Annual Report 1995

Department of Agronomy

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Contents

Preface

The Department of Agronomy is one of about sixty departments of the Wageningen Agricultural University. The Department of Agronomy was established after the merging of the former Departments of Field Crops and Grassland Science, and Tropical Crops on 1 September 1992.
A first report, Report 1992-1994, was published in February 1995. The present Annual Report 1995 gives an overview of our teaching activities carried out in the academic year 1994/1995 and our research results in the year 1995.

We expect that this report is of interest to you and look forward to suggestions, as well as to continued or new cooperation.

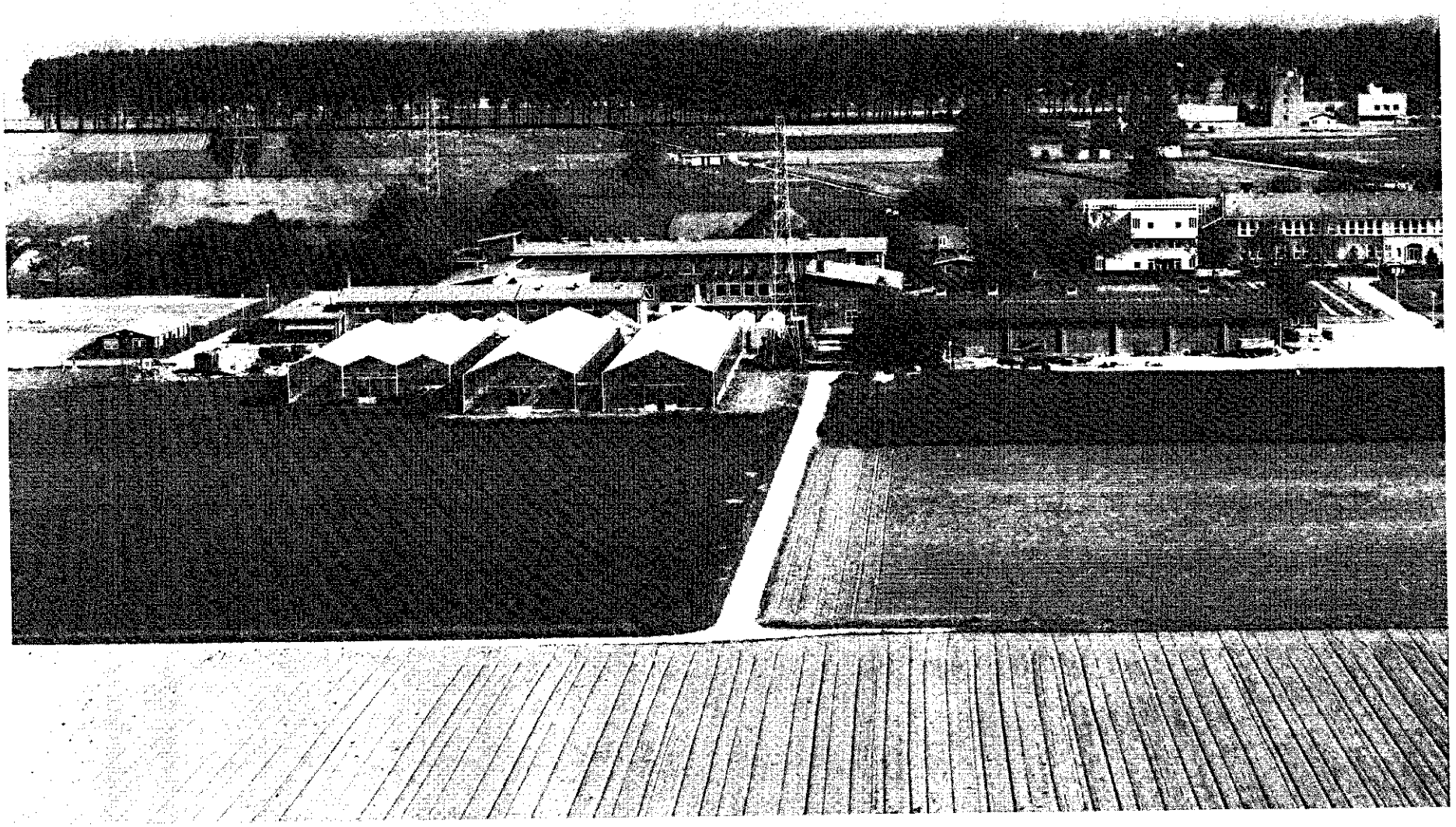
Highlights of 1995

During 1995 the Field Crops section and the Grassland section merged and a new section Crop and Grassland Science was created.
A new structure of the teaching programme was developed and will be implemented further the coming years. Presentations of the teaching and research programmes of The Department for scholars and students were intensified.
'Resource use efficiency', 'yield and quality of plant and crop production' and 'analysis and design of agro-ecosystems' were identified as general research themes.

During 1995 11 PhD theses, 74 scientific papers, 9 abstracts and 17 other publications were produced.

Prof. dr. ir. L. 't Mannetje received an honorary doctorate from the University of Debrecen, Hungary, on December 19, 1995.

During the summer of 1995 the Department of Agronomy and the Department of Horticulture decided to cooperate more closely with the intention to merge in the near future. In autumn, a committee was established by the sector Plant Sciences to investigate the possibility of a wider merger of the Departments of Agronomy, Horticulture, Ecological Agriculture and Theoretical Production Ecology.



1 THE DEPARTMENT OF AGRONOMY

1.1 Introduction

The production of food is essential for society. Hence, a productive and sustainable agriculture is of the utmost importance. Over the past decades, the scientific knowledge of agriculture has increased considerably. This knowledge has contributed to the high productivity of agriculture in many countries. Much has been achieved, but new problems and challenges have arisen. In some areas of the (sub)tropics, production increases lag behind population growth. Worldwide, agricultural practices threaten the environment.
In agriculture, man influences the interactions between crops, grassland vegetation, animals and the natural environment. Insight into the functioning of agro-ecosystems is a prerequisite for development of sustainable production of food, feed and raw materials, and is necessary to promote a better management of land and vegetation.
The ultimate goal is the development of a sustainable agriculture which is profitable and acceptable, conserves the soil and other internal production factors, uses external inputs efficiently and causes minimal damage to the environment.

1.2 Agronomy as a science

Agronomy as a science focusses on human intervention in agro-ecosystems through cropping techniques and management practices in order to obtain useful products for mankind and to promote sustainable land use.
The Department of Agronomy works on solutions for agronomic problems by developing scientific knowledge about the ecology of (grass) vegetations, and the growth of crops for food, feed and raw material. By means of teaching and research, the Department aims to achieve a more thorough understanding of the functioning of agro-ecosystems and to contribute to the development of sustainable agriculture worldwide.

1.3 Mission statement of the Department

In teaching and research the Department of Agronomy has the following aims:
1. to study the biological, physical and chemical aspects of the intervention by man in agro-ecosystems through cropping techniques and management practices, recognizing that these are also determined by socio-economic conditions;
2. to integrate knowledge from other disciplines for the purpose of the analysis, improvement and design of cropping techniques and management practices and of agro-ecosystems;
3. to study agro-ecosystems at two key aggregation levels: crop/vegetation and cropping system, while also analyzing the underlying ((sub-)plant) and the upperlying (land-use system) levels.

1.4 Sections of the Department

The Field Crops section studies the growth of food and non-food crops of temperate regions as influenced by biotic and abiotic factors, including technological and environmental aspects, the quality of raw material and its significance for the storage and processing of plant products;
The Grassland section investigates the production, physiology and nutritive value of forages in temperate and tropical regions and the ecology of grasslands, including grass vegetations for combined agricultural and nature conservation purposes;
The Tropical Crops section studies existing and improved crop production systems for the (sub)tropics with special emphasis on annual and perennial cropping systems and the development of regional land-use models.

These three sections existed within the Department, each headed by a full-time professor; however, since 1 November 1995 the Field Crops section and the Grassland section have merged and a section Crop and Grassland Science was established, headed by one full-time professor. The area of the Tropical Crops section was broadened to: Plant Production Systems (tropics and subtropics).

1.5 Facilities

The Department of Agronomy has several lecture rooms, areas for practical training, modern computer facilities and an extensive library at its disposal. Plant and soil samples can be analyzed chemically in the Department's laboratory.

The experimental facilities of several departments belonging to the Sector Plant and Crop Sciences of the University have been combined into UNIFARM, the UNIversity Facilities for Agronomic Research and Management, in June 1994.
This includes an experimental farm of 120 ha on different soil types (64 ha heavy river clay, 12 ha very light sand, 7 ha light sand, 37 ha humid sand) with facilities to house approximately 200 oxen. There are facilities for feeding experiments with animals. In demonstration gardens, many crops and their cultivars, grassland plants and weeds are grown. The major crops of different tropical eco-regions are exhibited in the greenhouses. For experiments under controlled conditions there are greenhouses and growth chambers in which environmental factors like photoperiod, temperature, carbon dioxide concentration and relative humidity can be regulated. There is a mobile laboratory for photosynthesis and transpiration measurements in the field.
In the Rhizolab Wageningen, a joint facility of the Research Institute for Agrobiology and Soil Fertility (AB-DLO) and the Agricultural University, the growth and development of crops above and below ground can be studied.
The Department of Agronomy cooperates with many partners, which are mentioned per research project.

1.6 Personnel

Personnel of the Department of Agronomy on December 31, 1995 is listed in the left hand column, whereas staff members who left the Department during 1995 are mentioned in the right hand column.

Current staff (31.12.95)

Section Crop and Grassland Science

Almekinders, Dr Ir C.J.M.[6]
Bos, Ir H.J.[1]
Deinum, Dr Ir B.
Dhanapal, MSc, G.N.[1,2]
Elgersma, Dr Ir A.
Elzebroek, A.Th.G.
Engels, Dr F.M.
Groot, Ir J.C.J.[1]
Illipronti Jr., MSc, R.A.[1,2]
Kerkhoff, Ir P.[6]
Lommen, Dr Ir W.J.M.
Lootsma, Ir M.[1,2]
Mannetje, Prof Dr Ir L. 't[4,6]
Nassiri Mahalati, MSc, M.[1,2]
Neuteboom, Drs J.H.
Putten, P.E.L. van der
Schlepers, H.
Scholte, Dr Ing. K.
Schouls, Ir J.
Struik, Prof Dr Ir P.C.
Tarla, MSc, F.[1,2]
Timmermans, P.C.J.M.
Vos, Dr Ir J.
Waaijenberg, Dr Ir H.
Warringa, Ir J.W.[1,2]
Wind, K.

Section Plant Production Systems

Belde, J.J.M.
Berg, Ir M.M. van den[6]
Bessembinder, Ir J.[1]
Brink, Ir M.[2]
Flach, Prof Dr Ir M.[4]
Fokkema-Lentink, E.M.[7]
Fresco, Prof Dr Ir L.O.
Gerritsma, Ir W.[2]
Guiking, Ir F.C.T.
Koning, Ir G.H.J. de[1]
Ogtrop, Ir F.G. van[7]
Oyen, Ir L.[7]
Ridder, Drs N. de
Schuiling, Ir D.L.[2]
Siemonsma, Dr Ir J.S.[7]
Slaats, Dr J.J.P.[6]
Stomph, Dr Ir T.J.
Westphal, Dr Ir E.
Wienk, Dr Ir J.F.
Zeijl-Rozema, Ir A.E. van[6]

Staff left during 1995

Amati, Ir M.[2]
Biemond, Dr Ir H.[1,2]
Ellen, Ing. J.[4]
Hasselt, G.A.M. van
Heering, Ir J.H.[1,2]
Maassen, A.H.T.M.
Mol, Dr Ir L.[1]
Smit, Ir A.B.[1,2]
Straten, Ir L.E. van der[6]

Duivenbooden, Dr Ir N. van[2]
Jong, Dr F-S.[1]
Steenhuijsen Piters, Dr Ir B. de[1]
Veldkamp, Dr Ir A.[2]

[1] PhD-student, [2] external, [3] visiting scientist, [4] retired staff member, [5] partly external, [6] guest, temporary, [7] PROSEA.

Current staff (31.12.95)

Laboratory staff

Halm, H.D.

Administrative staff

Bosman, M.P.
Kuijpers, T.W.H.M.[2]
Loualidi, B.[2]
Schouwenburg, I.C. van[5]
Visser-Kamstra, G.J.

Computer centre staff

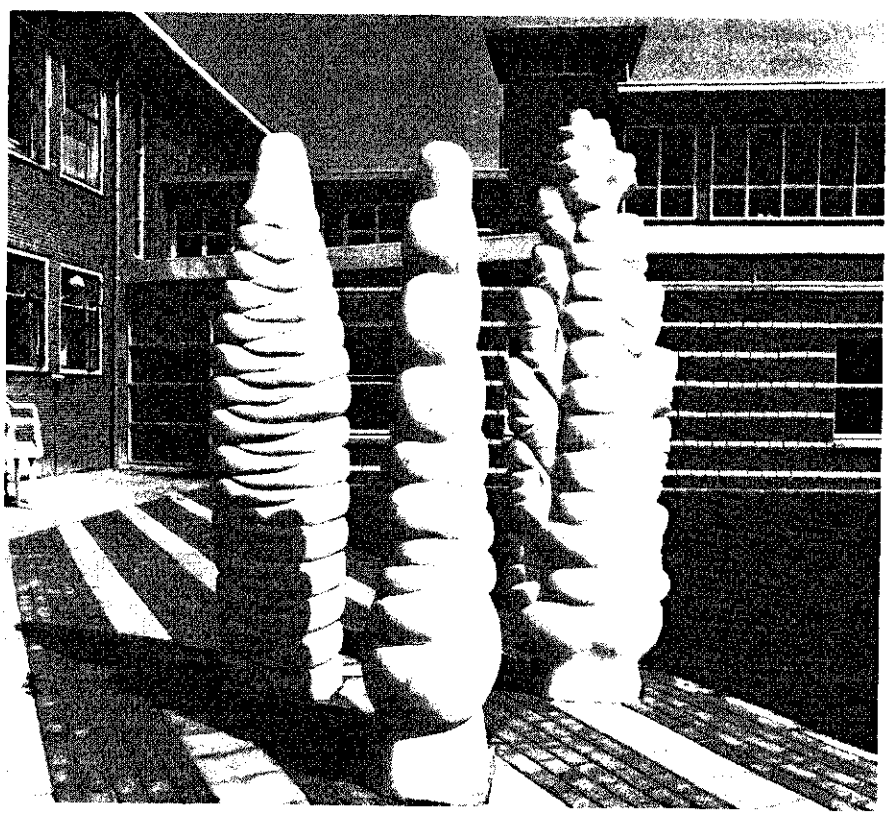
Romberg, J.A.
Soolsma, J.

[1] PhD-student, [2] external, [3] visiting scientist, [4] retired staff member, [5] partly external, [6] guest, temporary, [7] PROSEA.

Visiting scientists and guests during 1995:

E. Alvarez Davila, MSc (until January 15)
Dr Li Fengrui (until January 4)
J. Korva, MSc (from July to December)
Ms G. Posca, Dt. (from June to November)
Dr Ir A. van Schoonhoven (from December)

On February 20, Prof. Ir. L.J.P. Kupers and on December 26, Prof. Ir. J.G.P. Dirven passed away. Prof. Kupers was emeritus professor of Field Crops Science and prof. Dirven emeritus professor of Tropical Grassland Science. Dr M. Sylla died on August 28. He had completed his PhD thesis in 1994.



1.7 Organizational structure

The Department Board decides on matters relevant for teaching and research. L.O. Fresco was chairperson and P.C. Struik vice-chairperson until September; thereafter they changed positions.
On December 31, 1995 the following persons were member of the Department Board (the first seven members listed form the Executive board of the Department on December 31, 1995):

P.C. Struik (chairperson; head of the section Crop and Grassland Science)
L.O. Fresco (vice-chairperson; head of the section Plant Production Systems)
J.F. Wienk (secretary, manager)
A. Elgersma (coordinator for external relations)
A.T.G. Elzebroek (representative of the technical staff)
J. Vos (coordinator for research)
E. Westphal (coordinator for teaching)

J.J.M. Belde
J. Bessembinder
H.J. Bos
M.P. Bosman
B. Deinum
F.M. Engels
J.C.J. Groot
F.C.T. Guiking
E.J. Hommes*
W.J.M. Lommen
A. van der Maden*
J.H. Neuteboom
F.W. Oberthür*
P.E.L. van der Putten
N. de Ridder
K. Scholte
J. Schouls
J.S. Siemonsma
J.A.J. van Soesbergen*
T.J. Stomph
K. Wind
G. Wink*

* Student members

During 1995 the following members left the Department Board: T. von Berswordt-Wallrabe*, P. van Eijndthoven*, W. Gerritsma and L. 't Mannetje.

Heads of sections during 1995:

Professor L.O. Fresco, Plant Production Systems (tropics and subtropics).
Professor L. 't Mannetje, Grassland Science (until 1 November 1995).
Professor P.C. Struik, Field Crop Science (temperate regions); since 1 November 1995 Crop and Grassland Science.

1.8 Prizes and awards

Prof. dr. ir. L. 't Mannetje received an honorary doctorate from the University of Debrecen, Hungary, on December 20, 1995, for his outstanding and international performance in teaching and research of grassland science, with emphasis on the effects of ecological factors on grasslands and the efficiency of animal production based on grasslands.

2 TEACHING

2.1 Introduction

At present there are 19 degree courses at the Wageningen Agricultural University. They train students to obtain the degree of "ingenieur" (Ir). The Department of Agronomy teaches students of many different degree courses, but especially students of those of Crop Science (T10), Tropical Land Use (O10), Rural Development Studies (O20), and Animal Sciences (T20). The Department is also involved in international courses for students from developing countries, such as the MSc courses Crop Science, Animal Production, Ecological Agriculture and Agroforestry.

The Department focusses its teaching and research on a better understanding of interactions between environmental factors and primary production as influenced by management. Its main objective is the development of the scientific requirements for sustainable production systems, primarily on the basis of crop physiology and ecology.
The emphasis in teaching is on the analysis of agro-ecosystems and on the development of sustainable alternatives. A thorough knowledge of the physiology and ecology of crops and grassland is a prerequisite. This knowledge is integrated at higher levels (cropping system, farm, watershed, region), using information from other disciplines such as soil science or farm economics. Methodology of research and analysis is a major part of the curriculum.
Objectives are to attain knowledge, insight and skills in relation to different aspects of plant production in a multitude of agro-ecological and social-economic situations, all based on a solid background of basic and associated sciences. This refers to, on the one hand, the general principles involving the influence of environmental factors on the behaviour of plants and crops in relation to productivity, quality and effects on the environment; and on the other hand, the general principles of cropping techniques which influence the development, productivity, quality and environmental effects. Besides these general principles, specific knowledge and insight in the different crops is necessary.

After an introductory phase in which knowledge in the basics of agricultural science and land use is taught, subjects covering general processes in ecology and crop science follow. Within the so-called "problem-oriented subjects", students learn to recognize, formulate and solve agricultural problems. Methods of research and analysis are taught in practicals in Wageningen and in Spain.
An important part of the degree courses is the practical training period. For this students often go abroad. During four to six months, students obtain working experience and an impression of future professional career opportunities.
During the latter part of the curriculum, the student carries out a research project under the supervision of a member of the scientific staff and writes a MSc-thesis. Thus, the student gains research experience: i.e. developing a hypothesis, designing and executing research, analysis and interpretation of data, and reporting.
A graduate agronomist is an academic who can analyze complex problems and convert them into answerable questions. He or she should also be capable of integrating this knowledge at higher aggregation levels such as a farm or a region. The analysis of competing goals of society at large may play an important role in this. Thanks to a helicopter view and a problem-solving and practice-oriented approach, these scientists may play a leading role in the radical changes which must take place in the present world's agriculture.

Employment of graduate agronomists is quite diverse. They may work in the Netherlands or abroad, in research institutes, government organizations, educational organizations (e.g. universities), development organizations, consultancy agencies, the (agro)industry or in commerce.

2.2 Degree course programmes

In 1995 the following functions in degree course programmes were carried out by members of the Department of Agronomy:

Tropical Land Use (O10):
- student advisor: F.C.T. Guiking (for the specialization Tropical Crop Science)
- chairperson exam committee: L.O. Fresco

Crop Science (T10):
- student advisor: J. Schouls
- chairperson course committee: P.C. Struik
- secretary course committee: W.J.M. Lommen
- chairperson exam committee: P.C. Struik

Professional Master Agronomy (T10P):
- secretary: J. Schouls
- member: P.C. Struik
- chairperson exam committee: P.C. Struik

Animal Sciences (T20):
- advisor course committee: B. Deinum

MSc course Ecological Agriculture:
- member programme committee: P.C. Struik
- member exam committee: P.C. Struik

2.3 Student numbers

The number of students per course given by the Department of Agronomy is listed below for 1994/'95

Code	Course	Total student number	Distribution of students among various degree course programmes				
			B	L10	L30	L50	L60
F350-001	Stage landbouwplantenteelt (P3)	6	-	-	-	-	-
F350-003	Beschrijvende landbouwplantenteelt	39	1	-	1	1	17
F350-004	Practicum gewassenkennis (gem. gebied)	30	1	-	1	-	6
F350-005	Kennis van tropische gewassen	78	1	-	-	-	-
F350-006	Tropisch landgebruik	92	6	1	2	-	-
F350-007	Tropische gewassen en teelttechnieken in relatie tot duurzame teeltsystemen	89	1	1	-	-	-
F350-008	Praktijksimulatie tropen	69	-	-	-	-	-
F350-009	Practicum graslandbotanie	21	-	-	-	-	-
F350-010	Practical tropical grassland*	26	-	-	-	-	-
F350-200	Praktijkweek oogsthandelingen	29	-	-	-	-	28
F350-202	Practicum plantaardige produktie	12	-	-	-	-	-
F350-203	Teelt en biologie van akkerbouwgewassen	14	-	-	-	-	1
F350-205	Algemene graslandkunde	38	-	-	1	-	15
F350-207	Tropical grassland*	29	2	1	-	-	-
F350-209	PGO I: landbouw in bedrijfsverband	12	-	-	-	-	-
F350-210	PGO II: landbouwplt. en graslandkunde	4	-	-	-	-	-
F350-211	Analyse van literatuur	8	-	-	-	-	-
F350-212	Onderzoeksmethodieken	24	-	-	-	-	-
F350-213	Produktkunde	6	-	-	-	-	-
F350-214	- 217 Capita selecta grasland[1]	61	8	-	-	-	-
F350-218	- 220 Capita selecta akkerbouw[1]	55	-	-	-	-	-
F350-223	Excursie buitenland	14	-	-	-	-	-
F350-227	Literature analysis*	2	-	-	-	-	-
F350-228	Milieu-aspecten van de landbouw	15	1	-	-	-	-
F350-300	Landbouw en teeltsystemen*	68	-	-	-	-	1
F350-302	Verdieping ecol., teelttechniek en gewas	15	-	2	-	-	-
F350-304	Gewasbotanie	9	-	-	-	-	-
F350-305	Open vak agronomie B	-	-	-	-	-	-
F350-306	- 308 Capita selecta tropla[1]	26	-	-	-	-	-
F350-309	Colloquia tropische plantenteelt	7	-	-	-	-	-
F350-310	Binnenlandse excursie tropla	-	-	-	-	-	-
F350-311	Projectstudie tropische plantenteelt	-	-	-	-	-	-
F350-312	Veldpract. duurz. landgebruik, ond. tropla	8	-	-	-	-	-
F350-315	Ecofysiol. grondslagen van de teelt*	42	-	-	-	3	-
F350-316	Open vak agronomie A	31	-	-	-	1	5
F350-317	QUASI*	13	-	-	-	1	-
F350-318	PGO bodem en teelt	17	-	-	-	-	-
F350-600	Stage agronomie (12)	4	-	-	-	-	-
F350-601	Stage agronomie (15)	8	-	-	-	-	-
F350-602	Stage agronomie (21)	5	-	-	-	-	-
F350-603	Stage agronomie (27)	2	-	-	-	-	-

* taught in English

[1] units of 1 credit point

Distribution of students among degree course programmes during 94/95, continued.											Total student number during		
M10	M21	O10	O20	T10	T12	T15	T20	T32	MSc	Misc.**	92/93	93/94	94/95
-	-	-	-	5	-	-	-	1	-	-	3	11	6
10	-	-	-	4	-	4	-	1	-	-	30	52	39
11	-	-	-	6	-	4	-	1	-	-	28	52	30
3	-	44	25	2	-	-	2	-	-	1	96	97	78
-	-	44	36	1	-	1	-	-	-	1	81	96	92
3	-	41	32	2	-	1	2	-	-	6	81	102	89
-	-	41	25	2	-	-	-	-	-	1	65	85	69
-	-	-	-	10	-	-	10	1	-	-	32	23	21
-	-	9	3	2	-	-	3	-	7	2	9	18	26
-	-	-	-	1	-	-	-	-	-	-	5	17	29
-	-	-	-	12	-	-	-	-	-	-	20	13	12
-	-	1	-	9	-	1	-	-	-	2	14	9	14
2	-	3	-	1	-	-	14	-	-	2	61	42	38
-	-	9	1	-	-	-	7	-	7	2	17	26	29
-	-	-	-	9	2	-	-	-	-	1	10	5	12
-	-	-	-	4	-	-	-	-	-	-	10	11	4
-	-	-	-	8	-	-	-	-	-	-	9	11	8
-	-	-	-	10	-	-	1	-	9	4	24	25	24
-	-	1	-	5	-	-	-	-	-	-	11	5	6
3	5	17	-	10	-	-	18	-	-	-	45	53	61
-	-	3	-	46	-	-	-	-	-	6	38	38	55
-	-	2	-	12	-	-	-	-	-	-	10	4	14
-	-	-	-	-	-	-	-	-	2	-	5	9	2
-	-	3	-	10	-	-	-	1	-	-	16	8	15
-	-	36	8	-	-	-	1	-	18	4	117	117	68
-	-	13	-	-	-	-	-	-	-	-	15	12	15
-	-	9	-	-	-	-	-	-	-	-	11	11	9
-	-	-	-	-	-	-	-	-	-	-	6	5	-
-	-	18	-	-	-	-	-	-	4	4	31	51	26
-	-	7	-	-	-	-	-	-	-	-	16	8	7
-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	12	1	-
-	-	7	-	-	1	-	-	-	-	-	9	11	8
-	-	23	-	8	-	-	-	-	8	-	49	32	42
1	-	1	-	19	-	-	-	2	-	2	1	2	31
-	-	10	-	1	-	-	-	-	1	-	-	4	13
-	-	17	-	-	-	-	-	-	-	-	14	10	17
-	-	-	-	3	-	-	1	-	-	-	3	6	4
-	-	5	-	1	-	-	-	2	-	-	20	15	8
-	-	1	-	4	-	-	-	-	-	-	20	10	5
-	-	-	-	2	-	-	-	-	-	-	4	1	2

**Miscellaneous = L14, L20, M30, T13, T31, T34

For names of degree courses, see Table 1 on page 40.

The number of students that completed a MSc thesis during 1994/'95 at the Department of Agronomy.

Code	Thesis (credit points)	Total	T10	T15	O10	L15	T20	L50	MSc
F350-701	AV Akkerbouw (13)	3	2	1	-	-	-	-	-
F350-702	AV Akkerbouw (17)	2	1	1	-	-	-	-	-
F350-703	AV Akkerbouw (21)	5	5	-	-	-	-	-	-
F350-716	Thesis Agronomy (27)	3	-	-	-	-	-	-	3
F350-705	AV Grasland (13)	3	1	-	2	-	-	-	-
F350-706	AV Grasland (17)	4	2	-	2	-	-	-	-
F350-707	AV Grasland (21)	6	3	-	-	-	3	-	-
F350-717	Thesis Grassland (27)	1	-	-	-	-	-	-	1
F350-712	AV Tropische plantenteelt (9)	3	-	-	3	-	-	-	-
F350-713	AV Tropische plantenteelt (13)	3	-	-	3	-	-	-	-
F350-714	AV Tropische plantenteelt (17)	6	-	-	5	-	-	1	-
F350-715	AV Tropische plantenteelt (21)	3	-	-	2	1	-	-	-
F350-718	AV Tropische plantenteelt (27)	2	-	-	2	-	-	-	-

2.4 Other teaching activities

The following members of the Department of Agronomy participated in other teaching activities:

Contributions in courses of other Departments of WAU:

- H. Schlepers in Animal nutrition on the farm, E350-207;
- W.J.M. Lommen in Production of seed and propagules, F750-215

Contributions in courses of the Veterinary Faculty of the University of Utrecht:

- L. 't Mannetje in Tropical Forage Production

Contributions in courses of the International Agricultural Centre (IAC, Wageningen):

- W.J.M. Lommen, K. Scholte and P.C. Struik in International Potato Course: Production, Storage and Seed Technology
- L. 't Mannetje, H. Schlepers and K. Wind in Dairy Production and Rural Development
- F.C.T. Guiking in Nutrient Management for Sustainable Agriculture
- J.S. Siemonsma in Vegetable Course

Contributions in the "Stage sur les Plants de Pomme de Terre":

- W.J.M. Lommen
- P.C. Struik

2.5 Improvement of lecture notes

During 1994 and 1995 the study materials of the following courses were renewed or updated:

W.J.M. Lommen.
Kwaliteit van uitgangsmateriaal: Kiemkracht en vigour van zaaizaad. F350-218.

W.J.M. Lommen.
Zaaizaad- en plantgoedproduktie, teeltkundig gedeelte. F750-205.

M.K. van Ittersum, A.H. van Schaik, P.C. Struik en W.J.M. Lommen (met medewerking van: L. Mol, K. Scholte, J. Schouls en A.B. Smit).
Produktkunde. F350-213

J. Vos, A.Th.G Elzebroek, K. Scholte.
Milieu-aspecten van de landbouw. F350-228

A.Th.G. Elzebroek, P.C.J.M. Timmermans, Tj. P. Wijngaarden, K. Wind.
Handleiding en werkboek practicum Gewassenkennis. F350-004

A.Th.G. Elzebroek, M. Lootsma, J. Vos. Redactie: P.C.J.M. Timmermans.
Practicumhandleiding Plantaardige produktie (gematigd gebied). F350-202.

J.M.A. Schrauwen, L. 't Mannetje and A. Elgersma.
Grasland en Milieu. F350-214.

L. 't Mannetje, J.H. Neuteboom, B. Deinum, E.A. Lantinga.
Algemene Graslandkunde. F350-205.

P.C. Struik, L Mol, A. Elgersma en A.Th.G. Elzebroek (met bijdragen van J. Vos, J. Schouls, H. Biemond en A.B. Smit. Redactie: P.C.J.M. Timmermans.
Beschrijvende Landbouwplantenteelt. F350-003.

F.T.C. Guiking.
Introduction to the field training project 'Sustainable land use' in Álora, Spain. F350-312.

F.T.C. Guiking.
Soil fertility management at farm level. F350-318.

T.J. Stomph and B.C.M. van Koppen.
Praktijksimulatie tropen. F350-008.

2.6 Computer-based interactive multimedia education programme on tropical crops

In 1993, D.L. Schuiling began to explore the possibilities to upgrade the introductory course on tropical crops (F350-005) with a computer-based interactive multi-media component.
A project group was formed in which scientists of the Departments of Communication and Innovation Studies, and Agricultural Education took part. The group discussed the educational, media, and technical aspects of such a computer-based education programme. A sketch prototype was produced and presented in January 1994.

At present D.L. Schuiling is finalising a full prototype of this programme called TROPCROP, which includes an extensive electronic encyclopedia on tropical crops and a course on tropical crop recognition and identification. Part of this cours, viz. the evaluation module Crop Quizzz, was tested in 1995 and was well-received by students.

2.7 Restructuring of the teaching programme

After the merger in 1992 the Department of Agronomy decided to restructure its teaching programme in order to emphasize the global approach and to differentiate more clearly between the aggregation levels of plant, crop, cropping system and land-use system. The following general outline of the new teaching programme has been approved by the Department Board:

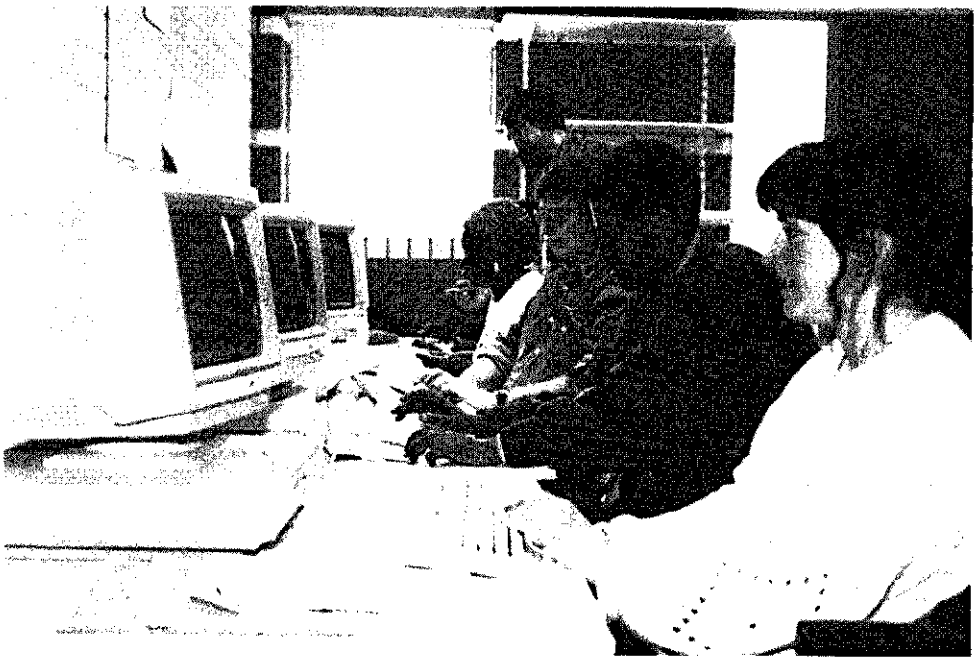
1 Introductory courses
- 1.1 'Land use' (global/regional level);
- 1.2 'Cropping and management techniques depending on crop/vegetation, soil and climate in relation to sustainable agro-ecosystems (cropping system level);
- 1.3 'Knowledge of crops and vegetations' (crop/vegetation level);
- 1.4 'Orientation on farmer's practice and on a professional agronomic career'.

2 Advanced courses
- 2.1 'Ecophysiological principles of cropping' (crop/vegetation level);
- 2.2 'Agriculture and cropping systems' (cropping system level; global);
- 2.3 'Agro-ecological characterization' (higher integration level);
- 2.4 'Effects of agriculture on nature and environment' (global).

3 Specialized courses
- 3.1 'Produce science';
- 3.2 'Production and quality of seed & planting material;
- 3.3 'Growth and quality of forages';
- 3.4 'Grassland ecology';
- 3.5 'Quantitative analysis of plant and crop growth & development'.

4 Methodology courses
- 4.1 'Research methodologies';
- 4.2 'Quantitative analysis of agro-ecosystems at higher integration levels';
- 4.3 'Field methodology of sustainable land use'.

The following courses are being revised or newly developed during the academic year 1995-1996:
* Land use,
* Orientation on the professional agronomic career,
* Ecophysiological principles of cropping (with emphasis on annual crops),
* Ecophysiological principles of perennial crops,
* Cropping systems,
* Agro-ecological characterization,
* Research methodologies,
* Quantitative analysis of agro-ecosystems at higher integration levels.



2.8 MSc theses in the period July 1994 - December 1995

Section Crop and Grassland Science

Former Field Crops section

Berswordt-Wallrabe, T. von, 1995. Riet voor dakbedekking. Een evaluatie van aspecten van belang voor de duurzaamheid van rietendaken.

Berswordt-Wallrabe, T. von, 1995. De invloed van mulch op de infectie met *Phytophthora infestans* en de groei van aardappel.

Biewenga, A., 1994. Bladoppervlakteontwikkeling in zomertarwe.

Boer, A.J.C., 1995. Optimalisering van het bestrijdend effect van mechanische onkruidbestrijding bij de veertandeg.

Dijkhuizen, M., 1995. Nitraatgehalte in aardappelen. Een literatuurstudie en een onderzoek naar de betrouwbaarheid van de nitrachekmethode.

Fontanet i Colell, N., 1995. Studies on the development of field crops from potato minitubers with different weights until tuber initiation.

Haanstra, J., 1995. De invloed van de pH in de bodem op de interactie tussen de mycofage bodemfauna en *Rhizoctonia solani* AG-3 op aardappel.

Kamsteeg, R., 1995. Energieteelt voor elektriciteitsopwekking in Zuid Nederland.

Kamuchapa, E.E.B.,1995. Variation in soyabean (*Glycine max*) seed quality within a seed lot.

Ruissen, H.J.A., 1994. Voorspelling van het eiwitgehalte van een partij brouwgerst.

Soesbergen, M.A.T. van, 1995. Invloed van fungiciden op het optreden van knolaantasting in aardappelen veroorzaakt door *Phytophthora infestans*.

Stoffers, H., 1994. Kwaliteitsverlies van ingekuilde vezelhennep na uitkuilen.

Swart, A.P.M. de, 1995. Optimale oogsttijdstip van suikerbieten.

Welten, A.S.A., 1994. De invloed van de gewichtsklasse van miniknollen van aardappel op de bladontwikkeling en bladgroei.

Former Grassland section

Duku, S., 1995. Effects of shading on grass-legume competition.

Hagting, L., 1995. Ontwikkeling van generatief Engels raaigras in relatie tot de verteerbaarheid.

Klein Robbenhaar, M., 1995. De vegetatie en natuurwaarde van slootkanten, perceelsranden en grasland.

Joenje, M., 1995. Adoption of improved pasture technologies in the Atlantic zone of Costa Rica.

Joenje, M., 1995. A cost-benefit analysis for the establishment of mixed pastures with and without legume trees, in humid tropical Costa Rica.

Kool, A., 1995. Stikstofuitspoeling onder grasklaverweiden.

Minderhoud, M.E., 1995. Mogelijke oorzaken van slechte groei bij vijf soorten leguminosen in een kasproef.

Minderhoud, M.E., 1995. Geschiktheid van *Arachis pintoi* cv. Amarillo als graslandleguminoos.

Roest, B.H., 1995. De soortsareaalcurve. Een methode voor karakterisering van botanische samenstelling van grasland.

Schrader, P., 1995. The performance of Siamese long tail lambs fed on an oil palm based ration.

Stienezen, M.W.J., 1995. Produktie en persistentie van witte klaver (*Trifolium repens*) bij drie verschillende groeivormen van *Lolium perenne* onder standweiden.

Veefkind, C., 1995. Establishment of grasses under rubber trees.

Wyngaert, I. v.d., 1995. Growth and degradation characteristics of the pastures in the Mindif-region, North-Cameroon.

Vogel, F., 1995. Production, quality and botanical composition of poorly drained pastures in the Atlantic Zone, Costa Rica.

Section Plant Production Systems (former Tropical Crops section)

Berg, M.M. van den, 1995. A dynamic data model for land use/land unit interactions. case study Alora, Spain.

Bergsma, C.J., 1995. Het rotatiesysteem in Andalucia, met name in de Guadalhorce.

Bergsma, C.J., 1995. Somatische embryogenese en plantregeneratie van cassave.

Braun, A., 1995. Nutrient flows in fallow systems and maize in Western Kenya.

Boxtel, M.E. van, 1995. Nutrient uptake from organic wastes by common cabbage (*Brassica oleracea* var. *capitata*).

Chin-Fo-Sieeuw, S.C., 1994. Agricultural research and extension in maize, palmheart and cassava in the Atlantic Zone of Costa Rica.

Dam, J. van, 1994. Cultivation and fruit ripening of avocado (*Persea americana*).

Dankers, C., 1995. The fear of heights of the stalk eyed fly; why *Diopsis macrophthalma* is prevalent in the lowest parts of the upland/inland swamp continuum of rice-growing environments in West Africa. I. Evaluation of possible factors.

Dankers, C., 1995. The fear of heights of the stalk eyed fly; why *Diopsis macrophthalma* is prevalent in the lowest parts of the upland/inland swamp continuum of rice-growing environments in West Africa. II. Experimental research.

Deugd, M. & Beuving, J, 1995. Farmers and their environments, application of an agro-ecological niche model in Ecuador.

Dikmoet, S.D., 1995. Grondbewerking in de natte rijstteelt met irrigatie.

Durang, T.M., 1994. Yam and the Mekong Delta, Vietnam.

Eijndthoven, P.J. van, 1995. Analysis of land cover and land use related to landscape.

Eijdthoven, P.J. van & Trouwborst, K.O., 1995. Variation on Farm and Field Level in the Farm Systems of Hua Jiao Village in China.

Ghafoerkhan, J., 1995. Effect van zaadgewicht en fysiologische zaadleeftijd op zaailinggewicht bij rijst.

Ghafoerkhan, J., 1995. De teelt van meelbanaan in Suriname (beperkingen en oplossingen).

Haan, J.J. de, 1995. Ontwerp en toetsing van een dynamisch waterbalans model voor een *kunstmatige helling*.

Hartkamp, A.D., 1995. Modelling Light-interception in Mountainous Areas, FILMA, an hourly sub-model for LINTUL.

Kajiru, G.J., 1995. Study on the non-acceptance of fertilizer recommendations in Malaya rice valley, Lake zone, Northwest, Tanzania.

Kamstra, A.S., 1995. Phosphorus in bambara groundnut. Effect of concentration and period of P-supply.

Kohne, R., 1995. De gecombineerde invloed van *temperatuur en daglengte op groei en ontwikkeling* van Bambara aardnoot (*Vigna subterranea*), selecties uit West- en zuidelijk Afrika.

Linden, M. v.d., 1994. 'GREATER YAM'. De teelt van *Dioscorea alata* in Zuid-Oost Azië.

Peters, L., 1995. Shifting cultivation in the uplands of Quirino, the Philippines.

Premchand, V., 1995. De teelt van Xanthosoma Schott.

Rooij, A. van, 1993. De aardappel in Z.O.-Azië. Een casestudie Filippijnen.

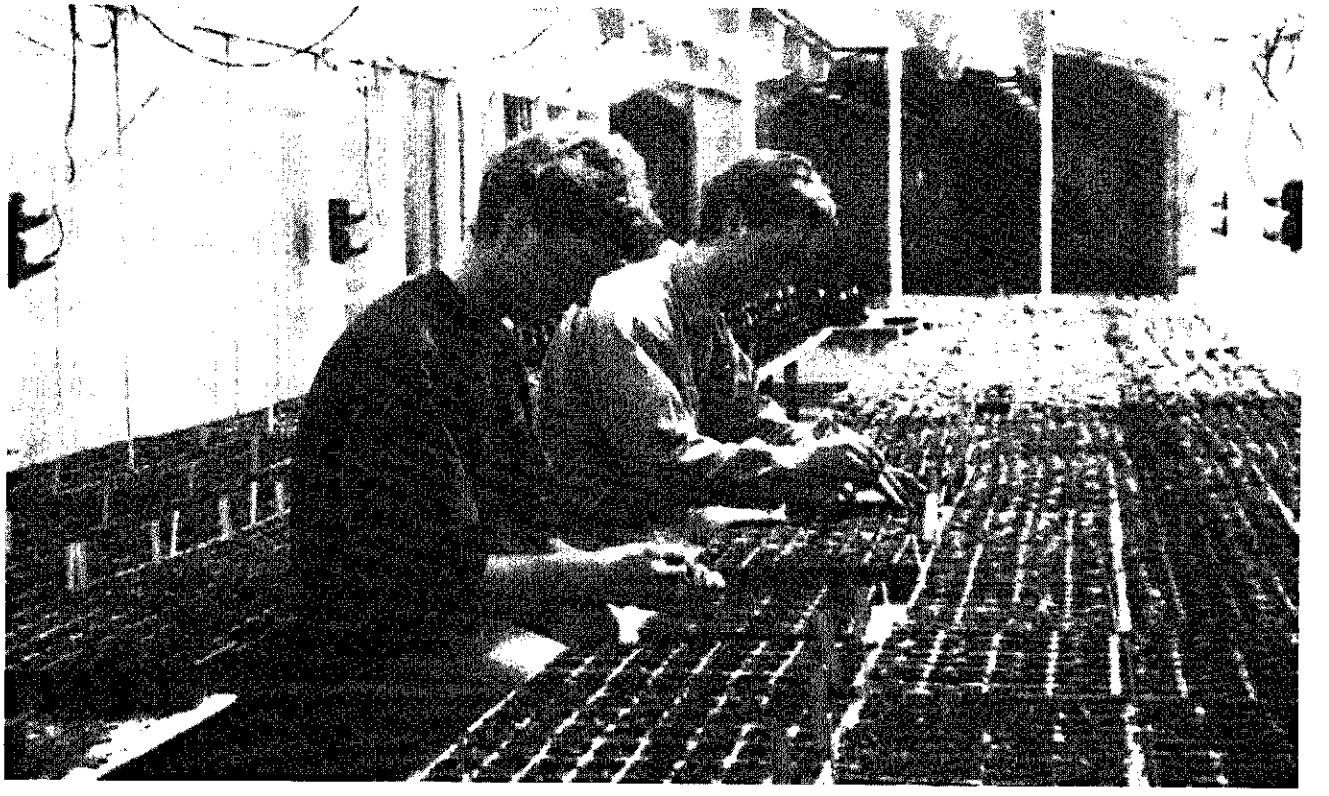
Rozema, A.E., 1995. Modellering van stikstof in een statisch waterbalans model (deel A). B. De koppeling tussen een statisch water- en stikstofbalans model en een geografisch informatie systeem (GIS).

Ruijter, H.A.A.M., 1994. Rice cultivation on former mangrove swamps along the Great Scarcies river in Sierra Leone; farmers perspective and field trails related to salinity and acidity.

Visser, M. de, 1995. Food, money and gifts. An assessment of agrarian interventions of a rural development project in northern Malawi.

Wiegers, E., 1995. An integration of GIS, remote sensing and fieldwork for land use classification and erosion risk estimation.

Wilk, C. van der, 1995. De teelt van *Amorphophallus*.



3 RESEARCH

3.1 Introduction

The research programme of the Department of Agronomy is focused on various aspects and scales of agro-ecosystems, from plant physiology and crop or grassland ecology to land-use planning. The methods of research range from experiments in the laboratory, the greenhouse or the field to computer simulation.
The Department's research is of a fundamental nature and is focused on ecological and physiological processes in agro-ecosystems. Although practical application is not the first objective, the Department collaborates with more practice-oriented research institutes and experiment stations. Research projects are often conducted together with other departments of the Agricultural University or with universities or research institutes in the Netherlands and abroad.

The Department's research can be divided into the following two themes:

- Physiology

Physiological research is aimed at the processes influencing the quality and yield of crops and forages. The processes concerned are those which manifest themselves at (sub-)plant or crop level. Climate-controlled greenhouses and growth chambers are often used because many physiological processes can be studied more accurately in controlled environments.
Physiological research is especially oriented towards the quantitative analysis and regulation of crop development, production and quality. Examples are the quantitative analysis of tillering and its consequences for crop structure of wheat or digestibility of a grass sward.

- Agro-ecosystems design

Research is focused on the development and design of sustainable agro-ecosystems. Growth and development of grass vegetations and crops, and their weeds and pests are studied in relation to abiotic circumstances and management. This comprises both research with mathematical models of biological-physical processes as well as long-term field research.
Important fields of interest concerning European agriculture are the flow of nutrients in arable crops and grassland and the prevention of soil-related pests by crop rotation. Other research concerns the persistence of white clover in grassland and the use of grasslands for nature conservation.
In Costa Rica, the Department investigates problems of and possibilities for sustainable land use in high-rainfall areas. This is done by research on long lasting rotations and improvement of grass vegetations with legumes. In West Africa, rice-based cropping systems for small valleys are being designed, which use water and nutrients optimally. In Cameroon, there is a research project on degradation of rangelands. In Bolivia the Department is participating in a project to extend the use of grain and pasture legumes by small farmers.
The dynamics and optimization of land use are also research subjects within this theme. This research is of importance in the light of goals like increasing food production in developing regions, decreasing pollution and safeguarding employment. The relation between land use and worldwide climatic change is studied as well.
Research is based on a combination of field work, the use of geographical information (maps, aerial photographs, satellite images) and syntheses using computer programmes. An example of research within this theme is the development of a regional agro-ecological optimization model for the Atlantic Zone in Costa Rica, and a model for land use/cover change.

3.2 List of research projects

The research projects of the Department of Agronomy are listed below for each section. The page number refers to the place with further information.

3.2.1 Section Crop and Grassland Science

Projects covered by the former Field Crops section

Projects covered by the former Grassland section

3.2.2 Section Plant Production Systems

Research results of each project are presented on the next pages. Projects are core research, unless indicated otherwise. Co-operators, VF-programmes and research schools are mentioned where appropriate. Research (graduate) schools are Production Ecology (PE), Wageningen Institute for Animal Sciences (WIAS), and Wageningen Institute for Environment and Climate studies (WIMEK).

3.2.3 Completed PhD theses

3.3 Description of research projects

3.3.1 Section Crop and Grassland Science

3.3.1.1 Projects carried out by the former Field Crops section

Manipulation of tuber size distribution of potato (*Solanum tuberosum* L.)

Researchers	: P.C. Struik, W.J.M. Lommen, P.C.J.M. Timmermans
Project leader	: P.C. Struik
Term	: 1982-1999
Research school	: PE
Cooperation with	: Department of Plant Physiology, AB-DLO, PAGV

Potatoes are grown for different markets, each with their own quality demands. Important quality characteristics are: the average tuber size and its variation. Both are strongly influenced by yield and final number of harvestable tubers.
Tuber number, yield and the resulting tuber size distribution are regulated by many diverse, interacting mechanisms and therefore difficult to control. The project focusses on processes influencing the number of tubers per stem and the interactions between tubers of the same stem during tuber bulking. Objectives are:
1. Analysis of the initiation and growth of stolons and tubers in relation to plant factors (e.g. position of stolon on stem, position of tuber on stolon) and environmental factors (such as soil temperature and soil bulk density),
2. Analysis of tuber growth and tuber size distribution within a conceptual model of plant and crop structure, and
3. Integration of insight and knowledge in crop production systems (both seed and ware potatoes) and for novel techniques of rapid multiplication.
This work will contribute to whole-plant physiology of tuber induction, tuber initiation, tuber growth and competition among tubers growth, and explore of possibilities to manipulate tuber size distribution in commercial potato production or seed programmes.
Progress: In 1995 an EU-FAIR proposal was formulated, two PhD-theses were finalized and work was continued, mainly through research of D. Caldiz (Argentina) and He Wei (China). Summaries of the theses of Lommen and Almekinders are printed below.

Production and quality of propagation material

Researchers	: W.J.M. Lommen, R.A. Illipronti Jr.
Project leader	: W.J.M. Lommen
Term	: 1994-1998
Research school	: PE
Form	: R.A. Illipronti Jr.: PhD-project
Cooperation with	: CPRO-DLO

The goal is to acquire an improved and integral insight in the processes determining yield and quality of propagation material and the way these processes affect the further performance. With this insight, it will be possible to manipulate yield and quality of propagation material during its production and to work out scenarios for new production programmes. The research includes vegetatively and generatively propagated crops (potato and soybean), different types of propagules of one crop when relevant; - e.g. plantlets or tubers for potato, and several types of quality characteristics (e.g. propagule size, vigour, storability). Goals are achieved by:
(1) Fundamental studies on the processes determining yield and quality of different types of propagation material during the subsequent production stages on techniques to manipulate these processes;
(2) The development of an integral chain view on quality of vegetatively and generatively propagated crops;
(3) Fundamental studies on the influence of differences in quality on the later development, yield formation and quality in several climatic conditions and under different cropping techniques;
(4) The development of a quality concept for propagation material;
(5) Integrating the acquired knowledge into models by which different production methods and production programmes can be compared with regard to time, number or weight of propagules produced, area and achievable yield.
Progress: The first experimental results are currently being analyzed and prepared for publication. Lines for future research are being described.

Growth of arable crops in intensive cropping systems with environment-friendly control strategies against soil pathogens

Researcher	: K. Scholte
Project leader	: K. Scholte
Term	: 1994-2001
Research school	: PE

Lower yields and/or poor quality of crops grown in short rotations cannot be ascribed to a single pathogen only, but are the result of the combined effects of a complex of harmful and non-harmful organisms. Pathogenic organisms interact mutually with the non-pathogenic soil flora and fauna, with the abiotic environment, with the crops and cultivars grown in the rotation and with cultural practices. Cultural practices may affect directly or indirectly the density of the population of harmful soil organisms. Studying the mechanism of action of cultural practices contributes to the prevention of damage on crops by pathogens and reduces the dependency on chemicals to control them. Efficacy and magnitude of the effect of cultural practices on the whole complex of (harmful and non-harmful) soil organisms will be investigated under field conditions by repeated application of treatments on the same field in a series of successive years. Effects of cultural practices

(mechanisms of action) on separate organisms will be investigated in small-scale field experiments and experiments in conditioned greenhouses and growth chambers. The work will contribute to a better understanding of the behaviour of soil pathogens in an intensive cropping system. The effect of cropping practices, trap crops and crops with a nematicidal action will be evaluated.
The efficacy, interaction and magnitude of the effect of various cropping practices on the population density of a natural population of harmful soil organisms and the consequences for the crops grown are investigated in a crop rotation experiment. The cultural practices should either diminish the reproduction rate of plant pathogens or should stimulate the antagonistic soil flora and fauna to these pathogenic organisms.
Progress: in 1994 and 1995 plots were artificially infested with soil pathogens and the first treatments were applied. Soils were analyzed on infestation levels.

Cultivation techniques to control *Rhizoctonia solani* on potato

Researcher	: M. Lootsma
Project leaders	: K. Scholte, J. Vos
Term	: 1991-1996
Research school	: PE
Form	: PhD-project

Rhizoctonia solani (AG-3) is a soil-borne plant pathogen causing canker on potato stems and stolons. Severe canker results in delayed emergence, fewer emerged stems, lower tuber yield, a high proportion of small, partly green and misshapen tubers with a lower dry matter content. The pathogen survives for several years in the soil by sclerotia. Sclerotia can also be formed on progeny tubers (black scurf).
This project aims to find non-chemical alternatives to control *Rhizoctonia* stem and stolon canker, especially by reduction of the soil infestation and the stimulation of the mycophagous soil fauna.
(1) Reduction of soil infestation. From 1991 to 1994 a two year lasting field experiment was conducted twice to asses effects of harvest methods of potato and chemical soil disinfection at planting on stem infection with *R. solani* in the subsequent year. Soil treatment at planting with pencycuron resulted in lowest disease severity in the subsequent year. Compared to chemical haulm killing and haulm pulling, immature-crop-harvesting resulted also in a lower disease severity in the subsequent year, however, only in the experiment where black scurf level of tubers in the preceding year was low at harvest.
(2) Stimulation of the mycophagous soil fauna. *Rhizoctonia* stem and stolon canker can be reduced by the soil fauna, especially collemboles and mycophagous nematodes can feed directly on the mycelium of *R. solani*. These animals occur naturally in arable field soils. From 1991 to 1994 a two year lasting field experiment was conducted twice to assess the possibility of suppressing *Rhizoctonia* stem canker by increasing the population densities of these mycophagous organisms. Several soil treatments with organic amendments (green manure crops and farmyard manure) were applied in the autumn/winter season. These treatments affected positively the density of the mycophagous soil fauna and the severity of *Rhizoctonia* stem/stolon canker was reduced. Effects of environmental factors on the potential suppression of *Rhizoctonia* stem/stolon canker by the springtail *Folsomia fimetaria* and the mycophagous nematode *Aphelenchus avenae* were investigated in growth chambers. Low soil temperature and relative dry soil conditions, which are favourable for *Rhizoctonia* stem canker, enhanced the suppressive potential of these organisms. The effect of addition of dried forage rape (*Brassica napus ssp. oleifera*) material to the soil on the suppressing ability of *F. fimetaria* and *A. avenae* to *Rhizoctonia* depended on the composition of the organic material and on soil pH.
Progress: one scientific paper was published in 1995 and three submitted.

Trap crops as an environmentally friendly cultural practice to control potato cyst nematodes

Researcher	: K. Scholte
Project leaders	: K. Scholte
Term	: 1995-1999

Potato cyst nematodes (PCN) are a serious problem in potato growing areas. Infested plants can result in substantial yield reductions. Two different species of PCN are distinguished: *Globodera rostochiensis* (golden PCN) and *G. pallida* (white PCN). Within each species various pathotypes/virulence groups occur. The population level of an infested field is related to the cropping frequency of potato. Short crop rotations involving potato will result in a distinct increase of soil infestation with PCN. In the absence of a host plant a limited number (20-30%) of juveniles will hatch spontaneously from the cysts. This will result in a gradual decrease in the population. However, under these circumstances it can take 15 years for all the juveniles to hatch from the cysts. When a potato crop is grown, hatching will increase significantly (up to 80%) as a result of the stimulating effect of potato root diffusates. If a susceptible potato cultivar is grown, reproduction will also take place in the roots after juveniles have hatched from the cysts and will result in an increase in the population.
Two major methods are applied to control PCN (i) cultivation of resistant cultivars and, (ii) soil disinfection with agro-chemicals. Broader crop rotations lack support from agricultural enterprises since they result in a decrease in revenue. In the past, resistance became ineffective due to selection for new pathotypes/virulence groups by repeated use of resistant cultivars and the use of soil disinfectants

in The Netherlands must be reduced due to governmental restrictions. In this respect the development of alternative control methods is a necessity. Such an alternative method could be the growth of a trap crop.
A trap crop stimulates hatching of juveniles from cysts by root diffusates. This may then decrease considerably the level of soil infestations, if the trap crop is destroyed before the reproduction of PCN can occur or if the trap crop is resistant to PCN.
The growth of a resistant trap crop with a high production level of hatching agent seems an ideal control method for PCN.
The objective of this research project is to identify a trap crop for PCN and to develop the cultivation techniques for such a crop that will result in the maximum effect on PCN. The main requirements for trap crops should be a very strong hatching effect in combination with full, or a high level of resistance to PCN. To optimize the control of PCN by a trap crop, an extensive root system, grown deeply and evenly through the soil, that produces high quantities of hatching agents is favoured. Optimal cultural practices during the growing season should be developed to maximize this hatching effect. This project includes the screening of several *Solananum* species on hatching activity, and detailed evaluation of agronomic traits and genetic characteristics of promising species.
Progress: more than 60 non-tuber bearing *Solanaceae* were screened on resistance to and hatching effect on PCN and in a preliminary experiment their growth potential was tested in the field. Various potential candidate trap crops were selected.

Analysis of input-output relations of nutrients on the level of crop and region for different systems of nutrient management

Researchers	: J. Schouls, G.O. Nijland
Project leader	: J. Schouls
Research school	: WIMEK
Term	: 1993-1998
Cooperation with	: Department of Ecological Agriculture

Resources in agriculture rarely have a recovery of 100 %. The use of inputs is therefore generally accompanied by accumulation of residues. Closing of cycles helps to prevent these residues.
The temporal and spatial variation in presence and use of nutrients and their effects have to be observed and elucidated. Temporal variation can be followed by dynamic modelling. The spatial variation may include the variation in a field, on a farm, in a region and in a country. All have to be considered separately because each has a certain independence. Mixed farming in a region may provide an opportunity to close cycles.
Central in the issue whether intensification or extensification in crop production is feasible are the relations between input, output and residue of nutrients, as well as markets and prices.
In recent studies, a sigmoidal course of the output curve has been demonstrated when various nutrients are increased in combination. In that case, rather high levels of nutrients are feasible thus minimizing residues. These results follow from the Mitscherlich curve for the relation between output and a single nutrient input.
However, we found on theoretical and empirical basis a Michaelis-Menten curve of response of yield and uptake with increasing amounts of nutrients, both single and in combination, as more appropriate. The highest efficiency of a nutrient is then found at zero input of nutrients (or at a very low level of nutrients in case of a crop with a harvest index which was hypothesized as increasing when production increases). The lowest residue may be expected when just producing with the reserves of nutrients in the soil.
Assuming a Michaelis-Menten relation, the residue per kg product is generally found to increase strongly with increasing input at higher levels of nutrients. At a low input level a constant residue per kg product is found, if yields and residues are proportional. In some (exceptional) cases we observed decreasing residue per kg product at increasing nutrients in the lower range of input, where apparently the greater size and activity of the root system with more nutrients used the available nutrients better.
Even in case of a linear relation between input and output with no decreasing marginal effects, increasing absolute and relative residues are found when producing a certain amount of product with more nutrients per area unit.
Economically one prefers the input level, where the absolute difference between output revenue and internal costs is the largest. This gross margin and the ecological efficiency appear not to be correlated. Because of the rather low nutrient prices in western countries the highest economical efficiency occurs at very high nutrient levels. Ecologically generally a low level is advisable. Thus a political consideration of this issue is necessary.
Relations between input, output and residue will be different on different soils. In case of a surplus of area, the issue whether to produce intensively on a small area or extensively on a large area has even wider dimensions. Our studies indicate that on the better soils higher levels of nutrients are ecologically more feasible than on the less fertile soils.
Progress: Papers are in preparation.

The development of a location specific bio-economic production model for tactical decision support in sugarbeet growing, with special reference to yield, quality and environment

Researcher	: A.B. Smit
Project leaders	: P.C. Struik, J.A. Renkema, J.H. van Niejenhuis (WAU); F.G.J. Tijink (IRS)
Term	: 1992 - 1996
Form	: PhD-project

Cooperation with : Institute for Sugar Beet Growing (IRS); Department of Farm Management

Agriculture often has to deal with making complicated decisions. This complexity results from interactions between external circumstances (partly unknown), effects of former decisions and biological processes. A bio-economic model, in which these interactions are quantitatively described, will be a great help in decision support systems. It can be used for tactical and semi-operational planning and to adjust the production process. This is also true for growing sugarbeets. To maximize its profit, the farmer has to make optimal decisions on e.g. plant density, N-fertilization, sowing and harvest time. He has to take into account weather, soil, payment system (based on harvest date, yield and quality) and environmental pollution level. Existing models are too general for this purpose. So, a farmer and location specific model is developed. IRS-data are important sources of information for derivation of different relationships between weather and soil conditions and growers' decisions on one hand and results on the other.
Progress: The basic model has been extended with the influences of plant density, nitrogen level and harvest date on the yield, quality, financial returns and environment. The project is now in its final stage. The publication of a thesis may be expected in 1996.

Analysis of the development and functioning of crops in relation to environmental factors, nitrogen in particular

Researchers : J. Vos, P.E.L. van der Putten
Project leader : J. Vos
Term : 1988-1998
Research School : PE

Three lines of research are reported:
1. Analyses of the effects of the nitrogen regime on processes of plant development and plant growth in potato and in nitrogen catch crops.
2. Analysis of the interaction between illumination of leaves and nitrogen distribution in the canopy.
3. Analyses of the cycling of nutrients (N,P,K) in several cropping systems

Program
1. Work consisted of analysing data. Because nitrogen affects leaf sizes (in potato), one would perhaps expect an interaction between nitrogen and stem density on attributes of leaves such as leaf size and specific leaf area. Surprisingly, the effects of both experimental factors were additive. A third and last experiment was started to estimate the potential nitrogen accumulation in nitrogen catch crops. The data will also be used to develop and test simulation models on catch crop performance (Dept of Theoretical Production Ecology - WAU).

2. A successful greenhouse experiment was done with potato. Experimental factors were rate of nitrogen supply (two levels) and manipulation of the light regime. The light regimes were (i) a control of spaced plants and (ii) a shading treatment where the lower part of the plant was enclosed in shade gauze, mimicking light extinction in a canopy. The light saturated rate of photosynthesis (Pmax) as well as changes in leaf area, dry weight and nitrogen concentration were monitored for leaf numbers 10 and 12 on the main stem. Shade appeared to induce a faster reduction with leaf age in Pmax.
Measurements were made to examine whether SPAD 502 chlorophyll meter readings could perhaps be used to assess Pmax. Preliminary analysis of the data showed encouraging results. If a close association between Pmax and SPAD values would exist, interesting opportunities would be opened to test and calibrate crop growth models that use Pmax as an input parameter.
In a subsidiary experiment leaf growth and Pmax were monitored for five levels of nitrogen supply. The results corroborated a large effect of nitrogen supply on leaf growth. However, there was no effect of nitrogen on Pmax.

3. Work on cycling of N, P and K in several cropping systems is relevant in view of the current efforts to define 'unavoidable' or 'unacceptable' nutrient losses in Dutch agriculture. In the long term experiment on nutrient flows in arable cropping systems, monitoring was continued of input and output of N, P and K. An undergraduate student combines all data from five years of monitoring nutrient balances of cropping systems with continuous cultivation of silage maize, and grass versus bare soil in winter as a main experimental factor.
Progress:
1. Among the publications evolving from this project one was based on results obtained in three experiments on the interaction between nitrogen supply and stem density (accepted by Potato Research).
2. The results of the 1995 experiment were of satisfactory quality, but some additional observations are needed to clarify inconsistencies at some points in the results from the series of experiments completed hitherto.
3. An international journal accepted a manuscript dealing with the nutrient balances of cropping systems dominated by potato in the north east of The Netherlands.

The effect of environmental factors on crop canopy structure

Researcher : H.J. Bos
Project leaders : J. Vos, J.H. Neuteboom, P.C. Struik
Term : 1992-1996
Research school : PE
Form : PhD-project

A crop canopy structure consists of leaves placed on tillers or branches of individual plants, grown at a certain plant density. The build-up of this canopy structure is influenced by several environmental factors as light, temperature, N, and plant density. The separate effects of environmental factors on plant structure are often well known, but extrapolations to the combined effects of those factors at crop level have not yet been satisfactorily made. The objective of this research is to quantify the effects of the most important environmental factors on crop canopy structure in order to provide building blocks for a general dynamic mechanistic simulation model. The focus is on two monocotyledonous crops: wheat (a tillering plant) and maize (a non-tillering plant). Experimental results show that in maize a high plant density or a low light intensity strongly reduce the leaf appearance rate and leaf width, but increase the full grown leaf length. In wheat, these effects on individual leaf parameters are much less pronounced, but the rate of tillering is strongly reduced by either a low light intensity or a high plant density. Plant density effects were mainly due to differences in assimilate availability in the plant, and not in red/far-red ratio. In wheat, higher temperatures reduced the total dry matter produced per main stem leaf stage and therefore decreased the tillering rate. The tillers arising from the coleoptilar or prophyll bud appear to be the most sensitive to environmental conditions. These experimental data together with literature data on other *Gramineae* crops form the basis of a dynamic mechanistic simulation model that is under construction.
Progress: Publications are being prepared.

Physiological aspects of seed formation in grasses

Researcher	: J.W. Warringa
Project leaders	: W.J.M. Meijer, P.C. Struik
Term	: 1992 - 1996
Research school	: PE
Form	: PhD-project
Co-financer	: Stichting Nederlands Graan-Centrum, 50%
Cooperation with	: AB-DLO

The aim of the project is to analyze the limiting factors in seed formation in *Lolium perenne.* Single plants of separate clones are used and experiments are carried out in the greenhouse. In a first experiment with five clones the effect of light intensity was investigated. Results show that the assimilate availability in the plant is not limiting to seed yield. The crucial step lies in the partitioning of the assimilates. Several sinks may compete with the seeds: 1) new tillering at the flowering stage, 2) the stem and 3) competition between seeds within the ear. Two experiments have been carried out in which tillering was manipulated at flowering. Results indicate no detrimental effect of tillering at flowering on seed growth. As in cereals, the stem seems to act as a temporary storage organ. Labelling, using $^{13}CO_2$, showed that the stem is a net exporter of carbon at the end of seed filling. The pattern of flowering and ripening across the ear was established and the duration of the seed filling period was measured between and within spikelets. The variation in time of flowering, seed set and seed weight was much larger within a spikelet than between spikelets. Upper, younger florets in a spikelet flower later than basal, older florets. The seed filling period was about 25% shorter in the upper florets, and growth rate was reduced by 46%, compared to the basal floret in a spikelet. This resulted in a 63% lower seed weight. Competition between seeds within the ear is investigated by removing whole spikelets and florets within a spikelet. Removing 50% of the whole spikelets increased the seed weight of the remaining seeds by 14% - 19%. Removing florets within a spikelet did not seem to increase seed weight in the remaining seeds in that spikelet. With regard to the partitioning af assimilates the limitations to seed filling seemed to lie within the ear itself. Which process(es) determine the interaction between seeds in the ear and seed filling is still unclear.
Progress: Experiments have been completed. Several papers have been submitted and a PhD thesis is expected in 1996.

Analysis of factors facilitating biotic breakdown of reed stems (*Phragmites australis*) used for thatching

Researcher	: A.T.G. Elzebroek
Project leaders	: A.T.G. Elzebroek, P.C. Struik
Term	: 1993-1995
Form	: no status

Dead stems of reed are widely used for thatching in Europe. In the past decades the thatching profession was confronted with early decay of reed roofs. Biological breakdown mainly by basidiomycete fungi is, among other (physical) mechanisms, an important mechanism of dry matter loss on a thatched roof. This study was undertaken to determine the different factors facilitating the biotic breakdown of reed stems used in thatching, as well as the significance of growing sites on reed quality. It was hypothesized that the mineral content of the stems (especially nitrogen) might influence decay. This implies that the growing site of the stems determines their durability. A different approach was that the differences in stem morphology might explain the susceptibility for biotic breakdown. Stems from three different natural reed stands in the Netherlands were sampled. Additionally plants from a natural reed stand were grown under four different nutrient regimes, from which stems were sampled. Of the stems the lignin-, nitrogen- and phosphorus-concentrations, the dry matter distribution, the number of nodes, the specific weight and various morphological parameters were determined. Also the water uptake of dead stems was measured. The decomposition of stem material was estimated with a driselase enzyme essay.

Measurements were made for each internode and additionally for two stem sections. It was shown that the rate of breakdown, as well as the lignin, N- and P-concentrations varied considerably within one stem. This led to the conclusion that in order to make a good comparison between different stems a standardization of the material related to height is absolutely necessary. The differences between stems either from one or different growing sites were much smaller than those within stems within a site. The natural reed grown under different nutrient regimes did not produce a comparable crop within one growing season. Research as such has to be done after some growing seasons to produce interpretable results. The comparison of the N- and P-concentrations of stem sections showed that P, much more than N is to be expected the limiting factor in biotic breakdown. The N/P ratios were greater than 10 in all cases. The influence of the growing site of the stems is expressed in morphological parameters rather than mineral contents and breakdown rates of the dry material. Good parameters are the number of internodes in relation to height and specific weight of the stems. It was shown that especially the specific weight was negatively influenced by nutrient rich growing sites. These sites resulted in longer and heavier stems with a lower specific weight. Therefore a roof thatched with those stems consists of 1.4 times less dry material than a roof constructed with stems from less nutrient rich growing sites. The former stems also had less nodes in the lower part of the stem. The number would have been even smaller after the necessary shortening of these stems. Nodes seem to disrupt water uptake by the dead stem. Water could be important as it is required for breakdown by fungi. There are various reports that early breakdown coincides with water soaked roofs.
Progress: The main results have been published. Further data are currently processed.

3.3.1.2 Projects carried out by the former Grassland section

Physiology of grasses in relation to development and digestibility of cell walls.

Researcher	: B. Deinum
Project leader	: B. Deinum
Research school	: WIAS
Term	: 1992-1998
Cooperation with	: CPRO-DLO

The objective is to improve our knowledge and understanding on the backgrounds of herbage digestibility by ruminants.
Maize, perennial ryegrass and some tropical grasses are grown under different environmental conditions. Growth, development and ageing of the various organs (consecutive leaf blades, leaf sheaths and stem internodes), mass of dry matter and of cell walls and digestibility of cell walls are determined. Histological and anatomical characteristics of these organs are also measured using light microscopy. In vitro digestion of cell walls is studied in thin microscopic sections.
Results obtained so far indicate that almost all cell wall and most of the indigestible cell wall is formed during development of organs. Adult organs often loose a great deal of the almost completely digestible cell contents during ageing, whereas the mass of indigestible cell wall increases slightly. Later developing leaves of seedlings are usually less digestible than earlier leaves in young adult stage. In tropical grasses, intensive shading reduced digestible cell wall mass and thickness of secundary walls of sclerenchyma, but had little effect on histological development. This was also the case in perennial ryegrass, but to a lesser extent. Defoliation of Italian ryegrass reduced masses of the new leaves and increased specific leaf area, but had little effect on histology and anatomy. A higher temperature reduced cell wall digestibility but had little effect on histology and anatomy of leaves.
Tensile strength in Italian ryegrass leaves, as a possible estimate of biting force, increased from leaf tip to base, associated with the greater number of sclerenchyma cells. The relation of tensile strength with digestibility is still unclear.
Extensive genetic variation in digestibility of organic matter and of cell walls has been found in vegetative perennial ryegrass under greenhouse conditions. This variation was much greater within populations and registered cultivars than between them. The reproducibility of these results is being tested now in the field in vegetative and reproductive stage. Associations of digestibility with histological and anatomical development are being studied. Such knowledge may help to develop better strategies for breeding and management of good quality forage in sustainable grassland farming systems.
Progress: results have been presented at a symposium.

Relation between mechanical - and histological properties of grass leaves

Researcher	: P. Kerkhoff
Project leader	: B. Deinum
Term	: 1995 - 1996

The main objective of this project is to investigate possible relations between strength and histology of leaf blades and organic matter digestion.
Among the leaves of grasses there is a great variation in the ability to withstand the strain of tear and shear. The strength of a leaf blade is thought to be principally linked to characteristics of the sclerenchyma and the vascular bundles. Also, there is possibly a negative relationship between the amount of sclerenchyma (and vascular bundle material) and organic matter digestibility.
Methodology for tensile strength measurements has been adapted to leaf blades.

Lolium perenne is the principal species being investigated; 20 genotypes have been selected and are grown in the greenhouse to serve as a source for plant material. Measurements of tensile strength are carried out at the Rheology Laboratory of the Department of Food Science at the WAU.
Progress: No results are available yet.

Physico-chemical research of lignocellulose synthesis in primary and secundary cell walls of plant tissues.

Researcher	: F.M. Engels
Project leader	: F.M. Engels
Research school	: WIAS
Term	: 1992-1998

Results reported concern maize stems. 1: Tissues with only primary walls-middle lamellae are completely degradable. 2: Primary walls-middle lamellae of tissues are converted into an undegradable layer due to lignification at the onset of secundary cell wall synthesis. 3: The developing secundary wall is completely degradable. Maize plants (industrial genotypes: W401, BM1 and BM3) were harvested at pollination (Wageningen) and at silage stage (Tienen, Belgium). Sections of 100 μm were made in the middle of top internode 4. Degradation and staining of sections was as reported earlier. At time of pollination stem parenchyma of the W401 and BM1 genotypes showed a similar distribution of violet-blue colored cell walls with the toluidine staining. The BM3 parenchyma was predominantly violet. Degradation of the parenchyma of the genotypes at 12, 24, 48 and 120 h showed that the overall cell wall degradation followed in order BM3 W401 BM1. In W401 and BM1 the secundary cell walls of the epidermis and sclerenchyma tissue were degraded completely and only primary walls were left. However, in BM3 these were degradaded completely after 24h. At time of harvast the stem parenchyma of the W401 and BM1 genotypes showed a typical pattern of violet-blue and blue colored cell walls with the toluidine staining. The BM3 parenchyma was still predominantly violet. During degradation it was observed that violet-blue parenchyma cell walls in W401 and BM1 were degraded. The blue parenchyma was not degradable. In BM3 all parenchyma was degraded. In epidermis and sclerenchyma of the three genotypes a fine network of primary walls remained. Some sclerenchyma around vascular bundles in BM3 in the stem center showed complete degradation of secundary and primary walls. Preliminar conclusions: 1: The degradability of maize parenchyma cell walls can be predicted with the toluidine staining method. 2: Primary walls of sclerenchyma and epidermal tissue of the BM3 genotype are completely degradable at pollination stage. 3: After pollination and before harvest, (silage) cell wall maturation (in all genotypes) resulted in loss of a number of rapidly degradable parenchyma cell walls. 4: The chemical composition of primary cell walls of epidermal and sclerenchyma tissue of BM3 is modified after pollination and turn into undegradable primary walls which has a large negative effect on cell wall degradability.
Progress: The results of these investigations have been presented at international conferences and workshops.

Simulation of *in-vitro* digestibility of grass on the basis of morphological and physiological plant characteristics

Researcher	: J.C.J. Groot
Project leaders	: J.H. Neuteboom, E.A. Lantinga, B. Deinum
Form	: PhD-project
Term	: 1992-1996
Research school	: PE
Cooperation with	: Department of Animal Nutrition, Department of Theoretical Production Ecology

Understanding of plant physiological processes determining changes in herbage quality will contribute to plant breeding efforts to improve grass digestibility and to efficient grassland management. The objectives are: (1) To explore processes underlying changes in digestibility characteristics of grass, related to development, growth and ageing of individual plant organs, and (2) investigation of the kinetics of *in-vitro* fermentation of plant material, in particular cell walls. In glasshouse and field experiments the digestibility of different Italian and perennial ryegrass populations was studied under various temperature and management regimes. Ageing of consecutive leaves of vegetative grass was studied in crops and individual plants. Additionally, effects of defoliation have been quantified. In crops of *Lolium multiflorum*, the initial organic matter digestibility and the rate of digestibility decline decreased for consecutive leaves until leaf 6. Leaves of higher insertion levels showed no differences in digestibility characters. The first leaf formed after defoliation showed a low initial digestibility and a high rate of decline of digestibility, but consecutive leaves had digestibilities similar to the same leaves in uncut plants. Population differences in ageing of plant organs of vegetative and reproductive grass were studied at three temperatures for *L. perenne*, but results have not been analyzed yet. The effects of cell wall ageing on fermentation processes and gas production kinetics were studied for *L. multiflorum* and *L. perenne*. In older leaves, the rate of fermentative gas production was lower than in young leaves. Digestibility calculations from gas production kinetics differed from standard *in-vitro* digestibility assessments. Differences tended to be non-linear. Detailed studies of fermentation of various compounds of grass leaves are being carried out. A method has been developed to assess the number of phases in the gas production curves, to enable staight-forward multiphasic analysis of gas

production kinetics. A simulation model will be developed, to calculate changes in digestibility during the growing season.
Progress: the experimental work has nearly been completed. Preliminary results have been presented at international conferences and workshops.

Evaluation and possibilities for agricultural use after extensification of the grassland exploitation

Researcher : J.H.Neuteboom, K. Wind
Project leader : J.H. Neuteboom

In this project, started in 1972 and focused on grasslands for nature conservation, long term effects of extensification measures (no or reduced fertilizer inputs) on botanical composition and agricultural output (dry matter yield, fodder quality and animal live weight gain) of grassland are studied.
The project serves primarily educational purposes. Increase of floristic diversity is a long term process. The very slow occurring botanical changes under extensification are not only due to a remaining high soil fertility, but are also related to soil moisture conditions. On moist sand soil also a dominant grass species of low soil fertility like *Agrostis capillaris* can form such a dense sward that other species hardly get the chance to establish.
Progress: Data have been presented at international conferences and workshops.

Persistence of white clover in permanent grassland

Researchers : A. Elgersma, H. Schlepers
Project leader : A. Elgersma
Term : 1991-1996
Research school : PE

Despite its nutritional benefits and its ability to fix N_2, white clover is hardly used in The Netherlands. However, as the amount of N fertilizer applied to grassland is decreasing, there is renewed interest in white clover. The lack of persistence of white clover in permanent pastures is a major problem. Clover content and persistence are affected by various factors. The objectives of this project are 1. to investigate the effect of clover cultivar, companion grass cultivar, management (cutting or grazing) and soil type on clover persistence, and 2. to study the effect of white clover on nitrate leaching. Mixtures of perennial ryegrass cultivars with contrasting growth habits, cvs. Condesa, Wendy and Barlet, and white clover cultivars with different leaf sizes, cvs. Alice, Gwenda and Retor are being evaluated under cutting (clay soil) and under grazing (sand and clay soils). No fertilizer N is applied. Under cutting, the large-leaved cv. Alice yielded significantly more than the small-leaved cv. Gwenda and the medium-leaved cv. Retor. Companion grass cultivar did not affect yield or botanical composition.
Nitrate leaching was studied with ceramic cups. The mixtures with Alice had the highest N-emissions, but the level did not exceed 50 mg/l. Grazing trials are conducted on mixed swards of the perennial ryegrass cultivars with white clover cv. Gwenda. The plots were continuously stocked with cattle, aiming at an average sward height of 7-8 cm. There was no effect of grass cultivar on liveweight gain or net production. The cutting and grazing trials will be continued to study clover persistence and nitrate leaching.
Progress: In 1995 work was continued and results have been presented at international conferences and workshops. New trials were established as part of the EU-COST programme on overwintering of white clover. An STW-proposal was formulated.

Modelling interactions in grass-white clover mixtures

Researcher : M. Nassiri Mahallati
Project leaders : A. Elgersma, E.A. Lantinga
Term : 1994-1998
Cooperation with : Department of Theoretical Production Ecology
Research school : PE

The aim of this study is to identify the differences between contrasting grass and clover cultivars in the rate of appearance, expansion and fate of their leaves and to observe differences between species in the investment of their resources into new leaf tissue (total leaf area and vertical distribution). This basic information is needed to explain changes in the composition of cut and grazed mixtures and to extend existing simulation models for competition between plants from the vertical distribution and capture of the resource light. The ultimate goal is to gain insight into mechanisms that determine clover persistence under various management strategies. The large-leaved white clover cultivar Alice and small-leaved cv. Gwenda were grown in combination with perennial ryegrass cv. Condesa in the field. There were two cutting frequencies. The spatial and temporal rate of change in leaf area, dry matter and radiation absorption were studied at weekly intervals in successive 5-cm canopy layers during one year. There were large differences in leaf area and dry matter distribution over height between both mixtures. Similarly, differences between cutting frequencies were found which changed during the season. Leaf area and radiation absorption profiles were different in clover and grass. They also differed between both clover cultivars, resulting in different patterns of dry matter distribution.
Progress: first results have been presented in a poster at the annual meeting of the PE research school in October 1995. New field trials were established in the autumn of 1995.

Degradation of rangelands

Researcher	: F. Tarla Nchembi
Supervisors	: L.'t Mannetje, J.H. Neuteboom
Period	: 1993-1996
Cooperation with	: Cameroon: Centre d'Etude de l'Environment et du Developpement au Cameroun, Maroua. The Netherlands: Centrum voor Milieustudie Leiden

The objective of the current work is to evaluate rangeland degradation in the extreme North province of Cameroon by studying vegetation productivity and grassland species dynamics. Sites with varying degrees of degradation have been selected for detailed studies of botanical composition, dry matter production, nutritive value, sward structure and processes of vegetation change. Measurements have been carried out during 1993, 1994 and 1995.
Progress: results are being analyzed in order to proceed to a PhD.

Persistence and productivity of herbaceous and woody legumes in grassland improvement in the tropics

Researcher	: S. Abarca Monge
Supervisor	: L. 't Mannetje
Term	: 1993 - 1998
Form	: VF Programme 94.34 (Sustainable land use in the tropics)

The objective of the research is to investigate the possibility of increasing the productivity and sustainability of improved pastures in the Atlantic Zone of Costa Rica by including woody species. The successful improved pasture mixture consisting of *Brachiaria brizantha* and *Arachis pintoi* was compared with the same mixture but including *Erythrina berteroana* or *Gliricidia sepium* at two stocking rates. Measurements consist of dry matter yield, botanical composition, nutritive value, intake by the animals, soil carbon and nitrogen levels, soil compaction, decomposition of leaf material and the effects of shade on grass and herbaceous legume yield and nutritive value. The main result sofar has been that the inclusion of a tree legume reduced total forage yield, probably as a result of shading by the tree species.
Progress: Results are being analyzed and prepared for publication.

The agronomy of grain and pasture legumes in Bolivia.

Researcher	: H. Waaijenberg, J. Jiménez
Project leader	: H. Waaijenberg
Supervisor	: L. 't Mannetje
Term:	: 1994-1998
Form	: Externally financed project (DGIS)
Cooperation	: Centro de Investigación Agrícola Tropical (CIAT), Centro de Investigación en Forajes (CIF) de la Universidad Mayor de San Simón, Programa Nacional de Leguminosas de Grano (PNLG) del Instituto Boliviano de Tecnología Agropecuaria (IBTA), Department of Microbiology, Agricultural University Wageningen.

The main objective is to improve the agronomy of grain and pasture legumes within the production systems of small farmers in the valleys and highlands of Bolivia. In the first instance research is being focused on identifying and producing *Rhizobium* inoculants for the legumes *Medicago sativa, Vicia faba, Phaseolus vulgaris* and *Pisum sativum.* Field experiments have been started in many localities with varying climates, soils and production systems on many small farms in the valleys and on the highlands, usually in cooperation with Non Governmental Organisations.
Apart from the use of appropriate inoculants, fertilizer treatments consisting of calcium, phosphate and nitrogen are being used to determine the most limiting production factors. Subsequently, the most suitable way of application of inoculants and fertilizer will be investigated (seed pelleting, fertilizer placement). Transfer of technology in the form of workshops and courses for research workers, students and farmers as well as the involvement of university students for thesis research will form an integral part of the activities.
Trials have been established to study the introduction of *Arachis pintoi* in existing *Brachiaria decumbens* grasslands on small farms in the tropical parts of the provinces Carrasco de Cochabamba and Yapacaní de Santa Cruz.
Progress: Preliminary results have been presented at local workshops.

3.3.2 Section Plant Production Systems

Evaluating the potential for bambara groundnut as a food crop in semi-arid Africa.

Researcher	: M. Brink
Project leader	: E. Westphal
Term	: 1993-1996
Form	: externally financed (EC)
Cooperation with	: part of the international research programme *Evaluating the potential for bambara groundnut as a food crop in semi-arid Africa.*

Because of their nitrogen fixing capacity, leguminous crops can play an important role in increasing the sustainability of tropical cropping systems. Bambara groundnut (*Vigna subterranea*) is an important leguminous crop in semi-arid Africa. Compared to groundnut, bambara groundnut performs relatively well under conditions of water stress and is less susceptible to diseases, but despite its agronomic potential, the crop has received little research attention. This programme links field experiments in Botswana, Tanzania, and Sierra Leone with controlled environment experiments in the U.K. and Wageningen. Research in Wageningen focusses on the effects of daylength and temperature on growth and development, the uptake and transport of major nutrients, quantification and modelling of crop development and dry matter partitioning, and methodology development. Experiments were carried out to quantify the combined influence of daylength and temperature on growth, development and dry matter distribution of bambara groundnut selections from Botswana, Tanzania, and Sierra Leone, to determine the inductive periods for podding, to compare the effects of constant, increasing or decreasing photoperiods, and to assess the influence of phosphate nutrition on growth, development, and dry matter distribution. The results are used to make a developmental routine for a bambara groundnut model, which will be validated with the results of field experiments, carried out by the programme partners in Africa. The bambara groundnut model will be used to assess the potential of the crop for different agro-ecological regions in these African countries.
Progress: The major part of the experimental work has been terminated and the influence of photoperiod and temperature on development rates of eight bambara groundnut selections has been quantified. Further analysis, modelling work, and validation are in progress.

Agro-ecological analysis of regional land use scenarios

Researchers	: J. Bessembinder, L.O. Fresco, R. Rabbinge, M.van Ittersum
Project leader	: L.O. Fresco
Term	: 1992-1996
Form	: PhD-project
Cooperation with	: the project is part of the "Programa Zona Atlantica" in Costa Rica, carried out in cooperation with the Centro Agronomico Tropical para Investigacion Enseñanza, the Ministerio de Agricultura Y Ganadería, the Universidad Nacional and the Wageningen Agricultural University.

The aim of the project is the development of a multiple goal linear programming-model (MGLP) for the bio-physical exploration of regional land use, with special emphasis on uncertainties in technical model coefficients and on operationalizing sustainability. For MGLP models a large amount of data is needed. In hardly any situation sufficient data are available, thus introducing uncertainties in model-coefficients and the final scenarios. Until now most MGLP-models for land use have been static. Sustainability, however, has a clear time aspect and therefore a multi-period model is used in this project. The model includes 6 types of land use (banana, cassava, maize, palmito, pasture, and tree plantations), representing the main problems and alternatives for the region. Two sustainability indicators are taken into account: nutrient leaching and biocide use. For a case-study the northern part of the Atlantic Zone of Costa Rica was chosen.
Crop production with different production technologies was calculated with simulation models. Nutrient balances, mineral fertilizer needs and nutrient losses were calculated for all 'land use - technology - soil' combinations. Different ways of estimating the risk of biocide leaching were compared. An inventory of uncertainties in technical coefficients, caused by a lack of knowledge on underlying processes and by a lack of data for quantification of these processes, was made. The methods used for the quantification of the inputs (labour, nutrients, biocides) and outputs (production, leaching of biocides and nutrients) were documented in detail.
Progress: A paper on uncertainties in technical coefficients was published in a special issue of the Netherlands Journal of Agricultural Science. A paper and poster were presented at a conference on Multiple Objective Decision Support Systems in Hawaii. Develpment of the MGLP-model is in progress.

Aspects of agricultural practices in relation to land-use planning

Researchers	: N. van Duivenbooden, L.O. Fresco, N. de Ridder, T.J. Stomph
Project leader	: L.O. Fresco
Term	: 1992 -1998
Form	: VF-programme 94-34 and externally financed by DGIS
Research school	: PE
Cooperation with	: Consortium for sustainable use of inland valley agro-ecosystems in sub-Saharan Africa, with IITA, WARDA, SC-DLO and national agricultural research agencies (NARS).

In 1994 the West African Inland Valley Consortium (IVC), a collaboration between several national and international research institutes, has been established. The Department of Agronomy participates in this consortium with the objective to

contribute through research in the development and testing of a multi-scale characterization method and of agricultural technologies for inland valleys in different agro-ecological zones. The multi-scale approach provides a good framework for the characterization of inland valley agro-ecosystems and will provide a tool to evaluate the possibilties to extrapolate locally developed technologies to other zones.
Progress: The characterization method used at the semi-detailled level, the transect method, has been developed. Future work will aim at the following. Decision criteria have to be developed for the exact location and number of transects to be laid out in individual inland valley systems. For that purpose land and land use are mapped for an entire valley segment in Burkina Faso. Statistical analysis of values of semi-detailed parameters as observed by different numbers and locations of transects will provide improved decision criteria. Further future fieldwork will investigate possible replacement of laborious soil observations to identify and determine boundaries of the hydromorphic zones by indicator vegetation types.

Development of a multi-scale model of rice-based agro-ecosystems in West Africa

Researchers	: N. de Ridder, T.J. Stomph
Project leader	: L.O. Fresco
Term	: 1993 - 1998
Form	: VF-programme 94-34
Research school	: PE
Cooperation	: part of the research theme "Development of a general applicable model (ideotype) of bio-physical processes in agro-ecosystems at different scales"

The project focus is on the bio-physical processes which influence - and are influenced by - agricultural practices like land preparation, land cultivation, anti-erosion measures, etc. The project concentrates on the following scales: field, toposequence of an inland valley and first order watershed. The objective is to quantify water and nutrient flows (N is given the highest priority) at different scales and in relation to different agricultural practices, ultimately including different crops. Explorative models simulating effects of land-use changes on nutrient and water flows at landscape scales, summarizing present knowledge, are used to target detailed process research in the field and in greenhouses. Results of detailed process research is fed back to the models: verifiable "building blocks" relating to sub-systems are composed to reduce the explorative nature of these models.
Progress: an explorative model to study the effects of land use changes on water and nitrogen flows at the scale of West African inland valleys has been developed. Water and nitrogen flows in relation to different cropping systems along the toposequence are studied in a continuing experimental lay-out at the WARDA research station in Ivory Coast. Run-off will be studied also in a small watershed in Burkina Faso at the scales of 1 m^2, fields of different sizes and the entire watershed. Furthermore, a deterministic model is being developed to simulate water flows in relation to agricultural practices at detailed scale: artificial toposequences in greenhouses are used to validate the processes simulated.

Evaluation of cacao cropping systems in different agro-ecological zones

Researcher	: W. Gerritsma
Project leader	: M. Wessel
Term	: 1992-1995
Form	: externally financed (Netherlands Cocoa Association)

West Africa has been the main producer of cacao in the world. This position as a leading cacao producer can only be maintained when a solution will be developed for the rehabilitation of the existing cacao plantings. New methods for the rehabilitation of the aged plantings need to be developed, since the ecological conditions have altered over the last decades. Disappearance of the rainforest, the natural shade component of low input cacao systems, is one of the main ecological drawbacks. Systems analysis of different cacao production systems with dynamic simulation models is the objective of this study. The development and testing of explanatory mechanistic simulation models for cacao is part of the project. Subsequently, various management practices and options can be compared quantitatively for their efficiency and sustainability.
Progress: The modelling work and report writing has been finalized. A review of the cocoa physiology was prepared for the final report, and the model was documented. A proposal for an extension has been drafted.

Modification of soil processes by mulching in the humid tropics

Researchers	: F.C.T. Guiking, D.M. Jansen
Project leader	: F.C.T. Guiking
Term	: 1993-1996
Form	: VF-programme 94-34 (Sustainable land use in the tropics)

The main positive effect of mulch in the humid tropics is likely to be the build up and maintenance of a flourishing soil (micro) fauna and flora. The activity of the resulting soil biota may prevent compaction, or result in decompaction. As a result, it is hypothesized that the rooting of crops may be facilitated to explore a larger soil volume which reduces losses of mobile

nutrients. It is difficult, however, to separate these effects from the nutrient additon effect of the mulch material.
This is currently being tested in an experiment in the Atlantic Zone in Costa Rica. The test crop is palmito (*Bactris gasipaes*), a palm (pejibaye) grown for palm heart. Plant density is 2.5 m x 1 m (4,000 plants.ha^{-1}). Under standard production practices the field receives a mulch of leaves from the crop. Treatments are: removal of mulch, standard practice (i.e. leave the pruned leaves in situ) and double the amount (pruned leaves from zero-plots added to these plots). To moderate the effect of removal of mulch (export of nutrients), and to test the effect of accelerated breakdown, treatments with fertilizers (mainly N) are included, viz. standard practice, half the amount, and nil. Measurements include soil dry bulk density, water holding capacity of the profile between 10 and 1600 kPa, soil penetrability, infiltration rates, breakdown rate of the mulch, nutrient status of soil and mulch, root proliferance studies and yield of harvestable product. Assessments of soil micro flora and fauna are currently considered. It is expected that this experiment will throw light on ways to stabilize agricultural production in the fragile environment of the humid tropics.
Progress: Monitoring of soil physical characteristics was discontinued due to logistical problems. Measurements of biomass production were intensified to produce data for a crop development model. Experimental data indicate that transfer of mulch involves large flows of Nitrogen, but without an effect on crop production. Final soil physical measurements are scheduled for early 1996, after which the experiment will be concluded.

Agro-ecological niches in Andean potato growing

Researchers	: G.H.J. de Koning, L.O. Fresco
Project leader	: G.H.J. de Koning
Term	: 1994-1998
Form	: PhD project
Cooperation with	: CIP (International Potato Centre)

Agro-ecological characterization is used for the identification of constraints to sustainable agricultural use, targeting and implementation of research, and extrapolation of research results and newly developed technologies to other areas with similar agro-ecological conditions. Furthermore, it can be used for the support of policy decisions at national and regional levels, and a better assessment of their effects.
The objective of this study is to develop further the agro-ecological characterization methodology by better implementation of the importance of human interventions (management) in the agro-ecosystem, and by investigating scale-dependence of phenomena of the agro-ecosystem. The concept "agro-ecological niche" will be used to structure agro-ecological characterization and to facilitate understanding of the factors management and scale. The agro-ecological niche is the multidimensional space in which an agricultural crop grows. This space is being delimited by the values of the biophysical dimensions that are of importance for the growth of the crop (light, water, temperature, nutrients, pests and diseases). The value of the biophysical dimensions is determined by the bio-physical environment (like climate and soil type) and human interventions (management) in that environment. Management, in turn, depends on the socio-economic environment and the perception of the biophysical environment by the actor. As a model system, potato production in Ecuador has been chosen. Due to the high agro-ecological diversity in Ecuador, potato is investigated in different agro-ecological niches. Data are being collected at different scales. At field and household level a data set of a farming system in the central Ecuadorian Andes has been collected. A comparable data set for the northern Ecuadorian Andes is available at CIP. The two studies concern situations that are different with respect to bio-physical environment, management of the farmers, and socio-economic conditions. These farming systems data are analyzed statistically (mainly through regression analysis) to describe the variables that are most decisive for the agro-ecosystem at this level, especially aiming at analyzing yield differences. For the regional scales, a grid with a resolution of 5' by 5' (minutes) will be constructed with data on land use, agricultural production, agricultural inputs, climate, soil, infrastructure, demography and socio-economic indicators. These data will also be analyzed with regression analysis in order to detect variables with which land use (changes) and, if possible, crop production can be described (with special reference to the potato crop). In order to allow a systematic analysis of spatial scale effects, the 5'x5' grids will be aggregated to larger grids, that are aggregations of 4, 9, 16 etc. 5' grid units, that way creating additional artificial spatial scales. These will all be analyzed in a similar way and results of the different scales will be compared. An example of this approach has been given by Veldkamp and Fresco (1995) for Costa Rica.
Progress: Results have not yet been published.

Multi-scale land use modelling

Researchers	: A. Veldkamp, L.O. Fresco
Project leader	: L.O. Fresco
Term	: 1993 - 1995
Form	: PostDoc project, externally financed by NOP (National Research Programme on Air pollution and Climate Change)

The project resulted in the development of concepts for handling the highly dynamic features of land use

change and its drivers for a small country (Costa Rica) at different spatial scales. An analysis of Costa Rican land use/cover system distribution and their dynamics at six different spatial scales demonstrated that the human/biophysical dimensions of land use/cover systems are scale dependent. Each land cover has its own specific set of human and biophysical scale related drivers. Most important Costa Rican drivers or their related proxies where urban and rural population, agricultural labour force, infrastructure, relief, soils, and climate. Most changes in land use from 1973 to 1984 were related to changes in population density and their distribution and confined to certain biophysical conditions. The reconstructed drivers were simulated and integrated within a dynamic model framework, Conversion of Land Use and its Effects (CLUE). The CLUE approach was applied successfully for Costa Rica using 913 (0.1°*0.1°) grids and leads us to conclude that the CLUE modelling framework is suitable to construct operational multi-scale land use/cover change models. CLUE allows geographically explicit modelling of the effects of changing demographical and biophysical driving forces or their proxies on land use/cover changes. By using different aggregation scales it can be demonstrated that local, regional and national trends can have opposite effects and results. The multi-scale aspect of the model allows the simulation of realistic system dynamics demonstrating the essential role of both top-down and bottom-up effects and processes. The multi-scale properties of the CLUE-CR model seem to stabilize model dynamics within realistic domains despite the limited data on which the model is based.
There are no methodological constraints to scale CLUE down and/or up and to link up with regional land use planning exercises and global climate change assessment studies. For the moment data limitations prevent such an exercise.
Progress: The results of the CLUE model have been published as 5 scientific papers and will now be further elaborated and validated in a series of two follow-up projects.
Future research will attempt to model human (demographic and socio-economic) and biophysical drivers of *global* land use/cover in an integrated and multi-scale effort. A follow-up project has been funded to combine the CLUE and IMAGE methodology to model land use/cover dynamics at various scales, allowing comprehensive quantitative perception of the model performances and the relations between driving forces, scale and land use dynamics and socio-economic feedbacks.

Growth and development of the sago palm (Metroxylon sagu) with special reference to the accumulation of starch in the trunk

Researcher	: D.L. Schuiling
Project leader	: M. Flach
Term	: 1988-1996
Form	: externally financed (NWO-WOTRO) (until 1992)

Sago palm is a starch crop of the perhumid lowlands of South-East Asia and western Oceania. Hundreds of thousands of people in eastern Indonesia and in Papua New Guinea have been using it as their staple. The palm stores hundreds of kilo's of starch in a single trunk during its 10- to 20-year vegetative life. These reserves largely disappear again during the subsequent generative stage, after which the trunk dies. Traditional harvesting is done from semi-wild stands by felling the palm at some time during the generative stage, splitting the trunk, pulverizing its pith and leaching the starch out of it with water. Sago palm is well on its way to becoming a plantation starch crop. This study aimed at providing a scientific basis for timing the harvest in a plantation situation. To this end, first the vegetative and generative stages of the palm had to be adequately described. Second, the starch accumulation and depletion in the trunk of the palm had to be monitored and linked to these stages. The latter was done by estimating trunk starch content and distribution through destructive sampling of some 35 palms of varying ages from semi-wild stands on the Moluccan islands of Seram and Saparua. Working with palms from semi-wild stands - opted for because of the undisturbedness of such stands as opposed to plantations - made it necessary to incorporate a third topic into the study, i.e. the natural variability of the sago palm. During a two-month study tour in Sarawak and Indonesia in 1992, the extent of this variability was further explored and a start was made with a sago palm germplasm collection in Seram.
Progress: Papers are being prepared and will be included in a PhD thesis.

Plant resources of South-East Asia (PROSEA)

Researchers	: J.S. Siemonsma, E. Westphal, L.P.A. Oyen
Project leader	: J.S. Siemonsma
Term	: 1985 - 2000
Cooperation with	: P.C.M. Jansen, R.H.M.J. Lemmens, M.S.M. Sosef, E. Boer (Department of Plant Taxonomy)

PROSEA is an international programme in which a network of seven institutions in South-East Asia (Indonesia, Malaysia, Papua New Guinea, Philippines, Thailand, Vietnam) and the Netherlands cooperate to arrive at a 'South-East Asian Plant Resources Information System', consisting of a multivolume Handbook and an operational Databank.
Wageningen Agricultural University participates actively in this network through the Departments of Agronomy and Plant Taxonomy. The Department of Agronomy houses the PROSEA Publication Office, whose main responsibility is the publication of a 20-volume Handbook on about 6,000 plant resources of

South-East Asia.
Progress:
From 7-9 November 1994, the Second PROSEA International Workshop was held in Cisarua, Indonesia. It was attended by 120 participants. The Workshop resulted in a blueprint for the development of the programme during the Second Implementation Phase 1996-2000. Proceedings were published in 1995.
In 1995, two new volumes of the Handbook were published, i.e. PROSEA 7: 'Bamboos', and PROSEA 5(2): 'Timber trees: Minor commercial timbers'. Work is in progress on PROSEA 5(3): 'Timber trees: Lesser-known timbers', PROSEA 9: 'Non-seed carbohydrate-producing plants', PROSEA 10: 'Cereals', PROSEA 11: 'Auxiliary plants in agriculture and forestry', PROSEA 12: 'Medicinal and poisonous plants', and PROSEA 15: 'Cryptogams'.
In the series of accompanying PROSEA Bibliographies, two volumes were published: PROSEA Bibliography 5(1): 'Timber trees: Major commercial timbers', and PROSEA Bibliography 8: 'Vegetables'.
In a joint venture with PUDOC-DLO, PROSEA published a first version of a semi-commercial CD-ROM, comprising the texts of Handbook volumes 1-4 and corresponding parts of the literature databases in the PROSEA Databank.
Miscellaneous output comprised the PROSEA Annual Report 1994, and three issues of the PROSEA Newsletter.
In cooperation with Dr. Clive Hackett, Plantsoft Services Australia, a PLANTGRO pilot project was carried out which led to the conclusion that it is very well possible to create good quality starter plant files for PLANTGRO on the basis of the articles in the PROSEA Handbook, complemented with additional personal experience/knowledge of the authors.

3.4 Summaries of completed PhD theses

3.4.1 Theses carried out under supervision of the section Crop and Grassland Science

3.4.1.1 Former Field Crops section

On flowering and botanical seed production in potato (*Solanum tuberosum* L.)
C.J.M. Almekinders
Promotor: P.C. Struik

The use of true potato seed (TPS) as a propagule for potato tuber (*Solanum tuberosum*) production is a viable alternative to the use of seed tubers. For this technology to be successful, efficient production of high-quality botanical seed is crucial. The objectives of the research were to define production practices that maximize quantity and quality of botanical seed produced, and to contribute to the understanding of above-ground development in potato.

Seed production was studied under field conditions in three contrasting agro-ecological zones in Peru. Seed production is described as a function of number of flowers produced, berry set and number of seeds produced per berry. Hundred-seed weight was used as seed-quality parameter. Flower production was analyzed as a function of inflorescence production, number of flower primordia initiated per inflorescence and flower primordia survival.
The results of the field experiments indicated that generally, later-produced inflorescences on a shoot or in a field, and later-produced flowers in an inflorescence have a lower berry set and produce fewer and smaller seeds per flower. The effect of the position of the flower in the inflorescence did not affect seed size in all cultivars. Hundred-seed weight of production from primary inflorescences was increased when later-produced inflorescences were not used for seed production, but this could not compensate for the reduction of seed yield.
Increasing plant density reduced the number of inflorescences per shoot and the number of flowers per inflorescence. Flower production per m^2 increased with plant density in two of the three cultivars used. Berry set, number of seeds per berry and 100-seed weight were reduced when comparing flowers at similar positions on the shoot. However, because increasing plant density shifted the flower production from later- to earlier-formed flowers, the effect on average berry set, number of seeds per berry and seed size of the total seed production was relatively small. The effect of plant density on seed production was largely determined by the effect on flower production. Artificial extension of the photoperiod and interruption of the night with incandescent light increased the flower production under warm tropical conditions. This effect was principally a result of an increased inflorescence production. Photoperiod treatments did not affect the seed production per flower.
Experiments in controlled conditions showed that increasing photoperiod and temperature increased the production of inflorescence positions per shoot, number of flower primordia per inflorescence and flower primordia survival in the temperature range of 15-25°C (24-h average). Shoot development and flowering in potato were quantified as functions of rates and durations of leaf and flower primordia initiation, and of stem production. Effects of increasing temperature and photoperiods on shoot development and flowering were a result of increasing thermal durations of stem production, and leaf and flower primordia production of individual stems. The effects on individual stems were, however, small compared to the effects on stem and inflorescence production.
Conclusions from the study for practical TPS production were that the last produced flowers in a field have a strongly reduced potential for seed production and that seed production can be best increased by increasing flower production through longer photoperiods and higher temperatures.

Basic studies on the production and performance of potato minitubers.
W.J.M. Lommen, 1995
Promotor: P.C. Struik

Mini-tubers are small seed potato tubers that can be produced year-round in glasshouses on *in vitro* propagated plantlets planted at high density. The agronomical and physiological principles of the production of mini-tubers and their performance under Dutch field conditions were studied. The mini-tubers had fresh weights between 0.125 and 4.000 g.
More than 3000 mini-tubers per m^2 were produced in 10 weeks (average fresh weights 1 - 2 g), when tubers were harvested 4, 7 and 10 weeks after planting, using a non-destructive harvesting technique in the first two harvests. Removing tubers in the first harvest resulted in initiation of new tubers because more potential tuber sites became available which were not subjected to the dominance of rapidly growing tubers. Part of the newly initiated tubers grew to a harvestable size within three weeks, but the number of tubers in harvestable sizes did not increase thereafter, whereas part of the undersized tubers was resorbed. The second harvest stimulated growth of tubers that otherwise would have been resorbed or would have remained too small.
Almost all mini-tubers $\geq$ 0.5 g survived storage at 2 °C for 1.5 years. After 6 months of storage, growth of plants from mini-tubers was still poor. Largest leaf areas were achieved after 10 - 11 months of storage, highest stem numbers, progeny tuber weights and harvest indices after 14 - 15 months of storage for cv. Agria and after 18 - 19 months for cv. Liseta.
The performance of mini-tubers was affected considerably by their weight. Lighter tubers had a longer dormant period, partly because of a slower sprout growth up to 2 mm (used to assess the end of dormancy). Plants from lighter tubers took longer to emerge and at emergence had thinner stems, lower root weights, and higher shoot:root ratios. Crops from lighter mini-tubers produced lower yields because of less radiation intercepted (slower ground cover) and a lower harvest index. Multiplication factors per planted tuber were lower in crops from lighter mini-tubers because fewer plants emerged or survived, and fewer progeny tubers and lower weights were produced per plant. Yield variation within a crop was higher in crops from lighter mini-tubers, but - when properly nursed - variation in yield over years was not affected by the weight. Effects of minituber weight generally became less clear in the higher weight ranges. Differences in performance between mini-tubers and conventional tubers were attributed to weight and age of seed tubers, presprouting method and crop husbandry.
Mini-tubers can be used in the first year of potato seed production programmes to speed up multiplication and to increase the quantity of seed from new cultivars.

Agronomic studies on the population dynamics of *Verticillium dahliae*
L. Mol, 1995
Promotor: P.C. Struik
Co-promotor: K. Scholte

Verticillium dahliae is a polyphagous fungus that causes wilt-disease in many crops, and is a world-wide spread soil pathogen with a very broad host range. In the temperate zones it is one of the most important pathogens of potato and reduces crop yields by causing early senescence. The pathogen survives in soil for many years by microsclerotia, which can be produced by the fungus in large quantities in dying plant tissue. *V. dahliae* is endemic in many soils because of the high potential survival of its microsclerotia and its wide host range.
The primary aim of the research was to investigate the feasability of reducing the inoculum density in the soil by stimulating the microslerotia to germinate. A second aim was to quantify the formation of microsclerotia on various crop species and cultivars, and various parts of potato plants. Haulm treatments to control the formation of microsclerotia on potato were tested and finally a theoretical model describing the long-term dynamics of the inoculum density in the soil was developed and tested.
All crops investigated stimulated the germination of microsclerotia in the soil. Host plants such as potato and field bean induced more microsclerotia to germinate than a non-host such as barley, but none of the crops was able to reduce the soil inoculum density effectively.
The highest total microsclerotial yield occurred in flax, followed by potato cultivars; the other crops lagged far behind. In potato, the mature aerial parts had the highest numbers of microsclerotia.
Potato cv. Element and field bean proved to be most sensitive to their own isolate. In plots cropped with good hosts, soil inoculum density increased very rapidly. Removing the debris of potato, field bean and flax from the field was effective in reducing the increase of inoculum density. Mechanical haulm treatments reduced the formation of microslerotia more than a chemical treatment.
A theoretical model built on the basis of biological and ecological principles gave a very high correlation when it was fitted to the data obtained in a long-term field experiment.
This study provided a quantitative basis on the interaction between crops and *V. dahliae* that deserves to be expanded in further research.

Analysis of growth, development and nitrogen uptake of field-grown vegetable crops in relation to the nutritional regime
H. Biemond, 1995
Promotor: P.C. Struik
Co-promotor: J. Vos

In order to be able to match nitrogen supply and nitrogen requirement of vegetable crops, an

understanding is necessary of the responses of important processes of growth and development to nitrogen . This study focused on effects of amount of nitrogen applied and fractionation of nitrogen supply on leaf attributes, accumulation and partitioning of dry matter and nitrogen in potato (*Solanum tuberosum*), Brussels sprouts (*Brassica oleracea* var *gemmifera*), leek (*Allium porrum*) and spinach (*Spinacia oleracea*). Effects of amount of nitrogen applied were always much more important than effects of fractionation of nitrogen supply. Rate of leaf appearance varied among crops from 0.15-0.60 leaves d^{-1}; it increased with more nitrogen in Brussels sprouts and spinach. Rates of leaf senescence were enhanced by nitrogen in Brussels sprouts. Life span of leaves was about 70 d for all crops. Rates of leaf expansion and maximum sizes of leaves increased with leaf number until a certain leaf number after which they gradually decreased. Both characteristics increased with more nitrogen. Duration of leaf expansion varied among crops from 18-40 d and decreased in Brussels sprouts with more nitrogen. Maximum size of a leaf was mainly determined by rate of leaf expansion. Except in potato, more nitrogen increased specific leaf area. Differences among nitrogen treatments in total green leaf area reflected the effects of nitrogen on rates of leaf expansion. Total dry matter production was strongly related to leaf area duration. Although more nitrogen applied resulted in more nitrogen taken up and more total dry matter produced, considerable variation was observed in the relation between total nitrogen uptake and total dry matter production. Harvest indices for dry matter varied among crops and treatments from about 0.10-0.87; more nitrogen increased it for Brussels sprouts, but decreased it for leek. Harvest indices for nitrogen varied from about 0.22-0.86; more nitrogen increased it for Brussels sprouts. In general, organic nitrogen concentration increased with increasing node number for leaf blades, petioles and leaf sheaths but not for sprouts. The gradient with node number resulted from a decreasing nitrogen concentration during the leaf's life. High nitrate concentrations in the marketable produce were only observed in spinach. Nitrate nitrogen concentrations of leaf blades, petioles and leaf sheaths decreased with increasing leaf number at any time of observation, but were not related to leaf age. However, in stems of Brussels sprouts and stems and tubers of potato, total nitrogen and nitrate nitrogen concentration were closely related.
The present findings elucidate the reactions of the crops to nitrogen fertilisation. This is helpful for the fine-tuning of nitrogen fertilisation and to develop modules on plant development in crop simulation models.

3.4.1.2 Theses carried out under supervision of the former Grassland section

Botanical and agronomic evaluation of a collection of *Sesbania sesban* and related perennial species.
J.H. Heering, 1995.
Promotor: L. 't Mannetje

The species *Sesbania sesban* has many attributes which make it attractive as a multi purpose tree for different agricultural production systems. This thesis focusses on the evaluation and classification of a *S. sesban* collection on morphological, agronomic and nutritional characteristics. It provides information on the chromosome numbers, breeding system and interspecific relations of *S. sesban* and the related perennial species *S. goetzei and S. keniensis*. It also demonstrates the multi disciplinary research approach which is required for the development of multi purpose tree germplasm.
The three species have a chromosome number of 2n = 12 and are able to produce viable seeds after interspecific hybridization. They are both self and cross compatible, although outbreeding is thought to be the common method of reproduction under natural conditions. The classification shows that the *S. sesban* accessions in the collection contain large variation in morphological, agronomic and nutritional characteristics. Through numeric analysis it is possible to identify distinct groups of accessions within the collection. This group structure can be used for the selection of accessions low in polyphenolics and with a high agronomic productivity.
The species is at the moment relatively under-utilized and there seems to be scope for a greater use of it, particularly in alley farming or for improved fallow. *S. sesban* has definite potential for the highlands and could further be introduced to the higher rainfall areas of the semi-arid zone and in some subhumid areas. It could be very useful to reclaim some of the areas with saline and alkaline soils and could also be grown in places prone to seasonal waterlogging and flooding.
The areas which require future research attention are among others, the collection of germplasm, the identification of anti-nutritional factors and the further adjustment of the management techniques to the systems in which the species is being used.

3.4.2 Theses carried out under supervision of the section Crop Production Systems (former Tropical Crops section)

Transition of shifting cultivation to more permanent cropping systems
J.J.P. Slaats, 1995
Promotor: M. Wessel
Co-promotor: B.H. Janssen (Department of Soil Science and Plant Nutrition)

In tropical Africa, traditional shifting cultivation can no longer provide sufficient food for the rapidly increasing population, whereas it threatens the remaining forests. An alternative is a fallow system based on the shrub *Chromolaena odorata*. Food crop cultivation in rotation with this fallow type in Ivory

Coast was analyzed and options for efficient and sustainable land use were identified. Farmers obtained 1.8 t ha^{-1} maize without external inputs in a three-year fallow-cropping cycle. Aftercrop harvest the *C. odorata* fallow vegetation established rapidly and effectively smothered herbaceous weeds. Experiments showed that the poor nutrient availability in this fallow system limited maize yields. During the cropping period *C. odorata* in maize was controlled by one weeding in the first month, whereas radical weeding practices set back its re-establishment after cropping. Shorter fallow periods and particularly extended cropping periods impaired both maize yield and *C. odorata* re-establishment. The *C. odorata* fallow system will be important for future food production because of the easy establishment and control of the species. To sustain intensive land use, farmers' cultivation practices can be improved by increasing nutrient availability, introducing suitable additional crops and developing practices that hardly check *C. odorata* re-establishment.

Sorghum agronomy in West Kenya: investigations from a farming systems perspective. Royal Tropical Institute, Amsterdam.
H.J. Enserink, 1995.
Promotor: M. Flach

An adaptive sorghum research and extension programme (1979-82) in West Kenya is reviewed. The focus is on factors operating at farm level. Research results are based on 70 on-farm trials and on some long-term experiments on NPK fertilizer and pest incidence. Extension results are based on two programmes using different approaches. 200 farmers participated in the demonstration approach; in the village approach 100 farmers participated the first year, and 400 the second year.

The impact of the rainfall pattern on local cropping systems is highlighted with respect to 'first rains' (March-June) and 'second rains' (August-November). Until recently, the short unreliable season of second rains played a minor role. However, current constraints on ox-ploughing result in delays in land preparation. This reduces the growing period for cereal crops during the first rains and increases the risk of failure for local late-maturing varieties. Cropping areas are increasingly restricted to what can be cultivated manually; more farmers are tempted to grow cereal crops during the second rains. As an assured food supply dominates farmer decisions, it was hypothesized that introduction of early-maturing sorghum varieties with a potential for ratooning would increase farmers management flexibility.
Initial knowledge of effects of sorghum pests, leaf blight and the weed *Striga hermonthica* proved insufficient. Crop moisture availability analyses commonly used in Kenya do not permit sufficient quantification of variability to understand farmer response to uncertainty. Three types of sorghum cropping seasons must be distinguished based on the variable start of the first rains. These types differ not only in length of growing period but also in shoot fly and midge incidence. Success of late planted crops varies with type of season. Farmers must play each season by ear; conditional recommendations on variety use and time of planting were developed accordingly. Some early-maturing cultivars were selected. However, their ratooning potential proved limited. Hence, attention shifted to planting these cultivars at the start of the second rains. As such plantings are seriously affected by shoot fly, more research on control by seed treatments and cultural methods is required.
Crop yields and weed composition in farmer fields are related to land use pattern and soil fertility depletion. P is the most limiting nutrient. As N applications often results in negative effects, P/N ratios may play a role. Current socio-economic conditions restrict P applications to first-rain crops to 20 kg/ha P_2O_5. Higher levels may only be recommended if residual effects of P on second-rain crops are optimized through land preparation. Row planting with 3 plants/hill is advised as it facilitates placement of P and rapid handhoe weedings.
The on-farm demonstration approach proved ineffective in stimulating farmer participation in the sorghum technology development process; it puts too much emphasis on selling preconceived messages. Also, the small isolated plots are threatened by birds. In contrast, the village approach proved effective. Its large, clustered plots generated much discussion among farmers and minimized the bird damage threat. Farmer opinions and crop-cut sampling results were used to fine-tune the recommendations for husbandry practices.
The former compartmentalized research structure in Kenya was not conducive to adaptive research. Insufficient critical mass was available within the small commodity sections at regional level. However, recent interdisciplinary adaptive Regional Research Programmes allow better priority setting. The Farming Systems Approach to Research, Extension and Training is used, which could lead to more demand-driven research.

Analysis of agricultural diversity of farming systems in northern Cameroon
C.B. de Steenhuijsen Piters, 1995
Promotor: L.O. Fresco

This research was inspired by the inability of agricultural research to deal adequately with phenomena of variation, diversity and heterogeneity in agriculture. Although these phenomena were observed as long ago as the beginning of this century, they are still causing concern. Until recently, analysis of variance was applied to any form of undesired variation in the experimental results. The statistical elimination of variation from the research coincided with attempts to standardize agriculture in order to optimize production. For a long time, deviations from the standardized average were

regarded as undesirable random effects.
Recent research has shown that variations in yield are very common in agro-ecosystems. They may be large, especially under difficult climatic conditions, and may even be considered as an asset to farmers. There is evidence that variations are not random, but are the result of systematic interaction between environment, crop genotype and management. This agrodiversity has important relations with the higher-level heterogeneity of the environment and diversity of farm households. At present, no comprehensive approach to its analysis is available, largely because agrodiversity is basically multidimensional in nature and may comprise several levels of aggregation.
The objective of this study was to contribute to the understanding of diversity in agro-ecosystems by focusing explicitly on variations of yield and their explanation at field and household level. Between 1991 and 1993, field work was done in one village in northern Cameroon. Yield variations of three crops, field properties, crop and management characteristics and household characteristics were assessed systematically. Various techniques for statistical analysis were employed to determine the magnitude of variation and to define the agrodiversity of the system.
Within the agro-ecosystem of the selected village, variations in yield were observed for rainfed sorghum, cotton and dry season sorghum. The magnitude of variation was more or less constant over the years of observation, but varied between the crops. Two rainfed sorghum cropping systems were distinguished and within one cropping system, three field types were defined according to their distance from the homestead. Thus stratified it was possible to reduce overall yield variation and to explain it within each stratum by a reduced number of variables. It was concluded that the composition of agrodiversity was not uniform over the strata. Yield levels, limitations and constraints of rainfed sorghum production were specific to each cropping system and field type.
Of the three crops, yield variation was greatest in cotton, despite many efforts of the cotton agency to standardize its cultivation. This variation was explained by distinguishing between types of variables, each explaining cotton yield variation to a different degree and in a particular way. Dry season sorghum showed least variation in yield, although it is subject to great environmental stress. Crop genotype and management proved to be adapted to one dominant field property, i.e. the water holding capacity of the soil. All farmers, irrespective of ethnic or socio-economic origin, agreed about the need to adjust mouskouari sorghum cultivation to field characteristics that define the water availability. Processes at field level leading to agrodiversity could be summarized by (1) spatial differentiation of the fields, (2) mechanisation of labour and (3) adaptation of cultivation to the environment.
Ethnic diversity explained the absolute difference in cotton production, and the distinction between rainfed sorghum cropping systems within the agro-ecosystem. Socio-economic diversity explained the relative differences in cotton yield, and the distinction between rainfed sorghum field types. Finally, gender differences highlighted variations in rainfed sorghum yields and in non-agricultural income. Gender differences and ethnic and socio-economic diversity proved to be interrelated, resulting in at least three classes of women farmers. It must be concluded that within one agro-ecosystem, crop yields may vary considerably. The agrodiversity explaining these variations proves to be crop specific. One agro-ecosystem may comprise several cropping systems and field types of the same crop. Agrodiversity is also spatially specific and is largely determined by ethnic and socio-economic diversity and gender differences at household level. The potentials and problems of crops and fields also prove to be specific to the farmer. Within the context of rural development, it is essential to distinguish between well defined target groups in order to prevent interventions from ineffective generalisation. To do so, variation, heterogeneity and diversity must be accepted as realistic phenomena in agro-ecosystems and considered as an important source of information.

Crops for energy production in the tropics
F.S. Jong, 1995
Promotor: M. Flach

The original project has been narrowed to "Research for the development of sago palm (*Metroxylon sagu*) cultivation in Sarawak". The broad objectives were to investigate the methods of crop yield improvement through botanical and agronomic studies. It covered the following topics:
1. Flowering biology of sago palm - Sago palms are largely but not strictly protandrous. Male and perfect flowers are found on the same palm but in some palms the perfect flowers open prematurely and the stamens are non functional. There is strong indication that it is an obligate cross pollinator and that insects play an important role in pollination.
2. Germination of sago palm seed - Mature and seeded fruits should be used for germination. Removal of scaly husk and/or fleshy integument;loosening of operculum and treatment with gibberellin enhanced germination. To maintain viability and promote germination, seeds should be kept at high humidity.
3. Factors affecting the survival of nursed sago paim suckers - To enhance the survival of sago palm suckers, they must be planted promptly. Sucker extraction with a good portion of rhizome attached, treatment with fungicide, shading during the dry season and planting depth affected its subsequent survival rate significantly. 4. Effects of sucker size on its subsequent establishment - Suckers of base diameter 10-15 cm are fastest in establishment. However, suckers of this size are too heavy (> 8 kg) and more difficult to obtain. Those of about 10 cm in base diameter are recommended for planting after

taking economic factors into consideration.
5. Effects of spacing on the growth of sago palm - After assessing the vegetative growth and potential trunk formation, the optimal density of sago palm appears to be around 100 palms per hectare.
6. The distribution and yield of starch in sago palm trunks in different stages of growth - Starch was accumulated progressively from the base to the upper portion of the trunk. Accumulation starts soon after trunks are formed. Palms should be harvested just before visible flower development to give maximum yield per unit time. A high negative correlation between the starch and moisture content was found in the trunk and a regression equation was formulated to predict starch yield. Most of the starch was mobilized for flower and fruit development at the end of its life span.
The most pressing problems that need attention in sago research is fertilizer application on the notoriously poor and badly drained peat soils. It is also important to start research on shortening the unproductive phase of the cultivation.

Geographical information systems as a tool to explore land characteristics and land use, with reference to Costa Rica.
J.J. Stoorvogel, 1995.
Promotors: J. Bouma (Department of Soil Science and Geology) and L.O. Fresco

An adequate inventory of land characteristics and land use is increasingly necessary to support agricultural land use planning, especially in view of the conflicting demands on scarce land resources. Fortunately new tools like GIS are being developed and adapted to support these inventories. Although GIS may be a useful tool for the storage and management of spatial data, its development is often "technology driven" and not directly focused on the applications. Approaches to use GIS in the inventory and analysis of land characteristics and land use are explored and illustrated for the perhumid tropical lowlands in the northeast of Costa Rica.
A procedure is formulated to develop and select database structures for soil survey data. The procedure is based on a five step approach in which i) a data model is developed for the soil survey data, ii) alternative database structures are created, iii) possible queries are analyzed, iv) the efficiency of the database structures is evaluated on the basis of quantitative indicators, and v) the most appropriate database structure is selected. The structure of the soil survey database is tested on the basis of a practical application: possible modelling approaches to deal with biocide leaching on the basis of the soil survey data. A rule base for each of the hierarchical levels (mapping units, pedons, and soil horizons) includes decision rules for the generalization of data at a specific hierarchical level.
Typically, the analysis of land use at a regional scale should be focused on its changes over time, but this is rarely done in a systematic way. The use of GIS to quantitatively describe land use dynamics is explored. Three different indicators for land use dynamics have been developed. The indicators include a singletime approach based on qualitative knowledge of the colonization history, Markov chains with soil type as a probability modifier, and Markov chains with a geographical analysis to stratify for polygon size, shape and neighbouring land covers. Often, users of GIS require very specific, disciplinary operations on geo-information that are not supported by GIS. These operations can be made available to the GIS through links with external models. A general structure for the GIS-model interface is presented and identifies six consecutive steps: i) geometry operations, ii) attribute operations, iii) data export from the GIS to the external model, iv) model run, v) data import from the model into the GIS, and, vi) visualisation or spatial analysis of the model results with the GIS. This structure is illustrated for a case study where a GIS is linked with a LP model for the analysis of alternative land use scenarios.
To explore the possibilities to reduce soil nutrient depletion in a settlement area, a GIS was linked with a model estimating soil nutrient depletion for land use systems and a LP model. The distribution of land use over different land units can be optimized with the LP model to minimize soil nutrient depletion in the settlement. This technique explores the geographical distribution of land utilization types to create a more sustainable basis for agriculture in the area.
To explore the trade offs between sustainability and economic objectives, different models and tools were integrated for the analysis of different land use scenarios for the Neguev settlement. Crop growth simulation and expert systems were used to describe alternative land use systems. A GIS was used for data storage, and the analysis and presentation of results. The optimization of land use was carried out by a LP model. Using a series of relevant land use scenarios, effects are studied of: (i) restrictions on biocide use; (ii) nutrient depletion as a negative contribution to farm income, and (iii) changes in capital availability. For the integration of models and tools, a modular approach is proposed, which is based on separate software packages and appropriate database structures. Data needs for land use analysis are studied and discussed for the analysis of regional production possibilities of maize, an analysis of sustainability indicators, and the possible contamination of ground and surface water with the commonly used nematicide Ethoprop. The different cases vary in their complexity and the level of detail required for the results. Data requirements change correspondingly. General inventories may already indicate which type of data collection is useful. Studies with a low level of detail must precede more detailed studies, while complex detailed studies could benefit from a change of scale, associated with a more generalized representation of data. Future challenges to incorporate the use of GIS in both disciplinary and interdisciplinary methodologies are recognized. This requires an integrated development of both GIS technology and applications.

Land use systems analysis as a tool in land use planning, with special reference to North and West African agro-ecosystems.
N. van Duivenbooden, 1995.
Promotors: H. van Keulen (Department of Animal Production Systems) and L.O. Fresco

In the past, many surveys and detailed studies related to land use in a particular region focused on all kinds of bio-physical and socio-economic processes, but frequently without a common framework with specified common goals. Consequently, it was often impossible to integrate the results from the various studies, and it was very difficult to understand the current situation of land use systems. As a result, it was almost impossible to make appropriate land use plans. The various projects in different agro-ecological zones were discussed; in hindsight all contributed to the concept 'Land Use Systems Analysis'. Hence, the purpose of this study was to place the results of these multidisciplinary projects with respect to the bio-physical part of land use systems in a holistic perspective. To enable this, four main parts were distinguished.
In Part A "*Characterization of actual and potential land use systems*", a method is presented for characterizing actual land use on the basis of transect surveys (as worked out for a case in Côte d'Ivoire). An interactive multiple goal linear programming model is described as a method to quantify natural and human resources, and to analyse the relations between various crop and animal husbandry systems.
In Part B "*Research on components and flows in land use systems*", nutrient relations were examined with the aim of arriving at fertilizer recommendations for cereals through field experiments (millet in Senegal), a literature review and simulation modelling. The nutrients considered were N, P and K in relation to millet, sorghum, maize, rice and wheat. The two nutrient relations investigated were fertilizer nutrient application to nutrient uptake, and nutrient uptake to crop yield. Additionally, the effects of grazing on subshrubs in Egypt were examined in field experiments and by simulation to quantify the availability of this feed resource.
In Part C "*Development of land use scenarios based on selected components and flows in land use systems*", possible land use options are presented on the basis of a simulation model for managing integrated small ruminant - barley - subshrub systems for the northwestern coastal zone of Egypt. A multiple goal linear programming model was used to examine the importance of fertilizer availability for self-sufficiency in food for the Fifth Region of Mali.
Part D, a synthesis presents 'Land Use Systems Analysis' after evaluating current methods of land use planning. After goal setting, the multidisciplinary analysis consists of four main steps that may include different agro-ecological zones and levels of detail. The importance of goals, scales, tools, and the time-path for attaining goals are discussed, and recommendations are made for the future application of land use systems analysis. They include (*i*) placing experiments in both a long-term and a multiscale plus multidisciplinary framework, (*ii*) training scientists in standardized techniques for data collection, storage and analysis, (*iii*) defining multisectoral land use systems for inclusion in analysis of prospective scenarios, and (*iv*) cooperating earlier with planners and land users.

4 PUBLIC RELATIONS

4.1 Information concerning the Department of Agronomy

The Department of Agronomy was established after the merging of the former Departments of Field Crops and Grassland Science, and Tropical Crops on 1 September 1992.
In 1994 A. Elgersma became coordinator for information, student recruitment and public relations of the Department of Agronomy.

A first report about the teaching and research activities of the Department of Agronomy, Report 1992-1994, was published in February 1995.

A video tape about the Department of Agronomy was made in Dutch and English, in which the various aspects of agronomy as a science in Western and tropical production systems are addressed.

4.2 Student recruitment

The WAU puts much effort into student recruitment. The Press and Public Relations Office is responsible for information about activities of the WAU to e.g. companies, research centres and the press. This Office also produces brochures and information leaflets for (potential) students.
The Office of Student Affairs distributes this information to (potential) students and informs them about a wide range of topics concerning the University and matters related to the study.

Traditionally, the Agricultural University presents its teaching programme to high school students and other potential students in November, with an emphasis on degree courses.
In addition, 'Open days' are now being organized annually in April at four sites in Wageningen. In 1994 and 1995 all Departments of the sector Plant and Crop Sciences presented their teaching and research programmes at the Department of Agronomy.

In 1994 and 1995 the WAU participated in the 'Week for Science and Technology'. In The Netherlands this week is organized annually for about 16-year old high school students to stimulate their interest in science and technology, enable them to visit universities, research institutes, etcetera, and give them an impression of future professional career opportunities.
The Department of Agronomy was one of the Departments of the WAU that organized a programme for these students.

During the last decade the number of students (Fig. 1) and the number of new students enrolled at the Agricultural University (Fig. 2) have declined.

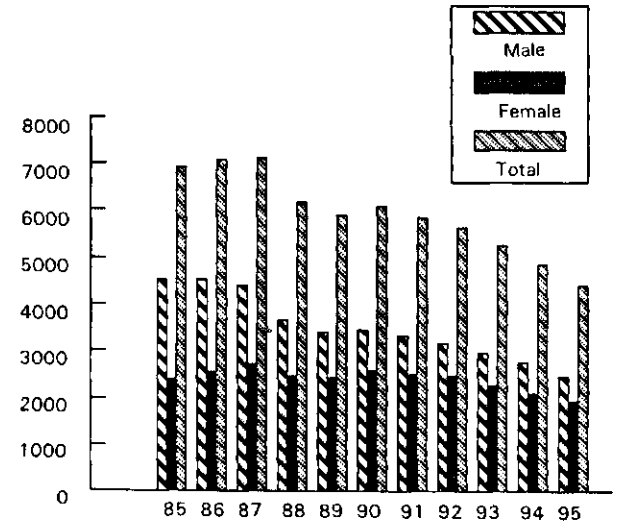


Fig. 1. The total number of registered students during the academic years 1985/6 - 1995/6.

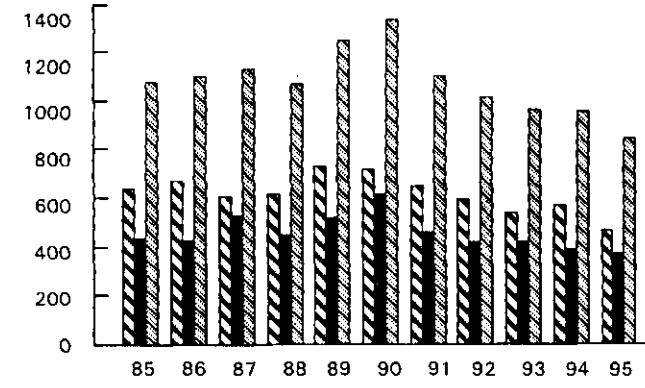


Fig. 2. The number of new students enrolled during the academic years 1985/6 - 1995/6.

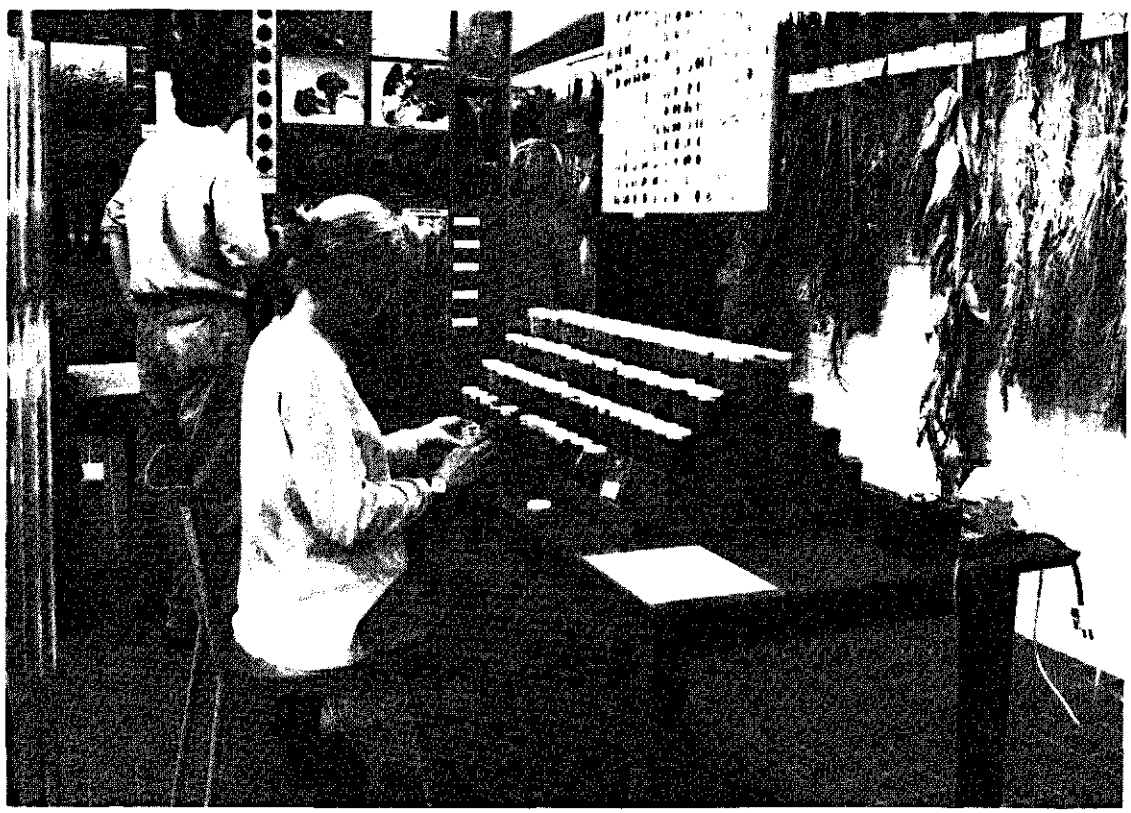
Especially degree courses in the areas of crop, animal and soil sciences were facing decreasing student numbers (Table 1).

L.O. Fresco participated in a Task Force Public Image which was established to analyse the image of the WAU and improve the stategy for student recruitment.

Once students have started their study at the Agricultural University in September, they are invited in October to the Department of Agronomy for a presentation of the teaching programme and ongoing research.
An information leaflet on the introductory courses of the Department of Agronomy, namely crop science, grassland science and land use systems, is mailed to students of certain degree course programmes.
Students who have attended courses at our Department receive a newsletter each trimester. By informing students about our courses and by continuous improvement of the courses we hope to attract more students.

Table 1. New students enrolled at the WAU 1989/1990 - 1995/1996

Year(►) / Degree course		1989/'90	1990/'91	1991/'92	1992/'93	1993/'94	1994/'95	1995/'96
BIO	Biology	66	80	70	64	75	95	83
L		0	1		1		0	0
L10	Forestry	34	39	39	37	28	36	55
L11	Physical planning	4	5					
L12	Land development	21	32					
L13	Tropical land development	10	0					
L14	Agricultural technology	8	0					
L20	Agricultural systems	19	17	16	14	11	13	8
L30	Physical planning	51	52	64	72	70	60	46
L40	Tropical land use	68	77					
L50	Soil, water, atmosphere	28	49	41	48	31	50	64
L60	Agricultural technology	19	33	32	44	33	30	24
M10	Agricultural economics	91	117	111	83	102	99	41
M21	Rural development studies	49	39			1		
M30	Household and consumer sciences	68	74	69	58	60	41	33
O				4		1	0	
O10	Tropical land use			37	54	43	43	59
O20	Rural development studies			36	29	44	38	36
T1		2	2	3			1	
T10	Crop science	34	27	16	14	15	8	8
T12	Horticulture	23	26	26	33	16	20	12
T13	Plant breeding	53	48	35	4			
T14	Plant protection	28	22	19	5			
T15	Plant breeding & plant protection				25	54	29	25
T20	Animal studies	131	90	99	87	89	87	73
T3		9	11	6	4	3	0	
T30	Food technology	139	129	113	99	61	76	67
T31	Human nutrition	52	77	41	51	49	52	42
T32	Environmental protection	163	163	140	94	107	85	75
T33	Molecular science	80	63	26	40	24	31	27
T34	Bioprocess technology	0	59	59	54	43	58	61
TOTAL		1250	1332	1102	1014	960	952	839



5 LIST OF PUBLICATIONS DURING 1995

5.1 PhD theses

Almekinders, C.J.M., On flowering and botanical seed production in potato (Solanum tuberosum L.). Promotor prof.dr.ir. P.C. Struik, Landbouwuniversiteit Wageningen, Wageningen, 1995, 133 p.

Biemond, H., Nitrogen nutrition effects on development, growth and nitrogen accumulation of vegetables. Promotor prof.dr.ir. P.C. Struik, co-promotor dr.ir. J. Vos, Landbouwuniversiteit Wageningen, Wageningen, 1995, 171 pp.

Duivenbooden, N. van, Land use systems analysis as a tool in land use planning. Promotoren prof.dr.ir. H. van Keulen & prof.dr.ir. L.O. Fresco, Landbouwuniversiteit Wageningen, Wageningen, 1995, 176 pp.

Enserink, H.J., Sorghum agronomy in West Kenya; Investigations from a farming systems perspective. Promotor Prof.dr.ir. M. Flach, Landbouwuniversiteit Wageningen, Koninklijk Instituut voor de Tropen, Amsterdam, 1995, xii + 291 pp.

Heering, J.H., Botanical and agronomic evaluation of a collection of Sesbania sesban and related perennial species. Promotor prof.dr.ir. L. 't Mannetje, Landbouwuniversiteit Wageningen, Wageningen, 1995, x + 127 pp.

Jong, F.S., Research for the development of sago palm (Metroxylon sagu Robbt.) cultivation in Sarawak, Malaysia. Promotor prof.dr.ir. M. Flach, Landbouwuniversiteit Wageningen, Sarawak, Malaysia, 1995, 139 pp.

Lommen, W.J.M., Basic studies on the production and performance of potato minitubers. Promotor prof.dr.ir. P.C. Struik, Landbouwuniversiteit Wageningen, Wageningen, 1995, 181 pp.

Mol, L., Agronomic studies on the population dynamics of Verticillium dahliae. Promotor prof.dr.ir. P.C. Struik, co-promotor dr.ir. K. Scholte, Landbouwuniversiteit Wageningen, Wageningen, 1995, 159 pp.

Slaats, J.J.P., Chromolaena odorata fallow in food cropping systems. An agronomic assessment in South-West Ivory Coast. Promotor prof.dr.ir. M. Wessel, co-promotor dr.ir. B.H. Janssen, Landbouwuniversiteit Wageningen, Wageningen, 1995, 177 pp.

Steenhuijsen Piters, C.B. de, Diversity of fields and farmers. Explaining yield variations in northern Cameroon. Promotor prof.dr.ir. L.O. Fresco, Landbouwuniversiteit Wageningen, Wageningen, 1995, 227 pp.

Stoorvogel, J.J., Geographical information systems as a tool to explore land characteristics and land use, with reference to Costa Rica. Promotoren prof.dr.ir. J. Bouma en prof.dr.ir. L.O. Fresco, Landbouwuniversiteit Wageningen, Wageningen, 1995, 151 pp.

5.2 Scientific papers

Almekinders, C.J.M., L.O. Fresco & P.C. Struik, The need to study and manage variation in agro-ecosystems. Netherlands Journal of Agricultural Science 43, 1995, 127-142.

Almekinders, C.J.M., J.H. Neuteboom & P.C. Struik, Relation between berry weight, number of seeds per berry and 100-seed weight in potato inflorescences. Scientia Horticulturae 61, 1995, 177-184.

Bessembinder, J.J.E., Uncertainties in input-output coefficients for land use optimization studies: an illustration with fertilizer use efficiency. Netherlands Journal of Agricultural Science 43, 1995, 47-59.

Biemond, H., Effects of nitrogen on development and growth of the leaves of vegetables. 2. Appearance, expansion growth and life span of leaves of leek plants. Netherlands Journal of Agricultural Science 43, 1995, 233-246.

Biemond, H., Effects of nitrogen on development and growth of the leaves of vegetables. 3. Appearance and expansion growth of leaves of spinach. Netherlands Journal of Agricultural Science 43, 1995, 247-260.

Biemond, H., J. Vos & P.C. Struik, Effects of nitrogen on development and growth of the leaves of vegetables. 1. Appearance, expansion growth and life span of leaves of Brussels sprouts plants. Netherlands Journal of Agricultural Science 43, 1995, 217-232.

Bouma, J., L.O. Fresco & S.B. Kroonenberg, Editorial. Quantitative land use analysis in Costa Rica. Netherlands Journal of Agricultural Science 43 (1), 1995, 1-3.

Bouwmeester, H.J., J.A.R. Davies, H.G. Smid & R.S.A. Welten, Physiological limitations to carvone yield in caraway (Carum carvi L.). Industrial Crops and Products 4, 1995, 39-51.

Bouwmeester, H.J., H.G. Smid & E. Loman, Seed yield in caraway (Carum carvi). 2. Role of assimilate availability. Journal of Agricultural Science, Cambridge 124, 1995, 245-251.

Dolstra,O., S.R. Haalstra, P.E.L. van der Putten & A.H.C.M. Schapendonk, Genetic variation for resistance to low-temperature photoinhibition of photosynthesis in maize (Zea mays L.). Euphytica 80, 1994, 85-93.

Duivenbooden, N. van, & P.N. Windmeijer, Characterization of rice-growing agro-ecosystems in West Africa. Technical Report 4. Manual for semi-detailed characterization of inland valley agro-ecosystems. SC-DLO, Wageningen, 1995, 85 pp., in opdracht van WARDA/DGIS.

Eeuwijk, F.A. van, & A. Elgersma, Incorporating environmental information in an analysis of genotype by environment interaction for seed yield in perennial ryegrass. In: Between and beyond additivity and non-additivity; the statistical *modelling of genotype by environment interaction in* plant breeding, F.A. van Eeuwijk, Proefschrift Landbouwuniversiteit Wageningen, Wageningen, 1995, p. 47-57.

Flach, M., Research priorities for sago palm development in Indonesia and Sarawak: an agenda for research. Fift International Sago Symposium. Acta Horticulturae 389, 1995, 19-39.

Fresco, L.O., Agro-ecological knowledge at different scales. Proceedings of a symposium on eco-regional appraoches in agricultural research, ISNAR, The Hague, 1994. Eco-regional approaches for sustainable land use and food production, J. Bouma, A. Kuyvenhoven, B.A.M. Bouman, J.C. Luyten & H.G. Zandstra (eds.), Kluwer Academic Publishers, Dordrecht, 1995, p. 133-141.

Fresco, L.O., Discussion paper - Comment : The role of East African soil science: When, where and how?. Geoderma 67, 1995, 171-177.

Heering, J.H., The effect of cutting height and frequency on the forage, wood and seed production of six Sesbania sesban accessions. Agroforestry Systems 30, 1995, 341-350.

Guiking, F.C.T., & T.J. Stomph, The modification of soil processes by mulching in the humid tropics. Proceedings of the Third International Conference on Sustainable Agriculture, Wye, UK, 1993. Soil management in sustainable agriculture, H.F. Cook & H.C. Lee (eds.), Wye College Press, Wye, Ashford, UK, 1995, p. 383-386.

Hernandez, M., P.J. Argel, M.A. Ibrahim & L. 't Mannetje, Pasture production, diet selection and liveweight gains of cattle grazing Brachiaria brizantha with or without Arachis pintoi at two stocking rates in the Atlantic Zone of Costa Rica. Tropical Grasslands 29, 1995, 134-141.

Jansen, D.M., & R.A. Schipper, A static, descriptive *approach to quantify land use systems*. Netherlands Journal of Agricultural Science 43 (1), 1995, 31-46.

Jansen, D.M., J.J. Stoorvogel and R.A. Schipper, Using sustainability indicators in agricultural land use analysis: an example from Costa Rica. Netherlands Journal of Agricultural Science 43 (1), 1995, 61-82.

Jansen, P.C.M., E. Westphal & N. Wulijarni- Soetjipto (general eds.), R.H.M.J. Lemmens, I Soerianegara & W.C. Wong (eds.), Plant resources of South-East Asia 5(2). Timber trees: Minor commercial timbers. Backhuys Publishers, Leiden, 1995, 655 pp.

Jansen, P.C.M., E. Westphal & N. Wulijarni- Soetjipto (general eds.), S. Dransfield & E.A. Widjaja (eds.), Plant resources of South-East Asia 7. Bamboos. Backhuys Publishers, Leiden, 1995, 189 pp.

Jong, F.S., & M. Flach, *The sustainability of sago* palm (Metroxylon sagu) cultivation on deep peat in Sarawak. Sago Palm 3 (1), 1995, 13-20.

Kabat, P., B. Marshall, B.J. van den Broek, J. Vos & H. van Keulen (eds.), Modelling and parameterization of the soil-plant-atmosphere system - a comparison of potato growth models. Wageningen Pers, Wageningen, 1995, 513 pp.

Kartasubrata, J., & J.S. Siemonsma, The workshop - An overview. The Second PROSEA International Workshop, Jakarta and Cisarua, Indonesia, 1994. Plant Resources of South-East Asia, Proceedings of the Second PROSEA International Workshop, R.E. Nasution & N. Wulijarni-Soetjipto (eds.), PROSEA Foundation, Bogor, Indonesia, 1995, p. 27-31.

Kartasubrata, J., & J.S. Siemonsma, PROSEA State of the Art. The Second PROSEA International Workshop, Jakarta and Cisarua, Indonesia, 1994. Plant Resources of South-East Asia, Proceedings of the Second PROSEA International Workshop, R.E. Nasution & N. Wulijarni-Soetjipto (eds.), PROSEA Foundation, Bogor, Indonesia, 1995, p. 43-64.

Koning, G.H.J. de, C.A. van Diepen & G.J. Reinds, Crop growth model WOFOST applied to potatoes. Modelling and parameterization of the soil-plant-atmosphere system - a comparison of potato growth models, P. Kabat, B. Marshall, B.J. van den Broek, J. Vos & H. van Keulen (eds.), Wageningen Pers, Wageningen, 1995, p. 275-279

Koning, G.H.J. de, H. van Keulen, R. Rabbinge & H. Janssen, Determination of input and output coefficients of cropping systems in the European Community. Agricultural Systems 48, 1995, 485-502

Kropff, M.J., L.A.P. Lotz, S.E. Weaver, H.J. Bos, J. Wallinga & T. Migo, A two parameter model for prediction of crop loss by weed competition from early observations of relative leaf area of the weeds. *Ann. app. Biol.* 126, 1995, 329-346.

Leloup, S.J.L.E., & L. 't Mannetje, Primary production of rangelands in southern Mali: a study of methodology. Tropical Grasslands 29, 1995, 177-182.

Linneman, A.R., E. Westphal & M. Wessel, Photoperiod regulation of development and growth in bambara groundnut (Vigna subterranea). Field Crops Research 40, 1995, 39-47.

Lommen, W.J.M., & P.C. Struik, Field performance of potato minitubers with different fresh weights and conventional seed tubers: Multiplication factors and progeny yield variation. Potato Research 38, 1995, 159-169.

Lotz, L.A.P., M.J. Kropff, J. Wallinga, H.J. Bos & R.M.W. Groeneveld, Techniques to estimate relative leaf area and cover of weeds in crops for yield loss prediction. Weed Research 34, 1994, 167-175.

Mannetje, L. 't, Potencial y perspectivas de leguminosas forrajeras tropicales con énfasis en America Latina. Memorias 2a Reuninon Nacional de Leguminosas de Grano, 3a Reunion Boliviana de Rhizobiologia, Cochabamba, Bolivia, 1995. Proyecto Rhizobiologia, Bolivia. CIAT-CIF-PNLG-WAU, 24-26 de mayo de 1995. Cochabamba - Bolivia, 1995, p. 131-135.

Meijer, E.P.M. de, & H.M.G. van der Werf, Evaluation of current methods to estimate pulp yield of hemp. Industrial Crops and Products 2, 1994, 111-120.

Meijer, W.J.M., H.M.G. van der Werf, E.W.J.M. Mathijssen & P.W.M. van den Brink, Constraints to dry matter production in fibre hemp (Cannabis sativa L.). European Journal of Agronomy 4 (1), 1995, 109-117.

Mol, L., Effect of plant roots on the germination of microsclerotia of Verticillium dahliae. II. Quantitative analysis of the luring effect of crops. European Journal of Plant Pathology 101, 1995, 679-685.

Mol, L., Formation of microsclerotia of Verticillium dahliae on various crops. Netherlands Journal of Agricultural Science 43, 1995, 205-215.

Mol, L., & E.M.J. Meijer, Quantification of microsclerotia of Verticillium dahliae in plant material by image analysis. European Journal of Plant Pathology 101, 1995, 705-709.

Mol, L., & K. Scholte, Formation of microsclerotia of Verticillium dahliae Kleb. on various plant parts of two potato cultivars. Potato Research 38, 1995, 143-150.

Mol, L., & K. Scholte, Effect of haulm treatments on the formation of microsclerotia of Verticillium dahliae Kleb. on potato. Potato Research 38, 1995, 151-157.

Mol, L., & H.W. van Riessen, Effect of plant roots on the germination of microsclerotia of Verticillium dahliae. I. Use of root observation boxes to assess differences among crops. European Journal of Plant Pathology 101, 1995, 673-678.

Mol, L., & A.J. Termorshuizen, Life cycle and ecology of Verticillium dahliae in potato. The second International Potato Modelling Conference, Wageningen, 1994. Potato ecology and modelling of crops under conditions limiting growth, A.J. Haverkort & D.K.L. MacKerron (eds.), Kluwer Academic Publishers, Dordrecht, The Netherlands, 1995, p. 251-263.

Ridder, N. de, & H. van Keulen, Estimating biomass through transfer functions based on simulation model results: a case study for the Sahel. Agricultural Water Management 28, 1995, 57-71.

Schipper, R.A., D.M. Jansen & J.J. Stoorvogel, Sub-regional linear programming models in land use analysis: a case study of the Neguev settlement, Costa Rica. Netherlands Journal of Agricultural Science 43 (1), 1995, 83-109.

Schuiling, D.L., The variability of the sago palm and the need and possibilities for its conservation. Fifth International Sago Symposium. Acta Horticulturae 389, 1995, 41-66.

Smit, A.B., & P.C. Struik, The first step towards a decision-support system for sugar-beet growing: selection of a basic growth model. Journal of Agronomy and Crop Science 175, 1995, 213-220.

Smit, A.B. & P.C. Struik, PlEteR: a field-specific production model for sugar-beet growing. Journal of Agronomy and Crop Science 175, 1995, 335-348.

Smit, A.B., P.C. Struik & J.H. van Niejenhuis, Modelling the influence of plant density on yield, sugar content and extractability of sugar beet. Proceedings 58th Congress of the International Institute for Beet Research, Beaune, France, 1995. IIRB & ITB (eds.), IIRB, Bruxelles, 1995, p. 413-424.

Steenhuijsen Piters, B. de, & L.O. Fresco, Farmers managing their most scarce natural resource: an example of local-level soil fertility management in Northern Cameroon. Local resource management in Africa, J.P.M. van den Breemer, C.A. Drijver & L.B. Venema (eds.), John Wiley & Sons Ltd., Chichester, 1995, p. 65-76.

Stoorvogel, J.J., R.A. Schipper & D.M. Jansen, USTED: a methodology for a quantitative analysis of land use scenarios. Netherlands Journal of Agricultural Science 43 (1), 1995, 5-18.

Straten, M. van der, W.G. Keltjens, A.C. Okoboi & E. Westphal, The calcium nutrition of bambara groundnut (Vigna subterranea (L.) Verdc.). Plant and Soil 176, 1995, 229-234.

Struik, P.C., & C.J.M. Almekinders, Biodiversiteit in de plantenteeltwetenschappen. Over het behouden, beheersen, beheren en benutten van diversiteit in agro-ecosystemen. Symposium Biodiversiteit, een natuurlijke hulpbron in de landbouw: de betekenis voor het landbouw- en milieuonderwijs, Wageningen, 1995. Verslag, R. van Haarlem & A. van Eldijk (eds.), Landbouwuniversiteit i.s.m. Nederlandse Vereniging voor Ecologie, Wageningen, 1995, p. 33-38.

Struik, P.C., & E. Ewing, Crop physiology of potato (Solanum tuberosum): responses to photoperiod and temperature relevant to crop modeling. The second International Potato Modelling Conference, Wageningen, 1994. Potato ecology and modelling of crops under conditions limiting growth, A.J. Haverkort & D.K.L. MacKerron (eds.), Kluwer Academic Publishers, Dordrecht, The Netherlands, 1995, p. 19-40.

Struik, P.C., H. Heemsbergen & A.J.W. Rotteveel, Verspreiding van de akkerdistel rond het Markiezaatsmeer. Tweede aanvullend deskundigenbericht, Wageningen, 1995, 7 pp., in opdracht van Arrondissementsrechtbank te 's Hertogenbosch.

Struik, P.C., Deskundigenrapport in de strafzaak tegen V.M. van der Stelt. Rapport, Wageningen, 1995, 3 pp, in opdracht van de Arrondissementsrechtbank te Groningen.

Sylla, M., A. Stein, N. van Breemen & L.O. Fresco, Spatial variability of soil salinity at different scales in the mangrove rice agro-ecosystem in West Africa. Agriculture, Ecosystems and Environment 54, 1995, 1-15.

Termorshuizen, A.J., & L. Mol, Modelling the dynamics of Verticillium dahliae. The second International Potato Modelling Conference, Wageningen, 1994. Potato ecology and modelling of crops under conditions limiting growth, A.J. Haverkort & D.K.L. MacKerron (eds.), Kluwer Academic Publishers, Dordrecht, The Netherlands, 1995, p. 265-280.

Turner II, B.L., D. Skole, S. Sanderson, G. Fischer, L. Fresco & R. Leemans (eds.), Land-Use and Land-Cover Change. Science/Research plan. IGBP Report No. 35 / HDP Report No. 7, Stockholm, 1995, 132 pp.

Veldkamp, A., & L.O. Fresco, Modelling land use changes and their temporal and spatial variability with CLUE. A pilot study for Costa Rica. Final report of NRP project, Department of Agronomy, Wageningen, 1995, 97 pp.

Veldkamp, A., & L.O. Fresco, Modelling land use dynamics by integrating biophysical and human dimensions (CLUE) Costa Rica 1973-1984.. Climate Change Research: Evaluation and Policy Implications, S. Zwerver, R.S.A.R. van Rompaey, M.T.J. Kok & M.M. Berk (eds.), Elsevier Science B.V., 1995, p. 1413-1416.

Vos, J., Nitrogen and the growth of potato crops. The second International Potato Modelling Conference, Wageningen, 1994. Potato ecology and modelling of crops under conditions limiting growth, A.J. Haverkort & D.K.L. MacKerron (eds.), Kluwer Academic Publishers, Dordrecht, The Netherlands, 1995, p. 115-128.

Vos, J., Foliar development of the potato plant and modulations by environmental factors. Modelling and parameterization of the soil-plant-atmosphere system - a comparison of potato growth models, P. Kabat, B. Marshall, B.J. van den Broek, J. Vos & H. van Keulen (eds.), Wageningen Pers, Wageningen, 1995, p. 21-38.

Vos, J., The effects of nitrogen supply and stem density on leaf attributes and stem branching in potato (Solanum tuberosum L.). Potato Research 38, 1995, 271-279.

Werf, H.M.G. van der, Agronomy and crop physiology of fibre hemp. A literature review. Report 142, CABO-DLO, Wageningen, 1991, 17 pp.

Werf, H.M.G. van der, A review of the literature. Agronomy and crop physiology of fiber hemp. Hemp today, E. Rosenthal (ed.), Quick American Archives, San Francisco, USA, 1994, p. 123-138.

Werf, H.M.G. van der, Fiber hemp in France. Hemp today, E. Rosenthal (ed.), Quick American Archives, San Francisco, USA, 1994, p. 213-220.

Werf, H.M.G. van der, Paper from Dutch hemp?. Hemp today, E. Rosenthal (ed.), Quick American Archives, San Francisco, USA, 1994, p. 225-228.

Werf, H.M.G. van der, Fiber hemp in the Ukraine, 1993. Hemp today, E. Rosenthal (ed.), Quick American Archives, San Francisco, USA, 1994, p. 279-288.

Werf, H.M.G. van der, & W. van den Berg, Nitrogen fertilization and sex expression affect size variability of fibre hemp (Cannabis sativa L.). Oecologia 103, 1995, 462-470.

Werf, H.M.G. van der, K. Brouwer, M. Wijlhuizen & J.C.M. Withagen, The effect of temperature on leaf appearance and canopy establishment in fibre hemp (Cannabis sativa L.). Ann. appl. Biol. 126, 1995, 551-561.

Werf, H.M.G. van der, W.C.A. van Geel, L.J.C. van Gils & A.J. Haverkort, Nitrogen fertilization and row width affect self-thinning and productivity of fibre hemp (Cannabis sativa L.). Field Crops Research 42, 1995, 27-37.

Werf, H.M.G. van der, M. Wijlhuizen & J.A.A. de Schutter, Plant density and self-thinning affect yield and quality of fibre hemp (Cannabis sativa L.). Field Crops Research 40, 1995, 153-164.

Wienk, J.F., Sisal and relatives. Agave (Agavaceae-Agaveae). Evolution of crop Plants, J. Smartt & N.W. Simmonds (eds.), Longman Scientific & Technical, Harlow, England, 1995, p. 4-8.

5.3 Abstracts

Elgersma, A., Breeding for seed yield - But how?. Journal of Applied Seed Production 13, 1995, 45-46.

Elgersma, A., & H. Schlepers, Contrasting perennial ryegrass / white clover mixtures under cutting and grazing. XIV Eucarpia Congress, Jyväskylä, Finland, 1995. Adaptation in Plant Breeding, Abstracts, University of Jyväskylä, Jyväskylä, Finland, 1995, p. 54.

Lootsma, M., Manipulation of the suppressive potential of soil organisms against Rhizoctonia stem canker on potato. Environmental biotic factors in integrated plant disease control, M. Manka (ed.), The Polish Phytopathological Society, Poznan, 1995, p. 357-360.

Mol, L., The influence of plant roots on the germination of microsclerotia of Verticillium dahliae in the soil. The 6th Verticillium Symposium, Dead Sea, Israel, 1994. Phytoparasitica 23 (1), 1995, 54.

Smit, A.B., & P.C. Struik, Modelling the influence of plant density on yield and quality of sugar beets. 58th IIRB Congress, Beaune, France, 1995, Abstracts of papers. Beaune, 1995, p. 85.

Struik, P.C., Elaboración y transformación de los alimentos de origen vegetal. Síntesis de las exposiciones presentadas en la Conferencia Mundial de la Ingeniería y la Alimentación, Buenos Aires, Argentina, 1995. Propuesta para el siglo XXI, Buenos Aires, Argentina, 1995.

Struik, P.C., & C.J.M. Almekinders, Over het behouden, beheersen, beheren en benutten van diversiteit in de plantaardige produktie / On conservation, controlling, managing and utilizing diversity in cropping systems. Symposium Biodiversiteit, een natuurlijke hulpbron in de landbouw: de betekenis voor het Landbouw- en Milieuonderwijs, Wageningen, 1995. Programmaboek, Landbouwuniversiteit i.s.m. Nederlandse Vereniging voor Ecologie, Wageningen, 1995, p. 6-7 / p. 14-15.

Struik, P.C., & C.J.M. Almekinders, On conservation, controlling, managing and utilizing diversity in cropping systems. Symposium Biodiversiteit, een natuurlijke hulpbron in de landbouw: de betekenis voor het landbouw- en milieuonderwijs, Wageningen, 1995. Verslag, R. van Haarlem & A. van Eldijk (eds.), Landbouwuniversiteit i.s.m. Nederlandse Vereniging voor Ecologie, Wageningen, 1995, p. 68-69.

Vos, J., Effects of nitrogen and stem density on leaf attributes and branching in potato. Potato Research 37, 1994, 459-460.

5.4 Other publications

Almekinders, C.J.M. L.O. Fresco & P.C. Struik, Response to the letter to the editor. Netherlands Journal of Agricultural Science 43, 1995, 349.

Berswordt-Wallrabe, Th. von, A.Th.G. Elzebroek & P.C. Struik, Een stevige rietstengel maakt nog geen goed rieten dak. Op weg naar een kwaliteitscertificaat van riet voor dakbedekking?. Dakenraad 7, oktober 1995, 30-33.

Duivenbooden, N. van, Integrating stakeholders' goals, research disciplines and levels of scale. Ileia Newsletter 11 (2), 1995, 16-18.

Elgersma, A. (compiler), Report 1992-1994. Department of Agronomy. Teaching and research activities. Department of Agronomy, Wageningen, 1995, 56 pp.

Engels, F.M., Difference in structure and degradation of tissues between W401, BM1 and BM3. 8th Zeneca Seeds Forage Maize Quality Workshop, Blois, France, 1995. J. Chojecki & C. Halpin, 8th Zeneca Seeds Forage Maize Quality Workshop, Report PJT/LIG/WG1/95/02A, Bracknell Berkshire, UK, 1995.

Fresco, L.O., Veranderende landschappen in Europa. Openingsmanifestatie Europees Natuurbeschermingsjaar 1995, Den Haag, 1995. Congresboek Europees Natuurbeschermingsjaar 1995, Goossens, Lokerman & Pauli (comp.), 1995, p. 1-3.

Hartemink, A.E., & J.F. Wienk, Sisal production and soil fertility decline in Tanzania. Outlook on Agriculture 24 (2), 1995, 91-96.

Ndege, L.J., B. de Steenhuijsen Piters, A. Nyanga & L. Ngimbwa, Tanzania/Netherlands Farming Systems Research Project, Lake Zone, Working Paper 17, Diagnostic Survey of Karagwe District. KIT / Karagwe District Rural Development Programme, Amsterdam / Bukoba, 1995, 85 pp.

Schröder, J.J., & J. Vos, De stikstofkringloop: keten of vergiet?. Themadag KLV, AB-DLO en PE, Wageningen, 1995. Hoe ecologisch kan de landbouw worden?, A.J. Haverkort & P.A. van der Werf (eds.), AB-DLO Thema's 3, Wageningen/ Haren, 1995, 37-63.

Steenhuijsen Piters, B. de, From frustration to information. Diversity in agroecosystems. Ileia Newsletter 11 (2), 1995, 6-7.

Struik, P.C., Samenspel van landbouw, natuur, overheid en samenleving. Naar een verweving van een natuurlijke landbouw met een agrarische natuur. Noorderbreedte 19 (3a), 1995, 68-72.

Struik, P.C., E.A. Goewie, J.C. van Lenteren, L.H.W. van der Plas & P. Stam, De positie van de groene sector van de Landbouwuniversiteit in een snel veranderende landbouwwereld. Een opiniestuk.. Landbouwuniversiteit Wageningen, Wageningen, 1995, 33 p.

Struik, P.C., E.A. Goewie, J.C. van Lenteren, L.H.W. van der Plas & P. Stam, De Groene Sector van de Landbouwuniversiteit in een snel veranderende landbouwwereld. Een opiniërende positiebepaling. Spil 135-136, 1995, 31-32.

Struik, P.C., De toekomst van de akkerbouw en de agronomie. De aardappeleters, Arvense Almanak 1994, A. Boer, J. van Halteren, R. Kamsteeg, M. van Soesbergen & H. de Vries (eds.), Wageningen, 1995, 22-28.

Struik, P.C., Review. J.E. Bradshaw & G.R. Mackay (eds.), Potato Genetics. Potato Research 38, 1995, 109.

Vos, J., & H.E. Soorsma, Van modellering naar advisering. Een ontwerp voor een interactief stikstof bemestingsadviessysteem. IKC-Informatie Akkerbouw en Vollegrondsgroente 6 (2), 1995, 13-16.

Zöbl, D., T. Baan Hofman, T. Baars, A. Elgersma & R. Schils. Wat de boer niet kent ... Klaver-bemesting. Natuur en Techniek 63 (8), 1995, p. 522-531.