations at the selected depths. Observations are therefore preferably made with simple recording type instruments.

2.5 (a) Validity, (b) limits imposed by basic concept, (c) constraints in application

(a) Valid for homogeneous soils; its high success in the tropics could be partly due to the closeness of patterns to real sine waves; (b) Bare soils should have low evaporation (dry surface for most of the time) if absolute values for one mulch are required. Comparisons of mulches or mulch stages are appreciably less sensitive to this requirement; (c) Albedo's should be approximately known if they are appreciably different for surfaces compared. If on surfaces with young plants, simple shade corrections should be made.

3. VALIDATION/PROVEN USES

Theory originally developed and validated for daily temperatures of soil surfaces with only different albedo’s (blackened and whitened) in Tanzania. Subsequently validated with monthly averaged diurnal patterns under three dry grass mulches under young tea and for a live grass mulch, with the mowings remaining on the soil, in Kenya. Idem for black plastic covered soil. Validated for different amounts of the same dry grass mulch in Tanzania. Used in Southern Nigeria under different conditions on peat soils.
4. REFERENCES

4.1 Author: Stigter, C.J., his collaborators and students. Originally developed when at the Physics Department, University of Dar es Salaam, Tanzania.

4.2 Address: c/o TTMI-Project. Department of Meteorology, Wageningen Agricultural University, Duivendaal 2, 6701 AP Wageningen, The Netherlands.

4.3 Reference source:


Date 1985 Language English Number of pages 6

5. AVAILABILITY/SOURCES OF ASSISTANCE FOR FUTURE USERS

5.1 Contacts: Stigter, C.J.

5.2 Nature of assistance available:

Advice and additional literature on validations.

6. REMARKS

More references given in source quoted above.

For information on validations in Nigeria, contact:

Mrs. Dr. O.A. Salau
University of Port Harcourt
Faculty of Social Sciences
Department of Geography
Port Harcourt, Nigeria

For more information on experimental conditions of validations in Kenya, contact:

Dr. C.O. Othieno, Director
Tea Research Foundation of Kenya
P.O. Box 820, Kericho, Kenya.
Proposed entry for CARS-FOOD (III), Nr. 2

1. OBJECT OF METHOD

1.1 Objective/title

Recommendations on design of (multiple) windbreaks for crop protection in the form of rows/strips, wider belts and scattered trees and bushes.

1.2 Key words

Crop protection Wind Wind breaks

(from the list)

1.3 Other potential key words

Agroforestry

2. DESCRIPTION OF METHOD

2.1 Output (expected results and accuracy)

Advice on recommended wind break characteristics from a literature survey in 1986.

2.2 Description

Recommendations have been collected on shape and geometrical composition (not on species!); height; length; width; direction; distance; number and permeability with regard to different types of windbreaks, together with recommendations on measurements, observations and other quantifications to be made in wind break research.

2.3 Input data

Covered by 2.2.

2.4 Operational requirements (including computer requirements)

Covered by 2.2.
2.5 (a) Validity, (b) limits imposed by basic concept, (c) constraints in application

Depending on wind strength, wind break system selected for design or already present and crops to be protected.

3. VALIDATION/PROVEN USES

To be obtained from the literature covered.

4. REFERENCES

4.1 Author: Stigter, C.J., T. Darnhofer and H. Herrera S.

4.2 Address: c/o TTMI-Project, Department of Meteorology, Wageningen Agricultural University, Duivendaal 2, 6701 AP Wageningen, The Netherlands.

4.3 Reference source:


Date 1989  Language English  Number of pages 9

5. AVAILABILITY/SOURCES OF ASSISTANCE FOR FUTURE USERS

5.1 Contacts: Stigter, C.J.

5.2 Nature of assistance available:

Advice and additional literature on validations.

6. REMARKS

For information on the use of the recommendations in Costa Rica, contact:

Ing. H. Herrera Soto
Director Agrometeorological Department
Agrometeorological Programme
Instituto Meteorologico Nacional
Apdo 7.3350, San Jose, Costa Rica
Proposed entry for CARS-FOOD (III), Nr. 3

1. OBJECT OF METHOD

1.1 Objective/title

Development, testing and validation of a shaded Piche evaporimeter to replace the aerodynamic term in the Penman equation.

1.2 Key words

Crop water requirements  Evaporation

(from the list)

Tropics  Correlations

1.3 Other potential key words

Penman equation  Piche evaporimeter

Appropriate Instrumentation

2. DESCRIPTION OF METHOD

2.1 Output (expected results and accuracy)

Shaded Piche evaporimeter suitable to replace through correlations the aerodynamic term in the Penman equation in a minimum input approach for tropical conditions.

2.2 Description

A Piche evaporimeter is provided with a round 25 cm diameter protection screen, of a type earlier developed by Stigter and associates, at about 10 cm from the blotting paper. Correlations are obtained with the aerodynamic term of the Penman equation for open water and a reference crop under tropical conditions in Sudan.

2.3 Input data

Shaded Piche evaporation on a weekly, decadal or monthly averaged daily basis, to be correlated with the aerodynamic term of the Penman reference crop as well as Penman open water evaporation.
2.4 Operational requirements (including computer requirements)

Calculator or computer for averaging daily meteorological input data, calculating Penman evaporation and for regression correlations.

2.5 (a) Validity, (b) limits imposed by basic concept, (c) constraints in application

(a) In the tropics. Separate correlations for different seasons give higher accuracies. (b) Shade developed for tropical high sun. (c) Daily Piche data taking needed.

3. VALIDATION/PROVEN USES

Physics of Piches improved in Tanzania from 1976 - 1984. Differently but equivalently shaded Piches had shown the approach to be valid in Tanzania, where relatively low evaporation conditions prevailed (up till 2 mm/day). Validated in Sudan with data from Wad Medani for high open water and reference crop evaporation values (2 - 7 mm/day) and applied in, at and near Lake Sennar.

4. REFERENCES

4.1 Author: Stigter, C.J. and his collaborators and students.

4.2 Address: c/o TTMI-Project. Department of Meteorology. Wageningen Agricultural University. Duvendaal 2, 6701 AP Wageningen, The Netherlands.

4.3 Reference source:

Development and validation of a shaded Piche evaporimeter for the tropics to replace humidity and wind speed data in the aerodynamic term of the Penman equation. In: Instrument and Observing Methods (TECIMO IV), Report Nr. 35, WMO/TD - No 303

Date 1989 Language English Number of pages 6

5. AVAILABILITY/SOURCES OF ASSISTANCE FOR FUTURE USERS

5.1 Contacts: Stigter, C.J.
5.2 Nature of assistance available:

Advice and additional literature on validations.

6. REMARKS

In supportive experimental work it has been shown that (a) the screen does not influence air movement over the blotting paper; (b) the results are not influenced by (i) small differences (up till 3 cm) in distance between screen and blotting paper; (ii) the colour of the lower screen side; (iii) the albedo of the surface above which it is mounted at a height of 1.50 m or more; (iv) radiation on protruding water filled Piche tube.

For details on the experimental work in Sudan, contact:

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Hydraulics Research Station
P.O. Box 318, Wad Medani, Sudan

Use of the shaded Piche in a minimum input approach of shallow lake evaporation determination at Lake Sennar (Sudan) has been summarized in:


The same instrument is presently tested as a simple relative anemometer/air movement indicator in agroforestry research projects in Sudan and Tanzania. The results in Tanzania in a shaded coffee crop are very encouraging. The results within a Eucalyptus shelterbelt in central Sudan are promising as well.