Research Report

FiBL

The Impact of Organic Cotton Farming on the Livelihoods of Smallholders

Evidence from the Maikaal bioRe project in central India



Frank Eyhorn, Paul Mäder, Mahesh Ramakrishnan

October 2005

Funded by:

- Swiss Agency for Development and Cooperation (SDC)
- World Wide Fund for Nature (WWF), Switzerland

DEZA DDC DSC SDC COSUDE

WWF

bioRe

Publisher
Research Institute of Organic Agriculture (FiBL), Ackerstrasse, P.O. Box, CH-5070 Frick, Switzerland.
Ph: +41 (0)62 865 72 72, Fax: +41 62 865 72 73, info.suisse@fibl.org, www.fibl.org

In cooperation with:
- Swiss Agency for Development and Cooperation (SDC), www.deza.admin.ch
- World Wide Fund for Nature (WWF), Switzerland, www.wwf.ch
- Remei AG, Switzerland, www.remei.ch / Maikaal bioRe (India) Ltd.

Distribution
This report and an executive summary are available from www.organiccotton.fibl.org.

Authors
Frank Eyhorn (FiBL), Paul Mäder (FiBL), Mahesh Ramakrishnan (ICCOA)

Cover photos
Frank Eyhorn

The publication was realized with support of:
- Swiss Agency for Development and Cooperation (SDC)
- World Wide Fund for Nature (WWF), Switzerland

Frank Eyhorn, Paul Mäder, Mahesh Ramakrishnan (2005): The impact of organic cotton farming on the livelihoods of smallholders. Evidence from the Maikaal bioRe project in central India.
Research Institute of Organic Agriculture FiBL, Frick, Switzerland

Extension tools for organic cotton
Within this research project, the following extension tools for organic cotton have been developed:

- **Organic Cotton Crop Guide**
  A reference manual for extension workers and organic farmers.
- **Organic Cotton Training Manual**
  Transparencies and didactic material to facilitate trainings.
- **Soil Fertility Training Manual**
  A set of transparencies for training on soil fertility in organic cotton.
- **Organic Cotton Project Guide**
  A guide to support designing and setting up organic cotton projects.
- **Producing Organic Cotton: A Toolkit**
  A CD containing the above documents and other tools for extension.

Free downloads of these documents are available from the website www.organiccotton.fibl.org. Hard copies can be ordered from FiBL (www.shop.fibl.org).

The documents and their Hindi versions are also available from the International Competence Centre for Organic Agriculture in India (www.iccoa.org).

Contents

Glossary 5
Abbreviations 6
Foreword 7
Acknowledgements 8
Abstract 9
1. Introduction 10
1.1 Organic cotton for improving farmers' livelihoods? 10
1.2 The organic cotton research project 11
1.3 Research objectives 12
2. Project area and research methods 13
2.1 The Maikaal bioRe project 13
2.2 The project region 13
2.3 Research approach 16
2.4 Farm sample selection 18
2.5 Soil sampling and analysis 20
2.6 Data processing 21
3. Results 22
3.1 Farm profiles 22
3.1.1. Socio-economic aspects 22
3.1.2. Agronomic aspects 25
3.1.3. Cotton production aspects 27
3.2 Economic performance 28
3.2.1. Labour and material inputs 28
3.2.2. Cotton yields 30
3.2.3. Production costs in cotton cultivation 33
3.2.4. Revenues and gross margins in cotton cultivation 33
3.2.5. Efficiencies in cotton cultivation 35
3.2.6. Rotation crops 36
3.3 Soil properties 40
3.3.1. Soil physical parameters 40
3.3.2. Soil organic matter 42
3.3.3. Soil nutrients 43
3.3.4. Soil salinity and pH 45
4. Discussion 46
4.1 Profiles of adopters 46
4.1.1. The role of early adopters 46
4.1.2. Changes in the farm profile due to organic farming 47
4.2 Economic impact of organic farming 47
4.2.1. The productivity of organic cotton production 47
4.2.2. Economic performance of organic cotton 51
4.2.3. Economic impact on the entire farm 53
4.3 Natural resource use 54
4.3.1. Water use 54
4.3.2. Impact on soil fertility 55
4.4 The logic of defaulting 56
4.5 Risks and vulnerability 57
4.6 Obstacles to conversion 58

5. Conclusions 60
6. Annex 61
6.1 Figures of Maikaal bioRe (2004-05) 61
6.2 Rain data 61
6.3 Approximation formula for irrigation water quantities 61
6.4 Result data tables 62
6.4.1. Farm profiles: Descriptives 62
6.4.2. Farm profiles: Means 63
6.4.3. Cotton performance 64
6.4.4. Rotation crops 66
6.4.5. Soil results 69
6.5 Size of farms that joined the Maikaal bioRe project 70
6.6 Linear regression models 71
6.6.1. Effect of non-inherent parameters on cotton yields 71
6.6.2. Models explaining cotton yields 72
6.6.3. Effect of non-inherent parameters on field gross margins 73
6.7 Bibliography 74

Glossary

Adopter	Farmer who adopts the innovation 'organic farming'.
Bio-dynamic agriculture	Special version of organic agriculture based on the research work and philosophy of Rudolf Steiner. It includes the use of plant-based or animal-based preparations and considers cosmic rhythms.
Border crop	Crop grown at the edge of organic fields bordering conventionally managed fields in order to reduce drift of pesticide sprays.
Bt-cotton	Genetically modified cotton varieties containing the gene of the bacterium *Bacillus thuringensis* that cause the death of caterpillars (especially cotton bollworms) when they feed on the crop.
Bt-preparation	Biological pest management item against caterpillars, using the bacterium *Bacillus thuringensis.* Note: Bt-preparations that do not origin from genetically modified organisms are allowed in organic farming.
Caste	Complex social structure of the Hindu society. Official surveys divide the various different castes and casteless groups into forward castes (FC), scheduled castes (SC), other backward castes (OBC) and scheduled tribes (ST). Scheduled castes and tribes, being the most underprivileged groups of society, enjoy certain quotas in education, public servant positions and elected bodies.
Conversion	The process of changing the farm management from conventional to organic practices as per the organic standards.
Cotton lint	Cotton fibre without seeds.
Crop revenue	Money received from crop sales.
Crop rotation	Sequence of crops grown in a field over several years.
Defaulters	Farmers who got excluded from the organic cotton project due to severe non-compliance with organic standards.
De-oiled cake of castor (DOC)	Residues of crushed castor seeds after oil extraction. It is used as an organic manure rich in nitrogen (4–5%) and phosphorus.
Efficiency	Ratio of input (labour, nutrients, costs etc.) per output unit (e.g. cotton yield).
Gross margin	Crop or field output (mainly revenues from sales of crop) minus variable production costs (seeds, fertilizers, sprays, hired labour etc.).
Inputs	Material inputs (seeds, fertilizers and manures, pest management items, irrigation water) and labour inputs.
Intercrop	Crop grown along with the main crop. After harvesting, it may serve as mulch. In cotton cultivation in the project region, most common intercrops are moong beans, chick peas and pigeon peas.
Internal control system (ICS)	An inspection system managed by the project to ensure that farmers follow the agreed-upon organic standards. For certification, the functioning of the ICS is evaluated by an external agency.
Kharif	Main cropping season in India, starting from the onset of the monsoon rains (in Madhya Pradesh about mid June) up to October / November.
Livelihood	A livelihood comprises the capabilities, assets (including both material and social resources) and activities required for a means of living.[1]
Microirrigation	Irrigation systems that apply water directly to the individual crop plants; especially drip irrigation (through tubes) and micro-sprinkler systems.
Nutrient exchange capacity	The ability of soil to absorb and release nutrients. Nutrient exchange capacity is highest with clay particles and soil organic matter.
Organic agriculture	Holistic farming system that avoids the use of synthetic fertilizers and pesticides. It emphasizes the set-up of a balanced agro-ecosystem and is based on methods like crop rotation, intercropping, organic manures, biological pest control etc.

[1] Definition according to DFID, see. www.livelihoods.org

Organic certification	A process verifying the compliance of farm management with organic standards; based on inspection results.
Organic inspection	Physical inspection of the farm and its documentation. This can involve chemical or genetic analysis of soil, leave and product samples.
Organic manures	Manures derived from animal products or plant residues. They usually have considerable nitrogen content, and contain most other nutrients essential for plant growth. In addition, they are important sources of organic matter.
Organic price premium	Percentage or fixed amount paid for an organic product in addition to the prevailing market price for non-organic products.
Organic standards	Minimum requirements for a farm and its products to be certified organic. Basic standards are defined on an international level by FAO in the Codex Alimentarius (www.codexalimentarius.net) and by IFOAM (www.ifoam.org). Organic standards for certification are specific to certain regions (e.g. EU-regulation EEC 2092/91) or private labels (e.g. Naturland, BIO SUISSE).
Pigeon pea	Pulse crop (*Cajanus cajan*).
Rabi	Winter cropping season in India, from November / December up to March / April.
Rotation crops	Crops grown in rotation (time sequence) with cotton on the same fields.
Seed cotton	Cotton as it is picked (fibre along with seeds).
Seed treatment	Treatment of seeds to protect them against soil- and seed-borne diseases and pests, and/or to improve germination and initial growth. In organic farming, seeds treated with synthetic pesticides cannot be used.
Soil organic matter	Organic substances in the soil originating from animal and plant residues in various stages of decomposition and re-formation. Also referred to as humus.
Staple length	Average length of the cotton fibres. An important parameter for defining the quality and thus the price of the cotton.
Stocking rate	Number of cattle kept per acre farmland.
Trap crop	A crop grown in order to attract pests and to distract them from the main crop. Pests thus can be destroyed by treating a small area, or by destroying the trap crop and the pests together.
Vermi-compost	Continuously fed compost system in which pre-decomposed organic material is eaten by large numbers of earthworms. Their faeces are high in silica and make an organic manure of excellent quality.
Water retention capacity	The ability of the soil to retain water and moisture.

Abbreviations

asl	above sea level
CF	Conventional farms
DF	Defaulted organic farms (excluded from the organic project)
DAP	Diammonium phosphate
DOC	De-oiled cake of castor
FYM	Farmyard manure
GMO	Genetically modified organisms (not permitted in organic agriculture)
ha	Hectares (1 ha = 10'000 m^2 = 2.47 acres)
ICS	Internal Control System
N	Number of observations in the sample
OF	Organic farms
RMSE	Root Mean Square Error (in linear regression models)
Rs.	Indian Rupees (INR). In 2004, 1 US$ was equal to approx. 48 Rs.
RSq	Indicator for how well a regression model describes the observed data.

Foreword

It was early in 2000 in Bhopal. I was discussing the advantages and disadvantages of organic agriculture with P.V. Rajgopalji, the renowned Ghandi Peace Foundation activist, and S.C. Bheher, advisor to the Chief Minister of Madhya Pradesh. At one point during these talks, S.C. Bheher said: "Organic farming has so many advantages; we should go ahead and convince farmers in Madhya Pradesh to do only organic farming."

I was of course pleased to hear these words. However, before introducing a new farming system and promoting it as successful, we should look deeply into the topic and contemplate its outcome. This is why I requested a study, which has now been completed and gives insight into the truth behind organic agriculture. I am glad to read that most of our thoughts have been verified and I am glad to have understood how credits in conventional farming – and all the more in genetically modified farming – increase farmers' vulnerability. But I am also glad to learn about the socio-economic challenges of organic cotton production. This gives us the possibility to improve our work, and it gives us the motivation to keep on searching for more answers.

With these results in hand I am more convinced than ever that organic agriculture is a key to a healthy social environment. Moreover, if it is well implemented and scientifically thought through, it can fulfil many community requirements. Organic agriculture is not a step backwards to the traditional farming our ancestors practiced. Organic agriculture is a key for the future and probably the most modern agriculture system one can promote.

Many people have taken a huge burden in their life to support this idea and to try to build up healthy communities. I am grateful to every single person, to my government and to the researchers, who have supported us and given us the chance to promote the ideas we stand for.

Thank you.

Patrick Hohmann

Managing Director Remei AG and
President Maikaal bioRe (India) Ltd.

Acknowledgements

Special thanks go to the following people and institutions:

- Maikaal bioRe (India) Ltd., especially Rajeev Baruah, Ritu Baruah and V. Tiwari, who opened their doors to the research project and provided all required support and information.
- The team members of Maikaal bioRe who facilitated the contact with the farmers and supported the research team in various ways. Special thanks go to Shriram Vishwakarma, Ishwar Patidar, Yogendra Shrivas, Dharmendra Singh Mandloi, Ashok Singh Chouhan, Rajeev Verma, Jitendra Vyas, Bheem Yadav, Dinesh Tripati, Sukhdev Gir, L.N. Karma, Raju Rawal, Prakash Hagatale, Rajesh Modi, Manoj Chouhan, Babu Kushwaha, Sharad Yadav, Paraikh-dada, Girish Yadav, Madhuri, Darbar, Surendra, Luniya, Kamal, Randheer, Sanju, and all the others.
- The Research Team of Maikaal bioRe: Prashant .V. Tekade, Lokendra Singh Chouhan, Gajendra Singh Chouhan, Raghuvir Singh Mandloi and Raj Rupesh Pandit.
- The farmers of the Nimar region who participated in the record keeping and patiently answered our questions.
- Dr. Ruedi Baumgartner (NADEL, ETH Zürich) and Dr. Urs Wiesmann (CDE, University of Berne) for their guidance in the research work and their feedback to the report.
- Dr. Uma Rani for her support in the interviews and her inspiration for the research design.
- Dr. Franco Weibel (FiBL) and Dr. Nicolai Meinshausen (ETH Zurich) for their guidance in the statistical processing of the data.
- Vaibhav Bhamoriya and IWMI for guidance in the calculation of irrigation water quantities.
- Patrik Schumacher (University of Zurich) and Christa Schwaller (University of Fribourg) for their contributions to the research within their diploma theses.
- Lukas Kilcher (FiBL) and Dr. Joan Davis for providing feedback.
- Dr. Gil Ducommun (SHL) and Jürn Sanders (FiBL) for guidance in agronomic matters.
- Dr. Adrian Müller for the review of the draft report.
- Remei AG, Switzerland, for information and support.
- The Steering Group of the Maikaal Research Project: Lukas Rüttimann (SDC), Patrick Hohmann (Remei AG), Dr. Walter Wagner (WWF), Dr. Urs Heierli (msd consulting), for providing guidance and feedback.
- The Swiss Agency for Development and Cooperation (SDC) and the WWF Switzerland for funding the research project.
- The Centre for International Agriculture (ZIL) and the Research Fellow Partnership Programme (RFPP) of SDC for funding the PhD project that has contributed to this research.

Abstract

This research report analyses the impact of conversion to organic cotton farming on the livelihoods of smallholders in the Maikaal bioRe organic cotton project in Madhya Pradesh, central India. For that purpose, it compares farm profile data, material and financial input/output and soil parameters of organic and conventional farms over two cropping periods (2003 – 2005). The results show that organic farms achieve cotton yields that are on a par with those in conventional farms, though nutrient inputs are considerably lower. With less production costs and a 20% organic price premium, gross margins from cotton are thus substantially higher than in the conventional system. Even if the crops grown in rotation with cotton are sold without organic price premium, profits in organic farms are higher. In the perception of most organic farmers, soil fertility significantly improved after conversion. However, the analysis of soil fertility parameters in soil samples from organic and conventional cotton fields has shown only minor differences in organic matter content and water retention.

The research indicates that organic cotton farming can be a viable option to improve incomes and reduce vulnerability of smallholders in the tropics. To use this potential it is important to find suitable approaches to enable marginalised farmers managing the hurdles of conversion to the organic farming system.

(An executive summary of the research report is available at www.organiccotton.fibl.org.)

1. Introduction

1.1 Organic cotton for improving farmers' livelihoods?

Cotton cultivation provides livelihood for many Million smallholders in developing countries. It is the backbone of the cotton industry that is a major contributor to export revenues in several countries of Central and West Africa. India is the third largest producer of cotton, producing 15% of the worldwide production (Roberson 2000), but due to low productivity having the largest area under cotton cultivation (8.9 million ha). Cotton cultivation in India employs 7 Million people for the living, and the cotton textile industry contributes 38% of the country's export earnings (Rajendran, Venugopalan et al. 2000). Over the last decade many developing countries have been facing declining cotton yields, either due to a decline of soil fertility or due to pesticide resistance and increased occurrence of pests (Townsend 2001). At the same time, application of pesticides and fertilizers has increased, resulting in higher production costs. Since the mid-1990s, world prices for cotton have fallen by half, putting the cotton sector of many countries like Brazil, Burkina Faso, Mali, Benin and Chad into a deep crisis (Oxfam 2002). Cotton consumes 10–12% of all pesticides and 24% of all insecticides used world wide (The Pesticides Trust 1998). In India, cotton is grown on 5% of the cultivable land, but receives 54% of the insecticides used in agriculture (Rajendran, Venugopalan et al. 2000). Cotton grown under irrigation consumes considerable amounts of freshwater – up to 30'000 liters per kg cotton lint (Meyer 2001). In many semi-arid regions, intensive cotton cultivation has led to depletion of fresh water sources and depletion of groundwater levels (Schwank, North et al. 2001).

Pesticide resistance of important cotton pests is considered a major problem since several decades (Jackson 1989). It is estimated that approx. 500 insect species have developed resistance against certain insecticides. In addition, pests of formerly minor importance become a serious problem because populations of natural enemies have been diminished due to the application of broad spectrum pesticides (Oswald and Sauerborn 1995). This has led many cotton farmers into a so-called 'pesticide treadmill', characterized by increasing input costs and decreasing marginal returns (Poswal and Williamson 1998).

Over the last decade, a number of organic cotton projects were initiated in several countries of the South (e.g. India, Pakistan, Mali, Tanzania, Uganda, Benin, Kirgistan, Peru etc.), with the aim to improve the ecological, social and/or economic sustainability of cotton production (Ton, Foguelman et al. 1998; Lima and Oliveira 2000; Valenghi 2002). The largest organic cotton project in India is Maikaal bioRe, presently involving more than 1500 smallholder farmers. Since large manufacturers and retailers entered the field, market demand for organically produced cotton has increased (Marquardt 2001; Ton 2004). Switzerland has taken a lead in the promotion of organic cotton: *Remei AG* presently is the largest trader of organic cotton yarn[2], and produces organic cotton fiber in its projects in India (Maikaal bioRe) and in Tanzania (bioRe Tanzania). The supermarket chain *Coop* is the largest retailer worldwide of garments produced with organic cotton yarn. Swiss development cooperation NGOs like Helvetas support a number of organic cotton projects in the South, and the World Wide Fund for Nature (WWF) are promoting organic cotton production and integrated pest management (IPM) in cotton since several years.

The economic and ecological performance of organic farming systems compared to conventional ones has been studied extensively in Europe and in the USA (Tilman 2002; Mäder, Fließbach et al. 2002; Drinkwater, Wagoner et al. 1998; Lotter 2003). There are few studies available analysing the ecological impact of organic cotton cultivation (e.g. von Boguslawski and Basedow 2001; Meyer 2001). However, so far only little systematic research has been done on the agronomic and socio-economic impact of organic farming systems in developing countries (Ramesh, Singh et al. 2005). A number of case studies report that yields have increased substantially after conversion to organic farming (Parrott and Marsden 2002; Giovannucci 2005; Mendoza 2004). However, in most cases the investigated farms converted from traditional farming systems with low inputs of synthetic fertilizers and pesticides to intensive organic

---

[2] according to Remei AG (personal communication)

systems. Most people will accept that the avoidance of synthetic fertilizer and pesticide application in organic farming will have a positive environmental impact also in tropical cotton farming. But what is the actual impact of conversion to organic production on farmers' livelihoods?

In the context of organic cotton farming, this question could be of great importance both at the policy level ('Should governments and development agencies promote and support organic cotton projects?') as well as at the field level ('What can farmers expect from conversion to organic cotton?'). The lack of reliable data, especially on yields, production costs and income, presently stands against a wider dissemination of the organic cotton production system in the South.

1.2 The organic cotton research project

To investigate the economic viability of organic cotton farming and the impact of conversion on the livelihoods of the involved farmers, the Swiss Agency for Development and Cooperation (SDC) and the World Wide Fund for Nature (WWF), Switzerland, have mandated the Research Institute of Organic Agriculture (FiBL) to implement a research project on organic cotton farming in the Maikaal bioRe project. The management of Maikaal bioRe itself had motivated this research project by approaching FiBL with the request to scientifically analyse the impact of their work. Maikaal bioRe is considered a suitable case study for the above goal for several reasons: First, it is a well established project, existing since more than 10 years. Second, it is located in a country and in a region where cotton farmers are in an acute crisis and look for alternatives. Third, the project has a sufficiently large basis of farms spread over a defined geographic region. Last but not least, Maikaal bioRe was ready to host the research project for a period of three years and to vide necessary support and access to farms and data.

The organic cotton research project covered three fields: a system comparison study, an analysis of the adoption and dissemination process, and the development of practical improvements on the technology level and in extension. The connection between the three project levels and the guiding questions is shown in Figure 1. The approach and methodology of the overall project are described in detail in the concept of the organic cotton research project (Eyhorn, Verma et al. 2003). This report only covers the results of the system comparison study on organic cotton farming based on the agronomic data monitoring (first level of the overall research project)[3]. In the discussion chapter it relates the findings to insights gained in the other parts of the research project.

[3] For results and outputs related to the second and third level of the project, please refer to www.organiccotton.fibl.org.

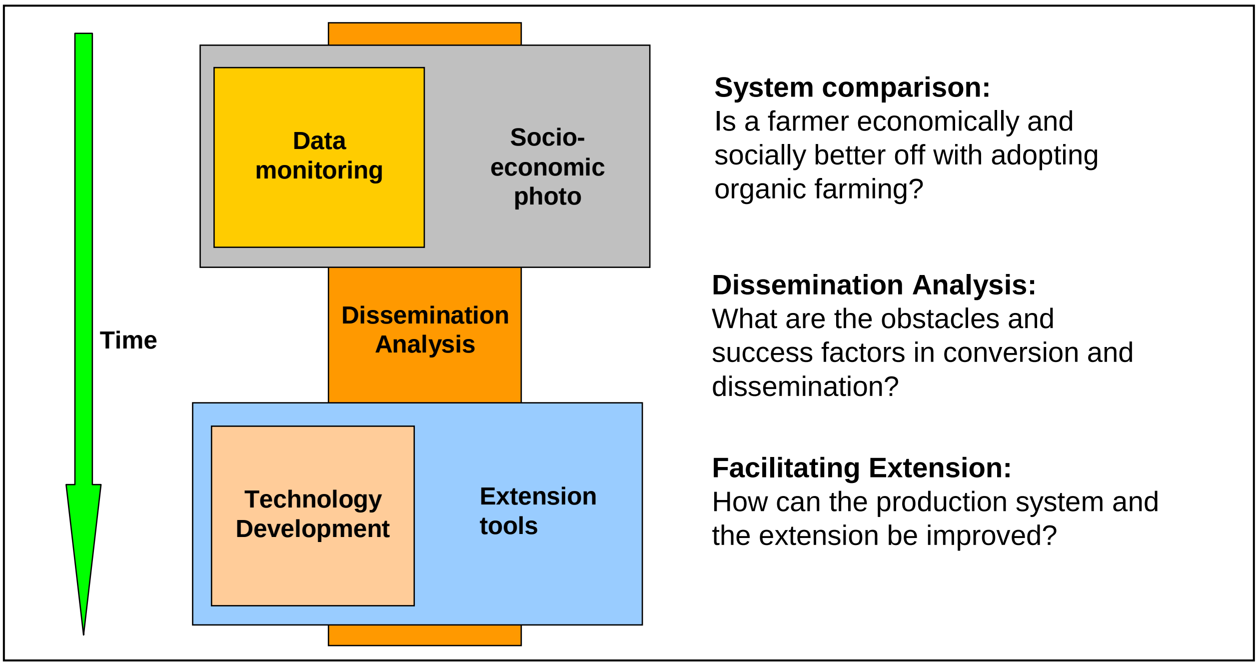


Figure 1: Connection of the three levels of the organic cotton research project, illustrating the overlapping of the elements and their timely sequence.

To implement the research project, we set up a field office hosted by Maikaal bioRe and formed a field research team of two agronomists and three assistants under the lead of FiBL. Over the two years of the data monitoring, the research team visited the selected farmers in regular intervals, interviewed them and guided them in the record keeping.

1.3 Research objectives

The research covered in this report compares the profiles and the agronomic performance of organic and conventional farms that grow cotton as their main cash crop. The objective of this system comparison research is to find out whether, and to what extent, conversion to organic cotton farming contributes to better incomes and overall improvement of farmers' livelihoods. As farming depends to a large extent on the fertility of the operated land, the research also investigates the impact of organic farming on soil fertility.

In comparing organic and conventional farms, we test the following research hypotheses:

1. Organic cotton farming involves less material input (per kg output) for plant nutrition, pest management and irrigation, but requires more labour.
2. Overall production costs (per ha) are lower in organic cotton farming.
3. Yields of cotton and of its rotation crops are lower in organic farms.
4. Organic cotton farming is more profitable (higher gross margins).
5. Organic management in cotton farms improves overall soil fertility. Specifically, it leads to an increase in soil organic matter and in water retention capacity.

To our knowledge, this is the first in-depth research study on the impact of organic farming on the livelihoods of smallholder farmers in a developing country. Though the study focuses on cotton and its rotation crops, and is based on a single case study in India, we believe that it can provide valuable insight into the potential of organic agriculture to poverty reduction in general.

2. Project area and research methods

2.1 The Maikaal bioRe project

In 1991, the Swiss yarn trader Remei AG and the Indian spinning mill Maikaal Fibres (India) Ltd. initiated the Maikaal bioRe® organic cotton project[4] in Madhya Pradesh, Central India. What had started as a non-commercial experiment to help cotton producers find a way out of debt and secure a sustainable livelihood has meanwhile developed into an enterprise that joins social responsibility and ecology with economic profit. Maikaal bioRe has grown to become one of the largest (in terms of production) and most well-known organic cotton projects worldwide, now involving more than 1500 smallholder farmers[5] and producing more than 3'100 t of seed cotton per year (approx. 1'000 t cotton lint) on an area of 4'250 ha cultivated with cotton[6]. Maikaal bioRe is a joint stock company that employs a team of 52 staff. 300 of the participating farmers have already become shareholders of the company, and the Board of Directors presently includes two farmer representatives and a social activist. An independent but related organization, the bioRe® Association, runs a training centre, offering education in organic farming and related subjects to farmers. The Association also provides credit to farmers to promote the development of infrastructures such as drip irrigation and biogas facilities. It further supports community projects in the villages, such as installing hand pumps for drinking water.

Maikaal bioRe passes contracts with farmers which include a 5-year purchase guarantee. It provides advisory services to the farmers through a team of 20 extension workers. These visit the farmers monthly during the entire growing period and provide technical advice. Maikaal bioRe purchases the seed cotton from the contracted farmers at prevailing market rates and pays up to 20% price premium to farmers who have completed the three-year conversion period. Maikaal bioRe also provides farmers with farm inputs (seeds, de-oiled castor, rock phosphate, botanical and microbial pesticides etc.). In the first year, farmers receive the inputs on credit base, while in the following years input costs are adjusted with the price premium from the previous year. Maikaal bioRe processes the seed cotton in its own modern ginnery, offering safe working conditions.

To ensure the organic integrity of the production, the Maikaal bioRe project operates an internal control system (ICS). The internal inspectors physically inspect each farm at least twice a year to check compliance with the requirements of the specified organic standards[7]. Farmers who default by applying synthetic fertilizers or pesticides, or by sowing GMO seeds[8] are excluded from the project. An independent, accredited external certification body checks the functioning of the ICS. This includes physical re-inspection of part of the farms at least once a year.

The cotton lint is sold entirely to a bioRe® partner spinning mill. The yarn is then processed into fabric and garments, following specified environmental and social criteria. Remei AG works in partnership with various European retailers to bring the garments to the market. Thus, Remei AG manages an integrated and verified textile chain from the farmers to the consumers[9].

2.2 The project region

The project region is located in the Nimar Valley in Madhya Pradesh, central India, that spreads on both sides of the Narmada River. To the North, the valley is bordered by the Vindhyas Range (max. 881 m asl), and to the South by the Satpura Range (max. 999 m asl). The region is part of the central Indian cotton belt and is home to several dozens of spinning mills. The Maikaal bioRe project is active in 75 villages of Khargone and Badwani District.

---

[4] hereafter referred to as Maikaal bioRe

[5] Approx. 1100 farms in Maikaal and approx. 400 farms in the satellite projects in Malgaon and Dhule.

[6] Status of 2004-05, see Annex 6.1

[7] EC Regulation 2092/91, see europa.eu.int/eur-lex/en/consleg/main/1991/en_1991R2092_index.html

[8] All farms are tested on the use of genetically modified cotton seeds.

[9] see www.remei.ch

The project area can roughly be divided into two main regions with distinct agricultural characteristics: the Narmada belt that stretches approximately 5 km to both sides of the Narmada river, and the adjacent undulating upland (see Figure 2). The Narmada belt is characterized by its more or less flat topography (approx. 200 m above sea level) with occasional intrusive rocks forming hills. The soils are up to several meters deep, dark, rich in clay and of high fertility. There are numerous irrigation pipelines from the Narmada and some smaller rivers, and wells and tube wells with comparatively good water supply. Sugarcane, bananas, guavas and vegetables are grown in this area. The upland is more heterogeneous due to its undulating profile. It has shallow, light, brownish soils on elevations, but deep, dark, heavy soils in topographic depressions. Irrigation water is generally scarce, as there are no river pipelines and only few channels from small dams. Sugarcane and banana cultivation is limited to few pockets with good irrigation facilities. The shares of farms of the Maikaal bioRe project in the Narmada belt and in the upland are about equal.

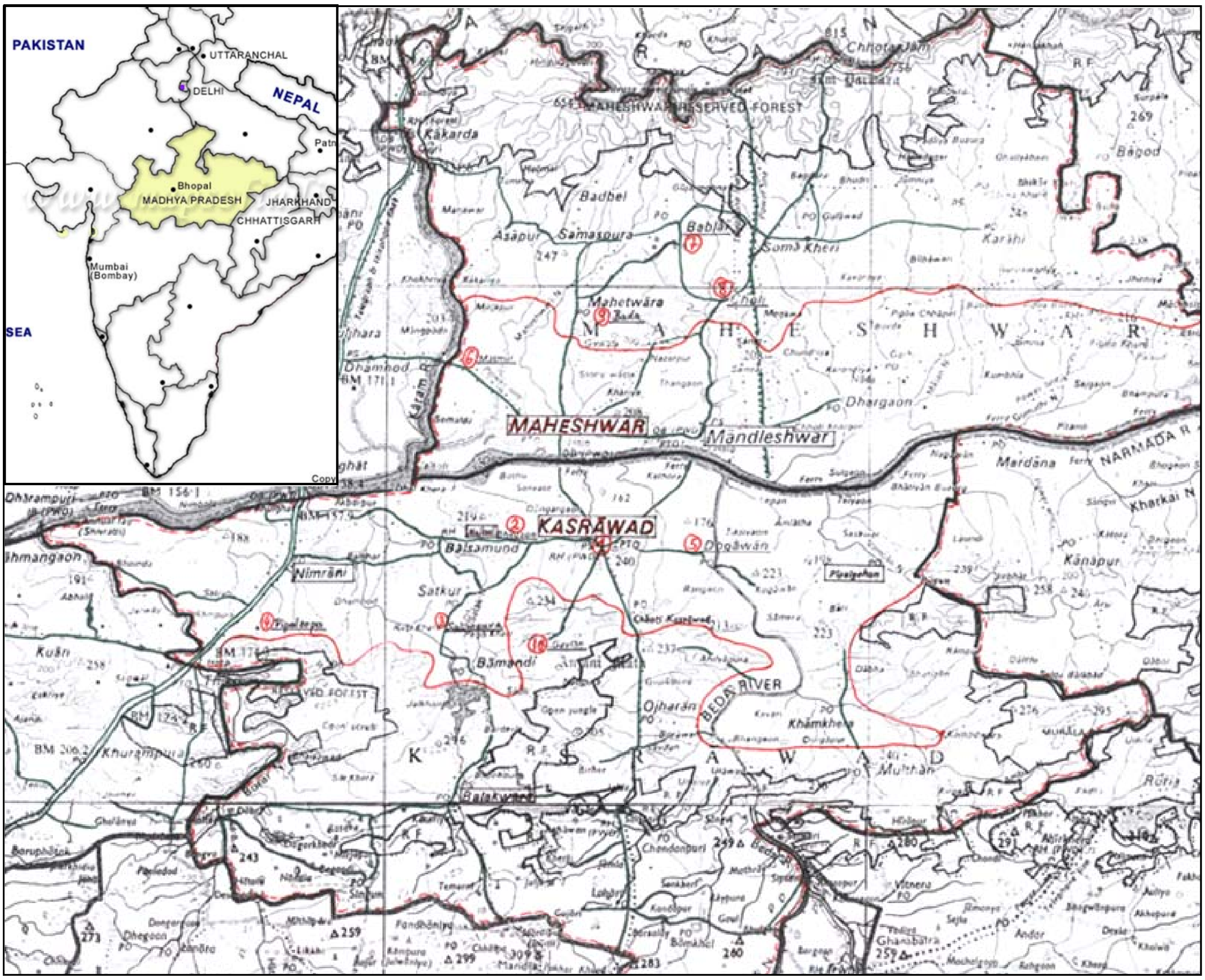


Figure 2: Map of the project region (West Nimar, Madhya Pradesh) and the researched villages. The red line demarcates the Narmada belt from the upland, numbers demarcate the villages selected for the research in 2003/04.

Like most of central India, the project region has a semi-arid climate, receiving between 300 and 1100 mm annual precipitation (on an average approx. 800 mm) in a single peak monsoon season usually lasting from June to September. Rains during monsoon are irregular, sometimes with dry periods of several weeks. This constitutes a major threat to the newly sown or planted crop. Heavy rainfall that exceeds the capacity of the soils to absorb water occasionally occurs in the Monsoon season, resulting in high surface flow off, erosion and crop damage. In addition, rainfalls are unequally distributed in the area. The region has always been affected by occasional droughts. According to interviewed farmers, in droughts of earlier years the groundwater level used to be sufficient for irrigating at least part of the fields through open wells. In the years 1999 to 2002, however, the amount of rainfall in the area was 45% less than the average of 1994 to 1998, and groundwater levels in the wells declined. 2003 was a year with normal precipitation (in average 866 mm in the studied villages), and farming conditions were comparatively good. In 2004, precipitation was slightly less (769 mm) and the distribution was less favourable, with longer dry periods and some incidences of high rainfall that caused flood erosion and water logging in some fields, thus affecting yields. The rainfall measured in 2003 and 2004 in selected villages of the project region is given in Annex 6.1.

A majority of the population in the project region are Hindus, with some Muslims and few Jains and Christians. Tribal communities like the Bhil and Panwar make up 18% of the population. The majority of the population stem from groups that migrated to this area from Gujarat in the 15-16th century, when the area was largely covered by virgin forests. The most frequent Hindu castes among farmers are Patidar, Rajput and Yadav. Scheduled castes (those officially considered underprivileged) account for approx. 10% of the farm families in the project region.

Prevailing soils in the Western part of Madhya Pradesh are vertisols, the so-called black cotton soils, and related soils (for soil classification see Summer 2000). Vertisols are rich in calcium and magnesium carbonates, iron and alumina. They are poor in phosphate, nitrogen and organic matter. Zinc and boron are occasionally found to be deficient in agricultural soils of the region. Basically, the soils in the area can, in a first approach, be described with a topo-sequence model: on elevations and slopes, the finer clay and silt particles got eroded over the time, leaving shallow soils with high sand content (inceptisols and entisols). The finer particles got accumulated in depressions, forming deep soils of high clay contents (vertisols). The distribution of the three main soil types prevalent in the region therefore can almost be predicted from the topography (Figure 3).

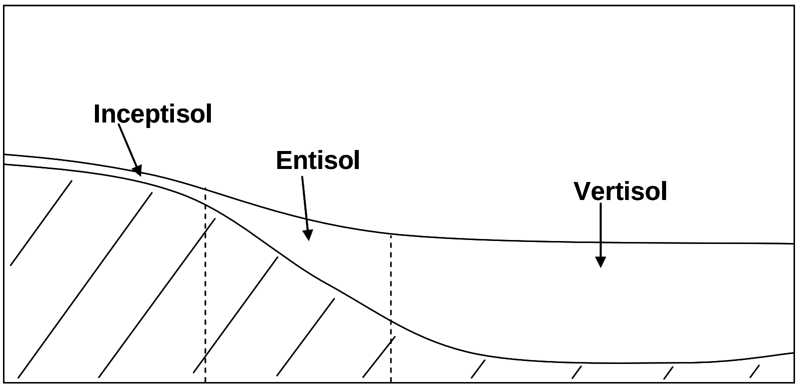


Figure 3: Topo-sequence of soils in the Nimar region

Due to the semi-arid climate, the main limiting factor for crop production in the project region is the availability of water. The single peak rainfall pattern of the summer monsoon climate divides the year into two main cropping seasons: the monsoon-season called ‘Kharif’ (mid June to end October) and the winter-season called ‘Rabi’ (November to March/April). Thanks to the dry climate, crops are not exposed to high pressure of fungal diseases, and the proliferation of most insect pests is also limited compared to humid tropics.

Farming systems in the Nimar Valley are mainly cotton based. According to official statistics, 40-50% of the agricultural land of the concerned districts is cultivated with cotton. Cotton is grown in rotation with a number of other crops, mainly wheat, soy bean, pigeon pea, sorghum, maize and chilli. Where ample irrigation is available, sugarcane, vegetables, bananas and perennial fruits are grown on part of the land. Most farmers sow cotton at the onset of the monsoon in June and harvest the mature bolls until the plants dry up. If irrigation water is available before the monsoon starts, which is mainly the case within the reach of river pipelines or channels, cotton can already be sown in April or May (summer sowing). By October, about 2/3 of the bolls have reached maturation, and many farmers uproot the cotton crop in order to grow wheat, provided they have sufficient water for irrigation. Others induce a ‘second flush’ in cotton through irrigation in November or December, and keep the cotton crop until the end of the vegetation period (i.e. until March/April).

If water for irrigation is available, cotton fields are irrigated before and/or after the monsoon season through furrows. Shortage of electricity for running the pumps has become one of the main limiting factors for irrigation. Some farms (around 10%) use drip irrigation systems in cotton fields.

2.3 Research approach

To assess the impact of organic cotton farming on the socio-economic condition of farmers, we compared a representative sample of farms that are associated with the Maikaal bioRe project since at least the year 2000 with a representative sample of conventional farms in the same village. Data were collected in two years: 2003 and 2004. Covering two years does not permit analysing the development over time but rather serves as two distinct sets of observations.

At the beginning of the study, basic profile data on the general farm characteristics listed in Table 1 were collected in interviews.

Farm characteristics	Details
Social parameters	Caste, education and age of the farmer, house type, family type, number of family members
Land holding	Own land, leased land
Crop rotation pattern	Area under main crops; crop rotation patterns
Agricultural equipment	Equipment for soil cultivation and transportation
Cattle	Stocks of cows, bullocks, buffaloes, goats
Incomes (other than from crops)	Milk sales, off-farm income
Agricultural labour	Family own labour (male, female), permanently hired labour
Irrigation systems	Micro-irrigation systems, wells

Table 1: Farm characteristics assessed in the data collection.

For wealth characterisation we defined a simple wealth indicator based on the main parameters that farmers in the region use to describe the wealth status of co-farmers. The parameters and their weighting were identified through interviews with farmers, asking them to name and to rank the most important features of a wealthy farmer. Based on this explorative exercise, we defined the wealth indicator W as follows: W = (3 * Land holding / Average land holding) + (2 * Equipment value per ha / Average equipment value per ha) + Off-farm income / Average off-farm income) + (0.5 * Irrigation water quantity per ha / Average irrigation water quantity per ha). With the help of this indicator we divided the farms participating in the study into three groups of equal size: poor, medium and wealthy. The aim of this grouping is to get a rough idea whether wealth has an influence on the adoption behaviour on the one hand and on the performance of cotton production on the other hand.

To compare stocking rates of farm animals with regard to the availability of farmyard manure, we made rough estimates on livestock units (LSU) as per expected dung droppings that are used as manure in the fields. Adult cows, bullocks and buffaloes were calculated as 1 LSU, young cows and buffaloes up to 1 year as 0.5 LSU, adult goats as 0.4 LSU and young goats as 0.2 LSU. As the conditions of the animals as well as the efficiencies in using their dung as manure (part of it is used as fuel) vary to a great extent among the farms, it did not seem workable to make more sophisticated calculations of livestock units.

Data on the agronomic performance of cotton and the main rotation crops were collected based on farm records maintained by the farmers themselves. The research team of the project[10] instructed the selected farmers in keeping detailed records on material as well as monetary inputs and outputs with the help of record forms printed in Hindi. Record keeping covered two full production periods, i.e. from May 2003 to April 2004 (referred to as 2003) and from May 2004 to April 2005 (referred to as 2004). During this period, the research team regularly visited the farms, checked the entries and supported the farmers in maintaining the records. In cotton production, separate records were kept for each cotton field, while for the major rotation crops summarized farm data were recorded. The parameters covered in the record keeping are listed in Table 2.

[10] Two agronomists and three field research assistants were employed for the project.

Cotton fields parameters	Details
Field details	Field size (measured), soil type, tenure
Cotton crop characteristics	Sowing and final harvest date, variety, spacing
Crop rotation in cotton	Previous crops, intercrop, wheat share
Labour input	Labour days: male/female, own/hired, days for weeding, fertilizer/manure application, pest management
Material input	seeds, fertilizers/manures (Urea, DAP, NPK, Superphosphate, muriate of potash, FYM, compost, vermin-compost, de-oiled castor, rock phosphate, sugarcane press mud); pest management items
Irrigation	Irrigation rounds, duration, pump details (well depth, diameter, power), micro-irrigation
Production costs	Labour costs (own/hired), costs for fertilizers/manures, costs for pest management items, other costs (hiring equipment, repairs, electricity bills, fuel, irrigation cost); production costs in wheat crop
Yields	Seed cotton yields, wheat yields, intercrop yields
Prices	Rate at which individual cotton lots were sold; market value of wheat and intercrops
Crop condition	Classification (1-5), description
Rotation crops parameters	**Details**
Crop characteristics	Area under the crop (according to the farmer), sowing and final harvest date, variety, spacing
Crop rotation	Crop shares, intercrop
Labour input	Labour days: own/hired
Production costs	Labour costs (own/hired), costs for fertilizers/manures, costs for pest management items, other costs (hiring equipment, repairs, electricity bills, fuel, irrigation cost)
Yields, values	Crop yields, total crop value (home consumption at market rates)[11]
Crop condition	Description

Table 2: Parameters covered by the record keeping.

At the start of each cropping season, the research team measured the size of each individual cotton field through triangulation using measurement tapes. In order to analyse the influence of soil properties on the agronomic performance, and to assess the impact of organic management on soil fertility, representative soil samples were taken from each field for analysis (see Chapter 2.5). The collected data were continuously entered into a data base (Access), scrutinized for plausibility and cross-checked in case of doubts. In addition, the field research coordinator checked records and measurements in randomly selected farms from time to time.

Irrigation water quantities for each cotton field were estimated based on the irrigation time recorded by the farmer, the engine power of the pump, the depth of the well and the diameter of the suction pipe. The approximation formula used is given in Annex 6.3.

In order to encourage the selected farmers to participate in the study, two excursions to cotton farms and agricultural research stations in neighbouring Maharashtra were organized. To ensure that farmers get access to the collected data, each farmer got handouts in Hindi of the economic results and soil parameters for each cotton field, along with an interpretation provided by the research team. In order to validate the results and to ensure that the interpretation by the researchers is in line with field realities, overall research findings were individually discussed in detail with 15 farmers of the sample.

[11] Maize, sorghum and wheat also yield straw that is used as fodder for cattle. Due to practical reasons (measurability) straw yields and values were not assessed in this study.

2.4 Farm sample selection

The agronomic data monitoring initially covered a representative sample of 60 organic and 60 conventional farms in ten randomly selected villages of the project region. In each village, six organic and six conventional farms were randomly selected from name lists established with the help of the Maikaal bioRe extension team and village leaders. For the selection we considered farmers holding between 1.2 and 20 ha (3 to 50 acres) of land (this covers 96% of the farmers in the Maikaal bioRe project), who cultivate cotton on min. 25% of their land and who gain their main income from farming. We selected organic farms that had converted to organic agriculture before the year 2000 and that are under the Maikaal bioRe certification scheme since then. As conventional farms we defined those never having been under an organic certification scheme and that regularly use synthetic fertilizers and pesticides in cotton. Comparison of average farm size in the sample with those of organic farms (based on data of Maikaal bioRe) and conventional farms (based on official statistics) showed that the research sample is representative for the respective group.

In September 2003, the routine inspections of the Maikaal bioRe certification scheme (internal control system and external inspections) excluded about 43% of the farms from the project, mainly due to application of synthetic fertilizers. In the research sample, 27 of 60 organic farms (45%) were excluded (compare Figure 4). 16 of them were ready to continue record keeping in order to be able to compare their performance to non-defaulted organic farms. Where possible, we replaced defaulted farms by randomly selected organic farms from the same village (9 farms). Two conventional farms dropped out from the record keeping in the first year.

In the second year, the data monitoring of farms that got defaulted in 2003 was discontinued. We replaced two villages having high rates of defaulted farms with two new randomly selected villages, and selected nine additional organic farms in the previously monitored villages, resulting in a sample size of 59 organic and 56 conventional farms (two conventional farmers discontinued record keeping in the second year). In September 2004, the inspection system again excluded approx. 30% of the organic farms from the Maikaal bioRe project, mainly due to the use of genetically modified cotton varieties (Bt-cotton). In the research sample, 16 of 59 farms got defaulted (27%).

In order to ensure that only data from genuine organic farms are processed, we excluded those organic farms that got defaulted by the certification system in the following year and of which the data were not plausible (nine farms in 2003). Data of farms with particularly high yields were cross-checked thoroughly and in case of doubt the farms were excluded (two farms in 2003 and three farms in 2004). The development of the sample in the two years is depicted in Figure 4.

Naturally, the exceptionally high rate of defaulted organic farms in the two years of data monitoring constituted a considerable challenge to the system comparison. The research project happened to take place during the most difficult phase in the 13-year old history of the Maikaal bioRe project. Replacing defaulted farmers in the data monitoring, and at the same time ensuring the representativeness of the samples, meant additional efforts for the research team. Thanks to the stringent exclusion of farms where the research team doubted whether they completely comply with organic standards, we are confident that the results really reflect the performance of genuine organic farms.

On the other hand, the occurrence of defaulting and its detection through the strict quality management system of Maikaal bioRe allowed gaining valuable insights into the obstacles of organic farming. In order to better understand the logic of defaulting, we requested defaulted farms to continue record keeping for the data monitoring so that we can compare their farms with those of genuine organic farmers. As the loss of integrity is one of the biggest threats to organic farming projects, we can draw lessons from the unplanned analysis of defaulted farms that might be crucial for the further development of organic cotton farming.

Figure 4: The development of the farm sample in 2003 and 2004 for the agronomic data monitoring (ADM).

2.5 Soil sampling and analysis

From each cotton field, representative soil samples were taken, combining 12 samples evenly distributed over the field to one composite sample. Soil samples were taken to a depth of 15 cm, using a heavy type single gouge auger (Ejkelkamp, 30 mm diameter). The samples were air dried, crushed in a wooden bowl, and gravel and other particles of more than 2 mm were removed with a sieve. The samples were analysed in the soil laboratory of ICRISAT, Hyderabad, for the parameters listed in Table 3.

Soil parameter	Method	Details
Texture (sand, silt, clay)	Hydrometer method	Contents of sand (0.05 – 2.0 mm), silt (0.002 – 0.05 mm) and clay (< 0.002 mm). Reference: Methods of Soil Analysis Part 1, Physical and Mineralogical Properties, Agronomy No. 9. Editor C.A. Black et al., ASA, Madison, USA, Pages 549-567.
Water retention capacity	Pressure membrane method	Plant available water, i.e. the difference between field capacity (-33 kPa) and permanent wilting point (-1500 kPa).
Organic carbon content	Tube digestion	Using block digester at 150 ºC. Also detects carbon bound to the clay fraction. Reference: Methods of soil analysis, Part-3: Chemical methods. Editor D.L. Spartks, SSSA Book Series. Pages 995-998.
Extractable phosphorus (P)	Olsen Method	Bicarbonate extractable P (Olsen-P). Bicarbonate extraction followed by P-estimation by auto analyzer. Reference: Methods of soil analysis, Part-3: Chemical methods. Editor D.L. Spartks, SSSA Book Series. Pages 895-897.
Exchangeable potassium (K)	Ammonium acetate extractable K	Ammonium acetate extraction followed by K-estimation by AAS. Reference: Methods of soil analysis, Part-2: Chemical and microbiological properties. Editor A.L. Page, ASA. Madison, USA, Pages 159-165.
Extractable Zinc (Zn)	DTPA method	DTPA extraction followed by Zn-estimation by AAS. Reference: Lindsay W.L and Norvell. W.A 1978. Development of DTPA soil test for Zinc, Iron, Mn and Cu. Soil Sci. Am. J 42:421-428.
Extractable Boron	ICP method	0.02M hot $CaCl_2$ extraction followed by B-estimation by ICP.
pH	In water	Dilution soil with water 1:2. Reference: Methods of soil analysis, Part-3: Chemical methods. Editor D.L. Spartks, SSSA Book Series. Pages 487-488.
Total salt content	Electric conductivity	Dilution soil with water 1:2. EC by Pye Unicam metre; unit: Decisiemens /metre. Reference: Methods of soil analysis, Part-3: Chemical methods. Editor D.L. Spartks, SSSA Book Series. Pages 420-421.

Table 3: Soil parameters and analytical methods.

In order to compare the distribution of soil parameter values in the two farming systems, we defined status groups for each parameter as listed in Table 4. In the case of soil texture, the types are defined as per established soil classification[12]. For water retention and organic matter, established classification for the specific site conditions was not available. Ranges were therefore defined based on observations, dividing the sample into reasonably sized groups. For soil nutrients and salinity, yield-response data for cotton in the particular soils of the region were not available. Status groups were therefore defined as per soil sample interpretations used for cotton in Australia[13], adapted to local conditions based on recommendations by soil scientists of

[12] see e.g. Soil Science Society of America, www.soils.org/sssagloss/pdf/figure1.pdf

[13] see NUTRIpak – A practical guide to cotton nutrition; http://cotton.pi.csiro.au

regional research stations. As pH values are all in the alkaline range, we did not allocate status groups to this parameter.

The definition of the status groups may well be subject to debate. However, our focus is more on comparing the distribution patterns of the parameters in soil samples from organic and conventional fields, rather than the absolute allocation to the respective status groups.

Parameter	**Status groups**			
Texture	***Clay soil***	***Silt soil***	***Loamy soil***	***Sandy soil***
Soil types	> 40% clay	> 60% silt	< 40% clay and < 60% silt and < 50% sand	> 50% sand
Water retention and organic matter	***Very low***	***Low***	***Medium***	***High***
Water retention capacity status	< 10%	10-13%	13-15%	> 15%
Organic carbon status	< 0.7%	0.7-0.9%	0.9-1.2%	>1.2%
Organic carbon/clay ratio	< 1.7%	1.7-2.0%	2.0-3.0%	> 3.0%
Soil nutrients	***Deficient***	***Slightly deficient***	***Optimum***	***Very high***
Phosphorus status (P)	< 4 mg/kg	4-7 mg/kg	7-15 mg/kg	> 15 mg/kg
Potassium status (K)	< 100 mg/kg	100-150 mg/kg	150-300 mg/kg	> 300 mg/kg
Zinc status (Zn)	< 0.3 mg/kg	0.3-0.5 mg/kg	0.5-1.0 mg/kg	> 1.0 mg/kg
Boron status (B)	< 0.2 mg/kg	0.2-0.3 mg/kg	0.3-0.8 mg/kg	> 0.8 mg/kg
Salinity		***No salinity***	***Medium salinity***	***High salinity***
Salinity status		< 0.4 dS/m	0.4-0.6 dS/m	> 0.6 dS/m

Table 4: Definition of soil status groups.

2.6 Data processing

Research data were processed with the help of the statistics programmes SPSS and JMP. For the comparison of means, extreme values were excluded to avoid distortion. Significance of differences was tested with independent samples T-test (95% confidence interval). For analysing the effects of production variables on cotton yields, linear regression models were fitted (standard least square). For this, the data of the two years were combined and leverage points were excluded. A year-dummy was included to control for effects from the two cropping periods (2003/04 and 2004/05). The most relevant predictor variables were identified by fitting models stepwise backward, starting with the complete model and eliminating parameters with $p > 0.100$.

3. Results

In this chapter we present the results of the agronomic data monitoring, while possible interpretations are discussed in Chapter 4. To guide the reader through the complex setting we provide brief introductions to each topic. The number of defaulted organic farms that remained in the data monitoring was large enough to process their data as a separate group. As their profile and performance data allow gaining valuable insight into the logic of defaulting (see Chapter 4.4), we present their results in the figures as a separate group.

Due to large heterogeneity among the farms concerning soil conditions, irrigation, choice of crops and varieties etc., the data exhibit high variability. For graphical reasons we present the results in bar diagrams of mean values without error bars, indicating whether differences between the groups are statistically significant (* for p ≤ 5% and ** for p ≤ 10%; for 5% respectively 10% confidence interval levels).

3.1 Farm profiles

Studying farm profiles, i.e. a set of parameters describing characteristic features of the farm household and the production system, serves two purposes: firstly, to analyse which types of farmers choose to convert to organic farming, or to switch back to conventional farming, and secondly, to assess the impact of organic production on livelihood and production system aspects. In this, it is not always possible to clearly separate between cause and effect, i.e. whether different profiles lead to differentiated adoption behaviour, or are a result of the adoption of organic farming. Generally, socio-economic aspects like education levels, castes, house types, family size and land holdings are comparatively robust parameters and thus potentially less influenced by the farming system than dynamic agronomic variables like labour units, stocking rates, and crop shares.

3.1.1. Socio-economic aspects

A comparison of socio-economic parameters shows that organic farmers in the Maikaal project are of higher socio-economic status than conventional farmers in the region. A greater percentage of the organic farmers had higher education, belong to higher castes and live in better houses (Figure 5 a, b, c). However, farmers who got excluded from the sample (defaulters and suspected farmers) were of considerably higher socio-economic status than the organic farmers. Consequentially, as in 2004 two villages with high defaulting rates were replaced with new villages (see Chapter 2.4), the difference in socio-economic status between organic and conventional farmers is less pronounced in the second year.

The higher socio-economic status of organic farmers and defaulted farmers also becomes visible when grouping the farmers based on the wealth indicator defined in Chapter 2.3. With the help of this indicator, farmers were divided into three groups of equal size: resource poor, medium and wealthy (Figure 5 d).

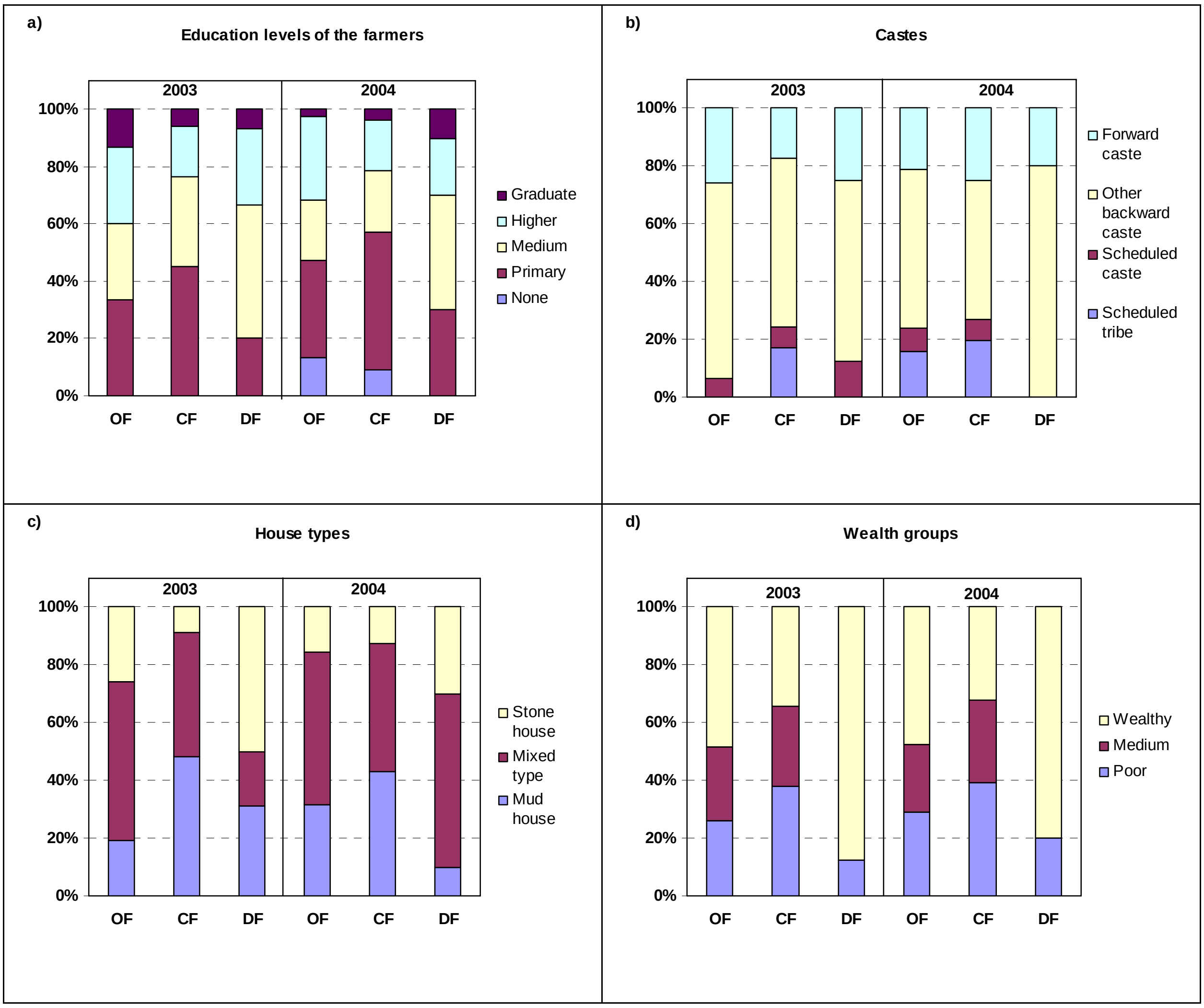


Figure 5: Social status indicators (% of cases) of organic farms (OF), conventional farms (CF) and defaulted organic farms (DF) in the samples 2003 and 2004: (a) education levels of the farmers, (b) caste groups, (c) house types and (d) wealth groups based on a wealth indicator combining land holding, equipment value, off-farm income and availability of irrigation. All parameters are given in declining order of social status. N in 2003: OF: 31, CF: 58, DF: 16; N in 2004: OF: 38, CF: 56, DF: 10.

In addition to the higher social status, organic farms in the project are also better equipped with production means (land holding, agricultural and transportation equipment, and micro-irrigation sets) than conventional farmers in the region (Figure 6 a, b, c). This is even more pronounced with defaulted organic farms. Equipment values include the costs of ploughs, cultivators, threshers, pump sprayers, motorbikes, bullock carts and tractor trolleys. On an average, organic farmers also have 50% to almost 100% higher off-farm income, and approx. 50% higher income from milk sales than conventional farmers (Figure 6 d).

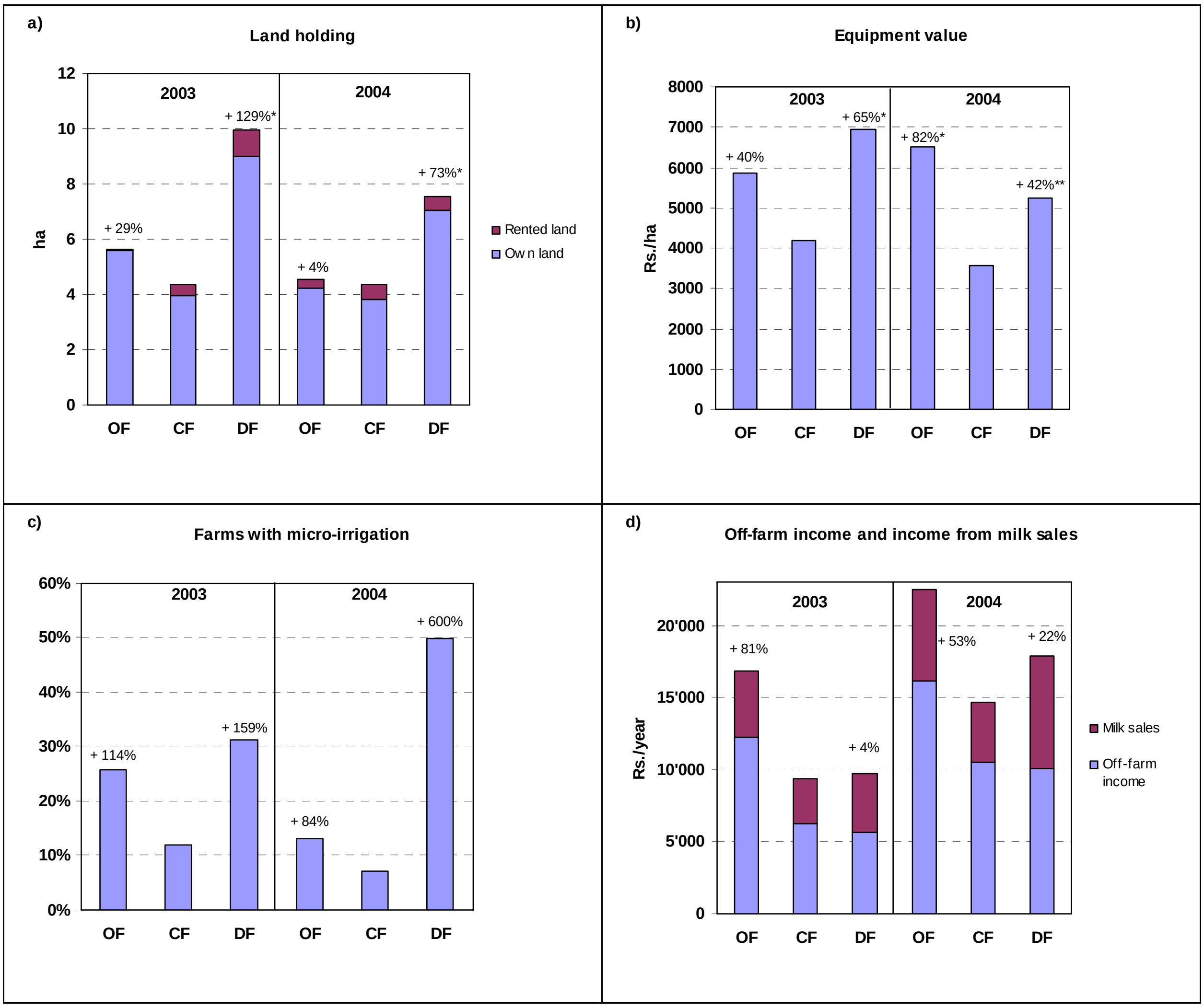


Figure 6: Production means and wealth indicators of organic farms (OF), conventional farms (CF) and defaulted organic farms (DF) in the samples 2003 and 2004: (a) total arable land of the farm, (b) value of main agricultural and transportation equipment, (c) share of farms possessing micro-irrigation systems and (d) average off-farm income and income from milk sales. In (a), (b) and (d), the bars indicate mean values and the figures above the bars indicate percentage deviation from means of conventional farms. In c) the figures indicate deviation from the percentage values for conventional farms. N in 2003: OF: 31, CF: 58, DF: 16; N in 2004: OF: 38, CF: 56, DF: 10. Significant difference (T-test): * p ≤ 5%, ** p ≤ 10%.

A greater share of organic farmers live in joint families (two or more closely related families under one roof, operating the land jointly) compared to conventional farmers (Figure 7 a). Average family size, however, was not different, except for defaulted organic farms in 2003, which had more family members than organic and conventional farms (Figure 7 b). The average age of the farmer (i.e. the decision maker concerning the farming operation) is about the same in all three types of farms (between 41 and 44 years).

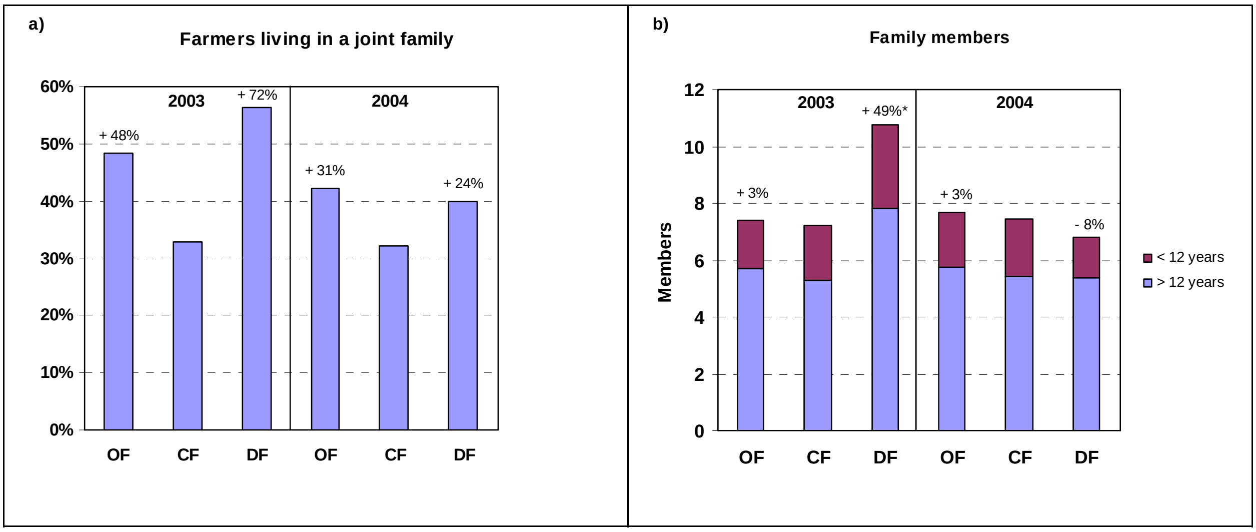


Figure 7: (a) Family type (% of cases) and (b) average family size of organic farms (OF), conventional farms (CF) and defaulted organic farms (DF) in the samples 2003 and 2004. In (a) the figures indicate deviation from the percentage values for CF. In (b) the bars indicate mean values and the figures above the bars indicate percentage deviation from means of conventional farms. N in 2003: OF: 31, CF: 58, DF: 16; N in 2004: OF: 38, CF: 56, DF: 10. Significant difference (T-test): * $p \leq 5\%$, ** $p \leq 10\%$.

3.1.2. Agronomic aspects

To compare the labour availability on organic and conventional farms, we collected data on the agricultural labour units (LU) of family own labour and permanent hired labour involved in farming activities (all crops). If a person does not devote all his or her time for agricultural activities (e.g. house wives or children in education), the respective work share was taken into consideration. Based on estimates by farmers, persons below 18 years and above 60 years were counted as 0.5 LU, and children of 12 to 16 years working in the farm as 0.2 LU. Figure 8 a) shows a tendency of organic farms having 11% (2003) respectively 27% (2004) more agricultural labour units, - especially more women - , involved per ha land holding, compared to conventional or defaulted organic farms.

Domestic animals play an important role in cotton farms, as they provide milk (for subsistence and sale), dung, draught power and serve as savings deposit. In organic farming, the relevance of dung production is particularly high. Thus it is not surprising that stocking rates in organic farms were 20% (2003) to 29% (2004) higher than in conventional farms (Figure 8 b). Livestock units (LSU) of different farm animals were calculated as per their estimated dung dropping units (see Chapter 2.3).

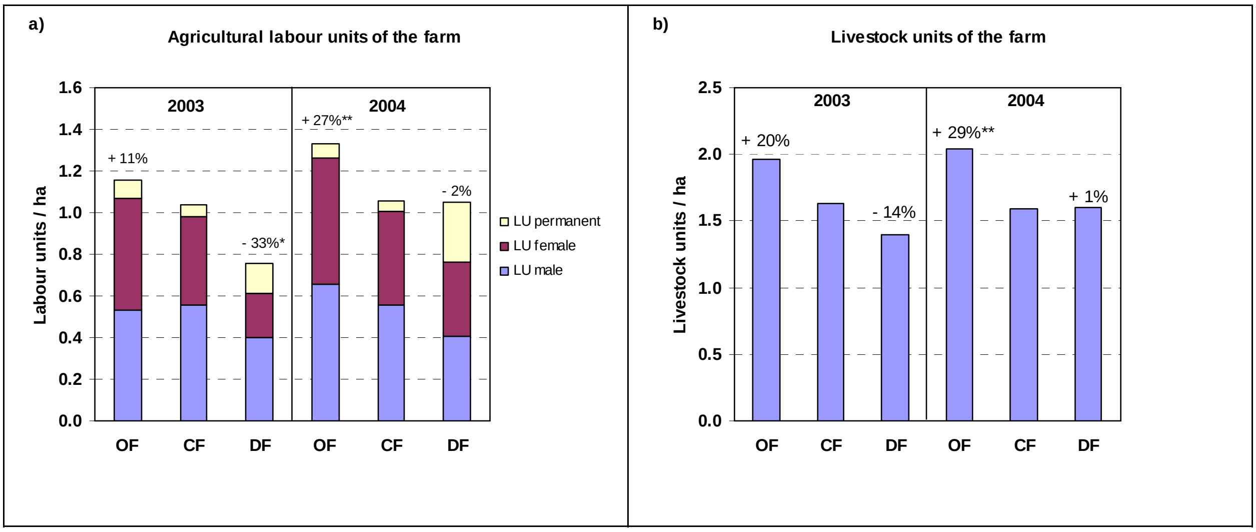


Figure 8: (a) Average agricultural labour units on the farm per ha arable land and (b) average animal units per ha on organic farms (OF), conventional farms (CF) and defaulted organic farms (DF) in the samples 2003 and 2004. Figures above the bars indicate percentage deviation from means of conventional farms. N in 2003: OF: 31, CF: 58, DF: 16; N in 2004: OF: 38, CF: 56, DF: 10. Significant difference (T-test): * p ≤ 5%, ** p ≤ 10%.

The cropping pattern of organic and conventional farms, defined as the shares of major crops on the total land operated by the farmer, is quite similar (Figure 9 a). In both years, organic farms had somewhat smaller land shares under chillies and pigeon pea, while the share of soy bean was higher. Defaulted organic farms had considerably higher land shares under soy bean compared to organic and conventional farms. Wheat shares in the winter season (Rabi crop) were about the same in organic and conventional farms, while they were 21% (2003) to 32% (2004) higher among defaulted organic farms (Figure 9 b).

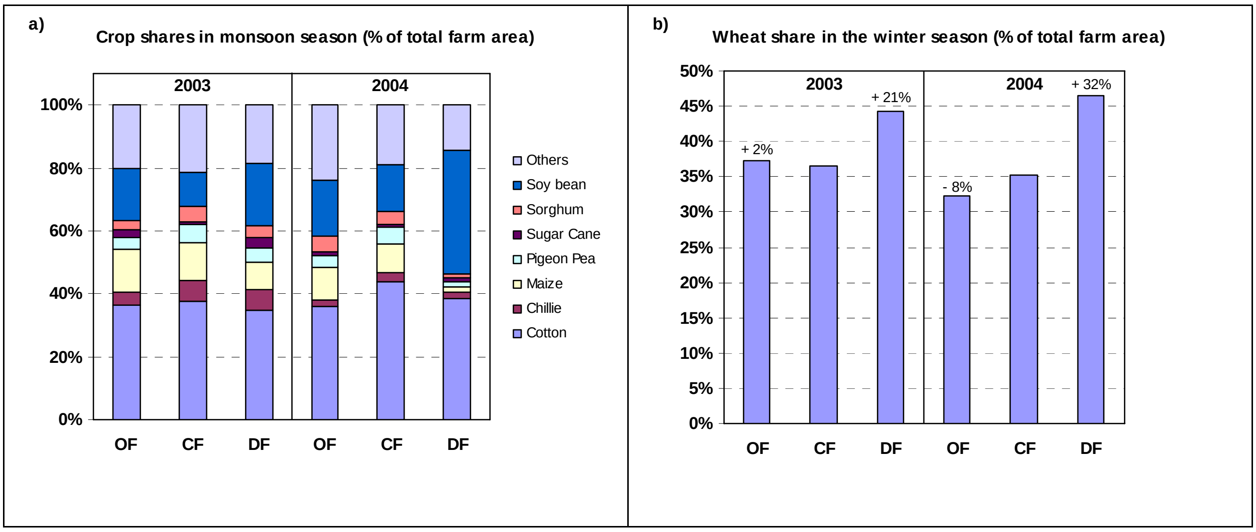


Figure 9: Cropping patterns in organic farms (OF), conventional farms (CF) and defaulted organic farms (DF) in the samples 2003 and 2004: (a) average shares of major crops in the monsoon season (Kharif crop, June to November), and (b) average wheat shares in the winter season (Rabi crop, November to April). Figures above the bars in (b) indicate percentage deviation from means of conventional farms. N in 2003: OF: 31, CF: 58, DF: 16; N in 2004: OF: 38, CF: 56, DF: 10.

3.1.3. Cotton production aspects

Cotton production patterns differ between organic and conventional farms to a considerable extent (Figure 10). Both organic and conventional farmers use a wide range of cotton varieties (Figure 10 a). The shares of the six most frequently used varieties are different in organic, conventional and defaulted organic farms. The pattern in 2003 was substantially different from that in 2004, when 43% of all conventional cotton fields were cultivated with Bt-varieties (genetically modified cotton).

Organic cotton fields had less chilli and more legumes as the main previous crop, while the shares of cereals (wheat, maize and sorghum) were about the same (Figure 10 b). The percentage of fields in which cotton was grown directly after cotton was 7% (2003) to 15% (2004) lower in organic farms. However, the percentage of these fields increased from 22% in 2003 to 37% in 2004 also in organic cotton fields.

About 29% of the organic cotton fields had an intercrop of legumes, while this share was only 3% (2003) to 11% (2004) in conventional cotton fields (Figure 10 c). According to bioRe internal standards intercrops are compulsory when crop rotations are too narrow. However, intercrops are frequently poorly developed in the fields.

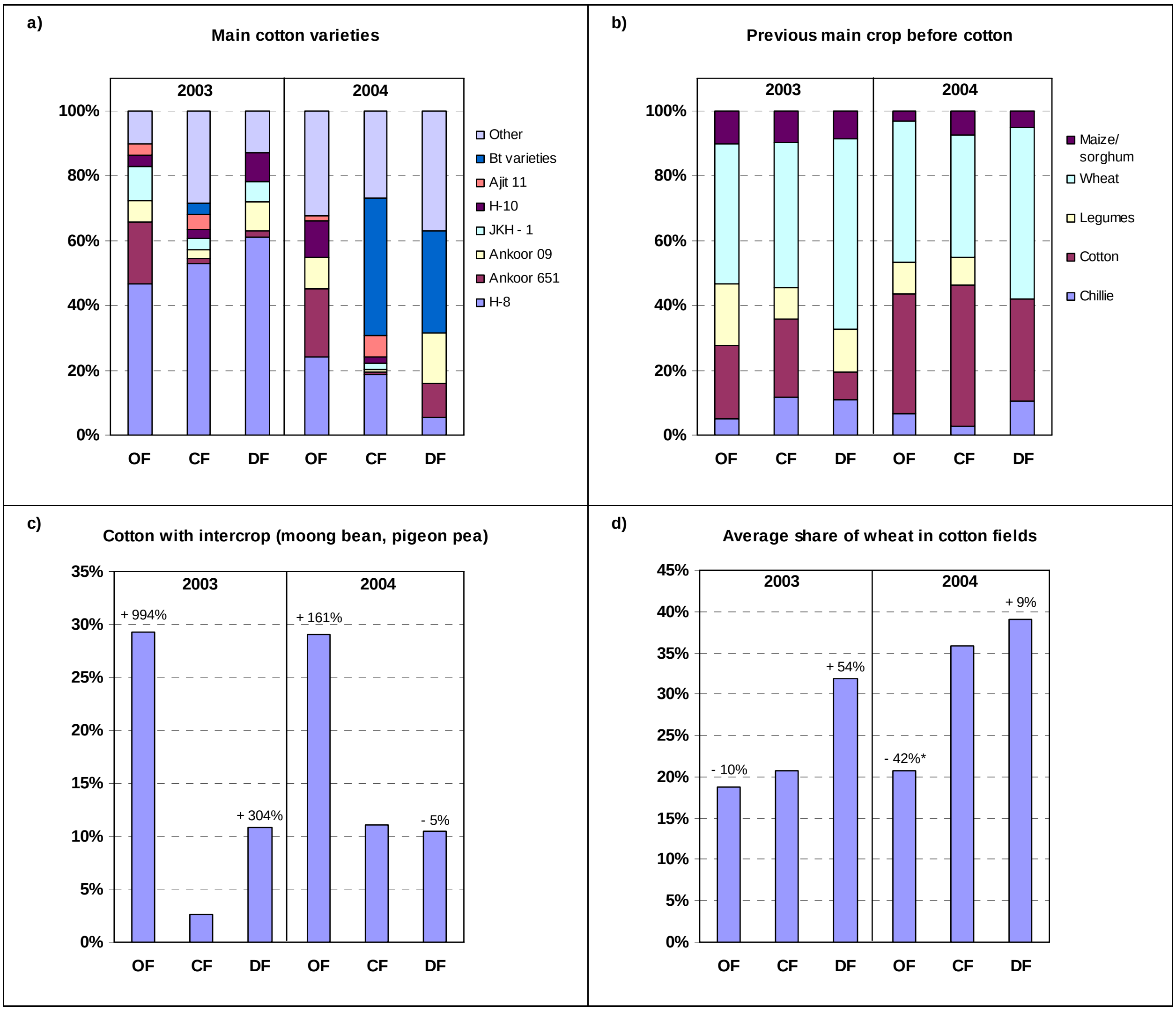


Figure 10: Cotton production patterns in the cotton fields of organic farms (OF), conventional farms (CF) and defaulted organic farms (DF) in the samples 2003 and 2004: (a) main cotton variety grown in the field, (b) previous main crop grown in the cotton field, (c) percentage of cotton grown along with an intercrop (frequently poorly developed) and (d) average share of wheat area in the cotton field. Figures above the bars indicate percentage deviation from means of conventional cotton fields. N in 2003: OF: 58, CF: 112, DF: 46; N in 2004: OF: 62, CF: 108, DF: 19. Significant difference (T-test): * p ≤ 5%, ** p ≤ 10%.

Many farms uproot a part of the cotton at the end of the Kharif (monsoon) season in order to grow wheat in the Rabi (winter) season. The average share of wheat in the organic cotton fields was lower by 10% (in 2003) and 42% (in 2004) compared to conventional cotton fields (Figure 10 d). Fields of defaulted organic farmers had a far higher share of wheat in both years.

Farm profiles: Points for discussion

The different profiles of organic and conventional farms raise two questions that will be discussed in Chapter 4.1:

1. What are the reasons that certain farm types are more likely to adopt organic farming? (Chapter 4.1.1)
2. What changes occur in farm profiles due to conversion to organic farming? (Chapter 4.1.2)

In addition, the distinctly different profiles of defaulted organic farmers call for a deeper look into the reasons and motivations for defaulting. This aspect will be discussed in Chapter 4.4.

3.2 Economic performance

In this chapter we compare the inputs and outputs as well as the financial performance of organic and conventional cotton farms based on their production costs and revenues in cotton and in the major rotation crops. The resulting gross margins are an important parameter to assess the impact of conversion on farmers' income.

3.2.1. Labour and material inputs

The main non-monetary inputs in cotton farming are labour, seeds, fertilizers, pest management items and irrigation. As the seed density is basically the same in organic and conventional farming, seed quantities were not analyzed. The quantities of applied pest management items can not easily be compared due to the different nature of preparations.

Our initial hypothesis concerning labour intensity[14] was that due to the more laborious preparation and application of organic manures, and possibly more weeding, organic cotton cultivation involves more labour than conventional farming. However, average total labour inputs were 2% lower in 2003 and 13% higher in 2004 (Figure 12 a). The differences were not significant. Organic farms employed a greater fraction of hired labour than conventional farms. In both years, organic farms used 6% more labour for weeding, but considerably less labour for pest management, while labour needed for fertilizer application was about the same (Figure 12 b). However, these three activities account for only 11-15% of total labour requirements, while the majority of the labour is required for intercultural operations, irrigation and harvesting. Labour required for these activities was not analyzed separately as practices are not different in the two production systems and there were no indications that labour requirements are systematically different. The time that organic farmers require for attending trainings and maintaining farm documents for certification is not included in this calculation. However, compared to the labour directly involved in cultivation activities this amount of time is almost negligible (on an average approx. 1 day/ha per year).

[14] Chapter 1.3, Hypothesis 1

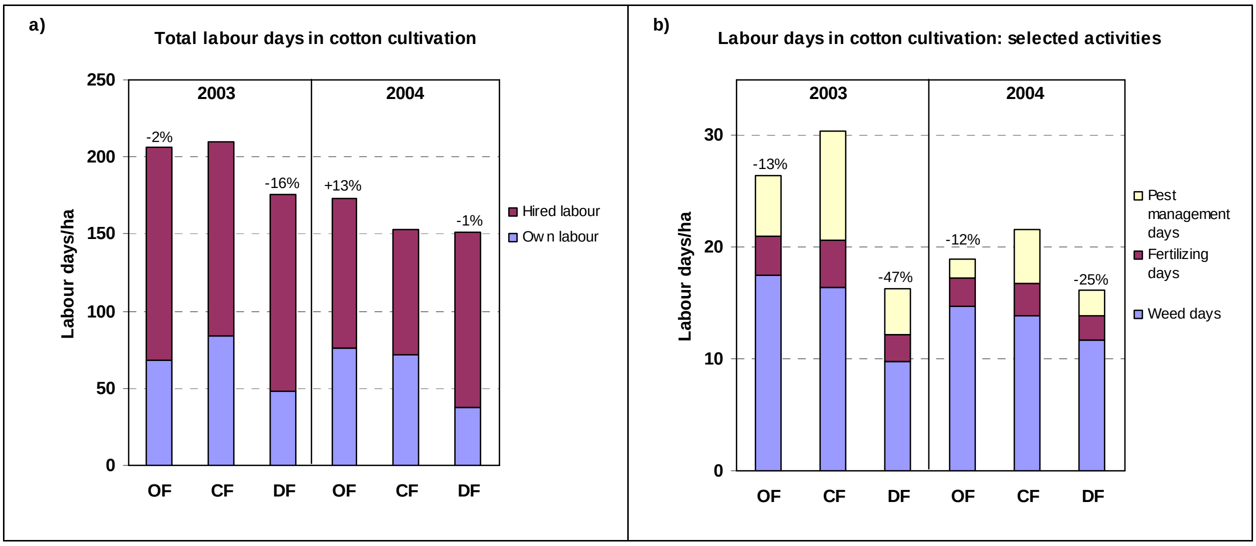


Figure 11: Labour inputs in cotton production in organic farms (OF), conventional farms (CF) and defaulted organic farms (DF) in the samples 2003 and 2004: (a) total labour days, (b) labour days required for weeding, fertilizer handling and pest management. Figures above the bars indicate percentage deviation from means of conventional cotton fields. N in 2003: OF: 58, CF: 112, DF: 46; N in 2004: OF: 62, CF: 108, DF: 19. Significant difference (T-test): * p ≤ 5%, ** p ≤ 10%.

Inputs of nitrogen and phosphorus through manures and fertilizers were considerably lower in organic cotton fields than in fields of conventional farms, while potassium inputs were about the same (Figure 12 a). Nitrogen inputs in organic fields were 50% lower in 2003, and 39% lower in 2004. In organic cotton farming, all nitrogen input stems from organic manures (mainly from farm yard manure, composts and oil-cakes), while in conventional farms the majority of nitrogen is applied through synthetic fertilizers (mainly NPK-fertilizers, diammonium phosphate (DAP) and urea) (Figure 12 b). The average application of organic manures in organic cotton fields was 95% higher in 2003 and 87% higher in 2004 compared to conventional farms. In 2004, synthetic fertilizer application in conventional cotton fields was 28% lower than in 2003. Changes in overall fertilizer application from year to year are common in the region, as farmers apply fertilizers based on the crop condition and the availability of water (from rains or from irrigation), rather than as per general fertilizer recommendations. Conditions in 2004 were obviously less conducive, as the lower rainfall quantities show (Annex 6.1).

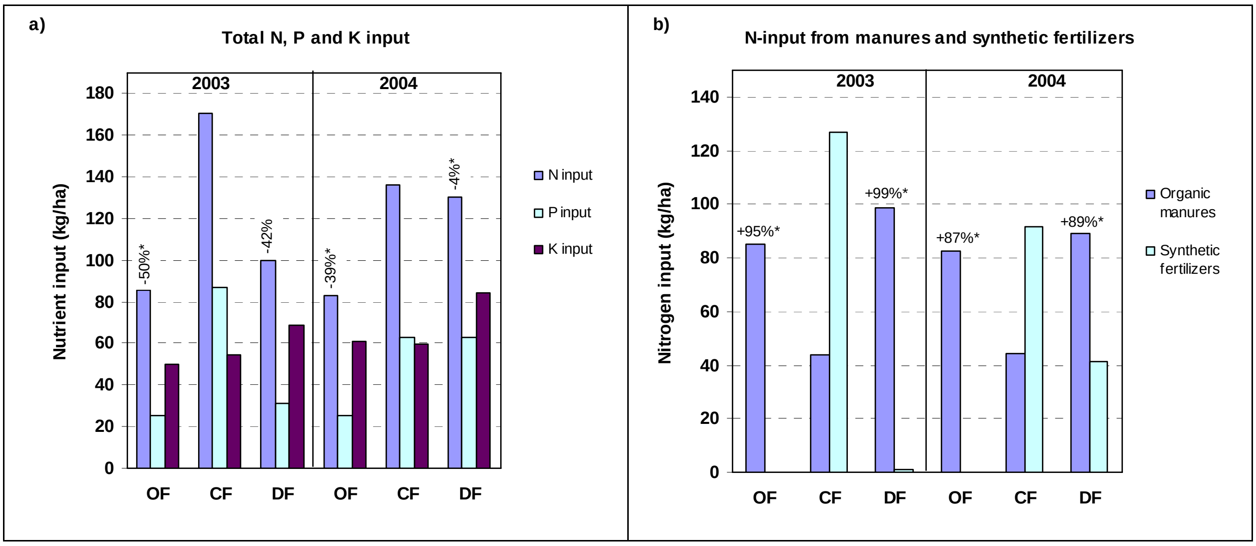


Figure 12: Nutrient inputs in cotton production in organic farms (OF), conventional farms (CF) and defaulted organic farms (DF) in the samples 2003 and 2004: (a) total nutrient input and (b) break-up of nitrogen applied through organic manures and synthetic fertilizers. Figures above the bars indicate percentage deviation from means of conventional cotton fields. N in 2003: OF: 58, CF: 112, DF: 46; N in 2004: OF: 62, CF: 108, DF: 19. Significant difference (T-test): * p ≤ 5%, ** p ≤ 10%.

Our initial hypothesis concerning irrigation[15] was that organic farms apply less irrigation water in cotton, as their soils can take up and store water better thanks to higher quantities of organic manures applied. However, there was no significant difference in water inputs between the two systems. Surprisingly, estimated average irrigation water inputs in organic cotton fields even showed a tendency to be higher than in conventional cotton fields, by 17% in 2003 and by 5% in 2004 (Figure 13 a). As the variability in water application is generally high in the region, the differences between farming systems were not significant. In addition to this, the error in estimating water quantities based on well depth, pump details and irrigation duration might be quite substantial, as the maintenance condition of the pump and power fluctuations can have substantial impact on pump output. In average, organic and conventional farmers irrigated their cotton fields 4-5 times in both years. There was no significant difference between systems in the average number of irrigation rounds, and the distribution of irrigation frequencies did not exhibit a clearly distinct pattern (Figure 13 b).

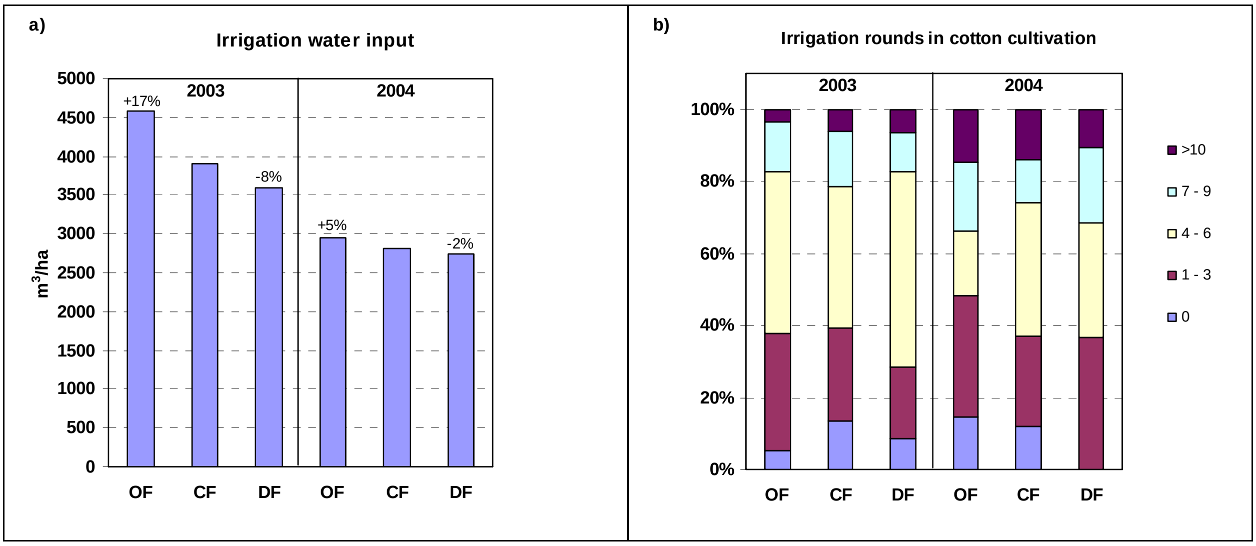


Figure 13: (a) Average irrigation water inputs and (b) frequencies of irrigation rounds in cotton production in organic farms (OF), conventional farms (CF) and defaulted organic farms (DF) in the samples 2003 and 2004. Figures above the bars indicate percentage deviation from means of conventional cotton fields. N in 2003: OF: 58, CF: 112, DF: 46; N in 2004: OF: 62, CF: 108, DF: 19. Significant difference (T-test): * p ≤ 5%, ** p ≤ 10%.

3.2.2. Cotton yields

As cotton is the main cash provider in the investigated farms, cotton yields play a central role. In contrast to our initial hypothesis[16] that yields in organic cotton cultivation are somewhat lower than in conventional farming, average seed cotton yields in organic cotton fields were 4.3% higher in 2003 and 6.1% higher in 2004 than in conventional fields (Figure 14 a). However, due to high variability these differences were not significant.

Yields could possibly also depend on parameters not influenced by the farming system, such as the time of sowing and uprooting, the soil type or the amount of irrigation. We therefore compared yields of different sub-groups (summer cotton/monsoon cotton, with Rabi crop/without Rabi crop, different cotton varieties, different villages, different wealth groups, and different soil types). Relevant differences are described in the following paragraph. In addition, we analysed correlations with production parameters and checked their influence by fitting regression models (see next paragraph).

[15] Chapter 1.3, Hypothesis 1

[16] Chapter 1.3, Hypothesis 3

Cotton yields in different sub-groups

In all farming systems and in both years, yields were higher in summer sown cotton (with irrigation) compared to cotton sown after the start of the monsoon rains (Figure 14 b). Yields in organic cotton fields were slightly higher than in conventional fields, both in summer sown cotton and in monsoon sown cotton, though none of the differences were significant.

As mentioned in Chapter 3.1.3, some farmers prefer to uproot a part of the cotton crop in November or December in order to grow wheat in the Rabi (winter) season, instead of continuing to harvest the cotton. Thus, they sacrifice part of the cotton yield in favour of wheat. On the other side, wheat is usually grown on more fertile fields, where yields are generally higher. As a result, the comparison of average cotton yields in fields with and without wheat crop is heterogeneous (Figure 14 c): in 2003, yields in organic fields were higher where a wheat crop was grown, and they were higher than in conventional fields, while in 2004 it was just the opposite.

When comparing cotton yields of fields belonging to different soil types, it is striking that in organic farms yields are highest in sandy soils (Figure 14 d). In both years the advantage of organic over conventional farming is highest in this soil type.

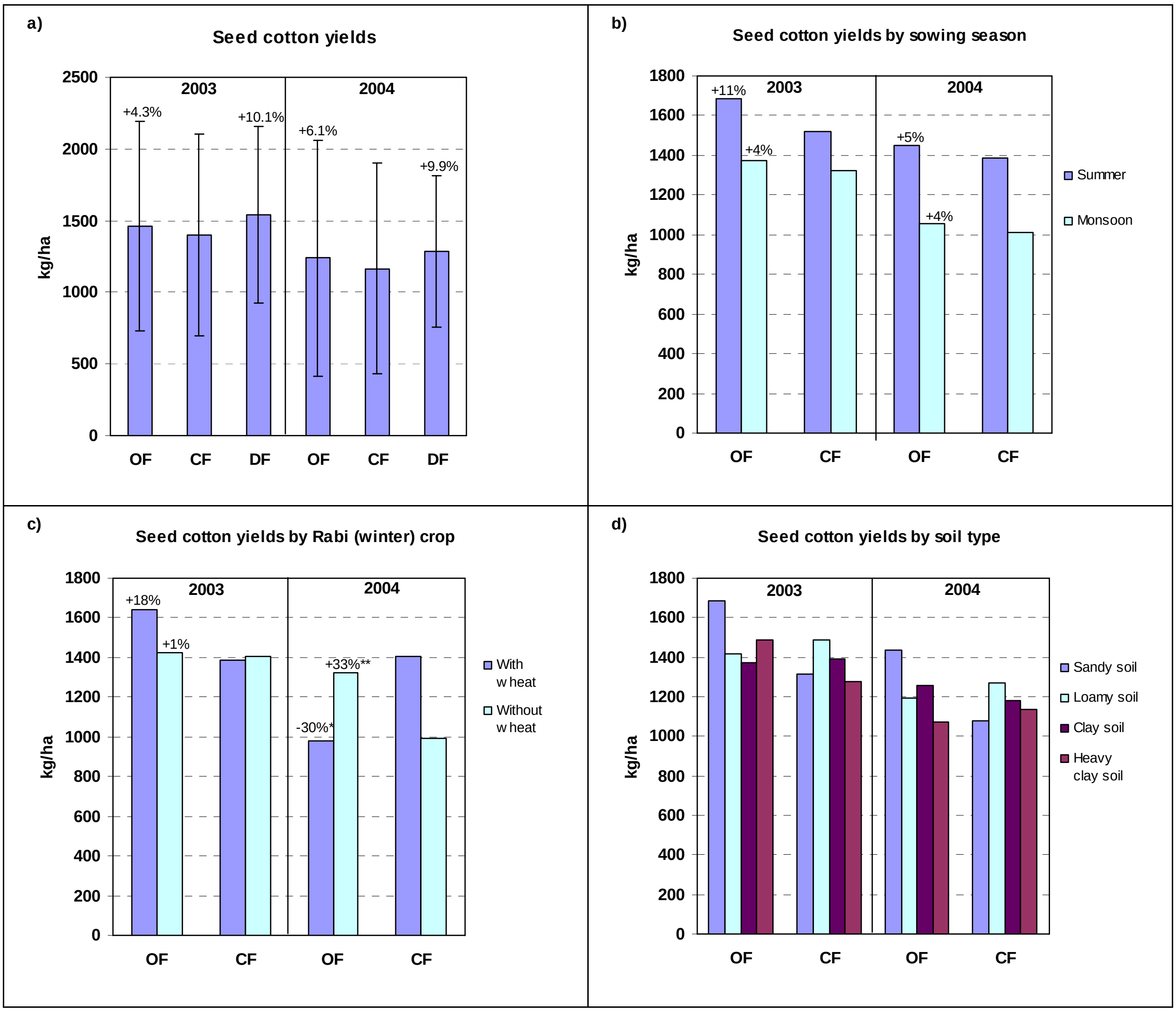


Figure 14: Seed cotton yields in organic farms (OF), conventional farms (CF) and defaulted organic farms (DF) in the samples 2003 and 2004: (a) yields ungrouped with error bars indicating standard deviations, (b) yields grouped by growing season, (c) by presence of wheat in the same field in the Rabi season and (d) by soil type. Figures above the bars indicate percentage deviation from means of conventional cotton fields. N in 2003: OF: 58, CF: 112, DF: 46; N in 2004: OF: 62, CF: 108, DF: 19. Significant difference (T-test): * p ≤ 5%, ** p ≤ 10%.

Parameters that influence cotton yields

Cotton yields obviously are not only determined by the farming system (i.e. organic or conventional farming), but also by a number of factors not inherent to the farming system, like site conditions (soil types, rainfall), the time of sowing and uprooting, wheat shares or access to irrigation. We refer to these parameters not inherently associated with the production system as 'non-inherent parameters'. Thus it could be that, if the samples of organic and conventional cotton fields for some reason defer in these parameters, the comparison of average yields in the two systems is biased. To check this possibility, we fitted a linear regression model for the cotton yields, including all available non-inherent parameters that possibly could influence yields. The model is given in Annex 6.6.1.

This regression model shows that there are indeed parameters significantly influencing cotton yields: village (a parameter for the site), crop duration and irrigation (total irrigation hours). In this model, average yields corrected by non-inherent parameters are still 4% higher in organic fields. However, the effect is not significant.

Which parameters – whether inherent or non-inherent to the system – have the biggest and most significant impact on cotton yields in the two systems? To answer this question we fitted linear regression models on cotton yields separately for the data from organic and conventional cotton fields, including all parameters that could possibly influence yields. To identify production functions containing the most relevant predictor variables, we eliminated those that were not significant (stepwise backward model fit). The resulting models are given in Annex 6.6.2. The parameters that have the strongest impacts, with their respective effects on cotton yields, are listed in Table 5.

Parameter	**Estimated yield effect in OF (kg/ha)**	**Range of the estimated effect in OF (kg/ha)**	**Estimated yield effect in CF (kg/ha)**	**Range of the estimated effect in CF (kg/ha)**
Year (for 2003)	(not significant)	---	98.2	15 – 181
Wealth (for wealthy farmers)	101.5	2 – 201	80.5	3-178
Rainfall (mm)	0.83	0.2 – 1.4	(not significant)	---
Village	significant effects	---	significant effects	---
Previous main crop (for wheat)	(not significant)	---	93.4	12-174
Crop duration (days)	5.72	3.2 – 8.2	5.3	3.3 – 7.4
Cotton variety	(not significant)	---	significant effects	---
Sowing density (pl./m^2)	significant effects	---	(not significant)	---
Nitrogen from organic manures (kg/ha)	4.85	1.8 – 7.9	(not significant)	---
Nitrogen from synthetic fertilizers (kg/ha)	not applicable	---	3.27	1.2 – 5.3
Clay content (%)	-12.0	-2.5 – -21.6	(not significant)	---
Soil organic carbon content (%)	1085.3	497-1673	(not significant)	---
Soil potassium content (ppm)	0.87	0.2 – 1.5	(not significant)	---
Soil pH	534.7	155-914	(not significant)	---
Irrigation rounds	(not significant)	---	31.7	11-52

Table 5: Parameters significantly influencing cotton yields in organic and conventional farming and their estimated effect on yields, based on production functions established through linear regression models. The estimated yield effect indicates the predicted increase (or reduction) of cotton yields for the specified group (in the case of the parameters year, wealth group and previous main crop) respectively for the change of the influencing parameter by one unit (in the case of the continuous parameters). The range indicates the 95% confidence interval of the estimated effect[17].

[17] predicted value ± 1.96 * standard deviation

3.2.3. Production costs in cotton cultivation

To calculate production costs that are directly related to cotton production (variable production costs), we collected field data on costs for hired labour, inputs (seeds, fertilizers including organic manures, pest management items) and other costs (machine rent, irrigation costs etc.). Variable production costs in organic cotton fields were 13% lower in 2003 and 20% lower in 2004 than in conventional fields (Figure 15 a). This is in line with our initial hypothesis[18]. In organic cotton farming, costs for hired labour make out the largest proportion in production costs (53% in 2003 and 48% in 2004), while in conventional farming input costs are the dominating factor (58% in 2003 and 60% in 2004). As indicated in Chapter 3.2.1, inputs of farm own labour were higher in conventional cotton fields. If opportunity costs for farm own labour (calculated at actual rates for hired labour) are included in the calculation, production costs in organic cotton fields were 15% lower in both years.

Input costs (seeds, fertilizers, pest management items) in organic cotton fields were 38% lower in 2003 and 44% lower in 2004 than in conventional farms (Figure 15 b). In 2003, seed costs in organic cotton fields were slightly lower, possibly because Maikaal bioRe offers their farmers some cotton varieties at slightly subsidised rates. In 2004, due to the widespread use of more costly seeds of Bt-varieties, seed costs in conventional cotton farming were 42% higher than in organic farming. The main difference in production costs between organic and conventional farming, however, is in costs for fertilizers and pest management items.

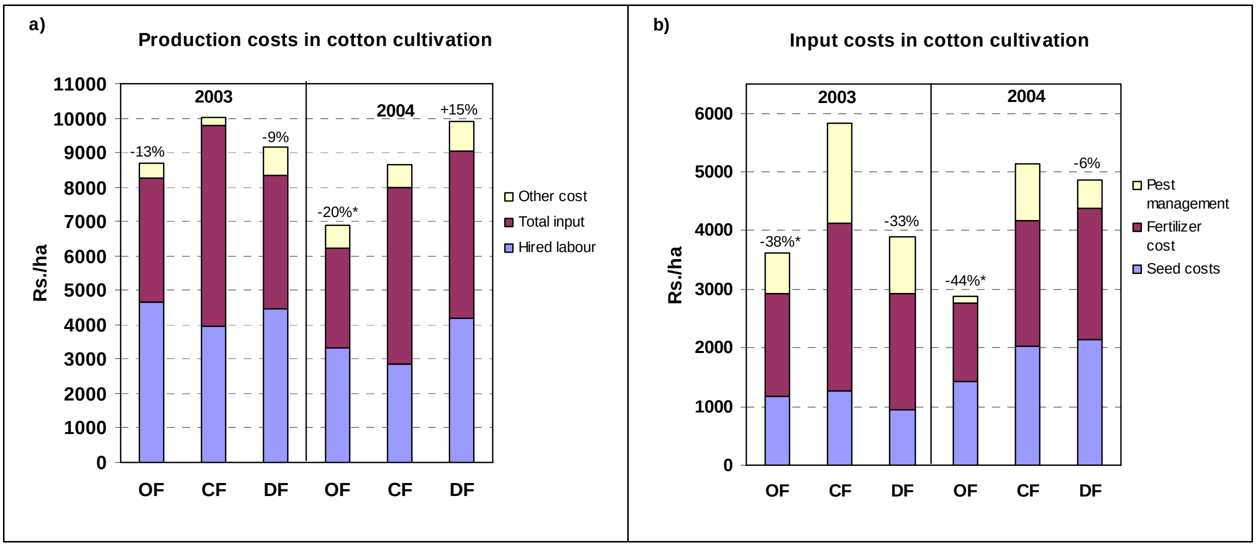


Figure 15: Production costs in cotton production in organic farms (OF), conventional farms (CF) and defaulted organic farms (DF) in the samples 2003 and 2004: (a) total production costs including hired labour costs, input costs and other costs (machine rent, irrigation costs), and (b) break up of total input costs into seed costs, fertilizer costs and pest management items costs. Figures above the bars indicate percentage deviation from means of conventional cotton fields. N in 2003: OF: 58, CF: 112, DF: 46; N in 2004: OF: 62, CF: 108, DF: 19. Significant difference (T-test): * p ≤ 5%, ** p ≤ 10%.

3.2.4. Revenues and gross margins in cotton cultivation

Before calculating gross margins we need to look at the revenues generated from cotton fields. Revenues from the cotton crop include the market value of the cotton harvest (yields multiplied by actual market rates at which the cotton was sold), the intercrop value (moong bean or pigeon pea for subsistence, calculated at average market rates) and in organic farming the 20% price premium paid by Maikaal bioRe. Market rates for cotton fluctuate heavily, and farmers use to sell their cotton in several lots. Average weighted cotton rates that organic farmers received from Maikaal bioRe were 5% higher in 2003, while they were 5% lower in 2004, compared to those received by conventional farmers. Altogether, average cotton rates in all farms were 26% lower in 2004 (16.85 Rs./kg) compared to 2003 (22.82 Rs./kg).

[18] Chapter 1.3, Hypothesis 2

Revenues from intercrops were higher in organic cotton fields, though the absolute average amount is negligible compared to revenues from cotton (approx. 0.5%). Total revenues from the cotton crop in organic cotton fields, including the organic price premium, were 31% higher in 2003 and 28% higher in 2004 (Figure 16 a). Without organic price premium, revenues were still 9% higher in 2003 and 6% higher in 2004.

However, in order to compare the value generated from a particular field, revenues from the wheat crop grown in some of the fields in the winter season need to be taken into consideration. As described in Chapter 3.1.2, many farmers uproot cotton at the end of the monsoon season in order to grow wheat, while others continue with the cotton crop. Sometimes only part of the cotton field is uprooted for wheat, making it necessary to consider the average area share under wheat. Due to lower average shares of wheat in organic cotton fields, and slightly lower absolute wheat yields (see Chapter 3.2.6), average revenues from wheat in organic cotton fields were considerably lower than in conventional fields (Figure 16 b). This calculation also includes fields in which no wheat is grown. For a comparison of absolute wheat yields and revenues in organic and conventional farms, please refer to Chapter 3.2.6.

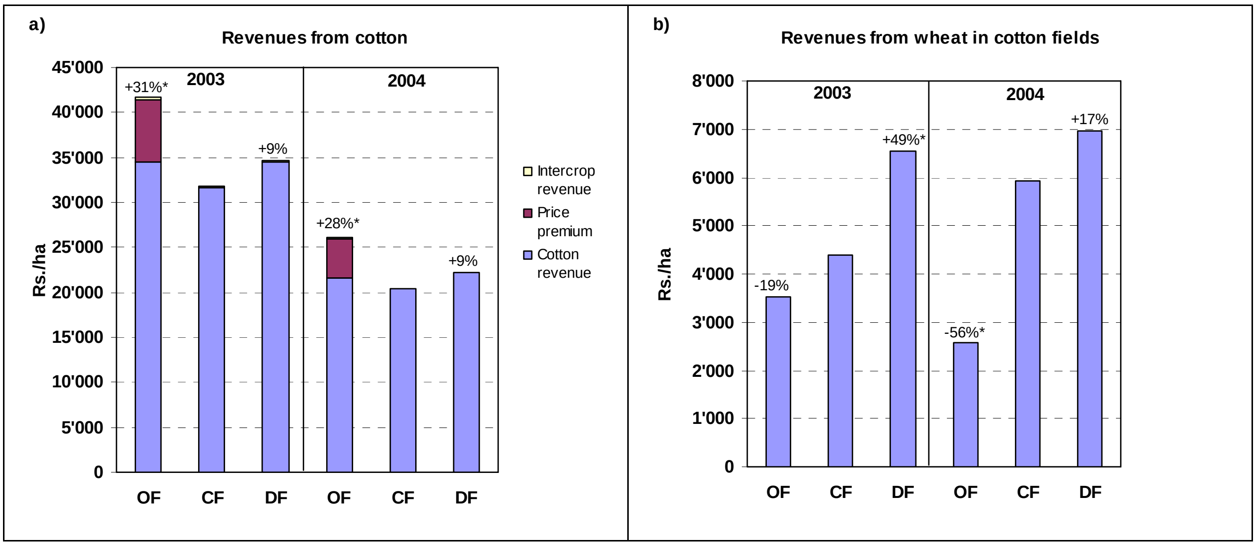


Figure 16: (a) Revenues from the cotton crop (including intercrops) and (b) from wheat grown in the Rabi season in part of the cotton fields in organic farms (OF), conventional farms (CF) and defaulted organic farms (DF) in the samples 2003 and 2004. Figures above the bars indicate percentage deviation from means of conventional cotton fields. N in 2003: OF: 58, CF: 112, DF: 46; N in 2004: OF: 62, CF: 108, DF: 19. Significant difference (T-test): * p ≤ 5%, ** p ≤ 10%.

Cotton gross margins are defined as the revenues from the cotton crop (cotton value, organic price premium and intercrop value) minus the variable production costs (hired labour costs, input costs and other costs like machine rent and irrigation costs). They indicate how much a line of production (i.e. cotton cultivation) contributes to covering fixed costs of the farm (depreciation on investments, interests, salaries for permanent hired labour, land rents etc.) and to the farm profit. The calculation of gross margins does not include costs of conversion to organic farming. As organic farming systems in the region only require simple and cheap equipment and infrastructure (e.g. compost heaps, vessels for preparing liquid manures), investment costs for equipment are not likely to be much different from conventional farming.

Due to slightly higher cotton yields, the 20% organic price premium and lower production costs, cotton gross margins in organic cotton were 52% higher in 2003 and 63% higher in 2004, compared to conventional cotton (Figure 17 a). If opportunity costs of farm own labour are included in the calculation (see explanation in the previous chapter), cotton gross margins in organic fields were 63% higher in 2003 and 77% higher in 2004. In this, the 20% price premium that Maikaal bioRe pays to its farmers increased average gross margins by 27% in 2003 and by 29% in 2004.

To compare the gross margins of the entire cotton field, the revenues and production costs in the wheat crop cultivated in the Rabi season need to be taken into consideration. With this, field gross margins in organic cotton fields were 43% higher in 2003 and 30% higher in 2004. Even without price premium in organic cotton, field gross margins in organic cotton fields would have been 15% higher in 2003 and 3% higher in 2004.

Gross margins in cotton fields of defaulted organic farms were higher than in conventional cotton fields, but lower than in organic cotton fields.

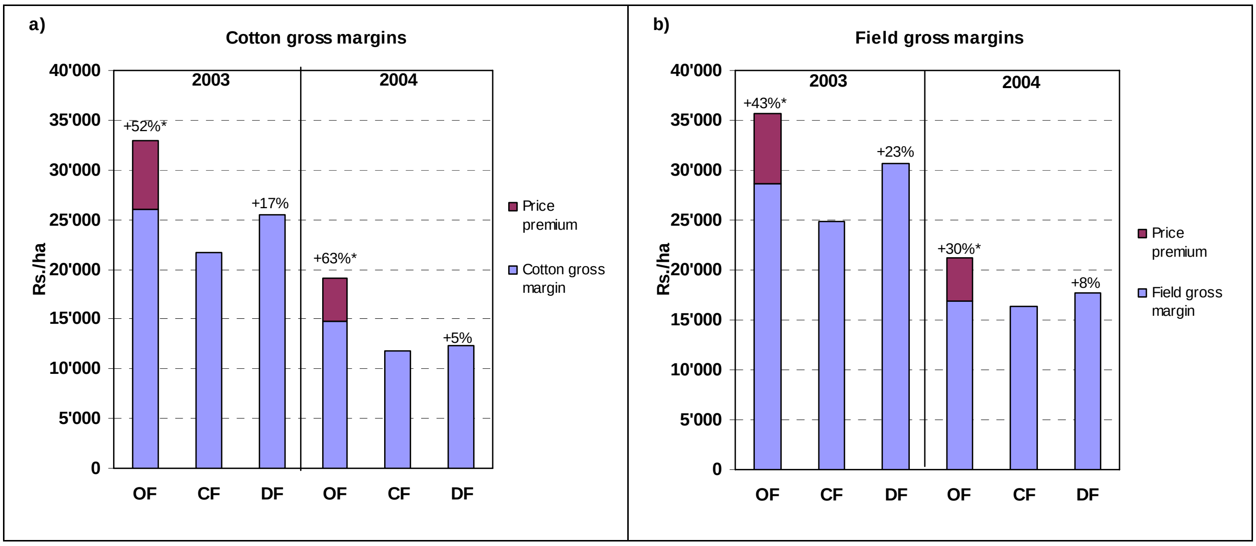


Figure 17: Gross margins in cotton fields of organic farms (OF), conventional farms (CF) and defaulted organic farms (DF) in the samples 2003 and 2004: (a) gross margins from the cotton crop (including intercrop) and (b) gross margins from the entire cotton field (including wheat grown in the Rabi season). Figures above the bars indicate percentage deviation from means of conventional cotton fields. N in 2003: OF: 58, CF: 112, DF: 46; N in 2004: OF: 62, CF: 108, DF: 19. Significant difference (T-test): * p ≤ 5%, ** p ≤ 10%.

As in the case of cotton yields, we checked whether parameters not inherent to the production system distort the comparison of field gross margins in organic and conventional farms. For this, we fitted a linear regression model taking into consideration all possible parameters that could influence margins but are not related to the farming system. In addition to the parameters possibly influencing cotton yields, we also included average wages for hired labour and average cotton rates in the model (see Annex 6.6.3). The model shows that these two new parameters have a strong effect on field gross margins. In this model, average gross margins corrected by non-inherent parameters are still 26% higher in organic fields (significant effect).

3.2.5. Efficiencies in cotton cultivation

As efficiencies in cotton cultivation we define the input required to produce 1 kg of seed cotton harvest. The less input is required, the more efficient is the production system regarding this specific input.

Efficiencies in organic cotton cultivation were higher concerning labour input, fertilizer input and input costs, but lower concerning irrigation water input (Figure 18). Due to slightly higher yields, labour inputs per kg seed cotton in organic cotton farming were 9% lower in 2003 and 6% lower in 2004 (Figure 18 a). Total nitrogen input through fertilizers or manures, per kg seed cotton harvest, were 55% lower in 2003 and 46% lower in 2004 (Figure 18 b). Organic farms required about half the input costs for seeds, fertilizers and pest management items per kg cotton harvest compared to conventional farms (Figure 18 c). However, organic farmers applied 4% respectively 8% more irrigation water per kg seed cotton (Figure 18 d). Average estimated irrigation water application in organic and conventional cotton fields was 3.0 to 3.5 m^3 water per kg seed cotton.

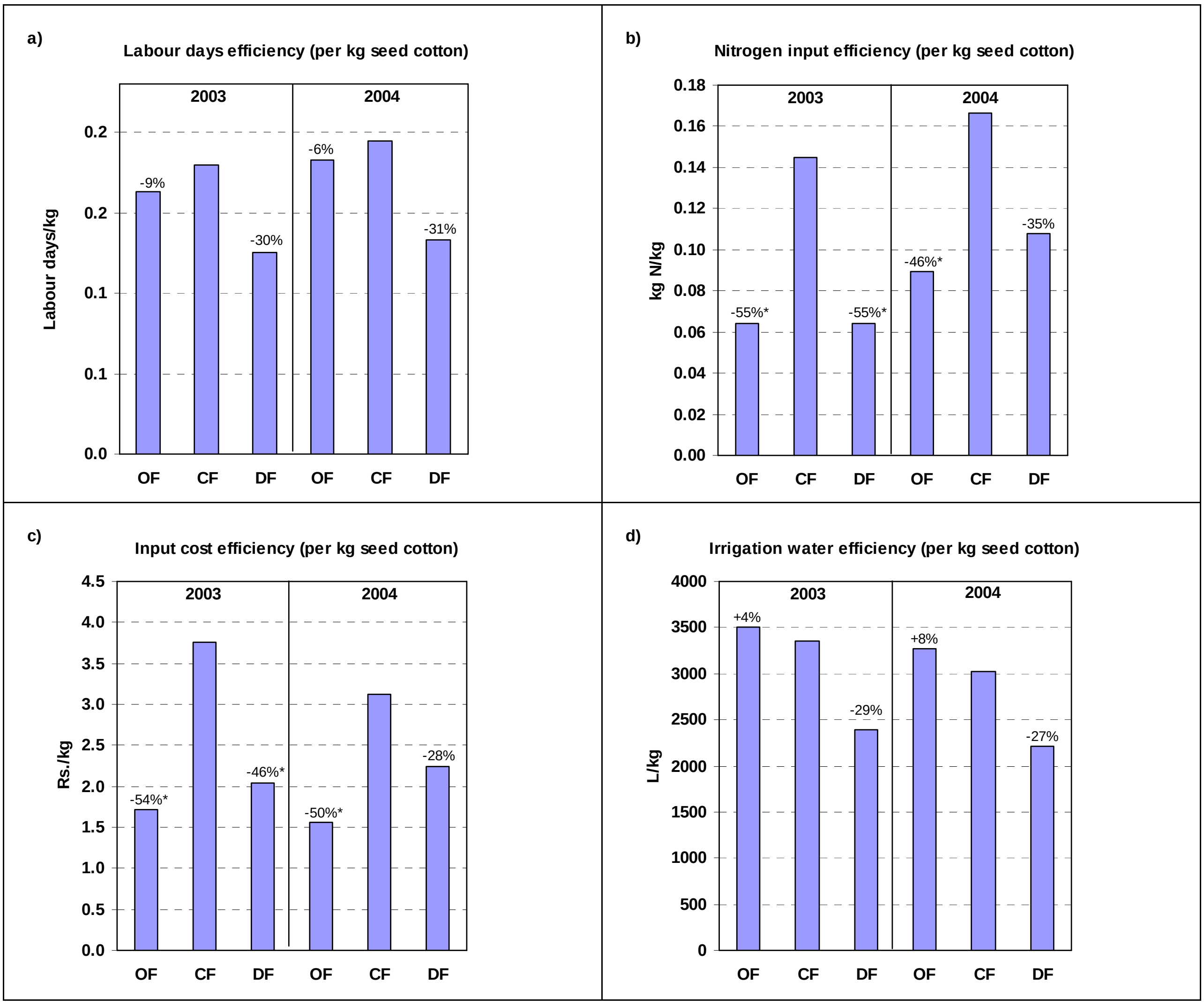


Figure 18: Efficiencies (input per kg seed cotton harvest) in cotton fields of organic (OF), conventional (CF) and defaulted organic farms (DF) in the samples 2003 and 2004. (a) labour days efficiency, (b) efficiency of nitrogen input through manures and fertilizers, (c) input cost efficiency (for seeds, fertilizers and pest management), and (d) irrigation water use efficiency. Figures above the bars indicate percentage deviation from means of conventional cotton fields. N in 2003: OF: 58, CF: 112, DF: 46; N in 2004: OF: 62, CF: 108, DF: 19. Significant difference (T-test): * p ≤ 5%, ** p ≤ 10%.

3.2.6. Rotation crops

Cotton is grown in rotation with various other crops that are cultivated either for cash income (chillies, sugar cane, banana, soy), for subsistence, or for both (maize, sorghum, pigeon pea, chick pea, wheat). So far, most rotation crop harvests of organic farms were sold in the open market without organic price premium. In order to compare the total gross margins from plant production of organic and conventional farms, we collected data also from the most widespread rotation crops.

In contrast to cotton, average yields of the six major rotation crops – chillies, maize, pigeon pea, sorghum, soy and wheat – were usually lower in organic farms than in conventional farms (Figure 19). In chillies, yields were 75% lower in 2003 and 69% lower in 2004, though the comparison is limited through the low number of observations and the fact that weights of green and dried chillies were not recorded separately. In the other crops, yields in organic farms were up to 13% lower, with the exception of maize and sorghum yields in 2004, which were higher than in conventional farms. Maize, sorghum and wheat not only yield grains, but their straw also serves as an important fodder for cattle. Straw yields and their values, however, were not measured in this study.

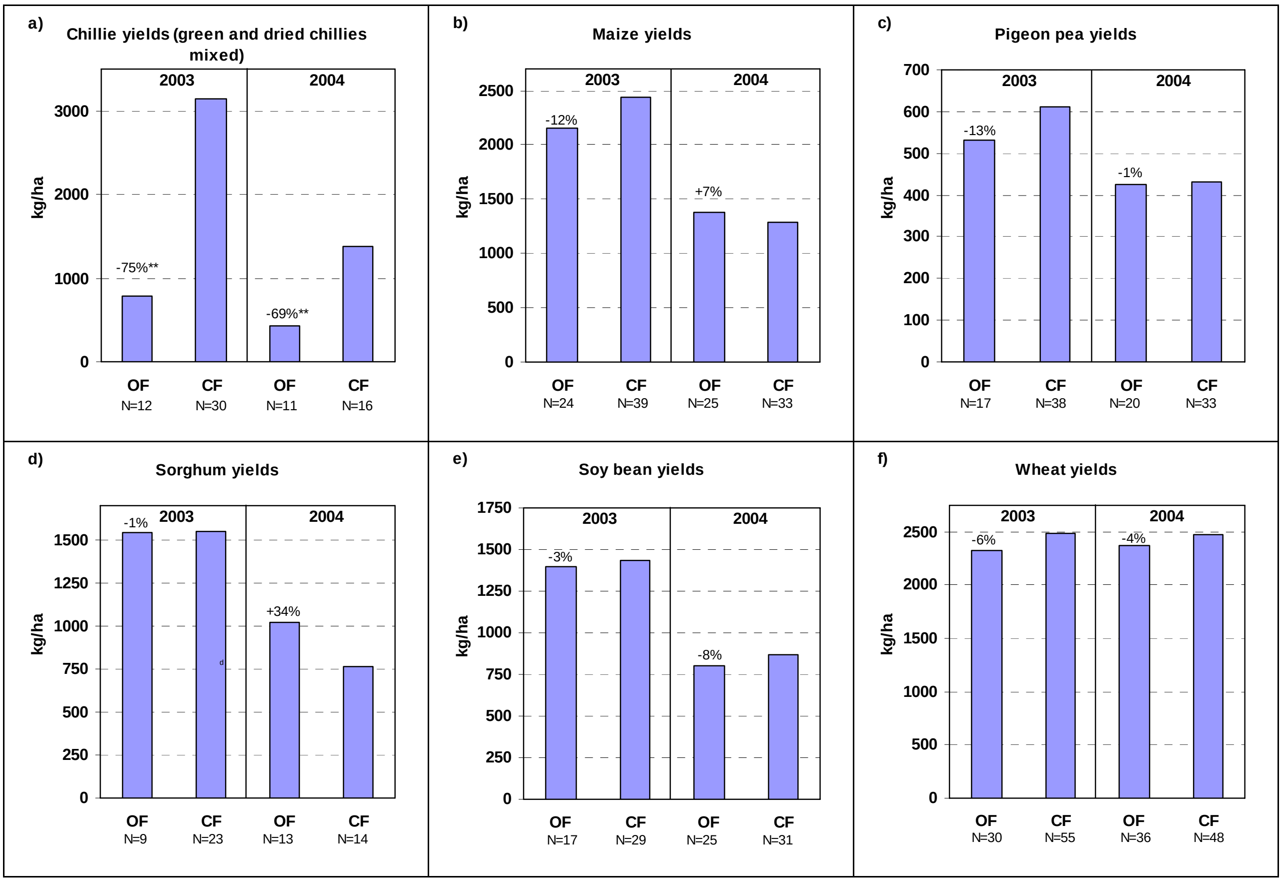


Figure 19: Yields of the main rotation crops grown along with cotton in organic farms (OF) and conventional farms (CF) in the samples 2003 and 2004. Figures above the bars indicate percentage deviation of the gross margins from means of conventional farms. Significant difference (T-test): * p ≤ 5%, ** p ≤ 10%.

In all crops and in both years, production costs of the rotation crops in organic farms were lower than in conventional farms (Figure 20). In most rotation crops, gross margins were up to 12% lower in organic farms. In chillies, gross margins were 57% lower in 2003 and the crop failed almost completely in 2004. In 2004, maize and sorghum in organic farms had 19% respectively 61% higher gross margins than in conventional farms.

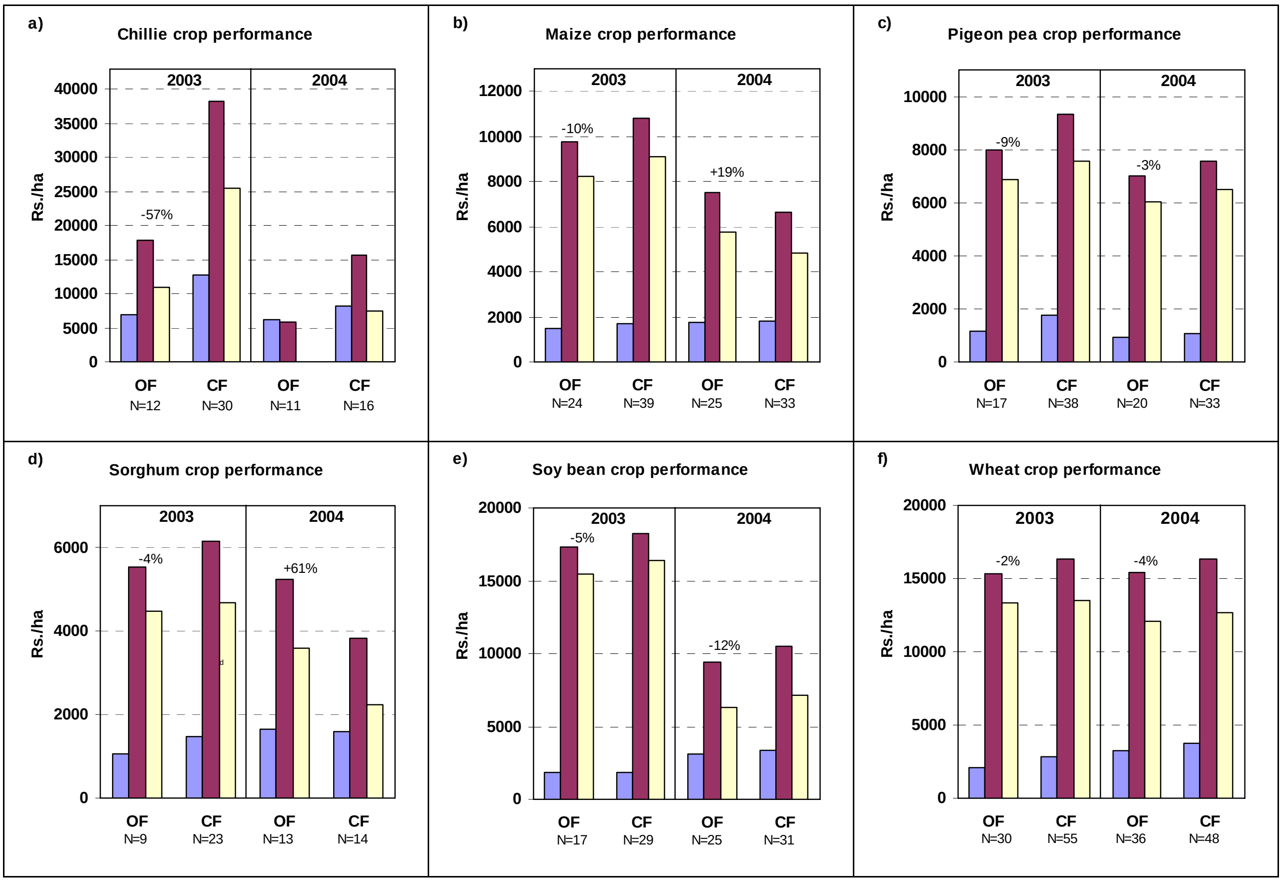


Figure 20: Economic performance of the main rotation crops grown along with cotton in organic farms (OF) and conventional farms (CF) in the samples 2003 and 2004. The bars indicate production costs (left bar, blue), crop revenues (central bar, purple) and gross margins excluding own labour costs (right bar, yellow). Figures above the bars indicate percentage deviation of the gross margins from means of conventional farms. Significant difference (T-test): * p ≤ 5%, ** p ≤ 10%.

With organic farms achieving higher gross margins in cotton but lower gross margins in most of the rotation crops, the question is whether the total farm economic performance is better or worse. To approach this question we calculated the total gross margins of the seven main crops of an average farm of 4.9 ha arable land, considering the shares of the respective crops. As cropping patterns slightly differ between organic and conventional farms (see Chapter 3.1.2), we calculated total gross margins of the 7 main crops as per the average crop shares in the respective farming system (Figure 21 a). Such a model organic farm would have achieved 12% higher gross margins in 2003 and 7% higher gross margins in 2004, compared to a conventional farm of the same size.

However, crop shares between organic and conventional farms do not differ substantially, and the crop shares seem to be rather determined by site and market conditions than by the farming system. Therefore, we also calculated the total gross margin of the seven major crops assuming same crop shares in both farming systems (Figure 21 b). With this assumption, total gross margins of the model organic farm were 14% higher in 2003 and 18% higher in 2004. These results verify our initial hypothesis[19] that cotton based organic farming is more profitable compared to conventional systems.

[19] Chapter 1.3, Hypothesis 4

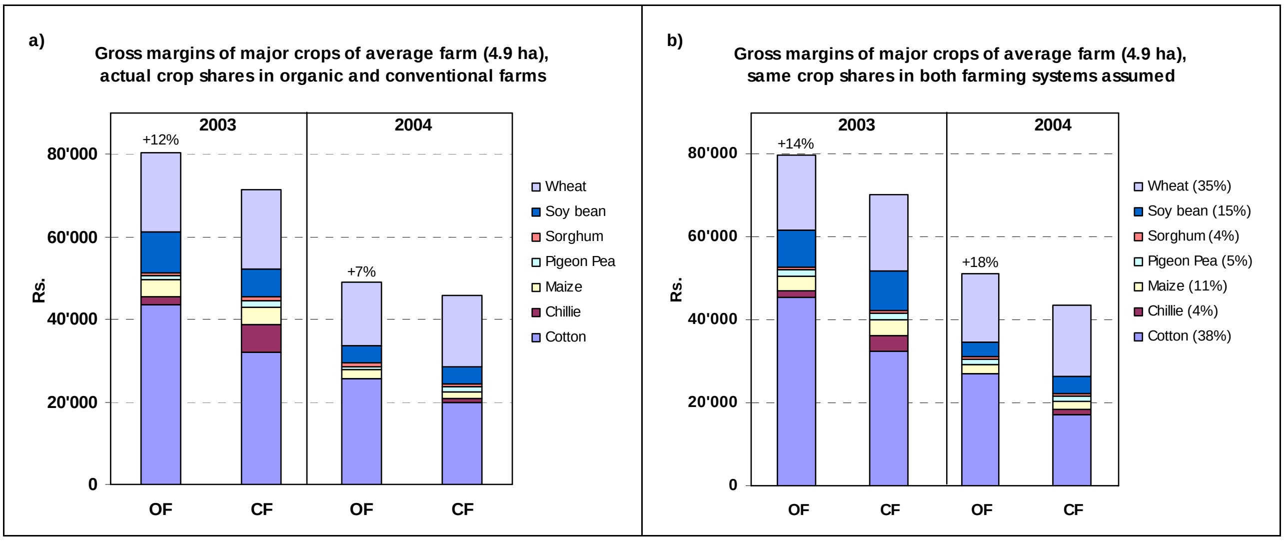


Figure 21: Gross margins of major crops of an average farm (4.9 ha land holding, 80% cultivated with the listed crops) in organic farming (OF) and conventional farming (CF) in the samples 2003 and 2004: (a) crop shares based on actual average shares in organic and conventional farms, (b) same average crop shares in organic and conventional farms assumed. Figures above the bars indicate percentage deviation from means of conventional farms. N in 2003: OF: 31, CF: 58; N in 2004: OF: 38, CF: 56.

Economic performance: Points for discussion

The results of the economic comparison of organic and conventional farms raise three immediate questions that will be discussed in Chapter 4.2:

1. How can organic farms produce yields that are on a par with those in conventional farms, with far less nutrient input and about the same labour input? (Chapter 4.2.1)
2. What are the implications of lower production costs, higher gross margins and mostly higher production efficiencies in organic cotton? (Chapter 4.2.2)
3. What is the economic impact of converting to organic management for the entire farm? (Chapter 4.2.3).

Related to the third question, two more aspects come up that deserve further reflection:

4. What is the risk involved in organic farming, and how does conversion change the vulnerability of farm households?
5. If organic cotton farming is more profitable, what are the factors hindering conversion, and how can they be overcome?

These aspects will be taken up in Chapter 4.5 and Chapter 4.6.

3.3 Soil properties

In this chapter we present the analysis results of the soil samples taken in the cotton fields of the monitored farms in 2003 and 2004. On the one hand, the soil parameters are site specific and influence the potential fertility and productivity of the respective field. This is especially true for the soil texture (particle size distribution). On the other hand, soil parameters are to some extent influenced by the agricultural management. Thus the soil analysis served two purposes: firstly to estimate the site specific influence on yields and agronomic performance, and secondly to assess the impact of different management systems on soil properties.

The change of the investigated soil parameters over the years is rather slow, and differences of means between the two years are small. The number of fields under organic respectively conventional management was similar in both years of investigation. Thus in the following chapters we analyze all soil samples taken in 2003 and 2004 together.

For each of the investigated soil parameters we indicate the share of fields allocated to a certain status regarding this parameter (first figure) as well as the means of the parameter (second figure). The allocation of parameter values to a specific status is described in Chapter 2.5.

3.3.1. Soil physical parameters

The soil type as defined by its texture (particle size distribution) is mainly site specific and is – except in the case of severe erosion – not much influenced by the farming system. However, it determines to a great deal other soil properties like structure, water retention capacity, organic matter content, and nutrient exchange capacity. Especially the finest soil particles, the clay fraction, play a central role in this. Organic matter content and water retention capacity, for example, are both correlated with the clay content (Figure 22).

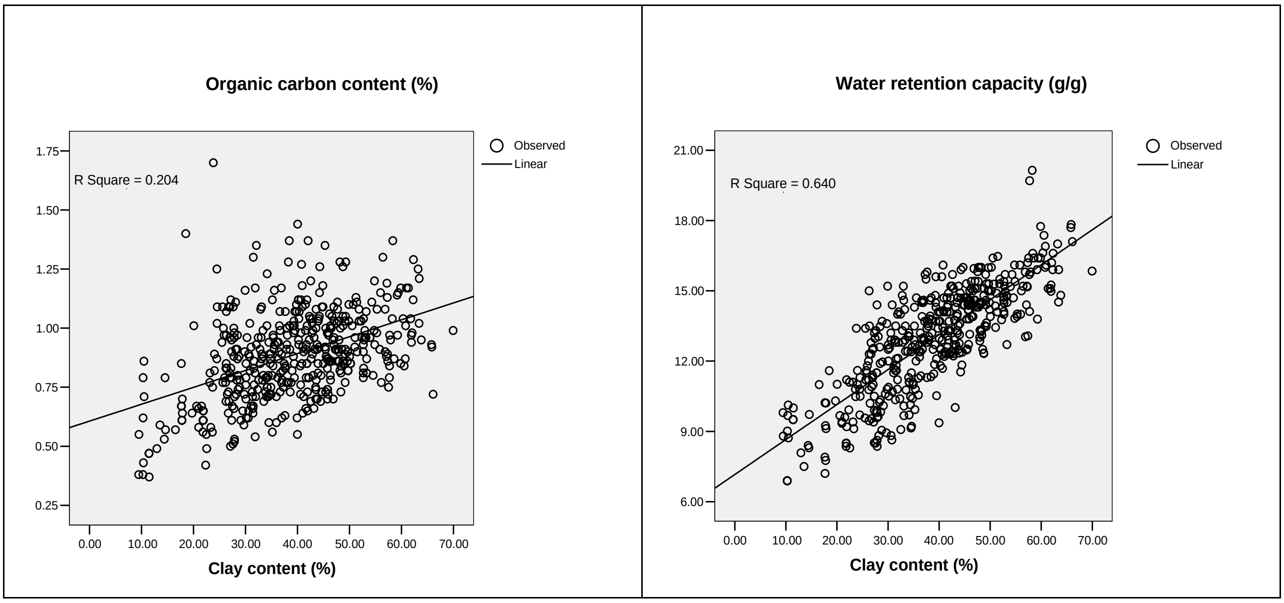


Figure 22: Correlations of clay content with (a) organic carbon content and (b) with water retention capacity in all cotton fields sampled in 2003 and 2004. Model fits (ANOVA) are highly significant ($p < 0.001$). N: OF: 121, CF: 204, DF: 102.

The distribution of soil types and average contents of sand, silt and clay are almost the same in the investigated organic and conventional cotton fields of the sample. In the sample of organic farms, 52.1% of the cotton fields belong to clay soils (clay content > 40%), while in the conventional farms their share is 50.5% (Figure 23 a). The average clay content in the organic cotton fields is 40.0%, which is 1.9% higher than in conventional cotton fields (Figure 23 b). Cotton fields of defaulted organic farms had a greater share of loamy soils, while their average particle size distribution was similar to those of organic and conventional farms.

The analysis of water retention capacity in the sampled fields does not provide a clear enough picture to corroborate our initial hypothesis that organic management in cotton farms leads to an increase in water retention capacity[20]. Though the share of fields classified as medium or high in water retention (above 13% respectively 15% water retention capacity) is slightly higher in organic farms, average water retention capacity is lower by 1.1%. As differences are small we can assume that water retention capacity is about the same in organic and conventional cotton fields.

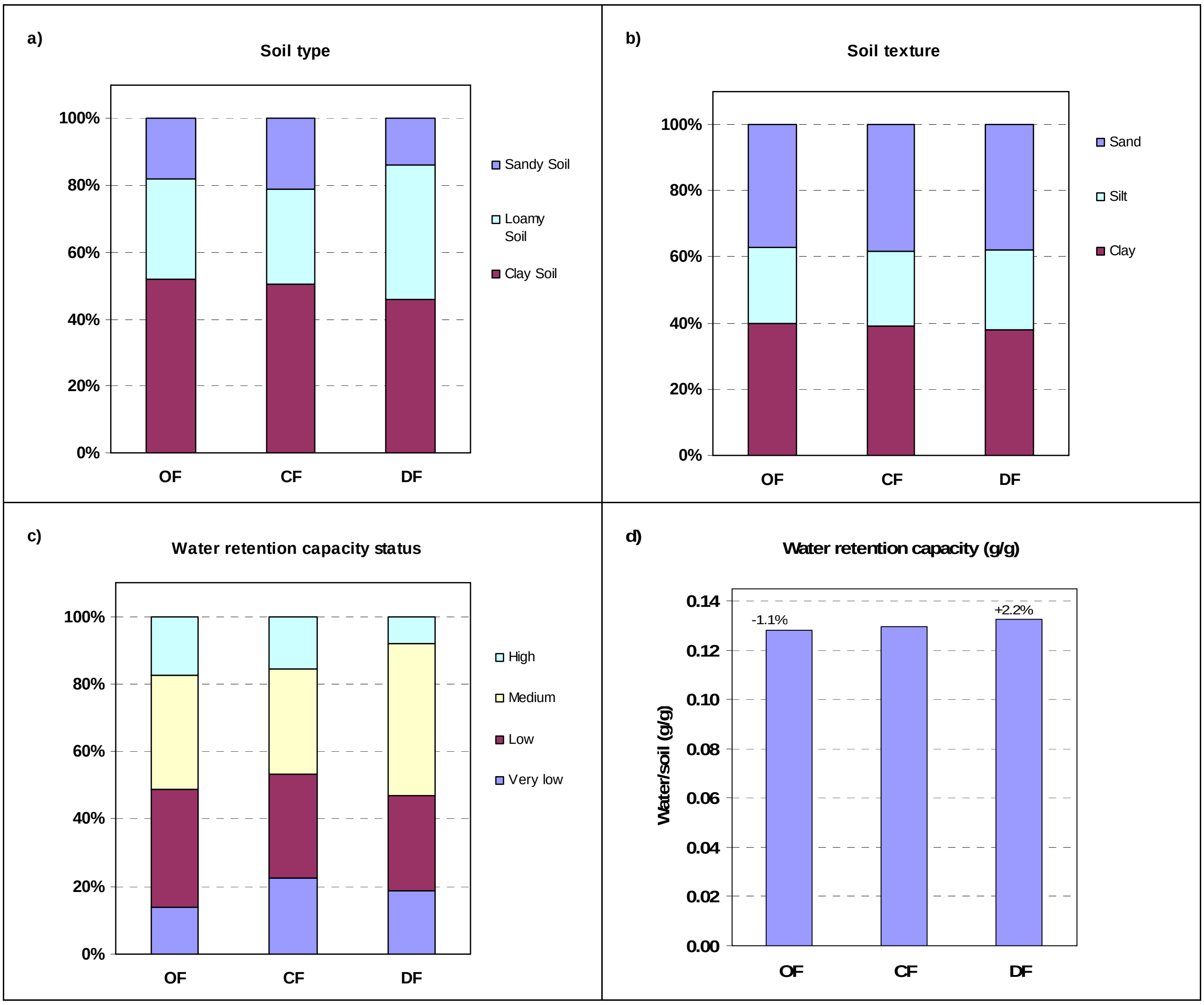


Figure 23: Soil texture and water retention in cotton fields of organic farms (OF), conventional farms (CF) and defaulted organic farms (DF) sampled in 2003 and 2004: (a) soil types (clay soil: > 40% clay, sandy soil: > 50% sand; loamy soil: in-between), (b) soil texture means, (c) water retention capacity status and (d) water retention capacity means. Figures above the bars indicate percentage deviation from means in conventional cotton fields. N: OF: 121, CF: 204, DF: 102. Significant difference (T-test): * p ≤ 5%, ** p ≤ 10%.

[20] Chapter 1.3, Hypothesis 5

3.3.2. Soil organic matter

The content of soil organic matter, measured as organic carbon (C_{org}), plays a central role in organic farming. Soil organic matter is an important parameter of overall soil fertility, as it positively influences soil structure, water holding, nutrient exchange, and microbial activity. Organic carbon contents in the investigated organic and conventional cotton fields are not significantly different. In organic cotton fields, the percentage of soils with organic carbon content of more than 1.2% (classified as high) is higher than in conventional cotton fields (9.9% compared to 3.4%) (Figure 24 a). The average organic carbon content in organic cotton fields is 0.90%, which is only 1.8% higher than in the conventional cotton fields (Figure 24 b).

As organic carbon content is correlated with the clay content, we calculated the ratio of organic carbon / clay content in order to estimate the change in organic matter due to soil management. Organic farms had less cotton fields with organic carbon / clay ratio < 0.02 (classified as low and very low), but also less fields with a ratio > 0.03 (classified as high), compared to conventional farms (Figure 24 c). The average ratio is 4.2% lower in organic cotton fields than in conventional cotton fields (Figure 24 d). However, the difference is not significant.

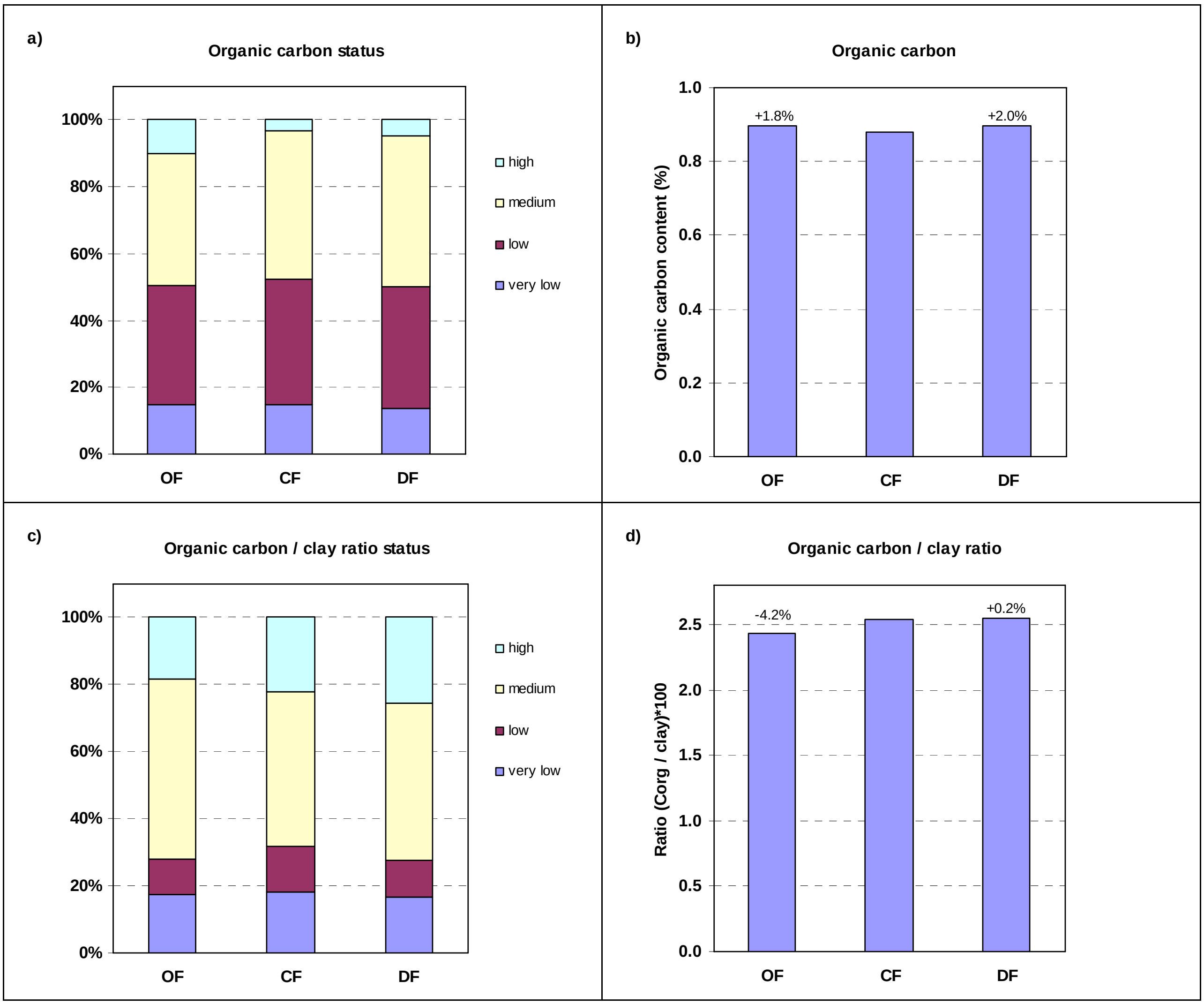


Figure 24: Organic carbon levels in cotton fields of organic farms (OF), conventional farms (CF) and defaulted organic farms (DF) sampled in 2003 and 2004: (a) organic carbon status and (b) means; (c) organic carbon to clay ratio status and (d) means. Figures above the bars indicate percentage deviation from means in conventional cotton fields. N: OF: 121, CF: 204, DF: 102. Significant difference (T-test): * $p \leq 5\%$, ** $p \leq 10\%$.

3.3.3. Soil nutrients

The shares of cotton fields with exchangeable phosphorus contents lower than 4 mg/kg (classified as deficient), and with contents higher than 15 mg/kg (classified as very high) are both lower in the investigated organic farms compared to conventional farms (Figure 25 a). Fields classified as slightly deficient are more frequent in organic farms. Average exchangeable phosphorus contents in organic cotton fields are 11.4% lower than in conventional fields (Figure 25 b).

The analysis of exchangeable potassium contents provides a similar picture: fields with contents less than 100 mg/kg (classified as deficient) are less frequent, but those with 100 – 150 mg/kg (classified as slightly deficient) are more frequent in organic farms compared to conventional farms (Figure 25 c). Average exchangeable potassium contents in organic cotton fields are 5.6% lower than in conventional cotton fields (Figure 25 d).

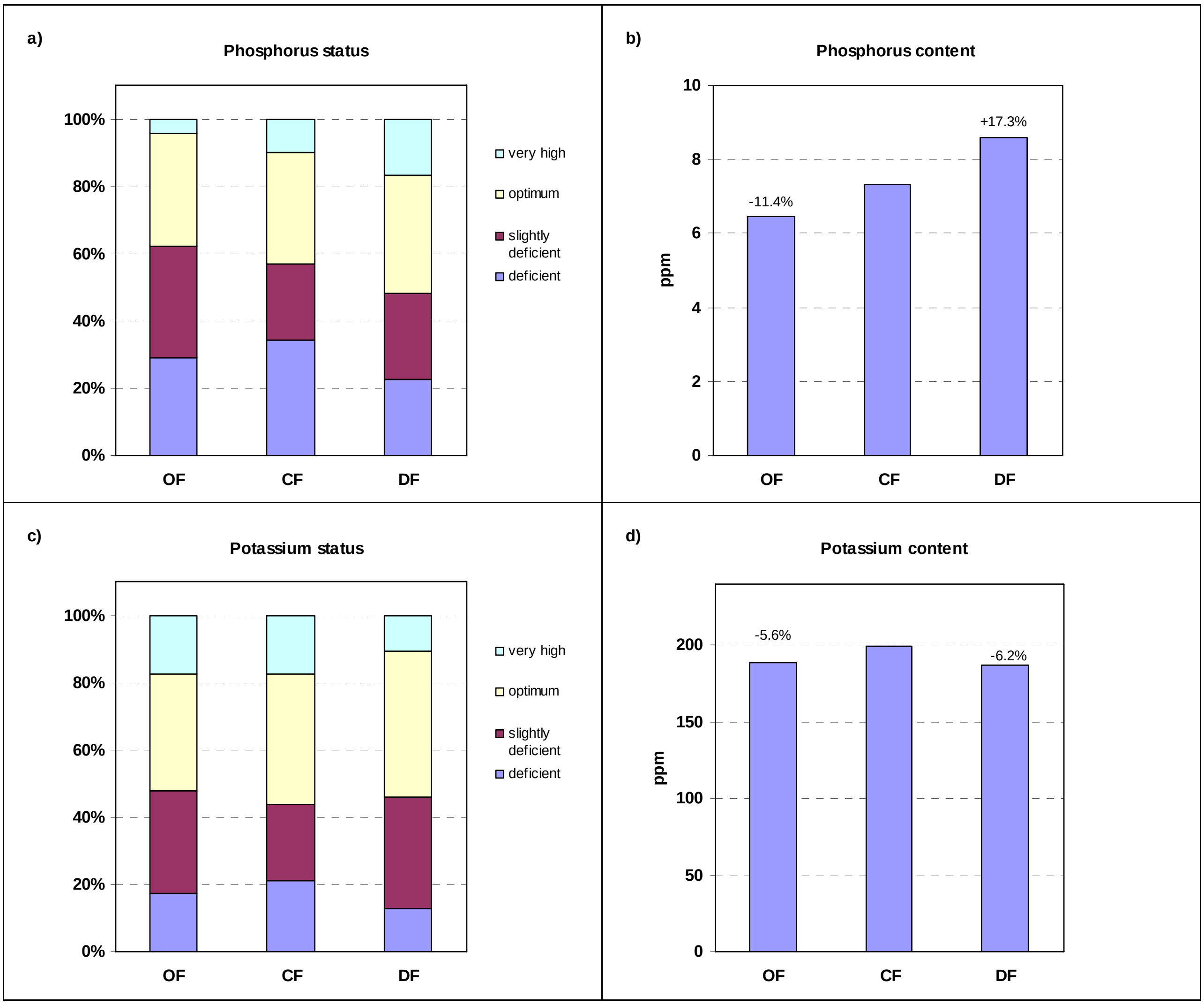


Figure 25: Available soil nutrients in organic farms (OF), conventional farms (CF) and defaulted organic farms (DF) in all cotton fields sampled in 2003 and 2004: (a) Phosphorus (Olsen-P) status and (b) means; (c) Potassium (exchangeable K) status and (d) means. Figures above the bars indicate percentage deviation from means in conventional cotton fields. N: OF: 121, CF: 204, DF: 102. Significant difference (T-test): * p ≤ 5%, ** p ≤ 10%.

Cotton is particularly sensitive to Zinc and Boron deficiency, and deficiencies of these nutrients are likely in the soils of the project region. The occurrence of Zinc deficiency and average contents of available Zinc are almost the same in organic and conventional cotton fields (Figure 26 a, b). Boron deficiency, however, is far less common in organic cotton fields, and average contents of available Boron are 17.3% higher compared to conventional cotton fields (Figure 26 c, d).

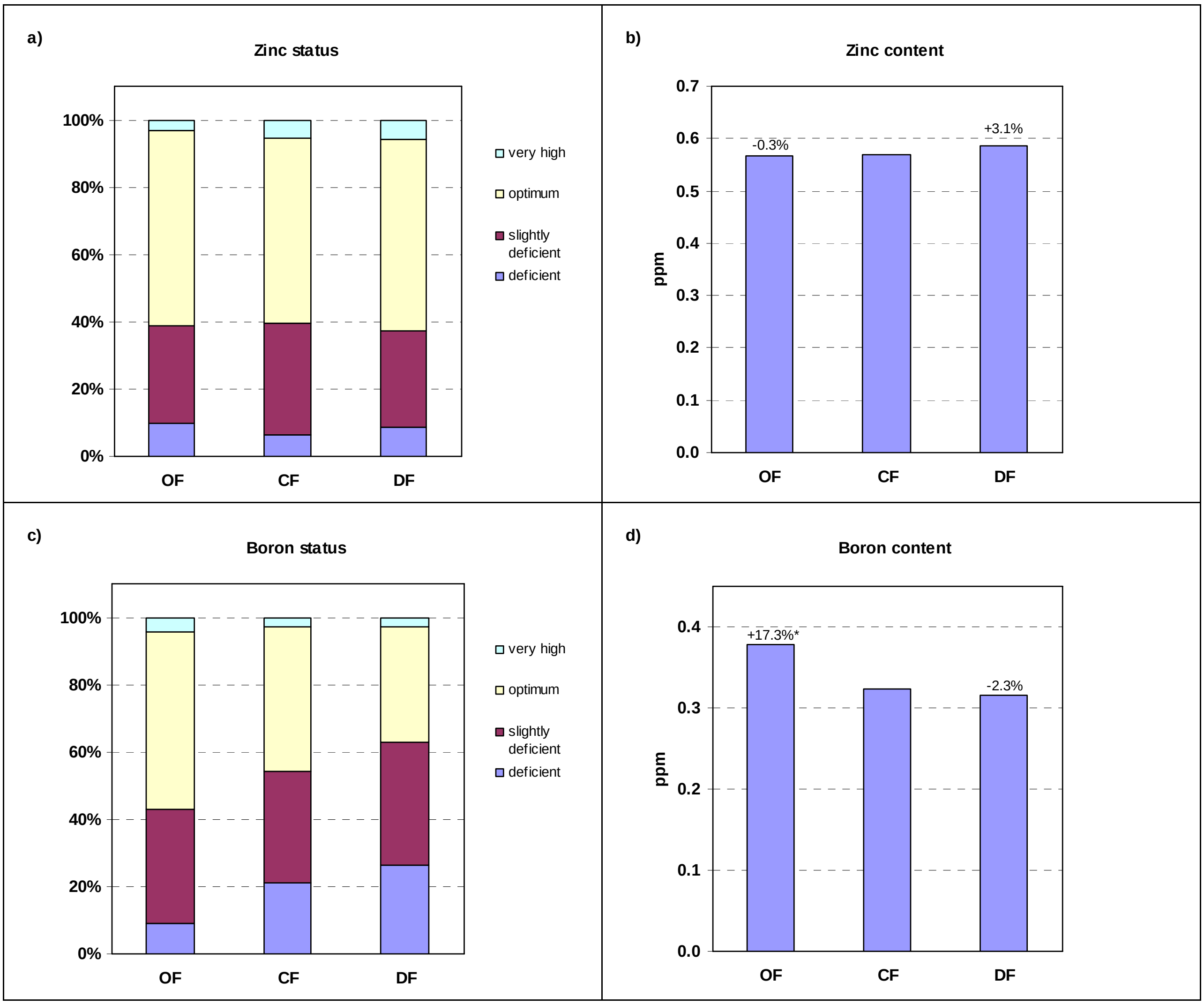


Figure 26: Available soil micro nutrients in organic farms (OF), conventional farms (CF) and defaulted organic farms (DF) in all cotton fields sampled in 2003 and 2004: (a) Zinc (exchangeable Zn) status and (b) means; (c) Boron (exchangeable B) status and (d) means. Figures above the bars indicate percentage deviation from means in conventional cotton fields. N: OF: 121, CF: 204, DF: 102. Significant difference (T-test): * $p \leq 5\%$, ** $p \leq 10\%$.

3.3.4. Soil salinity and pH

So far, soil salinity has not been a major problem in the project region. Only few fields presently show signs of salinity. Cotton fields with high salinity (electric conductivity > 0.6 dS/m) are less frequent in organic farms, and average salt contents are 10.3% lower compared to conventional farms (Figure 27 a, b).

Soils in the project region are all on the alkaline side and soil acidity is not a major problem. Average soil pH in organic cotton fields is 8.24, while in conventional cotton fields it is 8.09 (Figure 27 c). This difference is significant[21].

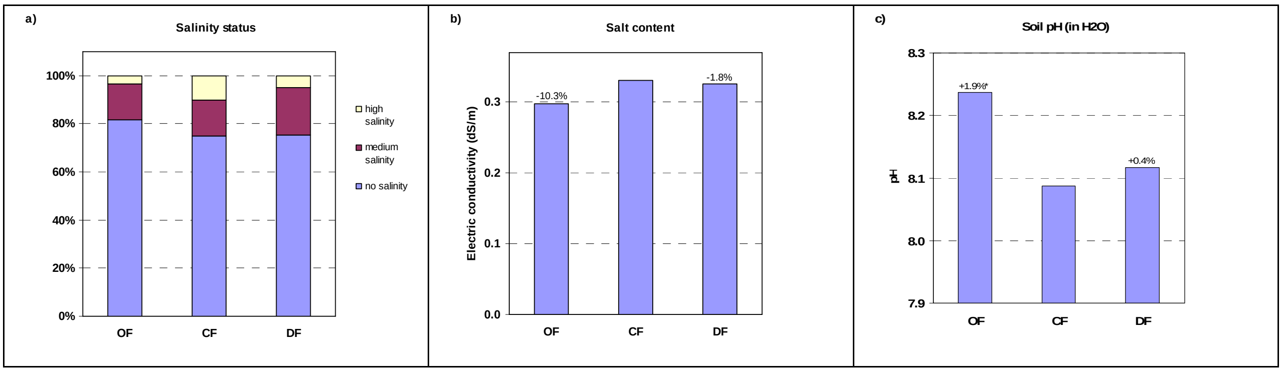


Figure 27: (a) Salinity status, (b) salt content via electric conductivity and (c) soil pH in organic farms (OF), conventional farms (CF) and defaulted organic farms (DF) in all cotton fields sampled in 2003 and 2004. Figures above the bars indicate percentage deviation from means in conventional cotton fields. N: OF: 121, CF: 204, DF: 102. Significant difference (T-test): * p ≤ 5%, ** p ≤ 10%.

Soil properties: Points for discussion

The results of the soil sample analysis are too heterogeneous to unambiguously verify our initial hypothesis that organic management in cotton farms improves overall soil fertility[22]. The question arises whether conversion to organic cotton farming actually leads to a more sustainable use of the natural resources water and soil. This question will be discussed in Chapter 4.3.

[21] As the pH is defined as the negative logarithm of the proton concentration, the difference of 1.9% in pH units is equivalent to 30% less acidity in organic fields.

[22] Chapter 1.3, Hypothesis 5

4. Discussion

4.1 Profiles of adopters

In this chapter we discuss the results of the analysis of socio-economic, agronomic and cotton production aspects of farm profiles that are presented in Chapter 3.1.

4.1.1. The role of early adopters

Organic farmers in the project region are of higher socio-economic status (see Chapter 3.1.1). As they are better-off also in rather robust parameters like education level of the farmer, caste affiliation and house type, we can assume that they have been wealthier than the average already before adopting organic farming. This indicates that wealthier farmers were either more responsive to organic farming promoted by Maikaal bioRe, or were given preference in the selection of farmers for the project. The latter possible explanation is unlikely, as Maikaal bioRe includes all farmers who meet their criteria concerning organic farming, irrespective of farm size, status or wealth. An analysis of the farms that have joined Maikaal bioRe since the beginning of the project in 1993 shows that average land holdings of new farmers decreased considerably over the years (see Annex 6.5). Thus it is likely that the higher socio-economic status of organic farmers is partly an effect of the higher status of early adopters that still can be seen in the data. This phenomenon of early adopters is well known in development theory (Rogers 1995), and we can safely assume that it also applies to a certain extent in the case of organic cotton farming.

What could be the reasons that – at least initially - wealthier farmers were more responsive to organic farming? One likely reason is that – thanks to better education - they are more aware of the possible benefits of converting to organic farming and are in a better position to acquire the necessary know-how and skills for producing organically. A second reason could be that farmers of higher social status (caste affiliation!) generally are more likely to be leaders in adopting innovations of any kind (e.g. the adoption of micro-irrigation technologies). Indeed, farmers whom we have interviewed in the region confirmed that the wealthier and socially better situated farmers adopt innovations first, while less privileged farmers wait and observe their neighbours, to adopt the innovation only once the success of the early adopters proofs their advantage.

The probably most important reason, however, is that adoption of organic farming requires certain investment to compensate income loss during the conversion period, during which yields are usually lower and additional efforts are required to build up soil fertility, while the organic price premium is lower in the first two years. It is likely that farmers of higher socio-economic status are in a better position to bear this investment, along with the risk that the expected benefits can not be realized. An additional advantage of the early adopters in the project might be that they depend to a lesser extent on their crop sales, as off-farm incomes and income from milk sales are higher.

On the other side there are a number of very poor farmers in the project who converted to organic farming. Interviews of these farmers showed that most of them were heavily indebted and deprived of most resources when they decided to join the Maikaal bioRe project. To them, adoption of organic farming was an option to get out of the hideous cycle of indebtedness, as organic farming involves less production costs and allows substituting off-farm inputs through man power (e.g. compost preparation instead of using synthetic fertilizers).

On an average, farmers who joined the organic project avail of more farm own agricultural labour and have higher cattle stocking rates compared to conventional farms (see Chapter 3.1.2). As the conversion to organic farming is likely to increase the work load at least during the initial years (for compost preparation, improved management of the dung, home preparation of pest management items, maintenance of inspection documents etc.), higher labour availability might have facilitated conversion. Cattle dung plays a far more important role in organic production systems than in conventional farming. Thus, high stocking rates could be another factor conducive to conversion. Several conventional farmers whom we asked in interviews for their reasons not to convert to organic farming stated that they do not have sufficient cattle to produce the required amount of farmyard manure. However, it is also possible that the higher stocking rates are an effect rather than a cause of adoption, i.e. that organic farmers keep additional cattle.

4.1.2. Changes in the farm profile due to organic farming

As mentioned earlier, it is difficult to separate between cause and effect when it comes to explaining higher socio-economic status figures of organic farms. As gross margins are considerably higher in organic farms (see Chapter 3.2.4), it is likely that the better economic performance leads to an improved socio-economic status, possibly reflected in higher equipment value, cattle stocking rates, wealth status and off-farm income. Indeed, many organic farmers stated in interviews that they use the additional income gained through organic farming for purchasing cattle or land, or for developing off-farm income opportunities (e.g. shops or tailoring businesses). In the words of an organic farmer who joined the project in 2000: "Organic farming bought me this herd of milk buffaloes. They provide me additional income and help me to improve the fertility of my land year by year." That his latter statement holds true is supported by the positive correlation of organic manure inputs with cotton yields (see Chapter 3.2.2).

As the lack of irrigation is a major constraint to many farmers for increasing the productivity of their land, one of the first choices for investment is to build irrigation facilities, including micro-irrigation systems. The availability of more income thus could enable organic farmers to re-invest into agriculture (in irrigation, but also in land and in cattle) and thus could eventually contribute to increased production. However, to validate this hypothesis, analysis of investment behaviour and development of farm productivity over a longer period of time would be required.

The different crop shares in organic farms (see Chapters 3.1.2 and 3.1.3) are likely to be at least to a certain extent a result of the conversion to organic farming. Maintaining a diverse crop rotation involving legumes (e.g. soy bean), and growing intercrops or trap crops are integral parts of organic production systems. Maikaal bioRe enforces that cotton is not grown in the same field in two consecutive years unless an intercrop is grown. On the other side, many organic farmers seem to abandon chilli cultivation due to low productivity[23].

The lower share of wheat grown in organic cotton fields in the Rabi season could be partly due to the organic price premium being paid solely for cotton. Part of the slightly higher cotton yields in organic farms is therefore likely to stem from this shift. To a certain extent the cotton price premium could constitute an incentive to farmers for keeping more land under cotton rather than cultivating rotation crops, which is adverse to the principles of organic agriculture. This emphasizes the need to access organic markets also with other rotation crops.

The distinct preference of organic farmers in the selection of cotton varieties is probably due to the fact that Maikaal bioRe provides untreated seeds[24] of some varieties that are suitable for organic farming at slightly subsidised rates. While this does not have a significant impact on input costs, it is likely to influence farmer's decision on which varieties to chose. Since 2004, an important reason for different variety selection is the widespread use of Bt-cotton varieties in conventional farms, which is not permitted in organic farming.

4.2 Economic impact of organic farming

This chapter discusses the results of the productivity and of the economic analysis of organic cotton farming, including the performance of the main rotation crops, as presented in Chapter 3.2.

4.2.1. The productivity of organic cotton production

One of the characteristics of organic farming is that off-farm inputs (fertilizers and pesticides) are substituted by management practices (e.g. intercropping, crop rotation) and inputs produced on the farm (e.g. compost, botanical pesticides). Thus it would be logic to expect higher labour inputs in organic farms, especially due to the more laborious preparation and application of organic manures. Many case studies indeed report higher labour requirement in organic farming (Giovannucci 2005). Average labour inputs in the monitored organic cotton fields, however, were not significantly higher than in conventional fields (Chapter 3.2.1). It must be admitted that so far

---

[23] The reasons for low chilli yields in many organic farms are most likely insufficient nutrient supply and problems in preventing or controlling spider mites and aphids.

[24] In organic farming, the treatment of seeds with chemical pesticides or fungicides is not permitted.

compost production in the monitored organic farms has not been very prevalent: only few were following the recommended procedures for setting up and maintaining compost heaps, while the majority just pile up the available dung without turning the heaps or controlling moisture. If practices of managing farmyard manure would improve, labour requirements could increase to an extent in the range of 3-5 work days per ha. Even with this increase, labour required for the preparation and application of manures would still only account for ca. 3-4% of the total labour input, while the majority of the work involved in cotton production still would be for intercultural operations, irrigation and harvesting. An earlier study on the Maikaal project showed that in these activities there are no differences in labour input between organic and conventional farms (Schumacher 2004). The labour required for picking the cotton is closely correlated with cotton yields.

It is surprising that own labour inputs in cotton cultivation are lower in organic farms, although the availability of own labour per ha farm land is higher (see Chapter 3.1.2). It might be that organic farms rather utilize farm own labour for activities not related to cotton, e.g. for animal husbandry or for other crops. Proofing this would require additional investigation.

Lower nutrient application levels are typical for organic farming systems (Parrott and Marsden 2002), and the results of the monitored cotton fields are in line with this general characteristic. Application of nitrogen and phosphorus is considerably lower in the researched organic farms, despite that conventional farmers in the region have also reduced fertilizer application compared to what they used to apply a decade ago[25]. The fact that average nitrogen input from organic manures is almost double in organic cotton fields shows that organic farmers not only discontinue the application of synthetic fertilizers, but that they take extra efforts to produce or purchase more organic manure. However, they only substitute synthetic fertilizers with organic manures to an extent that they reach about half the nutrient input as in conventional cotton production.

It is a striking result that cotton yields in organic farms are not lower. On the contrary: average cotton yields in the monitored farms were even 4-6% higher than those in conventional farms. This result is surprising especially when considering the fact that organic farms achieve these yields with about half the amount of nitrogen and phosphorus applied to the crop. According to the study conducted by IWMI in 2003 in the project region, cotton yields in organic farms were 2.2% higher than in conventional farms (Shah, Verma et al. 2005). Although these figures are based on recall data stated by the farmers in interviews, they are in line with the findings of this study.

Subsequently we discuss possible reasons to explain this positive performance of organic cotton production. We distinguish between reasons that inherently belong to the organic production system (Table 6), and reasons that are not directly related with organic farming (Table 7). For each possible reason we provide general cause and effect lines, evidence from the research data and statements of interviewed farmers that support the argumentation.

---

[25] Source: interviews with farmers and statements of extension workers.

Possible reasons related to the organic production system
Better soil fertility
Possible cause and effects: Higher application of organic manures improves soil organic matter content, soil structure, microbial activity and nutrient exchange capacity. ***Evidence from the data:*** Application of organic manures is almost double in organic cotton fields. Organic carbon content (C_{org}) has a strong positive influence on cotton yields in the regression model. However, C_{org} is only 1.8% higher than in conventional cotton fields (not significant). Soil structure parameters and microbial activity were not measured. ***Statements of farmers:*** Many conventional farmers in the project region report that they observed a decline in soil fertility over the past one to two decades. They relate this trend to the negative impact of chemical fertilizers on overall soil fertility. On the other hand, most organic farmers claim that thanks to the increased application of organic manures the fertility of their soils has improved after the conversion to organic farming (better soil structure, easier ploughing, less crack formation).
Improved nutrient management
Possible cause and effects: Compared to synthetic fertilizers, nutrients applied through organic manures are less prone to leaching. Timing of application is less critical, as organic manures release nutrients over a longer period of time. Organic manures contain all macro- and micro-nutrients in balanced composition. ***Evidence from the data:*** Application of nitrogen through organic manures and nitrogen use efficiency are about double in organic cotton fields. Boron contents in organic soils are higher and Boron deficiency is less frequent. ***Statements of farmers:*** Organic farmers in the project confirmed that the effect of organic manure lasts longer. Many apply farmyard manure only every second year to the field. Many conventional farmers stated that they need to increase fertilizer application year by year in order to maintain yields.
Better crop rotation
Possible cause and effects: Better crop rotation with higher shares of leguminous crops and more intercropping have a beneficial impact on cotton yields. ***Evidence from the data:*** Though cropping patterns do not differ much, organic farmers do grow more soy bean, practise more intercropping and grow less cotton immediately after cotton in the same field. ***Statements of farmers:*** Farmers claim that cotton grows particularly well after chillies, soy bean and wheat.
Improved water household
Possible cause and effects: Due to better soil structure and higher organic matter content, organically managed fields have better infiltration of rain or irrigation water, better retention of soil moisture, and less risk of water logging. Lower nitrogen application results in less vegetative growth, lowering the water requirement of the crop and making it less susceptible to short periods of drought. ***Evidence from the data:*** As water retention capacity in organic cotton fields is not higher, but irrigation water application is 17% higher, this possible reason is not supported by the research data. Possibly, water infiltration and retention would be different in undisturbed soil samples. Due to practical reasons, water retention was measured in sieved soil samples. ***Statements of farmers:*** Many organic farmers claim that after some years of organic management their soils keep moisture better and water logging occurs less. As the crop sustains short periods of drought better, they need less irrigation rounds.
Better crop health
Possible cause and effects: Lower nitrogen application makes the crop less attractive to sucking pests. The absence of chemical pesticide sprays in organic farms augments populations of natural predators to pests. More balanced nutrition improves general crop health and resistance. ***Evidence from the data:*** Plant health and pest incidence were not assessed. ***Statements of farmers:*** Farmers in the region observed that urea application attracts more sucking pests (white fly and aphids).

Table 6: Possible reasons for higher yields in organic cotton fields that are related to the organic production system.

Possible reasons not related to the organic production system
Organic farmers posses better land
Possible cause and effects: The higher share of wealthier farmers could go hand in hand with better land quality (more heavy soils) and thus automatically result in better yields of organic cotton fields. ***Evidence from the data:*** The distribution of soil types among organic and conventional farms is almost the same. The effect of clay content (the most relevant parameter concerning soil type) on yields is not significant in the regression model.
Organic farmers have better access to irrigation
Possible cause and effects: Better socio-economic status of organic farmers could enable them to have better access to irrigation (sources, equipment, and electricity). ***Evidence from the data:*** Irrigation water application in organic cotton fields is indeed 17% higher than in conventional fields. In the linear regression model that includes irrigation quantity, corrected yields in organic cotton fields are still higher. Thus, better access to irrigation does not fully explain the better performance of organic cotton fields.
Trade-off between cotton and wheat
Possible cause and effects: Due to the price premium for organic cotton, organic farmers prefer to continue the cotton crop in the winter (Rabi) season instead of cultivating wheat. ***Evidence from the data:*** Shares of wheat in organic cotton fields are indeed considerably lower than in conventional fields. However, yields of cotton are not systematically lower in fields where wheat is grown in the Rabi season. The influence of wheat shares on cotton yields is not significant in the regression model.
Effect of uneven sample size in different locations
Possible cause and effects: If site conditions (e.g. rainfall, availability of irrigation water) have an important effect on crop yields, a larger share of organic farms in favoured villages could distort the result. ***Evidence from the data:*** The share of organic cotton fields in villages with high yields is slightly lower than that of conventional fields. The effect of total rainfall on cotton yields is not significant in the regression model.

Table 7: Possible reasons for higher yields in organic cotton fields that are not related to the organic production system.

The discussion above supports the conclusion that the positive performance of organic cotton fields in the sample is indeed due to organic management rather than to effects not related to the farming system, such as site conditions or access to irrigation. It shows that organic farms, after having completed the conversion period, are able to produce similar and in some cases even higher cotton yields with considerably less nutrient input. This result is not in contradiction with the few available data on crop yields of organic smallholder farms in tropical countries. In a review of the status of organic farming in the South, Parrott & Marsden list a number of case studies where yields have increased due to the conversion and conclude that organic farming in the South is neutral in terms of yields (Parrott and Marsden 2002). A thematic evaluation on the potential of organic agriculture for poverty reduction in Asia implemented by the International Fund for Agricultural Development (IFAD) arrives at the same conclusion (Giovannucci 2005). However, both documents are based on reports of case studies and lack of in-depth research data.

It is not surprising that yields of defaulted organic farmers (i.e. farmers who had applied synthetic pesticides, fertilizers or had used Bt-cotton seeds) are slightly higher than those of their colleagues who strictly adhered to organic standards. However, it is a striking result that defaulted organic farms on an average also achieved 10% higher yields than conventional farms. One plausible explanation could be that the use of chemical fertilizers, in combination with larger quantities of organic manures than the average organic farmer applies, may result in temporarily higher yields due to accelerated decomposition of organic matter. More likely is that the considerably higher wealth status of defaulted organic farms (and thus the access to better land and irrigation) had a strong influence on the positive performance.

It is surprising that yields in organic cotton farms were highest in sandy soils, which usually are less fertile for cotton production due to their shallowness and low water retention. In 2003, yields were also high in heavy clay soils. In conventional cotton fields, yields were higher in medium soil types. Could it thus be that organic farming has a comparative advantage especially on extreme soils? A possible explanation could be that the fertility of sandy and heavy clay soils strongly depends on soil organic matter, for water retention and nutrient exchange in the case of sandy soils and for infiltration and soil structure in the case of heavy clay soils, while medium soil types respond better to the application of synthetic fertilizers. Further research would be needed to test this vague hypothesis.

Possible measures to increase cotton yields

The analysis of parameters influencing cotton yields, especially in the regression models (Chapter 3.2.2), enables us identifying fields for further improvement of cotton productivity:

- The duration of the cotton crop has a strong positive influence on cotton yields. Early sowing, if possible before the onset of the monsoon with the help of irrigation, allows inducing a second flush and harvesting the cotton over a longer period of time.
- The data show that increased application of organic manures has a positive effect on cotton yields. On an average, as per the regression analysis, an additional input of 1 kg nitrogen through organic manures (equivalent to ca. 100 kg FYM, or 20 kg DOC) increases cotton yields by 1.8 – 7.9 kg/ha. In addition, it can contribute to augmenting soil organic matter contents.
- Soil organic matter content has a strong positive influence on cotton yields. In average soil conditions, if farmers manage to increase soil organic carbon by 10% (i.e. from 0.9% to 1% C_{org}), cotton yields could increase by 50 – 167 kg/ha. Measures to increase organic matter in the soil are thus likely to pay off.
- Increased application of irrigation water does not necessarily increase cotton yields. The low correlation of cotton yields with irrigation water quantities could indicate that the applied quantities, or the timing of irrigation, not always suit the requirements of the cotton crop. The high susceptibility of cotton to water logging could be a reason for this.

4.2.2. Economic performance of organic cotton

Production costs

Considering the lower fertilizer inputs and similar labour inputs it is not surprising that total variable production costs in organic cotton cultivation are 13 – 20% lower than in conventional farming (see Chapter 3.2.3). In addition, organic farms spend considerably less on pest management. Costs for machine rent, irrigation and fuel, summarized as ‘other costs’ do not appear to be specific to the farming system, and they only account for 5 – 10% of total variable production costs.

The fact that input costs for seeds, fertilizers and pest management items are about 40% lower in organic cotton farming has important implications on the financial liquidity of the farms. While costs for harvesting are due shortly before the respective cotton lot is sold, inputs need to be paid already before or at the beginning of the crop season. For this, most conventional farms need to take up credits at interest rates between 14% (government cooperatives) to over 30% (private money lenders). The requirement for taking up credits is far less in organic farming, as interviewed farmers confirm. An additional benefit for farmers associated with Maikaal bioRe is that they can get part of the price premium from the previous season in the kind of farm inputs (DOC, rock phosphate, Neem extracts, Bt-preparations). Thus they do not need to pay interests on loans (see discussion of risk aspects in Chapter 4.5).

While in conventional farming expenses for fertilizers and pesticides end up in the chemical industry, commercial inputs into organic cotton cultivation such as oil cakes, composts, sugar cane press mud or neem seed extracts originate from the agricultural sector itself. Therefore, these expenses may contribute to income generation in rural areas.

The results emphasize the importance of labour costs in cotton cultivation. On the one hand, the labour intensive production techniques with mostly manual labour create important employment opportunities and keep capital requirements for machinery low. On the other hand, there is only limited scope for further reducing production costs in organic cotton farming without substantially increasing labour efficiency.

In interviews, organic as well as conventional farmers named lower production costs as an important advantage of organic farming. In a study conducted in the project region by the International Water Management Institute lower production cost even was the most frequently named motivation for adopting organic farming (Shah, Verma et al. 2005). However, few farmers were able to tell their actual cost of production. Increasing farmers' awareness for the relevance of production costs, possibly through introducing simple record keeping of inputs and outputs, could help optimize the production system with regard to production costs.

Revenues and gross margins

The data on cotton revenues (Chapter 3.2.4) highlight the importance of the highly variable cotton selling prices. A first factor that determines the price the farmer gets for a certain lot of seed cotton is the quality of the harvest, especially fibre length (depending on the cotton variety, growing conditions and harvest time) and the degree of contamination with foreign matter. With optimized quality management farmers can improve their cotton revenues by up to 10%. More relevant for cotton rates, however, are general market price fluctuations. Within one cropping season rates can fluctuate substantially, opening up opportunities for gains - or losses! - through speculative withhold of cotton lots. The strong decline of farm gross margins in 2004 compared to the previous year, which is to a large extent due to the 26% drop of average cotton rates, shows how vulnerable farmers are to cotton market rate fluctuations.

Though average yields of intercrops were low, some farmers achieved revenues from intercropped moong bean or pigeon pea of 1700 to 2200 Rs./ha, while cotton yields were still above the average. Optimizing the use of intercrops could thus be a promising option for directly increasing revenues, besides the positive impact on soil fertility and their use as trap crop.

The lower shares of wheat grown in the Rabi season in organic fields might indicate a trade-off between wheat and cotton in organic farms. As organic farmers so far received a price premium only for cotton, they possibly prefer to continue the cotton crop rather than uprooting it for growing wheat. This incentive to focus on cotton could narrow crop rotations, which is against the objectives of organic farming. The same incentive might work in the overall crop rotation in the farm. If farmers received a price premium also for the rotation crops, rotation patterns in organic farms might be more diverse than in conventional farms.

In 2003, average gross margins from cotton fields (including the wheat crop in the winter season) were 43% higher in organic farming. Organic cotton farming performed 30% better even in 2004, despite significantly lower cotton rates – and thus total price premiums. As cotton is the most important cash earner for the majority of farms in the region, the better performance of organic cotton farming has a considerable impact on farmers' overall economic condition (see Chapter 4.2.3).

It is a surprising result that, at least in the two cropping periods covered by the data collection, organic cotton farming would have achieved slightly higher gross margins even without price premium. This observation could mislead to the conclusion that the price premium in organic farming is unnecessary, even setting wrong incentives as in the case of narrowing crop rotations discussed above. However, one should keep several points in mind in this regard: Firstly, this only applies for the cotton crop, where yields were slightly higher in organic farms, while yields of the rotation crops were usually lower. Thus the price premium helps to ensure that the overall performance of the farm is better under organic management. Secondly, these results are achieved by farms practising organic farming for more than 4 years. During the conversion period yields are likely to be considerably lower, and expenses might be higher. Therefore, the price premium partly needs to compensate for the costs of conversion. Thirdly, farmers take extra efforts and create added value (a product with low pesticide residues, and environmental benefits). This is remunerated by the price premium.

4.2.3. Economic impact on the entire farm

Though cotton is the most important cash crop in most farms of the project region, it only accounts for approx. half the income from crop production (3.2.6). Wheat and soy bean, and in some cases chillies and sugar cane, significantly contribute to cash income, too. Maize, sorghum, pigeon pea and other pulses are less important for farm income, though their relevance for subsistence consumption should not be underestimated. In addition, straw and stalks of Maize and sorghum are important cattle fodder.

The data indicate that organic farmers in the Maikaal project have managed to design their cotton production system in a way that they achieve the same or even higher yields than their conventional colleagues. This is not so in the rotation crops. While sophisticated measures for optimized nutrient and pest management have been developed in cotton, organic practices in the rotation crops are mainly confined to skipping synthetic fertilizers and pesticides. Development of suitable organic production methods for the rotation crops could thus help to further improve the performance of organic farms. This is especially needed in the case of chillies, where nutrient management and the control of diseases still constitute major challenges to most organic farmers. Some organic farmers, however, seem to have developed appropriate management practices in chilli production, enabling them to achieve similar gross margins as in conventional farms. It might be worth investigating in these practices and developing the production techniques further through on-farm research.

Gross margins of the rotation crops are lower in organic farms due to lower yields and the absence of price premiums. The scope for further reducing production costs in the rotation crops is low – their production does not involve much off-farm inputs even in conventional farms. However, it might be possible to gain access to organic markets where some of the food crops could be sold with an organic price premium. If, for example, organic farmers could sell their wheat and soy beans with a 20% price premium, average farm gross margins from crop husbandry would increase by 8 – 10%. Organic soy beans and chillies could find buyers in the export market, though quality specifications need to be taken into consideration. In India, demand for organic food products like wheat and pulses also emerges in the domestic market. This market segment is still in its infant stage, but the potential is promising (Garibay and Katke 2003). Nevertheless, even with the constraints in the rotation crops mentioned above, an average farm in the project region achieves 7 – 18% higher gross margins from organic crop husbandry than in the conventional prevailing system.

Average income from animal husbandry is higher in organic farms, too, as the higher incomes from sales of cow and buffalo milk show (Figure 6 d). The higher off-farm incomes of organic farms can only partly be attributed to the farming system: though better incomes from organic farming may well contribute to opening up new off-farm income opportunities (e.g. through opening a shop or workshop, or through better access to education), it is more likely that the organic farms in the sample already had higher off-farm incomes before converting to organic farming. Still, organic farming in the study region has a definitely positive impact on farm incomes.

Organic farmers have several options to further improve the profitability of cotton based farming. In the previous chapter we already discussed some suggestions for improving cotton yields. Further guidelines on improved management practices in cotton are available in the Organic Cotton Crop Guide developed within this research project (Eyhorn, Ratter et al. 2005). Many of these recommendations also apply for the rotation crops. In addition, advice can be sought from crop specific manuals on organic farming[26]. The largest potential for further reducing production costs in organic farming lies in replacing off-farm organic manures through compost. The scope for increasing labour efficiency is probably rather limited as long as labour is too cheap to justify investments on labour saving equipment. To a certain extent farmers can increase revenues in cotton and chillies through improved quality management. Selection of suitable varieties and timely nutrient and pest management are important factors in this. The biggest scope for improving profitability, however, probably lies in an improved performance of the rotation crops and in their marketing with an organic price premium.

---

[26] see www.ifoam.org and www.naturland.de

When comparing the profitability of organic and conventional farms we should keep in mind that we did not take into consideration the costs of conversion to organic farming, i.e. the extra investments of time and money and the potential loss of yields and thus income during the conversion period. This aspect is discussed in Chapter 4.6.

4.3 Natural resource use

The focus of this research was on the economic impact of organic cotton cultivation on farm households. The adverse affects of synthetic fertilizers and chemical pesticides on human health, water quality, soil life and biodiversity are already well documented (Ton 2002; Parrott and Marsden 2002). The positive impacts of organic cotton cultivation on freshwater resources and ecosystems have been studied in a number of case studies (Myers and Stolton 1998; Schwank, North et al. 2001). Therefore, the research did not concentrate on the environmental impacts of organic cotton cultivation. Nevertheless, to a limited extent, we studied the impact of organic cotton farming on the use of the central natural resources water and soil. In this chapter we discuss the differences in irrigation water input and in the soil analysis results of organic and conventional cotton fields (see Chapter 3.2 and 3.3).

4.3.1. Water use

In interviews, many organic farmers reported their observation that after some years of organic management their soils absorbed and retained water better. Claims that less rounds of irrigation are required and that the crop can longer sustain periods of drought are numerous. A case study conducted on the Maikaal project by INFRAS in 2001 mentions that farmers observed an improvement of soil fertility after 3-5 years of organic management, resulting in better infiltration and better water retention capacity (Schwank, North et al. 2001). It is thus surprising that average water application seems higher in organic cotton fields. The limitations in estimating water quantities accurately relativise this result only to some extent. However, it is likely that the lower shares of wheat in organic cotton fields explain part of this difference: when cotton is continued in the Rabi season instead of uprooting it and growing wheat, it requires more irrigation.

Altogether, irrigation water application seems mainly determined through the availability of ground or river water and farmers' access to it, limited through the availability of wells, pumps and electricity. We can assume that, in case farmers manages to require less water through better water retention capacity of the soil or better application technique, they will use the saved water for irrigating other fields rather than keeping it in the well or aquifers. The study conducted by IWMI in the project region confirmed this tendency of farmers to use water that has been saved for expanding the area under irrigation (Shah, Verma et al. 2005). As the State usually provides electricity for running pumps free of cost, there is no economic incentive to save water.

It is also doubtful whether farmers always apply irrigation water as per the actual requirement of the crop. As cotton yields are not significantly correlated with estimated irrigation water quantity (only with the duration of irrigation) it could be that in a number of cases irrigation practices even lead to adverse effects. Too high water application could result in reduced yields due to water logging or stimulation of vegetative growth rather than production of bolls[27].

To compare actual water requirements in organic and conventional cotton farming, further studies are needed. In doing so, investigators should accurately measure applied water quantities with the help of water meters and control management practices like crop shares to a certain extent. Plot trials are likely to be more suitable than on-farm research to tackle this question.

---

[27] see for example www.fao.org/ag/agl/aglw/cropwater/cotton.stm

4.3.2. Impact on soil fertility

We had expected that soil fertility in organic farms is higher due to higher application of organic manures and the absence of harmful effects from chemical fertilizers and pesticides. Our initial hypothesis, therefore, was that average soil organic matter content and water retention capacity are higher in organically managed cotton fields. Our research results neither support nor disprove this hypothesis. While average organic matter contents were slightly higher in organic cotton fields, average water retention was slightly lower. Both differences were not significant. The ratio between organic carbon and clay content, with which organic carbon is closely correlated, is even lower in organic cotton fields. Thus, the absence of significantly higher organic matter content in organic fields can not be explained with distortions in the farm sample.

Though this result may not satisfy the ambition of organic farming to substantially increase soil organic matter contents, it is also not very surprising. Firstly, ranges of organic matter contents are mainly specific to the site (soil type, climate) and to general land use (arable crops, pasture etc.), rather than to specific management practices. Secondly, the response of soil organic matter contents to changes in farm management are rather slow, as the results of long term field trials show (Mäder, Fließbach et al. 2002). Thirdly, organic management practices in the Maikaal project are not entirely different from conventional systems concerning crop rotation patterns and the application of organic manures. Conventional farmers also apply farm yard manure, though in lesser quantities, and proper composting is still rather the exception than the norm in the investigated organic farms. Thorough composting could result in a greater fraction of stable humus and thus contribute to the build up of soil organic matter in the field (Fließbach, Oberholzer et al. submitted). The strong and significant correlation of soil organic matter with cotton yields supports its importance for overall soil fertility.

While the soil analysis results do not show a significant improvement of soil organic matter content and water retention capacity, a majority of organic cotton farmers report in interviews that their soils have become softer, are easier to plough and that overall soil fertility has improved (Shah, Verma et al. 2005; Schwaller 2004). This perception was also confirmed by the farmers whom we had interviewed for the research feedback. Either could it be that the perception of the farmers concerning soil properties differs from the actual field situation. Another possibility is that the parameters that we have measured are not suitable to reflect the changes in soil fertility observed by the farmers. Therefore it might be worth comparing other parameters related to soil fertility, like microbial biomass and activity, or soil structure parameters. As the application of organic manures is significantly higher in organic cotton fields, while the organic matter content is not, we can assume that the turnover of organic material is higher, too. Still, differences in soil parameters are likely to be small compared to sample heterogeneity. Therefore, plot trials are likely to be more suitable than on-farm research to compare soil fertility status of different farming systems.

Though contents of exchangeable phosphorus as well as potassium are lower in organic cotton fields, and the percentage of soils classified as deficient or slightly deficient is higher, yields are not lower. This could be an indication that nutrient availability in organically managed soils is improved, possibly through enhanced microbial activity, as observed in comparison trials in Europe (Mäder, Fließbach et al. 2002; Oberson, Besson et al. 1996; Oehl, Sieverding et al. 2003). The increased efficiency of yield per nutrient input thus can be interpreted as a sign for improved soil fertility. To assess whether the current practice in organic cotton farms in the long term leads to mining of phosphorus and potassium, we compared the nutrient input from manures with the estimated nutrient output exported from the field as seed cotton harvest. While the potassium input is far higher than the output, the phosphorus supply just covers the export through seed cotton[28]. If cotton stalks are removed from the field, a net export of phosphorus is therefore likely – an argument for increasing the application of compost or rock phosphate.

The significantly higher content of boron in organic cotton fields could be due to the greater application of organic manures, as available boron in soils is mainly associated with organic

[28] In 2003, an estimated nutrient export through seed cotton of 18kg P and 12 kg K stood against an input through manures and natural mineral fertilizers of 25 kg P and 50 kg K.

matter (Adams, Hamzah et al. 1991). Although soil acidity is unlikely to play an important role in the soils prevailing in the region, the slightly increased soil pH in organic cotton fields could further soil fertility, as its positive correlation in the yield regression model suggests. The lower pH in conventional cotton fields is most likely due to the acidic reaction of synthetic nitrogen fertilizers.

While soil salinity is not (or not yet) a major problem in the Nimar region, it is a serious threat in many other cotton growing regions such as Punjab or Coimbatore in India, or Sindh in Pakistan (Alam and Naqvi 2003; Praharaj and Rajendran 2004). Besides the impact of saline irrigation water, the application of synthetic fertilizers and the buffering effect of soil organic matter play important roles in causing respectively suppressing salinity. To answer the question whether organic management can effectively contribute to overcoming salinity problems in affected regions requires further research.

4.4 The logic of defaulting

The research data of the farms that got excluded from the Maikaal bioRe project due to non-compliance with organic standards, but still remained in the data monitoring, enables us to discuss possible reasons for defaulting.

The socio-economic profiles of the so-called 'defaulters' are quite different from those of organic farmers who adhered to the standards. On an average, defaulters of the project are wealthier, live in better houses, and possess more land and equipment than organic and conventional farmers. Thus, the decision to apply prohibited inputs like fertilizers, pesticides or GMO seeds does not seem to be in response to severe poverty or out of desperation – as one could assume - , but rather out of some kind of opportunism. However, defaulted farms also differ from average organic farms in other parameters. They have less farm-own labour units per land area and lower stocking rates with cattle. Their production seems to be on a more intensive level, as the higher nitrogen inputs and higher total production costs suggest. Altogether it might be that their constitution is less conducive to organic farming. In addition, they have larger land shares under soy beans and wheat. Therefore, the focus on cotton and with it the relevance of the price premium in cotton are less pronounced than in average organic farms. The higher percentage of defaulted farms living in a joint family might indicate that controversies within the family also play a certain role. Some defaulted farmers explained that they switched back to conventional farming practices because not all of the brothers who manage the land jointly were convinced of the benefits of organic farming.

The comparison of gross margins clearly shows that the use of prohibited inputs did not pay off for the defaulted farmers. The higher yields did not compensate for the loss of the organic price premium. Had they not been excluded from the project, i.e. had they received the price premium despite using prohibited inputs, the result obviously would be different. The defaulted farmers were aware that the use of these inputs is against the internal regulations of Maikaal bioRe they committed to by signing the contract, and that they will be excluded from the project and thus deprived of the price premium in case the input use is detected by the control system. Interviews with defaulters indicate that the main reasons to nevertheless apply synthetic fertilizers or pesticides are either based in a fear of losing a crop due to pest infestation or insufficient plant nutrition, or in the hope to increase yields (without the input use being detected). Some farmers who had used genetically modified cotton seeds stated that they were motivated to try out Bt-cotton by hearing success stories about its performance. This underlines the importance of a well functioning control system in organic cotton projects.

Farms in organic cotton projects that do not strictly adhere to the organic standards are a serious threat to the credibility and the economic stability of the project. Firstly, if not discovered by the internal control system they jeopardize the organic certification of the entire project. Secondly, drop-out of farms that have been supported to convert to organic farming with considerable effort (training, advice, inputs) are an economic loss for cotton projects. Last but not least defaulting farmers might de-motivate other farmers as well as project staff. Thus, organic cotton projects should find ways to avoid defaulting to the best possible extent. Careful selection of farms that are suitable for conversion to organic farming and appropriate initial training could be key factors in this. Further it seems important to cultivate a spirit of project ownership and coherence among the farmers, leading to mutual social control.

4.5 Risks and vulnerability

Although an observation period of only two years is too short to analyse probability of gains and losses in organic cotton farming, the results provide some insight into the nature and extent of the production risk that cotton farmers in the Nimar region have to face.

The biggest threat is partial or complete crop failure due to unfavourable weather conditions. Droughts occur every few years, with devastating impact on crop yields. But also in years of sufficient annual precipitation, crops may be severely affected either by dry intermediary periods or by flooding due to heavy rainfall. Although the soil analysis data do not show increased water retention capacity of soils in organic farms, many farmers reported in interviews that their crops are better equipped to withstand periods of drought thanks to improved soil fertility. This is in line with the evaluation on organic agriculture in Asia implemented by the International Fund for Agricultural Development, which concludes that the risk of crop failure due to drought is less in organic farming systems (Giovannucci 2005). Water stress is enhanced through widespread shortage of irrigation, due to depleted groundwater aquifers, lack of equipment or frequent cuts in electrical power supply. Micro-irrigation systems can help overcome these shortages in situations where a minimum of ground water is available and electricity supply is sufficiently reliable (see Shah, Verma et al. 2005).

The cotton crop can also suffer considerably due to pest attack. In some years, cutworms cause major damage already in the seedling stage, while bollworms are the most serious threat once the crop is established. Neither conventional nor organic farming systems so far have managed to eliminate this risk completely, as low yields due to pest attack in some of the studied organic and conventional fields show. While we do not have data from a sufficiently long period of time to be able to study risk aspects in detail, there are no indications that the risk of crop failure is considerably different in organic and conventional cotton farming. The percentage of cotton fields that ran on a loss due to particularly low yields was approximately the same in both systems (4.1% in organic cotton fields and 5.4% in conventional cotton fields), and the variability of yields is also similar. Some organic farmers claimed that the occurrence of severe pest attacks has reduced due to organic management, as natural enemy populations are in a better position to prevent mass-proliferation of pests. To proof this statement right or wrong, further studies would be needed.

As the risk of crop failure can not be eliminated completely, we should also consider the extent of loss that a farmer incurs in case a crop fails. Costs for seeds, fertilizers and to some extent pest management items incur regardless whether the crop succeeds or not, while harvesting costs are directly linked with yields. As input costs are considerably lower in organic cotton farming, the loss in case of crop failure is also much lower. In addition, Maikaal bioRe provides inputs as interest free loans in the first year of conversion, and later adjusts input costs with part of the price premium of the previous year. Thus organic farmers do not need to take up loans from cooperative banks or private money lenders to purchase inputs for cotton cultivation. Indeed, the interview-based study conducted by IWMI concludes that organic farmers in the project region have lower debt burdens (Shah, Verma et al. 2005). The lower financial risk and less dependency on loans in organic farming could have significant relevance in reducing the vulnerability of farm households with respect to getting caught in a ‘debt trap’ (Vidyasagar and Suman Chandra 2004).

Besides the production risks discussed above, farmers also face risks related to the selling of cotton. Some conventional farmers reported that they occasionally get cheated by local intermediary traders who buy the cotton from the farmers in the villages and sell it in a regional cotton market (the so-called ‘mandi’). They claim that some traders take advantage of farmers’ limited access to up-to-date information on prevailing market rates. Organic farmers interviewed about this point responded that this problem does not occur when selling the crop directly to Maikaal bioRe. Some also emphasized that they feel more secure due to the fact that the company buys the cotton directly from the farmer’s door step. Thus they face less risk of being robbed on the way back from the ‘mandi’.

The low cotton revenues in 2004 show that the fluctuations of cotton market prices form a considerable risk for the farmers. As long as cotton is the only major cash crop for organic farmers, and prices for organic cotton are fixed based on market rates of conventional cotton, this vulnerability to drops in cotton prices will remain. Buyers of organic cotton lint could reduce the impact of price falls by guaranteeing a minimum price at which they purchase the harvest of their contracted farms. Fixing price premiums in absolute amounts rather than percentages of the market price could be another possible option to buffer the effect of market price fluctuations[29].

The biggest potential for reducing farmers' vulnerability probably is in the diversification of income sources. If organic projects manage to tie up market linkages with buyers of organic food crops, this could considerably reduce farmer's dependency on cotton. Several organic farmers have invested their extra income in buying cattle for dairy business, or invested in irrigation facilities enabling them to grow remunerative crops like sugar cane, vegetables or chillies. Others invest in starting a shop or a small service business in their town, in order to be less dependent on agriculture. In interviews, most farmers stated that they invest in higher education of their children, with the aim that at least one family member gets access to off-farm income opportunities. If extra income gained through organic farming indeed enables farmers to diversify their livelihood bases, organic farming could substantially contribute to poverty reduction.

4.6 Obstacles to conversion

In our study we only included organic farms that have converted to organic farming at least three years before the beginning of the data collection. We thus do not have agronomic data of farms in the conversion stage to organic farming. For a detailed analysis of the developments of yields, production costs and revenues during the conversion period, additional research is required. Nevertheless, we have asked the organic farmers participating in the study about their experiences and observations in the initial years after adopting organic farming practices. The interviewed farmers reported that their yields had dropped by 10 – 50% in the first one to two years of conversion. According to the farmers, yields usually recovered from the third year onwards, with soil fertility increasing due to organic management practices. This is in line with observations in other case studies on organic agriculture in India (Giovannucci 2005).

We can safely assume that a major reason for the initial drop in yields is that some time is needed until the soils respond to organic management and until populations of natural enemies re-establish. Another reason might be that farmers first need to gain some experience with the new production technique in order to be able to optimize farm management.

With lower yields, extra work load (e.g. for training, compost preparation etc.) and a price premium of initially only 10 – 15% in the case of the Maikaal bioRe project[30], organic farmers are likely to face considerably lower farm incomes during the first two years of conversion. Most of the interviewed organic farmers confirmed that they incurred some loss during this period. Conventional farmers in the study who have been asked about their reasons for not converting to organic farming responded that they are either not willing or not in a position to bear losses due to reduced yields. We thus can conclude that, even if farmers are eventually better off with organic farming as the research results suggest, the conversion period is a serious obstacle to farmers converting to organic farming.

There is no nostrum to overcome these obstacles to conversion, but a combination of measures that together can smooth the way. To tackle the drop in yields, application of sufficient amounts of organic manures is crucial. Increasing the amount of organic manure generated on the farm itself, e.g. through increasing stocking rates, better management of farm yard manure and composting of available biomass can definitely contribute to this, but has its own limits. Purchasing organic manures from outside (like cow dung) and by-products from processing (like

---

[29] Guaranteed minimum prices and fixed organic premiums are part of the Fair Trade concept (see www.fairtrade.net).

[30] Price premiums in the Maikaal bioRe project: 10% after the first year of conversion, 15% after the second year, 20% after the completion of the three years conversion period.

sugar cane press mud or de-oiled castor), can help reduce drop of yields, but requires capital or access to loans. The cultivation of green manures could be an option in some farms, though its use at a larger scale is limited by the scarcity of irrigation water. Instead of converting the entire farm at once, farmers could start with part of the land in the first year and the remaining part in the second year. Although this would delay the possibility of getting certified and thus of receiving a price premium, part conversion could enable the farmer to gain experience with the new production system and avoid putting economic survival at stake.

The better the farmers are equipped with knowledge on designing economically viable organic farming systems, and the more familiar they are with organic production techniques, the more likely it is that they manage to overcome the hurdles in the conversion period. Systematic training of farmers before and during the conversion is therefore of crucial importance. Professional individual support in planning the conversion process, and regular advice on optimizing farm management during the conversion period need to complement training activities.

Despite all these measures, conversion to organic farming will still involve certain initial investment respectively bearing of income loss. Many farmers in the project region seem to be in such a desolate economic condition that they can not make this investment without jeopardizing their economic survival. Organic cotton projects therefore need to find ways to effectively support these marginal farmers in the first two years of conversion. Financial supports, subsidies on inputs, and loan schemes have their own inherent disadvantages and should be used with care. The research results show that organic cotton farming, in the medium and long term, does have the potential to be an economically sound business proposition also for marginal farmers. Therefore, business approaches to overcome the hurdles of the conversion period seem more appropriate than charitable support. An option that could be worth exploring further might be that organic cotton projects (i.e. the unit purchasing the seed cotton from the farmers) equip formal groups of contracted farmers with revolving funds that can be used to facilitate conversion to organic farming. The management of these funds could be entrusted to the producer groups, with periodic monitoring by the project. However, whether this approach is suitable to overcome the obstacles to conversion needs to be tested.

5. Conclusions

Organic cotton farming improves farmers' livelihoods

The results of the study show that smallholder organic farms in India achieve the same or even slightly higher cotton yields as conventional farms, though nutrient inputs are considerably lower and labour input is on a par with conventional farms. With lower production costs and a 20% organic price premium, gross margins from cotton are thus substantially higher than in the conventional system. Even if the crops grown in rotation with cotton can not be sold with a price premium, conversion to organic farming can lead to a substantial increase in farm incomes. Hence, organic farming in a setting with assured price premium for cotton can significantly improve the livelihoods of smallholders.

Organic farming has the potential for more sustainable use of natural resources

In the perception of most organic farmers, soil fertility significantly improved after conversion. However, the analysis of soil fertility parameters in soil samples from organic and conventional cotton fields has shown only minor differences in organic matter content and water retention. To quantify the impact of conversion to organic management on soil fertility and water use, long-term field trials are likely to be more suitable. If organic management actually improves soil structure and increases water retention, this can reduce the crop's susceptibility to drought. As water is the main limiting factor for agricultural production in many semi-arid regions, this aspect deserves further investigation.

Organic cotton farming reduces overall vulnerability of farm households

As organic cotton farming involves less production costs and generates higher incomes, farmers are less prone to become indebted. Vulnerability of cotton farms – both for organic as well as for conventional farms – is highest when it comes to changes in cotton world market prices. To reduce the effect of drops in cotton prices, organic cotton projects could guarantee minimum purchase prices and develop organic marketing options for the main rotation crops. In the long term, conversion to organic farming can significantly reduce vulnerability of farm households as the additional income enables them to invest in better irrigation systems (e.g. drip irrigation) and to diversify their income sources (e.g. dairy farming or small-scale businesses).

Opportunistic behaviour of some farmers and initial drop of yields are major challenges

Farms that do not strictly adhere to the organic standards are a serious threat to the credibility and the economic stability of organic cotton projects. As on an average it is the more wealthy farmers who tend to violate the standards, the motivation seems to be opportunism rather than need. A well-functioning internal control system, along with a strong mutual social control among the farmers, is thus crucial to prevent opportunistic behaviour. The observed drop of yields and incomes in the first two years of conversion constitutes a major obstacle to adoption of organic cotton farming, especially for marginalized farms. It is thus necessary to find suitable approaches to enable poor farmers managing the hurdles of the conversion period. Competent training on farm management, technical advice during the conversion period, and appropriate models for financing costs of conversion can be important elements in this.

The potential of organic farming for poverty reduction can be further improved

Organic cotton farming systems in the tropics are still in an initial stage, with considerable potential for improvement. Formal research and participatory technology development on production methods could help to achieve similar yields as in conventional farms also in the rotation crops. Appropriate training and extension in order to transfer the know-how to the farm level are needed. If organic cotton projects could facilitate access to domestic or export markets where rotation crops can be sold with an organic price premium, this would have a strong positive impact on farmers' incomes.

Further research is required to explore what conclusions from central India can be transferred to other regions, and to other cropping systems.

6. Annex

6.1 Figures of Maikaal bioRe (2004-05)

Number of participating farmers	1’516
Area under cotton (ha)	4’260
Seed cotton harvest (tonnes)	3’127
Cotton lint (tonnes)	1’028
Number of employees	52

Table 8: Figures of the Maikaal bioRe organic cotton project (2004-05).

6.2 Rain data

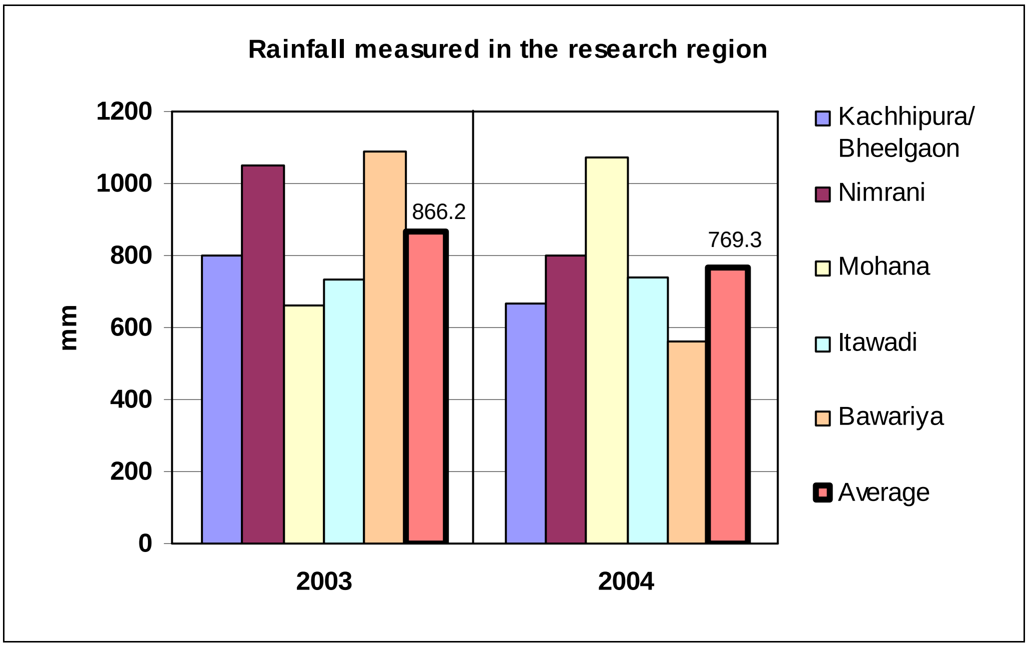


Figure 28: Total rainfall measured with rain gauges in 5 villages of the research project in 2003 and 2004. The last bar shows the average of the five measurements, with the figures above this bar indicating its value.

6.3 Approximation formula for irrigation water quantities

$$Q = t*129574.1*BHP/(d+((255.5998*BHP^2)/(d^2*D^4)))$$

Q = Irrigation water quantity (in litres)
t = total duration of irrigation (in hours)
BHP = engine power of pump (in HP)
d = average depth of the well (in metres)
D = diameter of the suction pipe (in inches)

Assumptions:

1) The lifting head is equal to the depth of the well.
2) Differences in pump efficiency (maintenance condition, voltage fluctuations in electrical power supply) are not considered.

6.4 Result data tables

6.4.1. Farm profiles: Descriptives

Descriptives 2003

Farms 2003 - Profiles (10 villages) Descriptives	Organic % (N = 31)	Conventional % (N = 58)	OF versus CF (%)	Relevance	Defaulters % (N = 16)	DF versus CF (%)
Education						
Primary only	33.3%	45.1%	-26%	Yes	20.0%	-56%
Up to Medium only	26.7%	31.4%	-15%	No	46.7%	49%
Up to High school or Higher secondary only	26.7%	17.6%	51%	Yes	26.7%	51%
Diploma, graduation or post graduation	13.3%	5.9%	127%	Yes	6.7%	13%
House Type						
Kaccha (mud wall house)	19.4%	48.3%	-60%	Yes	31.3%	-35%
Mixed	54.8%	43.1%	27%	No	18.8%	-57%
Pakka (soild house, stone walls)	25.8%	8.6%	199%	Yes	50.0%	480%
Family type						
Joint family	48.4%	32.8%	48%	Yes	56.3%	72%
Caste						
Scheduled tribe (ST)	0.0%	17.2%	-100%	Yes	0.0%	-100%
Scheduled caste (SC)	6.5%	6.9%	-6%	No	12.5%	81%
Other backward caste (OBC), minority	67.7%	58.6%	16%	Yes	62.5%	7%
Forward caste (FC)	25.8%	17.2%	50%	Yes	25.0%	45%
Wealth groups						
Poor	25.8%	37.9%	-32%	Yes	12.5%	-67%
Medium	25.8%	27.6%	-6%	No	0.0%	-100%
Wealthy	48.4%	34.5%	40%	Yes	87.5%	154%
Irrigation						
With micro-irrigation	25.8%	12.1%	114%	Yes	31.3%	159%

Table 9: Frequencies of socio-economic status groups of organic farms, conventional farms and defaulted organic farms (‘defaulters’) in the sample 2003. The column ‘OF versus CF’ shows the increase or reduction in organic farms compared to conventional farms in percent. The column ‘relevance’ indicates whether the difference is meaningful (own assessment).

Descriptives 2004

Farms 2004 - Profiles (10 villages) Descriptives	Organic % (N = 38)	Conventional % (N = 56)	OF versus CF (%)	Relevance	Defaulters % (N = 10)	DF versus CF (%)
Education						
None	13.2%	8.9%	47%	Yes	0.0%	-100%
Primary only	34.2%	48.2%	-29%	Yes	30.0%	-38%
Up to Medium only	21.1%	21.4%	-2%	No	40.0%	87%
Up to High school or Higher secondary only	28.9%	17.9%	62%	Yes	20.0%	12%
Diploma, graduation or post graduation	2.6%	3.6%	-26%	No	10.0%	180%
House Type						
Kaccha (mud wall house)	31.6%	42.9%	-26%	Yes	10.0%	-77%
Mixed	52.6%	44.6%	18%	No	60.0%	34%
Pakka (soild house, stone walls)	15.8%	12.5%	26%	No	30.0%	140%
Family type						
Joint family	42.1%	32.1%	31%	Yes	40.0%	24%
Caste						
Scheduled tribe (ST)	15.8%	19.6%	-20%	Yes	0.0%	-100%
Scheduled caste (SC)	7.9%	7.1%	11%	No	0.0%	-100%
Other backward caste (OBC), minority	55.3%	48.2%	15%	No	80.0%	66%
Forward caste (FC)	21.1%	25.0%	-16%	No	20.0%	-20%
Wealth (Resources: land, equipment, irrigation, off-farm income)						
Poor	28.9%	39.3%	-26%	Yes	20.0%	-49%
Medium	23.7%	28.6%	-17%	No	0.0%	-100%
Wealthy	47.4%	32.1%	47%	Yes	80.0%	149%
Irrigation						
With micro-irrigation	13.2%	7.1%	84%	Yes	50.0%	600%

Table 10: Frequencies of socio-economic status groups of organic farms, conventional farms and defaulted organic farms (‘defaulters’) in the sample 2004. The column ‘OF versus CF’ shows the increase or reduction in organic farms compared to conventional farms in percent. The column ‘relevance’ indicates whether the difference is meaningful (own assessment).

6.4.2. Farm profiles: Means

Farms 2003 - Profiles (10 villages) Means	Organic (N = 31)	Conventional (N = 58)	OF versus CF (%)	Significance (t-Test)	Defaulters (N = 16)	DF versus CF (%)
Age of farmer (years)	42.5	42.3	0%	No (.943)	44.3	5%
Land holding (ha)						
Own land	5.60	*3.98*	41%	Yes (.050)	*8.98*	126%
Rented land	0.03	0.38	-93%	Yes (.005)	0.99	156%
Total land (possessed or operated)	5.62	4.36	29%	No (.128)	9.97	129%
Family members	***7.39***	***7.21***	3%		***10.75***	49%
Total members	5.71	5.29	8%	No (.432)	7.81	48%
Children	1.68	1.91	-12%	No (.489)	2.94	53%
Equipment and Animals						
Equipment value (excl. depreciation)	45274	24491	85%	Yes (.010)	95625	290%
Equipment value per ha	5869	4198	40%	No (.117)	6944	65%
Animal units total	8.17	5.91	38%	Yes (.016)	13.37	126%
Animal units per ha	1.97	1.63	20%	No (.216)	1.40	-14%
Labour units per ha total land						
Farm agricultural labour units - male	0.53	0.56	-4%	No (.775)	0.40	-27%
Farm agricultural labour units - female	0.54	0.42	26%	No (.167)	0.21	-50%
Farm agricultural labour units - permanent	0.09	0.06	47%	No (.379)	0.15	145%
Farm agricultural labour units - total	1.16	1.04	11%	No (.415)	0.70	-33%
Other Income	***16864***	***9342***	81%		***9727***	4%
Off-farm income (Rs. per year)	12245	6259	96%	No (.379)	5608	-10%
Income from milk sales (Rs. per year)	4619	3083	50%	No (.440)	4119	34%
Crop share (% of total area) 2003/04						
Cotton	36.4%	37.5%	-3%	No	34.8%	-7%
Chillie	4.3%	6.8%	-36%	No	6.5%	-4%
Maize	13.3%	12.1%	10%	No	8.8%	-28%
Pigeon Pea	3.9%	5.5%	-29%	No	4.4%	-20%
Sugar Cane	2.6%	1.1%	144%	No	3.3%	210%
Sorghum	3.0%	4.9%	-39%	No	4.0%	-18%
Soya bean	16.4%	10.7%	54%	Yes (.050)	19.8%	85%
Wheat	37.3%	36.6%	2%	No	44.2%	21%

Table 11: Mean values of farmer’s age and of agronomic parameters of organic farms, conventional farms and defaulted organic farms (‘defaulters’) in the sample 2003. The column ‘OF versus CF’ shows the increase or reduction in organic farms compared to conventional farms in percent.

Farms 2004 - Profiles (10 villages) Means	Organic (N = 38)	Conventional (N = 56)	OF versus CF (%)	Significance (t-Test)	Defaulters (N = 10)	DF versus CF (%)
Age of farmer (years)	46.2	43.6	6%	No (.328)	40.9	-6%
Land holding (ha)						
Own land	4.23	3.81	11%	No (.520)	7.04	85%
Rented land	0.32	0.55	-41%	No (.299)	0.51	-6%
Total land (possessed or operated)	4.55	4.36	4%	No (.771)	7.55	73%
Family members	***7.66***	***7.43***	3%		***6.80***	-8%
Total members	5.76	5.41	7%	No (.509)	5.40	0%
Children	1.89	2.02	-6%	No (.750)	1.40	-31%
Equipment and Animals						
Equipment value (excl. depreciation)	42237	23259	82%	Yes (.014)	66200	185%
Equipment value per ha	6527	3579	82%	Yes (.001)	5227	46%
Animal units total	7.39	6.05	22%	No (.132)	10.09	67%
Animal units per ha	2.04	1.59	29%	No* (.081)	1.61	1%
Labour units per ha total land						
Farm agricultural labour units - male	0.66	0.55	19%	No (.207)	0.41	-27%
Farm agricultural labour units - female	0.60	0.45	33%	No (.103)	0.35	-22%
Farm agricultural labour units - permanent	0.07	0.05	52%	No (.396)	0.29	492%
Farm agricultural labour units - total	1.35	1.06	27%	No* (.072)	1.05	-1%
Other Income	***22477***	***14659***	53%		***17846***	22%
Off-farm income (Rs. per year)	16147	10504	54%	No (.468)	10100	-4%
Income from milk sales (Rs. per year)	6330	4155	52%	No (.385)	7746	86%
Crop share (% of total area) 2003/04						
Cotton	36.0%	43.8%	-18%	Yes (.030)	38.6%	-12%
Chillie	2.2%	3.0%	-27%	No	2.0%	-34%
Chickpea	0.9%	0.7%	25%	No	0.5%	-33%
Maize	10.2%	9.1%	12%	No	1.6%	-83%
Pigeon Pea	3.5%	5.3%	-34%	No	1.9%	-65%
Sugar Cane	1.5%	0.7%	127%	No	1.0%	45%
Sorghum	4.7%	4.0%	17%	No	1.3%	-68%
Soya bean	18.1%	15.2%	19%	No	39.1%	157%
Wheat	32.2%	35.2%	-8%	No	46.5%	32%

Table 12: Mean values of farmer’s age and of agronomic parameters of organic farms, conventional farms and defaulted organic farms (‘defaulters’) in the sample 2004. The column ‘OF versus CF’ shows the increase or reduction in organic farms compared to conventional farms in percent. * $p \leq 10\%$.

6.4.3. Cotton performance

Means 2003

Cotton Fields 2003 - Economic performance (10 villages)	Organic (N = 58)	Conventional (N = 112)	OF versus CF (%)	Significance (T-test)	Defaulters (N = 46)	DF versus CF (%)
Inputs (unit per ha)						
Weed days	17.5	16.4	6.2%	No (.589)	9.8	-40.5%
Fertilizing days	3.5	4.2	-15.9%	No (.216)	2.4	-41.6%
Pest management days	5.4	9.8	-44.4%	Yes (.001)	4.0	-58.9%
Total labour days (incl. soil cultivation, picking etc.)	206.0	209.4	-1.6%	No (.824)	175.6	-16.1%
Own labour days (family members and permanent employees)	68.5	84.1	-18.5%	No (.165)	48.2	-42.7%
Hired labour days	137.4	125.3	9.7%	No (.318)	127.4	1.7%
N input (kg)	85.3	170.3	-49.9%	Yes (.000)	99.7	-41.5%
N input from organic manures (kg)	85.3	43.7	95.3%	Yes (.003)	98.6	125.8%
N input from synthetic fertilizers (kg)	0.0	126.6	-100.0%	Yes (.000)	1.1	-99.2%
P input (kg)	25.2	86.9	-71.1%	Yes (.000)	31.2	-64.1%
K input (kg)	49.9	54.2	-7.9%	No (.694)	68.7	26.7%
Irrigation water (cubic metres)	4587	3912	17.3%	No (.252)	3596	-8.1%
Production costs (Rs. per ha)						
Cotton crop production costs (excl. own labour cost)	8700	10025	-13.2%	No (.128)	9159	-8.6%
Hired labour cost	4646	3958	17.4%	No* (.094)	4444	12.3%
Total Input costs (seeds, fertilizers, pesticides)	3613	5826	-38.0%	Yes (.000)	3885	-33.3%
Seed costs (purchased seeds)	1164	1274	-8.6%	No (.306)	944	-25.9%
Fertilizer cost (purchased fertilizers)	1761	2858	-38.4%	Yes (.005)	1973	-31.0%
Pest management items cost (purchased items)	688	1694	-59.4%	Yes (.000)	967	-42.9%
Other cost (irrigation rent, hiring equipment, electricity etc.)	441	241	83.3%	No* (.061)	830	244.9%
Cotton crop production costs incl. own labour cost	10937	12922	-15.4%	Yes (.042)	10843	-16.1%
Own labour cost	2238	2897	-22.8%	No* (.072)	1684	-41.9%
Rabi production costs (wheat)	873	1211	-27.9%	No (.408)	1380	13.9%
Yields (kg per ha)						
Cotton yield (seed cotton)	1459.3	1399.7	4.3%	No (.547)	1540.4	10.1%
Rabi yield (wheat, average of all fields)	544.2	675.6	-19.5%	No (.402)	1007.4	49.1%
Intercrop yield (moong), all fields	13.3	2.6	408.9%	Yes (.012)	12.6	381.9%
Crop revenues (Rs. per ha)						
Cotton rate (Rs./kg)	23.70	22.52	5.2%	Yes (.000)	22.43	-0.4%
Cotton revenue excl. price premium	34541	31687	9.0%	No (.271)	34468	8.8%
Cotton price premium (organic: 20% of cotton revenue)	6908	0			0	
Intercrop revenue						
Cotton crop revenue (incl. intercrop revenue and price premium)	41649	31726	31.3%	Yes (.000)	34657	9.2%
Rabi revenue (wheat, average of all fields)	3537	4391	-19.5%	No (.547)	6548	49.1%
Gross margins (revenues minus direct production costs)						
Cotton gross margin, without price premium	26042	21701	20.0%	No (.056)	25498	17.5%
Cotton gross margin, with price premium	32950	21701	51.8%	Yes (.000)	25498	17.5%
Cotton gross margin incl. own labour costs, with price premium	30712	18804	63.3%	Yes (.000)	23814	26.6%
Rabi crop gross margin (wheat, average of all fields)	2664	3180	-16.2%	No (.625)	5168	62.5%
Field gross margin (Kharif and Rabi), without price premium	28705	24882	15.4%	No (.131)	30666	23.2%
Field gross margin (Kharif and Rabi), with price premium	35614	24882	43.1%	Yes (.000)	30666	23.2%
Efficiencies (per kg seed cotton)						
Litre water per kg cotton	3498	3350	4.4%	No (.834)	2394	-28.5%
Kg N-input per kg cotton	0.064	0.145	-55.5%	Yes (.000)	0.064	-55.5%
Rs. input cost per kg cotton	1.72	3.76	-54.2%	Yes (.000)	2.04	-45.7%
Labour days per kg cotton	0.163	0.179	-9.2%	No (.300)	0.125	-30.1%
Gross margin per own labour day (excl. price premium)	749	546	37.4%	No (.406)	735	34.8%
Gross margin per own labour day (incl. price premium)	950	546	74.1%	No (.121)	735	34.8%

Table 13: Mean values of economic performance parameters of organic farms, conventional farms and defaulted organic farms (‘defaulters’) in the sample 2003. The column ‘OF versus CF’ shows the increase or reduction in organic farms compared to conventional farms in percent. * p ≤ 10%.

Means 2004

Cotton Fields 2004 - Economic performance (10 villages)	Organic (N = 62)	Conventional (N = 108)	OF versus CF (%)	Significance (T-test)	Defaulters (N = 19)	DF versus CF (%)
Inputs (unit per ha)						
Weed days	14.7	13.9	5.8%	No (.531)	11.7	-16.3%
Fertilizing days	2.6	2.8	-9.5%	No (.411)	2.2	-21.4%
Pest management days	1.7	4.8	-65.3%	Yes (.000)	2.3	-52.7%
Total labour days (incl. soil cultivation, picking etc.)	173.5	153.1	13.3%	No* (.061	151.2	-1.3%
Own labour days (family members and permanent labour)	76.2	72.1	5.7%	No (.635)	37.6	-47.9%
Hired labour days	97.2	81.0	20.0%	No (.104)	113.6	40.2%
N input (kg)	82.8	136.2	-39.2%	Yes (.002)	130.6	-4.1%
N input from organic manures (kg)	82.8	44.4	86.5%	Yes (.004)	89.3	101.3%
N input from synthetic fertilizers (kg)	0.0	91.8	-100.0%	Yes (.000)	41.3	-55.0%
P input (kg)	25.4	62.6	-59.5%	Yes (.000)	63.0	0.6%
K input (kg)	61.1	59.4	2.9%	No (.883)	84.2	41.8%
Irrigation water (cubic metres)	2944	2804	5.0%	No (.770)	2752	-1.9%
Production costs (Rs. per ha)						
Cotton crop production costs (excl. own labour cost)	6892	8643	-20.3%	Yes (.026)	9910	14.7%
Hired labour cost	3326	2849	16.7%	No (.215)	4184	46.9%
Total Input costs (seeds, fertilizers, pesticides)	2883	5143	-43.9%	Yes (.000)	4856	-5.6%
Seed costs (purchased seeds)	1426	2031	-29.8%	Yes (.003)	2142	5.4%
Fertilizer cost (purchased fertilizers)	1349	2147	-37.2%	Yes (.001)	2246	4.6%
Pest management items cost (purchased items)	107	965	-88.9%	Yes (.000)	468	-51.5%
Other cost (irrigation rent, hiring equipment, electricity etc.)	683	651	5.0%	No (.817)	871	33.8%
Cotton crop production costs incl. own labour cost	9391	11046	-15.0%	Yes (.036)	11313	2.4%
Own labour cost	2500	2403	4.0%	No (.738)	1403	-41.6%
Rabi production costs (wheat)	554	1310	-57.7%	Yes (.006)	1655	26.4%
Yields (kg per ha)						
Cotton yield (seed cotton)	1236.9	1166.2	6.1%	No (.563)	1282.2	9.9%
Rabi yield (wheat, average of all fields)	397.3	912.9	-56.5%	Yes (.007)	1070.0	17.2%
Intercrop yield (moong), all fields	9.4	3.3	187.8%	No (.115)	0.0	-100.0%
Crop revenues (Rs. per ha)						
Cotton rate (Rs./kg)	16.28	17.12	-4.9%	No* (.083)	17.17	0.3%
Cotton revenue excl. price premium	21578	20381	5.9%	No (.584)	22268	9.3%
Cotton price premium (organic: 20% of cotton revenue)	4316	0		Yes	0	
Intercrop revenue						
Cotton crop revenue (incl. intercrop revenue and price premium)	26048	20430	27.5%	Yes (.000)	22268	9.0%
Rabi revenue (wheat, average of all fields)	2582	5934	-56.5%	Yes (.007)	6955	17.2%
Gross margins (revenues minus direct production costs)						
Cotton gross margin, without price premium	14841	11788	25.9%	No* (.063)	12358	4.8%
Cotton gross margin, with price premium	19157	11788	62.5%	Yes (.000)	12358	4.8%
Cotton gross margin incl. own labour costs, with price premium	16657	9385	77.5%	Yes (.000)	10955	16.7%
Rabi crop gross margin (wheat, average of all fields)	2029	4624	-56.1%	Yes (.011)	5299	14.6%
Field gross margin (Kharif and Rabi), without price premium	16870	16341	3.2%	No (.801)	17657	8.1%
Field gross margin (Kharif and Rabi), with price premium	21185	16341	29.6%	Yes (.032)	17657	8.1%
Efficiencies (per kg seed cotton)						
Litre water per kg cotton	3265	3028	7.8%	No (.763)	2207	-27.1%
Kg N-input per kg cotton	0.089	0.167	-46.3%	Yes (.013)	0.108	-35.4%
Rs. input cost per kg cotton	1.57	3.12	-49.9%	Yes (.000)	2.25	-28.0%
Labour days per kg cotton	0.182	0.194	-6.1%	No (.674)	0.133	-31.3%
Gross margin per own labour day (excl. price premium)	385	281	37.2%	No (.265)	378	34.4%
Gross margin per own labour day (incl. price premium)	517	281	84.1%	Yes (.045)	378	34.4%

Table 14: Mean values of economic performance parameters of organic farms, conventional farms and defaulted organic farms (‘defaulters’) in the sample 2004. The column ‘OF versus CF’ shows the increase or reduction in organic farms compared to conventional farms in percent. * p ≤ 10%.

6.4.4. Rotation crops

Means 2003

Farms 2003 - Rotation crop performance (10 villages)	Organic (N = 31)	Conventional (N = 58)	OF versus CF (%)	Significance (T-test)
Chillie (OF: 12, CF: 30)				
Production cost (HL, FC, PMC) (Rs./ha)	6897	12664	-45.5%	Yes
Hired labour cost (Rs./ha)	4809	4609	4.3%	No
Fertilizer cost (Rs./ha)	1287	4641	-72.3%	Yes
Pest management items cost (Rs./ha)	801	3414	-76.5%	Yes
Yield (kg/ha) (mixed green and red chilli!)	789	3146	-74.9%	No*
Price received (Rs./kg)	17.5	23.3	-24.9%	No
Crop revenue (Rs./ha)	17832	38241	-53.4%	Yes
Gross margin (Rs./ha)	10936	25577	-57.2%	No*
Maize (OF: 24, CF: 39)				
Production cost (HL, FC, PMC) (Rs./ha)	1503	1702	-11.7%	No
Hired labour cost (Rs./ha)	1050	879	19.5%	No
Fertilizer cost (Rs./ha)	453	823	-44.9%	Yes
Pest management items cost (Rs./ha)	0	0		No
Yield (kg/ha)	2148	2434	-11.8%	No
Price received (Rs./kg)	4.5	4.5	0.1%	No
Crop revenue (Rs./ha)	9754	10824	-9.9%	No
Gross margin (Rs./ha)	8250	9122	-9.6%	No
Pigeon Pea (OF: 17, CF: 38)				
Production cost (HL, FC, PMC) (Rs./ha)	1143	1770	-35.4%	No
Hired labour cost (Rs./ha)	913	801	13.9%	No
Fertilizer cost (Rs./ha)	230	643	-64.2%	No
Pest management items cost (Rs./ha)	0	326	-100.0%	No
Yield (kg/ha)	533	611	-12.8%	No
Price received (Rs./kg)	15.0	15.2	-1.3%	No
Crop revenue (Rs./ha)	7996	9327	-14.3%	No
Gross margin (Rs./ha)	6853	7557	-9.3%	No
Sugar Cane (OF: 2, CF: 2)				
Production cost (HL, FC, PMC) (Rs./ha)	10454	9437	10.8%	No
Hired labour cost (Rs./ha)	8911	7458	19.5%	No
Fertilizer cost (Rs./ha)	1543	1979	-22.0%	No
Pest management items cost (Rs./ha)	0	0		No
Yield (kg/ha)	56371	47286	19.2%	No
Price received (Rs./kg)	0.8	0.8	0.0%	No
Crop revenue (Rs./ha)	47352	39720	19.2%	No
Gross margin (Rs./ha)	36897	30284	21.8%	No
Sorghum (OF: 9, CF: 23)				
Production cost (HL, FC, PMC) (Rs./ha)	1067	1481	-28.0%	No
Hired labour cost (Rs./ha)	910	824	10.4%	No
Fertilizer cost (Rs./ha)	157	657	-76.2%	Yes
Pest management items cost (Rs./ha)	0	0		No
Yield (kg/ha)	1540	1552	-0.8%	No
Price received (Rs./kg)	3.8	4.0	-5.0%	No
Crop revenue (Rs./ha)	5533	6157	-10.1%	No
Gross margin (Rs./ha)	4466	4676	-4.5%	No
Soy bean (OF: 17, CF: 29)				
Production cost (HL, FC, PMC) (Rs./ha)	1846	1865	-1.0%	No
Hired labour cost (Rs./ha)	1382	1012	36.6%	No
Fertilizer cost (Rs./ha)	464	828	-44.0%	Yes
Pest management items cost (Rs./ha)	0	26		No
Yield (kg/ha)	1395	1436	-2.8%	No
Price received (Rs./kg)	12.5	12.7	-1.2%	No
Crop revenue (Rs./ha)	17335	18246	-5.0%	No
Gross margin (Rs./ha)	15489	16381	-5.4%	No
Wheat (OF: 30, CF: 55)				
Production cost (HL, FC, PMC) (Rs./ha)	2051	2844	-27.9%	Yes
Hired labour cost (Rs./ha)	1501	1264	18.8%	No
Fertilizer cost (Rs./ha)	550	1579	-65.2%	Yes
Pest management items cost (Rs./ha)	0	1		No
Yield (kg/ha)	2326	2486	-6.4%	No
Price received (Rs./kg)	6.6	6.6	0.0%	No
Crop revenue (Rs./ha)	15353	16373	-6.2%	No
Gross margin (Rs./ha)	13302	13529	-1.7%	No

Table 15: Economic performance of rotation crops in the sample 2003. The number of observations is given for each crop. Gross margins excluding seed cost, own labour and other cost. * $p \leq 10\%$.

Means 2004

Farms 2004 - Rotation crop performance (10 villages)	Organic (N = 38)	Conventional (N = 56)	OF versus CF (%)	Significance (T-test)
Chillie (OF: 11, CF: 16)				
Production cost (HL, FC, PMC) (Rs./ha)	6145	8174	-24.8%	No
Hired labour cost (Rs./ha)	3095	3160	-2.0%	No
Fertilizer cost (Rs./ha)	1300	1856	-30.0%	No
Pest management items cost (Rs./ha)	71	461	-84.6%	Yes
Other cost (Rs./ha)	1679	2698	-37.8%	No
Production cost incl. own labour cost	9091	10084	-9.8%	No
Own labour cost (Rs./ha)	2946	1910	54.2%	No
Yield (kg/ha) (mixed green and red chilli!)	424	1383	-69.3%	No*
Price received (Rs./kg)	11.0	11.6	-5.9%	No
Crop revenue (Rs./ha)	5791	15708	-63.1%	No*
Gross margin (Rs./ha)	-354	7534	-104.7%	No
Gross margin incl. own labour cost	-3301	5624	-158.7%	No
Chickpea (OF: 3, CF: 5)				
Production cost (HL, FC, PMC) (Rs./ha)	0	1471	-100.0%	No*
Hired labour cost (Rs./ha)	0	623	-100.0%	No
Fertilizer cost (Rs./ha)	0	218	-100.0%	No
Pest management items cost (Rs./ha)	0	167	-100.0%	No
Other cost (Rs./ha)	0	463	-100.0%	No
Production cost incl. own labour cost	1322	2916	-54.7%	No
Own labour cost (Rs./ha)	1322	1446	-8.5%	No
Yield (kg/ha)	332	325	2.1%	No
Price received (Rs./kg)	14.7	15.4	-4.8%	No
Crop revenue (Rs./ha)	4868	5104	-4.6%	No
Gross margin (Rs./ha)	4868	3633	34.0%	No
Gross margin incl. own labour cost	3546	2188	62.1%	No
Maize (OF: 25, CF: 33)				
Production cost (HL, FC, PMC) (Rs./ha)	1772	1824	-2.9%	No
Hired labour cost (Rs./ha)	639	408	56.5%	No*
Fertilizer cost (Rs./ha)	193	612	-68.5%	Yes
Pest management items cost (Rs./ha)	0	0		No
Other cost (Rs./ha)	941	804	17.0%	No
Production cost incl. own labour cost	3241	2973	9.0%	No
Own labour cost (Rs./ha)	1469	1149	27.8%	No
Yield (kg/ha)	1373	1287	6.7%	No
Price received (Rs./kg)	5.3	5.2	2.5%	No
Crop revenue (Rs./ha)	7510	6661	12.7%	No
Gross margin (Rs./ha)	5737	4837	18.6%	No
Gross margin incl. own labour cost	4269	3688	15.7%	No
Pigeon Pea (OF: 20, CF: 33)				
Production cost (HL, FC, PMC) (Rs./ha)	940	1068	-11.9%	No
Hired labour cost (Rs./ha)	578	580	-0.2%	No
Fertilizer cost (Rs./ha)	138	218	-36.8%	No
Pest management items cost (Rs./ha)	0	0		No
Other cost (Rs./ha)	224	270	-17.0%	No
Production cost incl. own labour cost	2178	2570	-15.3%	No
Own labour cost (Rs./ha)	1237	1502	-17.6%	No
Yield (kg/ha)	424	430	-1.4%	No
Price received (Rs./kg)	15.3	15.9	-4.0%	No
Crop revenue (Rs./ha)	6997	7545	-7.3%	No
Gross margin (Rs./ha)	6057	6477	-6.5%	No
Gross margin incl. own labour cost	4819	4975	-3.1%	No
Sugar Cane (OF: 3, CF: 2)				
Production cost (HL, FC, PMC) (Rs./ha)	14185	20020	-29.1%	No
Hired labour cost (Rs./ha)	7898	16626	-52.5%	Yes
Fertilizer cost (Rs./ha)	0	3395	-100.0%	Yes
Pest management items cost (Rs./ha)	0	0		No
Other cost (Rs./ha)	6287	0		No
Production cost incl. own labour cost	14719	20428	-27.9%	No
Own labour cost (Rs./ha)	534	408	30.9%	No
Yield (kg/ha)	47166	64865	-27.3%	No
Price received (Rs./kg)	1.1	1.0	5.4%	No
Crop revenue (Rs./ha)	51970	67552	-23.1%	No
Gross margin (Rs./ha)	37785	47532	-20.5%	No
Gross margin incl. own labour cost	37251	47125	-21.0%	No

Farms 2004 - Rotation crop performance (10 villages)	Organic (N = 38)	Conventional (N = 56)	OF versus CF (%)	Significance (T-test)
Sorghum (OF:13, CF: 14)				
Production cost (HL, FC, PMC) (Rs./ha)	1647	1602	2.8%	No
Hired labour cost (Rs./ha)	718	392	83.4%	No
Fertilizer cost (Rs./ha)	186	299	-37.9%	No
Pest management items cost (Rs./ha)	0	0		No
Other cost (Rs./ha)	743	911	-18.4%	No
Production cost incl. own labour cost	2204	2456	-10.3%	No
Own labour cost (Rs./ha)	557	854	-34.8%	No
Yield (kg/ha)	1022	765	33.6%	No
Price received (Rs./kg)	3.2	3.9	-18.8%	No
Crop revenue (Rs./ha)	5232	3825	36.8%	No
Gross margin (Rs./ha)	3585	2224	61.2%	No
Gross margin incl. own labour cost	3028	1369	121.1%	No
Soy bean (OF: 25, CF: 31)				
Production cost (HL, FC, PMC) (Rs./ha)	3146	3395	-7.3%	No
Hired labour cost (Rs./ha)	789	815	-3.2%	No
Fertilizer cost (Rs./ha)	234	626	-62.7%	Yes
Pest management items cost (Rs./ha)	0	26	-100.0%	No*
Other cost (Rs./ha)	2123	1928	10.1%	No
Production cost incl. own labour cost	3808	3982	-4.4%	No
Own labour cost (Rs./ha)	662	587	12.8%	No
Yield (kg/ha)	803	870	-7.7%	No
Price received (Rs./kg)	18.0	12.9	40.3%	No
Crop revenue (Rs./ha)	9444	10544	-10.4%	No
Gross margin (Rs./ha)	6298	7149	-11.9%	No
Gross margin incl. own labour cost	5636	6562	-14.1%	No
Wheat (OF: 36, CF: 48)				
Production cost (HL, FC, PMC) (Rs./ha)	3281	3733	-12.1%	No
Hired labour cost (Rs./ha)	1235	1060	16.5%	No
Fertilizer cost (Rs./ha)	378	1413	-73.2%	Yes
Pest management items cost (Rs./ha)	0	6	-94.6%	No
Other cost (Rs./ha)	1667	1253	33.0%	No*
Production cost incl. own labour cost	4546	5041	-9.8%	No
Own labour cost (Rs./ha)	1265	1308	-3.3%	No
Yield (kg/ha)	2369	2472	-4.1%	No
Price received (Rs./kg)	6.5	7.6	-14.8%	No
Crop revenue (Rs./ha)	15395	16364	-5.9%	No
Gross margin (Rs./ha)	12115	12632	-4.1%	No
Gross margin incl. own labour cost	10850	11324	-4.2%	No

Table 16: Economic performance of rotation crops in the sample 2004. The number of observations is given for each crop. Gross margins excluding seed cost, own labour and other cost. * p ≤ 10%.

6.4.5. Soil results

Status groups (2003 and 2004)

Cotton fields 2003 and 2004 - Status groups (OF: 121, CF: 204, DF: 102)	OF	CF	DF	OF versus CF (%)	DF versus CF (%)
Soil types					
Clay Soil	52.1%	50.5%	46.1%	3.1%	-8.7%
Loamy Soil	29.8%	28.4%	40.2%	4.6%	41.4%
Sandy Soil	18.2%	21.1%	13.7%	-13.7%	-34.9%
Water retention capacity					
Very low	14.0%	22.5%	18.6%	-37.7%	-17.4%
Low	34.7%	30.9%	28.4%	12.4%	-7.9%
Medium	33.9%	30.9%	45.1%	9.7%	46.0%
High	17.4%	15.7%	7.8%	10.6%	-50.0%
Corg					
very low	14.9%	14.7%	13.7%	1.2%	-6.7%
low	35.5%	37.7%	36.3%	-5.8%	-3.9%
medium	39.7%	44.1%	45.1%	-10.1%	2.2%
high	9.9%	3.4%	4.9%	189.0%	42.9%
Ratio Corg to Clay					
very low	17.4%	18.1%	16.7%	-4.3%	-8.1%
low	10.7%	13.7%	10.8%	-21.7%	-21.4%
medium	53.7%	46.1%	47.1%	16.6%	2.1%
high	18.2%	22.1%	25.5%	-17.6%	15.6%
Phosphorus status					
deficient	28.9%	34.3%	22.5%	-15.7%	-34.3%
slightly deficient	33.1%	22.5%	25.5%	46.6%	13.0%
optimum	33.9%	33.3%	35.3%	1.7%	5.9%
very high	4.1%	9.8%	16.7%	-57.9%	70.0%
Potassium status					
deficient	17.4%	21.1%	12.7%	-17.7%	-39.5%
slightly deficient	30.6%	22.5%	33.3%	35.6%	47.8%
optimum	34.7%	38.7%	43.1%	-10.4%	11.4%
very high	17.4%	17.6%	10.8%	-1.7%	-38.9%
Zinc status					
deficient	9.9%	6.4%	8.8%	55.6%	38.5%
slightly deficient	28.9%	33.3%	28.4%	-13.2%	-14.7%
optimum	57.9%	54.9%	56.9%	5.4%	3.6%
very high	3.3%	5.4%	5.9%	-38.7%	9.1%
Boron status					
deficient	9.1%	21.1%	26.5%	-56.9%	25.6%
slightly deficient	33.9%	33.3%	36.3%	1.7%	8.8%
optimum	52.9%	42.6%	34.3%	24.0%	-19.5%
very high	4.1%	2.9%	2.9%	40.5%	0.0%
Salt content					
no salinity	81.8%	75.0%	75.5%	9.1%	0.7%
medium salinity	14.9%	14.7%	19.6%	1.2%	33.3%
high salinity	3.3%	10.3%	4.9%	-67.9%	-52.4%

Table 17: Frequencies of soil status groups of organic farms (OF), conventional farms (CF) and defaulted organic farms (DF) in all fields sampled in 2003 and 2004. The column ‘OF versus CF’ shows the increase or reduction in organic farms compared to conventional farms in percent.

Means of soil parameters (2003 and 2004)

Cotton fields 2003 and 2004 Soil properties (OF: 121, CF: 204, DF: 102)	OF	CF	DF	OF versus CF (%)	Significance (t-Test)	DF versus CF (%)
Sand (%)	0.372	0.384	0.379	-3.2%	No (.447)	-1.2%
Silt (%)	0.229	0.224	0.240	2.2%	No (.231)	7.3%
Clay (%)	0.400	0.392	0.381	1.9%	No (.621)	-3.0%
Water retention capacity (g/g)	0.128	0.130	0.133	-1.1%	No (.605)	2.2%
Organic carbon (%)	0.896	0.881	0.898	1.8%	No (.479)	2.0%
Organic carbon / clay ratio	2.432	2.538	2.544	-4.2%	No (.393)	0.2%
Phosphorus (ppm)	6.475	7.310	8.576	-11.4%	No (.160)	17.3%
Potassium (ppm)	188.5	199.6	187.2	-5.6%	No (.752)	-6.2%
Zinc (ppm)	0.567	0.569	0.586	-0.3%	No (.955)	3.1%
Boron (ppm)	0.379	0.323	0.316	17.3%	Yes (.008)	-2.3%
Salt content (dS/m)	0.297	0.331	0.325	-10.3%	No (.107)	-1.8%
pH	8.237	8.087	8.117	1.9%	Yes (.000)	0.4%

Table 18: Mean values of soil parameters of organic farms (OF), conventional farms (CF) and defaulted organic farms (DF) in all fields sampled in 2003 and 2004. The column 'OF versus CF' shows the increase or reduction in organic farms compared to conventional farms in percent. * $p \leq 10\%$.

6.5 Size of farms that joined the Maikaal bioRe project

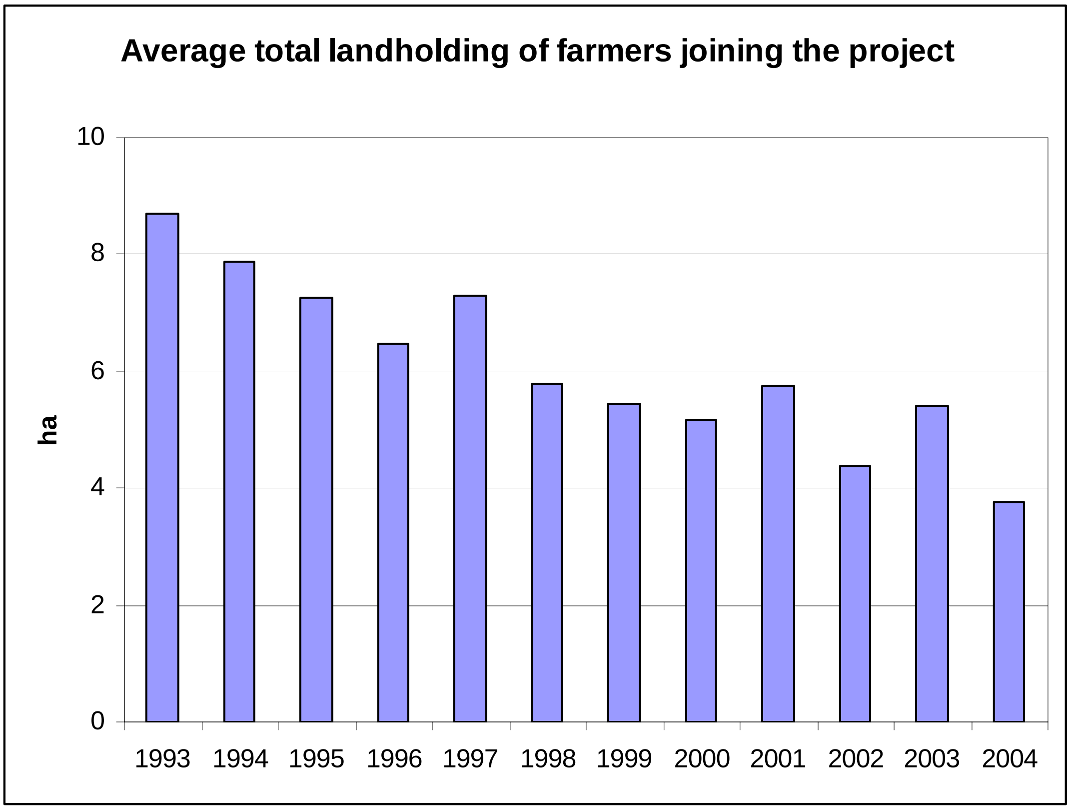


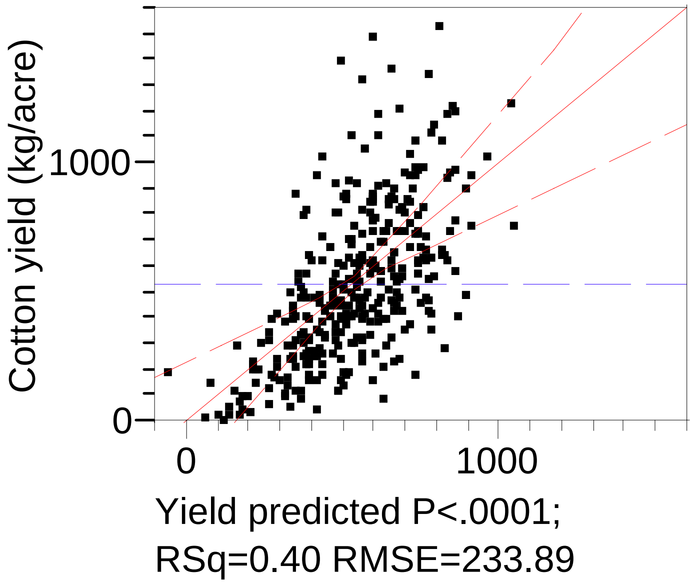
Figure 29: Average total land holdings of farmers joining the Maikaal bioRe project in the years 1993 to 2004. Source: Database of Maikaal bioRe.

6.6 Linear regression models

The linear regression models below follow the equation $y = \alpha x_1 + \beta x_2 + \gamma x_3 + ... + C$, where y is the response parameter (cotton yield in 6.6.1and 6.6.2, field gross margin in 6.6.3), x_1, x_2, x_3 etc. are the parameters influencing the response parameter, and α,β, γ etc. are the estimated effects of the influencing parameter on the response parameter.

6.6.1. Effect of non-inherent parameters on cotton yields

Model fit for cotton yields



Summary of Fit

RSquare	0.399307
RSquare Adj	0.354595
Root Mean Square Error	233.8897
Mean of Response (kg/acre)	534.0771
Observations (or Sum Wgts)	333

Effect Tests

Parameter	Estimated yield gain (kg/acre)	F Ratio	Prob > F
Farming system	9.65 (Organic)	0.4387	0.5082
Year	8.03 (2003)	0.2530	0.6153
Wealth	-27.72 (poor farmers)	3.2089	0.0417
Village	-229.0 (lowest) 222.1 (highest)	7.4324	<.0001
Total rainfall (mm)	0.088 (per mm)	0.8978	0.3441
Gropping period	-23.70 (Monsoon)	1.6636	0.1981
Crop duration (days)	2.20 (per day)	27.6123	<.0001
Sowing density (p/sqm)	-28.30 (per plant/sqm)	2.8766	0.0909
Wheat share	58.12 (with wheat)	1.8477	0.1750
Micro-irrigation	31.86 (without)	0.5471	0.4601
Clay content (%)	1.39 (per% clay)	1.1814	0.2779
Irrigation (hours/acre)	1.56 (per h)	18.3790	<.0001

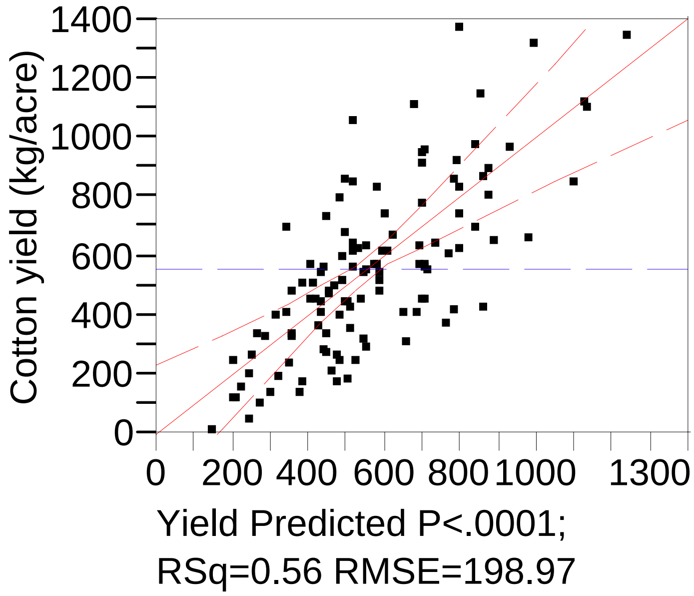
Effect of farming system on cotton yields

System	Mean without correction (kg/ha)	Corrected mean (kg/ha)	Std Error (kg/ha)
Organic cotton fields	1378.5	1315.8	111.7
Conventional cotton fields	1288.7	1268.1	106.9

6.6.2. Models explaining cotton yields

The following linear regression models include the parameters that have a significant effect on cotton yields.

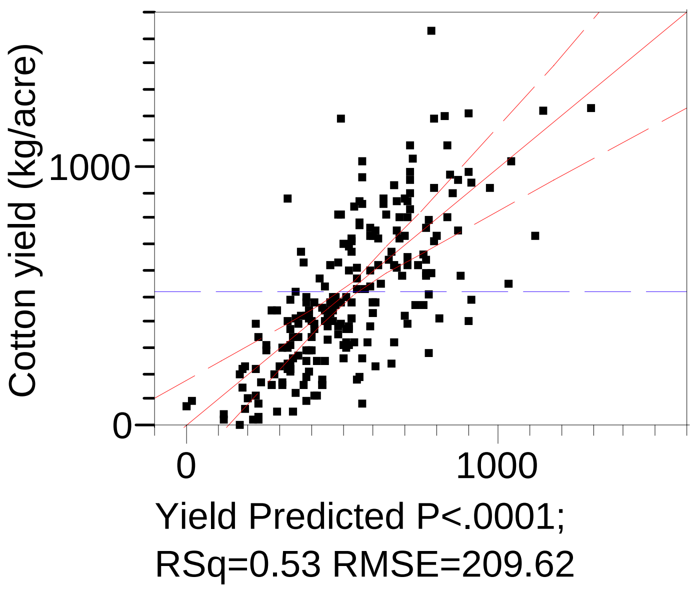
Model fit for organic cotton fields



Summary of Fit

RSquare	0.555258
RSquare Adj	0.507761
Root Mean Square Error	198.9712
Mean of Response (kg/acre)	557.8629
Observations (or Sum Wgts)	115

Model fit for conventional cotton fields

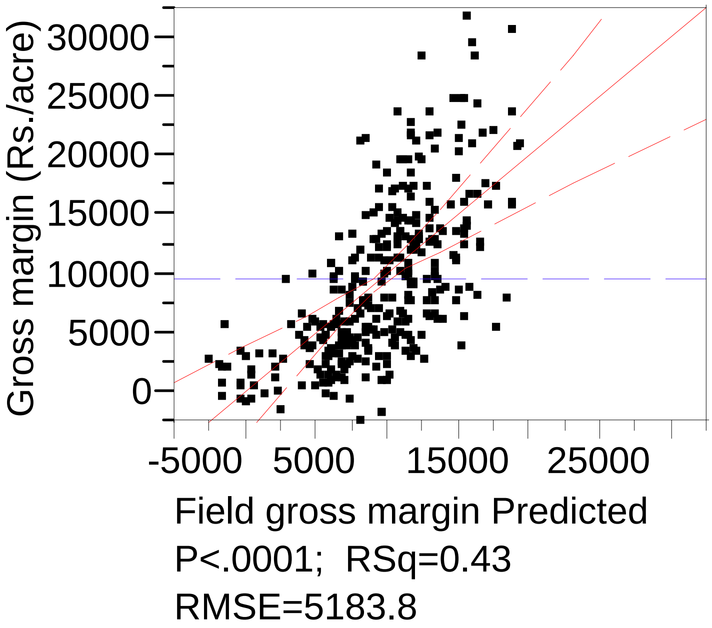


Summary of Fit

RSquare	0.527807
RSquare Adj	0.492916
Root Mean Square Error	209.6199
Mean of Response (kg/acre)	520.9101
Observations (or Sum Wgts)	219

6.6.3. Effect of non-inherent parameters on field gross margins

Model fit for gross margins



Summary of Fit

RSquare	0.42989
RSquare Adj	0.385176
Root Mean Square Error	5183.825
Mean of Response	9477.754
Observations (or Sum Wgts)	331

Effect Tests

Source	Sum of Squares	F Ratio	Prob > F
Farming System	326651982	12.1558	0.0006
Year	27020316	1.0055	0.3168
Wealth	8722785.32	0.1623	0.8503
Village	1001122406	3.3868	0.0002
Total rainfall (mm)	7562895.36	0.2814	0.5961
Gropping period	209360871	7.7910	0.0056
Crop duration (days)	27057532.3	1.0069	0.3164
Micro-irrigation	12509004.3	0.4655	0.4956
Clay content	13045495.1	0.4855	0.4865
Irrigation rounds	115885340	4.3125	0.0387
Irrigation quantity (l)	42025680.3	1.5639	0.2120
Labour wages (Rs./d)	441657319	16.4356	<.0001
Cotton rate (Rs./kg)	362980714	13.5077	0.0003

Effect of farming system on field gross margins

System	Corrected Mean (Rs./ha)	Std Error (Rs./ha)	Mean without correction (
Organic cotton fields	11196.957	1015.8556	11614.9
Conventional cotton fields	8871.368	998.9014	8339.9

6.7 Bibliography

Adams, J. A., Z. Hamzah, et al. (1991). "Availability and Uptake of Boron in a Group of Pedogenetically-related Canterbury, New Zealand Soils." Aust. J. Soil Res. **29**: 415-423.

Alam, S. M. and M. H. Naqvi (2003). Pakistan Agriculture - 2003. Pakistan Economist. Karachi, Pakistan.

Drinkwater, L. E., P. Wagoner, et al. (1998). "Legume-based cropping systems have reduced carbon and nitrogen losses." Nature **396**: 262-265.

Eyhorn, F., S. G. Ratter, et al. (2005). Organic cotton crop guide. A manual for practitioners in the tropics. Frick, Switzerland, FiBL.

Eyhorn, F., S. Verma, et al. (2003). Detailed Concept of the Maikaal Research Project. Project Document. Frick, Switzerland, FiBL.

Fließbach, A., H.-R. Oberholzer, et al. (submitted). "Soil organic matter and biological soil quality indicators after 21 years of organic and conventional farming." Agriculture Ecosystems and the Environment.

Garibay, S. and J. Katke (2003). Market Opportunities and Challenges for Indian Organic Products. Frick, FiBL.

Giovannucci, D. (2005). Organic agriculture and poverty reduction in Asia: China and India Focus. Thematic evaluation. Rome, International Fund for Agricultural Development (IFAD).

Jackson, G. J. (1989). Insecticide Resistance - the challenge of the decade. Pest management in cotton. M. B. Green and D. J. de B.Lyon. West Sussex, Ellis Horwood Ltd.**:** 27-30.

Lima, P. and T. S. Oliveira (2000). "The experience of family farmers from Taua, Brazil organic cotton." Leisa **16**(4): 18-19.

Lotter, D. W. (2003). "Organic agriculture." Journal of Sustainable Agriculture **21**(4): 59-128.

Mäder, P., A. Fließbach, et al. (2002). "Soil fertility and biodiversity in organic farming." Science **296**: 1694-97.

Marquardt, S. (2001). Organic cotton: production and marketing trends in the U.S and globally-2000. 2001 Proceedings Beltwide Cotton Conferences.

Mendoza, T. C. (2004). "Evaluating the benefits of organic farming in rice agroecosystems in the Philippines." Journal of Sustainable Agriculture **24**(2): 93-115.

Meyer, A. (2001). Produktbezogene ökologische Wettbewerbsstrategien. Wiesbaden, Deutscher Universitats Verlag.

Myers, D. and S. Stolton (1998). Organic Cotton. From Field to Final Product. London, Intermediate Technology Publications.

Oberson, A., J. M. Besson, et al. (1996). "Microbiological processes in soil organic phosphorus transformations in conventional and biological cropping systems." Biol. Fertil. Soils **21**: 138-148.

Oehl, F., E. Sieverding, et al. (2003). "Impact of land use intensity on the species diversity of arbuscular mycorrhizal fungi in agroecosystems of central Europe." Applied and Environmental Microbiology **69**: 2816-2824.

Oswald, A. and J. Sauerborn (1995). "Ecological methods of management - a niche for cotton production." Tropenlandwirt **96**(October): 127-140.

Oxfam, I. (2002). Cultivating Poverty. The Impact of US Cotton Subsidies on Africa. Oxfam Briefing Paper**:** 36.

Parrott, N. and T. Marsden (2002). The Real Green Revolution- Organic and agroecological farming in the south. London, Green Peace Environmental Trust.

Poswal, A. and S. Williamson (1998). Stepping Off the Cotton Pesticide Treadmill- Preliminary findings from a farmer particiatory cotton IPM training project in Pakistan, CABI Bioscience centre, Pakistan and CABI Bioscience UK Centre**:** 2-9.

Praharaj, C. S. and T. P. Rajendran (2004). Soil salinity management in cotton. The Hindu. Coimbatore, India.

Rajendran, A. T. P., B. M. V. Venugopalan, et al. (2000). Organic cotton farming in India. Agricultural technologies, Indiaagronet.

Ramesh, P., M. Singh, et al. (2005). "Organic farming: Its relevance to the Indian context." Current Science **88**(4): 561-568.

Roberson, R. R. (2000). Major World Cotton Producers for 1999-2000. 2000 Beltwide Cotton Conferences.

Rogers, E. M. (1995). Diffusion of innovations. New York, The Free Press.

Schumacher, P. (2004). Comparison of Conventional and Biological Cotton Production in India, Maikaal Area: Cropping Patterns, Production Costs and Farmer Income (Diploma thesis). Department of Geography. Zurich, University of Zurich. Diploma.

Schwaller, C. (2004). Agricultural decision-making with regard to organic cotton farming in the Nimar region, and the role of women in the decision-making process. Philosophical Faculty. Fribourg, University of Fribourg. Licenciat.

Schwank, O., N. North, et al. (2001). Freshwater and Cotton Field Case Studies. Assessment of selected cotton projects in India,Pakistan and Turkey. Zurich, WWF Switzerland.

Shah, T., S. Verma, et al. (2005). Social impact of technical innovations. Study of Organic Cotton and Low Cost Drip Irrigation in the Agrarian Economy of West Nimar Region. Anand, India, IWMI.

Summer, M. E., Ed. (2000). Handbook of Soil Science. Entisols, CRC Press.

The Pesticides Trust (1998). "Success with Cotton IPM." Pest management Notes **10**.

Tilman, D., K.G. Cassmann, P.A. Matson, R. Naylor, and S. Polasky (2002). "Agricultural sustainability and intensive production practices." Nature **418**: 671-677.

Ton, P. (2002). Organic cotton Production in Sub saharan Africa: The need for scaling up. Proceedings of the 14th International IFOAM Organic World Conference,Victoria, Canada., Victoria Canada, IFOAM; Tholey-Theley; Germany.

Ton, P. (2004). The international market for organic cotton. 04 Cotton: A European conference on developing the Organic Cotton market, Hamburg, PAN-Germany.

Ton, P., D. Foguelman, et al. (1998). Organic cotton and sustainability in northern Benin. Organic agriculture the credible solution for the 21st Century. Proceedings of the 12th International IFOAM Scientific Conference, Mar del Plata, Argentina, November 15-19, 1998., Mar del Planta, IFOAM; Tholey-Theley; Germany.

Townsend (2001). World Cotton market conditions. Cotton economics and marketing conference.

Valenghi, D. (2002). Organic fibres- Organic cotton production in Mali. Third International Conference on Organic textiles 7-9 August 2002 Düsseldorf Germany, Düsseldorf Germany, Institute for marketecology Weinfelden Switzerland.

Vidyasagar, R. M. and K. Suman Chandra (2004). Debt Trap Or Suicide Trap? Countercurrents.org. Hyderabad, Centre for Social Development, National Institute of Rural Development. 2005.

von Boguslawski, C. and T. Basedow (2001). "Studies in cotton fields in Egypt on the effects of pheromone mating disruption on Pectinophora gossypiella (Saund.) (Lep., Gelechiidae), on the occurrence of other arthropods, and on yields." Journal of Applied Entomology-Zeitschrift Fur Angewandte Entomologie **125**(6): 327-331.