Final Report
Consolidated Scientific Report

VEGSYS

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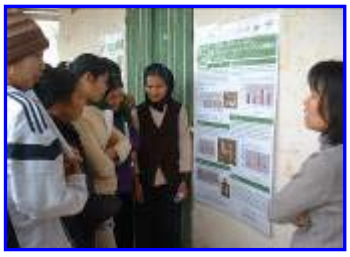

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Sustainable technologies for pest, disease and soil fertility management in smallholder vegetable production in China and Vietnam (VEGSYS)

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Abstract

The overall objective of this project was to assist in the development of economically viable vegetable production systems without compromising the natural resource base in China and Vietnam.

To achieve this goal the following activities were carried out using the following methodologies:

- Identified and analysed the key biophysical and economic constraints to productivity, profitability and sustainability of smallholder vegetable farming systems. Using the following methodologies:
  - Rapid Diagnostic Appraisal
  - Quantitative farm monitoring using the NUTMON Toolbox
  - Multi-disciplinary analysis of collected information
- Developed and tested in a participatory manner improved soil fertility, pest and disease management techniques in vegetable farming systems with increased efficiency of use, effectiveness and reduced impact on the environment. Using the following methodologies:
  - Multi-disciplinary research design of solutions for focus crops and focus problems using elements of the Participatory Technology Development approach
  - Farmer field trials
- Created and applied a simple tool to assess leaching hazard of pesticide use for the study areas in Sichuan, China and Northern Vietnam. Using the following methodology:
  - Application of the PEARL model under local conditions
- Identification of marketing strategies that increase the profitability of vegetable production. Using the following methodologies:
  - Structure-Conduct-Performance approach
  - Market surveys among consumers, retailers, collector and wholesalers
  - Value chain analysis
- Made information on developed technologies widely available to farmers and formulation of complimentary policy and programme options at the local or regional level to promote adoption of the improved production techniques. Using the following methodologies:
  - Organisation of feedback meetings with farmers, traders, extension and other stakeholders
  - Dissemination of results through the popular media (TV and Newspapers)
  - Policy level workshops were organised in both countries
  - Presentation of results in national, international conferences and publication of results in scientific journals

The following major results were achieved:

- Comprehensive analysis and publications of major constraints in vegetable cultivation in Hanoi Province and Pengzhou County
- Successfully developed and tested cultivation innovations for four major vegetables, of which three innovations provided a financially viable and more sustainable alternative compared with the current farmer practices
- Publication of the first and only quantitative assessments in Sichuan Province of the risks of leaching of pesticides to groundwater
- Analysed and published, for the first time ever in Sichuan Province, the results of the comprehensive marketing studies on vegetables
- Analysed and published the results of the vegetable value chain analysis in Hanoi Province and the current and potential role of cooperatives
- Developed a Good Agricultural Practices protocol for a smallholder vegetable cooperative in Hanoi Province
- Linked VEGSYS farmers to an important company in Europe. Developed and implemented a value chain in which smallholder vegetable farmers export fresh vegetables from Vietnam to Europe.
- Three new software tools were developed and made available for use in scientific research

Dissemination:

- 38 project reports were published and made available on the project website
- Seven papers presented in international conferences and three papers accepted for conferences after the project date
- Four papers published in international journals
- Fourteen papers published in national scientific journals in China and Vietnam
- One paper published in an international popular scientific agriculture journal
- Various articles in local newspapers and appearances in regional TV programs
- Organised six large workshops for wide range of stakeholders ranging from farmers, traders, extensionist, agribusinesses, policymakers to researchers
- More than 5000 hits on the project website: www.vegsys.nl from people located in at least 25 different countries and from the following continents:
    - 67% of hits from Europe
    - 28% of hits from Asia
    - 5% from North America
    - 1% from Africa
    - 1% from Australia
    - 1% from Latin America
    - 2% unknown

The following steps are taken to ensure application of the results:

- A project with a large supermarket chain and a large agriculture input supplier started in January 2006 to develop sustainable vegetable value chains in which farmers will receive continuous technical backstopping and long term supply contracts to reward them for their use of more sustainable cultivation practices
- A PhD project was started to develop sustainable year-round vegetable rotation schemes for the Red River Delta in North Vietnam
- A PhD project was started to study in more detail how public policy in Vietnam can have more impact to influence the safe and more rational use of pesticides in horticulture
- A special cooperation program between various Dutch and Chinese government agencies and institutes was started to improve the pesticide registration testing procedures in China. In this program use will be made of the VEGSYS developed PRIMET software, which is a tool to carry out environmental risk assessments of pesticides.
- Several of the VEGSYS project team members in Vietnam and from the Netherlands started a private consulting and R&D company to assist all actors within a supply chain to better produce, package and market vegetables
- In China several of the VEGSYS team members are starting a company to assure farmers get access to high quality vegetable seedlings

1 Summary of Final Report

1.1 Objectives

The general objective of this project is to contribute to the development of economically viable vegetable production systems by smallholder farmers in Sichuan Province, China and Northern Vietnam without compromising the natural resource base. To achieve this goal, improved technologies for vegetable cash crop production will be developed using a combination of on-farm testing and participatory experimentation. To achieve this general objective the following specific objectives were formulated:

1. To identify and analyse the key biophysical and economic constraints to productivity, profitability and sustainability of smallholder vegetable farming systems.
2. To develop and test in a participatory manner improved soil fertility, pest and disease management techniques in vegetable farming systems with increased efficiency of use, effectiveness and reduced impact on the environment.
3. To create and apply a simple tool to assess leaching hazard of pesticide use for the study areas in Sichuan, China and Northern Vietnam.
4. To identify marketing strategies that increase the profitability of vegetable production.
5. To make information on developed technologies widely available to farmers and to formulate complimentary policy and programme options at the local or regional level to promote adoption of the improved production techniques.

1.2 Activities

1.2.1 WP1: Identification of key constraints to productivity, profitability and sustainability

- Selection of research sites
- Training of a research team of 20 Vietnamese researchers and 16 Chinese researchers in farmer participatory research
- Implementation of a rapid diagnostic appraisal in two sites in Vietnam and three sites in China
- Development of a tailor made version of the NUTMON software
- The development of Weed, Pest and Disease monitoring forms, software and database, which is linked to the NUTMON farm database
- Developed the Word to Access Reporting Tool (WART) for the production of farm reports in the English and local languages (Chinese and Vietnamese)
- A seven days NUTMON and WPDmon training course in China and Vietnam
- Quantitative farm monitoring
    - → 124 farms in China and Vietnam monitored 1x per month
    - → Occurrence and incidence of pests, diseases and weeds monitored on 20 farms in China and 20 farms in Vietnam
    - → 14 months of monitoring data entered in databases and checked.
    - → 124 farm reports in English, 60 farm reports in Chinese and 64 farm reports in Vietnamese
- Soil sampling protocol developed for the four different research sites
- Soil samples collected an analysed
- Analysis of the farm monitoring data and compilation of four disciplinary analysis reports
- The analysed data of the quantitative farm monitoring were fed back to farmers in several workshops, based upon which the design for the experiments in WP 2 were made.

1.2.2 WP2: Integrated testing of improved techniques for plant protection and soil fertility management

- Training of Chinese and Vietnamese research teams in participatory crop problem identification and solution development

- Crop problem and solution workshops organised in 4 research sites
- Innovation protocols developed for four different vegetables
- Additional fertilizer recommendation trial designed for research site in Vietnam
- Experimental farmers selected by the farmers in the research sites
- Trials implemented with the selected farmers
- Trials monitored to collect quantitative data on agronomic performance, financial data, changes in soil fertility, occurrence of pests, diseases and weeds.
- Organised mid-term review field meetings with all farmers in the research sites
- Organised full-term review meetings with all farmers in the research sites to qualitatively assess the results of the trials
- In Vietnam the trials were repeated three times for each crop
- In China the trials were only carried out one time because of the long crop growth and cultivating the crop in the right season
- Collected data of the trials were analysed, published in reports and presented back and discussed with main stakeholders in the vegetable sector in the 4 research sites.

1.2.3 WP3: Pesticide leaching

- An inventory was made of farmers' perceptions of environmental and health risks
- Based on the quantitative farm monitoring, hazard assessments were made for the crop management practices currently applied by farmers in the research areas
- Field measurements were done to be collect data for the various parameters needed for the PEARL model
- A quantitative risk assessment for groundwater was undertaken with the PEARL model
- Analysis and reporting

1.2.4 WP4: Marketing strategies

- Training of research teams in China and Vietnam in marketing research in general and the Structure-Conduct-Performance approach in general
- In Pengzhou County (Sichuan Province, China) a formal structured questionnaire was used to interview a large number of wholesalers and semi-structured guidelines were used to interview other actors along the vegetable chain. A detailed list can be seen as follows:
    - Structured questionnaire interview of 213 vegetable wholesalers
    - Interviewed 3 vegetable storage companies
    - Interviewed 6 vegetable transporters
    - Interviewed 10 vegetable processors
    - Interviewed 10 vegetable retailers
    - Interviewed 10 vegetable growers
    - Interviewed relevant governmental officers, including the Vegetable Office and Bureau of Industry and Commerce
- In Vietnam the survey focused on the retail sector, the following activities were carried out:
    - Field survey of 40 retail markets
    - Interview 5 supermarkets
    - Interview 5 vegetable shops
    - Structured-interviews of 209 vegetable retailers
    - Literature review
- Study implemented on the vegetable sourcing by leading vegetable processors in Pengzhou (China)
- Study among a representative group of vegetable consumers in Chengdu about their preferences for different public and private food safety standards
- In depth case study of vegetable supply chains to supermarkets in Chengdu (China)
- A large study was conducted among vegetable cooperatives in Hanoi Province to investigate how joint action can be successful to link smallholders to large markets.

1.2.5 WP5: Dissemination and recommendations

- Organisation of the seminar "Development of sustainable horticulture in Hanoi Province", March 28th, 2003. 30 different stakeholders ranging from farmer extension, researchers, district level and provincial level government officials.
- Organisation of the seminar "Development of sustainable horticulture in Penghzou County", February 21st, 2004, Penghzou, Sichuan Province, China. Participation of 60 different stakeholders ranging from farmer union, traders, county level and provincial level government officials. The meeting was covered by a television station in Sichuan Province
- Organisation of two farmer feedback workshops with results of farm monitoring, one in Penghzou (China) and one in Dong Anh (Vietnam)
- Organisation of two crop solution development workshops with farmers, one in China and one in Vietnam
- Organisation of two mid-term review workshops with researchers and farmers in Vietnam
- Organisation of trial result workshops in Vietnam with farmers, researchers, extension, farmer union and agriculture district officials. The meeting was covered by national newspapers
- Publication of simple leaflets with a summary of the trial results and implications
- Thirty eight VEGSYS project reports were made and published on the VEGSYS website
- Project results presented in various international conferences
- Project results published in various international and national journals

1.3 Results achieved

1.3.1 WP1: Identification of key constraints to productivity, profitability and sustainability

1.3.1.1 WP 1.1: Rapid Diagnostic Appraisal

In both countries the implementation of the RDA was very successful. In Vietnam a team of about 20 researchers, all from different backgrounds, cooperated closely and wrote two very informative reports, based upon (group) discussions with in total about 180 farmers. In China the team of 16 researchers, also covering a large number of disciplines, managed to implement the RDA in three villages, about which they also wrote three reports. The Chinese team managed to base these reports on the opinions of in total about 244 farmers. The large response and willingness of the farmers to participate during the RDA and the high attendance of farmers during the feedback workshops indicates that there is a good basis for cooperation between the researchers and farmers in all villages.

The RDA revealed that within the villages quite some diversity in wealth classes and farm types could be distinguished. For each of those different wealth classes and farm types different problems and opportunities with regard to vegetable farming were found. For example, the poorest group of farmers, which on average made up about 10 percent in all villages, even had problems in meeting their food requirements. These farmers had very different soil fertility management possibilities compared with the other wealth classes. While for the large majority of the farmers the information seems to indicate that too much nutrients are applied (nutrient accumulation), the poorer farmers do not seem to apply enough nutrients (nutrient mining). These examples show that it is difficult to generalise, but still quite some similar results were found in all villages. As both in China and Vietnam the same kind of policy reforms were implemented also remarkably the same kind of changes in the farming systems occurred. Farmers shifted from food crop production to vegetable production and also off-farm income become more important. These shifts have led to high intensive farming systems, in which farmers use large amounts of chemical biocides and fertilizers. In Vietnam for example the nitrogen input to the crops through urea ranged between 230 and 894 kilograms per hectare. So this nitrogen gift does not yet contains the nitrogen through compound and organic fertilisers.

The largest constraint with regard to marketing for farmers in all investigated villages were the volatility of the prices and their unpredictability. Vegetable prices fluctuate day by day, making it difficult for farmers to plan. Farmers were also worried that within their own villages they were competing against each other. Therefore, farmers see a need of uniting themselves and try to obtain fixed contracts for the supply of their vegetables to shops and restaurants. In China the farmers wanted the Pengzhou Vegetable Association to play a role in this and in Vietnam already some local initiative within the villages was taken to form a production and marketing group. These groups are still very small, consisting of only five members in one village and seven members in the other village, but a good initiative to which our project can contribute. Of all vegetable production activities, the management of pests and diseases were perceived as the most complicated aspect. In Vietnam the number of pests and diseases seem to have increased the last five years, for which farmers blame the high cropping intensity and monocultures. Leaving land fallow and treat it with lime during one or two seasons was mentioned as a technical solution, but with the little land that farmers have this does not seem an option, probably only for households who have enough off-farm income. In China farmers also had the impression that the number of pests and diseases increased, for which they thought that both pesticide resistance and climate change were responsible. According to them rainfall has increased the last 20 years and the winters have become less cold and the summers warmer.

A key element which came out of all RDAs was that farmers perceive the lack of knowledge as an important bottleneck in vegetable production. Farmers are especially interested in knowledge with regard to the use of chemicals (pesticides and chemical fertilizers). The institutional analysis made by the farmers showed that the national extension services do not seem to supply this information, if they do it is mostly about rice cultivation and not about vegetable cultivation. Therefore, farmers were very interested and willing to cooperate with the VEGSYS project.

1.3.1.2 WP 1.2: Farming systems analysis

All four research sites are located in the most important vegetable growing areas of their province. The trend of a large and rapid increase in the sown area with vegetables that occurs both in China and Vietnam at a national level, also takes place in the districts of our research sites. Despite this fast and growing importance of vegetables, the farming systems in the four research sites are still engaged in both rice crop production for own consumption, livestock rearing and off-farm activities. The hard work of the farmers in the four research sites, resulted in quite modest incomes. In Vietnam the average family earnings, which includes all income (cash and non cash) from farming activities (both livestock and crops) and off-farm income, were just below US$ 1000 per household per year. Of these total family earnings, about 42% was generated with the cultivation of vegetables and between 8 and 14% by rice. The family earnings per consumer unit were below one US$ per day. In China the average family earnings were well above US$ 1,000 per in Shengli village and just below this figure in Xibei. Farmers in Shengli had on average the highest dependence on vegetables (50%) for their income and Xibei the lowest (30%). In all four villages off-farm income forms a substantial part of the family earnings, ranging between 34% and 47% in the four sites.

In both countries the production of vegetables mainly takes place in the cool winter season, while in the warm summer season wet rice is cultivated. In Vietnamese sites soil type varies mainly from sandy loam to medium loam and soil organic matter content is low. Both low soil fertility and bad soil structure are important bottlenecks. The problem with soil structure is mainly caused by the alternation of dry land vegetable crops on raised beds with the cultivation of wet rice. The high cropping intensity and low soil fertility (both organic and inorganic) makes fertilizers the most important cost item for farmers. These costs range between 43 and 52 percent of all cash expenses. Cash expenses on pesticides are the third most important cost item ranging between 14 and 17% of total cash expenses. As this is a substantial cost, pesticide reduction from an environmental point of view might also be interesting for farmers from a financial point of view. In the Chinese research sites soil fertility is much better, although one of the locally identified soil type is rather shallow. But also in China fertilizers are the most important cost item, about 41 to

50% of total costs. The big difference with the Vietnamese research villages is that farmers in the Chinese sites only spend cash on mineral fertilizers. This is not compensated by higher use of organic fertilisers from their own farm. The Vietnamese farmers even have more manure available as they have slightly more animals. In the Chinese villages it will be more difficult to reduce pesticide use through a financial incentive as the total cash spent on pesticides is only 7% of the total cash expenses.

What is most striking of the monitoring data is the huge variation in management strategies among farmers. An enormous variation in different types of inputs and quantities applied on the same kind of crops, cultivated on the same soil types and within the same period. Twenty farmers in one village who cultivated wrapped heart mustard for example used 72 different brands of pesticides. In another village 22 farmers who cultivated cowpea used 75 different brands of pesticides. Off course input use and timing of the input is influenced by many factors such as the occurrence of certain pests, diseases and/or weeds, resources of the household but most important the knowledge of the farmers. Although quite some of these brands probably contained the same kind of active ingredients, these examples clearly illustrate how farmers are desperately seeking and trying to solve their problems. The only one who seems to be able to provide some " solution" are the pesticide shops. This clearly illustrates the need for farmers to increase their knowledge and for the development of good agricultural practices.

1.3.1.3 WP 1.2: Agronomic constraints

In the two VEGSYS research sites in Vietnam, in Dong Anh district, Hanoi Province, the production of dry land vegetables mainly takes place in the cool winter season, while in the warm wet summer season rice is cultivated. Major vegetable crops cultivated belong to the *Brassicaceae*, *Solanaceae* and *Cucurbitaceae.* Most of the crops are transplanted. The soil type in the two villages varies mainly from sandy loam to medium loam and soil organic matter content is low. A qualitative analysis of the vegetable cultivation system in two villages, indicated low product quality, poor transplant production and suboptimal soil conditions as major constraints for the production of high quality vegetable products for upscale commercial markets. It is expected that these and other constraints can be alleviated when a system of permanent dry-land vegetable cultivation is adopted. A proposal for such a vegetable production system has been formulated and will be studied in a separate PhD program as a follow up of the VEGSYS project.

For the two research sites in the peri-urban area of Pengzhou County, Sichuan Province, China, a description of the climate and soils of the villages and details of the cropping system and cultivation techniques of the major vegetables has been made. Vegetable production is an important activity for farmers in Shengli and Xibei and a great number of different vegetable species are cultivated. Vegetable cultivation is mainly concentrated in the winter season. The largest single vegetable crop is garlic, followed by lettuce. Most of the vegetable crops are transplanted and grown in rotation with wet rice. A small area is used for continuous dry land vegetable production. The length of the vegetable growing period varies with the vegetable cultivars and the cultivation period. Some vegetables are sown directly in the field, most vegetables, however, are transplanted. Seed supply is mainly from commercial markets. Both fertilizers and organic manure are used. Pesticides are frequently used for pest and disease control. Quality criteria for products are not clearly defined. Prices are positively related to the appearance of the vegetable product. Recommendations to improve the vegetable production focus on variety research, modern transplant production methods, off-season cultivation and improved knowledge on pest and disease control.

1.3.1.4 WP 1.3: Pest and disease problems

In both sites the management of pests and diseases is a major bottleneck for farmers. In the Vietnamese sites several common brassicaceous insect-pests like *Plutella xylostella, Phyllotreta striolata* were commonly found on field cabbage. Two major diseases were observed on field cabbage, i.e. leaf yellowing (unidentified pathogen*)* and *Plasmodiophora brassicae.* However, as

per farmers' perception, pests caused more damage to their field cabbage crop than diseases. In addition *Bemisia tabaci*, *Liriomyza sativae, Spodoptera litura, Helicoverpa armigera, Phytophthora infestans, tomato virus, Ralstonia solanacearum* on tomato in Sondu, and *P. xylostella, P. striolata, S. litura, Xanthomonas campestris pv cam*, and an unidentified leaf spot disease on kohlrabi (for both Tangmy and Sondu) were recorded. In Tangmy, on wax gourd, *Thrips palmi, L. sativae, Cercospora* spp., *Erwinia* spp. and wax gourd viruses were the most important insect, pests and diseases, respectively. In China the most important biotic constraint was thrips outbreaks on vegetable crops and thrips-caused yield losses, especially in garlic. Thrips were the most frequently recorded pests on various vegetables. Combined virus infections and thrips damage possibly made the garlic plants susceptible to freezing damage during early January, explaining the high prevalence of the so-called "Huo Feng" disease in both villages. Other notorious pests were whiteflies on summer vegetables in both villages with partly high population levels. Monitoring data and interviews with farmers revealed the presence of leafminers (*Liriomyza* spp.). Especially *Liriomyza huidobrensis* was a very important pest in both villages. Yet farmers were able to effectively control leafminers by using abamectin. Generally, plant diseases were very damaging to the crops and poorly controlled by farmers. Here all incidence data is based on observation of symptoms. *Fusarium* and *Verticillium* wilt, *Fusarium* and *Phytophthora* root rot resulted in complete losses of the plants and were poorly controlled in both villages. Even *Sclerotinia* and *Botrytis* rot on lettuce and other vegetables, easily to be controlled by carbendazim spraying, were commonly observed at harvest.

1.3.1.5 WP 1.4: Soil fertility problems

In Dong Anh the soils in both research sites belong to the Acrisols soil group. The topsoil texture in both sites generally varies from sandy loam to medium loam. In Tang My village the majority of the soils belong to the sandy loams, with the second largest group belonging to the medium loam type. In Son Du village about half of the soils belong to the light loams, while the remainder are mostly of a more light texture. The clay content of the soils increases with depth. The top soils mostly are acid to medium acid. In Son Du the area with acid (pH-H_2O < 5.5) to very acid (pH-H_2O < 4.5) soils is about 80 %. For Tang My this value is only 18 %. The top soils are poor in organic matter and nitrogen. Organic matter contents were found to be in the range of 0.55 to 1.26 %. Total nitrogen varied from 0.06 to 0.11 %. Potassium content of the soils is low. Total K_20 values were below 0.6 %. Available K_20 mostly was below 10 mg 100 g^{-1} soil, but in some areas available K_2O was higher, probably due to past fertilizer application. The Cation Exchange Capacity (CEC) of the top soils is limited. In Son Du most of the area had a CEC below 6 meq 100 g^{-1} soil. For Tang My CEC in the majority of the soils was in the range of 6 to 13 meq 100 g^{-1} soil. In general the soils of the Tang My area appear to be more fertile as compared to the Son Du area soils.

The rather light texture of the top soils implies a limited water holding capacity. In combination with the low CEC, the low pH values and the low organic matter content of the soils this indicates a low basic soil fertility and a low nutrient holding capacity. The low water holding capacity and the low basic soil fertility are the main constraints of these soils for vegetable cultivation. In view of the soil characteristics, another physical constraint could be a weak structural stability, limiting workability. No data are available to evaluate this assumption. The structural stability of this type of soils could be negatively influenced by the repeated wetting and drying, when dryland vegetable production is alternated with wet rice cultivation.

Field observations for vegetables showed only a limited tilled topsoil layer of about 15 to 25 cm deep and a compact subsoil with a clear horizon boundary just below the tilled topsoil. This latter characteristic probably limits subsoil drainage. In combination with the limited water storage capacity of the tilled topsoil, this may result in surface run-off in case of short bursts of abundant precipitation.

In Penghzou County (China) the soils in the research sites can be classified as grey alluvial soils. Based on the soil classification of the farmers and observations made by the soil scientists, this general soil type was split up in three different local soil types. These three soil types where

further investigated through soil profiles and soil analysis. Especially the Shatian soil is rather shallow, with large stones appearing in the lower layers. Therefore, farmers mention as the main problem of the Shatian soil the low water and nutrient holding capacity. For the Nitian soil they mention as the main constraint the stickiness of the soil which makes it hard to plough. For Youshatian farmers did not see any constraints.

The soil fertility sampling revealed that in general soil fertility of all three soil types is good. In soil fertility no differences could be found between the three local soil types, only in the texture and soil depth. These results confirm the problems mentioned by the farmers, the shallowness of the Shatian soil, making it difficult to hold water, while the Nitian texture of clay loam explains why farmers might find this soil type difficult to plough.

As can be seen in the soil maps, the Youshatian soil type covers by far the largest area in both villages. As this soil type had little problems according to the farmers, the constraints by the soils in vegetable production seem to be limited. The second largest part of both villages are covered by the Shatian soil type, which had more problems. So specific attention to soil related problems should be given to farmers cultivating vegetables in the part of the village where the Shatian soil is located.

1.3.1.6 WP 1.5: Analysis and feedback to farmers

Both the Chinese and Vietnamese team organised two farmer feedback workshops. These meetings have been documented in two project reports (PR09 and PR10). In preparation of the final feedback workshop, LEI, SFI and HAU produced individual farm reports in English, Chinese and Vietnamese. Each farmer of the 124 monitored farmers got their own report in which their farm management and financial performance are compared with the average of the village. During the final feedback workshop (see reports PR20 and PR21) farmers selected the focus crops for the innovation experiments.

1.3.2 WP 2: Integrated testing of improved techniques for plant protection and soil fertility management

1.3.3 WP 2.1: Formulation of integrated pilot experiments

Based on the priorities of farmers and an assessment of researchers the following four focus crops for improved and more sustainable production technologies were selected (see Figure 2):

- Garlic (Xibei, Pengzhou County, China)
- Eggplant (Shengli, Pengzhou County, China)
- Wax gourd (Tang My, Dong Anh district, Vietnam)
- Wrapped heart mustard (Tang My, Dong Anh district, Vietnam)

During crop problem identification workshops in April 2004 farmers and researchers had discussions about the most urgent problems in the focus crops. The aim of these workshops was to select the most urgent problem for which solutions had to be developed and which would be tested by the farmers. These workshops were prepared and implemented by the VEGSYS teams in China and Vietnam and backstopped by Prabhat Kumar. Combining the collected data, with the cropping calendar approach and leading questions farmers came up with the the most urgent problems which they could not solve (see Table 1). Based on the selected crops and focus problems the researchers developed possible solutions and a protocol of how to test these solutions (See table 1). These solutions were discussed extensively with the farmers, after which the protocols were updated.

In addition to the these protocols, farmers in one research site in Vietnam also indicated to want more knowledge on fertilizer use on their main vegetable crop, wrapped heart mustard. Therefore, the VEGSYS team designed a fertilizer experiment, in which it involved a Dutch MSc. Student to work closely with the farmers and a Vietnamese student.

Table 1 Solutions tested for focus crops and focus prolems

Country	Crop	Problem	Tested solution
Vietnam	Wax gourd	Virus transmitted by thrips	Thrips control with Spinosad
	Wrapped heart mustard	Club root disease	Timing and dose of lime application
		Non optimal ferilizer use	Fertilizer dose rates
China	Garlic	Virus	Improved fertilizer application
	Eggplant	Wilt complex including verticillium wilt	Grafting local varieties on verticillium wilt resistance rootstock vareties

The complete protocols were published in the following VEGSYS reports:

PR22 Innovation protocol for thrips control in wax gourd and control of club root disease in wrapped heart mustard in Dong Anh district

PR23 Innovation protocols for improved and sustainable management of garlic and eggplant

PR32 Fertiliser recommendations for field vegetables in Dong Anh district

1.3.3.1 WP 2.2: On farm testing

Within each of the four research sites, the farmers selected 3 to 5 experiment farmers who would carry out the experiments. On farm trials were executed with them. At the start, halfway and at the end of the trial, field days were organized to invite all other farmers in the village to monitor the trials and understand the results. The periods in which each of the trials took place are presented below.

Table 2 Solutions tested for focus crops and focus prolems

Country	Crop	Number of seasons tested
Vietnam	Wax gourd	1st cropping cycle: October 2004 to January 2005 2nd cropping cycle: February 2005 to May 2005 3rd cropping cycle: June 2005 to August 2005
	Wrapped heart mustard	1st cropping cycle: October 2004 to December 2005 2nd cropping cycle: February 2005 to March 2005 3rd cropping cycle: April 2005 to June 2005
	Wrapped heart mustard: fertilizer	1st cropping cycle: September 2005 to November 2005
China	Garlic	1st cropping cycle: September 2004 to May 2005
	Eggplant	1st cropping cycle: research station variety trials 2nd cropping cycle: April 2005 to August 2005

1.3.3.2 WP 1.3: Analysis of results

The complete results of the trials are presented in the following reports:

PR24 Mid-term review of wax gourd innovation experiment in Dong Anh district, Vietnam

PR30 Farmer reviews of wax gourd and wrapped heart mustard experiments in Tang My & Son Du

PR32 Fertiliser recommendations for field vegetables in Dong Anh district

PR33 Effect of timing of lime application on management of club root disease on wrapped heart mustard, Dong Anh, Hanoi, Vietnam.

PR34 Effect of spinosad application on the management of thrips transmitted viruses on wax gourd in Dong Anh district, Vietnam.

PR35 Studies on the effects of fertilization and Messenger® application on garlic yield and diseases

PR36 Control of Verticillium wilt of eggplant using rootstock "Torubam"

The results of the trials were analysed and discussed with farmers in various workshops. Leaflets and large posters were made which were used in a "roving poster exhibition". Each experimental farmer presented back one poster to all the other farmers in the village.

Main results of eggplant experiments

Verticillium Wilt is one of the most important diseases in eggplant productions. It caused severe losses in northern China and has spread to southern China and becoming one of the main constrains on eggplant production in recent years. One of the effective control methods of this disease is to root eggplants on resistant rootstocks. This study tested to grow rootstocks

"Torubam" and "Chiqie" in greenhouses to 5-6 leaves old before the grafting of the cutting varieties at the stages of 4-5 leaves. Eggplants of different varieties as well as the grafted plants were transplanted to pots of soil after the recovering of the cutting on the rootstocks. Suspension of Verticillium dahliae conidia were poured into the pot soil 7 days after transplanting to observe the disease symptom and death of the plants every two days. There is significant difference in latent days, disease and death rates between the different varieties and rootstocks. Eggplant "Shuzha No. 1" was susceptible to Verticillium wilt but had the longest latent days and lowest death rates. Both rootstocks "Torubam" and "Chiqie" were found to be immune to the isolate used in the experiment.

The planting of the susceptible variety rooted on "Torubam" in the fields of the three farmers at Shengli village in Pengzhou City, Sichuan Province of China has resulted in an significant decrease in disease plants and increase in the eggplant yield although the secondary infection has still to be eliminated. Higher grafting joint and the avoiding of the transmission of the fungus by scissors had show satisfying results.

Main results of fertilizer trials for garlic

Garlic is an important vegetable crop in China. The study site is one of the top 10 Chinese garlic production areas. Garlic area accounts for more than 80% of the vegetable area of Xibei village (the study village), and garlic has been planted more than 20 years at this place. Because of the long history of garlic planting and without commercial breeding, garlic was infected by many plant viruses, the garlic product quality and yield was reduced strongly. In this study, three experiments about fertilization protocols and spraying plant activator HarpinEA were carried out from September, 2004 to May, 2005 in 4 farmers' fields at Tianpeng Township of Pengzhou City, Sichuan, China in rotation with rice to find the method of garlic virus controlling. From the results of experiments, it can be concluded that fertilization protocol 1, which are currently applied by the local farmers, could resulted in the higher yield of flower stalk of the garlic than control and protocol 2 which designed by researchers, and the similar yield of early stalk and cloves to that resulted from protocol 2. The data from this study showed no effects either by fertilization or spray of HarpinEA. The failure of the later treatment may be referred to many factors such as application dosages and local climate. The low temperature during the over-winter of garlic may be also an limiting factors.

Main results of thrips control trials for wax gourd

Wax Gourd is a high income crop for farmers in Tang My, Dong Anh district. A year long farm monitoring exercise preceded the innovation phase of the program; where on weekly basis the abundance of pests were monitored on most vegetables crops cultivated by farmers. A thorough post-monitoring analysis revealed that the thrips complex and thrips vectored tospoviruses are the most important reasons for the low productivity and quality of WG crop in the village.

The innovation development began with a clear objective to manage the thrips complex with Spinosad (Spinosyn A, 85%: Spinosayn D, 15%). Spinosad is a bio-rational pesticide derived from aerobic fermentation of the actinomycetes soil bacterium *Saccharopolyspora spinosa* with a world wide use on over 200 crops against insect-pest of several orders like Lepidoptera, Diptera, Thysanoptera, Siphonaptera, Coleoptera and Hymenoptera etc. yet have little effect on other insects, mammals or other wildlife and is classified as a reduced-risk pesticide by the US Environment Protection Agency (Cleveland et al., 2001). Therefore, Spinosad is allowed to be used in organic agriculture.

The main conclusions of the trials were:

1. Of the three seasons, the highest density of thrips was found in winter 2004 and the lowest in summer-fall 2005. Thrip density in spring-summer 2005 was a bit higher than that in summer-fall 2005.
2. The average of thrips on trap (thrips/cm2 BST) and thrips on leaf (thrips/cm2 leaf) in the control experiment was significantly higher than those in farmer's practice and SPINOSAD.

3. In general, under high rainfall conditions (Summer season) pesticides should be applied more often than under dry conditions (Winter season). But in case of thrips control, the number of thrips was much lower under high rainfall condition which counterbalances the higher runoff of the pesticides. In the summer season even the non-insecticide treatment performed quite well.
4. Because of the large problem with thrips in the winter season, the frequency of Spinosad application in the winter should have been increased, while in the summer it could have been decreased. This is also clear from comparing the financial performance. The higher investment in increased spinosad application is not compensated enough for by better yields.
5. The rate of virus-infected plants in the control (CT0) was always higher than that in farmer's practice (CT1) and in SPINOSAD (CT2). The average of proportion of infected virus plant in winter 2003 was 60% whereas that in the latter two seasons was 2% and 5%, respectively.
6. During the wet seasons (spring-summer and summer-fall 2004), the percentage of good fruits (identical fruits with dark green or white powder) was considerably higher than that in the dry season (winter 2004). The percentage of good fruits was lowest in the control (in winter 2004 more clear). There was almost no difference in the percentage of good fruits between farmer's practice and SPINOSAD treatments.
7. Yield of wax gourd in farmer's practice and in SPINOSAD treatment was greatly higher than that in the control. Yield of wax gourd in farmer's practice did not differ from that in SPINOSAD treatment.
8. Using SPINOSAD to eliminate thrips on wax gourd appears to be a better method compared to farmer's practice due to the following reasons: (1) fewer frequencies of spraying were done (2-4 times/season); 60-67% less amount of pesticides was used. Moreover, SPINOSAD is a far more environmentally friendly product compared to Marshal commonly used by farmers.
9. The financial performance of the Spinosad treatment in the winter season for farm 3 was significantly better than the no insecticide treatment. But the increased number of Spinosad applications in the spring and summer season did not result in a better financial performance compared with the non insecticide application and even worse compared with the farmers usual practice.

Main results of trials to control club root disease for wrapped heart mustard

Seven experiments were carried out in which the effect of the application of lime was studied for control of club root (Plasmodiophora brassicae) incidence on wrapped heart mustard (Brassicae juncea var. rugosa). Lime was applied at a rate of 603 kg/ha (CaO content: 71.7%), one or fourteen days before sowing. The rate of club root infection in the experiments was at a low level, ranging from 1.3 to 13.3 per cent. For all experiments combined, application of lime significantly reduced the incidence of club root disease. Indications were found that application of lime fourteen days before sowing gives better control than application one day before sowing.

Main results of fertilizer trials for wrapped heart mustard

Based on literature from the South East Asian region, recommendations for nitrogen, phosphorus and potassium fertiliser applications for fourteen vegetables commonly cultivated in Vietnam have been formulated. It is important to indicate that these results are suggestive rather than conclusive. Recommendations have to be tested under local field conditions.

Two field experiments were carried out in Hanoi province, Vietnam, to determine the effect of nitrogen on growth and yield of wrapped heart mustard (*Brassica juncea* var. *rugosa*). It was found that with the highest application of 200 kg/ha N no optimum for net weight was reached yet. The real optimum has to be determined in an experiment with a nitrogen application higher than 200 kg/ha. Since the experiments presented in this report did not cover such high applications, it is impossible to comment more precisely on the N application that would produce a crop with the highest net weight.

Concerning financial gains a notable optimum was found with a nitrogen application of 80 kg/ha. This was related to the preference crop collectors, consumers and farmers expressed towards a wrapped heart mustard crop with some yellow leaves at harvest. It is likely that these yellowish leaves were now obtained due to nitrogen deficiency, but for the future there is an interest among

the involved farmers in the cultivation of different wrapped heart mustard varieties that produce crops with yellowish leaves. Since these varieties do not depend on nitrogen deficiency anymore to produce yellow leaves, an optimal N level can be applied, producing a crop with a higher net weight and financial yield.

The Apparent Fertiliser Recovery (AFR calculated as ((N uptake + fertiliser) – (N uptake – fertiliser)) / N gift) indicates that, although a larger quantity of nitrogen is taken up when more nitrogen is applied to the crop, the nitrogen utilisation declines. The share of applied nitrogen that is absorbed by the crop reduces with higher applications, leading to larger shares of the fertiliser being lost to the environment. It is concluded that for economical and ecological reasons attention has to be paid to the development of methods of fertiliser application that results in higher fertiliser recoveries.

1.3.4 WP3: Pesticide leaching

Many publications claim that the environmental problems caused by pesticide use in intensive agriculture in Asia are enormous. However, proper risks assessments, taking into account the hazard of the pesticides and the environmental setting in which they are used, are hardly ever done. In this study a well established pesticide leaching model was applied to the Chinese setting in order to estimate risks for groundwater. The results can be used to advise farmers on the use of pesticides in various settings.

It was concluded that the approach was successful, and could be improved on two aspects. First, simplification of the model is necessary for more extensive applications. Secondly, besides risk assessments for groundwater, risk assessments for soil, surface water and humans are required to fully assist farmers and policy makers. This approach was developed in a follow-up project.

The WP3 and work in a follow up project resulted in a monitoring tool (NUTMON-P) to get quantitative data of pesticide use for a large number of farmers. The results of the monitoring can be used in a risk assessment tool (PRIMET), to estimate the risks of certain pesticide application strategies. The comprehensive risks assessments can be used in three contexts:
(i) in environmental programs aiming at sustainable agriculture;
(ii) in supply chain management;
(iii) for pesticide registration purposes at national level.

1.3.5 WP4: Marketing strategies

In the marketing strategies work package a Structure-Conduct-Performance (SCP) analysis was carried out in both project locations, but with a slightly different approach. The SCP study in Hanoi focused more at the retail level while the Sichuan study targeted the wholesale level.

The major finding is that the vegetable sector in Pengzhou is going through a very dynamic phase. Its structure, conduct and institutions have been changing dramatically during the last two decades. Private players are currently dominating the whole vegetable supply chain. Market outlets are well developed with Pengzhou Wholesale Market at the centre and other small scale markets around. Improved infrastructure in Sichuan during the last decade further stimulated the vegetable production and expanded their market coverage to other parts of China. However, profit margin in the Pengzhou vegetable sector was stagnated or even dropped in recent years due to lower prices and increased competition from other part of China. Opportunities lie in several different dimensions. Vegetable processing industry is steadily developing in Pengzhou. This trend could both add more values to vegetables and absorb large quantity of local vegetables. However, the processing industry is under increasing pressures on improving their quality assurance systems demanded by their customers, mainly exporting companies. More funding channels should be available to enable them to update their processing technology. The local government could provide vegetable farmers with better information on new varieties and new market opportunities (specially supermarkets in Chengdu). Farmers should be more actively organising themselves

through co-operatives or associations so that they are more equipped to communicate with vegetable processing industry and supermarkets.

Regarding the vegetable retailing in Hanoi province, there are three types of retail marketing outlets, namely open markets, supermarkets and vegetable shops. The open markets can be further categorized as formal markets and informal markets, which differ in size, construction, and management aspects. A formal market is established by local authorities and monitored by the Department of Trade. An informal market is spontaneously set up but de factor accepted by the local community. Two types of retailers are active in the open markets, namely mobile retailers and fixed retailers. The Hanoi government estimates that there are 120 formal retail markets and 600 informal retail markets with over 200 of fixed and mobile retailers. These fixed retailers are most full time trades in a selected market while most mobile retailers are part time farmers who would like to make some extra income for their households. There are in total 13 supermarkets and 22 vegetable shops in Hanoi at this moment. Besides the traditional owners of these supermarkets, foreign joint venture is emerging as well. These two types of market outlets are specialised in marketing 'Safe Vegetables'. However, their market share only accounts for less than 2%. Nevertheless, the vegetable is priced here 4 times higher than in the open markets. In order to ensure higher quality products, most of these shops are contracting vegetable suppliers for 'Safe Vegetables'.

Our study of vegetable retailing in Hanoi shows how important the traditional retail sector is as an income generating activity for the poor. The current strengths of the traditional retail sector is expected to maintain its dominant position in the total retail sector. Supermarkets now have a share of 2% of vegetables sold to consumers in Hanoi, this share is expected to grow slowly, but at a slower pace than the total growth in demand for vegetables. But based on experiences in neighbouring countries, it is important for the traditional sector to innovate as on the long run supermarkets will become more important. Most important, innovation is needed in guaranteeing consumers vegetables which are safe to consume. Through cooperation with farmer groups, a few wholesalers and a group of traditional retailers this should be feasible.

Our study of sourcing practices by supermarkets in Chengdu (Sichuan Province, China) shows that small scale farmers are not necessarily excluded from the supermarket procurement system. Innovative institutions (such as associations and co-operatives) and local governments could facilitate this transition.

The VEGSYS team in Vietnam managed to link farmers to an European fruit and vegetables import company which built a post harvest centre in the project area, which also creates off farm jobs for the sorting, cleaning and packaging of the fresh products.

1.3.6 WP5: Dissemination and recommendations

1.3.6.1 Dissemination results

The following dissemination results were achieved:

- 38 project reports were published and made available on the project website
- Seven papers presented in international conferences and three papers accepted for conferences after the project date
- Four papers published in international journals
- Six papers published in national scientific journals in China and Vietnam
- One paper published in an international popular scientific agriculture journal
- More than 5000 hits on the project website: www.vegsys.nl from people located in at least 25 different countries and from the following continents:
    - 67% of hits from Europe
    - 28% of hits from Asia
    - 5% from North America
    - 1% from Africa, 1% from Australia, 1% from Latin America and 2% unknown

- Various articles in local newspapers and appearances in regional TV programs
- Organised six large workshops for wide range of stakeholders ranging from farmers, traders, extensionist, agribusinesses, policymakers to researchers

The following steps are taken to ensure application of the results:

- A project with a large supermarket chain and a large agriculture input supplier started in January 2006 to develop sustainable vegetable value chains in which farmers will receive continuous technical backstopping and long term supply contracts to reward them for their use of more sustainable cultivation practices
- A PhD project was started to develop sustainable year-round vegetable rotation schemes for the Red River Delta in North Vietnam
- A PhD project was started to study in more detail how public policy in Vietnam can have more impact to influence the safe and more rational use of pesticides in horticulture
- A special cooperation program between various Dutch and Chinese government agencies and institutes was started to improve the pesticide registration testing procedures in China. In this program use will be made of the VEGSYS developed PRIMET software, which is a tool to carry out environmental risk assessments of pesticides.
- Several of the VEGSYS project team members in Vietnam and from the Netherlands started a private consulting and R&D company to assist all actors within a supply chain to better produce, package and market vegetables
- In China several of the VEGSYS team members are starting a company to assure farmers get access to high quality vegetable seedlings

1.3.6.2 Recommendations

- In both China and Vietnam it is crucial that new farmer groups (in research sites in Penghzou) and existing ones strengthened. There is enough demand in the market to link these farmer groups directly to supermarkets, processors and large food caterers. The farmer groups will need skills on technical management of the vegetables, development of internal quality control systems, transparent financial management, facilitating group work, development of marketing strategies and sales skills
- There is an enormous need for more applied research on vegetable cultivation. Especially improvements in agronomic practices can be achieved. Hardly any clear GAPs are available for farmers. The VEGSYS project developed a team which can develop GAPs. So far this has been done for 4 different vegetables, while in one village (of 400 farms) about 30 to 40 different vegetables are cultivated.
- Currently vegetable production is rotated during the year with rice production, which has a very bad impact on soil structure and costs farmers a lot of extra labour. Furthermore, farm income could be tripled if vegetables could be produced year round. The possibilities for such a radical farming system change should be studied and experimented in detail.
- Quantification at both micro and macro level of the impacts of new emerging supply chains (supermarkets) on rural development, poverty reduction and participation of the poor

1.4 Problems encountered

- Language problems were the main reason for the change of subcontractor in China because the staff of the department of plant protection could hardly communicate in English. With the other partners this is not a big problem, only in writing English. Publishing results in international scientific journals, in policy briefs, and in a project working paper series, required a lot of writing and editing effort from the European partners.
- The main problem for the project in 2003 were the travel bans to China and Vietnam for the European partners, because of the SARS virus. For the same reason the Chinese partners also were confronted with some restrictions for travelling within Sichuan province. Thanks to the creativity of the project partners and their hard work, the problems caused by SARS did not lead to any serious delay in the implementation of project activities.

- Another problem was that due to health reasons the senior researchers of the Spanish partners could no longer travel to the project sites to backstop the soil fertility work. This problem was solved by carrying over the soil fertility backstopping to Alterra.
- The identification of the weeds from Vietnam took much more time than anticipated, because of the lack of relevant botanical data and literature concerning weeds in Vietnam.
- The limited analytical capacity of the laboratory of Hanoi Agriculture University was a big constraint in the determination of the exact virus in wax gourd. The same problem was also faced by the partners in Sichuan when they tried to identify the virus in the garlic. Trying to get plant samples to the laboratory of Hanover University was blocked by Chinese and Vietnamese custom authorities.
- For a four year project, with researchers from many different institutes and countries is has been remarkable how little turnover there has been in the participating researchers. This has allowed the formation of a very well cooperating international team, with a lot of friendships developing the different partners. But in the beginning of 2005, the VEGSYS team had to deal with one of the key-players leaving the project. The team leader of Hannover University, Prof Borgemeister, was offered the chance the become the director of ICEPE in Kenya and left his position for this new challenge. But luckily Hannover University was able to replace with Prof Borgemeister with Prof Poehling.
- In 2005 we discovered that the approach for risk assessments for groundwater could not be applied to the Vietnamese research site. Due to the complex hydrological and soil physical situation, the pesticide leaching model could not be applied. We recruited a student to do additional hydrological and soil physical field measurements that should yield enough information for further simulations. Unfortunately, this did not work out. Even with the new information model simulations could not be done. It was concluded that the water simulation module of PEARL is not suitable for simulation of water flow in soil profiles with highly smeared soil layers.

1.5 Conclusions

The conclusions are organised on the basis of key questions, which give insight on what the project has achieved, which lessons we have learned and what remains to be done.

1) Have the project results been used, and if yes by whom, where and how?

- As the technologies where developed with farmers the chance of uptake is large. It would probably be the best to have an monitoring and evaluation study next year to see how many farmers are now using the newly developed technologies.
- Our farm recording, monitoring and feedback system was an important reason for the private to work with the VEGSYS farmers, as farm monitoring is an important requirement for international markets
- The insight we provided into how farmers manage pest and diseases and why, is important information which is used to design a new product stewardship program funded by the private sector
- The insight in marketing and working with farmers forms the basis for the development of a domestic supply chain with a large international supermarket chain in 2006

2) What has been the benefit or impact?

- The largest impacts of the developed innovations are expected for the use of spinosad in thrips control in the winter period in Northern Vietnam. This impact will be mostly by much less environmental pollution, lower input costs and better quality of the wax gourd fruits. For Pengzhou County the new eggplant cultivation technology will have a large positive financial impact on the smallholders and will lead to much lower pollution levels.
- Farmers who are now supplying the export company achieve higher income levels and because indigenous herbs are exported no pesticides are needed in production. So farmers are switching from vegetables with high pesticide consumption to indigenous herbs for which zero to little amount of pesticides are needed.

3) Future research on Rural Development and Sustainable Agriculture

- There is an enormous need for more applied research on vegetable cultivation. Especially

improvements in agronomic practices can be achieved. Hardly any clear GAPs are available for farmers. The VEGSYS project developed a strong team which can develop GAPs. So far this has been done for 4 different vegetables, while in one village (of 400 farms) about 30 to 40 different vegetables are cultivated.

- Currently vegetable production is rotated during the year with rice production, which has a very bad impact on soil structure and costs farmers a lot of extra labour. Furthermore, farm income could be tripled if vegetables could be produced year round. The possibilities for such a radical farming system change should be studied and experimented in detail.
- Quantification at both micro and macro level of the impacts of new emerging supply chains (supermarkets) on rural development, poverty reduction and participation of the poor

4) Which insights were gained by employing a multidisciplinary methodology that would have been missed by disciplinary research?

- The insights which were gained during the Rapid Diagnostic Appraisal were based on the work of multi-disciplinary teams.
- During the VEGSYS project proposal design a mistake was made by not putting enough attention on agronomy. Thanks to the involvement of PPO, the crucial knowledge of vegetable agronomy became available and was of very big importance for the design of improved production technologies.
- The marketing research linked the farmers to markets where consumers are willing to pay for safe vegetables, which is an important incentive for the farmers to use the improved production technologies.

5) *Interactions between research and decision makers in China and Vietnam*

- Within China and Vietnam a lot of interaction with district and provincial level policymakers was achieved. But this resulted in no clear outputs. Only in Vietnam the intense relations with provincial level policymakers facilitated all arrangements to get permits for the Dutch company to build a post harvest centre in the project village. In China the provincial level policymakers were very interested in the financial results of the farm monitoring, but it is not clear what they did with this information.
- An interesting link was developed with a national level governmental organization (ICAMA) who is responsible in China for the licensing of pesticides for the Chinese market. They are very interested in using the tools which were developed and tested by Alterra in the VEGSYS project

6) Which important things remain to be done that could not be achieved by the project?

- All original project objectives have been achieved but so much more needs to be done to improve vegetable production and marketing.
- It would be very useful to evaluate one year after the project ended if the developed technologies are being used by the farmers
- Development of a clear handbook of for which crops, pest/disease combinations what pesticides (which can be bought on the local market) are the least worse to use and the specific GAP for that pesticide, crop-pest/disease combination
- Developing a science based system for pesticide admission in China and Vietnam

7) Which important challenges in the area of rural development in the tropics are there in the near future (say 5 to 10 years)?

- For both the research sites in China and Vietnam the challenge will be how all these smallholders can continue to grow out of poverty. Their small landholdings (0.27 ha per farm), makes it difficult to increase income. The coming 5 years there are still enough improvements which can be made, especially developing a sustainable system of year round vegetable production. But for the longer term it will be important to see how the government can create an enabling environment for good farmers (innovative, entrepreneurs). How can they grow? How can they obtain more land and capital? Land consolidation policies will be very crucial.
- How agro-chemical use by farmers can be influenced by a combination of policies, regulations, and market incentives

8) What type of research could contribute to addressing these challenges?

- Applied research which can improve productivity of smallholders, especially developing sustainable year round vegetable cultivation systems
- Policy research to find out how land consolidation should be organized, how land laws can be adjusted and how the growing group of farmers without land can be employed by successful growing farms.
- Impact assessment if government regulations and market incentives with regards to agrochemicals are influencing farmers in the right direction

1.6 Main publications

Besides the 38 VEGSYS project reports a large number of papers were presented in conferences (7 papers), national (18 articles) and international journals (4 articles).

Table 3 Main publications by the VEGSYS project

Authors	*Title paper*	*Conference/Journal*
Dr. Xiaoyong Zhang (LEI), Xinhong Fu (SAU) and Jinxiu Yang (SAU)	The Evolution of Chinese Vegetable Supply Chain	International conference of the International Food and Agribusiness Management Association (IAMA), 9-11 June 2004, Montreux, Switserland
M.S. van Wijk, Cuong Trahuu, Bu Thi Gia, Nguyen An Thru and Pham Van Hoi	The traditional vegetable retail marketing system of Hanoi and possible impacts of supermarkets	International conference on Supply Chain Management in Transitional Countries, International Society of Horticulture Science (ISHS), 19-23 July 2005, Chiang Mai, Thailand
Xiaoyong Zhang ,Xinhong Fu, Jinxiu Yang and M.S. van Wijk	Vegetable Supply Chains of Supermarkets in Sichuan, China and their Implication for Supply Chain Management	International conference on Supply Chain Management in Transitional Countries, International Society of Horticulture Science (ISHS), 19-23 July 2005, Chiang Mai, Thailand
A.P. Everaarts, Nguyen Thi Thu Ha and Pham Van Hoi	Agronomy of a rice-based vegetable cultivation system in Vietnam. Constraints and recommendations for commercial market integration	International conference on Supply Chain Management in Transitional Countries, International Society of Horticulture Science (ISHS), 19-23 July 2005, Chiang Mai, Thailand
Arij Everaarts, Nguyen Van Dung, Pham Van Hoi, Nguyen Thi Thu Ha	Some recommendations for a better vegetable production in Dong Anh peri-urban district, Hanoi City (in Vietnamese)	Vietnam Soil Science 23 (2005) 112-115
A.P. Everaarts, Nguyen Thi Thu Ha and Pham Van Hoi	Agronomy of a rice-based vegetable cultivation system in Vietnam. Constraints and recommendations for commercial market integration	Acta Horticulturae, February 2006
M.S. van Wijk, Cuong Trahuu, Bu Thi Gia, Nguyen An Thru and Pham Van Hoi	The traditional vegetable retail marketing system of Hanoi and possible impacts of supermarkets	Acta Horticulturae, February 2006
Xiaoyong Zhang ,Xinhong Fu, Jinxiu Yang and M.S. van Wijk	Vegetable Supply Chains of Supermarkets in Sichuan, China and their Implication for Supply Chain Management	Acta Horticulturae, February 2006
M.S. van Wijk, R. Engels, Tran Huu Cuong, Nguyen Anh Tru and Pham Van Hoi	Opportunities for farmers: "safe" vegetables for Hanoi.	LEISA Magazine, June 2005
Xiaoyong Zhang , Tran Huu Cuong, Nguyen Anh Tru and Siebe van Wijk	Vegetable Co-operatives: Linkage of Small Farmers and Markets	Paper accepted for presentation during the 7th International Conference on Management in Agrifood Chains and Networks (Ede, 2006)
Pham Van Hoi (HAU), Lin Chaowen (SFI) and Rik van den Bosch (Alterra)	Leaching potential of pesticides used in peri-urban vegetable farming in Hanoi (Vietnam) and Chengdu (China)	The 4th World Conference of the "Society of Environmental Toxicology and Chemistry (SETAC)", 14-18 November 2004, Portland, USA.
Rik van den Bosch, Lin Chaowen and Pham van Hoi	"Inventory of pesticide use and farmers' perception in peri-urban vegetable production in Hanoi (Vietnam) and Chengdu (China)"	The 4th World Conference of the "Society of Environmental Toxicology and Chemistry (SETAC)", 14-18 November 2004, Portland, USA.

Authors	*Title paper*	*Conference/Journal*
LIN Chao-wen; CHEN Yi-bing; HUANG Jing-jing; Rik van den Bosch; Mechteld M. S. ter Horst	Effect of irrigation on pesticides leaching in vegetable farming in Chengdu plain using PEARL model (in Chinese)	ECOLOGY AND ENVIRONMENT
Xiong Wenlan; Chen Yibing Lin Chaowen	The Pollution Evaluation of Pesticide Infiltration to Groundwater by PEARL Model(in Chinese)	Science of Soil and Water Conservation
XIONG Wen-lan; CHEN Yi-bing	Research review of the effect of pesticide leaching on groundwater(in Chinese)	Southwest China Journal of Agricultural Sciences
LIN Chao-wen, CHEN Yi-bing, HUANG Jingjing, Rik van den Bosch	Pesticide Use and Related Risks for Groundwater Pollution in Vegetable Production in Pengzhou County, Sichuan Province, China	Southwest China Journal of Agricultural Sciences
Fu X.H	Present status and countermeasures analyses: The study of vegetable industry	Journal on Rural Economy, Vol.9，2003
Fu X.H, Yang J.X	Marketing opportunities and countermeasures analyses: The study of Chinese vegetable market	Journal on Xinjiang Reclamation Economy, Vol.2，2003
Yang J.X, Fu X.H	Vegetable-intermediary agency's contribution to farmers' income	Journal on Rural Economy, Vol.11，2003
Li D.M, Xiao H.A, Fu X.H	Present status and countermeasures analyses on industrialization of Pengzhou vegetable	Research of Agricultural Modernization, Vol. Special issue，2003
Yang J.X, Fu X.H	Logistics distribution of fresh produce's distribution to farmers' income, in: Development of agricultural science and technology	Sichuan Doctor & expert Forum Publishers，2004
Yang J.X	Strategy on development of vegetable wholesale market	Journal on Rural Economy, Vol.4，2004
Yang J.X, Fu X.H	Logistics distribution study on fresh produce	Rural Economy and Science-Technology, Vol.9，2004
Zhang S.Q, Fu X.H	SCP analyses on production of garlic bolt	Journal on Rural Economy, Vol.5，2004
Chen L.N, Yang J.X	International competitiveness of processing food in China	Research of Agricultural Modernization, supplementary issue，2004
Xie Y.J, Fu X.H	Study on Behaviour of Farmer Households' Vegetables Production	Journal on Rural Economy, Vol.3,2005
Zhang J, Fu X H	Supply Chain Management and Vegetable Delivery,	Rural Economy and Science-Technology, Vol.7，2005
Zhang J, Fu X H Yang J X	Supermarket Vegetable dealing and Market Behaviour of Supply-chain Participants: A Case Study of Chengdu Sichuan	Journal on Rural Economy, Vol.1,2006

With regard to PhD's and MSc's the following results were achieved:

→ In China:
- 2 Chinese researchers obtained their PhD based on the work in the project.
- 2 Chinese researchers obtained their MSc
- 1 Dutch student carried out her MSc thesis in the VEGSYS project

→ In Vietnam:
- 5 Dutch students carried out their MSc thesis in the VEGSYS project
- 1 Vietnamese researcher started with his Phd in Wageningen University based upon VEGSYS methodology and data (WOTRO scholarship)

2 Objectives

The general objective of this project is to contribute to the development of economically viable vegetable production systems by smallholder farmers in Sichuan Province, China and Northern Vietnam without compromising the natural resource base. To achieve this goal, improved technologies for vegetable cash crop production will be developed using a combination of on-farm testing and participatory experimentation. To achieve this general objective the following specific objectives were formulated:

a) To identify and analyse the key biophysical and economic constraints to productivity, profitability and sustainability of smallholder vegetable farming systems.
b) To develop and test in a participatory manner improved soil fertility, pest and disease management techniques in vegetable farming systems with increased efficiency of use, effectiveness and reduced impact on the environment.
c) To create and apply a simple tool to assess leaching hazard of pesticide use for the study areas in Sichuan, China and Northern Vietnam.
d) To identify marketing strategies that increase the profitability of vegetable production.
e) To make information on developed technologies widely available to farmers and to formulate complimentary policy and programme options at the local or regional level to promote adoption of the improved production techniques.

Figure 1 Eggplant trials in China with clear difference between grafted and non-grafted eggplants

3 Activities

3.1 WP1: Identification of key constraints to productivity, profitability and sustainability

- Selection of research sites
- Training of a research team of 20 Vietnamese researchers and 16 Chinese researchers in farmer participatory research
- Implementation of a rapid diagnostic appraisal in two sites in Vietnam and three sites in China
- Development of a tailor made version of the NUTMON software
- The development of Weed, Pest and Disease monitoring forms, software and database, which is linked to the NUTMON farm database
- Developed the Word to Access Reporting Tool (WART) for the production of farm reports in the English and local languages (Chinese and Vietnamese)
- A seven days NUTMON and WPDmon training course in China and Vietnam
- Quantitative farm monitoring
    - → 124 farms in China and Vietnam monitored 1x per month
    - → Occurrence and incidence of pests, diseases and weeds monitored on 20 farms in China and 20 farms in Vietnam
    - → 14 months of monitoring data entered in databases and checked.
    - → 124 farm reports in English, 60 farm reports in Chinese and 64 farm reports in Vietnamese
- Soil sampling protocol developed for the four different research sites
- Soil samples collected an analysed
- Analysis of the farm monitoring data and compilation of four disciplinary analysis reports
- The analysed data of the quantitative farm monitoring were fed back to farmers in several workshops, based upon which the design for the experiments in WP 2 were made.

Figure 2 From left to right: Siebe van Wijk (LEI), Dr. Arij Everaarts (PPO), Rik vd Bosch (Alterra), Ms. Huong (HAU) and Pham Van Hoi (HAU) checking soil types in Tang My (Vietnam)

3.2 WP2: Integrated testing of improved techniques for plant protection and soil fertility management

- Training of Chinese and Vietnamese research teams in participatory crop problem identification and solution development
- Crop problem and solution workshops organised in 4 research sites
- Innovation protocols developed for four different vegetables
- Additional fertilizer recommendation trial designed for research site in Vietnam
- Experimental farmers selected by the farmers in the research sites
- Trials implemented with the selected farmers
- Trials monitored to collect quantitative data on agronomic performance, financial data, changes in soil fertility, occurrence of pests, diseases and weeds.
- Organised mid-term review field meetings with all farmers in the research sites
- Organised full-term review meetings with all farmers in the research sites to qualitatively assess the results of the trials
- In Vietnam the trials were repeated three times for each crop
- In China the trials were only carried out one time because of the long crop growth and cultivating the crop in the right season
- Collected data of the trials were analysed, published in reports and presented back and discussed with main stakeholders in the vegetable sector in the 4 research sites.

Figure 3 Lime application to control club root disease in wrapped heart mustard

3.3 WP3: Pesticide leaching

3.3.1.1 Work plan for field work

In September 2002 a work plan for WP 3 for the entire project period was developed. Since no financial means were available to perform risk assessments for groundwater, surface water and soils, etc. the team decided in the project initiation phase to focus on risk assessments for groundwater. Based on the results of the RDAs and expert knowledge of the local partners this choice was reconsidered and still considered the best choice, since risks for groundwater seamed to be highest. The work plan therefore focussed on a risk assessment for groundwater.

Guidelines were developed for field work to gather the necessary input for the pesticide leaching model. This entailed information on soils, climate, groundwater, hydrology and crops. Data on pesticide applications by farmers were used from the NUTMON surveys in WP 1. The work plan is described in detail in VEGSYS MR4 (WP3 Pesticide Leaching: Start up of field activities)

3.3.1.2 Backstopping field work

During a complete year the field work was carried out by HAU and SFI with continuous backstopping of the activities by Alterra through email and phone. During the 1st Project Workshop

(Feb 2003) and during an extra visit (Nov 2003) Alterra assisted the partners with the field work and interpretation of the data. All results of the field work are presented in the annexes of Bosch et al., 2006.

3.3.1.3 Contribution to farm monitoring and development of NUTMON-P

The NUTMON monitoring tool used for the farm monitoring had to be adjusted to properly monitor pesticide applications and generate useful output for the environmental analyses. This involved development of a monitoring strategy and carry out adaptation in the NUTMON software. This entailed facilities to register the use of all local formulations, link this (with a concentration) to an active ingredient in database with active ingredients and their physical and chemical properties, changes in the data processing facility and an extra data export facility. This resulted in the NUTMON-P tool (P stands for pesticides), a tool suitable to monitor pesticide use in vegetable farming. The partners were coached in the additional monitoring.

3.3.1.4 Database for formulations, active ingredients and active ingredient properties

After the first season of monitoring an analysis was made of pesticide application by farmers in the four research villages. For each village the 25 most frequently used pesticides were selected. For each pesticide the active ingredients and their concentrations were determined by the Asian partners. A search was done by Alterra in international literature and databases to gather the required chemical and physical parameters for each of the active ingredients encountered. These parameters are required for hazard assessments and risk assessments.

3.3.1.5 Inventory of farmers' perceptions of environmental and health risks

Based on the results of the RDA farmers (63 in Dong Anh; 39 in Pengzhou) were interviewed focusing on the following topics:

- identification of pests and diseases and selection of pesticides against a specific pest or disease;
- main sources of information farmers use for pest and disease control;
- consumption patters of farmers (vegetables and water);
- health issues and the possible relation with pesticide use.

3.3.1.6 Hazard assessments

Based on the farm monitoring, hazard assessments were made for the crop management practices currently applied by farmers in the research areas. Hazard estimations are based on pesticide parameters solely and do not take into account site specific aspects, such as climate, soil type and application practices. Therefore hazard estimations give a relative ranking of the hazards associated with pesticide use patterns. Hazard assessments do not differentiate between different circumstances, such as soil types, climate, crops or application strategies. A hazard assessment can be performed in many different ways. In this study three different types of hazards are considered: occupational hazard to human health, hazard to aquatic life , and hazard to groundwater pollution. For each type of hazard a hazard indicator is selected, which are described below.

The *WHO Classification by hazard* is used to classify pesticides according to the acute risk to health that might be encountered accidentally by a person handling the product in accordance with the directions for handling by the manufacturer. The classification distinguishes between the more and the less hazardous forms of each pesticide in that it is based on the toxicity of the chemical compound and on its formulation. Therefore, allowance is made for the lesser hazards from solids as compared to liquids. The classification is primarily based on the acute oral and dermal toxicity to the rat. Provision is made for the classification of a particular compound to be adjusted if, for

any reason, the acute hazard to man differs from that indicated by the LD_{50} assessments alone (WHO, 2004).

The *Aquatic Toxicity Index* (ATI) is used to classify the pesticides according to their acute hazard to aquatic life. The classification is based on the No Effect Concentration (NEC, ug/l) to the water flea Daphnia. Dissipation rate in water is not taken into account. Decision rules according to Table 2 were used.

Table 4 Relation between the NEC and the Aquatic Toxicity Index

NEC (ug/L)	***Aquatic Toxicity Index***
<0.01	Very high
0.01-0.1	High
0.1 – 1	Moderate
1 – 10	Low
>10	Very Low

The *GUS or Groundwater Ubiquity Score* (Wauchope et al., 1992) is used to rank pesticides for their potential to move towards groundwater. GUS is an empirically derived value that relates pesticide persistence (half-life) and sorption in soil (sorption coefficient, K_{oc}). The GUS index is calculated as follows

$$GUS = \log\ (DT_{50}) \times [4 - \log (K_{oc})]$$

The pesticide movement rating is derived from the GUS. Movement ratings range from extremely low to very high. The GUS should be interpreted as indicated in Table 3.

Table 5 Relation between the GUS index and the potential to move to groundwater

GUS	***potential to move to groundwater***
<1	Very low
1.0-2.0	Low
2.0-3.0	Moderate
3.0-4.0	High
>4.0	Very high

The soil half-life (Degradation Time 50%: $DT_{50,soil}$) is a measure of the persistence of a pesticide in soil. Pesticides can be categorized on the basis of their half-life as non-persistent, degrading to half the original concentration in less than 30 days; moderately persistent, degrading to half the original concentration in 30 to 100 days; or persistent, taking longer than 100 days to degrade to half the original concentration. A "typical soil half-life" value is an approximation and may vary greatly because persistence is dependent on variations in site, soil, and climate.

The sorption coefficient (K_{oc}) describes the tendency of a pesticide to bind to soil particles. Sorption retards movement and may also increase persistence because the pesticide is protected from degradation. The higher the K_{oc}, the larger the sorption potential. K_{oc} is derived from laboratory data. Many soil and pesticide factors may influence the actual sorption of a pesticide to soil.

3.3.1.7 Risk assessment for groundwater

The RDAs and interviews showed that farmers in the research areas depend for 95% on groundwater for domestic use, including drinking. Most farmers use their own drilled wells (depth 15-20 meters) and in Pengzhou (China) some farmers still use open, hand-dug wells, which are shallower (8-10 meters). In combination with the intensive use of pesticides, we expect a possible risk for groundwater pollution and health of persons using groundwater for consumption.

For a risk assessment estimated or measured exposure concentrations have to be compared with safe concentrations. In this study the exposure concentrations were defined as the average annual concentration in the percolating soil water at the bottom of the soil profile. This concentration is

estimated using the computation model PEARL (Pesticide Emission Assessment at Regional and Local scales). This model predicts (amongst others) pesticide leaching to groundwater under specific circumstances (see 2.5.2). The EU drinking water standard of 0.1 ug/l is used for all active ingredients as a safe concentration.

Model simulations were done at Alterra using the results of the field work by HAU and SFI. At SFI one staff was trained to use the PEARL model. She made additional simulations in order to estimate the effect of irrigation on pesticide leaching in the Pengzhou area.

3.3.1.8 Analysis and reporting

The results of the hazard assessments and risk assessments were reported in PR17.

- An inventory was made of farmers' perceptions of environmental and health risks
- Based on the quantitative farm monitoring, hazard assessments were made for the crop management practices currently applied by farmers in the research areas
- Field measurements were done to be collect data for the various parameters needed for the PEARL model
- A quantitative risk assessment for groundwater was undertaken with the PEARL model
- Analysis and reporting

Figure 4 Study soil profiles for PEARL model in Dong Anh district

3.4 WP4: Marketing strategies

- Training of research teams in China and Vietnam in marketing research in general and the Structure-Conduct-Performance approach in general
- In Pengzhou County (Sichuan Province, China) a formal structured questionnaire was used to interview a large number of wholesalers and semi-structured guidelines were used to interview other actors along the vegetable chain. A detailed list can be seen as follows:
    - Structured questionnaire interview of 213 vegetable wholesalers
    - Interviewed 3 vegetable storage companies
    - Interviewed 6 vegetable transporters
    - Interviewed 10 vegetable processors
    - Interviewed 10 vegetable retailers
    - Interviewed 10 vegetable growers
    - Interviewed relevant governmental officers, including the Vegetable Office and Bureau of Industry and Commerce
- In Vietnam the survey focused on the retail sector, the following activities were carried out:
    - Field survey of 40 retail markets
    - Interview 5 supermarkets
    - Interview 5 vegetable shops
    - Structured-interviews of 209 vegetable retailers
    - Literature review
- Study implemented on the vegetable sourcing by leading vegetable processors in Pengzhou (China)
- Study among a representative group of vegetable consumers in Chengdu about their preferences for different public and private food safety standards
- In depth case study of vegetable supply chains to supermarkets in Chengdu (China)
- A large study was conducted among vegetable cooperatives in Hanoi Province to investigate how joint action can be successful to link smallholders to large markets.

3.5 WP5: Dissemination and recommendations

- Organisation of the seminar “Development of sustainable horticulture in Hanoi Province”, March 28th, 2003. 30 different stakeholders ranging from farmer extension, researchers, district level and provincial level government officials.
- Organisation of the seminar “Development of sustainable horticulture in Penghzou County”, February 21st, 2004, Penghzou, Sichuan Province, China. Participation of 60 different stakeholders ranging from farmer union, traders, county level and provincial level government officials. The meeting was covered by a television station in Sichuan Province
- Organisation of two farmer feedback workshops with results of farm monitoring, one in Penghzou (China) and one in Dong Anh (Vietnam)
- Organisation of two crop solution development workshops with farmers, one in China and one in Vietnam
- Organisation of two mid-term review workshops with researchers and farmers in Vietnam
- Organisation of trial result workshops in Vietnam with farmers, researchers, extension, farmer union and agriculture district officials. The meeting was covered by national newspapers
- Publication of simple leaflets with a summary of the trial results and implications
- Thirty eight VEGSYS project reports were made and published on the VEGSYS website
- Project results presented in various international conferences
- Project results published in various international and national journals

4 Results

4.1 WP1: Identification of key constraints to productivity, profitability and sustainability

4.1.1 WP 1.1: Rapid Diagnostic Appraisal

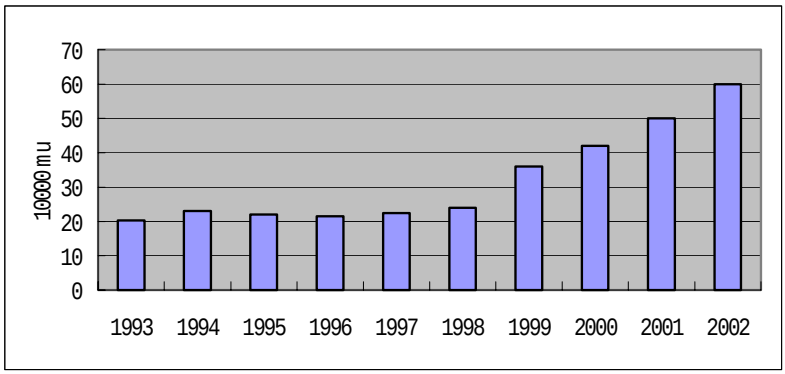
4.1.1.1 Research sites

Both the research sites in Vietnam and China are located in the proximity of very large cities. The two villages in Dong Anh district are about 30 to 40 kilometres from the city centre of Hanoi, with an population of about three million persons, a large market for fresh vegetables. The two villages in Pengzhou County are also located about 40 kilometres from Chengdu, a huge city with a population of about 10 million persons.

Figure 5 Maps of research locations (indicated by red oval) in Hanoi Province (left map) and Sichuan Province (right map)

The rapid urbanisation in both countries the last decade and the increasing incomes, of especially the urban population, have led to an enormous increase in the demand for vegetables. As can be seen in Figures 6 and 7, both in Pengzhou and Hanoi farmers have reacted to this demand by increasing their sown area with vegetables.

Figure 6 Sown area with vegetables in Pengzhou county (in 10,000 mu[1])

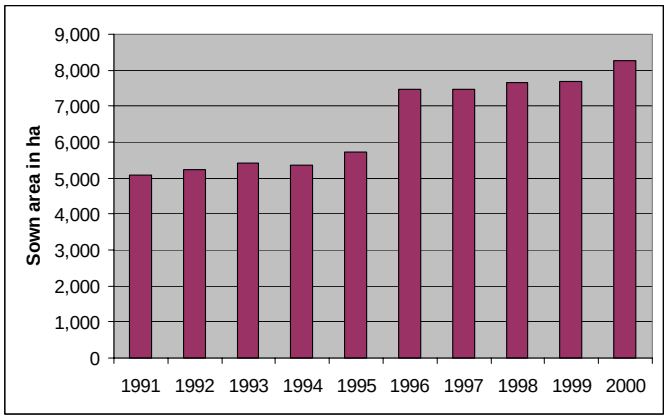


Source: VEGSYS Project report no. PR11

[1] 1 ha = 15 mu

Pengzhou county is the most important vegetable production area of Sichuan Province and has the largest vegetable wholesale market of West China. Within Hanoi Province, Dong Anh district is the most important vegetable producing district. So in both countries, research sites were selected in the most important vegetable production areas which supply the megapoles of Hanoi and Chengdu with fresh vegetables.

Figure 7 Area used for vegetable production in Hanoi Province



Source: Hanoi Statistical Office, 1994, 1998 and 2000

4.1.1.2 Rapid Diagnostic Appraisal

In both countries the implementation of the RDA was very successful. In Vietnam a team of about 20 researchers, all from different backgrounds, cooperated closely and wrote two very informative reports, based upon (group) discussions with in total about 180 farmers. In China the team of 16 researchers, also covering a large number of disciplines, managed to implement the RDA in three villages, about which they also wrote three reports. The Chinese team managed to base these reports on the opinions of in total about 244 farmers. The large response and willingness of the farmers to participate during the RDA and the high attendance of farmers during the feedback workshops indicates that there is a good basis for cooperation between the researchers and farmers in all villages.

The RDA revealed that within the villages quite some diversity in wealth classes and farm types could be distinguished. For each of those different wealth classes and farm types different problems and opportunities with regard to vegetable farming were found. For example, the poorest group of farmers, which on average made up about 10 percent in all villages, even had problems in meeting their food requirements. These farmers had very different soil fertility management possibilities compared with the other wealth classes. While for the large majority of the farmers the information seems to indicate that too much nutrients are applied (nutrient accumulation), the poorer farmers do not seem to apply enough nutrients (nutrient mining). These examples show that it is difficult to generalise, but still quite some similar results were found in all villages. As both in China and Vietnam the same kind of policy reforms were implemented also remarkably the same kind of changes in the farming systems occurred. Farmers shifted from food crop production to vegetable production and also off-farm income become more important. These shifts have led to high intensive farming systems, in which farmers use large amounts of chemical biocides and fertilizers. In Vietnam for example the nitrogen input to the crops through urea ranged between 230 and 894 kilograms per hectare. So this nitrogen gift does not yet contains the nitrogen through compound and organic fertilisers.

The largest constraint with regard to marketing for farmers in all investigated villages were the volatility of the prices and their unpredictability. Vegetable prices fluctuate day by day, making it difficult for farmers to plan. Farmers were also worried that within their own villages they were competing against each other. Therefore, farmers see a need of uniting themselves and try to obtain fixed contracts for the supply of their vegetables to shops and restaurants. In China the

farmers wanted the Pengzhou Vegetable Association to play a role in this and in Vietnam already some local initiative within the villages was taken to form a production and marketing group. These groups are still very small, consisting of only five members in one village and seven members in the other village, but a good initiative to which our project can contribute. Of all vegetable production activities, the management of pests and diseases were perceived as the most complicated aspect. In Vietnam the number of pests and diseases seem to have increased the last five years, for which farmers blame the high cropping intensity and monocultures. Leaving land fallow and treat it with lime during one or two seasons was mentioned as a technical solution, but with the little land that farmers have this does not seem an option, probably only for households who have enough off-farm income. In China farmers also had the impression that the number of pests and diseases increased, for which they thought that both pesticide resistance and climate change were responsible. According to them rainfall has increased the last 20 years and the winters have become less cold and the summers warmer.

A key element which came out of all RDAs was that farmers perceive the lack of knowledge as an important bottleneck in vegetable production. Farmers are especially interested in knowledge with regard to the use of chemicals (pesticides and chemical fertilizers). The institutional analysis made by the farmers showed that the national extension services do not seem to supply this information, if they do it is mostly about rice cultivation and not about vegetable cultivation. Therefore, farmers were very interested and willing to cooperate with the VEGSYS project.

4.1.2 WP 1.2: Quantitative surveys of production systems

4.1.2.1 Climate

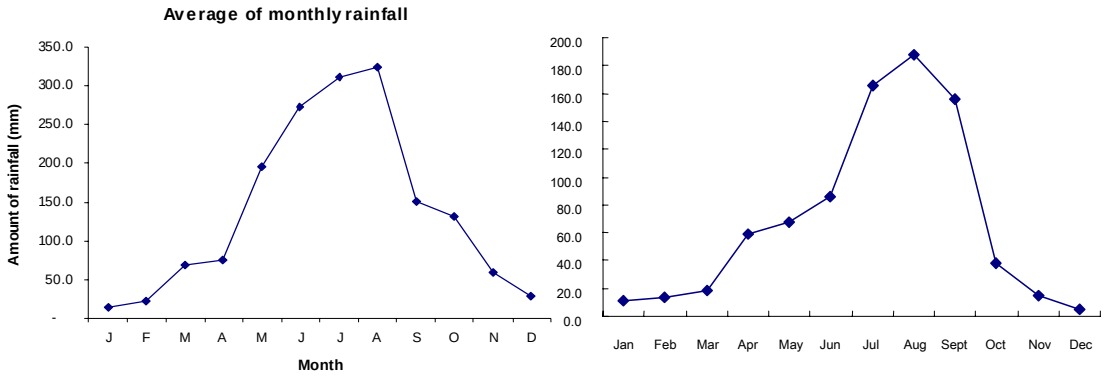
Vietnam

Dong Anh district has a tropical monsoon climate. Mean annual rainfall is around 1,660 mm. There is considerable variation in distribution of precipitation during the year. The amount of rainfall is limited in the period from November to April, the dry season. The period from May to October is characterized as the rainy season. Monthly precipitation in this period increases to a maximum of more than 300 mm around July to August, then decreases towards January. Available radiation, as indicated by the average number of sunshine hours per month, is lowest in January and increases towards a maximum in July. The mean daily temperature follows the same pattern as mean monthly sunshine hours. The average annual daily temperature is 24.2 ^{o}C. Relative humidity does not fluctuate as much during the year as the average monthly rainfall or the average monthly sunshine hours. Lowest values for average daily relative humidity are found from November to January. Maximum average daily relative humidity is recorded in April, 84 %.

China

In Pengzhou County the average annual precipitation is 822 mm, which is about half the amount which falls down in Dong Anh district. Although about 62% of the rainfall in Pengzhou is falling during three months, July to September, there is still some rainfall in April (59.0 mm), May (68.1 mm) and June (85.4 mm). As can be seen in the graphs, the dry season is approximately from November to March and the wet season from April to September.

Figure 8 Average monthly rainfall in Dong Anh district (left figure) and Pengzhou County (right picture)



Source: VEGSYS project report series PR14 and PR15

In both Dong Anh and Pengzhou the main vegetable production season is from about August/September until February/ March, when the temperatures are lower (the winter season). This clearly implies the importance of irrigation, as rainfall is very low during these months.

4.1.2.2 Soils

Vietnam

In Dong Anh the soils in both villages belong to the Acrisols soil group. The topsoil texture in both villages generally varies from sandy loam to medium loam. In Tang My the majority of the soils belong to the sandy loams, with the second largest group belonging to the medium loam type. In Son Du about half of the soils belong to the light loams, while the remainder are mostly of a more light texture. The clay content of the soils increases with depth.

The top soils mostly are acid to medium acid. In Son Du the area with acid (pH-H_2O < 5.5) to very acid (pH-H_2O < 4.5) soils is about 80 %. For Tang My this value is only 18 %. Most of the soils in Tang My have a pH in the medium range (pH-H_2O 5.5 – 6.5). The top soils are poor in organic matter and nitrogen. Organic matter contents were found to be in the range of 0.55 to 1.26 %. Total nitrogen varied from 0.06 to 0.11 %. The phosphorus content of the top soils showed variation, depending on the history of phosphorus fertilizer application. The range of P_2O_5 values found was 0.03 to 0.11 % for total P_2O_5. Available P_2O_5 was mostly found to be in the medium to very high availability range (2.5 to > 9.0 P_2O_5 mg 100 g^{-1} soil). Potassium content of the soils is low. Total K_20 values were below 0.6 %. Available K_20 mostly was below 10 mg 100 g^{-1} soil, but in some areas available K_2O was higher, probably due to past fertilizer application. The Cation Exchange Capacity (CEC) of the top soils is limited. In Son Du most of the area had a CEC below 6 meq 100 g^{-1} soil. For Tang My CEC in the majority of the soils was in the range of 6 to 13 meq 100 g^{-1} soil. In general the soils of the Tang My area appear to be more fertile as compared to the Son Du area soils.

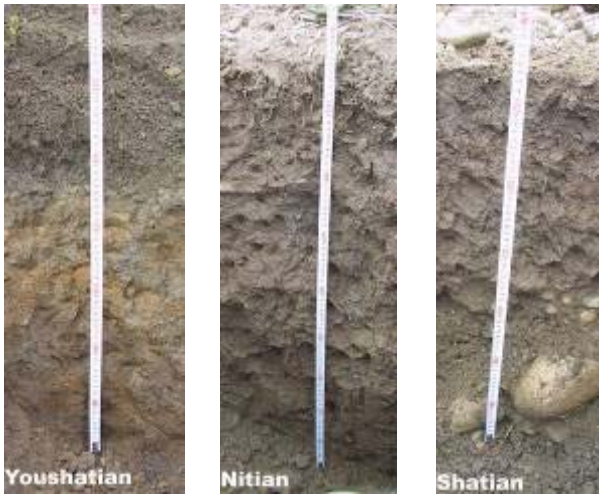
The rather light texture of the top soils implies a limited water holding capacity. In combination with the low CEC, the low pH values and the low organic matter content of the soils this indicates a low basic soil fertility and a low nutrient holding capacity. The low water holding capacity and the low basic soil fertility are the main constraints of these soils for vegetable cultivation. In view of the soil characteristics, another physical constraint could be a weak structural stability, limiting workability. No data are available to evaluate this assumption. The structural stability of this type of soils could be negatively influenced by the repeated wetting and drying, when dryland vegetable production is alternated with wet rice cultivation.

Field observations for vegetables showed only a limited tilled topsoil layer of about 15 to 25 cm deep and a compact subsoil with a clear horizon boundary just below the tilled topsoil. This latter characteristic probably limits subsoil drainage. In combination with the limited water storage capacity of the tilled topsoil, this may result in surface run-off in case of short bursts of abundant precipitation.

China

In general the soil in the research villages can be classified as grey alluvial soils. Based on the soil classification of the farmers and observations made by the soil scientists, this general soil type was split up in three different local soil types. These three soil types where further investigated through soil profiles and soil analysis. As can be seen in Figure 9, especially the Shatian soil is rather shallow, with large stones appearing in the lower layers.

Figure 9 Soil profiles of the three local soil types identified by the farmers



Therefore, farmers mention as the main problem of the Shatian soil the low water and nutrient holding capacity. For the Nitian soil they mention as the main constraint the stickiness of the soil which makes it hard to plough. For Youshatian farmers did not see any constraints.

The soil fertility sampling revealed that in general soil fertility of all three soil types is good. In soil fertility no differences could be found between the three local soil types, only in the texture and soil depth. These results confirm the problems mentioned by the farmers, the shallowness of the Shatian soil, making it difficult to hold water, while the Nitian texture of clay loam explains why farmers might find this soil type difficult to plough.

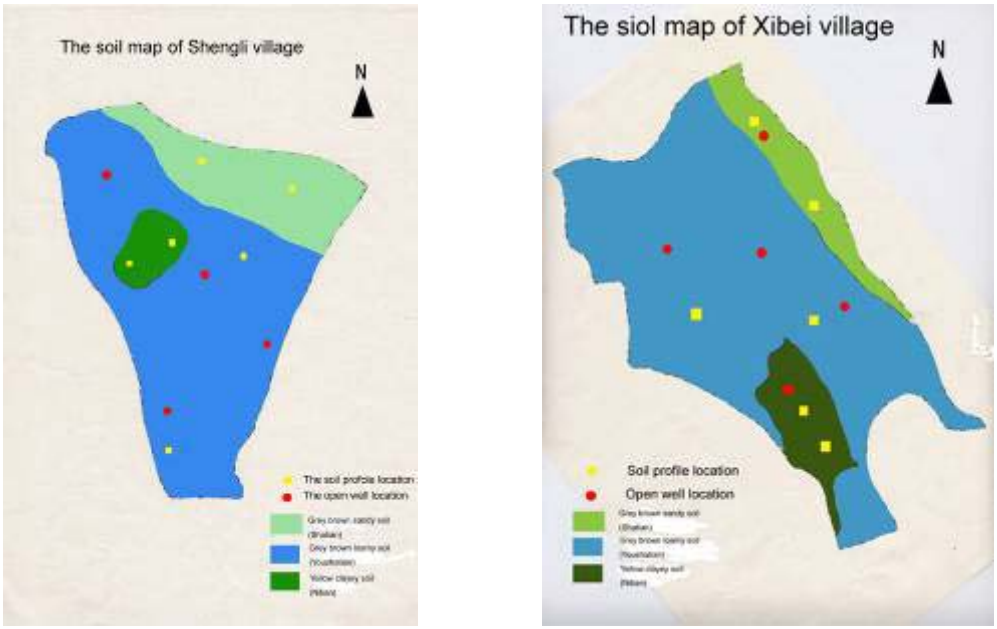
Table 6 Soil sampling results

	Youshatian	*Shatian*	*Nitian*
pH	6.1	6.1	5.9
N-total (%)	0.40	0.39	0.38
Organic C (%)	3.80	4.33	3.68
Total phosphorus (%)	0.11	0.11	0.11
Extractable potassium (mg/kg)	242.1	222.5	209.7
Texture	Loam	Sandy	Clay loam
Soil depth	52 cm	31 cm	82 cm

As can be seen in the soil maps, the Youshatian soil type covers by far the largest area in both villages. As this soil type had little problems according to the farmers, the constraints by the soils in vegetable production seem to be limited. The second largest part of both villages are covered by the Shatian soil type, which had more problems. So specific attention to soil related problems

should be given to farmers cultivating vegetables in the part of the village where the Shatian soil is located.

Figure 10 Soil maps of Shengli village and Xibei village



4.1.2.3 Farming systems

The number of household members per farm is higher in Dong Anh than in Pengzhou. The households in Dong Anh also have more consumer units per labour unit than in Pengzhou. On average about 2.3 consumer units are depending on one labour unit, while in Pengzhou only 1.25 consumer units are depending on one labour unit. This implies that either farmers in Dong Anh will need to work harder to feed their dependant household members or that their labour productivity should be higher, compared with the farmers in Pengzhou.

Figure 11 Ploughing the soil after rice harvest, to prepare the field for the winter production of vegetables in Tang My village, Vietnam

In both sites the mean amount of land owned per household is very small, approximately 0.25 hectares in all four research villages. In Dong Anh the minimum amount of land owned by a household is 0.07 hectare and the largest amount 0.89 hectare. In Pengzhou the range is between 0.08 and 0.48 hectare per household. With such small land holdings, farmers will have a preference for crops which combine both a short growing period with high returns per land unit.

Table 7 Household resources of the monitored farms in the four research sites

	Dong Anh, Hanoi Province, Vietnam				*Pengzhou County, Sichuan Province, China*			
	Tang My (n=31)		Son Du (n=32)		Shengli (n=30)		Xibei (n=30)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Number of household members	4.7	1.40	4.4	1.34	3.57	1.04	3.8	1.1
Total farm area (in Ha)	0.27	0.14	0.27	.09	0.27	0.08	0.22	0.07
Tropical Livestock Units	1.01	0.82	1.03	1.24	0.94	0.81	0.50	0.35
Value of livestock (in US$)	160	108	169	184	132	98	85	63
Number of consumer units per labour unit	2.36	2.17	2.44	4.18	1.25	0.37	1.26	0.38
Available land per labour unit (in Ha/labour unit)	0.21	0.28	.21	.42	0.14	0.05	0.10	0.03

It seems that livestock is slightly more important for the vegetable farmers in Dong Anh than in Pengzhou. Especially ownership of water buffalo's and cows is more common among the monitored farmers in Dong Anh then in Pengzhou. In both areas pigs are the most important livestock. Almost all households have pigs, on average a number of four pigs per household. Only in Xibei village the number of households with pigs is lower and also the number of pigs they possess. It is further interesting to notice that in Tang My village five farmers combine vegetable production with aquaculture.

Table 8 Average number of animals owned by monitored households during one year

Livestock type	*Dong Anh, Hanoi Province, Vietnam*				*Pengzhou County, Sichuan Province, China*			
	Tang My (n=31)		Son Du (n=32)		Shengli (n=30)		Xibei (n=30)	
	Mean	Number of farms with this livestock	Mean	Number of farms with this livestock	Mean	Number of farms with this livestock	Mean	Number of farms with this livestock
Water buffalo	1	4	1	4	6	3	-	-
Cow	1	6	1	13	-	-	-	-
Pig	4	29	4	28	4	27	2	23
Poultry	38	23	65	23	12	28	10	8
Rabbit	-	-	-	-	9	6	4	30
Fish		5	-	-	-	-	-	-

Besides the cultivation of crops and livestock production, off-farm work is another important activity in which the monitored farm households are involved. Almost all households

Table 9 Average number of days allocated to off-farm work per household during one year

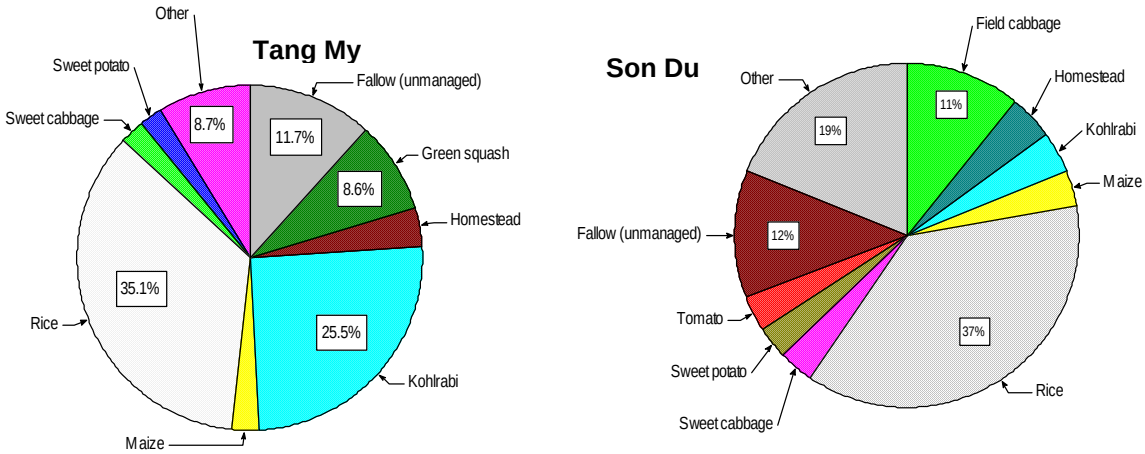
	Dong Anh, Hanoi Province, Vietnam				*Pengzhou County, Sichuan Province, China*			
	Tang My (n=31)		Son Du (n=32)		Shengli (n=30)		Xibei (n=30)	
	Mean days	Number of farms with off-farm income	Mean	Number of farms with off-farm income	Mean	Number of farms with off-farm income	Mean	Number of farms with off-farm income
Off-farm work	285	31	311	30	186	25	268	27

4.1.2.4 Land use

Vietnam

In both villages the monitored farmers grow an enormous number of different crops. In total 31 different crops were grown in Tang My during the monitoring period of one year, while in the other village farmers even grew 36 different crops. All the different fruit trees are even not taken into account in this number. But only a smaller number of crops are grow on a large area (see Figure 10). Both in Tang My and Son Du rice takes up the largest share of the total sown area. In Tang My the next most important crops (based on sown area) are kohlrabi and wax gourd (a type of wax gourd). In Son Du farmers are less specialised, but there the most important crops after rice are field cabbage, sweet cabbage and tomato. In the pie charts of both villages one can see the item fallow, which needs some explanation. During each monthly monitoring period, an inventory was made of the plots which were sown and harvested. If a plot was harvested but not yet sown again, the plot was defined as fallow. If during the next monitoring period the fallow plot was sown again with a crop, the plot ended to be fallow. Most plots only stayed fallow for just a few weeks. Hardly any of the plots stayed fallow longer then one month. For each of the different crops the research teams in Vietnam also tried to monitor which different varieties farmers used. Remarkably most farmers did not have this information, only for rice. Most farmers buy their vegetables as seedlings, with no information of which cultivar.

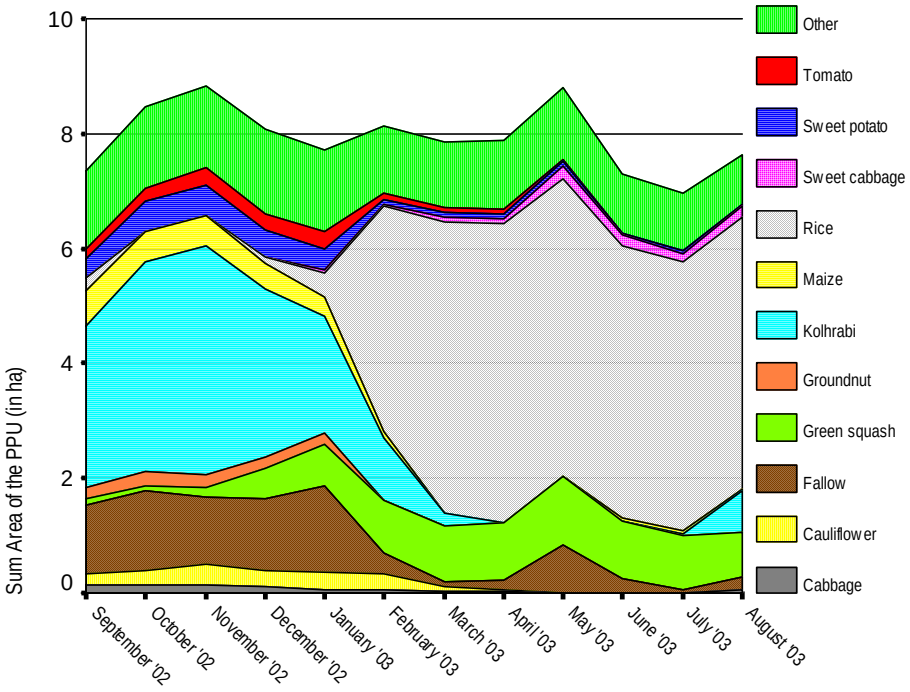
Figure 12 Sown area of all monitored farmers in the two research villages in Dong Anh, during the period September 2002 – August 2003[2]



[2] The correct name for green squash = wax gourd; Field cabbage= wrapped heart mustard

To get a better insight in the seasonality of the land use, we present the graphs in Figure 13 and 14. In these graphs the land use per month are presented. In Figure 13 one can distinguish two different cropping periods. From September until February when vegetables such as kohlrabi, tomato and fodder crops such as maize and sweet potato are cultivated. In fact farmers distinguish three cropping seasons, winter, spring and summer. The difference in cropping pattern between the spring and summer season is difficult to see, because farmers plant rice twice after each other, in spring and in summer.

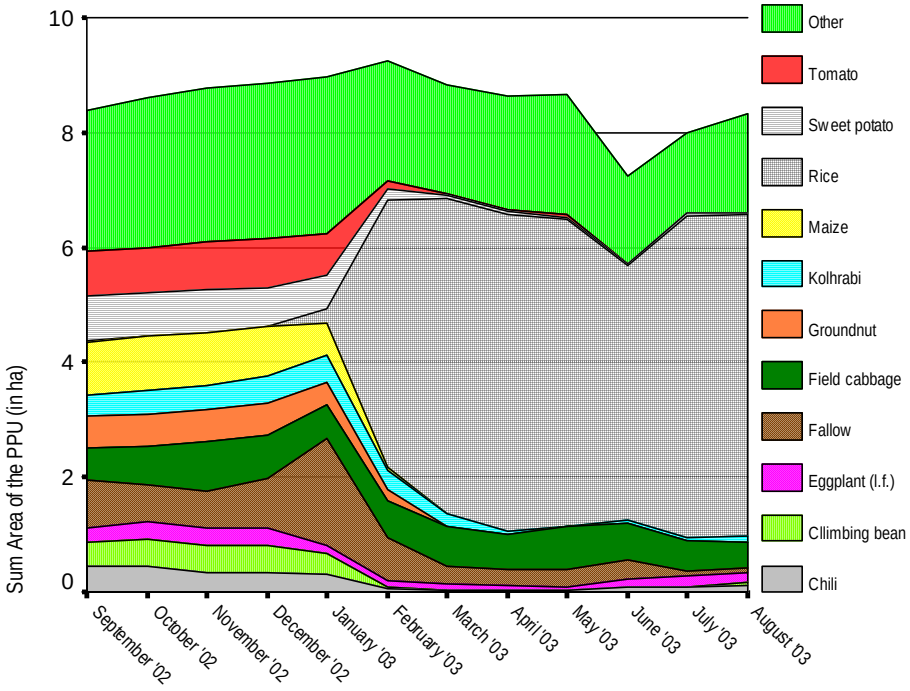
Figure 13 Land use per month of all monitored farms in Tang My village



Most farmers start with planting their rice in February, although some are was already planted with rice in December/January. It is further interesting to see that although the majority of the area planted with kohlrabi takes place in the period September to January, some farmers continue with the cultivation of kohlrabi until March. Also for wax gourd there are some farmers who manage to cultivate this the whole year round. But the majority of the farmers start planting wax gourd in January.

The cropping pattern per month in Son Du is more or less the same as in Tang My. Also in Son Du most farmers cultivate rice in both the spring and summer season. An interesting difference is that in Son Du farmers try to cultivate more crops the whole year round, such as field cabbage. Although on a very small scale, some farmers even cultivate kohlrabi, eggplant and tomato whole year round. If farmers manage to harvest these vegetables in the hot and humid late spring and summer season, they will get higher prices.

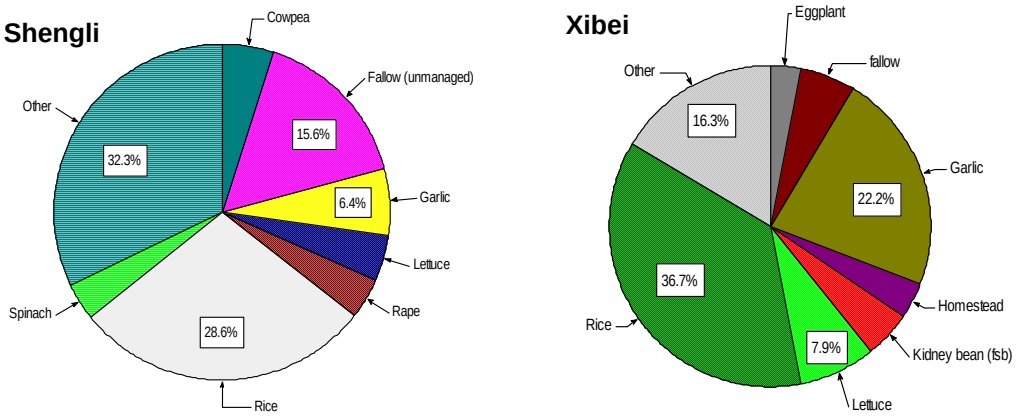
Figure 14 Land use per month of all monitored farms in Son Du village



China

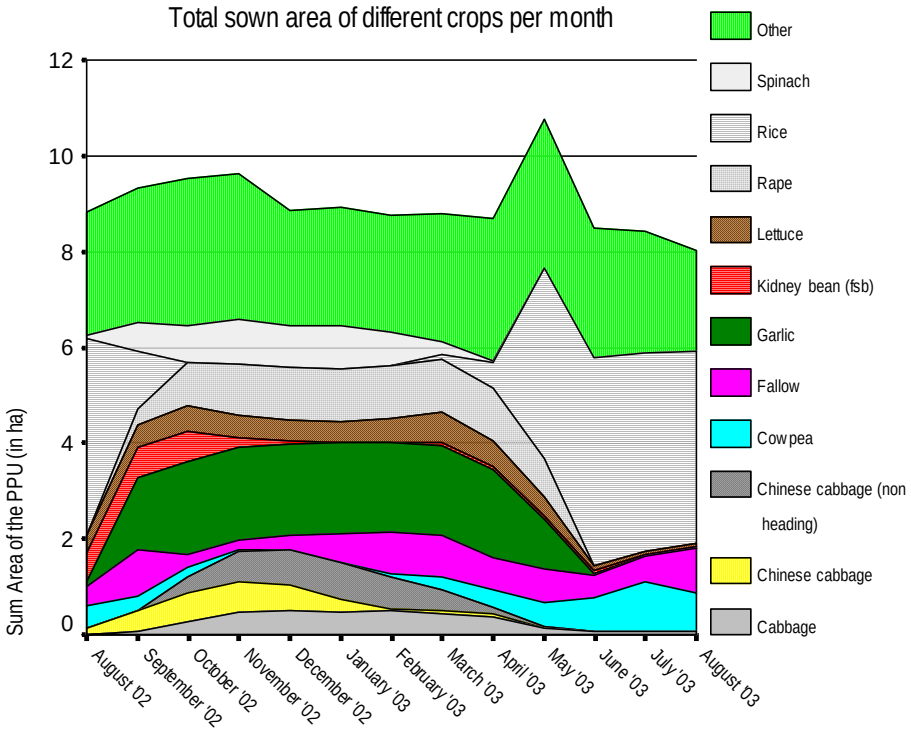
Also in the Chinese research sites farmers are trying to diversify. They experiments on quite small plot sizes with very different crops. This is especially the case in Shengli where the "other" category is very large, with a share of 32% of the total sown area. In Xibei this other category is much smaller, only 16%. Despite their very small land holdings the 30 monitored farmers cultivated 50 different crops. For most of these crops farmers were also able to distinguish all the different varieties as well. So for example for cowpea farmers cultivated nine different varieties. In Xibei farmers cultivated 32 different crops. Like in Vietnam the sown area with rice takes up the largest share in both villages, followed by garlic. Especially in Xibei villages farmers have specialised in this crop. In Shengli the other important crops are cowpea, lettuce, rape seed and spinach. In Xibei, after rice and garlic, the crops lettuce, kidney bean and eggplant are most important.

Figure 15 Sown area in the two research villages in Pengzhou during the period August 2002 – July 2003



To get more insight in the seasonality of the land use we present the figures below. Compared with the research sites in Vietnam, the main difference is that only one rice crop is grown. Most farmers start planting rice in April/May (see Figure 16). The strange peek in the total sown area in May 2003 is caused by the fact that the inventory of crops grown by the farmers is made on a monthly basis. So if the farmers harvested for example their garlic in the first two weeks of May and plant the rice in the last two weeks of May, then there will be a double counting in the total sown area during that month. During the summer season when most of the land is cultivated with rice, cowpea is the most important crop, through which the farmers earn their cash.

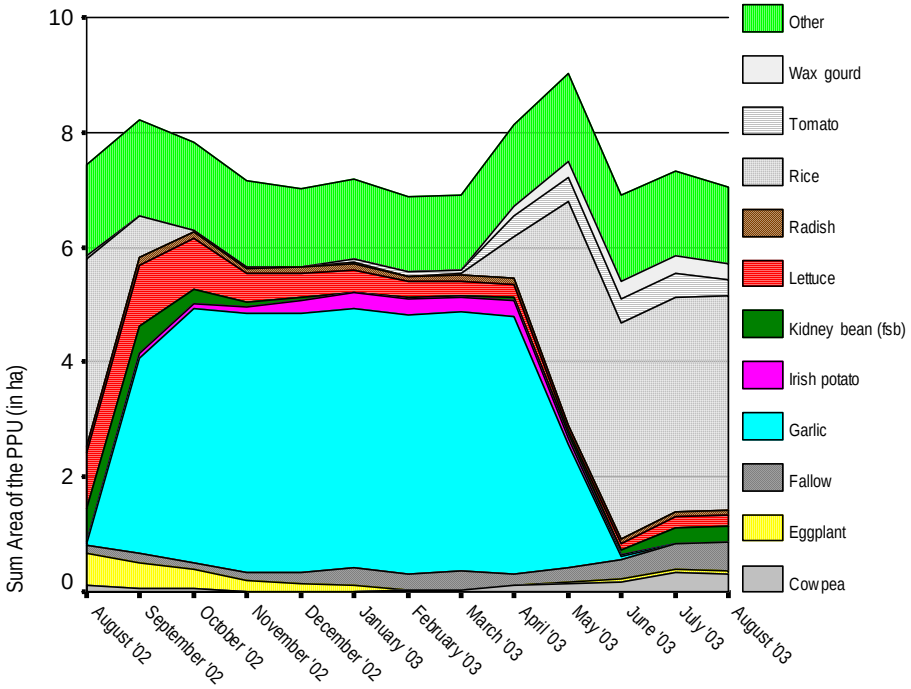
Figure 16 Land use per month of all monitored farms in Shengli village



In Figure 17 it is clear how important garlic is for the farmers in Xibei village. After the garlic harvest[3], farmers plant rice, tomato, wax gourd and cow pea. Lettuce is cultivated the whole year round.

[3] Harvested garlic products are the clove, the stem and flower

Figure 17 Land use per month of all monitored farms in Xibei village

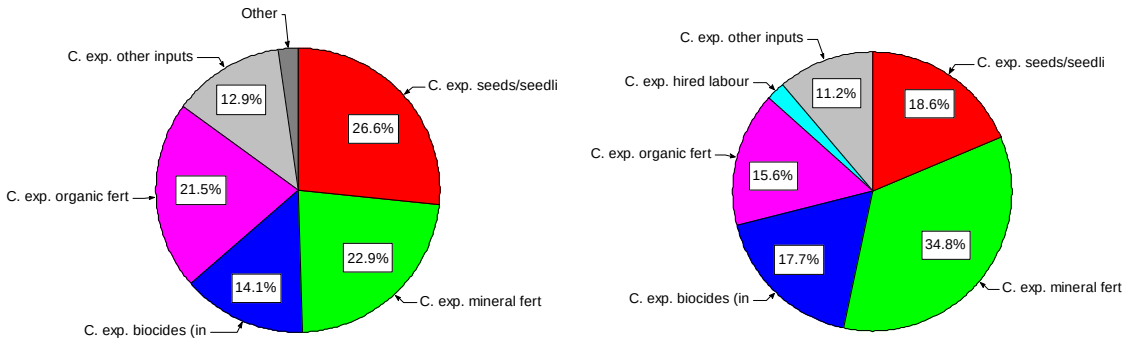


4.1.2.7 Financial performance crops

Vietnam

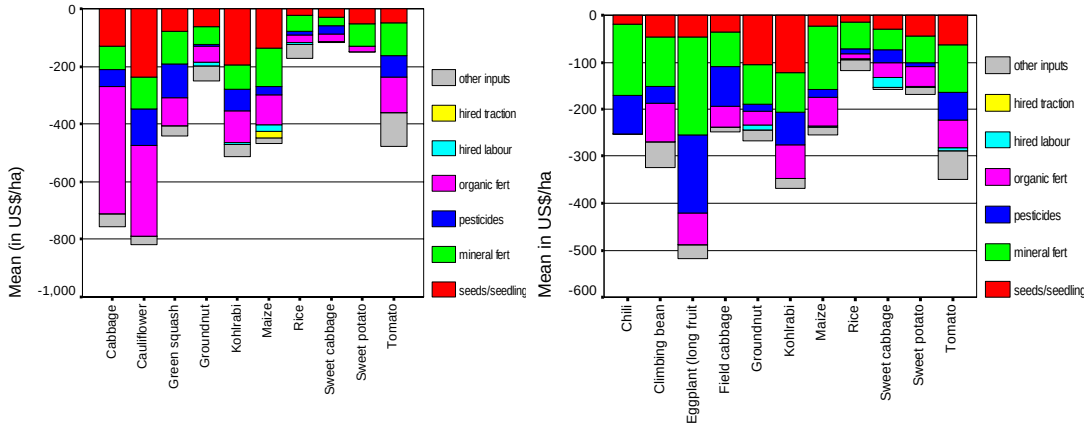
As the soil fertility analysis data already showed the low soil fertility is forcing farmers to spend the largest share of their cash expenses on buying organic and chemical fertilizers. In Tang My about 43 percent of all cash expenses made by the monitored farmers is spent on fertilizers, in Son Du this is even 52 percent. A remarkable difference is that farmers in Son Du spend much more cash on chemical fertilizers, a much smaller share is used for organic fertilizers. The reason for this difference has to be further investigated. The next important cost item are the expenses on seeds and seedlings. Cash expenses on pesticides are the third important item, this could be an incentive for reducing pesticide input use, as the expenses are significant.

Figure 18 Shares of total cash expenses during one full monitoring year on different items of all monitored farmers in Tang My (left pie chart) and Son Du (right pie chart)



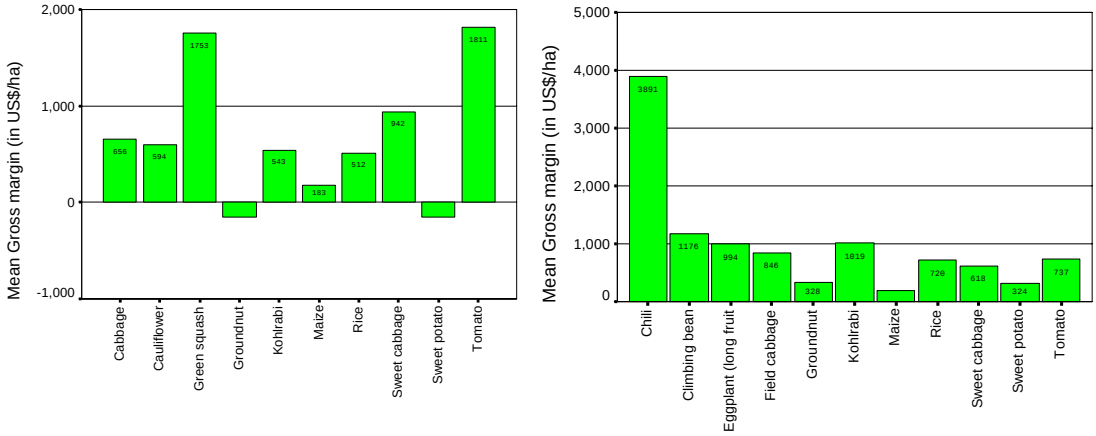
The cash expenses depend for a large part on the crop. In Tang My for example the cash expenses for the cultivation of one hectare of cauliflower are more then US$ 800, while for wax gourd this is just over US$ 400 per hectare. In Son Du the cash expenses are highest per hectare for eggplant, on which especially chemical fertilizer and pesticides are important cost items.

Figure 19 Average cash expenses for the most important crops in Tang My (left) and Son Du (right)



The profitability of the crops measured in the average gross margin per hectare is presented in Figure 20. The gross margin includes all inputs used, so inputs bought from outside the farm and inputs from the own farm are accounted for. Only family labour is not included in these gross margins. In Tang My the gross margin of wax gourd and tomato are the highest. The gross margin for rice is also quite good. Hardly any of the rice is sold, almost all rice is consumed by the household. So for cash generation the farms completely depend on vegetables. In Son Du the gross margin for chilli is very high, but this average is only based on a small number of plots.

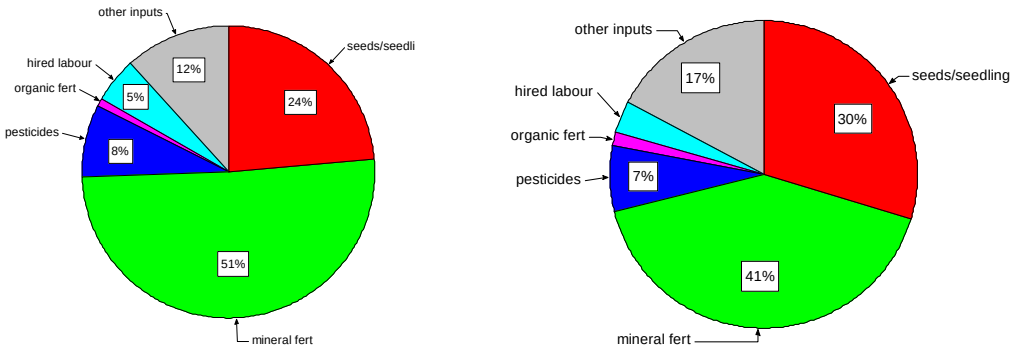
Figure 20 Average gross margins of most important crops in Tang My (left) and Son Du (right)



China

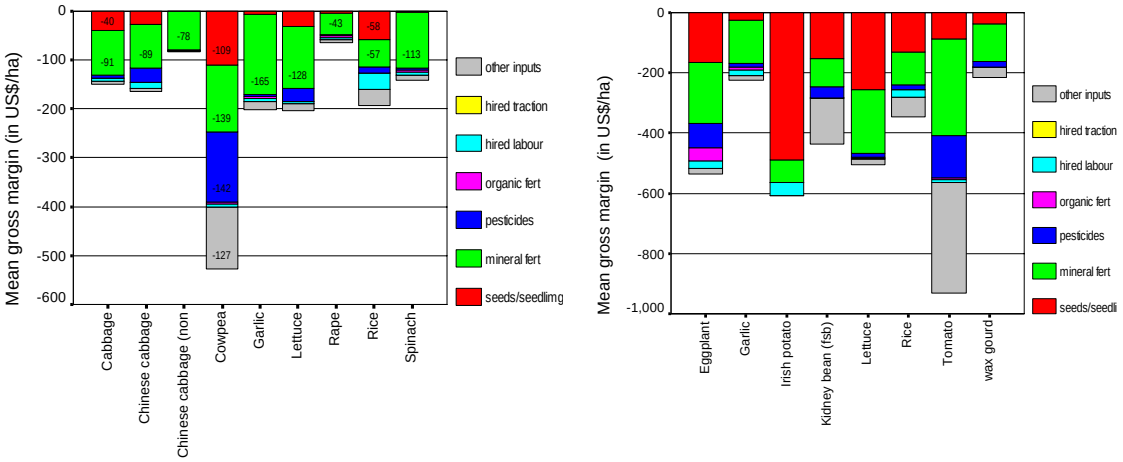
Like the farmers in research site in Vietnam, the Chinese farmers spend most of their cash on fertilizers. An important difference is that they hardly use it to buy organic fertilizers, but only for chemical fertilizers. The second most important cost item are seeds and seedlings. Expenses on pesticides are very modest, which will probably make it more difficult to use this as an incentive for farmers to reduce pesticide use.

Figure 21 Shares of total cash expenses during one full monitoring year on different items of all monitored farmers in Shengli and Xibei



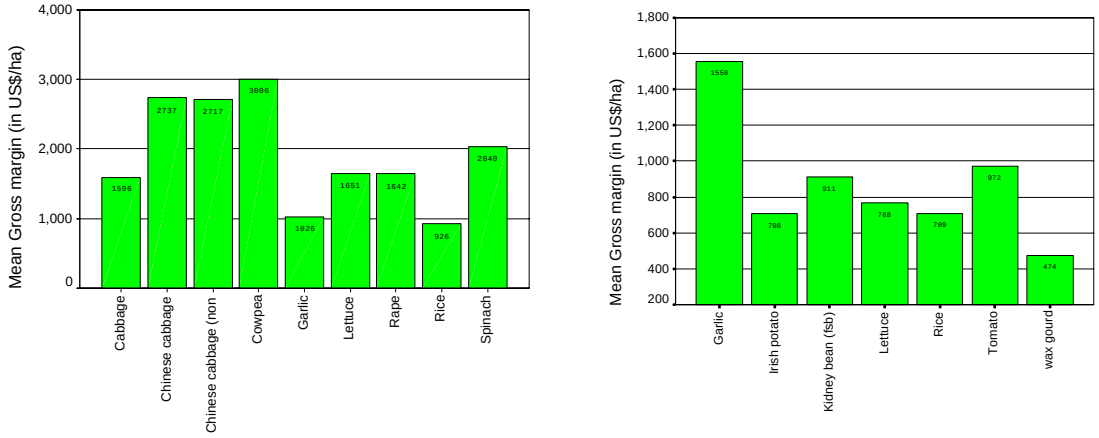
The crop with the highest cash expenses per hectare in Shengli is cowpea, with an average of more then US$ 500. All other crops in Shengli are below US$ 200 per hectare. In Xibei the average cost to cultivate one hectare are highest for tomato, but also the costs for other crops are higher. The farmers in Xibei especially seem to spend more cash on seeds/seedlings. Cash seed costs for garlic are low in both villages, because farmers use their own seeds. Other inputs are costs for bamboo sticks and plastic. In Shengli it seems interesting to see if the cash expenses on pesticides for cow pea can be reduced, while in Xibei there good be an incentive to do the same for tomato and egg-plant.

Figure 22 Mean cash expenses for the most important crops in Shengli (left) and Son Du (right)



In general the profitability of the crops in China (in US$/ha) seems to be higher then in Vietnam. Especially the gross margins in Shengli are much higher then in the research sites in Vietnam. Cow pea, cabbages, lettuce and spinach are very profitable in Shengli. In Xibei the highest gross margin is achieved with garlic, other crops are far less profitable. But if the long growing period for garlic is taken into account (six to seven months), the difference becomes less. For both sites in China and Vietnam it will be important to estimate the gross margin is US$ per day of family labour as well. As in both countries farmers are relatively close to large cities they have the opportunity to find an off-farm job as well. Therefore, farmers will compare their profitability of farming with the off-farm possibilities. For women the off-farm labour opportunities are less then for men. We, therefore, expect that in households with more female labour that the profitability of the crop per land unit will be an important decision criteria in growing a certain crop.

Figure 23 Average gross margins of most important crops in Shengli (left) and Xibei (right)



4.1.2.8 Household financial indicators

The hard work of the farmers in the four research sites, resulted in quite modest incomes. In Vietnam the average family earnings, which includes all income (cash and non cash) from farming activities (both livestock and crops) and off-farm income, were just below US$ 1000 per household per year. Of these total family earnings about 42% was generated by vegetables and between 8 and 14% by rice. The family earnings per consumer unit[4] were below one US$ per day. In China the average family earnings were well above US$ 1,000 per in Shengli and just below this figure in Xibei. Farmers in Shengli had on average the highest dependence on income from vegetables. In Xibei the average value generated by rice is the highest among the four research sites. In all four villages off-farm income forms a substantial part of the family earnings. This was 43%, 37%, 34% and 47% in respectively Tang My, Son Du, Shengli and Xibei.

[4] One consumer unit is equal to the consumption needs of an adult male

Table 10 Household financial indicators

Financial indicators	*Tang My*		*Son Du*		*Shengli*		*Xibei*	
	Mean	*Range*	*Mean*	*Range*	*Mean*	*Range*	*Mean*	*Range*
Family earnings (in US$/hh/year)	985	74 - 2,610	977	269 - 2,340	1,345	-205 - 3,187	917	-164 - 3,329
Family earnings per consumer unit (in US$/consumer unit/year)	298	25 - 926	200	117 - 637	586	-110 - 1,846	334	-60 - 1,040
Net farm income (in US$/hh/year)	560	4 - 2,513	617	48 - 2,094	884	-215 - 2,725	487	-376 - 2,204
Off-farm income (in US$/hh/year)	425	0 - 1,690	361	0 - 2,016	460	0 - 2,350	430	0 - 1,573
Dependence of family earnings on vegetables	41%		43%		50%		30%	
Dependence of family earnings on rice	8%		14%		12%		18%	

The range in incomes was quite large, with some households generating more then US$ 2000 with farm activities alone, while other households even had a negative income. The main reason for this negative income is that some farm households have made quite some large investments during the monitoring period. In Shengli for example, there is one farmer who invested a lot of money in buying ornamental tree seedlings. This will take quite some years before this pays off.

4.1.3 WP 1.3: Weeds, Pests and Diseases

4.1.3.1 Vietnam[5]

Insect pests and disease varied with the choice of a crop and growing seasons (temperature, humidity, photoperiods) in both villages. Several common brassicaceous insect-pests like *Plutella xylostella, Phyllotreta striolata* were commonly found on field cabbage.

Table 11 Proportion and incidence of major pests on wrapped heart mustard in Sondu

Pest	**Winter season**		**Spring season**		**Summer season**	
	Pp[1]±SE[2]	***Inc[3]±SE***	***Pp±SE***	***Inc±SE***	***Pp±SE***	***Inc±SE***
Phyllotreta striolata	59.9±9.2	91.67±8.3	63±9.2	61±9.0	62.5±6.3	66.7±6.7
Plutella xylostella	21.75±3.5	33.3±3.3	19.02±7.9	21.5±13.5	9.4±3.1	10±3.3
Brevicoryne brassicae	-	-	+	+	-	-
Spodoptera litura	-	-	15.17±4.1	16.5±8.5	9.4±3.1	10±3.3
H elicoverpa armigera	-	-	+	+	18.8±0.0	20±0.0
Oxya chinensis	+	+	-	-	-	-

[1]Pp – proportion; [2]SE – standard error of mean; [3]Inc – incidence; + pests appeared at the monitoring time, but took low effect; - pests not recorded.

[5] For a detailed analysis of pests and disease in the sites in Vietnam the readers are referred to PR16

Two major diseases were observed on wrapped heart mustard, i.e. leaf yellowing (unidentified pathogen*)* and *Plasmodiophora brassicae.* However, as per farmers' perception, pests caused more damage to their field cabbage crop than diseases.

Table 12 Proportion and incidence of major pests on wax gourd in Tang My

Pests	Winter season		Spring season		Summer season	
	Pp[1]±SE[2]	***Inc[3]±SE***	***Pp±SE***	***Inc±SE***	***Pp±SE***	***Inc±SE***
Thrips palmi	50.9±0.0	80±0.0	58.3±7.8	89.9±7.0	65.13±5.1	70.62±2.7
Omiodes indicata	23.64±0.0	37.14±0.0	-	-	-	-
Liriomyza sativae	16.36±0.0	25.7±0.0	27.4±5.2	55.3±3.1	24.65±4.6	30.3±8.1
Anomis flava	+	+	-	-	-	-
Oxya chinensis	+	+	-	-	-	-
Spodoptera litura	-	-	8.46±2.2	18.2±4.2	4.1±2.0	5.2±2.6
Tetranychus cinnabarinus	-	-	+	+		
Helicoverpa armigera	-	-	+	+	6.1±3.7	6.86±4.1

[1]Pp – proportion; [2]SE – standard error of mean; [3]Inc – incidence; + pests appeared at the monitoring time, but took low effect; - pests not recorded.

In addition *Bemisia tabaci*, *Liriomyza sativae, Spodoptera litura, Helicoverpa armigera, Phytophthora infestans, tomato virus, Ralstonia solanacearum* on tomato in Sondu, and *P. xylostella, P. striolata, S. litura, Xanthomonas campestris pv cam*, and an unidentified leaf spot disease on kohlrabi (for both Tangmy and Sondu) were recorded. In Tangmy, on wax gourd, *Thrips palmi, L. sativae, Cercospora* spp.*, Erwinia* spp. and wax gourd viruses were the most important insect, pests and diseases, respectively (see Table 13 and 14).

Table 13 Proportion and incidence of diseases on wax gourd in Tangmy

Diseases	Winter season		Spring season		Summer season	
	Pp[1]±SE[2]	*Inc[3]±SE*	*Pp±SE*	*Inc±SE*	*Pp±SE*	*Inc±SE*
Cercospora spp.	100	94.3	45.2±12.2	29.2±9.04	7.78±2.75	4.43±1.5
Wax gourd virus	-	-	11.86±8.12	7.62±6.2	34.52±9.75	23.81±6.3
Erwinia spp.	-	-	25.9±8.06	13.71±5.16	57.7±8.4	34.95±6.4
Erysiphe cichoracearum	-	-	+	+	-	-
Rhizoctonia solani	-	-	+	+	-	-

[1]Pp – proportion; [2]SE – standard error of mean; [3]Inc – incidence; + pests appeared at the monitoring time, but took low effect; - pests not recorded.

Table 14 Proportion and incidence of diseases on wax gourd in Tangmy

Diseases	Winter season		Spring season		Summer season	
	Pp[1]±SE[2]	*Inc[3]±SE*	*Pp±SE*	*Inc±SE*	*Pp±SE*	*Inc±SE*
Cercospora spp.	100	94.3	45.2±12.2	29.2±9.04	7.78±2.75	4.43±1.5
Wax gourd virus	-	-	11.86±8.12	7.62±6.2	34.52±9.75	23.81±6.3
Erwinia spp.	-	-	25.9±8.06	13.71±5.16	57.7±8.4	34.95±6.4
Erysiphe cichoracearum	-	-	+	+	-	-
Rhizoctonia solani	-	-	+	+	-	-

[1]Pp – proportion; [2]SE – standard error of mean; [3]Inc – incidence; + pests appeared at the monitoring time, but took low effect; - pests not recorded.

4.1.3.2 China[6]

Insect and mite pests, diseases and weeds were the most important yield-limiting factors for the smallholder vegetable cultivation in the VEGSYS project sites in Pengzhou County, Sichuan Province. The occurrence of insect and mite pests and diseases varied with the choice of crop and

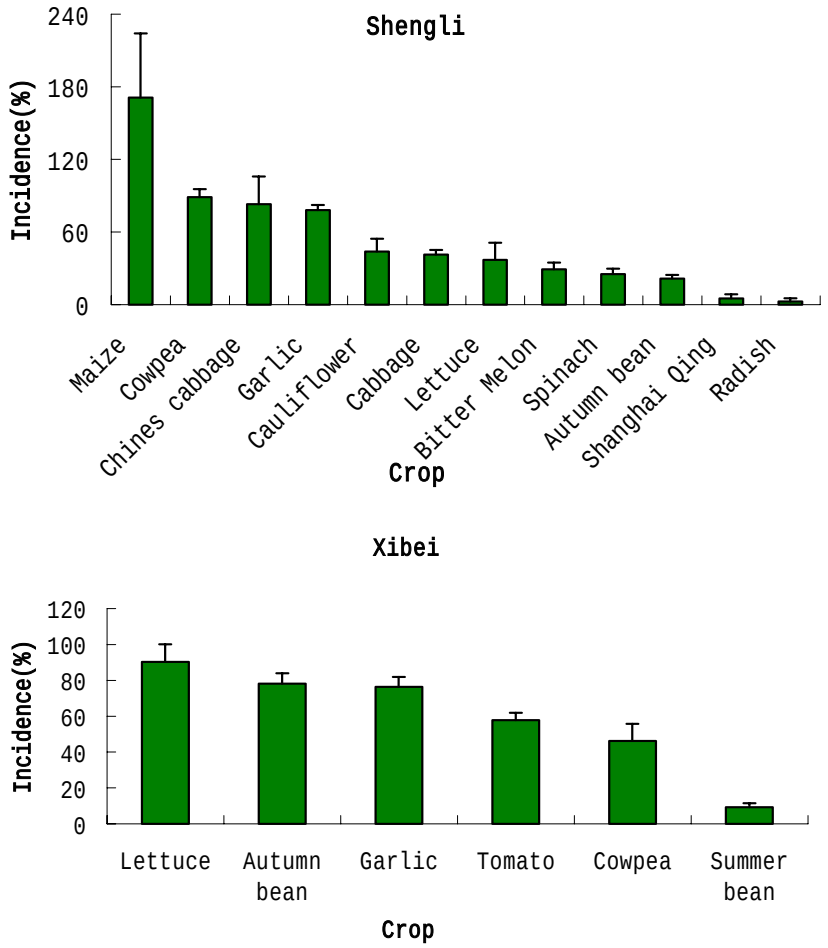
[6] For a detailed analysis of weeds, pests and disease in the sites in China the readers are referred to PR15

season. In Xibei, the prevalent rice-garlic rotation system made *Poa annua* instead of *Stellaria media* to be the most frequently recorded weed species, although the latter species still scored the highest average in the community proportion. Occurrence of diseases and insect and mite pests were strongly related to the crop choice, followed by growing season and environmental factors (temperature, humidity, photoperiods). The investigation periods coincided with the late growth stages of the autumn crops, resulting in higher incidences of insect and mite pests and diseases than in the summer crops. The effects of soil nutrition and crop management activities such as the application of pesticides and fertilizers need further studies.

The year-long monitoring in Xibei and Shengli village elucidated several prevailing pests, causing high yield losses. The most important biotic constraint was thrips outbreaks on vegetable crops and thrips-caused yield losses, especially in garlic. Thrips were the most frequently recorded pests on various vegetables. Combined virus infections and thrips damage possibly made the garlic plants susceptible to freezing damage during early January, explaining the high prevalence of the so-called "Huo Feng" disease in both villages. Other notorious pests were whiteflies on summer vegetables in both villages with partly high population levels. Monitoring data and interviews with farmers revealed the presence of leafminers (*Liriomyza* spp.). Especially *Liriomyza huidobrensis* was a very important pest in both villages. Yet farmers were able to effectively control leafminers by using abamectin.

Generally, plant diseases were very damaging to the crops and poorly controlled by farmers. Here all incidence data is based on observation of symptoms. *Fusarium* and *Verticillium* wilt, *Fusarium* and *Phytophthora* root rot resulted in complete losses of the plants and were poorly controlled in both villages. Even *Sclerotinia* and *Botrytis* rot on lettuce and other vegetables, easily to be controlled by carbendazim spraying, were commonly observed at harvest.

Figure 24 Disease incidences in vegetable crops in Shengli and Xibei



A total of 83 and 87 weed species were recorded in Shengli and Xibei village, respectively. When the crops in both villages were grouped into summer (planted from May to September) and winter crops (October to April), there differences in the weed community between seasons were observed. In the summer crops in both villages the most important weeds were *Digitaria sanguinalis*, *Amaranthus lividus*, *Mazus japonicus, Stellariamedia* and *Centipeda minima*, accounting to about 50 % of the total scores of the average PPUs. In winter crops, the most important weed in both Shengli and Xibei was *Stellaria media* (24 and 16 % of the total scores, respectively).

Insufficient knowledge of farmers on insect and mite pests, diseases and weed's growth and development cycles in relation to crop ecology and yield losses coupled with the fact that the extension services are unable to assist farmers with the identification and control of plant diseases at the village level were identified as major constraints. Hence there is a great need to develop capacities among vegetable farmers to enable them to take timely, informed and ecologically sound decisions regarding insect , mite pests and disease management as mandated in our project objectives.

4.1.4 WP 1.4: Soil fertility management

4.1.4.1 Soil fertility management

An analysis of the use of fertilizers in vegetable production in 4 research sites in China and Vietnam was made. Over more than 50 different types of fertilizers were used, which were applied in a range of 0-700 kg N/ha. Timing of fertilizer applications also differed between crops and between villages. The amount of N applications was largely governed by crop-type. Less than 50% of the variations in yields could be explained by variations in fertilizer applications. Other sources of variation were differences in soil treatment, crop varieties, fertilizer types, timing of fertilization, occurrences of pests and diseases and errors and biases in source data. Consequently, partial nutrient balances, showing the difference between manageable nutrient inputs and nutrient outputs, varied largely between crops, seasons and villages.

Table 15 Top 10 most frequently used fertilizers in each village during the monitoring period (September 2002-September 2003).

China		Vietnam	
Shengli	**Xibei**	**Son Du**	**Tangmi**
FYM[1]	NH_4HCO_3	urea	urea
NH_4HCO_3	manure	SSP[2]	SSP
15/15/15 (blend)	15/15/15 (blend)	KCl	KCl
urea	SSP	poultry mixed with FYM	chicken manure
SSP[2]	urea	household waste	ash
KCl	animal excreta	cattle manure	phan con co[3]
$NH_4H_2PO_4$	$NH_4H_2PO_4$	human excreta	householde waste
household waste	household waste	phan vi sinh[3]	phan chim[3]
human excreta	human excreta	phan con co[3]	cattle manure mixed with FYM
10/5/10 (blend)	BB	ash	human excreta

[1]= Farm yard manure [2] = single superphosphate [3]= organic fertilizer from factory.

The main results of the soil fertility management analyses were:

- About 60% of the household incomes were spent on mineral and organic fertilizers; improving the effectively of fertilizer application may largely improve the financial positions of farm-households.
- A large variety of fertilizers was used (>50 different types were recorded), but the top 10 of fertilizer types accounted for >90% of the total nitrogen application.
- The timing of fertilizer application largely depended on crop type. Some crops only received start dressings while others were fertilized throughout the growing period.

- Total amount of N applied with fertilizers (mineral + organic) ranged from 0 to 700 kg N/ha. The amount of N applications was largely driven by crop type. Hence, there was a common knowledge per village on how much N to apply to what crop.
- Differences in fertilizer applications accounted for not more than 50% of the variations in yields. Hence, other sources of variation (e.g. soil preparation, crop varieties, pests, diseases) also largely determined the yield.

4.1.4.2 Review of fertilizer recommendations

The current fertilisation practice in many Chinese and Vietnamese farms involves an approach of 'the more the better'; a higher fertiliser application is expected to result in higher crop weights, yields and financial gains. But the results from the literature study and field experiments conducted for this research prove otherwise. Optimal crop weights and financial gains are often found with fertiliser applications much lower than the current practices. To improve the farm economical situation, but also reduce pollution of the environment and protect human health, it is important to fine tune fertilisation as much as possible to crop yields. Therefore recommendations for fertiliser applications are made for fourteen ground vegetables commonly cultivated in Vietnam and other South East Asian countries. It is important to indicate that these results are suggestive rather than conclusive.

Table 16 Recommended input quantities regarding nitrogen, phosphate and potassium fertiliser

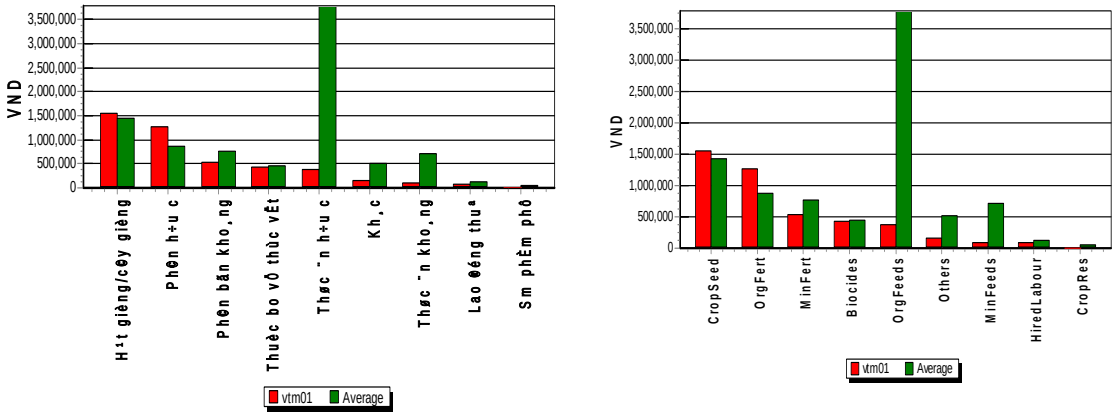
Crop	**N (kg/ha)**	**P (kg/ha)**	**K (kg/ha)**
Chinese cabbage	70 - 120	10 - 25	30 - 50
Wrapped heart mustard	90 - 100	25 - 45	40 – 70
Cauliflower	100 - 135	45 - 87	50 – 83
White cabbage	150 – 200	20 - 57	90 – 130
Purple cabbage	150 - 200	20 - 57	90 – 130
Kohlrabi	100 - 160	55 - 120	60 – 104
Broccoli	130	35	66
Wax gourd	90 - 110	45 - 55	50 – 100
Cucumber	56 - 71	15 - 24	83 – 100
French bean	90	20 - 30	50 - 75
Climbing bean	90	20 - 30	50 - 75
Tomato	120 - 250	30 – 40	130 – 300
Eggplant	145 - 296	20 - 29	70 - 170
Hot pepper	100 - 130	10	110

4.1.5 WP 1.5: Analysis and feedback to farmers

In preparation of the final feedback workshop, LEI, SFI and HAU produced individual farm reports in English, Chinese and Vietnamese. Each farmer will get their own report in which their farm management and financial performance are compared with the average of the village. An example

In the figure below an example is given of one of the graphs from the individual farm report. In this example farm VTM01 can compare his cash expenses on different categories with average in the village. This farm spends slightly more on seeds and seedlings and more then average on organic fertilisers, but less on organic and mineral feeds for his livestock.

Figure 25 Example of a graph from the individual farm report. The left graph is in Vietnamese and the right graph is exactly the same but in English



In the next example (Table 17) the farmer can compare the rank of his expenses with all 31 other monitored farms. So if his expenses where the lowest he gets rank number 1. So for example for his expenses on organic fertiliser, the farmer can see that there were only 7 other farms which spent has much as she did on organic fertilisers.

Table 17 Cash expenses on different categories of agricultural inputs which where bought from outside the farm by

Category	*Total cash value (in)*	*Cash value (in %) of the total cash expenses*	*Total Kilograms*	Rank[1]	Mean	*Min*	*Max*
Seed/seedling	1,546,600	34	1,918	21	1,435,797	433,780	3,546,138
Org. Fert	1,276,322	28	1,206	26	877,890	43,200	2,956,639
Min. Fert	533,900	12	262	8	771,412	317,300	1,851,660
Pesticides	431,065	10	3	16	445,636	2,500	963,264
Org. Feeds	382,061	8	2,030	5	3,785,395	76,000	47,038,300
Others	162,010	4	26	2	515,922	20,000	1,155,950
Min. Feeds	89,500	2	12	3	707,961	32,000	3,567,300
Hired Labour	85,000	2	40	10	116,736	9,000	509,200
Crop Residues	0	0	45	1	62,244	0	174,500
Total		**100%**					

[1]The farm with the **lowest** cash expenses for a certain category of products is number 1, followed by the farm with the second lowest cash expenses for that product category

Both the Chinese and Vietnamese team organised two farmer feedback workshops. These meetings have been documented in two project reports (PR09 and PR10). In preparation of the final feedback workshop, LEI, SFI and HAU produced individual farm reports in English, Chinese and Vietnamese. Each farmer of the 124 monitored farmers got their own report in which their farm management and financial performance are compared with the average of the village. During the final feedback workshop (see reports PR20 and PR21) farmers selected the focus crops for the innovation experiments:

- wax gourd (Vietnam)
- wrapped heart mustard (Vietnam)
- garlic (China)
- eggplant (China)

Figure 26 Farmers discussing the result posters during the feedback meeting

4.2 WP2: Integrated testing of improved techniques for plant protection and soil fertility management

4.2.1 WP 2.1: Formulation of integrated pilot experiments

Based on the priorities of farmers and an assessment of researchers the following four focus crops for improved and more sustainable production technologies were selected (see Figure 2):

- Garlic (Xibei, Pengzhou County, China)
- Eggplant (Shengli, Pengzhou County, China)
- Wax gourd (Tang My, Dong Anh district, Vietnam)
- Field cabbage (Tang My, Dong Anh district, Vietnam)

During crop problem identification workshops in April 2004 farmers and researchers had discussions about the most urgent problems in the focus crops. The aim of these workshops was to select the most urgent problem for which solutions had to be developed and which would be tested by the farmers. These workshops were prepared and implemented by the VEGSYS teams in China and Vietnam and backstopped by Prabhat Kumar. Combining the collected data, with the

cropping calendar approach and leading questions farmers came up with the following problems as the most urgent problems which they could not solve.

Table 18 Main results of crop problem selection workshop

Country	Crop	Problem
Vietnam	Wax gourd	Virus
	Wrapped heart mustard	Club root disease
China	Garlic	Virus
	Eggplant	Wilt complex including verticillum wilt

For more details see mission report no. MR13 and project reports no. PR20 and PR21.

Figure 27 All four vegetables on which the experiments are focussing

Wax gourd traders in Dong Anh

The wrapped heart mustard experiment plot

Eggplant production in Shengli

Garlic post harvesting in Xibei

Table 19 Solutions tested for focus crops and focus problems

Country	Crop	Problem	Tested solution
Vietnam	Wax gourd	Virus transmitted by thrips	Thrips control with Spinosad
	Wrapped heart mustard	Club root disease	Timing and dose of lime application
		Non optimal ferilizer use	Fertilizer dose rates
China	Garlic	Virus	Improved fertilizer application
	Eggplant	Wilt complex including verticillium wilt	Grafting local varieties on verticillium wilt resistance rootstock vareties

The complete protocols were published in the following VEGSYS reports:

PR22 Innovation protocol for thrips control in wax gourd and control of club root disease in wrapped heart mustard in Dong Anh district

PR23 Innovation protocols for improved and sustainable management of garlic and eggplant

PR32 Fertiliser recommendations for field vegetables in Dong Anh district

4.2.2 WP 2.2: On farm testing

Within each of the four research sites, the farmers selected 3 to 5 experiment farmers who would carry out the experiments. On farm trials were executed with them. At the start, halfway and at the end of the trial, field days were organized to invite all other farmers in the village to monitor the trials and understand the results. The periods in which each of the trials took place are presented below.

Table 20 Solutions tested for focus crops and focus problems

Country	Crop	Number of seasons tested
Vietnam	Wax gourd	1st cropping cycle: October 2004 to January 2005 2nd cropping cycle: February 2005 to May 2005 3rd cropping cycle: June 2005 to August 2005
	Wrapped heart mustard	1st cropping cycle: October 2004 to December 2005 2nd cropping cycle: February 2005 to March 2005 3rd cropping cycle: April 2005 to June 2005
	Wrapped heart mustard: fertilizer	1st cropping cycle: September 2005 to November 2005
China	Garlic	1st cropping cycle: September 2004 to May 2005
	Eggplant	1st cropping cycle: research station variety trials 2nd cropping cycle: April 2005 to August 2005

4.2.3 WP 1.3: Analysis of results

The complete results of the trials are presented in the following reports:

PR24 Mid-term review of wax gourd innovation experiment in Dong Anh district, Vietnam

PR30 Farmer reviews of wax gourd and wrapped heart mustard experiments in Tang My & Son Du

PR32 Fertiliser recommendations for field vegetables in Dong Anh district

PR33 Effect of timing of lime application on management of club root disease on wrapped heart mustard, Dong Anh, Hanoi, Vietnam.

PR34 Effect of spinosad application on the management of thrips transmitted viruses on wax gourd in Dong Anh district, Vietnam.

PR35 Studies on the effects of fertilization and Messenger® application on garlic yield and diseases

PR36 Control of Verticillium wilt of eggplant using rootstock “Torubam”

The results of the trials were analysed and discussed with farmers in various workshops. Leaflets and large posters were made which were used in a “roving poster exhibition”. Each experimental farmer presented back one poster to all the other farmers in the village.

4.2.3.1 Main results of eggplant experiments

Verticillium Wilt is one of the most important diseases in eggplant productions. It caused severe losses in northern China and has spread to southern China and becoming one of the main constrains on eggplant production in recent years. One of the effective control methods of this disease is to root eggplants on resistant rootstocks. This study tested to grow rootstocks "Torubam" and "Chiqie" in greenhouses to 5-6 leaves old before the grafting of the cutting varieties at the stages of 4-5 leaves. Eggplants of different varieties as well as the grafted plants were transplanted to pots of soil after the recovering of the cutting on the rootstocks. Suspension of Verticillium dahliae conidia were poured into the pot soil 7 days after transplanting to observe the disease symptom and death of the plants every two days. There is significant difference in latent days, disease and death rates between the different varieties and rootstocks. Eggplant "Shuzha No. 1" was susceptible to Verticillium wilt but had the longest latent days and lowest death rates. Both rootstocks "Torubam" and "Chiqie" were found to be immune to the isolate used in the experiment.

After the rootstocks were selected, the farmer field experiments began. The Torubam variety was used as a rootstock for the popular (in the market) local varieties. The occurrence of the wilt symptom on grafted plants was observed to be 20-30 days after transplanting on the three fields (data not shown here). The effects of the different fields in the same village of Shengli on the disease and death rates of the grafted or control eggplants were not significant (F=3.00 or 3.10, P=0.087 0r 0.082). But the difference between the grafted and control eggplant was significant 40 days after transplanting when there were 0.56% -14.44% diseased grafted plants whereas the disease rate of the control plants reached to 21.67% to 50%. Till the middle of June, 7.22% of the grafted plants died whereas 14.44-48.89% of the control plants were dead in the three fields. The difference in disease or death rates between the grafted and control plants became insignificant at the time 100 days after transplanting except in one field (Table 21).

Figure 28 Dr. Peng inspecting the eggplant trials

Table 21 Disease and death rates of grafted eggplants on "Torubam" caused by Verticillium dahliae at Shengli Village, Pengzhou City of Sichuan Province

Field	*Treatment*	*Disease rate (%)*		*Death rate (%)*	
		June	August	June	August
I	Control	21.67bc	100.00b	14.44b	99.44c
	Grafting	0.56a	100.00b	0.00a	94.44ab
II	Control	50.00c	100.00b	48.89c	98.33bc
	Grafting	1.11a	98.33a	0.00a	93.33ab
III	Control	40.00bc	100.00b	28.33bc	97.22abc
	Grafting	14.44ab	100.00b	7.22ab	92.78a

Although there was no significant differences in the weight of the individual harvested fruits between grafted and control plants (data not shown), the total fruit yields of the plots of grafted plants were significantly higher than that of the control plants (Table 5). It was noted that the effects of the different field on the eggplant yields was also significant (F=93.16%, $P \leqq 0.01$) but there was no significant interactions between the grafting and fields (F=3.62, P=0.059).

Table 22 Fruit yields of grafted eggplants on "Torubam" in the tree fields infested with Verticillium dahliae at Shengli Village, Pengzhou City of Sichuan Province

Treatment	*Harvested fruit weight (kg)*[1]		
	Field I	Field II	Field III
Control	123.5 a[1]	39.6 a	33.3 a
Grafting	145.0 b	90.3 b	48.0 b

[1]: Weight of the plots of each 60 plants.

[2]: Averages in the same column followed by the same letter were not significantly different after Duncan's multiple comparison (P ≦ 0.05) .

This research has proved the efficiency of the "Torubam" and "Chiqie" as the resistant rootstocks against *Verticillium* wilt of eggplant in Sichuan. No fungicides had to be applied on grafted eggplants for the control of the disease. Because the thorny stems of "Chi Qie" hampered the grafting efficiency by hands, "Torubam" was selected and to be used for scale grafting. No differences in the quality were found between the fruits from grafted or control plants.

By the end of field experiments, the majority of the grafted plants also died although the rootstock part kept alive and "Torubam" shootings emerged. So the secondary infection of the cutting could be an important factor to limit the further extension of this technology in Sichuan. Some of the secondary infection by farm operation transmitting the disease such as picking of old leaf and fruits by scissors could be avoided when all the plants in the field were grafted. But attention should also be paid to the control of the pest insects transmitting the disease. Closer mulching around the plants or a special circular piece of plastic around the base of the stem could be an option to prevent the splashing of the fungus onto the grafted joint or the stem of the cutting. Filed experiment with higher grafting joint without transmitting of the fungus by scissors has shown the satisfied result during the second eggplant season on the field II. A tolerant cutting should be able to further lower the loss caused by the secondary infection.

4.2.3.2 Main results of fertilizer trials for garlic

Garlic is an important vegetable crop in China. The study site is one of the top 10 Chinese garlic production areas. Garlic area accounts for more than 80% of the vegetable area of Xibei village (the study village), and garlic has been planted more than 20 years at this place. Because of the long history of garlic planting and without commercial breeding, garlic was infected by many plant viruses, the garlic product quality and yield was reduced strongly. In this study, three experiments about fertilization protocols and spraying plant activator HarpinEA were carried out from September, 2004 to May, 2005 in 4 farmers' fields at Tianpeng Township of Pengzhou City, Sichuan, China in rotation with rice to find the method of garlic virus controlling. From the results of experiments, it can be concluded that fertilization protocol 1, which are currently applied by the local farmers, could resulted in the higher yield of flower stalk of the garlic than control and protocol 2 which designed by researchers, and the similar yield of early stalk and cloves to that resulted from protocol 2. The data from this study showed no effects either by fertilization or spray of HarpinEA. The failure of the later treatment may be referred to many factors such as application dosages and local climate. The low temperature during the over-winter of garlic may be also an limiting factors.

Figure 29 Garlic experimental ploy in Xibei village

4.2.3.3 Main results of thrips control trials for wax gourd

Wax Gourd is a high income crop for farmers in Tang My, Dong Anh district. A year long farm monitoring exercise preceded the innovation phase of the program; where on weekly basis the abundance of pests were monitored on most vegetables crops cultivated by farmers. A thorough post-monitoring analysis revealed that the thrips complex and thrips vectored tospoviruses are the most important reasons for the low productivity and quality of WG crop in the village.

The innovation development began with a clear objective to manage the thrips complex with Spinosad (Spinosyn A, 85%: Spinosayn D, 15%). Spinosad is a bio-rational pesticide derived from aerobic fermentation of the actinomycetes soil bacterium *Saccharopolyspora spinosa* with a world wide use on over 200 crops against insect-pest of several orders like Lepidoptera, Diptera, Thysanoptera, Siphonaptera, Coleoptera and Hymenoptera etc. yet have little effect on other insects, mammals or other wildlife and is classified as a reduced-risk pesticide by the US Environment Protection Agency (Cleveland et al., 2001). Therefore, Spinosad is allowed to be used in organic agriculture.

Figure 30 Farmers evaluating the Wax Gourd field trials

The main conclusions of the trials were:

- Of the three seasons, the highest density of thrips was found in winter 2004 and the lowest in summer-fall 2005. Thrip density in spring-summer 2005 was a bit higher than that in summer-fall 2005.
- The average of thrips on trap (thrips/cm2 BST) and thrips on leaf (thrips/cm2 leaf) in the control experiment was significantly higher than those in farmer's practice and SPINOSAD.
- In general, under high rainfall conditions (Summer season) pesticides should be applied more often than under dry conditions (Winter season). But in case of thrips control, the number of thrips was much lower under high rainfall condition which counterbalances the higher runoff of the pesticides. In the summer season even the non-insecticide treatment performed quite well.
- Because of the large problem with thrips in the winter season, the frequency of Spinosad application in the winter should have been increased, while in the summer it could have been decreased. This is also clear from comparing the financial performance. The higher investment in increased spinosad application is not compensated enough for by better yields.
- The rate of virus-infected plants in the control (CT0) was always higher than that in farmer's practice (CT1) and in SPINOSAD (CT2). The average of proportion of infected virus plant in winter 2003 was 60% whereas that in the latter two seasons was 2% and 5%, respectively.
- During the wet seasons (spring-summer and summer-fall 2004), the percentage of good fruits (identical fruits with dark green or white powder) was considerably higher than that in the dry season (winter 2004). The percentage of good fruits was lowest in the control (in winter 2004 more clear). There was almost no difference in the percentage of good fruits between farmer's practice and SPINOSAD treatments.
- Yield of wax gourd in farmer's practice and in SPINOSAD treatment was greatly higher than that in the control. Yield of wax gourd in farmer's practice did not differ from that in SPINOSAD treatment.
- Using SPINOSAD to eliminate thrips on wax gourd appears to be a better method compared to farmer's practice due to the following reasons: (1) fewer frequencies of spraying were done (2-4 times/season); 60-67% less amount of pesticides was used. Moreover, SPINOSAD is a far more environmentally friendly product compared to Marshal commonly used by farmers.
- The financial performance of the Spinosad treatment in the winter season for farm 3 was significantly better than the no insecticide treatment. But the increased number of Spinosad applications in the spring and summer season did not result in a better financial performance compared with the non insecticide application and even worse compared with the farmers usual practice.

4.2.3.4 Main results of trials to control club root disease for wrapped heart mustard

Seven experiments were carried out in which the effect of the application of lime was studied for control of club root (Plasmodiophora brassicae) incidence on wrapped heart mustard (Brassicae juncea var. rugosa). Lime was applied at a rate of 603 kg/ha (CaO content: 71.7%), one or fourteen days before sowing. The rate of club root infection in the experiments was at a low level, ranging from 1.3 to 13.3 per cent. For all experiments combined, application of lime significantly reduced the incidence of club root disease. Indications were found that application of lime fourteen days before sowing gives better control than application one day before sowing.

Further investigation of factors influencing the rate of club root disease is needed. The present experiments deserve to be repeated, under conditions with a higher degree of club root infestation. Next to that, currently an effective fungicide for club root disease called Nebijin 0.3 DP produced by the Japanese Mitsui chemicals company is being used in Lamdong province. However the cost is quite high of 8 million VND/ha/season. This cost is affordable for such a big-scale vegetable production as in Lamdong but it is uncertain if this high-cost product will financially rewarding for the smallholders in Son Du.

Figure 31 Farmers and researchers harvesting WHM and measuring the weight

4.2.3.5 Main results of fertilizer trials for wrapped heart mustard

Two field experiments were carried out in Hanoi province, Vietnam, to determine the effect of nitrogen on growth and yield of wrapped heart mustard (*Brassica juncea* var. *rugosa*). It was found that with the highest application of 200 kg/ha N no optimum for net weight was reached yet. The real optimum has to be determined in an experiment with a nitrogen application higher than 200 kg/ha. Since the experiments presented in this report did not cover such high applications, it is impossible to comment more precisely on the N application that would produce a crop with the highest net weight.

Crop yields
Statistical analysis reflects that both experiments (field Thanh and field Tu) show a similar reaction to nitrogen application (data not shown). Because no interaction exists with the location, the results from both experiments can be compared.

The average results of both experiments show that there was significant difference ($p<0.001$) between all treatments on total net crop weight (Table 23). Results from the individual experiments reflect that significant difference existed between all treatments except between T1 (25 kg N/ha) and T2 (50 kg N/ha) for field Thanh. Field Tu shows that significant difference existed between all treatments except between T2 (50 kg N/ha) and T3 (100 kg N/ha).

Table 23 Effect of different nitrogen levels on net crop weight of wrapped heart mustard (kg/ha)

Location treatment	0 kg/ha N T0	25 kg/ha N T1	50 kg/ha N T2	100 kg/ha N T3	200 kg/ha N T4
Thanh	9213 a	18113 b	20440 b	29000 c	35780 d
Tu	6173 a	16153 b	21920 c	25100 c	34513 d
Average	7693 a	17133 b	21180 c	27053 d	35147 e

Application of 200 kg N/ha (T4) produced the highest total net crop weight (35147 kg/ha on average), while the control application T0 (0 kg N/ha) gave the lowest total net crop weight (7693 kg/ha on average). An increasing line can be observed in the total net crop weights from T0 to T4. With the highest application of 200 kg N/ha (T4), the total net crop weight is still increasing, no optimum is reached yet. A nitrogen application higher than 200 kg N/ha would have produced a higher total net crop weight.

Weight of rejected leaves, as a percentage of total leaf weight is not significant (data not shown), marking that an increase in net crop weight does not lead to a higher proportion of rejected leaves per plant.

The optimum nitrogen level for the present two experiments, and their average, as determined with the broken stick model (Table 12) show that an average application of 136 kg N/ha would have produced a crop with the highest net weight in these experiments (a higher nitrogen application did not have a significant increase in net weight as a result, in these particular experiments). It has to be noted that these optimum N applications are only valid for the two experiments described in this report, since no real optimum was reached yet with 200 kg N/ha as the highest application. The real optimum has to be determined in an experiment with a nitrogen application higher than 200 kg/ha.

Table 24 Optimal nitrogen application to receive the highest net crop weight

Location treatment	Optimal N application to receive highest net weight (kg/ha)	Variance Accounted For (VAF) (%)
Thanh	133	91,4
Tu	140	87,8
Average	136,4	89,7

Financial yields

Both experiments (field Thanh and field Tu) show a similar reaction to nitrogen application regarding financial gains (data not shown). Because no interaction exists with the location, the results from both experiments can be compared.

The results regarding financial gains are based on information provided by the crop collector. The price the collector pays for the harvested crop differs according to crop quality. Under the conditions of this experiment the collector had a preference for the crops grown in T3 (100 kg N/ha). He paid the full price (100%) for the crops in this treatment. The plants in the other treatments were considered inferior, and the following division was made for payment:

T0 (0 kg/ha N) = 60% of the price
T1 (25 kg/ha N) = 60% of the price
T2 (50 kg/ha N) = 80% of the price
T3 (100 kg/ha N) = 100% of the price
T4 (200 kg/ha N) = 60% of the price

The prices paid (in Vietnam Dong/ha) for the wrapped heart mustard crop grown in different treatments can then be read from Table 25. These calculations were made with a price of 2400 Vietnam Dong (VND) for a kilogram of wrapped heart mustard. This was the price the crop

collector paid for the wrapped heart mustard from treatment 3 (100% of the price). The price was recalculated for the other four treatments according to the percentages mentioned above.

The average results of both experiments show that there was significant difference ($p<0.001$) between all treatments regarding financial yields (Table 13). And the individual experiments reflect a similar significant difference between all treatments.

Table 25 Effect of different nitrogen levels on financial gains of wrapped heart mustard (1000dong/ha)

Location treatment	0 kg/ha N T0	25 kg/ha N T1	50 kg/ha N T2	100 kg/ha N T3	200 kg/ha N T4
Thanh	13.264 a	26.080 b	39.248 c	69.600 d	51.520 e
Tu	8.896 a	23.264 b	42.080 c	60.240 d	49.696 e
Average	10.064 a	24.672 b	40.672 c	64.928 d	50.608 e

An increasing line can be observed in financial gains from T0 to T3. But with a nitrogen application of 200 kg/ha (T4) the financial gains decrease again, compared to T3 (100 kg N/ha). A notable optimum in financial gains in these experiments can thus be found with a nitrogen application of 100 kg/ha (T3).

But when interpreting the results from the broken stick model for optimum financial nitrogen level (Table 14) it became clear that not even the full 100 kg N/ha applied in T3 was necessary. An average application of 80 kg N/ha would already have given the highest financial gains.

Table 26 Optimal nitrogen application to receive the highest financial gains

Location treatment	Optimal N application to receive highest financial gains (kg/ha)	Variance Accounted For (VAF) (%)
Thanh	91,1	86,3
Tu	70,6	93
Average	79,7	88,9

Apparently collectors, customers and farmers have a preference for wrapped heart mustard that shows some yellow leaves at harvest. The taste of these crops is claimed to be better than the green wrapped mustard crop. The crop in T3 showed more yellow leaves than the T4 crop, which might likely come from a nitrogen deficiency. That is the main reason for the collector to pay the highest price for T3-crops.

Concerning financial gains a notable optimum was found with a nitrogen application of 80 kg/ha. This was related to the preference crop collectors, consumers and farmers expressed towards a wrapped heart mustard crop with some yellow leaves at harvest. It is likely that these yellowish leaves were now obtained due to nitrogen deficiency, but for the future there is an interest among the involved farmers in the cultivation of different wrapped heart mustard varieties that produce crops with yellowish leaves. Since these varieties do not depend on nitrogen deficiency anymore to produce yellow leaves, an optimal N level can be applied, producing a crop with a higher net weight and financial yield.

The Apparent Fertiliser Recoveries in the experiments were low and declined with increasing applications of nitrogen (Table 27).

Table 27 Nitrogen (N) uptake by Wrapped heart mustard (kg/ha) and Apparent Fertiliser Recovery (AFR, %).

N application (kg/ha)	Expt 1 N uptake	AFR	Expt 2 N uptake	AFR
0	13	0	4	0
25	29	64	14	39
50	34	42	22	35
100	40	27	45	40
200	62	24	66	31

Table 29 show that an increase in nitrogen application to the wrapped heart mustard crop results in an increase in nitrogen uptake. Since more nitrogen is available for crop uptake the crop uses a larger quantity of this nutrient. But the Apparent Fertiliser Recovery (AFR calculated as ((N uptake + fertiliser) – (N uptake – fertiliser)) / N gift) indicates that, although a larger quantity of nitrogen is taken up when more nitrogen is applied to the crop, the nitrogen utilisation declines. The share of applied nitrogen that is absorbed by the crop reduces with higher applications, leading to larger shares of the fertiliser being lost to the environment.

It is concluded that for economical and ecological reasons attention has to be paid to the development of methods of fertiliser application that results in higher fertiliser recoveries.

An analysis of the 'Fresh weight of above ground plant parts' indicated that a period of about 25 – 30 days goes by before crop growth actually sets of. When transplanting wrapped heart mustard, instead of sowing, a time period of about 20 days could be saved. The plants would need several days for recovery after transplanting, but after that they would directly be at the start of the rapid growing period. In a vegetable sequence, the total time saved by transplanting instead of sowing could perhaps allow the cultivation of an extra crop in a year.

Crop collectors, customers and farmers expressed a preference for wrapped heart mustard that shows some yellow leaves at harvest. Better use could be made of the aspect of yellow leaf preference when another variety of wrapped heart mustard was chosen for production. Varieties with a closed crop heart, which prevent sunlight to reach the inner leaves, and thus photosynthesis to take place, produce a crop with some yellowish leaves. Since this crop does not depend on nitrogen deficiency anymore to produce yellow leaves, an optimum N level can be applied, producing a crop with a higher net weight and financial yield.

The results from the two experiments described in this report were presented to the involved farmers and interested colleagues in the village. From a discussion after the presentation it became clear that farmers prefer T3. Wrapped heart mustard from T3 was easiest to sell and the best quality crop according to them. The yield was however not very high. Although T4 produced a higher yield, it was less attractive because of a higher incidence of fungus disease and a lower market value. The proposal to introduce a different variety of wrapped heart mustard, which forms yellowish leaves, was received with a lot of interest. A wrapped heart mustard variety trial in Son Du village might be a useful follow-up on the research presented in this report.

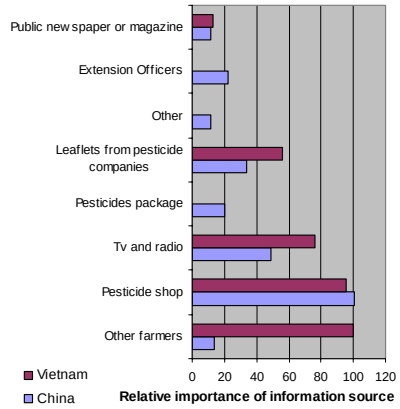
4.3 WP3: Simulation of pesticide leaching

4.3.1 Results of the RDA and structured interviews (Pengzhou and Dong Anh)

Farmers do have concerns about the quality of their living environment but they often do not know as to what extent pesticide use has an impact on the environment. Most farmers rely on groundwater for domestic purposes and therefore further assessment of the risks of leaching of pesticides to groundwater was recommended. Farmers do experience health problems which they relate to the use of pesticides. Skin allergy and headache were mentioned most frequently. Training of farmers in safe storage and use of pesticides is recommended and can improve the health situation of the farmers.

Reliability/efficacy of the pesticide and adequate accompanying information are the most important criteria for pesticide selection. For information on pests, diseases and chemical control farmers rely heavily on own experience, neighbours (Dong Anh only) and pesticide traders in the village. Neither the local nor the national government plays an important role in providing farmers with information.

Figure 32 Information sources farmers use for pest and disease management



The development of a pest control guide for farmers is recommended including simple indications of the environmental and health risks related to the crop protection strategy.

4.3.2 Results of farm monitoring and hazard assessments, Dong Anh (Vietnam)

On the packages of about 20% of the formulations encountered in the field information on the type of active ingredient was missing. In these cases farmers do not know what they are applying to the crop and have to rely fully on information of the pesticide trader. Quality control of the formulations is not possible in these cases. Stricter control of the obligations of the manufacturers to provide this information is recommended. Chinese cabbage, tomato, climbing bean, wrapped heart mustard kohlrabi, wax gourd, cauliflower, kohlrabi and rice seedlings receive the highest amounts of active ingredients. IPM training should be focused on these crops first.

Highest hazards to *human health* are related to the use of Monitor 40EC (containing methamidophos) and Lanate 40SP (containing methomyl). The active ingredients are ranked as highly hazardous and are mainly applied to soy bean, cauliflower (Monitor) and wax gourd, kohlrabi and wax gourd (Lanate). Safe use training should be geared towards the use of these compounds. Highest hazards to *surface water* are related to the use of formulations containing propineb, butachlor, trichlorfon, carbendazim, and dimethoate (especially Antracol 70WP), applied to an

array of different vegetables, with high doses on egg plant, different types of bean and kohlrabi. Especially in vulnerable scenarios (proximity of surface water bodies to the agricultural fields, vulnerable ecosystems downstream) application of these formulations poses a potential risk. The hazard assessment for *groundwater* showed that formulations containing propineb, trichlorfon, carbendazim, and dimethoate, mainly applied to bean, eggplant, tomato and kohlrabi, posed the highest hazard for groundwater. Especially in vulnerable scenarios (e.g. with shallow groundwater tables) application of these formulations poses a potential risk.

Table 28 Active Ingredients, formulations and crops posing potential high hazard (Dong Anh (Vietnam))

AI	*Class*	*Formulations*	*Crops*
Potential high hazard to humans (using WHO Classification)			
Methamidophos	High	Monitor 40EC	Soy bean, cauliflower
Methomyl	High	Lanate 40 SP	Wax gourd, kohlrabi, wax gourd
Cypermethrin	Moderate	Cymerin 10C, 5EC, Cyrin 25C, Bestox 5EC, Sherpa 25EC, Cymkill 10EC, Arrivo 5EC	On may different vegetables, with highest doses on cauliflower, bean, cabbage
Fenobucarb	Moderate	Bassa 50EC	Various vegetables, with highest doses on wax gourd, soy bean, tomato, wax gourd
Endosulfan	Moderate	Cyclodan 35EC, Kilodan	Various vegetables, with highest doses on cabbage, cauliflower, radish and eggplant
Potential high hazard to aquatic life (using ATI)			
Propineb	Very high	Antracol 70WP	kohlrabi, French bean
Butachlor	High	Butoxim 60EC, Butan 60EC	maize, rice and various vegetables such as sweet potato, tomato broccoli, cauliflower, wrapped heart mustard
Trichlorfon	High	Terex 90SP	Various vegetables, with highest doses on bean, eggplant, tomato
Carbendazim	High	Vicarben-S 75BTN, Carbenzim 50WP,	Various
Dimethoate	High	Bi 58 40EC, Dithoate 40EC, Vidithoat 40ND	Various, with highest doses on climbing bean, eggplant, kohlrabi
Potential high hazard to groundwater (using GUS index)			
Propineb	Very high	Antracol 70WP	Kohlrabi, French bean
Trichlorfon	High	Terex 90SP	Various vegetables, with highest doses on bean, eggplant, tomato
Carbendazim	High	Vicarben-S 75BTN, Carbenzim 50WP	Various
Dimethoate	High	Bi 58 40EC, Dithoate 40EC, Vidithoat 40ND	Various, with highest doses on climbing bean, eggplant, kohlrabi

4.3.3 Results of farm monitoring and hazard assessments, Pengzhou (China)

On the packages of about 50% of the formulations encountered in the field information on the type of active ingredient was missing. In these cases farmers do not know what they are applying to the crop and have to rely fully on information of the pesticide trader. Quality control of the formulations is not possible in these cases. Stricter control of the obligations of the manufacturers to provide this information is recommended. In Pengzhou Cow pea, Chinese cabbage (Shengli) and garlic, tomato and eggplant (Xibei) received the highest amounts of active ingredients. Safe use training and IPM training should be focused on these crops first.

Highest hazards to *human health* are related to the use of dichlorvos, triazophos, and methomyl all ranked as highly hazardous and mainly applied to cow pea and eggplant. Safe use training should be geared towards the use of these compounds. Pyridaben poses a very high hazard for *surface water*. Pyridaben is mainly used on eggplant, and to a lesser extend on wax gourd, cow pea and lettuce. Butachlor poses a high risk for aquatic life. Butachlor is mainly used on the staple crops

maize and rice and on various vegetables, such as sweet potato, tomato broccoli, cauliflower, wrapped heart mustard, eggplant, mung bean and Irish potato. The hazard assessment in Pengzhou for *groundwater* showed that formulations containing ziram and oxadixyl (mainly applied to tomato, grape and garlic) pose a very high hazard. Formulations containing imidacloprid and fenaminosulf also pose a potential high risk to groundwater, but their use (on egg plant, cow pea and wax gourd) was rather limited.

Table 29 Active Ingredients, formulations and crops posing potential high hazard (Pengzhou (China))

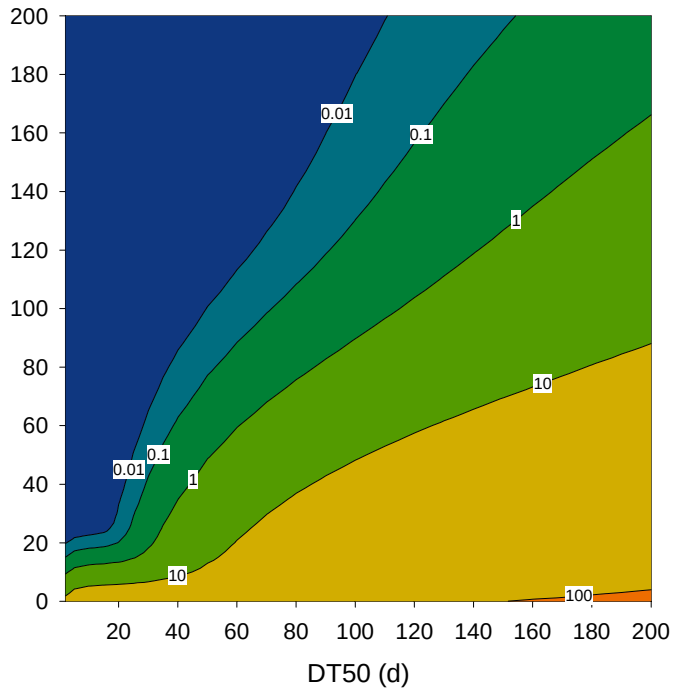
AI	***Class***	***Formulations***	***Crops***
Potential high hazard to humans (using WHO Classification)			
Parathion	Extremely high	1605 or Agrade-1605	Grapes, pig spinach
Dichlorvos	High	Di di wei, Ban qian ling	Cowpea, eggplant
Triazophos	High	San zuo ling	Cowpea, eggplant, rice
Methomyl	High	Wan ling, Chu sha 2001	Cowpea, eggplant
Potential high hazard to aquatic life (using ATI)			
Pyridaben	Very high	Shao man jing, Da man ling	Mainly eggplant, also wax gourd, cowpea and lettuce
Butachlor	High	Tian shuang, Paozaibao and '40'	Eggplant, rice, mung bean
Potential high hazard to groundwater (using GUS index)			
Ziram	Very high	Lanbo, Qieguo'an, Tuijunte	tomato, grape and garlic
Oxadixyl	Very high	San zuo ling, Sha du fan	Tomato
Trichlorfon	High	Di bai chong	cow pea and rice
Carbendazim	High	Duo jun ling, Qieguo'an	lettuce, ginger, wax gourd
Dimethoate	High	Le Guo	Cowpea
Metalaxyl	High	Lei duo mi er, Rei du mei, Mi duo er, Jiashuangling, Jia suan tong	cabbage, cow pea
Imidacloprid	High	Ya shi jing, Si ji hong, Lv xian feng, Ai mei le, Xing, Wan neng	low doses on egg plant and wax gourd
Fenaminosulf	High	Gen fu ling	low doses on egg plant and cow pea

Figure 33 Farmer mixing pesticides

4.3.4 Results of the risk assessment for groundwater

Leaching Contour Graphs (LC Graphs) were developed to estimate risks to groundwater for various scenarios. An example of an LC Graph is given in the figure below.

Figure 34 Leaching contour graphs



Each LC graph is valid for ***one*** specific scenario (a combination of a soil, a climate, a crop) and for ***all*** pesticides. Once the $DT_{50,\ soil}$ and the K_{om} of a pesticide are known, it can simply be placed in the graph for a certain scenario, and the expected average concentration in the soil water at the bottom of the soil profile can be read from the graph, using the 'iso-leaching lines'. For risk assessment the EU drinking water standard of 0.1 ug/l is used for all active ingredients. That means that all active ingredients that find a position in the LC graph below the 0.1 ug/l line pose a risk for groundwater quality. The graph can be used by non-scientific staff for any pesticide without new model calculations as long as the sorption coefficient (K_{om}) and (degradation rate ($DT_{50,\ soil}$) of the activity ingredient are known.

In Pengzhou (China) the Youshatian and Shatian soils are more susceptible to leaching than the Nitian soil. On the Youshatian and Shatian soils the use of active ingredients with high leaching risk (ziram, trichlorfon, propineb, methomyl, methamidophos, fenaminosulf, acephate) could be restricted, especially in areas with shallow groundwater tables. Of the active ingredients reported by the farmers in Pengzhou acephate, fenaminosulf, methamidophos, oxadixyl, propineb, trichlorfon and ziram pose very high risks for at least one soil type. These active ingredients are mainly applied to tomato, grape and garlic.

The groundwater risk assessment for Dong Anh (Vietnam) failed because the complicated hydrology could not be simulated.

4.4 WP4: Marketing Strategies

4.4.1 China

The various marketing studies undertaken in Sichuan shows that there are interesting market chances for the farmers in the VEGSYS research sites. The first interesting market are the vegetable processor industry in Penghzou county. Also the consumer study shows that among Chengdu consumers there is a real demand for pesticide residue free vegetables. To be able to get access to both the vegetable processors and the more lucrative urban market, farmers will have to organise themselves into farmer groups. This is especially important as supermarkets are rapidly becoming the most important channel for vegetable retailing in Chengdu.

Supermarkets started to appear in Sichuan Province in the late 1990s. Up till now, there are about 20 supermarket chains in its capital Chengdu with over 400 shops. Foreign supermarkets have been leading the way since the 1990s when they first entered the capital city of Chengdu. The 'take-off' stage of supermarkets in Chengdu seems to have started in 2003 when both domestic and foreign supermarkets introduced their first shops in Chengdu. Generally speaking, supermarkets in Chengdu can be grouped into three categories: foreign supermarkets, domestic supermarkets and local supermarkets. The foreign supermarkets include both joint-venture and foreign-owned ones. They often open large stores and operate as hypermarkets and warehouse clubs. Furthermore, they have the capacity and resources to focus on fresh produces. The second category, the domestic supermarkets, are those which have their origins mainly in other provinces than Sichuan, such as Shanghai and Guangdong. This group closely follows the foreign competitors in terms of marketing strategies. The last group, the local supermarkets, originate from Sichuan. They operate on a small scale in terms of floor space per store, but they have a substantial number of stores **in and** around Chengdu. These local supermarkets do not normally market fresh produce.

Vegetables in supermarkets compete with prices. Vegetable prices are set based on competitors' prices and local open markets. Vegetable prices in supermarkets are normally set 5% to 20% lower than those in the open markets. Price levels change every day, even more than once for some stores in order to keep the lowest price possible. Other promotion instruments, such as brochures, free shuttles, and coupons, were also found.

A combination of different procurement systems is used to obtain different quality levels of vegetables. Normal vegetables are often obtained from wholesale markets whilst professional suppliers provide higher quality vegetables, such as Pollution Free Vegetables (PFV). Limited Green vegetables, Organic vegetables and exotic vegetables are often flown in from their China headquarters in Shanghai.

Half the number of our sampled supermarkets were making a loss on their vegetable sections. Lower vegetable prices were the major cause. However, supermarkets do not expect their vegetables to be a profitable product. The purpose of the vegetable section is to attract as many consumers as possible by strongly promoting it. Regarding its future development, the focus will be on vegetable quality improvement and further market expansion (more stores will be added shortly).

Our field interview indicates that small scale farmers in Sichuan have not been excluded from the supermarket supply chain. Their products enter the supermarket via three channels: traditional wholesale markets, indirectly contracted by professional suppliers, and farmers' own associations. The fact that four out of six interviewed supermarkets are obtaining their vegetables to a different degree from wholesale markets demonstrates the significance of wholesale markets as part of the supermarket procurement scheme. However, in order to sustain their market position, wholesale institutions have to reinforce a proactive regulatory environment regarding food safety issues as supermarkets expect more regarding these demands in the future.

Opportunities for small scale farmers

The other two channels in our survey through which farmers' products enter the supermarkets are professional suppliers and farmers' vegetable associations. Both schemes have to deal with the same issue: how to organize all these small-scale farm productions so as to guarantee the quantity and quality requirements imposed by the supermarkets. In Latin America and some parts of Asia, supermarkets often select large producers as their 'preferred suppliers' (Reardon, 2003) whilst striking off the list small scale producers. The case in China is so unique in the sense that large vegetable producers do not exist in China, thanks to its Household Responsibility System, which resulted in an average of 0.5 hectare farm size for each household. This fragmented production system often imposes tremendous pressure whenever the issues of product quantity and safety requirements are raised.

After decades of restraining the farmers' own organisation, there is an indication that the Chinese government has begun to realise the importance of it to the rural economy and has started to encourage its development. Local governments, particularly at township and village levels, could be of assistance to its development and play a facilitating role between individual farmers and professional suppliers/supermarkets. Our investigation shows that small scale farmers are not necessarily excluded from the supermarket procurement system. Innovative institutions (such as associations and co-operatives) and local governments could facilitate this transition.

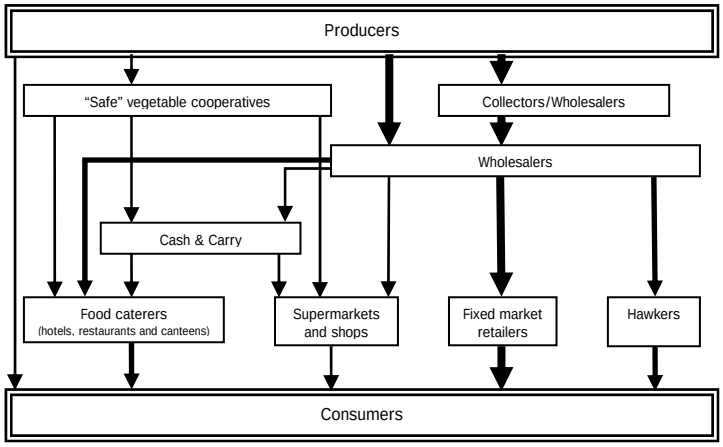
4.4.2 Vietnam

New and profitable markets are the incentive most farmers need to convert to safer more sustainable vegetable production. The present marketing system in Vietnam makes it difficult to develop a 100 percent watertight "safe" vegetable supply chain but the efforts being made in this direction are clearly benefiting some small-scale vegetable producers. Farmers who work through the newer marketing channels of "safe" vegetable cooperatives and sell to canteens, restaurants, shops and supermarkets, stand a good chance of getting a higher price for their products.

4.4.2.1 Vegetable market

From the first supermarket in 1993 and the 130 supermarkets by the end of 2002, the modern retail sector only seems to have managed to gain a 1 to 2% share of the vegetable retail market in Hanoi and HCMC. Compared with the far larger growth in the total demand for vegetables, vegetable retailers who are currently active in the traditional retail sector have probably not lost turnover due to the rise of the supermarket sector.

Figure 35 The vegetable marketing system of Hanoi



Although the rise of the supermarket sector might cause a slower growth of the traditional retail sector for vegetables, it is unlikely that in the short term vegetable retailers will go out of business because of supermarkets. A larger threat might be caused by the fast growing share of street food and restaurants. If the food catering sector starts to source their vegetables from

supermarkets or the cash & carry outlets, this might slow the growth of the traditional sector more.

For the future, probably the most decisive factor in gaining market share in vegetable retailing will depend on who can best serve the consumers need for convenience. Currently, consumers clearly prefer to buy their vegetables at locations close to their home, which saves time and costs. As supermarkets do not yet have the same dense cover as traditional retail markets, the last market type seems to have an advantage. This advantage might diminish because of the increasing ownership of refrigerators which favours the supermarkets, as it allows consumers to do all their shopping one or two times per week, making it worthwhile for the consumer to travel to less conveniently located supermarkets. Luckily for the traditional retailers, the increasing economic development is also causing more and more traffic jams, which will favour the traditional retail system.

The second important factor is the development of vegetable prices in the different outlets. A recent study of prices in different retail outlets undertaken by a consortium of Vietnamese and French research institutes concludes that supermarket prices for tomatoes and water spinach are higher than in the traditional retail outlets (MALICA, 2005).

The last factor is the growth in the share of vegetable consumers for whom food safety becomes the key-decision factor. Although Vietnamese consumers find food safety important, for the majority of them it is not more important than convenience and a low price. For the consumers who have food safety as the major decision factor, supermarkets have the best image both in HCMC and Hanoi. However, this image does not yet seem to be based on facts; supermarkets should change this situation quickly before consumer confidence is hurt. It is expected that they will apply the same strategies as supermarkets in other countries, moving away from sourcing of vegetables on spot markets towards preferred suppliers who can meet private sector safety and quality standards.

Although the consequences for the traditional vegetable retailers in Hanoi seem to be limited in the coming years, the sector should not stand still. Vegetable producers, wholesalers and retailers should innovate and develop new ways of cooperation, so that they can also provide their consumers with the same level of food safety as the supermarkets.

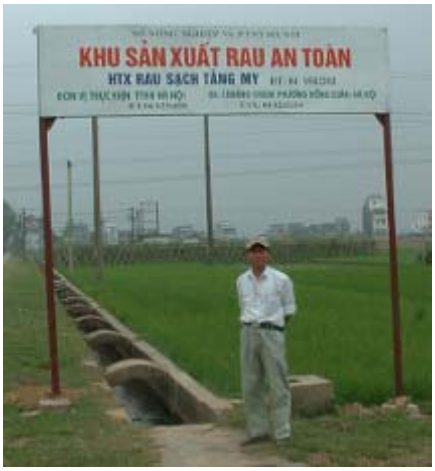
4.4.2.2 Cooperatives

Two types of co-operatives can be distinguished in Hanoi: transformed co-operatives and newly established co-operatives. Transformed co-operatives are the old-style collective co-operatives that were transformed after the adoption of the Co-operative Law in 1997. New co-operatives are those established after the new law. These two types of co-operatives have different characteristics and strategies. Transformed co-operatives are more engaged in input supply services whereas newly established co-operatives are active in marketing and promotion. The consumer's demand for safe vegetables and the characteristics of small-scale farming are fundamental factors stimulating the development of co-operatives in Hanoi.

The structure of the co-operatives is generally clear. However, their managers often lack management experience which hampers the development of the business. Another internal factor obstructing the co-operatives' development is the poor participation of co-operative farmers, particularly those of the transformed co-operatives. The co-operatives in Hanoi play a central role in linking its member farmers with high-end markets, particularly with vegetable shops and supermarkets. Whilst different types of co-operatives have contributed substantially to the social and economic development of farm households in Hanoi, the full potential benefits of the co-operatives still remain to be tapped, especially with regard to the transformed co-operatives.

Currently, most of the safe vegetables are sold through direct contacts between cooperatives and large institutions or company canteens. Much more coordination and cooperation between farmers, assemblers, wholesalers and retailers is needed to increase the demand for safe vegetables for the retail sector as well. An increase in demand from supermarkets, for example, might provide a strong incentive for farmers to produce high-quality and "safe" vegetables. This is already happening in neighbouring Thailand and China, where supermarket chains concerned about their image and brand are increasingly demanding food products free of pesticide residues. In order to win the confidence of consumers and retailers, however, contracts accompanied by strict protocols, internal control systems, input record keeping and simple tracing systems, as well as strict social control within the cooperatives themselves, will be needed.

Figure 36 Safe vegetable (Rau An Toan) cooperative advertisement boards in MAPET research site



4.4.2.3 Farmers strategies to increase the price of vegetables

The main aim of the VEGSYS project is to contribute to the development of economically viable vegetable production systems of smallholder farmers in Vietnam. This study aimed to indicate which factors enable smallholder farmers in Vietnam to adopt strategies that would increase the profitability of their vegetable production. To be able to reach this goal, statistical analyses have been carried out on data collected by the VEGSYS team and additional interviews have been made with both farmers and traders.

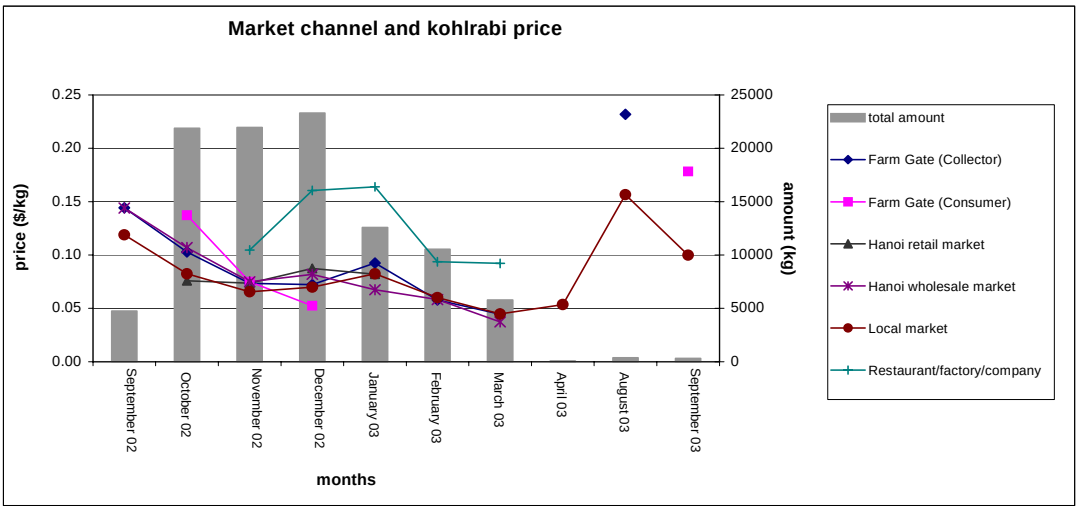
Vegetable production contributes to an important share of the total smallholder farmers' income. On average, twenty eight percent of the family earnings come from vegetable production. Vegetable production is capital and labour intensive, making it difficult for the poorest farmers to start with or to intensify their vegetable production. Farmers can increase their income in several ways. This thesis focuses on how farmers can increase their output price of vegetables. Two strategies that farmers can adopt have been selected for research, the marketing channel choice and marketing timing. The analysis focused on three vegetables, wax gourd, kohlrabi and wrapped heart mustard (see Table 30).

Table 30 Selection criteria and values for highest scoring vegetables

Vegetables	Share of households cropping (%)	Share in total vegetable area (%)	Share in total vegetable income (%)	Gross margin ($/ha)	Gross Margin ($/day/ha)
Wrapped HM	37	15	15	644	4.84
Wax gourd	49	12	24	1867	14.47
Kohlrabi	73	37	25	611	5.41
Sweet cabbage	37	7	5	488	
Tomato	38	6	8	954	

The marketing channel choice does influence the price farmers receive, as prices are significantly different between marketing channels. Farmers receive significantly higher kohlrabi and field cabbage prices from the farm gate collector than at the Hanoi wholesale market or the local market respectively (Figure 37). Farmers receive the highest wax gourd prices at the Hanoi wholesale market. This market requires good quality, the local market requires less good quality. Therefore, farmers with livestock sell more often to the local market, as they have less time to pay attention to their vegetable production. Farmers who are able to sell large quantities will sell to the collector or at the Hanoi wholesale market. Farmers with off-farm activities are selling to the collector as their opportunity costs of labour are high and selling vegetables to the collector minimises the labour spent on trading vegetables. Households owning a motorcycle are more likely to sell at the Hanoi wholesale market or at the local market than to the collector.

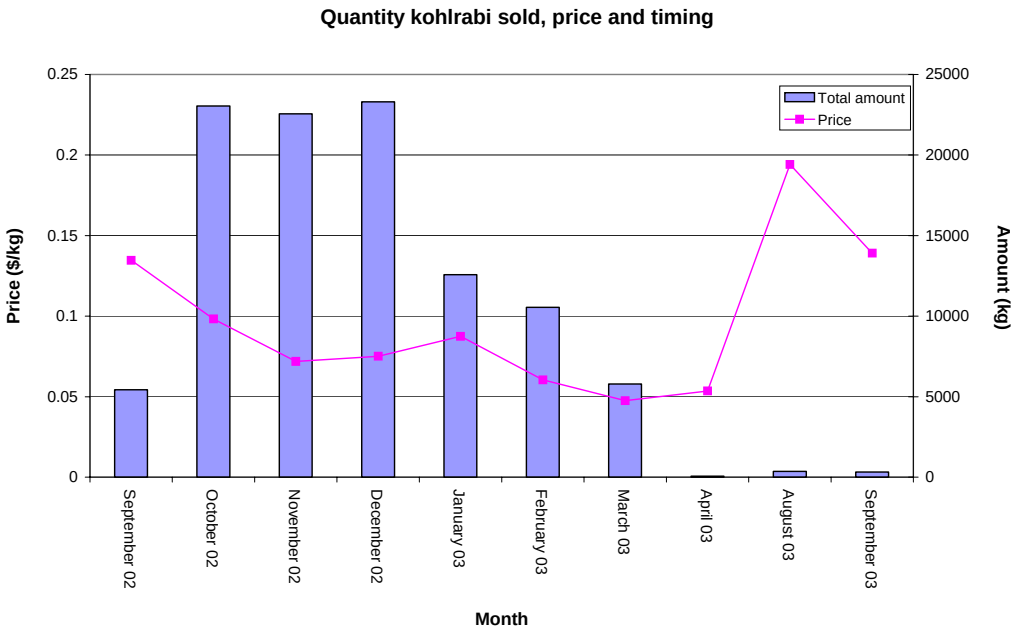
Figure 37 Producer prices of kohlrabi in all marketing channels and total amount sold in



Son Du and Tang My between September 2002 and October 2003

The timing of marketing also influences the vegetable price farmers receive (Figure 38). Vegetables in early season receive significantly higher prices than those in the rest of the year. But producing vegetables in early season is hampered by suboptimal climate conditions. Farmers face more problems with pests and diseases, in addition plants are also more likely to die due to unsuitable temperatures or rainfall. Early producing vegetables requires more education, labour and capital due to higher use of pesticides and more time needed to nurse the crops. The costs of early production are high, limiting the profit. It will be a challenge for the farmers and researchers to reduce these costs and, therefore, making this strategy worthwhile for the farmers to increase their income.

Figure 38 Amount of kohlrabi sold, its price and timing in Son Du and Tang My from September 2002 until October 2003



4.4.2.4 Export of fresh vegetables by VEGSYS farmers

Figure 39 The newly started fresh vegetable export company with the VEGSYS farmers in Vietnam. The post harvest activities generate a lot of extra paid off-farm employment

4.5 WP 5: Dissemination and recommendations

4.5.1 Dissemination results

The following dissemination results were achieved:

- 38 project reports were published and made available on the project website
- Seven papers presented in international conferences and three papers accepted for conferences after the project date
- Four papers published in international journals
- Six papers published in national scientific journals in China and Vietnam
- One paper published in an international popular scientific agriculture journal
- More than 5000 hits on the project website: www.vegsys.nl from people located in at least 25 different countries and from the following continents:
    - 67% of hits from Europe
    - 28% of hits from Asia
    - 5% from North America
    - 1% from Africa
    - 1% from Australia
    - 1% from Latin America
    - 2% unknown
- Various articles in local newspapers and appearances in regional TV programs
- Organised six large workshops for wide range of stakeholders ranging from farmers, traders, extensionist, agribusinesses, policymakers to researchers

Figure 40 Lin Chaowen and Siebe van Wijk presenting results during a seminar in Pengzhou County and filmed by Pengzhou Television

The following steps are taken to ensure application of the results:

- A project with a large supermarket chain and a large agriculture input supplier started in January 2006 to develop sustainable vegetable value chains in which farmers will receive continuous technical backstopping and long term supply contracts to reward them for their use of more sustainable cultivation practices
- A PhD project was started to develop sustainable year-round vegetable rotation schemes for the Red River Delta in North Vietnam
- A PhD project was started to study in more detail how public policy in Vietnam can have more impact to influence the safe and more rational use of pesticides in horticulture
- A special cooperation program between various Dutch and Chinese government agencies and institutes was started to improve the pesticide registration testing procedures in China. In this program use will be made of the VEGSYS developed PRIMET software, which is a tool to carry out environmental risk assessments of pesticides.
- Several of the VEGSYS project team members in Vietnam and from the Netherlands started a private consulting and R&D company to assist all actors within a supply chain to better produce, package and market vegetables
- In China several of the VEGSYS team members are starting a company to assure farmers get access to high quality vegetable seedlings

Figure 41 VEGSYS team visiting a modern horticulture farm in Chiang Mai, Thailand

4.5.1.1 Recommendations

- In both China and Vietnam it is crucial that new farmer groups (in research sites in Penghzou) and existing ones strengthened. There is enough demand in the market to link these farmer groups directly to supermarkets, processors and large food caterers. The farmer groups will need skills on technical management of the vegetables, development of internal quality control systems, transparent financial management, facilitating group work, development of marketing strategies and sales skills
- There is an enormous need for more applied research on vegetable cultivation. Especially improvements in agronomic practices can be achieved. Hardly any clear GAPs are available for farmers. The VEGSYS project developed a team which can develop GAPs. So far this has been done for 4 different vegetables, while in one village (of 400 farms) about 30 to 40 different vegetables are cultivated.
- Currently vegetable production is rotated during the year with rice production, which has a very bad impact on soil structure and costs farmers a lot of extra labour. Furthermore, farm

income could be tripled if vegetables could be produced year round. The possibilities for such a radical farming system change should be studied and experimented in detail.

- Quantification at both micro and macro level of the impacts of new emerging supply chains (supermarkets) on rural development, poverty reduction and participation of the poor

5 Problems encountered

- Language problems were the main reason for the change of subcontractor in China because the staff of the department of plant protection could hardly communicate in English. With the other partners this is not a big problem, only in writing English. Publishing results in international scientific journals, in policy briefs, and in a project working paper series, required a lot of writing and editing effort from the European partners.
- The main problem for the project in 2003 were the travel bans to China and Vietnam for the European partners, because of the SARS virus. For the same reason the Chinese partners also were confronted with some restrictions for travelling within Sichuan province. Thanks to the creativity of the project partners and their hard work, the problems caused by SARS did not lead to any serious delay in the implementation of project activities.
- Another problem was that due to health reasons the senior researchers of the Spanish partners could no longer travel to the project sites to backstop the soil fertility work. This problem was solved by carrying over the soil fertility backstopping to Alterra.
- The identification of the weeds from Vietnam took much more time than anticipated, because of the lack of relevant botanical data and literature concerning weeds in Vietnam.
- The limited analytical capacity of the laboratory of Hanoi Agriculture University was a big constraint in the determination of the exact virus in wax gourd. The same problem was also faced by the partners in Sichuan when they tried to identify the virus in the garlic. Trying to get plant samples to the laboratory of Hanover University was blocked by Chinese and Vietnamese custom authorities.
- For a four year project, with researchers from many different institutes and countries is has been remarkable how little turnover there has been in the participating researchers. This has allowed the formation of a very well cooperating international team, with a lot of friendships developing the different partners. But in the beginning of 2005, the VEGSYS team had to deal with one of the key-players leaving the project. The team leader of Hannover University, Prof Borgemeister, was offered the chance the become the director of ICEPE in Kenya and left his position for this new challenge. But luckily Hannover University was able to replace with Prof Borgemeister with Prof Poehling.
- In 2005 we discovered that the approach for risk assessments for groundwater could not be applied to the Vietnamese research site. Due to the complex hydrological and soil physical situation, the pesticide leaching model could not be applied. We recruited a student to do additional hydrological and soil physical field measurements that should yield enough information for further simulations. Unfortunately, this did not work out. Even with the new information model simulations could not be done. It was concluded that the water simulation module of PEARL is not suitable for simulation of water flow in soil profiles with highly smeared soil layers.

6 Technology Implementation Plan

6.1 Software

The VEGSYS project resulted in three new software tools:

- NUTMON Toolbox 3.0
- WPDmon
- WART

As this software has been developed with public funds it was decided to make the software tools available for free for the scientific community. The software tools can be downloaded on: www.nutmon.org

In addition to these tools, Alterra used the VEGSYS project and two other EU funded projects (MAPET (www.mapet.nl) and MAMAS (www.mamasproject.nl)) to develop PRIMET (Brink et al., 2005). PRIMET is a decision support system (DSS) to assess the risks of pesticide use on aquatic and terrestrial ecosystems, groundwater and human heath. PRIMET is applicable to low data environments and can be operated by non-scientific staff.

6.2 Vegetable cultivation improvements

Of the four developed improvements of vegetable cultivation the following follow-up is given:

- In Vietnam the organic pesticide Spinosad is commercially exploited by a plant protection multinational. But for farmers in the research area it is very difficult to find a shop where the product is sold. Therefore, the VEGSYS team contacted the distributor and introduced them to the experiments with Spinosad and the farmers in the research area who want to buy and use the product
- In China the virus free garlic seeds and grafted eggplant seedling were very good technologies to solve the problem of "huofeng" disease of garlic and wilt disease of eggplant. They were fully accepted by farmers and local government, but these two technologies needed to be tested and improved further to be suitable with the farming condition. The local government and Chinese partners are investing in follow up trials to fine-tune these technologies

6.3 VEGSYS approach

The VEGSYS multi-disciplinary approach has attracted the attention of both the public and private sector:

- A follow up project was financed by the private sector in order to establish a guaranteed pesticide residue free vegetable supply chain from smallholders to supermarkets
- An export supply chain of fresh herbs to Europe was developed
- Alterra, IoPP and SFI will be involved in a new project with the Chinese Pesticide Registration authority (ICAMA) of the Chinese Ministry of Agriculture. In 2006 and 2007 ICAMA has to include environmental criteria in the pesticide registration procedures, and 600 registrations have to be reconsidered using these new criteria. ICAMA has asked Alterra and the Chinese VEGSYS team to assist in this process, and the tools developed in the VEGSYS projects may play a role in this
- Several of the VEGSYS project team members in Vietnam and from the Netherlands started a private consulting and R&D company to assist all actors within a supply chain to better produce, package and market vegetables
- In China several of the VEGSYS team members are starting a company to assure farmers get access to high quality vegetable seedlings

7 Publications and Papers

Seven papers have been presented in international and national conferences by the VEGSYS researchers. Also numerous papers have been published in international and national journals.

Table 31 VEGSYS papers presented during international conferences and publications in national and international journals

Authors	*Title paper*	*Conference/Journal*
Dr. Xiaoyong Zhang (LEI), Xinhong Fu (SAU) and Jinxiu Yang (SAU)	The Evolution of Chinese Vegetable Supply Chain	International conference of the International Food and Agribusiness Management Association (IAMA), 9-11 June 2004, Montreux, Switserland
M.S. van Wijk, Cuong Trahuu, Bu Thi Gia, Nguyen An Thru and Pham Van Hoi	The traditional vegetable retail marketing system of Hanoi and possible impacts of supermarkets	International conference on Supply Chain Management in Transitional Countries, International Society of Horticulture Science (ISHS), 19-23 July 2005, Chiang Mai, Thailand
Xiaoyong Zhang ,Xinhong Fu, Jinxiu Yang and M.S. van Wijk	Vegetable Supply Chains of Supermarkets in Sichuan, China and their Implication for Supply Chain Management	International conference on Supply Chain Management in Transitional Countries, International Society of Horticulture Science (ISHS), 19-23 July 2005, Chiang Mai, Thailand
A.P. Everaarts, Nguyen Thi Thu Ha and Pham Van Hoi	Agronomy of a rice-based vegetable cultivation system in Vietnam. Constraints and recommendations for commercial market integration	International conference on Supply Chain Management in Transitional Countries, International Society of Horticulture Science (ISHS), 19-23 July 2005, Chiang Mai, Thailand
Arij Everaarts, Nguyen Van Dung, Pham Van Hoi, Nguyen Thi Thu Ha	Some recommendations for a better vegetable production in Dong Anh peri-urban district, Hanoi City (in Vietnamese)	Vietnam Soil Science 23 (2005) 112-115
A.P. Everaarts, Nguyen Thi Thu Ha and Pham Van Hoi	Agronomy of a rice-based vegetable cultivation system in Vietnam. Constraints and recommendations for commercial market integration	Acta Horticulturae, February 2006
M.S. van Wijk, Cuong Trahuu, Bu Thi Gia, Nguyen An Thru and Pham Van Hoi	The traditional vegetable retail marketing system of Hanoi and possible impacts of supermarkets	Acta Horticulturae, February 2006
Xiaoyong Zhang ,Xinhong Fu, Jinxiu Yang and M.S. van Wijk	Vegetable Supply Chains of Supermarkets in Sichuan, China and their Implication for Supply Chain Management	Acta Horticulturae, February 2006
M.S. van Wijk, R. Engels, Tran Huu Cuong, Nguyen Anh Tru and Pham Van Hoi	Opportunities for farmers: "safe" vegetables for Hanoi.	LEISA Magazine, June 2005
Xiaoyong Zhang , Tran Huu Cuong, Nguyen Anh Tru and Siebe van Wijk	Vegetable Co-operatives: Linkage of Small Farmers and Markets	Paper accepted for presentation during the 7th International Conference on Management in Agrifood Chains and Networks (Ede, 2006)
Pham Van Hoi (HAU), Lin Chaowen (SFI) and Rik van den Bosch (Alterra)	Leaching potential of pesticides used in peri-urban vegetable farming in Hanoi (Vietnam) and Chengdu (China)	The 4th World Conference of the "Society of Environmental Toxicology and Chemistry (SETAC)", 14-18 November 2004, Portland, USA.
Rik van den Bosch, Lin Chaowen and Pham van Hoi	"Inventory of pesticide use and farmers' perception in peri-urban vegetable production in Hanoi (Vietnam) and Chengdu (China)"	The 4th World Conference of the "Society of Environmental Toxicology and Chemistry (SETAC)", 14-18 November 2004, Portland, USA.
LIN Chao-wen; CHEN Yi-bing; HUANG Jing-jing; Rik van den Bosch; Mechteld M. S. ter Horst	Effect of irrigation on pesticides leaching in vegetable farming in Chengdu plain using PEARL model (in Chinese)	ECOLOGY AND ENVIRONMENT
Xiong Wenlan; Chen Yibing Lin Chaowen	The Pollution Evaluation of Pesticide Infiltration to Groundwater by PEARL Model(in Chinese)	Science of Soil and Water Conservation
XIONG Wen-lan; CHEN Yi-bing	Research review of the effect of pesticide leaching on groundwater(in Chinese)	Southwest China Journal of Agricultural Sciences
LIN Chao-wen, CHEN Yi-bing, HUANG Jingjing,	Pesticide Use and Related Risks for Groundwater Pollution in Vegetable Production in Pengzhou	Southwest China Journal of Agricultural Sciences

Authors	*Title paper*	*Conference/Journal*
Rik van den Bosch	County, Sichuan Province, China	
Fu X.H	Present status and countermeasures analyses: The study of vegetable industry	Journal on Rural Economy, Vol.9，2003
Fu X.H, Yang J.X	Marketing opportunities and countermeasures analyses: The study of Chinese vegetable market	Journal on Xinjiang Reclamation Economy, Vol.2，2003
Yang J.X, Fu X.H	Vegetable-intermediary agency's contribution to farmers' income	Journal on Rural Economy, Vol.11，2003
Li D.M, Xiao H.A, Fu X.H	Present status and countermeasures analyses on industrialization of Pengzhou vegetable	Research of Agricultural Modernization, Vol. Special issue，2003
Yang J.X, Fu X.H	Logistics distribution of fresh produce's distribution to farmers' income, in: Development of agricultural science and technology	Sichuan Doctor & expert Forum Publishers，2004
Yang J.X	Strategy on development of vegetable wholesale market	Journal on Rural Economy, Vol.4，2004
Yang J.X, Fu X.H	Logistics distribution study on fresh produce	Rural Economy and Science-Technology, Vol.9，2004
Zhang S.Q, Fu X.H	SCP analyses on production of garlic bolt	Journal on Rural Economy, Vol.5，2004
Chen L.N, Yang J.X	International competitiveness of processing food in China	Research of Agricultural Modernization, supplementary issue，2004
Xie Y.J, Fu X.H	Study on Behaviour of Farmer Households' Vegetables Production	Journal on Rural Economy, Vol.3,2005
Zhang J, Fu X H	Supply Chain Management and Vegetable Delivery,	Rural Economy and Science-Technology, Vol.7，2005
Zhang J, Fu X H Yang J X	Supermarket Vegetable dealing and Market Behaviour of Supply-chain Participants: A Case Study of Chengdu Sichuan	Journal on Rural Economy, Vol.1,2006

With regard to the VEGSYS project report series, a total of 38 reports have been produced. All these project reports are already available on the VEGSYS project website and are disseminated to relevant stakeholders in China and Vietnam. The reports form the basis for scientific publications and a book on vegetable production, marketing and the environment which the VEGSYS team is planning to make.

Table 32 VEGSYS Project report series

Report code	*Author(s)*	*Title*
PR01	Chen Yibing, M.S. van Wijk, Lin Chaowen, Fu Xinhong, Xiayong Zhang	An overview of vegetable production in Sichuan Province of China
PR02	Pham Van Hoi, Tran Huu Cuong, To Xuan Phuc	An overview of vegetable production in the Red River Delta in Vietnam
PR03	Pham Van Hoi, M.S. van Wijk, Nguyen Thi Kim Oanh, Tran Huu Cuong, Nguyen Van Dung	Farmers' perceptions of constraints and opportunities in vegetable based farming systems in the Red River Delta of Vietnam: Report of the Rapid Diagnostic Appraisal in Nam Hong commune, Dong Anh District
PR04	Pham Van Hoi, Nguyen Thi Kim Oanh, Tran Huu Cuong, Nguyen Van Dung	Farmers' perceptions of constraints and opportunities in vegetable based farming systems in the Red River Delta of Vietnam: Report of the Rapid Diagnostic Appraisal in Nguyen Khe commune, Dong Anh District
PR05	Chen Yibing, Lin Chaowen, Zhang Jianhau, Pang Liangyu, Peng Yuliang, Chen Xiaojuan, Ye Huili, Lu Daihua, Fu Xinhong, Li Dongmei, Yang Jinxiu, Xiao Shishun, Zhou Wei	Farmers' perceptions of constraints and opportunities in vegetable based farming systems in Sichuan Province of China: Report of the Rapid Diagnostic Appraisal in Shengli

Report code	*Author(s)*	*Title*
PR06	Chen Yibing, Lin Chaowen, Zhang Jianhau, Pang Liangyu, Peng Yuliang, Chen Xiaojuan, Ye Huili, Hu Yapeng, Fu Xinhong, Xiao Shishun and Yin Qi	Farmers' perceptions of constraints and opportunities in vegetable based farming systems in Sichuan Province of China: Report of the Rapid Diagnostic Appraisal in Xibei
PR07	Chen Yibing, Lin Chaowen, Pang Liangyu, Peng Yuliang, Chen Xiaojuan, Ye Huili, Li Dong Mei, , Xiao Shishun and Zhang Shuangqiu	Farmers' perceptions of constraints and opportunities in vegetable based farming systems in Sichuan Province of China: Report of the Rapid Diagnostic Appraisal in Bishan
PR08	Nguyen Van Dung and Pham Van Hoi	Soil classification and analysis of soil fertility Dong Anh district, Hanoi
PR09	Chen Yibing, Lin Chaowen, Peng Yuliang, Yang Jinxiu, Wang Fang and Zhang Shuangqiu	Report on the farmer feedback workshop in Shengli and Xibei village, Pengzhou County.
PR10	Pham Van Hoi, Nguyen Thi Kim Oanh, Tran Huu Cuong, Nguyen Van Dung	Report on the farmer feedback workshop in Tang My and Son Du village, Dong Anh district.
PR11	CAET, Sichuan Agricultural University	Structure, conduct and performance of the vegetable sector in Pengzhou county
PR12	Dr. Bui Thi Gia, Mr. Tran Huu Cuong, Mr. Nguyen Anh Tru and Ms. Tran Thi Thu Huong	Vegetable retail marketing in Hanoi Province
PR13	Lin Chaowen, Arij Everaarts, Chen Yibing and Zhang Jianhua	The vegetable cultivation system in two villages in Sichuan Province, China. Constraints and recommendations.
PR14	Nguyen Thi Thu Ha Arij Everaarts	Vegetable cultivation in Tang My and Son Du village, Dong Anh district, Hanoi; Description and recommendations
PR15	Peng Yunliang Ji Hongli Prabhat Kumar	Constraints in vegetable production by weeds, pests and diseases in Pengzhou County (China)
PR16	Dr. Nguyen Thi Kim Oanh Ms. Cao Hong Luyen Prabhat Kumar	Constraints in vegetable production by weeds, pests and diseases in Dong Anh district (Vietnam)
PR17	Rik (H.) van den Bosch, Lin Chaowen, Pham Van Hoi, , Mechteld ter Horst, Paul van den Brink, Peng Yunliang, Chen Yibing, Nguyen van Dung, Siebe van Wijk and Joost Vlaming	Environmental risk of pesticide use in intensive vegetable farming systems in peri-urban Hanoi and Chengdu.
PR18	Chen Yibing , Lin Chaowen, Zhang Jianhua, Pang Liangyu and Xiong Wenlan	Soil classification and analysis of soil fertility in Pengzhou County, Sichuan Province
PR19	Christy van Beek, Nguyen Van Dung, Lin Chaowen and Chen Yibing	Fertilizer use and soil fertility constraints in vegetable production in Dong Anh district and Pengzhou County
PR20	Dr. Nguyen Thi Kim Oanh, Ms. Cao Hong Luyen, Prabhat Kumar, Mr. Tran Huu Cuong,	Crop problem identification workshop for vegetable production in Dong Anh district, Hanoi
PR21	Chen Yibing, Lin Chaowen, Peng Yunliang, Fu Xinhong and Prabhat Kumar	Crop problem identification workshop for vegetable production in Pengzhou County, Sichuan
PR22	Pham Van Hoi, Nguyen Van Dung Nguyen Thi Kim Oanh, Prabhat Kumar, Arij Everaarts, Christian Borgemeister and Siebe van Wijk	Innovation protocol for thrips control in wax gourd and control of club root disease in wrapped heart mustard in Dong Anh district
PR23	Chen Yibing, Peng Yunliang, Lin Chaowen, Prabhat Kumar, Arij Everaarts and Christian Borgemeister	Innovation protocols for improved and sustainable management of garlic and eggplant
PR24	Pham Van Hoi, Nguyen Thi Kim	Mid-term review of wax gourd innovation experiment in

Report code	*Author(s)*	*Title*
	Oanh, Tran Manh Tuong and Cao Hong Luyen	Dong Anh district, Vietnam
PR25	Maarten Peeters	Soil physical properties of fields used for rice and vegetable production in Dong Anh district
PR26	Rolien Wiersinga	Strategies to increase the price of vegetables in Vietnam; Research on marketing channel choice and marketing timing
PR27	Regina Engels	In depth case study of safe vegetable supply chains in Tang My and Son Du (Vietnam)
PR28	Xiaoyong Zhang, Yang Jinxiu and Fu Xinhong	The evolution of Chinese vegetable supply chains
PR29	Xiaoyong Zhang, Yang Jinxiu and Fu Xinhong	The vegetable supply chain of supermarkets in Sichuan Province, China
PR30	Pham Van Hoi	Farmer reviews of wax gourd and wrapped heart mustard experiments in Tang My & Son Du
PR31	Nienke de Bode	Developing GAPs for vegetable production in Hanoi: a chain-oriented approach
PR32	Kelly Leers	Fertiliser recommendations for field vegetables in Dong Anh district
PR33	Nguyen Van Dung, Arij Everaarts, Cao Hong Luyen, Tran Manh Tuong, Tran Mai Huong, Prabhat Kumar, Siebe van Wijk and Pham Van Hoi.	Effect of timing of lime application on management of club root disease on wrapped heart mustard, Dong Anh, Hanoi, Vietnam.
PR34	Prabhat Kumar, Nguyen Thi Kim Oanh, Arij Averaarts, Cao Hong Luyen, Nguyen Van Dung, Siebe van Wijk, Derek Eaton, Pham Van Hoi, Tran Manh Tuong and Tran Mai Huong	Effect of spinosad application on the management of thrips transmitted viruses on wax gourd in Dong Anh district, Vietnam.
PR35	Lin Chaowen, Peng Yunliang, Chen Yibing, Huang Jingjing, Ji Hongli, Prabhat Kumar, Arij Everaarts	Studies on the effects of fertilization and Messenger® application on garlic yield and diseases
PR36	Ji Hongli, Lin Chaowen, Arij Everaarts, Chen Yibing, Yang Xianqi, Wei Ling, Huang Jingjing, Prabhat Kumar, Michael Poehling, Peng Yunliang and Siebe van Wijk	Control of Verticillium wilt of eggplant using rootstock "Torubam"
PR37	Yang Jinxiu, Fu Xinhong, Xiaoyong Zhang, Zhang Jing, Zhao Lijiong, Wang Yan'an	Development of marketing strategies for smallholder vegetable farms in Sichuan Province, China
PR38	Tran Huu Cuong, Nguyen Anh Tru Xiaoyong Zhang	Institution building for the vegetable sector; A case study on Vegetable Cooperatives in Hanoi, Vietnam

8 Conclusions

The conclusions are organised on the basis of key questions, which give insight on what the project has achieved, which lessons we have learned and what remains to be done.

2) Have the project results been used, and if yes by whom, where and how?

- As the technologies where developed with farmers the chance of uptake is large. It would probably be the best to have an monitoring and evaluation study next year to see how many farmers are now using the newly developed technologies.
- Our farm recording, monitoring and feedback system was an important reason for the private to work with the VEGSYS farmers, as farm monitoring is an important requirement for international markets
- The insight we provided into how farmers manage pest and diseases and why, is important information which is used to design a new product stewardship program funded by the private sector
- The insight in marketing and working with farmers forms the basis for the development of a domestic supply chain with a large international supermarket chain in 2006

2) What are the outputs in terms of capacity-building and partnerships?

Farmers

→ 124 farmers were trained in record keeping. All of them received reports in Vietnamese/Chinese with an analysis of their farm, benchmarked with the average of the whole sample. Several training sessions were given to train the farmers in understanding the reports

→ 15 farmers were selected for the Participatory Technology Development process. On farm trials were executed with them. At the start, halfway and at the end of the trial, field days were organized to invite all other farmers in the village to monitor the trials and understand the results

→ One small farmer producer group was selected to benchmark their current production and processing practices with international standards. Based on this an extensive GAP checklist was made, after which the group was trained in understanding what they had to change to meet these standards

Researchers

→ 25 researchers in Vietnam and 16 researchers in China were trained in Farmer Participatory Research

→ 15 researchers in Vietnam and 10 researchers in China were trained in using the NUTMON toolbox

→ 3 researchers in Vietnam and 3 researchers in China were trained in pest and disease monitoring and data analysis

→ 5 researchers in Vietnam and 5 researchers in China were trained in designing, implementing and analysing field experiments

→ 3 researchers in Vietnam and 3 researchers in China have received training in marketing research

→ 2 researchers in China and 2 researchers in Vietnam received training in the PEARL model

→ In China:
  - 2 Chinese researchers obtained their PhD based on the work in the project.
  - 2 Chinese researchers obtained their MSc
  - 1 Dutch student carried out their MSc thesis in the VEGSYS project

→ In Vietnam:
  - 5 Dutch students carried out their MSc thesis in the VEGSYS project
  - 1 Vietnamese researcher started with his Phd in Wageningen University based upon VEGSYS methodology and data (WOTRO scholarship)

Partnerships

→ A partnership with the VEGSYS farmers in one of the research villages in Vietnam was established with a Dutch company. Since its establishment in May 2005 the following milestones have been achieved:
  - o A post harvest centre with cold storage facilities was built in the village
  - o Ten farmers (mostly female) are now supplying about 1 ton of fresh herbs per week. About six women from the village are employed by the company to sort, grade and package the fresh herbs

→ A partnership with METRO Cash & Carry has been established. A joint proposal has been developed and plans for sourcing vegetables from VEGSYS farmers are currently worked out

→ A partnership has been established with Syngenta for a project about safe use of pesticides

→ In China cooperation with:
  - o Bureau of Agriculture in Pengzhou
  - o Vegetable office of Pengzhou
  - o Horticulture farmer union in Pengzhou

→ In Vietnam research cooperation with:
  - CIRAD
  - RIFAV (Research institute for fruits and vegetables)
  - FAO IPM Community program.
  - Ministry of Agriculture and Rural Development

3) What has been the benefit or impact?

- The largest impacts of the developed innovations are expected for the use of spinosad in thrips control in the winter period in Northern Vietnam. This impact will be mostly by much less environmental pollution, lower input costs and better quality of the wax gourd fruits. For Pengzhou County the new eggplant cultivation technology will have a large positive financial impact on the smallholders and will lead to much lower pollution levels.
- Farmers who are now supplying the export company achieve higher income levels and because indigenous herbs are exported no pesticides are needed in production. So farmers are switching from vegetables with high pesticide consumption to indigenous herbs for which zero to little amount of pesticides are needed.

3) Future research on Rural Development and Sustainable Agriculture

- There is an enormous need for more applied research on vegetable cultivation. Especially improvements in agronomic practices can be achieved. Hardly any clear GAPs are available for farmers. The VEGSYS project developed a strong team which can develop GAPs. So far this has been done for 4 different vegetables, while in one village (of 400 farms) about 30 to 40 different vegetables are cultivated.
- Currently vegetable production is rotated during the year with rice production, which has a very bad impact on soil structure and costs farmers a lot of extra labour. Furthermore, farm income could be tripled if vegetables could be produced year round. The possibilities for such a radical farming system change should be studied and experimented in detail.
- Quantification at both micro and macro level of the impacts of new emerging supply chains (supermarkets) on rural development, poverty reduction and participation of the poor

4) Which insights were gained by employing a multidisciplinary methodology that would have been missed by disciplinary research?

- The insights which were gained during the Rapid Diagnostic Appraisal were based on the work of multi-disciplinary teams.
- During the VEGSYS project proposal design a mistake was made by not putting enough attention on agronomy. Thanks to the involvement of PPO, the crucial knowledge of vegetable agronomy became available and was of very big importance for the design of improved production technologies.
- The marketing research linked the farmers to markets where consumers are willing to pay for safe vegetables, which is an important incentive for the farmers to use the improved production technologies.

5) *Interactions between research and decision makers in China and Vietnam*

- Within China and Vietnam a lot of interaction with district and provincial level policymakers was achieved. But this resulted in no clear outputs. Only in Vietnam the intense relations with provincial level policymakers facilitated all arrangements to get permits for the Dutch company to build a post harvest centre in the project village. In China the provincial level policymakers were very interested in the financial results of the farm monitoring, but it is not clear what they did with this information.
- An interesting link was developed with a national level governmental organization (ICAMA) who is responsible in China for the licensing of pesticides for the Chinese market. They are very interested in using the tools which were developed and tested by Alterra in the VEGSYS project

6) Which important things remain to be done that could not be achieved by the project?

- All original project objectives have been achieved but so much more needs to be done to improve vegetable production and marketing.
- It would be very useful to evaluate one year after the project ended if the developed technologies are being used by the farmers
- Development of a clear handbook of for which crops, pest/disease combinations what pesticides (which can be bought on the local market) are the least worse to use and the specific GAP for that pesticide, crop-pest/disease combination
- Developing a science based system for pesticide admission in China and Vietnam

7) Which important challenges in the area of rural development in the tropics are there in the near future (say 5 to 10 years)?

- For both the research sites in China and Vietnam the challenge will be how all these smallholders can continue to grow out of poverty. Their small landholdings (0.27 ha per farm), makes it difficult to increase income. The coming 5 years there are still enough improvements which can be made, especially developing a sustainable system of year round vegetable production. But for the longer term it will be important to see how the government can create an enabling environment for good farmers (innovative, entrepreneurs). How can they grow? How can they obtain more land and capital? Land consolidation policies will be very crucial.
- How agro-chemical use by farmers can be influenced by a combination of policies, regulations, and market incentives

8) What type of research could contribute to addressing these challenges?

- Applied research which can improve productivity of smallholders, especially developing sustainable year round vegetable cultivation systems
- Policy research to find out how land consolidation should be organized, how land laws can be adjusted and how the growing group of farmers without land can be employed by successful growing farms.
- Impact assessment if government regulations and market incentives with regards to agrochemicals are influencing farmers in the right direction

Contract number: ICA4-CT-2001-10054 **Final report**

Annex 1 Data sheet for the annual report

1. Dissemination activities	Totals (cumulative)
Number of communications in conferences (published)	7
Number of communications in other media (internet, video, tv)	35
Number of publications in refereed journals (published)	4
Number of articles/books (published)	14
Number of other publications	38
2. Training	
Number of PhDs	2
Number of MSc	5
Number of visiting scientists	0
Number of exchanges of scientists (stays longer than 3 months)	5
3. Achieved results	
Number of patent applications	0
Number of patent granted	0
Number of companies created	2
Number of new prototypes/products developed	1
Number of new tests/methods developed	0
Number of new norms/standards developed	1
Number of new software/codes developed	3
Number of production processes	0

4. Industrial aspects				
Industrial contacts	Yes	X	No	
Financial contribution by industry	Yes	X	No	
Industrial partners: - Large	Yes	X	No	
- SME	Yes	X	No	

5. Comments

Other publications include project reports published on project website. Publications in other media include newspaper articles and television coverage.

Completed Catalogue

Summary
Smallholder vegetable farmers in many Asian countries are intensifying their market-oriented vegetable production with increased use of agrochemical inputs for pest and plant nutrition management. This results in increased damage to the natural resource base, while productivity and profitability gains are quickly eroded. This project will promote an environmentally sustainable and economically viable vegetable production sector in Sichuan, China and Northern Vietnam.

Through a process of participatory technology development, the project will work on-farm with smallholder farmers to analyse their specific constraints and to develop and test new techniques to address pest, disease and soil fertility constraints that increase productivity, profitability and sustainability.

Results achieved

- Comprehensive analysis and publications of major constraints in vegetable cultivation in Hanoi Province and Pengzhou County
- Successfully developed and tested cultivation innovations for four major vegetables, of which three innovations provided a financially viable and more sustainable alternative compared with the current farmer practices
- Publication of the first quantitative assessments ever of the risks of leaching of pesticides, that were used in vegetable production, to groundwater vegetable cultivation and the risks of leaching to groundwater in Sichuan Province
- Analysed and published, for the first time ever in Sichuan Province, the results of the comprehensive marketing studies on vegetables
- Analysed and published the results of the vegetable value chain analysis in Hanoi Province and the current and potential role of cooperatives
- Developed a Good Agricultural Practices protocol for a smallholder vegetable cooperative in Hanoi Province
- Developed a value chain of smallholder vegetable farmers in Vietnam to Europe
- Three new software tools were developed and made available for use in scientific research
- 38 project reports were published and made available on the project website
- More than 5000 hits on the project website: www.vegsys.nl from people located in at least 25 different countries and from the following continents; 67% of hits from Europe, 28% of hits from Asia, 5% from North America, 1% from Africa, 1% from Australia, 1% from Latin America and 2% unknown
- Seven papers presented in international conferences and three papers accepted for conferences after the project date
- Four papers published in international journals and eighteen papers in national journals
- One paper published in an international popular scientific agriculture journal
- Various articles in local newspapers and appearances in regional TV programs
- Organised six large workshops for wide range of stakeholders ranging from farmers, traders, extensionist, agribusinesses, policymakers to researchers
- A project with a large supermarket chain and a large agriculture input supplier started in January 2006 to develop sustainable vegetable value chains in which farmers will receive continuous technical backstopping and long term supply contracts to reward them for their use of more sustainable cultivation practices
- A PhD project was started to develop sustainable year-round vegetable rotation schemes for the Red River Delta in North Vietnam
- A PhD project was started to study in more detail how public policy in Vietnam can have more impact to influence the safe and more rational use of pesticides in horticulture
- A special cooperation program between various Dutch and Chinese government agencies and institutes was started to improve the pesticide registration testing procedures in China. In this program use will be made of the VEGSYS developed PRIMET software, which is a tool to carry out environmental risk assessments of pesticides.
- Several of the VEGSYS project team members in Vietnam and from the Netherlands started a private consulting and R&D company to assist all actors within a supply chain to better produce, package and market vegetables
- In China several of the VEGSYS team members are starting a company to assure farmers get access to high quality vegetable seedlings

Annex 2 Contents of the CD with all Project Results

The CD which is enclosed to this scientific & management annual report is organised into the following folders:

- *Project reports*
  This folder contains all documents which report upon the research results, and which have the status of working papers. These working papers are the basis for the scientific articles which will be published by the VEGSYS project.
- *Mission reports*
  This folder contains all reports of missions, and the activities implemented during these missions, by the European research partners.
- *Project management reports*
  In this folder one can find all reports of project workshops and the reports which were prepared for the EU, such as the six month progress reports and annual reports.

In the tables below the reports which can be found in the different folders are presented.

Table 33 Project reports

Report code	*Author(s)*	*Title*
PR01	Chen Yibing, M.S. van Wijk, Lin Chaowen, Fu Xinhong, Xiayong Zhang	An overview of vegetable production in Sichuan Province of China
PR02	Pham Van Hoi, Tran Huu Cuong, To Xuan Phuc	An overview of vegetable production in the Red River Delta in Vietnam
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PR13	Lin Chaowen, Arij Everaarts, Chen Yibing and Zhang Jianhua	The vegetable cultivation system in two villages in Sichuan Province, China. Constraints and recommendations.
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PR15	Peng Yunliang Ji Hongli Prabhat Kumar	Constraints in vegetable production by weeds, pests and diseases in Pengzhou County (China)
PR16	Dr. Nguyen Thi Kim Oanh Ms. Cao Hong Luyen Prabhat Kumar	Constraints in vegetable production by weeds, pests and diseases in Dong Anh district (Vietnam)

Report code	*Author(s)*	*Title*
PR17	Rik (H.) van den Bosch, Lin Chaowen, Pham Van Hoi, , Mechteld ter Horst, Paul van den Brink, Peng Yunliang, Chen Yibing, Nguyen van Dung, Siebe van Wijk and Joost Vlaming	Environmental risk of pesticide use in intensive vegetable farming systems in peri-urban Hanoi and Chengdu.
PR18	Chen Yibing , Lin Chaowen, Zhang Jianhua, Pang Liangyu and Xiong Wenlan	Soil classification and analysis of soil fertility in Pengzhou County, Sichuan Province
PR19	Christy van Beek, Nguyen Van Dung, Lin Chaowen and Chen Yibing	Fertilizer use and soil fertility constraints in vegetable production in Dong Anh district and Pengzhou County
PR20	Dr. Nguyen Thi Kim Oanh, Ms. Cao Hong Luyen, Prabhat Kumar, Mr. Tran Huu Cuong,	Crop problem identification workshop for vegetable production in Dong Anh district, Hanoi
PR21	Chen Yibing, Lin Chaowen, Peng Yunliang, Fu Xinhong and Prabhat Kumar	Crop problem identification workshop for vegetable production in Pengzhou County, Sichuan
PR22	Pham Van Hoi, Nguyen Van Dung Nguyen Thi Kim Oanh, Prabhat Kumar, Arij Everaarts, Christian Borgemeister and Siebe van Wijk	Innovation protocol for thrips control in wax gourd and control of club root disease in wrapped heart mustard in Dong Anh district
PR23	Chen Yibing, Peng Yunliang, Lin Chaowen, Prabhat Kumar, Arij Everaarts and Christian Borgemeister	Innovation protocols for improved and sustainable management of garlic and eggplant
PR24	Pham Van Hoi, Nguyen Thi Kim Oanh, Tran Manh Tuong and Cao Hong Luyen	Mid-term review of wax gourd innovation experiment in Dong Anh district, Vietnam
PR25	Maarten Peeters	Soil physical properties of fields used for rice and vegetable production in Dong Anh district
PR26	Rolien Wiersinga	Strategies to increase the price of vegetables in Vietnam; Research on marketing channel choice and marketing timing
PR27	Regina Engels	In depth case study of safe vegetable supply chains in Tang My and Son Du (Vietnam)
PR28	Xiaoyong Zhang, Yang Jinxiu and Fu Xinhong	The evolution of Chinese vegetable supply chains
PR29	Xiaoyong Zhang, Yang Jinxiu and Fu Xinhong	The vegetable supply chain of supermarkets in Sichuan Province, China
PR30	Pham Van Hoi	Farmer reviews of wax gourd and wrapped heart mustard experiments in Tang My & Son Du
PR31	Nienke de Bode	Developing GAPs for vegetable production in Hanoi: a chain-oriented approach
PR32	Kelly Leers	Fertiliser recommendations for field vegetables in Dong Anh district
PR33	Nguyen Van Dung, Arij Everaarts, Cao Hong Luyen, Tran Manh Tuong, Tran Mai Huong, Prabhat Kumar, Siebe van Wijk and Pham Van Hoi.	Effect of timing of lime application on management of club root disease on wrapped heart mustard, Dong Anh, Hanoi, Vietnam.
PR34	Prabhat Kumar, Nguyen Thi Kim Oanh, Arij Averaarts, Cao Hong Luyen, Nguyen Van Dung, Siebe van Wijk, Derek Eaton, Pham Van Hoi, Tran Manh Tuong and Tran Mai Huong	Effect of spinosad application on the management of thrips transmitted viruses on wax gourd in Dong Anh district, Vietnam.
PR35	Lin Chaowen, Peng Yunliang, Chen Yibing, Huang Jingjing, Ji Hongli, Prabhat Kumar, Arij Everaarts	Studies on the effects of fertilization and Messenger® application on garlic yield and diseases
PR36	Ji Hongli, Lin Chaowen, Arij Everaarts, Chen Yibing, Yang Xianqi, Wei Ling, Huang Jingjing, Prabhat Kumar, Michael Poehling, Peng Yunliang and Siebe van Wijk	Control of Verticillium wilt of eggplant using rootstock "Torubam"
PR37	Yang Jinxiu, Fu Xinhong, Xiaoyong Zhang, Zhang Jing, Zhao Lijiong, Wang Yan'an	Development of marketing strategies for smallholder vegetable farms in Sichuan Province, China
PR38	Tran Huu Cuong, Nguyen Anh Tru Xiaoyong Zhang	Institution building for the vegetable sector; A case study on Vegetable Cooperatives in Hanoi, Vietnam

Table 34 Project management reports

Report code	*Author*	*Title/period*
PM01	D.J. Eaton and van M.S. Wijk	VEGSYS project proposal
PM02	M.S. van Wijk	Inception workshop report
PM03	M.S. van Wijk	Six month EU progress report
PM04	M.S. van Wijk	First scientific & management annual report
PM05	M.S. van Wijk	Cost statement covering period January 2002 – December 2002
PM06	M.S. van Wijk, X. Zhang, R. van den Bosch, C. Borgemeister and A. Everaarts	Progress workshop report; March 17th – March 28th 2003, Tam Dao and Ha Long Bay.
PM07	M.S. van Wijk	18 month EU progress report
PM08	M.S. van Wijk	Second scientific annual report
PM09	M.S. van Wijk	Second management annual report
PM10	M.S. van Wijk	Cost statement covering period January 2003 – December 2003
PM11	M.S. van Wijk	Progress workshop report
PM12	M.S. van Wijk	30 month EU progress report
PM13	M.S. van Wijk	Third annual scientific report
PM14	M.S. van Wijk	Third annual management report
PM15	M.S. van Wijk	Cost statement covering period January 2004 – December 2004
PM16	M.S. van Wijk	42 month EU progress report

Table 35 Project mission reports

Report code	*Author*	*Title/period*
MR01	M.S. van Wijk and J. Thompson	Mission report of the Rapid Diagnostic Appraisal Training and Implementation Workshop; Hanoi, 4th of May – 26th of May 2002
MR02	M.S. van Wijk	Mission report of the Rapid Diagnostic Appraisal Training and Implementation Workshop; Chengdu, 26th of May – 11th of June 2002
MR03	C. Borgemeister	Mission report of the Pest and Disease Monitoring planning; Chengdu & Hanoi, 28/7/2002 – 3/8/2002
MR04	H. van den Bosch	WP 3 Pesticide Leaching: Start-up of field activities; Chengdu and Hanoi, Aug 28 – Sept 7, 2002
MR05	M.S. van Wijk and J. Vlaming	Mission report of the Farm Monitoring Training and Implementation Workshops; Chengdu and Hanoi, 18/8/2002 – 20/9/2002
MR06	A. Everaarts	Mission Report Agronomy Aspects in the VEGSYS project Chengdu and Hanoi, 24/8/2002 – 9/9/2002
MR07	M.S. van Wijk	Review of farm monitoring and WPDmon activities and progress Chengdu, 22/11/2002 – 25/11/2002
MR08	M.S. van Wijk	Review of farm monitoring and WPDmon activities and progress Hanoi, 28/11/2002 – 01/12/2002
MR09	J. Pascual and C. Garcia	Mission report of the soil fertility protocol planning Chengdu and Hanoi, 8/11/2002 – 20/11/2002
MR10	A. Everaarts	Mission Report Agronomy aspects and Weeds in the VEGSYS project; Hanoi, 15/03/2003 – 29/03/2003
MR11	M.S. van Wijk and X. Zhang	Mission report backstopping farm monitoring and marketing research: September 2003
MR12	C. van Beek, Nguyen van Dung, Lin Chaowen and Chen Yibing	Mission report backstopping soil fertility team: November 2003
MR13	P. Kumar	Farmer's Crop Problem Identification & Prioritization Workshop

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PM07	Eighteen months progress reports
PM08	Second annual scientific report
PM09	Second annual management report
PM10	Cost statement covering period January 2003 – December 2003
PM11	Progress workshop report; February 17th – February 23rd 2004, Ya'an
PM12	Thirty-six months progress reports
PM13	Third annual scientific report
PM14	Third annual management report
PM15	Cost statement covering period January 2004 – December 2004
PM16	42 month EU progress report
PM17	Progress workshop report
PM18	Final consolidated scientific project report
PM19	Final management report

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If you are interested in receiving one of these reports as a hard copy then contact:

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