



AgEcon SEARCH
RESEARCH IN AGRICULTURAL & APPLIED ECONOMICS

The World's Largest Open Access Agricultural & Applied Economics Digital Library

This document is discoverable and free to researchers across the globe due to the work of AgEcon Search.

Help ensure our sustainability.

Give to AgEcon Search

AgEcon Search
<http://ageconsearch.umn.edu>
aesearch@umn.edu

*Papers downloaded from **AgEcon Search** may be used for non-commercial purposes and personal study only. No other use, including posting to another Internet site, is permitted without permission from the copyright owner (not AgEcon Search), or as allowed under the provisions of Fair Use, U.S. Copyright Act, Title 17 U.S.C.*

Staff Paper

***EX-ANTE* ASSESSMENT OF THE IMPACT OF DISEASE-
RESISTANT CUCURBITS GERMPLASM IN INDONESIA AND
SOUTH AFRICA**

David Mather, Richard H. Bernstein, and Mywish Maredia

Staff Paper 2002-28

October, 2002



**Department of Agricultural Economics
MICHIGAN STATE UNIVERSITY
East Lansing, Michigan 48824**

MSU is an Affirmative Action/Equal Opportunity Institution

EX-ANTE ASSESSMENT OF THE IMPACT OF DISEASE-RESISTANT CUCURBITS GERMPLASM IN INDONESIA AND SOUTH AFRICA

David Mather, Richard H. Bernstein, and Mywish K. Maredia

matherda@msu.edu, bernsten@msu.edu, maredia@msu.edu

Abstract /Executive Summary

This report presents a summary of the results of an ex-ante socioeconomic assessment of the potential impacts of the improved cucurbits germplasm in Indonesia and South Africa. The cucurbits technology was developed by Cornell University through support from the USAID-funded Agricultural Biotechnology Support Project (ABSP). The objectives of these assessments were to: a) investigate the current status of the cucurbits subsector in Indonesia and South Africa; b) evaluate and quantify potential/projected benefits and costs of the cucurbits technology to seed companies, producers, and consumers in Indonesia and South Africa; and c) identify key issues that ABSP researchers, the ABSP management team, and USAID need to take into account in the development and transfer of technology to developing countries in order to fully reap the potential benefits and minimize costs.

This study provides several key insights with respect to the characteristics of the cucurbit subsector in Indonesia and South Africa, the performance of Cornell's disease-resistant germplasm in recent in-country field trials, the potential farm- and market-level economic impact of this germplasm, institutional lessons, and opportunities to increase the impact of Cornell's collaboration with seed firms in these countries.

Preliminary field tests of the Cornell materials demonstrate that their sources of resistance appear to be valuable in the growing environments of Indonesia and South Africa. Analysis of the farm-level benefits of disease-resistant cucurbits show that adopting farmers in both countries would likely pay higher input costs, but would enjoy higher net revenues. Using assumed adoption rates—based upon subsector analysis of each cucurbit—the farm-level benefits are aggregated to the market level using a standard economic surplus model. These aggregate benefits are then compared in a benefit-cost framework with past and (assumed) future investment costs borne by ABSP and private sector seed companies in the development of these varieties. Under the baseline scenario, the internal rate of return to ABSP's investment in Indonesia and South Africa is 46.5% and the net present value (discounted net social gains) is US\$47.3 million. The collaborating seed companies in Indonesia and South Africa could potentially increase their gross revenues by US\$4.5 million, as a result of incorporating disease-resistance into their future cucurbit varieties.

Sensitivity analysis demonstrates that when using 50% of the baseline adoption rates and 50% of the baseline farm-level expected yield gain from disease-resistant cucurbit varieties, the rate of return is still favorable at 27.1% and the net present value is US\$6.9 million. With respect to poverty alleviation, the distribution of benefits and labor generation in Indonesia is ideal, as cucumber is produced by small-scale farmers throughout the country and consumed by all Indonesians. Although melon is produced by small-scale yet higher-resource farmers, it is consumed primarily by higher-income Indonesians. By contrast, the distribution of benefits in South Africa is less than ideal, as zucchini, cucumber, and melon are produced by large-scale (white) farmers and consumed by high-income whites. While these crops do generate labor for black women, they are not traditionally grown by small-scale (black) farmers. Furthermore, the constraints that small-scale (black) farmers face in producing these high-value crops cannot be alleviated solely through varietal improvement. An exception to this is butternut, which is grown by both white and black farmers and is consumed by all South Africans.

Keys to increasing future ABSP impact in cucurbits include: performing socioeconomic assessment of cucurbit subsectors in target countries to help set collaborative breeding priorities; encouraging Cornell to collaborate with several firms in each country (in order to avoid monopoly pricing of new technologies), and, in South Africa, working with cucurbits that small-scale farmers traditionally produce and consume—primarily pumpkins.

88 pages

***EX-ANTE* ASSESSMENT OF THE IMPACT OF DISEASE-RESISTANT CUCURBITS GERMPLASM IN INDONESIA AND SOUTH AFRICA**

October 2002

David Mather¹, Richard H. Bernsten¹, and Mywish Maredia¹

In Collaboration with:

Mark Henning², George Moriarty², and Karim Maredia³

This publication was made possible through support provided by the Office of Agriculture and Food Security, Economic Growth, Agricultural and Trade, U.S. Agency for International Development, under the terms of Cooperative Agreement No. DAN-A-00-91-00126-00 and support of the U.S. Agency for International Development, Cairo, Egypt, under the terms of Grant No. 263-G-00-96-00014-00. The opinions expressed herein are those of the author(s) and do not necessarily reflect the views of the U.S. Agency for International Development.

¹ Research Assistant and Ph.D. candidate; Department of Agricultural Economics; Professor, Department of Agricultural Economics; and Deputy Director, Bean/Cowpea CRSP and Adjunct Associate Professor, Department of Agricultural Economics, Michigan State University, East Lansing, MI.

² Research Technician, Department of Plant Breeding, Cornell University, Ithaca, NY.

³ Technology Transfer Coordinator, Institute of International Agriculture, Agricultural Biotechnology Support Project (ABSP); and Associate Professor, Department of Entomology, Michigan State University, East Lansing, MI.

Acknowledgments

Without the assistance of many colleagues, it would have been impossible to carry out this study. The authors would like to express special appreciation to several colleagues in Indonesia, South Africa, and the United States:

In Indonesia, the assistance provided by Dr. Muhammad Herman (Research Institute for Food Crop Biotechnology, who coordinated the fieldwork), Mr. Aernoudt Aardse (East West Seed Company), Dr. Witono Adiyoga (Research Institute for Vegetable Crops), Dr. Adi Duriat (Research Institute for Vegetable Crops), Dr. Achmad Fagi (Agency for Agricultural Development), Ms. Ketty Karyati (Research Institute for Food Crop Biotechnology), and Ms. Suparwati (Bureau of Central Statistics) was especially helpful and appreciated.

In South Africa, the assistance provided by Drs. Graham Thompson and Johan Brink (Agricultural Research Council, who coordinated the fieldwork), Ms. Jurinda Esterhuizen (Agricultural Research Council), Mr. Piet Grobler (Hygrotech Seed), and Mr. Bill Kerr (Alpha Seed) was especially helpful and appreciated.

In the United States, the assistance provided by Dr. Molly Jahn (Cornell University) and ABSP staff at Michigan State University—Ms. Sue Gibbons and Ms. Melba Lacey—was especially helpful and appreciated.

TABLE OF CONTENTS

	Page
Executive Summary	i
Acknowledgments	iii
1. Introduction	1
2. Conceptual Framework	
2.1 Rapid Appraisal Subsector Analysis	2
2.2 Benefit Cost Analysis	2
2.3 Fieldwork	4
3. The Indonesian Cucurbit Subsector	
3.1 An Overview of Indonesia and Its Agricultural Sector	5
3.2 Production of Major Vegetables	5
3.3 Government Policies	7
3.4 Vegetable Seed Firms	8
3.5 The Cucumber Subsector	9
3.6 The Melon Subsector	17
4. The South African Cucurbit Subsector	
4.1 An Overview of South Africa and Its Agricultural Sector	22
4.2 The South Africa Fruit and Vegetable Subsectors	23
4.3 Fruit and Vegetable Marketing	23
4.4 Socioeconomics of Fruit and Vegetable Production	26
4.5 Vegetable Seed Subsector	27
4.6 Government Policies Affecting the Vegetable Seed Subsector	28
4.7 Viruses and Diseases in Cucurbits	29
4.8 Zucchini Subsector	30
4.9 Melon Subsector	31
4.10 Butternut Squash Subsector	31
4.11 Cucumber Subsector	32
5. Cornell Cucurbit Lines	
5.1 ABSP and Cornell University	33
5.2 Indonesian Field Trials of Cornell's Experimental Lines	34
5.3 South African Field Trials of Cornell's Experimental Lines	36
6. Potential Farm-Level Effects of Disease-Resistant Cucurbits	
6.1 Introduction	39
6.2 Potential Farm-Level Impact of Disease-Resistant Cucumber (Indonesia)	40
6.3 Potential Farm-Level Impact of Disease-Resistant Melon (Indonesia)	41
6.4 Potential Farm-Level Impact of Disease-Resistant Zucchini (South Africa)	43
6.5 Potential Farm-Level Impact of Disease-Resistant Melon (South Africa)	44
6.6 Potential Farm-Level Impact of Disease-Resistant Butternut (South Africa)	45

6.7	Potential Farm-Level Impact of Disease-Resistant Cucumber (South Africa)	46
6.8	Section Summary	47
7.	Potential Market Effect of Disease-Resistant Cucurbits	
7.1	Market-Level Analysis Model	48
7.2	Costs of Developing Disease-Resistant Cucurbits	50
7.3	Potential Benefits of Disease-Resistant Cucurbits	51
7.4	Rate of Return to ABSP's Investment	57
8.	Institutional Issues in Technology Transfer	
8.1	Introduction	59
8.2	ABSP-Cornell Collaboration	59
8.3	Linkages with Private Sector Companies	60
8.4	Strengthening the ABSP/Cornell Private Technology Development and Transfer Model	60
8.5	Indonesia	62
8.6	South Africa	62
9.	Summary and Recommendations	
9.1	Summary	63
9.2	Recommendations	64
	References	66
	Appendix I. Tables	
	Appendix Tables 1 (a-d). Area Harvested, Production, and Yield of Cucumbers, by Province, Indonesia, 1990-99.	69
	Appendix Tables 2 (a-b). Production of Cucumber Entirely/Partly Harvested, by Month and Regency, West Java, Indonesia, 1999.	73
	Appendix Table 3. Budget for Without and With Resistance Varieties, Indonesia.	75
	Appendix Table 4. Budgets for Without and With Resistant Varieties, South Africa . . .	77
	Appendix Table 5. ABSP Investments in Technology Development and Dissemination, 1993-2002.	81
	Appendix Table 6. Combined Impact of Virus-Resistant Varieties in Indonesia and South Africa.	82

1. Introduction

Diseases are a major constraint to cucurbits production worldwide and cause substantial losses that affect both production and quality. Since 1993, the USAID-funded Agricultural Biotechnology Support Project (ABSP) at Michigan State University has collaborated with Dr. Margaret Kyle Jahn at Cornell University to facilitate the development and transfer of multiple virus- and fungal-resistant cucurbit germplasm (cucumber, melon, pumpkin, and squash) to developing countries⁴.

Dr. Jahn has built linkages with private companies in the U.S. and several developing countries to field-test and commercialize this improved cucurbit germplasm. Historically, U.S. universities have established collaborative relationships with national research institutes in developing countries, and worked with these public institutions to improve targeted food crops. However, increasingly, private seed companies are becoming major players in varietal development and dissemination, especially for vegetable crops. In an effort to strengthen the private seed sector in Indonesia and South Africa, Cornell/ABSP sought out private partners for varietal improvement.

In 2000, Cornell provided seed of several promising cucurbit lines to private sector seed companies in Indonesia and South Africa, which began to field-test these lines during January to April, 2001. An ABSP evaluation team visited Indonesia in February 2001 and South Africa in April 2001 to examine the field test results and to gather information for a study of the potential socioeconomic impact of these cucurbit lines in each country.

The principal goal of this study is to investigate the potential impact of the multiple disease-resistant cucurbit germplasm that has been distributed by Cornell/ABSP to private sector seed companies in Indonesia and South Africa. In pursuit of this goal, the evaluation team set the following specific objectives:

- 1) Investigate the current situation of the cucurbit subsectors in Indonesia and South Africa
- 2) Evaluate and quantify the potential benefits and costs of ABSP/Cornell cucurbit technology to producers, consumers, traders and seed companies in the two countries (at the farm and market levels)
- 3) Identify key issues that researchers and the ABSP management team need to consider in the development and transfer of technology to developing countries in order to fully reap the potential benefits and minimize costs

Section 2 presents the Study Methodology. Section 3 describes the Indonesian cucurbit subsector. Section 4 describes the South African cucurbit subsector. Section 5 presents the results of the field trials in Indonesia and South Africa. Section 6 presents the analysis of potential farm-level effects of technology adoption. Section 7 presents the analysis of potential market-level effects of technology adoption. Section 8 discusses institutional issues related to the development and transfer of this technology, and the institutional environment which may best facilitate continued technological development and transfer. Section 9 presents the overall conclusions.

⁴ ABSP has supported a two-tier approach for developing virus resistance in cucurbits. In addition to traditional plant breeding, ABSP has also funded research that uses new tools in biotechnology to incorporate multiple-disease resistance into cucurbits.

2. Conceptual Framework

2.1 Rapid Appraisal Subsector Analysis

The first objective of this study is to document the current status of the cucurbits subsector in Indonesia and South Africa. The subsector paradigm was first proposed by Shaffer (1973) as the study of “the vertical set of economic activities in the production and distribution of a closely related set of commodities”. This vertical set of activities is composed of horizontal levels, including input provision, farm-level production, assembly, processing, storage, transportation, wholesaling, retailing, and consumption. Each horizontal level, or industry, represents a transformation of inputs to produce a commodity with increasing value of time, space, and form. The subsector approach generates information especially useful to policy makers and scientists when “a commodity is undergoing rapid changes due to demand and supply factors or policy changes” (Byerlee, 1993).

A rapid appraisal subsector survey is characterized as a broad and preliminary overview of the organization, operation, and performance of a food system or components thereof, designed to identify key system constraints and opportunities (Holtzman, 1986). Thus, these techniques enable a researcher to synthesize data collected from secondary sources and key informants to generate an overview of the historical and current status of the subsector, without investing substantial resources. The rapid appraisal subsector survey that the evaluation team carried out in Indonesia and South Africa provided information required to estimate a baseline scenario of the input, production, and marketing situation of the cucurbit sector, and to project how this situation is likely to change with the introduction of new virus-resistant germplasm. As these changes and their impacts are not easily observable at the field-testing stage, the analysis utilizes an *ex ante* conceptual framework.

2.2 Benefit-Cost Analysis

Farm-Level Analysis. The second objective of this study is to evaluate and quantify the potential benefits and costs of ABSP/Cornell cucurbit technology to producers, consumers, traders, and seed companies in the two countries (at the farm and market levels). This quantitative analysis begins at the farm level, using a representative farm crop budget⁵ to estimate the potential effects of the new technology on yields, variable costs/hectare, and net revenues of a representative farmer. This analysis compares currently observed crop enterprise budgets with hypothetical ones, where the use of new germplasm is assumed. The new germplasm technology will be part of a technology package, which assumes changes in other inputs and production factors.

Potential benefits ascribed to this new technology are not the farmer’s net returns/hectare “with” the technology, but rather the difference between the farmer’s net return/hectare “with” the technology and his/her net return/hectare “without” the technology. Thus, benefit-cost analysis at any level of analysis always takes into account two scenarios—one in which the technology is adopted, and one in which it is not. Which scenario is hypothetical depends upon the situation. In this study, the hypothetical scenario is “with new technology”. Since the technology has not yet been released, it is not possible to measure the effects of this new technology under farmer’s conditions.

The following schematic describes the data necessary for *ex ante* farm-level impact analysis of a disease-resistant cucurbit variety:

⁵ Multiple representative budgets can be used, given different types of farmers, and given the availability of data specific to each type of farmer.

Historical “Without Technology” Scenario: Non-resistant Variety

- 1) Average Cost of Production (US\$/ha)
- 2) Average Revenue (US\$/ha)
 - a) Average yield (kg/ha) and yield losses due to virus/fungi
 - b) Average farmer price (US\$/kg)

Hypothetical “With Technology” Scenario: Resistant Variety

- 1) New Average Cost of Production (US\$/ha), due to:
 - a) An increase in seed costs?
 - b) A reduction in insecticide costs (less insecticide purchased; lower labor costs for insecticide application)?
 - c) A reduction in fungicide costs?
 - d) An increase in harvesting costs (longer harvest, more to harvest, *etc.*)?
 - e) An increase in packaging costs, due to a larger harvest?
- 2) New Gross Revenue (US\$/ha)
 - a) Yield improvement, compared with non-resistant variety (disease losses avoided)?
 - b) Quality changes in the harvested crop (squash, cucumbers, or melon), resulting from price discounts due to changes in appearance, taste, size, *etc.* or price premiums for incorporating desirable qualities/traits?

Market-Level Analysis. For the quantification of the expected/projected aggregate benefits to society as a whole, an economic surplus model is applied. Models of this kind are the most common approach used for evaluating returns to agricultural research and development (R&D). The methodology involves estimating the percentage downward shift in the commodity supply curve, resulting from the introduction of the new varieties, and calculating the change in total economic surplus as a result of this supply shift (Alston, *et. al.*, 1998). The shift factor in a given year will be derived from the technology’s projected potential reduction in per-unit cost and the technology adoption rate. The projected per-unit cost reduction is derived from the changes in yield and cost of production/hectare in the farm-level analysis. Thus, an *ex ante* economic surplus (market level) model simply aggregates farm-level benefits across an assumed percentage of adopted crop area in a given year, and uses information about how producers and consumers respond to resulting market price changes to allocate the benefits among producers and consumers.

Neoclassical economic theory of firm behavior predicts that technological change which lowers production costs leads firms to increase production. This occurs because the firm initially faces the same output price as before, although technological change lowers their input costs/unit produced. As more and more firms see the profits accrued by the innovators (early adopters), they will also adopt the technology, and thus add even more incremental production to the marketplace. When enough firms have increased their production, the aggregate supply increases, which leads to a decline in the market price. This market price decline eventually leads firms to discontinue expanding production, and maintain their new (higher) production level. In this manner, consumers benefit from lower prices, the adopting farmers benefit from initially high returns, and some high-cost farmers who do not adopt the technology eventually leave the industry because production is no longer profitable. This theory mirrors the experience of the effects of technical change in U.S. agriculture and explains how farmers’ welfare can improve—even if farm-level prices fall—while acknowledging that technical change often displaces some farmers.

Uncertainty Inherent in *Ex Ante* Impact Studies. *Ex post* socioeconomic analysis attempts to estimate the impact of previous investments in agricultural research. This analysis typically involves uncertainties regarding the measurement of the farm-level income effect of new technologies on adopters, as well as the rate of adoption across farmers. However, *ex ante* impact assessment is an inherently more tenuous exercise because its conclusions are based on assumptions about how the new technology will likely perform under farmers' conditions and assumptions concerning future events, such as technology adoption rates and the general state of the commodity sector over time (area planted, average yields, and prices)—all key factors that affect the farm- and market-level impact of a new technology.

Because disease-resistant cucurbit varieties have not yet been commercially released in either South Africa or in Indonesia⁶, there is little observable evidence to date as to how these lines will perform and much less evidence as to their acceptability to farmers. Thus, given the absence of reliable data, it may seem premature to analyze the potential impact (*ex ante*) of disease-resistant cucurbit germplasm in these countries. However, waiting to evaluate the impact of technology until *ex post* data are available would prevent ABSP from obtaining invaluable farm- and market-level feedback that ABSP needs to assess the prospect of achieving ABSP/USAID stated socioeconomic goals (*i.e.*, generating benefits to poor farmers) and in both prioritizing commodities within a given country and assessing the criteria for country targeting.

2.3 Fieldwork

The ABSP evaluation team which visited Indonesia in March 2001 included Dr. Karim Maredia (Institute of International Agriculture, ABSP Technology Transfer Coordinator, Michigan State University), Mark Henning (Technician, Cucurbit Program, Cornell University), Dr. Richard Bernsten (Professor, Department of Agricultural Economics, Michigan State University), and David Mather (Ph.D. student, Department of Agricultural Economics, Michigan State University). The Indonesia visit entailed one week of fieldwork for the entire team, followed by an additional week for the two economists. The fieldwork consisted of conducting key informant interviews with seed company staff, government officials, market traders, supermarket procurement managers, and farmers—as well as compiling secondary data from public and private sector sources. The Indonesia fieldwork also included a survey of 45 cucumber farmers, which was conducted by Dr. Witono Adiyoga (Agroeconomist, Research Institute for Vegetables, Lembang, Indonesia).

The ABSP evaluation team which visited South Africa in April 2001 included Dr. Karim Maredia (ABSP, Technology Transfer Coordinator, Michigan State University), George Moriarty (Technician, Cucurbit Program, Cornell University), and David Mather (Ph.D. student, Department of Agricultural Economics, Michigan State University). The South Africa visit entailed one week of fieldwork for the entire team, followed by an additional week for the economist. The fieldwork consisted of key informant interviews with seed company staff, government officials, market traders, supermarket procurement managers, and farmers—as well as the compilation of secondary data from public and private sector sources.

⁶ In both Indonesia and South Africa, the 2001 field trials of various Cornell lines in the two countries were the first such trials under local conditions.

3. The Indonesian Cucurbit Subsector

3.1 An Overview of Indonesia and Its Agricultural Sector

Physical Features. Indonesia, an archipelago of several thousand islands, has a total area of 1,957, 178 km²—about 28% larger than Alaska. However, five islands account for 92% of the country's land area—Kalimantan (28.3%), Sumatra (24.9%), Irian Jaya (21.9%), Sulawesi (9.9%), and Java (6.6%). In terms of topography, these islands consist of coastal plains and mountainous areas traversing their central regions. Soil quality varies considerably, ranging from the rich soils of volcanic origin in Java to the more fragile red-yellow podsollic soils of Sumatra. Annual rainfall tends to decline from north to south. While annual rainfall varies considerably by island and location (leeward versus windward side of the island), it is typically quite heavy⁷, especially in the central/higher elevation areas of each island. Most of the country has a distinct wet and dry season. In Java—the most intensively cultivated farming area—the wet season occurs in October-March and the dry season in April-September.

Population. Indonesia, the fourth most populated country in the world, has 206.5 million inhabitants in 1999. Over 95% the population is concentrated on five islands—Java (58.7%), Sumatra (21.3%), Sulawesi (7.2%), and Kalimantan (5.5%). Due to a highly successful family planning program, the rate of population growth averaged only 1.66% during 1990-95.

Agriculture. Indonesia's agricultural sector is dominated by food crops, which accounted for about 56% of the annual harvested area in 1999 (Table 3.1). The main staple food crops are rice (37.4% of harvested area) and maize (10.8%). Smallholder estate crops, the second most important sector, accounted for 33.3% of the harvested area. The most important smallholder estate crops are coconut (11.2% of harvested area,) rubber (9.1%), coffee (3.5%), and oil palm (3.1%). Large estate crops accounted for 10.7% of the harvested area—primarily oil palm (6.3%), rubber (1.7%), and sugar cane (1.3%). Vegetables accounted for 2.8% of the harvested area.

Farming Systems. Farms are relatively small—less than 1.0 ha per holding. Agriculture is very labor intensive and most farmers plant rice in the wet season. If farmers have access to irrigation, they typically grow rice again in the dry season, or secondary crops such as corn or vegetables.

3.2 Production of Major Vegetables

Lowland/Highland Vegetables. In Indonesia, vegetables are classified as either lowland or highland types. Lowland (tropical) vegetables—including cucumber, melon, chili, pumpkin, swamp spinach, shallot, and eggplant—are generally grown below 1,000 meters and most intensively in coastal areas. Highland (temperate) vegetables—including potato, cabbage, tomato, carrot, onion, leek, and garlic—are primarily grown in the mountainous areas that characterize central areas of the archipelago.

Harvested Area. In terms of harvested area⁸ (1999), Indonesia's most important vegetable crops are chili (183,347 ha), shallot (104,289 ha), yardlong bean (89,026 ha), cabbage (65,352 ha), potato (62,776 ha), Chinese cabbage (49,102 ha), cucumber (48,121 ha), and tomato (46,259 ha),

⁷ Annual rainfall for selected locations: Jakarta, West Java, 71"; Bogor, West Java, 167"; Semarang, Central Java, 97"; Surabaya, East Java, 61"; Padang, West Sumatra, 177".

⁸ BPS reports vegetable crop area as "entirely" and "partly" harvested hectares. "Entirely" harvested refers to fields in which no crop remained after the harvest. "Partly" harvested refers to fields harvested, but with some of the crop remaining in the field for harvest in the future. We assume that the "totally" harvested area is equivalent to the "planted" area.

Table 3.1. Harvested Area ('000 ha), by Sector and Crop Type, Indonesia, 1995-99

Sector/Crop	1995	1996	1997	1998	1999	Percent (1999)
Food Crops						
Lowland Rice	10,081.2	10,251.4	9,881.8	10,475.6	10,688.3	33.7%
Maize	3,651.8	3,743.6	3,355.2	3,847.8	3,434.9	10.8%
Cassava	1,324.3	1,415.1	1,234.4	1,205.4	1,340.8	4.2%
Upland Rice	1,357.5	1,318.3	1,258.8	1,254.8	1,165.5	3.7%
Soybean	1,477.4	1,279.3	1,119.1	1,095.1	1,143.0	3.6%
Peanuts	739.3	688.9	628.1	651.1	613.7	1.9%
Sweet Potatoes	<u>228.7</u>	<u>211.7</u>	<u>195.4</u>	<u>202.1</u>	<u>167.9</u>	<u>0.5%</u>
Subtotal	17,892.2	18,007.7	16,849.3	17,878.7	17,772.5	56.0%
Vegetables^a	NA	NA	NA	NA	901.8	2.8%
Large Estates						
Oil Palm	992.4	1,146.3	1,739.1	1,878.1	1,993.2	6.3%
Rubber	471.9	538.3	557.9	549.0	542.8	1.7%
Sugar Cane	496.9	400.0	378.1	370.4	402.2	1.3%
Cocoa	125.4	129.6	146.3	151.3	154.6	0.5%
Coconut	137.6	132.2	120.2	119.0	120.1	0.4%
Tea	81.0	88.8	89.3	91.9	88.2	0.3%
Coffee	49.3	46.7	61.8	62.5	63.2	0.2%
Other ^b	<u>31.8</u>	<u>18.6</u>	<u>14.4</u>	<u>10.6</u>	<u>13.2</u>	<u>0.0%</u>
Subtotal	2,386.3	2,500.5	3,107.1	3,232.8	3,377.5	10.7%
Smallholder Estates						
Coconut	3,584.5	3,603.9	3,548.0	3,556.0	3,558.8	11.2%
Rubber	2,952.7	2,978.5	2,875.5	2,828.3	2,888.1	9.1%
Coffee	1,109.5	1,031.7	1,105.1	1,109.1	1,110.4	3.5%
Oil Palm	658.5	738.9	813.2	892.0	972.7	3.1%
Cashew	455.9	484.4	490.1	494.7	490.8	1.5%
Cocoa	428.9	488.8	380.8	368.6	383.6	1.2%
Kapok	262.5	266.6	261.3	261.3	261.4	0.8%
Tobacco	217.5	222.0	245.3	218.4	219.6	0.7%
Candlenut	178.2	182.4	179.5	181.0	178.4	0.6%
Pepper	134.3	126.3	111.0	123.3	120.5	0.4%
Cassava	98.9	105.1	114.2	114.9	114.9	0.4%
Areca Nut	74.8	75.8	74.7	75.3	75.4	0.2%
Tea	61.2	65.4	64.5	64.8	65.0	0.2%
Nutmeg	59.1	59.1	57.5	58.3	59.0	0.2%
Other ^c	<u>53.0</u>	<u>62.9</u>	<u>61.4</u>	<u>62.4</u>	<u>63.4</u>	<u>0.2%</u>
Subtotal	10,329.5	10,491.8	10,382.1	10,408.4	10,562.0	33.3%
Total^d	30,608.0	31,000.0	30,338.5	31,519.9	31,712.0	100.0%

^aFor vegetables, data are collected monthly and summed to produce annual totals. As some vegetables are harvested during more than one month, these data may overestimate the harvested area for vegetables. ^bTobacco, kapok, roselle, and cinchona. ^cVanilla, ginger, patchouli, castor beans, cardamom, and citronella. ^dExcluding vegetables in 1995-1998. NA indicates data not available.

Source: GOI, BPS, 2000 (a); For vegetable data: GOI BPS, 2000 (b).

as shown in Table 3.2.

Production and Value of Production. However, given that vegetables vary in price, value of production more accurately reflects the relative importance of individual crops. Total production multiplied by 1999 wholesale prices at Pasar Induk [Pasar Induk (b), 2001] provides an approximate estimate of the value and relative importance (rank) of Indonesia's major vegetable crops (Table 3.2). In terms of crops value, the most important vegetables are chili, shallot, potato, cabbage, tomato, French bean, leek, carrot, and cucumber.

Table 3.2. Vegetable Harvested Area, Production, and Value of Production, Indonesia, 1999

Vegetables	Planted	Production	Price ^b	Wholesale Value	
	Area ^a (ha)	(mt)	(Rp/kg)	Rp million	Rank
Chili	183,347	1,007,726	8,043	8,105,140.2	1
Shallot	104,289	938,293	5,154	4,835,962.1	2
Yardlong Bean	89,026	386,188	NA	NA	
Cabbage	65,352	1,447,910	1,119	1,620,211.3	4
Potato	62,776	924,058	3,161	2,920,947.3	3
Chinese Cabbage	49,102	469,996	NA	NA	
Cucumber	48,121	431,950	741	320,075.0	9
Tomatoes	46,259	562,406	956	537,660.1	5
Eggplant	39,451	300,323	970	291,313.3	13
Red Kidney Bean	38,842	98,854	NA	NA	
Leek	36,882	323,855	1,521	492,583.5	7
Amaranth	34,614	81,433	NA	NA	
Swamp Cabbage	31,151	211,597	NA	NA	
French Bean	28,546	282,198	1,828	515,857.9	6
Carrot	17,985	286,536	1,217	348,714.3	8
Garlic	12,936	62,222	3,943	245,341.3	10
Pumpkin	9,176	121,233	243	29,459.6	12
Melon	2,150	25,451	2,164	55,076.0	11
Chinese Radish	1,778	13,967	NA	NA	
Total	901,783	NA	NA	NA	

^aHarvested area is equal to the area that BPS reports as "entirely harvested". ^bValued at the average 1999 Pasar Induk wholesale price. NA indicates data not available.

Source: GOI, BPS, 2000 (b); For commodity price data: *Pasar Induk*, 2001 (b).

3.3 Government Policies

Varietal Release/Seed Certification. Indonesia's National Seed Board is responsible for formulating policies and regulations for seed production and distribution. In order to register a new variety, seed companies are required to carry out multi-locational tests of proposed new releases on farmers' fields. To register a new variety, it must be different from existing varieties, be uniform, and have a stable yield. In addition, the Indonesian government's (GOI) regional inspection/certification centers have the right to review these test results and inspect the seed. Firms wishing to import seed must apply for a permit from the National Seed Agency and follow the government's plant quarantine regulations (Singh, 1994).

Genetically-Modified Varieties (GMO) and Biosafety. The GOI has established protocols for testing GMOs and several GMOs have been tested in Indonesia. However, only a genetically modified cotton variety, which has the *B.t. (Bacillus thuringiensis)* gene that provides resistance to insects, is currently being grown by farmers. After approval by the GOI, this variety was first planted in Southeast Sulawesi in February 2001. While GMOs are less controversial in Indonesia than in other Asian countries, several NGOs protested this introduction and filed legal action against the GOI (Pakpahan, personal communication).

Intellectual Property Rights (IPR) Legislation. With assistance from ABSP, Indonesia developed protocols which conform to the international standard, as required by the agreement on *International Trade Related Aspects of Intellectual Property Rights*. In December 2000, Parliament passed the Plant Variety Protection law. In 2001, the GOI developed three government regulations and four ministerial decrees for implementing the law (Herman, personal communication).

However, although these protocols have been enacted into law, it is unlikely that they will

provide significant protection to seed companies, who face the continual problem of having their varieties multiplied by “illicit” seed firms. While this legislation makes it possible for seed firms to sue firms that steal their varieties, the time and cost of initiating legal action would be excessive. Thus, since this is especially a problem with open pollinated (OP) varieties, key informants reported that the inability to protect their varieties is a primary reason why private vegetable seed companies are focusing on developing hybrids to replace their OP varieties.

3.4 Vegetable Seed Firms

While about a dozen firms market vegetable seed in Indonesia, the vegetable seed subsector is highly diverse. Some firms produce and market seed of several different vegetables, while others specialize in a few vegetables. While a few firms breed varieties specifically for Indonesian conditions, most import varieties from abroad. Furthermore, some firms focus on OP varieties, while others produce and/or market both OP varieties and hybrids (Table 3.3). Thus, while it is impossible to assess each firm’s market share because it varies by vegetable type, East West Seed Company (E-W Seed) and Chai-Tai are the dominant players in the vegetable seed market.

East West Seed Company. E-W Seed is Indonesia’s premier vegetable seed firm. This company, a joint venture with Enza-Zaden (Dutch), has operated in Asia since the early 1990s with sister firms in the Philippines, Thailand, Bangladesh, and Vietnam. While each firm works independently, germplasm is sometimes shared between these related companies.

E-W Seed maintains a substantial vegetable breeding operation, including a 10 ha research farm in Purwakarta, West Java, and two field stations in West Java. In addition to research plots, the Purwakarta facility has a phytopathology laboratory and cold storage facilities. Its staff includes approximately 15 researchers and 50 staff in its marketing division.

While E-W Seed produces both highland and lowland vegetable seed, it gives priority to lowland crops (including traditional vegetables) because these crops are planted to the largest area in Indonesia. Currently, E-W Seed sells seed of 56 varieties (21 different vegetable crops). Its priority crops are chili (OP and hybrid varieties), tomato (OP/H), and cucumber (OP/H); with a secondary emphasis on eggplant (OP/H), bitter melon (OP/H), squash (H), pumpkin (H), watermelon (H), cauliflower (OP), kale (OP), mustard green (OP), long bean (OP), water spinach (*kangkung*) (OP), lettuce (OP), amaranth (OP), celery (OP), carrot (OP), cabbage (H), and Chinese cabbage (H). E-W Seed does not currently sell melon seed.

E-W Seed, a major player in the quality cucumber seed market, commanded a major share of the hybrid and OP cucumber seed market in 1999. However, data on total sales and market shares are confidential (Table 3.4).

Table 3.3. Characteristics of Major Vegetable Seed Firms in Indonesia, 2001

Name	International Linkages	Primary Activities	Breeds Varieties	Target Environments/ Vegetables
East West Seed	Dutch	breed, test, market	Yes-OP & hybrids	lowland/highland
Koreana	Korea	test, market	No	chili, eggplant, watermelon
Seminis	Korea/Dutch	test, market	No	lowland/highland
Chai-Tai	Thailand	test, market	Starting	highland
Takii	Japan	test, market	No	highland
Benih Prima	None	breed, test, market	Yes-OP	lowland/highland
Knownyou	Taiwan	test, market	No	watermelon, pepper
Novartis	USA	test, market	No	lowland/highland

Table 3.4. East West Seed Company's Cucumber and Melon Varieties, Indonesia, 1999

Vegetable	Variety Name	Type ^a	Price/kg ^b (Rp)
Cucumber	Hybrida	H	600,000
	Venus	OP	150,000
	Panda	OP	150,000
Melon	None	NA ^c	NA ^c

^aVariety type: H indicates a hybrid variety; OP indicates an open pollinated variety. ^bFarmer-multiplied OP varieties sell for Rp75,000/kg. ^cNot applicable, as E-W Seed does not currently sell melon seed.

With respect to breeding priorities, E-W Seed focuses on yield, quality, and disease resistance, which reflects farmers' priorities. E-W Seed's varietal development strategy is to continue to develop OP varieties for traditional farmers and hybrid varieties for commercial farmers—due to their greater yield potential, problems with illegal multiplication of OP varieties, and because it is easier to incorporate new traits into hybrids.

Initially, E-W Seed screens promising material on-station at Perwakarta and at its field stations, and then conducts multi-locational trials on farmers' fields at 10-20 sites during both the wet, dry, and transitional seasons. The results of these trials are provided to the GOI, as is required prior to the registration/release of a new variety. E-W Seed multiplies its seed in both in Indonesia and abroad (by foreign firms contracted for seed multiplication).

Periodically, E-W Seed conducts a market survey to assess the demand for vegetable seed. However, this information is confidential. For cucumbers, the harvested area was 48,121 ha in 1999 [Appendix I. Table 1(d)], the seed rate is 1kg/ha, and about two-thirds of the farmers buy new seed each year—which suggests an annual cucumber seed demand of 32 mt. For melon, the harvested area was 2,150 ha in 1999, the seed rate is 0.5 kg/ha, and all farmers plant hybrid varieties—which suggests an annual melon seed demand of 1.1 mt.

Currently, E-W Seed markets its varieties through its extensive network of agents, who are located in every regency (county) of Java and some regencies in Kalimantan. However, E-W Seed is in the process of expanding its sales network into other provinces. To promote its varieties, E-W Seed advertises on the radio, distributes seed catalogues to its agents, places advertisements in agriculture magazines, and promotes its varieties at agriculture fairs. In addition, E-W Seed sponsors demonstrations in farmers' fields.

3.5 The Cucumber Subsector

3.5.1 Growing Environment and Harvested Area. Cucumber is grown throughout the lowlands of Indonesia. During the 1990-1999 period, Indonesia's cucumber area ranged from a low of 48,121 ha (1999) to a high of 56,055 ha (1996), as shown in Appendix I. Table 1 (a-d).

3.5.2 Production and Yields. During the 1990s, production from “entirely”⁹ harvested fields ranged from a low of 253,449 mt (1999) to a high of 286,765 mt (1998) [Appendix I. Tables 1 (a-d)]. While data in these tables indicate that annual national yields averaged around 5 mt/ha during the period, these estimates appear to be extremely low.

⁹ Since BPS only reported the “entirely” harvested area for 1990-1997, all annual totals data refer to the “entirely” harvested area.

This hypothesis was confirmed by reviewing monthly 1999 cucumber production data for all regencies in West Java, which was estimated (special computer run) by the Bureau of Central Statistics (BPS) at the request of the research team. These data report cucumber production from “partly” harvested fields [Appendix I. Table 2 (a)], “entirely” harvested fields [Appendix I. Table 2 (b)], and “total” production (Table 3.5)—which is the sum of “partly” and “entirely” harvested fields. Table 3.5 indicates that in 1999, West Java’s “total” cucumber production was 199,617 mt (19,963,161 quintal), which is about 66% greater than the 120,012 mt reported by BPS’s published statistical report [Appendix I. Table 1 (d)]. The difference between these two figure (79,604 mt) is equal to production from “partly” harvested fields [Appendix I. Table 2 (b)]. This suggests that in other years, BPS’s published data also underestimates “total” cucumber production because production from “partly” harvested fields is not included in BPS’s published data.

However, it is possible to revise BPS’s annual cucumber production estimates by using data published in another BPS document—*Agricultural Survey Production of Vegetables and Fruit Crops*—which reports production from both “totally” and “partly” harvested fields. In the years for which these data were available (1997, 1998, and 1999), national cucumber production from “partly” and “entirely” harvested fields totaled 489,487 mt (1997), 506,707 mt (1998), and 431,950 mt (1999).

In addition, these reports (*Agricultural Survey Production of Vegetables and Fruit Crops*) provide separate estimates of the “partly” and “entirely” harvested cucumber area. However, assuming that cucumber fields first reported in these data as “partly” harvested are later reported as “totally” harvested, the “total” harvested cucumber area is equal to the “entirely harvested” area (52,849 ha, 1997; 54,901 ha, 1998; and 48,121 ha; 1999), rather than the sum of the “partly” and “entirely” harvested area.

Drawing on the data revisions, as described above, it is possible to “revise” BPS’s estimates of cucumber yields for these three years by dividing the “revised” production estimate by the “entirely” harvested area estimates. The resulting “revised” yield estimates are 9.4 mt/ha in 1997, 9.2 mt/ha in 1998, and 9.0 mt/ha in 1999—rather than 5.6 mt/ha (1997), 5.2 mt/ha (1998), and 5.3 mt/ha (1999), as reported in BPS’s national aggregate data series [(Appendix I. Tables 1 (c-d)]. Thus, in recent years, national cucumber yields have likely averaged around 9.2 mt/ha.

However, in some provinces, yields far exceed the national average. For example, in West Java, which accounts for 46.2% of national production, yields averaged 11.6 mt/ha in 1999 [Appendix I. Table 1 (d)]. And in some regencies of West Java, cucumber yield far exceeded the provincial average, with the highest yield observed in Garut (24.9 mt/ha) (Table 3.5).

Furthermore, some commercial cucumber producers in West Java typically achieve even higher yields than the provincial average. For example, a group of farmers in Karawang Regency (*i.e.*, Indonesian administrative unit, similar to the size of a county), who were interviewed during the field visit, reported yields of 30-40 mt/ha in average years and 50 mt/ha in good years. E-W Seed estimates that commercial farmers typically produce 26 mt/ha (see budget analysis, below). Finally, among 50 cucumber producers in Bekasi and Purwakarta Regencies of West Java (based on a survey commissioned by this study), dry season yields averaged 26.6 mt, 25.9 mt/ha, 24.1 mt/ha, and 24.6 mt/ha in 1996, 1997, 1998, and 1999, respectively.

3.5.3 Provincial Distribution of Production. In 1999, the three most important cucumber-producing provinces accounted for over 60% of national production—West Java, 46.2%; North Sumatra, 8.7%; and Bengkulu, Sumatra, 7.3%) [Appendix I. Table 1 (d)].

West Java’s dominance in cucumber production is clearly due to its proximity to Jakarta—the nation’s capital and its largest city, with a population of 9.6 million (1999)—in addition to West

Table 3.5. Total Production (quintal^a) of Cucumber, by Month and Regency, West Java, Indonesia, 1999

Regency	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total (quintal)	Percent of Total	Harvested Area (ha)	Yield (mt/ha)
Bandung	6,276	2,412	354	1,747	1,802	1,063	2,896	1,255	814	1,772	532	2,910	23,833	1.2	713	3.3
Bekasi	12,027	12,276	4,436	4,696	3,784	5,665	6,256	8,718	10,511	11,002	8,526	9,299	97,196	4.9	618	15.7
Bogor	17,174	13,081	13,577	14,074	14,750	19,255	17,846	15,223	19,243	18,676	16,724	21,437	201,060	10.1	1,504	13.4
Ciamis	4,647	2,931	1,748	4,012	7,673	5,386	5,064	7,083	5,712	3,037	2,508	4,312	54,113	2.7	732	7.4
Cianjor	12,804	10,266	10,043	8,924	11,896	15,181	16,872	15,762	10,389	10,879	7,173	12,597	142,786	7.2	623	22.9
Cirebon	2,006	1,767	2,289	2,801	3,565	7,317	8,684	3,767	4,407	4,314	2,737	1,315	44,961	2.3	486	9.3
Garut	26,369	10,448	17,913	8,304	16,476	13,645	17,243	22,071	16,848	23,425	9,982	62,782	245,506	12.3	984	24.9
Indramayu	5,203	5,654	5,886	23,469	24,027	2,979	2,831	3,989	3,550	10,259	3,644	2,672	94,163	4.7	702	13.4
Karawang	5,923	8,803	7,836	8,922	7,956	8,948	7,263	15,952	13,991	12,239	10,744	5,357	113,934	5.7	767	14.9
Kuningan	75	0	145	40	168	218	96	126	76	105	140	150	1,339	0.1	35	3.8
Lebak	9,965	15,949	6,733	3,564	6,204	10,502	8,808	6,074	9,102	11,577	12,093	19,766	120,337	6.0	967	12.4
Majalengka	12,902	475	10,957	15,546	11,995	5,208	5,183	25,937	9,459	9,149	5,430	20,127	132,368	6.6	1,253	10.6
Pandeglang	2,798	2,591	1,254	792	1,726	3,573	2,967	2,235	1,732	2,433	1,483	3,969	27,553	1.4	710	3.9
Purwakarta	4,852	3,613	2,410	4,138	3,930	2,430	5,125	4,634	5,835	4,398	3,851	4,250	49,466	2.5	700	7.1
Serang	13,844	9,572	7,934	5,245	9,639	9,277	11,144	11,982	8,048	5,121	3,577	8,884	104,267	5.2	2,325	4.5
Subang	12,563	13,223	11,437	11,606	16,771	11,335	12,830	14,012	17,251	40,884	12,534	4,407	178,853	9.0	1,040	17.2
Sukabumi	6,645	4,721	8,295	5,439	3,744	6,018	5,182	7,598	7,571	5,631	7,198	7,834	75,874	3.8	864	8.8
Sumedang	5,800	6,439	9,346	10,323	5,425	3,456	6,690	8,316	8,119	5,631	1,404	3,512	74,461	3.7	428	17.4
Tangerang	15,693	16,402	10,384	8,045	8,534	10,428	13,856	10,221	8,011	5,260	24,874	9,150	140,858	7.5	891	15.8
<u>Tasikmalaya</u>	<u>5,048</u>	<u>7,046</u>	<u>4,212</u>	<u>5,071</u>	<u>4,641</u>	<u>5,508</u>	<u>6,423</u>	<u>5,738</u>	<u>3,807</u>	<u>6,214</u>	<u>5,717</u>	<u>5,331</u>	<u>64,756</u>	<u>3.2</u>	<u>712</u>	<u>9.1</u>
Total	183,585	148,488	137,915	147,479	165,459	148,193	163,736	191,207	165,014	192,462	141,204	211,519	19,962,161	100.0	17,136	11.6
Percent	9.2	7.4	6.9	7.4	8.3	7.4	8.2	9.6	8.3	9.6	7.1	10.6	100.0			

^a1 quintal equals 100 kg.

Source: GOI, BPS, 2001 (c and d).

Java's population of an additional 43.2. million. Within West Java, almost 65% of the province's cucumber production is concentrated in eight of 27 regencies—Garut (12.3%), Bogor (10.1%), Subang (9.0%), Tangerang (7.5%), Cianjur (7.2%), Majalengka (6.6%), Lebak (6.0%), and Karawang (5.7%), as shown in Table 3.5.

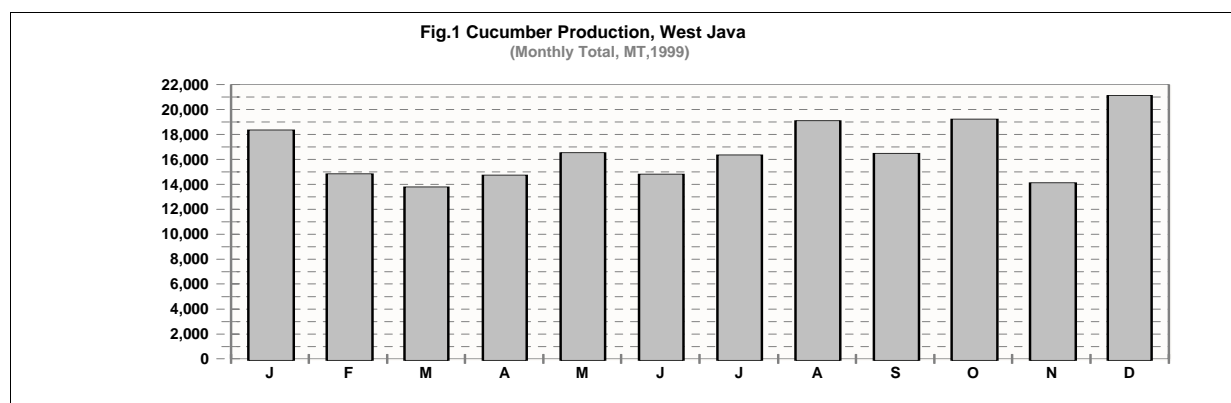
3.5.4 Seasonality. While cucumber is grown throughout the year, production follows a slightly seasonal pattern. For example, West Java—the dominant cucumber-producing province—the largest share of production is harvested in December (10.6%) and the smallest share is harvested in March (6.9%), as shown in Table 3.5 and Figure 1.

3.5.5 Varieties. Indonesian cucumber farmers grow both OP and hybrid varieties. Key informants estimate that 80% of the annual cucumber crop is planted to OP varieties, with farmers refreshing their seed stock with new seed every 2-3 years. E-W Seed markets two OP varieties (Venus, Panda) and one hybrid (Hybrida Baron F₁). Seed import statistics indicate that three varieties (Cucumber Big Seed F₁, Octapus, Cucumber Ruberto) accounted for 94% of the seed imported in 2000—of which 64% came from Thailand (GOI, Pusat Tanaman Pangan, 2001).

3.5.6 Pests and Diseases. Key informants at E-W Seed and the Research Institute for Vegetables reported that the zucchini yellow mosaic virus (ZYMV), which is transmitted by aphids, and downy mildew (a fungus) are both important constraints to higher cucumber yields. Key informants at the Research Institute for Vegetables estimated that virus diseases, especially ZYMV, reduce farmers' yields by 15-20% and also reduce the quality of the crop (fruit weight and length).

Only a limited number of studies have been carried out to quantify the incidence and impact of virus diseases on cucumber yields. Sutarya (1994), who collected 30 samples of cucumber leaves in Subang, Berbes, and Tegal (West Java), found that the percentage of virus infection (common mosaic virus and ZYMV) ranged from 30-100%. Gunaeni *et. al.*(2000) evaluated 20 cucumber cultivars and reported that none had resistance to ZYMV. In a screened house experiment, Sutarya and Duriat (1997) reported that when inoculated with ZYMV at 7, 14, and 21 days, yields were reduced by 49%, 39% and 6%, respectively. In another screened house study of three cucumber cultivars inoculated with ZYMV, Sutarya and Sumpena (1994) reported that yield losses ranged from 42-53%, compared to the non-inoculated control.

3.5.7 Farm Size and Cropping System. Cucumber is grown primarily by small-scale farmers, on fields of approximately 0.2 ha, often as a second crop following lowland rice. However, on the North coast of Java, it is common for farmers to organize themselves into groups



that specialize in intensive cucumber production. For example, three farmers interviewed in Karawang Regency (West Java)—who were landless laborers from Indramayu Regency—rented 1.5 ha of land and planted it to cucumber, targeting the Jakarta market. These farmers reported planting cucumber in the same field for 2-3 seasons, and then moving to a new site, as a strategy for minimizing disease incidence.

3.5.8 Enterprise Budgets: Inputs and Yields. Compared to crops like rice and corn, cucumber production is relatively labor and input intensive. Four sources of data are available to estimate farmers' costs of production and profits.

First, in 1997, BPS carried out a study to estimate the costs structure of cucumber production (Table 3.6). However, these data represent "average" costs and returns for all of the respondents in the sample—several thousand cucumber farmers throughout the country. Also, since BPS does not note the month during which these data were collected, it is problematic to convert the Rupiah

Table 3.6. Cost Structure of Cucumber Production (per ha), Indonesia, 1997

Item	Unit	Total Costs (Rp/ha)	Percent
INPUTS			
<i>Labor</i>			
Plowing	NA	214,912	12.2%
Planting	NA	75,756	4.3%
Input application	NA	169,654	9.6%
Harvesting	NA	149,213	8.5%
<u>Others</u>	NA	<u>23,787</u>	<u>1.3%</u>
Subtotal	NA	633,322	35.9%
<i>Material Inputs (kg)</i>			
Seeds	3.2	10,903	0.6%
Fertilizer: Urea	391.6	157,478	8.9%
TSP	170.9	72,426	4.1%
Others	NA	75,410	4.2%
Manure	1,703.2	63,207	3.6%
Pesticide & Fungicide	NA	129,070	7.3%
<u>Other</u>	NA	<u>5,284</u>	<u>0.3%</u>
Subtotal		513,818	29.1%
<i>Other Costs</i>			
Rent tools & Animals	NA	32,835	1.9%
Irrigation	NA	23,754	1.3%
Tools service	NA	21,850	1.2%
Wrapping	NA	25,529	1.4%
Transportation	NA	88,617	5.0%
Rent for land	NA	257,750	14.6%
Tax, Interest, & Depreciation	NA	34,418	1.9%
<u>Others</u>	NA	<u>133,153</u>	<u>1.3%</u>
Subtotal		617,906	35.0%
<i>Total Expense</i>		1,765,046	100.0%
OUTPUTS			
<i>Production (kg)</i>			
Harvesting by the owner	14,251	3,908,462	
<i>Lion^a</i>		69,445	
Harvesting by hired labor		80,898	
<u>Other</u>		<u>54,585</u>	
Subtotal		4,113,390 ^b	
FARMERS' INCOME		2,348,344	
INCOME OVER EXPENSES		133.0%	

^aSelling the plants before harvest. ^bCucumber price = Rp289/kg. NA indicates data are not available.

Source: GOI, BPS, 2000 (c).

values to US\$ equivalents—given that during 1997 the Rupiah fluctuated widely as a consequence of the Asian economic crisis (Figure 2). However, these data indicate that labor costs accounted for the largest share of production costs (36%), followed by other (35%), and material input (29%).

Second, E-W Seed provided the team with a “conservative” (E W Seed estimate that hybrids yield 20% more than OPs) enterprise budget for a “typical” cucumber farmer who planted a hybrid variety (Table 3.7). In this budget, material inputs accounted for 57.5% (US\$1,371) of total costs and labor accounted for 40.0% (US\$946) of total costs. Farmers’ income, based on an estimated yield of 32,000 kg/ha and a farm-gate price of US\$0.08/kg, is US\$117/ha.

Third, due to a lack of empirical data about cucumber farming in Indonesia, this project commissioned two economists at the Research Institute for Vegetables (RIV) to carry out a survey of 45 farmers in Bekasi and Perwakarta—important cucumber-producing regencies in West Java. On average, these farmers were 38 years old, had 3 years of schooling, had an average farm size of 0.47 ha, and typically rented their land (80%) which was irrigated in the dry season (100%). In the 2000 dry season, these farmers planted 0.34 ha to cucumber, all planted OP varieties (59% reported planting Venus—an E-W Seed variety—and 41% planted a variety named Lajer). Sixty-two percent of the farmers purchased their seed in 2000, while 38% planted saved seed from their previous crop. Table 3.8 presents the costs and returns analysis for the dry season 2000, based on recall data collected in March 2001. In this budget, purchased inputs accounted for 43.2% (US\$588/ha) of total costs. Total labor requirements averaged 629 person days/ha. Of this total, family labor averaged 294 person days/ha (54% male, 46% female) and hired labor averaged 335 person days/ha (47% male and 53% female). Hired labor accounted for 47.9% (US\$619/ha) of total costs. Estimated average Farmer’s Income, based on the farmers’ average yield of 26,572 kg/ha and a farm-gate price of US\$0.08/kg, is US\$447/ha. However, the farmers’ 2000 cucumber yields ranged from a high of 55,000 kg/ha to a low of 8,667 kg/ha (coefficient of variation = 38%). Also, yield varied greatly, depending on the variety planted. For example, farmers who planted Venus averaged 32,455 kg/ha, versus. 20,945 kg/ha for Lajer.

Finally, during the fieldwork phase of the study, the research team interviewed three commercial cucumber farmers in Karawan Regency (West Java). These farmers reported total per ha production costs of Rp11 million—including land rent (Rp1.6 million), poles (Rp2 million), fertilizer (Rp2 million), pesticide (Rp3 million), and hired labor for bed preparation, sticking, input application, and harvesting (Rp3 million). They also reported typically harvesting 40 mt/ha, with a range of 25-50 mt/ha.

Clearly, these budgets vary considerably with respect to specific cost items—which is most likely due to different definitions/categories used to report specific cost items, different reporting years, the way that each budget values family labor, and the difficulty of determining the exchange rate to use when converting costs and return items into US\$ (given the instability in the US\$ to

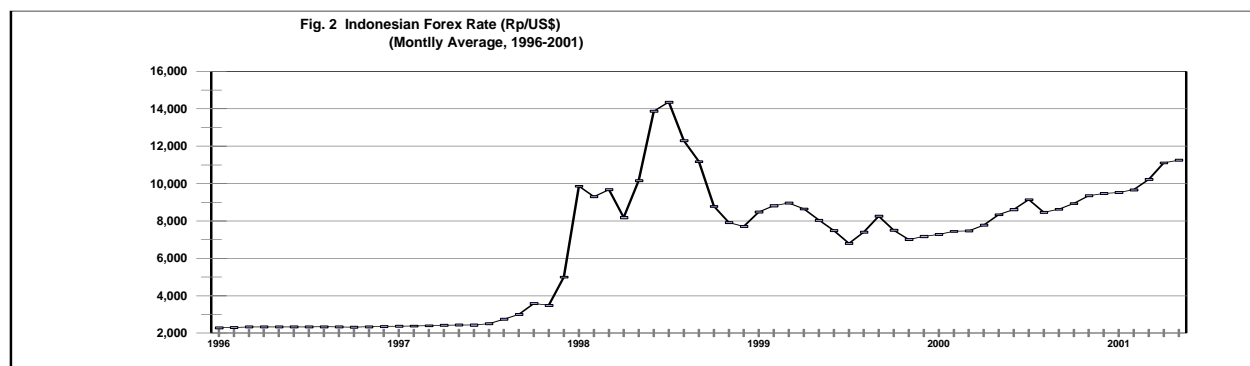


Table 3.7. Costs and Returns (per ha) to Commercial (hybrid) Cucumber Production, West Java, Indonesia, 2000

Item	Quantity	Unit	Unit price	Rp/ha	US\$/ha	Percent
INPUTS						
<i>Material Inputs</i>						
Seed	1	kg	600,000	600,000	58.65	2.5%
Fertilizer	2,300	kg	1,750	4,025,000	393.41	16.5%
Manure	20	m ³	30,000	600,000	58.65	2.5%
Plastic mulch	270	kg	10,750	2,902,500	283.70	11.9%
Stakes	32,000	pieces	75	2,400,000	324.58	9.8%
Bamboo	100	pieces	1,750	175,000	17.10	0.7%
Insecticide	32	liter	95,000	3,040,000	297.14	12.5%
<u>Foliar fertilizer</u>	16	kg	17,500	<u>280,000</u>	<u>27.37</u>	<u>1.1%</u>
Subtotal				14,022,500	1,370.59	57.5%
<i>Labor</i>						
Plowing	1	ha	500,000	500,000	48.87	2.0%
Bedding	7,500	meter	185	1,387,500	135.62	5.7%
Land preparation	108	md	12,500	1,350,000	131.95	5.5%
Transplanting	15	md	10,000	150,000	14.16	0.6%
Re-transplanting	2	md	10,000	20,000	1.95	0.1%
Staking	27	md	12,500	337,500	32.99	1.4%
Fertilizing	45	md	10,000	450,000	43.98	1.8%
Spraying	50	md	12,500	625,000	61.09	2.6%
Weeding	25	md	10,000	250,000	24.44	1.0%
Rouging	270	md	10,000	2,700,000	263.90	11.1%
<u>Harvesting</u>	200	md	10,000	<u>2,000,000</u>	<u>195.48</u>	<u>8.2%</u>
Subtotal				9,770,000	954.94	40.0%
<i>Equipment</i>						
Hand sprayer	2	pieces	140,000	280,000	27.37	1.1%
Bucket	10	pieces	3,500	35,000	3.42	0.1%
<u>Container</u>	20	pieces	7,500	<u>150,000</u>	<u>14.66</u>	<u>0.6%</u>
Subtotal				465,000	45.45	1.9%
<i>Other</i>						
Housing	1	pieces	150,000	<u>150,000</u>	<u>14.66</u>	<u>0.6%</u>
<i>Total Expenses</i>				24,407,500	2,385.64	100.0%
RETURNS (Gross Revenue)						
Production	32,000	kg	800 ^a	25,600,000	2,503.00	
FARMERS' INCOME				1,192,500	116.56	
INCOME OVER EXPENSES				4.9%		

^aEquivalent to US\$0.08 at the average March 2001 exchange rate of US\$1 = Rp10,228.

Source: E-W Seed Company's estimates of costs and returns to commercial cucumber production.

Rupiah exchange rate). However, these budgets suggest several key characteristics of cucumber production in West Java. First, cucumber is grown by small-scale farmers, especially landless farmers who rent land to grow the crop. Second, cucumber is extremely labor intensive (over 600 person days/ha) and provides employment to both male and female family members and hired labor. Finally, the farmer survey indicated that cucumber yields averaged 26,574 kg/ha. However, many farmers achieved significantly higher yields (and income), including the survey farmers who planted Venus (32,455 kg/ha), farmers who planted hybrids (32,000 kg/ha, E-W Seed's "conservative" estimate), and farmers interviewed during the field visit (40 mt/ha).

**Table 3.8. Costs and Returns (per ha) to Commercial Cucumber (open pollinated varieties)
Production, West Java, Dry Season, Indonesia, 2000**

Item	Family Labor (days)			Hired Labor (days)			Total	Cost ^a		
	Male	Female	Total	Male	Female	Total	(days)	Rp/ha	US\$/ha	Percent
INPUTS										
<i>Material Inputs</i>										
Seed	NA	NA	NA	NA	NA	NA	NA	333,587	39	3.0%
Fertilizer	NA	NA	NA	NA	NA	NA	NA	1,773,294	207	16.0%
Foliar fertilizer	NA	NA	NA	NA	NA	NA	NA	171,877	20	1.6%
Manure	NA	NA	NA	NA	NA	NA	NA	281,883	33	2.6%
Plastic mulch	NA	NA	NA	NA	NA	NA	NA	275,000	32	2.5%
Stakes	NA	NA	NA	NA	NA	NA	NA	466,973	55	4.2%
Insecticide	NA	NA	NA	NA	NA	NA	NA	570,415	67	5.2%
Herbicide	NA	NA	NA	NA	NA	NA	NA	181,339	21	1.6%
Fungicide	NA	NA	NA	NA	NA	NA	NA	210,277	25	1.9%
Ropes	NA	NA	NA	NA	NA	NA	NA	127,032	15	1.1%
Sacks	NA	NA	NA	NA	NA	NA	NA	272,100	32	2.5%
<u>Other</u>	NA	NA	NA	NA	NA	NA	NA	<u>111,000</u>	<u>13</u>	<u>1.0%</u>
Subtotal								4,774,777	558	43.2%
<i>Labor</i>										
Land preparation	5	0	5.3	76	0	76	81.5	1,142,049	134	10.3%
Planting	7	5	12	6	11	17	29	786,094	92	7.1%
Bedding	9	8	17	10	29	39	56	367,722	43	3.3%
Fertilizing	16	13	29	6	17	23	52	272,513	32	2.5%
Watering	30	14	44	10	11	21	65	632,759	74	5.7%
Staking	8	4	12	8	9	17	28	197,321	23	1.8%
Spraying	33	0	34	6	0	6	40	413,452	48	3.7%
Roping	14	14	29	4	31	35	64	336,136	39	3.0%
Harvesting	<u>61</u>	<u>52</u>	<u>112</u>	<u>32</u>	<u>70</u>	<u>102</u>	<u>214</u>	<u>1,143,905</u>	<u>134</u>	<u>10.0%</u>
Subtotal	184	110	294	157	178	335	629	5,291,951	619	47.9%
<i>Other</i>										
Land rent	NA	NA	NA	NA	NA	NA		985,614	115	8.9%
<i>Total Expenses</i>								11,052,342	1,293	100.0%
RETURNS (Gross Revenue)										
Production				26,572 kg/ha				26,572 kg/ha		
Price				Rp560/kg				US\$0.07/kg		
Gross Return				Rp14,880,320/ha				US\$1,740		
FARMERS' INCOME				Rp3,827,978/ha				US\$448		
INCOME OVER EXPENSES				34.6%						

^aExchange rate: US\$1 = Rp8,550 (mean of April-September 2000 rates).

Source: Survey, 2001.

3.5.9 Consumer Preferences. While at least two market classes of cucumber are grown, almost all consumers prefer fruit that is white-to-light green in color. Cucumber is consumed by all income groups—typically cut up into small pieces and added to a main dish.

3.5.10 Marketing Channels. Commercial cucumber farmers typically harvest their crop several times a week and sell it to middlemen who visit their farm. However, some farmers directly market their crop to vegetable sellers in nearby public markets or have contracts to supply supermarkets, which are located in large cities. In contrast, middlemen generally sell to large

wholesales markets, located in major urban areas. Virtually all of the cucumber produced in Indonesia is consumed domestically. Import and export statistics indicate that in recent years, Indonesia has imported/exported only small quantities of cucumber.

3.5.11 Farm-Gate Prices. Farmers interviewed during fieldwork reported that the price they received for their crop varied considerable from week-to-week, depending on supply and demand conditions. This was confirmed by sales price data collected during the farmer survey. For example, farmers surveyed in Bekasi and Perwakarta Regencies reported receiving prices that ranged from Rp200/kg (US\$0.02) to Rp1,500/kg (US\$0.17), with a mean of Rp560/kg.

3.5.12 Wholesale Prices. During the fieldwork phase of the study, weekly cucumber melon wholesale price data for January 2000 through March 2001 were collected from Pasar Induk—one of the main wholesale markets in Jakarta (Figure 3). These data indicate that prices vary considerably over the year.

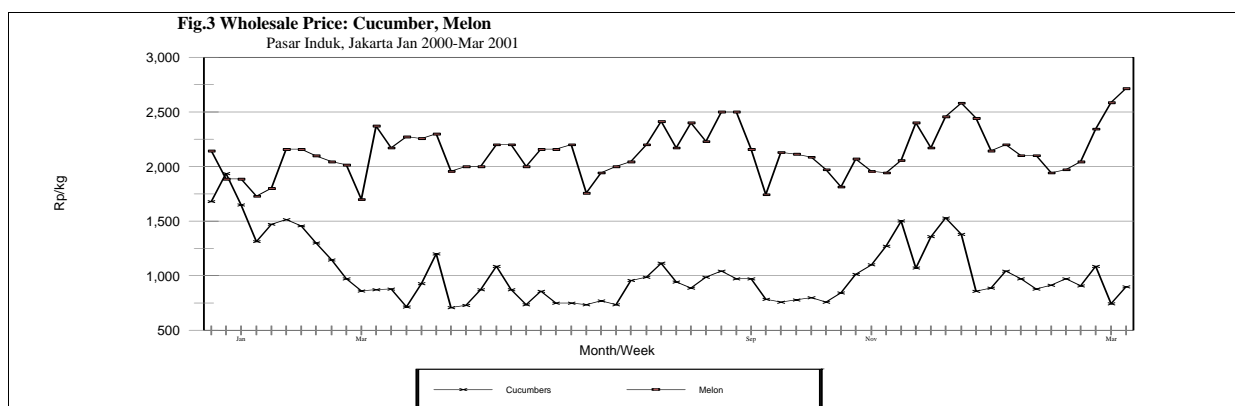
During June-August 2000 (harvest period for the surveyed cucumber farmers), the Pasar Induk wholesale price averaged Rp889, compared to the survey farmers' farm-gate price of Rp560/kg—indicating that the farm-gate price is approximately 63% of the wholesale price.

3.6 The Melon Subsector

3.6.1 Growing Environment and Harvested Area. Melons are grown in the lowlands of Indonesia. Prior to 1999, BPS only reported data for “all melons”—a category which includes watermelon and other types of melon. However, beginning in 1999 BPS began to report separate estimates for watermelon and melon. Thus, while it is not possible to document trends in harvested area, BPS estimated that 2,150 ha were planted to melon in 1999 (Table 3.9).

3.6.2 Production and Yields. BPS estimated that national melon production totaled 25,451 mt in 1999 and national average yield was 11,838 kg/ha (Table 3.9). However, average yields varied considerably across provinces. Yields were highest in the provinces with the largest share of melon hectares, including East Java (17,235 kg/ha) and Central Java (13,398 kg/ha).

3.6.3 Provincial Distribution of Production. Melon production is concentrated in Java, which accounted for 72% of the harvested area in 1999 (East Java, 689 ha; Central Java, 623 ha; Jakarta, 187 ha; West Java, 34 ha; and Yogyakarta, 14 ha) and 87% of national production (East



Java, 11,875 mt, 46.7%; Central Java, 8,347 mt, 32.6%; Jakarta, 1,220 mt, 4.8%; Yogyakarta, 403 mt, 1.6%; and West Java, 196 mt, 0.8%). Outside of Java, the provinces with the greatest harvested area were West Sumatra (142 ha), Aceh (105 ha), and Bali (99 ha)—which account for only 16% of Indonesia's melon area (Table 3.9).

3.6.4 Seasonality. No data are available to assess the seasonality of melon production. While it is likely that its production follows a seasonal pattern similar to cucumber, key informants reported that melons are more expensive in the wet season—suggesting that a larger share of the crop is produced in the dry season. However, disease risk is also higher in the wet season.

3.6.5 Varieties. All melon planted in Indonesia are hybrid varieties. Seed import statistics indicate that seed of 19 different melon varieties were imported (1.2 mt) in 2000 (GOI, Pusat Tanaman Pangan). The main seed sources were Thailand (91%) and Japan (4%) and the primary imported varieties were Action 434 (800 kg, 66%), A Plus (100 kg, 8%), National (100 kg, 8%),

Table 3.9. Area Harvested and Production of Melon, by Province, Indonesia, 1999

Province	Harvested Area (Ha)	Production (mt)				Yield (Kg/ha)
		Entirely	Partly	Total ^a	Percent	
Sumatra						
Aceh	106	67.2	0.0	87.2	0.3	640
North Sumatra	66	839.7	0.6	840.3	3.3	12,357
West Sumatra	142	745.4	0.0	745.4	2.9	5,249
Riau	20	8.5	37.7	46.2	0.2	2,310
South Sumatra	5	3.4	2.6	6.0	0.0	1,200
Lampung	7	1.3	1.3	2.6	0.0	371
Java & Madura						
Jakarta	187	1,220.0	0.0	1,220.0	4.8	6,524
West Java	34	182.3	13.8	196.1	0.8	5,768
Central Java	623	8,304.4	42.8	8,347.2	32.6	13,398
Yogyakarta	14	360.6	42.8	403.4	1.6	28,814
East Java	689	10,898.2	976.7	11,874.9	46.7	17,235
Bali & Nusa Tenggara						
Bali	99	902.1	109.1	1,011.2	4.0	10,214
West Nusa Tenggara	12	74.0	5.5	79.5	0.3	6,625
East Nusa Tenggara	13	88.0	1.0	89.0	0.3	6,846
Kalimantan						
West Kalimantan	2	4.0	0.4	4.4	0.0	2,200
Central Kalimantan	24	73.3	77.1	150.4	0.6	6,267
East Kalimantan	25	52.1	24.5	76.6	0.3	3,064
Sulawesi						
North Sulawesi	5	4.8	4.5	9.3	0.0	1,860
Central Sulawesi	15	59.5	0.6	60.1	0.2	4,007
South Sulawesi	7	141.6	4.5	146.1	0.6	20,871
Maluku & Irian Jaya						
Irian Jaya	0	0.0	0.0	0.0	0	0
	<u>54</u>	<u>65.1</u>	<u>9.7</u>	<u>74.8</u>	<u>0.3</u>	<u>1,385</u>
Total	2,150	24,095.5	1,355.2	25,450.7	100.0	11,838

^aTotal production is the sum of production of “entirely” and “partly” harvested fields.

Source: GOI, BPS, 2001 (a).

and Super Salmon (100 kg, 8%)—all of which were imported from Thailand. Given that the seed rate is 500 gm/ha and assuming that the melon area was approximately the same in 2000 as in 1999, these import statistics confirm that all melon seed is imported.

3.6.6 Pests and Diseases. There exists no research reports that document the impact of pest and diseases on melon yields. While key informants at the Directorate General for Horticulture did not consider viruses to be a major constraint, they noted that viruses may be under reported because they are difficult to recognize. However, key informants at the RIV and E-W Seed reported that virus diseases are a major constraint to higher yields and account for yield losses of about 15%.

3.6.7 Farm Size and Cropping System. Key informants reported that melon is primarily grown by small-scale farmers. However, because melon requires a substantially greater investment in purchased inputs and are more risky (due to virus diseases), it tends to be grown by small-scale farmers with greater access to cash. Key informants reported that some farmer groups produce melon as a cooperative venture—often obtaining seed and inputs from middlemen and then sell their crop to the middlemen. Also, private firms contract farmers to produce melons and supply them inputs, or private firms hire farmers as laborers on their melon farms.

Typically, farmers germinate melon seed in a plastic bag, transplant it into the field at 10-14 days after germination, and then establish a trellis for the plant to grow on. To insure the production of high quality fruit (price premium weight of 2 kg), farmers typically prune each plant so that it produces only one or two fruits. Melon is harvested 55-65 days after planting.

3.6.8 Enterprise Budgets: Inputs and Yields. Two sources of data are available to estimate the profitability of melon production. First, in 1977 BPS carried out a study to estimate the cost structure of melon production (Table 3.10). However, as was the case with similar data for cucumbers, these data “represent” average costs and return for all respondents in the sample who were located throughout the country. Second, since BPS did not note the month during which these data were collected, it is problematic to convert these Rupiah values to US\$ equivalents.

Finally, prior to 1999 BPS “melon” statistics did not distinguish between melon and watermelon. Thus, data in Table 3.10 likely reports the cost structure of a combination of melon and watermelon. However, these data do indicate that labor accounted for the largest share of production costs (41.9%), followed by other costs (37.9%), and material inputs (20.2%).

Second, in 1999 the Directorate of Horticulture developed a “representative” budget for commercial melon production (Table 3.11), as part of its efforts to promote melon exports. This budget indicates that melon production requires 655 person-days of labor, of which 18% was female labor. Labor accounted for 20.2% of total costs (US\$978/ha), while material inputs accounted for 56.6% (US\$2,739) of total costs. Farmers’ income, based on an estimated yield of 38,475 kg/ha and an average farm-gate price of US\$0.51/kg, is US\$14,925/ha.

This budget used a composite farm-gate price, which assumed that 65% of the output would be marketed as Class I (Rp5,000/kg), 25% as Class II (Rp3,500 /kg), and 1% as Class III (Rp2,000/kg) melon. However, the prices used in this budget represent prices that commercial producer would expect to receive, if they exported their produce. Thus, this price must be adjusted to “represent” the domestic price. Price data collected at Pasar Induk indicates that the average 2000 wholesale price for melon was Rp2,112. Assuming that the marketing margin from the farm-gate to the wholesale market is the same for melons as for cucumber (farm-gate cucumber price = 63% of the wholesale price), and applying this conversion factor to melon, gives a farm-gate price

Table 3.10. Cost Structure of Melon (hybrid^a) Production (per ha), Indonesia, 1997

	Unit	Total Cost (Rp/ha)	Percent
INPUTS			
<i>Labor</i>			
Plowing	NA	785,139	13.2%
Planting	NA	165,700	2.8%
Input application	NA	836,557	14.1%
Harvesting	NA	284,816	4.8%
<u>Others</u>	<u>NA</u>	<u>411,992</u>	<u>6.9%</u>
Subtotal		2,484,204	41.9%
<i>Material Inputs</i>			
	(kg)		
Seeds	0.5	187,540	3.2%
Fertilizer: Urea	141.8	59,161	1.0%
TSP	179.9	96,502	1.6%
KCL	134.8	44,989	0.8%
Others	395.2	202,362	3.4%
Manure	1,759.5	83,720	1.4%
Pesticide: Insecticide	3.7	69,050	1.2%
Fungicide	3.4	55,238	0.9%
Others	31.3	<u>399,411</u>	<u>6.7%</u>
Subtotal		1,197,973	20.2%
<i>Other Costs</i>			
Rent for farming tools	NA	7,908	0.1%
Irrigation	NA	321,191	5.4%
Tools service	NA	5,117	0.1%
Wrapping	NA	475,066	8.0%
Transportation	NA	160,247	2.7%
Rent for land	NA	414,921	7.0%
Tax	NA	64,320	1.1%
Interest	NA	111,638	1.9%
Depreciation	NA	3,449	0.1%
<u>Others</u>	<u>NA</u>	<u>683,363</u>	<u>11.5%</u>
Subtotal		2,247,220	37.9%
<i>Total Expense</i>		5,929,397	100.0%
OUTPUT			
Production	(kg)		
Harvesting by the owner	13,650	9,095,100	
Harvesting by hired labor		6,350,741	
Other		<u>18,053</u>	
Subtotal		15,463,894 ^b	
FARMERS' INCOME		9,534,497	
INCOME OVER EXPENSES		160.1%	

^a All melon varieties grown in Indonesia are hybrids. Melon price = Rp1,133/kg.

Source: GOI, BPS, 2000 (c).

Table 3.11. Costs and Returns to Melon (hybrid) Production (per ha), Java, Indonesia, 1999

	Quantity	Unit	Unit Price	Rp/ha	US\$/ha	Percent
INPUTS						
<i>Labor</i>						
Land clearing	50	MD	10,000	500,000	59.38	1.2%
Plowing	65	MD	10,000	650,000	77.20	1.6%
Bed construction	100	MD	10,000	1,000,000	118.77	2.5%
Manuring	45	MD	10,000	450,000	53.45	1.1%
Manuring	25	FD	20,000	500,000	59.38	1.2%
Seeding	75	FD	7,500	562,500	66.81	1.4%
Trellising	50	MD	10,000	500,000	59.38	1.2%
Seedling holes	5	MD	10,000	50,000	5.94	0.1%
Transplanting	50	MD	10,000	500,000	59.38	1.2%
Fertilizing	65	MD	10,000	650,000	77.20	1.6%
Spraying	60	MD	10,000	600,000	71.26	1.5%
Pruning	15	FD	75,000	1,125,000	133.62	2.8%
Harvesting						
Male labor	20	MD	10,000	200,000	23.75	0.5%
Female labor	10	FD	75,000	750,000	89.08	1.8%
Other	20	MD	10,000	200,000	23.75	0.5%
Subtotal	655	NA	NA	8,237,500	978.37	20.2%
<i>Material Inputs</i>						
Seed	500	gm	7,500	3,750,000	445.39	9.2%
Stakes	1,250	pieces	5,000	6,250,000	742.31	15.3%
Plastic for beds	200	kg	10,000	2,000,000	237.54	4.9%
Plastic seedlings bags	5	kg	15,000	75,000	8.91	0.2%
Plastic bags transplanting bags	50	kg	5,000	250,000	29.69	0.6%
Raffia bags for marketing	NA	NA	NA	500,000	59.38	1.2%
Fertilizer						
Urea	450	kg	1,200	540,000	64.14	1.3%
ZA	630	kg	1,200	756,000	89.79	1.9%
TSP/SP-36	900	kg	1,700	1,530,000	181.72	3.8%
KCI	720	kg	1,800	1,296,000	153.93	3.2%
Borate	18	kg	5,000	90,000	10.69	0.2%
Farmer fertilizer	1,800	kg	500	900,000	106.89	2.2%
Manure	27	mt	200	5,400	0.64	0.0%
Pesticide						
Carbofuridan	36	kg	15,000	540,000	64.14	1.3%
Insecticide	15	ltr	80,000	1,200,000	142.52	3.0%
Fungicide	25	kg	25,000	625,000	74.23	1.5%
Others	1	NA	NA	2,750,000	326.62	6.8%
Subtotal				23,057,400	2,738.53	56.6%
<i>Other</i>						
Land rent	4	months	500,000	2,000,000	237.54	4.9%
Shelter	1	shed	1,000,000	1,000,000	118.77	2.5%
Guard	100	days	10,000	1,000,000	118.77	2.5%
Other	NA	NA	NA	5,444,235	646.61	13.4%
Subtotal				9,444,235	1,121.69	23.2%
Total Expense				40,739,135	4,838.59	100.0%
RETURNS (Gross Revenue)						
Production	38,47	kg	4,325 ^a	166,404,375	19,763.84	
FARMERS' INCOME				125,665,240	14,925.26	
INCOME OVER EXPENSES				308.46%		

^aWeighted average price, equivalent to (US\$ 0.51/kg). The Directorate of Horticulture assumes that 65% of farmers' output will be sold as Class I (Rp5,000/kg), 25% as Class II (Rp3,500/kg), and 10% as Class III (Rp2,000/kg) produce. Market class is a function of fruit weight and quality. MD indicates male labor days. WD indicates female labor days.

Source: GOI, Direktorat Jenderal Bina Produksi Hortikultura, 2001

of Rp1,331/kg (US\$0.16¹⁰). Using this Pasar Induk price to “revalue” melon production’s gross returns in the Directorate of Horticulture budget (Table 3.11), gross returns (Rp51,210,225/ha, US\$6,082), less total expenses (Rp40,739,135/ha; US\$4,839), generates a farmers’ income of Rp10,471,090/ha (US\$1,244). While still high, this revised estimate of farmers’ income is far more realistic than the estimate reported in the original budget.

Clearly, these data indicate that melon production is quite profitable and generates a significant amount of employment—most of which is hired labor. While melon production is quite profitable, key informants noted that the level of total expenses (US\$4,839/ha, Department of Horticulture budget) required to produce melon is extremely high—over twice E-W Seed’s estimate of the costs/ha for commercial cucumber production (US\$2,386) and almost four times the level reported by the surveyed cucumber farmers (US\$1,293). Furthermore, key informants reported that melon production is extremely risky, due to pest and disease constraints. Thus, the high level of input costs and production risks represent barriers to entry to most small-scale Indonesian farmers.

3.6.9 Consumer Preferences. Consumers prefer a melon that has finely-ribbed skin and weighs 2 kg (preferred market class). In contrast to cucumber, melon is primarily consumed by wealthier Indonesians—due to its higher price/kg.

3.6.10 Marketing Channels. Melon marketing channels are similar to cucumber marketing channels. However, given the high price of melon, middlemen transport almost all of the crop to large cities. In Java, most of the crop is sold in Jakarta—either to the wholesale market or supermarkets. While little or none of Indonesia’s melon crop is exported, the Directorate of Horticulture sees the potential to export to Asian markets, including Singapore, Malaysia, and Hong Kong.

3.6.11 Farm-Gate Prices. The only source of the farm-gate price is the Directorate of Horticulture’s budget (Table 3.11), which reports a price of US\$0.51/kg. However, as noted above, this does not appear to be a realistic domestic farm-gate price. Rather, the Pasar Induk wholesale price, adjusted for the marketing margin (Rp1,331/kg; US\$0.16), represents a more realistic domestic farm-gate price.

3.6.12 Wholesale Prices. As was the case for cucumber, wholesale melon prices vary greatly during the year (Figure 3). During the period January 2000 through March 2001, wholesale prices ranged from a low of Rp 1,700/kg to a high of Rp 2,714/kg. During 2000, the mean wholesale price averages Rp 2,112/kg.

4. The South African Cucurbit Sector

4.1 An Overview of South Africa and Its Agricultural Sector

Physical Features. South Africa has a total area of 1,223,200 km²--about 80% the size of Alaska. In terms of topography, South Africa consists of lowlands primarily near the coasts and highlands traversing its central regions. Annual rainfall averages 28" per year in Johannesburg.

Population. South Africa’s population is 40.5 million, of which about 80% are black, 10% are

¹⁰ Rupiahs are converted to US\$ at an exchange rate of US\$1 =Rp8,420.

Indian/Asian/Colored, and 10% are white (GOSA, NDA, 2001). About 51% of the population live in urban areas. The rate of population growth averaged 2.2% during 1990-95 (World Bank, 1997).

Agriculture. South Africa's agricultural sector is fairly balanced between production of field crops (30% total agricultural value), horticulture (26%), and livestock products (43%). The dominant field crops are maize, wheat and hay; the dominant estate crop is sugar cane; the dominant horticultural crops are citrus, deciduous fruit, and potatoes; and the dominant livestock products are poultry, beef, and dairy.

Socioeconomics and Agriculture. While 82% of total land area is used for agriculture, only 14% of the land is potentially arable. Resource inequality in South African agriculture is incredibly stark and clearly runs along racial lines. Of the potential arable land, 85% is owned by large-scale (white) commercial farmers, with an average farm size of 1,300 hectares. By contrast, 50% of black¹¹ farmers have less than 1 ha of land, 22% have 1-2 ha, and only 1% have more than 10 ha (GOSA, NDA, 2000). According to the 1996 Census (GOSA, Statistics South Africa, 1999), 41% of blacks in agriculture have received no schooling, and only 1% have completed high school (*Ibid*, 2000). By contrast, only 1% of whites in agriculture have received no schooling, and 77% have completed high school (*Ibid*, 2000). These physical and human capital resource inequalities underlie the challenges of facilitating black farmer participation in most high-value fruit and vegetable markets in South Africa.

4.2 The South African Fruit and Vegetable Subsectors

Fruit and Vegetable Production. South African fruit production (2000) is valued at about US\$1 billion (Table 4.1). Grapes, oranges, and apples together account for roughly 70% of the aggregate value of the fruit industry. The aggregate value of musk melon and sweet melon is approximately US\$21 million. South African vegetable production is valued at approximately US\$603 million (Table 4.2)¹². Potatoes, green mealies and sweet corn, and tomatoes together account for 78% of the aggregate value of the vegetable industry. The aggregate value of marrows (zucchini), cucumber, and butternut squash is approximately US\$64 million.

4.3 Fruit and Vegetable Marketing

Marketing Channels. South African fruit and vegetable producers have three principal marketing options for their produce: large wholesale markets in urban areas; smaller local wholesale markets; or contracts with supermarkets or processors. In general, the majority of vegetables moves through wholesale markets to supermarkets whereas the majority of fruit moves directly from farms to processors or exporters. However, the volume of produce in each marketing channel varies substantially for specific vegetables or fruits (Table 4.1 and 4.2). For example, most grape production is pressed for juice or exported fresh as table grapes, while other fruits such as bananas, mangoes, and melons are most often sold fresh in domestic markets. Most vegetables are consumed fresh with minimal processing.

Consumer demand for improved fruit and vegetable quality, consistency, and reliability has resulted in changes in the structure of the fruit and vegetable subsectors in South Africa over the

¹¹ Several terms are used to refer to black farmers in South Africa, including: "emerging," "resource poor," and "historically disadvantaged." In this paper, we use the term "black" for brevity.

¹² Vegetables and fruits included in Tables 4.1 and 4.2 are not an exhaustive list of all commodities. Rather, they represent those for which aggregate volume/value data were available.

Table 4.1. Fruit Production and Value, South Africa, 1990/00

Fruit	Total Prod. (‘000 mt)	Total Value of production (US\$ mil)	Share of Total Value of Industry (%)	Total Production via W. Markets (%)	Average W. Market Price (US\$/mt)
Grapes	1,530	\$438	40.9%	1%	\$441
Orange	1,049	\$196	18.3%	13%	\$120
Apple	583	\$114	10.6%	27%	\$286
Pears	301	\$63	5.9%	20%	\$211
Peaches	223	\$47	4.4%	12%	\$420
Banana	270	\$42	3.9%	84%	\$252
Naartjes	137	\$42	3.9%	14%	\$210
Lemons	112	\$27	2.5%	8%	\$185
Avocado	69	\$26	2.4%	28%	\$408
Grapefruit	147	\$23	2.2%	3%	\$130
Pineapples	160	\$17	1.6%	16%	\$297
Muskmelon	61	\$14	1.3%	21%	\$233
Mangoes	32	\$9	0.8%	63%	\$395
Watermelon	73	\$8	0.7%	66%	\$107
Sweet Melon	19	\$7	0.6%	20%	\$360
Total Value		\$1,073			

Source: NDA Abstract

Table 4.2. Vegetable Production and Value, South Africa, 1990/00

Vegetable	Total Prod. (‘000 mt)	Total Value of production (US\$ mil)	Share of Total Value of Industry (%)	Total Production via W. Markets (%)	Average W. Market Price (US\$/mt)
Potatoes	1,622	\$238	39.5%	58%	\$147
G. Mealies/S. Corn	299	\$102	16.9%	1%	\$36
Tomatoes	405	\$100	16.6%	65%	\$247
Marrow (Zucchini)	75	\$42	7.0%	5%	\$563
Onions	329	\$37	6.2%	81%	\$113
Pumpkins	202	\$17	2.8%	28%	\$83
Carrots	97	\$13	2.2%	68%	\$137
Butternut squash	98	\$12	2.1%	50%	\$127
Cucumbers	20	\$10	1.7%	50%	\$522
Cabbage	190	\$10	1.7%	87%	\$53
Hubbard squash	103	\$8	1.4%	50%	\$81
Gem squash	53	\$7	1.1%	50%	\$130
Sweet potatoes	51	\$5	0.8%	57%	\$100
Total Value		\$603			

Source: NDA Abstract

past decade. Supermarkets, which currently sell between 50-60% of fresh fruit and vegetables in South Africa, are sourcing less of their produce from large fresh produce markets and more product directly from farmers. This change has implications for the resource requirements necessary for farmers to participate in such contracts.

Large Wholesale Fresh Produce Markets. For cucurbits, the most common marketing option is for the farmer (or group of farmers or perhaps a hired intermediary) to transport his/her produce to one of the country's 16 large fresh wholesale markets, which are located in or near large urban

areas. These include the Johannesburg Fresh Produce Market or the markets in Cape Town, Pretoria, and Durban. From these large central markets, the produce is channeled to smaller supermarkets, green grocers, and hawkers (informal sector). The Johannesburg market handles approximately 50-60% of the fruit and vegetables channeled through the 16 fresh markets. While farmers' produce is physically present at the market, the wholesale market agents do not actually purchase produce from farmers. Instead, the agent negotiates its sale to formal and informal retailers or processors, charging the farmer a commission of 12.5% of the actual sale value (7.5% goes to the sales agency, 5% to the market authority).

These markets appear to be highly competitive for several reasons. First, because the market agent receives approximately 40% of his/her agency's commission fee for a given sale, they have a clear financial incentive to negotiate a high price on behalf of the farmer. Second, given that five or more agencies operate at each market, and given the high volatility of vegetable and fruit prices, it is unlikely that price collusion by agents against retailers would be manageable. Third, market authorities release information on daily market price and volume every day, diminishing information asymmetry between agents and retailers with respect to market conditions. And finally, because of the high information cost of monitoring the quality of produce, as well as the high number of transactions over time between agents and retailers, retailers rely heavily upon trust in their transactions with agents. Thus, it is not in the long-term interest of an agent to try to negotiate an unfair price from a retail client who most certainly would be expected to return for future business.

While the large fresh markets do not have formal grades or standards with respect to quality, agents and retailers nevertheless use informal standards to price product of differential quality. Because most produce is sold by the box, visual inspection is not as costly as in smaller markets. Some larger farmers are able to "brand" the produce they sell through the large markets by labeling their boxes with the name of the farm. Thus, some farmers are able to capture consistently higher prices based upon a recognition by retailers of the consistent quality of the farmer's produce.

Supermarkets. While the large wholesale markets still play a major role in the marketing of many vegetables (and some fruits), recent changes in consumer demand have led South African supermarkets to contract an increasing share of produce directly from farmers. Bennett's Law states that as the income of consumers increases, their demand increases for fresh fruits and vegetables, dairy products, and meat. However, not only do higher-income consumers demand more fresh produce, but in addition they demand more specific characteristics of those goods. As has occurred in the subsectors of many commodities in developed economies, the high transaction costs associated with marketing temporal products¹³ (and, in general, more highly specialized commodities) is leading to increased use of contracting between producers and retailers in South Africa as a way to minimize these transaction costs. Some farmers are still marketing their produce through the large fresh markets, mitigating transaction costs through the use of farmer branding or trust with agents and retailers. Nevertheless, retailers are simply not able to rely upon these markets for high-quality produce on a consistent basis. Thus, as affluent (predominantly white) South

¹³ Transaction costs common to temporal products include high information cost to inspect quality (it is difficult or costly to inspect a melon for ripeness without cutting it open), the potential for "hold-up" by the buyer (a supermarket or processor knows that the farmer must sell his/her produce within days or lose the entire value of the product, thus the buyer can negotiate the price downwards upon harvest), and the desire of processors to reduce the uncertainty of throughput for their operations (a large processing plant requires consistent volume of inputs in order to maintain profitable operation) (Williamson, 1985).

African consumers' incomes have risen over the past decade, supermarkets have responded by contracting directly with select farmers, who produce fruit and vegetables under specific guidelines intended to satisfy consumers' demand for increased quality and consistency.

While the terms of contracts between supermarkets and farmers differ, in general, the supermarket sets grades and standards for the produce (variety, general management, and quality specifications¹⁴) as well as a minimum volume expected. At harvest, contract farmers wrap and package their produce and deliver it to nearby distribution centers of the retailer. Even the timing of harvesting is negotiated between the retailer and the farmer.

Woolworth's (WW), a large retailer of high-end clothes, household goods, and food, is the leader in the high-end cucurbit retail market. WW acquires 100% of their fresh produce from contracts in order to have a complete system of traceability. The firm contracts 20 farmers to grow cucurbits. These irrigated farms range from 10-150 has, and are typically diversified in several vegetables. The farmer's price is based on a formula which includes a weighted average fresh market price over the past six months. Relative to fresh market prices, contract farmers typically receive 10-20% premiums and more stable prices. WW has a complete cold storage and transport chain from distribution centers to the supermarket.

Small Wholesale Markets. A third marketing option for farmers are smaller wholesale markets, located in or near smaller urban areas or rural towns. These markets are typically used by farmers who either do not have the means to transport their produce to a larger market, or by farmers whose produce does not meet the lowest of the informal grades at such markets. Black, resource-poor farmers with surplus production are the predominant suppliers to these markets.

4.4 Socioeconomics of Fruit and Vegetable Production

As with most social and economic activity in South Africa, the production and consumption of vegetables is highly segregated by race. This is due both to differences by race in consumer preferences, as well as to enormous disparities between the resource levels of white and black South African consumers and producers. Whites traditionally produce and consume vegetables such as potatoes, tomatoes, onions, carrots, lettuce, and cucumbers, while Blacks traditionally produce and consume pumpkins¹⁵, cabbage, spinach and some types of squash. White farmers market their produce through large urban wholesale markets or directly to retailers (supermarkets, green grocers, *etc.*). While some black farmers market their produce through the large urban wholesale markets, most sell to smaller local markets or informal hawkers.

Vegetables and fruits consumed principally by whites (or exported to Europe and Southern Africa) are typically highly-perishable, fresh products. While this implies higher retail and thus farm-level production value, production of such products typically involves high input costs (fertilizer, insecticide, fungicide, and irrigation), investment in irrigation, packaging and transport equipment, and tight market coordination prior to harvest. These higher production and marketing costs thus require good access to credit and human capital, and also imply a significant financial risk, given both the higher input costs as well as the temporal nature of the product.

Black farmers face various constraints to producing and marketing non-traditional fruits and vegetables. First, black farmers typically have poor access to the credit and land resources

¹⁴ Woolworth's quality specifications are that produce is not genetically modified, has no virus symptoms, and is the specified size, weight, freshness, sugar content, *etc.*, depending on the commodity.

¹⁵ In the South African context, "pumpkin" refers to *Cucurbita maxma*. In contrast, the "Halloween pumpkin" grown in North Americas is *Cucurbita pepo*.

necessary to meet the high fixed and variable input costs required in production of crops such as zucchini, cucumber, or melon. Second, these crops must be packaged and transported to markets immediately at harvest, which requires high variable costs of packaging and petrol, and a high fixed cost in transport. Third, as black farmers are not familiar with the production of fruits and vegetables consumed by whites, production of these commodities presents marketing challenges similar to those faced by many developing country farmers interested in producing non-traditional crops for export. Given these challenges, it is not surprising that the majority of black farmers are not engaged in the production and marketing of these higher-value fruits and vegetables.

An exception to this could be pumpkin and butternut squash. Black consumers have eaten various pumpkin types for years, and recently have begun to consume butternut. As these crops are generally more resistant to diseases and drought and are more storable, black farmers do not face the same demand for inputs (sprays) or immediacy of marketing more temporal products.

Black farmers are unlikely to be able to contract with supermarkets since they do not have the scale to meet volume requirements. Also, distribution centers which serve as collection points for supermarkets are located near white farmers (*i.e.*, far from where blacks farm).

4.5 Vegetable Seed Subsector

The South African vegetable seed subsector is dominated by the private sector which consists of five firms (Table 4.3). Three of these firms account for approximately 88% of the formal vegetable seed market¹⁶. Historically, seed firms have almost exclusively targeted white commercial farmers. Each of the five firms has extensive international linkages, although they each differ in their target crops, their seed sourcing, and their marketing approach.

Major Firms. **Hygrotech**, the largest South African vegetable seed firm, with approximately a 38% market share, is a regional distributor for Seminis. Hygrotech markets imported seed, but does not have a breeding program. Its evaluation program employs 10 staff (5 Ph.D. and 5 M.Sc. degree

Table 4.3. Major Vegetable Seed Firms in South Africa, 2001

Name of Firm	Main Office Location	International Linkages	Target Vegetables ^a	Primary Activities ^b	Annual Sales ^c (US\$)	Market Share (%)
Hygrotech	Pretoria	Seminis	pepper, sweet corn, bean, watermelon, tomato	MIS and inputs	7 million	38
Starke Ayres	Cape Town	Pannar	carrot, broccoli, muskmelon	MIS, some breeding	4.6 million	25
Mayford	Johannesburg	Sakata	bresica, tomato, bean	MIS, little breeding	4.6 million	25
Alpha Seed	Heneley-on-Klip		red beet, bean, tomato, melon, squash, pepper	Breeding	110,000	6
Selector	NA	Asgrow	NA	NA	110,000	6

^aVegetables in which the firm specializes. ^bMarket imported seed (MIS) or breed own seed. ^cAuthors' estimates. NA indicates data not available.

¹⁶ The total sales and market share figures in Table 4.3 are approximate and based on the estimates given by two firms. Although SANSOR, the national vegetable seed association, collects this information from vegetable seed firms, the team was not able to gain access to these data during its visit. However, the team did obtain SANSOR data on cucurbit seed sales (by commodity in aggregate, but not by firm).

holders), who source imported (or locally bred) seed and evaluate it at sites across the country. Hygrotech's marketing approach is a direct presence on the farm. The firm employs 38 sales/extension agents who are trained by the company and work out of 18 branch offices across the country. Hygrotech sells some seed through distributors and also sells some foliar fertilizer through its field sales staff.

Mayford, the oldest vegetable seed company in South Africa, has approximately a 25% market share. Mayford was recently purchased by Sakata and has branch offices across Southern Africa, as well as in Kenya. Mayford primarily markets imported seed, although they do some breeding in squash. While they used to have a cucurbit breeding program, it was terminated a few years ago when Sakata bought the firm. Mayford markets seed indirectly through nine franchises, who also sell non-seed inputs. Mayford bases its seed supply upon annual orders from its franchises (70%), as well as from spot orders (30%). The firm promotes its seed via brochures it distributes to its franchises, at farmer days, and through its strong brand name in Southern Africa.

Starke Ayres, another of the larger vegetable seed firms in South Africa, is the only large firm with a cucurbit breeding program.

Alpha Seed, established in 1995, is owned and managed by Bill Kerr. One of the few private sector cucurbit breeders, he primarily develops varieties using local and international lines and sells them to other firms for marketing and distribution. However, he also multiplies and sells some seed to select clients. Alpha Seed has collaborated in field trials of Cornell/ABSP materials.

4.6 Government Policies Affecting the Vegetable Seed Subsector

Agricultural Research. In South Africa, public agricultural research is coordinated, funded, and implemented by the Agricultural Research Council (ARC). In late-1998, the government (GSA) terminated its ARC-Roodeplat (VOPI) cucurbit breeding program, given the relatively small value of cucumbers, relative to vegetables such as potatoes. However, the ARC still maintains gene banks and works in some vegetables, with an increased focus on emerging farmers' crops.

Varietal Release/Seed Certification. Inspectors issue certification according to seed certification standards. Firms wishing to import seed must apply for a permit from the government and follow the GSA's phytosanitary regulations. Although a permit must be obtained for each shipment of seed, this is typically not a difficult process.

Genetically Modified Varieties (GMOs) and Biosafety. South Africa has established national-level biosafety guidelines, and farmers are currently using various genetically-modified field crops. GMO testing and biosafety is currently not an issue with cucurbits, as none of the seed firms plan to release GM varieties due to the perceived health concerns of higher-income consumers domestically and abroad. The Cornell materials, which are the focus of this assessment, are traditionally bred.

Intellectual Property Rights (IPR) Legislation. Plant Variety Protection (PVP) is concurrent with varietal listing—thus seed firms have IPR protection for their registered varieties. While PVP protects firms with respect to the other seed companies in South Africa, enforcing PVP with respect to individual farmers or illicit firms who might illegally multiply and sell OP seed is complicated by the enormous transaction costs of monitoring farmers' use of harvested OP seed, as well as the costs of litigation. In addition "farmers' rights" legislation gives a farmer the right to multiply seed for his/her own use. This legislation was intended to defuse the concerns of some consumer and producer groups over technology fees paid by U.S. farmers for certain GM crops.

Given the realistic challenges of enforcing PVP widely and the highly competitive nature of the South African vegetable seed market, this environment creates an incentive for seed companies to increasingly develop hybrids to protect their varieties. A direct implication is that seed

firms—which are now beginning to target seed to emerging farmers—may be hesitant to market lower-cost OP seed, and will instead prefer to market the higher-cost hybrids.

ABSP Collaboration with the Agricultural Research Council of South Africa. ABSP has been working in South Africa since 2000, in collaboration with the Vegetable and Ornamental Plants Institute (VOPI) of the Agricultural Research Council (ARC). The major research focus has been on developing insect-resistant potato germplasm through biotechnology. ABSP is also assisting the ARC's Business Development unit to strengthen intellectual property and technology management capacity in South Africa.

4.7 Viruses and Diseases in Cucurbits

Viruses. There are five principal viruses that attack cucurbits in South Africa: zucchini yellow mosaic virus (ZYMV), watermelon mosaic virus (WMV), cucumber mosaic virus (CMV), papaya ring spot virus (PRSV) and a more recent virus, watermelon mosaic virus-Moroccan strain (WMV-M). The yield loss due to virus for the cucurbits in this study is quite variable, and depends upon both the type of cucurbit, as well as the timing of the attack. For example, for zucchini (marrow), ZYMV is the most severe virus, and will manifest itself with fruit symptoms that make any fruit produced unmarketable. Other viruses weaken the zucchini plant and reduce yields, yet leave any emerging fruit still marketable. By contrast, butternut squash does not readily manifest virus symptoms on its fruit, and fungi are more of a problem.

Farmers apply insecticide to both control insect vectors to reduce the chance of virus spread and prevent insect damage to the plants and/or fruit. However, once a given plant is infected with a virus, there is nothing that the farmer can do except apply additional insecticide on his/her fields in the hope that aphids carrying the virus do not attack the entire field (or other crops in other fields).

Fungi. The principal fungi that threaten cucurbits in South Africa include: downy mildew (DM), powdery mildew (PM), Fusarium (melon) wilt, anthracnose, and gummy stem blight (GSB). In general, fungi decrease yield by sapping plant nutrients, although a severe fungal infection may kill the plant. Some fungi can also spot large fruit or shrivel young fruit. DM thrives primarily in humid weather, and can be spread by the wind. PM thrives in both humid and dry weather, with the spores spread by the wind to healthy plants. Under conditions favorable to PM, infection can spread through closely spaced planting in a matter of days or weeks. Anthracnose is most prevalent in humid, warm weather with frequent rain, and is spread by splashing water, cucumber beetles, and tools. GSB is both seed- and soil-borne. Wounding, cucumber beetles, aphid feeding, and PM infection all predispose plants to infection by GSB.

Farmers typically apply preventative fungicides and then additional fungicides, if and when fungi emerge on their crop. While fungicides can control fungi to some extent, they are expensive and often carcinogenic. Thus, cucurbits with fungal tolerance/resistance would enable farmers to reduce the labor and chemical costs of fungicide application, and would help both farm laborers and consumers avoid the adverse health effects of fungicide application.

Incidence of Viruses and Fungi. Only three studies of virus incidence have been conducted on South African cucurbits. von Wechmar, Jaffer, and Purves (1994) first identified the incidence of ZYMV in South Africa. van der Meer (1995) identified WMV-M (Moroccan) as the predominant strain of WMV in South Africa, with WMV-2 only in the Western Cape; and also found some wild cucurbit species with resistance to WMV-M. Cradock (1998) identified virus incidences in Kwazulu Natal in 1997 [ZYMV (64%), WMV-M (26%), WMV-2 (10%), CMV (10%), and mixed (32%)] and in 1998 [ZYMV (24%), WMV-M (20%), WMV-2 (48%), CMV (0%), and mixed (32%)]. Cradock's surveys demonstrates the variability of virus incidence over time and that one-third of the cases involve incidence of more than one virus at a time. Although few in number and

scope, these studies give credence to key informants' claims that all five viruses are present at varying levels across South Africa.

Economic Effects of Virus and Fungi. While there have been a few studies of virus incidence, there are no known empirical studies of cucurbit yield loss to virus and fungi in South Africa. However, even an empirical study of yield effects can only give a general indication of the potential losses to a farmer due to viruses and fungi. This is because three main factors determine the economic effect of viruses and fungi to a given farmer: 1) the frequency of virus and fungal incidence in the farmer's area; 2) the timing of an incidence; and 3) the type of virus or fungi.

The type of virus or fungi (or combination of several) determines whether and how much the plant is affected (yield loss), as well as whether or not the market value of the fruit produced is affected. While some key informants claimed that many viruses are endemic to South Africa, only anecdotal evidence is available. To add to this uncertainty, yield loss associated with virus or fungal incidence can be quite variable, depending upon when the virus attacks the crop. For example, given a continuously harvested crop such as cucumber or zucchini, a virus contracted late in the three week harvest period may have only a modest effect on total yield (total production divided by the area), while a virus contracted before harvest could result in losses approaching 100%. Thus, yield loss for a given farmer depends upon the type of virus or fungi, as well as the physiological stage of the crop when the virus or fungal pressure occurs, and the market value of any fruit produced depends upon the type of viral or fungal pressure.

Acknowledging the difficulty inherent in estimating yield loss to virus, this analysis uses anecdotal evidence from farmers and seed companies to arrive at single yield loss estimate which represents the expected average yield loss. This estimate combines the anecdotal probability of virus pressure with the expected loss in the event of infection—which itself is a function of the physiological stage at which the plant is infected.

4.8 Zucchini Subsector

Market Class. Summer squash types grown in South Africa are traditional green or dark zucchini, yellow summer squash and Patty Pan (scalloped squash). These squash are generally referred to as marrow, a loose term meaning any squash which is eaten immature. Additional types of summer squashes that do not fall under the term marrow include gem squash.

Area and Production System. There are approximately 5,000 ha of marrow in South Africa, roughly 3,750 ha of which is zucchini and 1,250 ha is Patty Pan. Seventy percent of marrows are produced in the high veld during the summer, close to urban areas. Zucchini is produced as a monocrop, with typical virus-free yields of 20-25 mt/ha. Zucchini is produced exclusively by large-scale (white) commercial farmers, and its production generates 350 person-days/ha of labor, predominantly provided by black women. Zucchini are harvested daily over a three-week period; and harvested zucchini are packaged in 10 kg cartons and transported immediately to a buyer.

Production Constraints. Key informants say that viruses are the most important constraint to zucchini production in South Africa. Due to quick perishability, zucchini are planted close to markets (urban areas), areas which unfortunately have a higher aphid drift. Combining the aphid problem with constant handling of the plants during the three-week harvest period, zucchini are especially susceptible to virus attack. Virus-infested zucchini fruit will only sell when prices are quite high, and then only at a very low price.

The most threatening viruses for zucchini include: zucchini yellow mosaic virus (ZYMV), WMV-M, and WMV. Cucumber mosaic virus (CMV) is also problematic for zucchini production. Principal fungi include DM, PM, and Fusarium wilt. Viruses and fungi can reduce zucchini yield

by an average of 30-35 %¹⁷. Of the cucurbits, zucchini suffer the highest virus-induced yield losses on average. Current zucchini varieties in South Africa are primarily hybrids, with only some virus and fungal tolerance.

Marketing. While most of the country's zucchini crop is contracted directly or indirectly to supermarkets, about 25% is exported to Southern Africa/Europe, and 5% is sold through the large fresh markets. Zucchini are most often consumed domestically by whites (high-income consumers) in fresh form.

4.9 Melon Subsector

Area and Production System. There are approximately 4,500 ha of honeydew melon and cantaloupe in South Africa (combined), 90% of which is produced in remote areas of the North, the Western Cape, and the Northern Cape in summer. These dry areas are preferred due to lower disease incidence. Melon, which is grown exclusively by large-scale (white) commercial farmers who grow 30-300 ha of the crop as a monocrop, typically produces virus-free yields of 20-25 mt/ha. Melon production generates 124 person-days/ha of labor, which is predominantly provided by black women. Harvested melons are packaged in 10 kg cartons and transported to a buyer. Because melons are often produced in remote areas, transport costs are high.

Production Constraints. According to key informants, the most threatening diseases for melon are fungi—Fusarium wilt, DM, PM, and anthracnose—although gummy stem blight (GSB) is an emerging problem. Viruses include ZYMV, WMV-M, and WM-2. Yield losses to fungi average 20-30%, while losses to viruses are 10%. Thirty to fifty percent of spraying for melon is typically preventative, with the rest based upon pest counts. Current melon varieties in South Africa are nearly 100% hybrids, which only have some fungal tolerance. Melon performs better as hybrids, as hybrids produce more vigorous plants that set larger fruit.

Marketing. Eighty percent of the melon crop is contracted directly or indirectly to supermarkets and 20% is sold through the large fresh markets. Melon is most often sold and consumed fresh by whites (high-income consumers). Currently South Africa only exports small amounts of melon to the EU (about 5% of total production), but this export volume is below that of previous years due to increases in airfreight costs since the recent devaluation of the Rand. South Africa competes in the EU market with Spain, Argentina, and Brazil. Because melon is produced in remote areas, disease resistance could enable producers to reduce their transport costs by growing closer to urban areas.

Market Class and Consumer Preference. Netted, orange fleshed varieties (cantaloupe) are more popular in general than the green-fleshed honeydew melon. Melon can be round-to-oval and sutures are not important. In the very dry areas, some Western Shipper types are grown, but Eastern melon (cantaloupe; *Spanspek* in Afrikaans) is more widely grown due to better disease resistance.

4.10 Butternut Squash Subsector

Area and Production System. There are approximately 18,000 ha of butternut in South Africa, which is produced throughout the country. Butternut is produced by white farmers as a monocrop, with typical virus-free yields of 20-30 mt/ha. Black farmers who produce butternut typically intercrop it with pumpkin, the leaves of which cover the butternut fruit and thereby hide it from

¹⁷ Woolworth's estimates that 10% of their expected volume from contracted marrow producers is lost due to viruses. Pic'N'Pay estimates that losses to their growers are 40-50%. Seed companies and key informant farmers estimated average losses at 30-40%.

birds. Butternut production generates 146 person-days/ha of labor, predominantly provided by black women. Harvested butternuts bound for markets are packaged in 10 kg bags and transported to a buyer either at harvest or within several weeks thereafter. Butternuts can be stored up to several months, thus immediate marketing is not necessary.

Production Constraints. The principal diseases for butternut are the fungi PM, DM, and, more recently, GSB. Viruses include ZYMV, WMV-M, WMV, and PRS, although butternuts are more resistant to virus than other cucurbits, and its fruit do not show virus symptoms as readily. Yield losses to fungi and viruses average 10-15%. Sixty to seventy percent of butternut varieties are open-pollinated and have some virus tolerance. However, since most black farmers do not presently purchase seed from the formal seed sector, reaching these farmers will require government action or new initiatives by the private sector.

Marketing. Forty percent of the butternut crop is contracted directly or indirectly to supermarkets, while 60% is sold through the large fresh markets, smaller markets, or consumed locally. Butternut is consumed both by whites and blacks.

4.11 Cucumber Subsector

Market Classes. There are three principal market classes of cucumber in South Africa. The dominant market class in South Africa is the English or Dutch cucumber, which is long, glossy, light to medium green, thin-skinned, and gynoecious⁶. This type is grown under protection in plastic tunnels on trellis at very high cost. Another fresh market class is the American slicer, which is fatter, shorter, and more uniform than the English class, with dark green, thick skin⁷ and white spines. The American slicer market is small and diminishing rapidly. The third principal market class type is pickling cucumbers.

Area and Production. There are approximately 475 ha of English cucumber in South Africa, most of which is grown close to large urban areas. Typical producers are white commercial farmers with 0.5-4 ha of mono-cropped tunnels, which are heated for year-round production. Normal virus-free yields are 40-60 mt/ha. English cucumber production generates 124 person-days/ha of labor, predominantly provided by black women. Harvested cucumbers are packaged in 10 kg cartons and transported to a buyer immediately after harvest.

Production Constraints. The most threatening cucumber diseases are the fungi—DM, PM, and

⁶ Gynoecious is a genetically-controlled flowering habit in which the plant produces only female flowers. In cucumber, this trait is important because it contributes to early and more concentrated fruit set in plants, thus reducing the number of harvests or facilitating mechanical harvest. The growth habit of gynoecious lines tend to be smaller, enabling them to be planted at high plant populations which result in higher fruit yields. Since pollination is required for fruit set, unless the variety is genetically parthenocarpic, a gynoecious variety is typically planted in combination with a monoecious pollinator line. A monoecious plant produces both male and female flowers on the same plant. When purchasing seed of a gynoecious hybrid cucumber, approximately 10 to 15% of seed of a pollinator line will be mixed in. Selection of an ideal monoecious variety as a pollinator is critical since the time of flowering must be synchronized with that of the gynoecious line and the fruit that it produces should have similar quality characteristics as the gynoecious line. For production of hybrid seed, a gynoecious line can serve as the female parent while a monoecious line (which produces male and female flowers) would serve as the male parent in the cross. Fruit is only harvested from the gynoecious line.

⁷ The American slicer's thick non-edible skin was selected years ago at Cornell in order to enable this cucumber to survive U.S. mechanical harvesting and extensive shipping with minimal damage to the fruit.

anthracnose—which result in annual yield losses of 20%. PM is a problem for cucumber year-round, while DM is more seasonal. Typically, viruses are not a problem because the tunnels keep out most insects which transmit viruses. As cucumber varieties currently available in South Africa only have tolerance to DM, fungi are typically controlled by fungicides. Thus, the principal benefit of fungal-resistance would be to reduced the cost of fungicide, since 50-70% of spray applications on cucumber is carried out as a preventative measure.

Marketing. Sixty percent of the cucumber crop is contracted directly or indirectly to supermarkets, and 40% is sold through the large fresh markets. English (Dutch) cucumber is most often consumed fresh by whites (high-income consumers).

5. Cornell Cucurbit Lines

5.1 ABSP and Cornell University

Collaboration with AGERI. ABSP's collaboration with Cornell University began in 1993 under a collaborative project with the Agricultural Genetic Engineering Research Institute (AGERI), Egypt, funded by USAID/Cairo. Cornell University has had a long history of working with Egypt, beginning when Dr. Henry Munger (Cornell cucurbits breeder) started a collaborative melon breeding program with Egypt in the 1970s. When the ABSP/Egypt project started in 1993, Dr. Munger was included as a collaborator to continue and build upon past linkages in collaborative melon breeding. Dr. Margaret Kyle Jahn took over the project when Dr. Munger retired in 1995.

The focus of ABSP's cucurbits project in Egypt has been to develop multiple virus-resistant cucurbit crops through the combination of conventional breeding and biotechnology. Melons and other high-value vegetable crops are exported from Egypt to European countries during the off season. Dr. Jahn at Cornell University focuses on conventional breeding and Dr. Rebecca Grumet at MSU focuses on biotechnology aspects of cucurbits research. The overall goal of the Egypt cucurbits project was to combine virus-resistant germplasm developed through conventional plant breeding at Cornell University, with biotechnology efforts at Michigan State University. However, the Cornell cucurbit lines that have been transferred to Indonesia and South Africa have been traditionally bred.

Extension of Collaboration Beyond Egypt to Other Developing Countries. Up until 1996, all the funding for the cucurbits research came from USAID/Cairo, and all of the work focused on Egypt. Considering that viruses are a serious problem all over the world, when the second phase of the ABSP core project started in 1997, Cornell University was given additional funds to enable them to expand their work beyond Egypt. Both before and since entering into collaboration with ABSP, Cornell has distributed multiple disease-resistant germplasm to both small local and large multinational companies all over the world including Egypt, Pakistan, Philippines, Indonesia, South Africa, Jordan, Brazil, India and Turkey.

As part of this effort to extend Cornell's cucurbit material to additional developing countries, in 2001, ABSP organized international trials of some Cornell materials. Two of the trial countries were South Africa and Indonesia, where Cornell already had contacts with seed companies who were willing to collaborate in the trials.

5.2 Indonesian Field Trials of Cornell's Experimental Lines⁸

In late-2000, Cornell sent several of its cucumber and melon breeding progenies to E-W Seed (Indonesia) for evaluation. The cucumber material consisted of five Beit alpha type cucumber progenies with multiple diseases resistance (Table 5.1). These progenies have resistance to four viruses—cucumber mosaic virus (CMV), papaya ringspot virus (PRSV), watermelon mosaic virus (WMV), and zucchini yellow mosaic virus (ZYMV)—and several leafspot diseases. Beit alpha, a Middle Eastern type, has smooth, glossy skin and very few spines. These progenies represent the culmination of 50 years of traditional cucumber breeding at Cornell.

In melon, 12 multiple disease-resistant melon progenies were sent in cantaloupe and honeydew types. These have been bred for powdery mildew resistance and resistance to the four viruses listed above. Unlike cucumber, virus resistance in melon has not been fixed. The progenies sent were heterozygous for virus resistance.

Also, eight gummy stem blight (GSB)-resistant progenies were sent. GSB is a very severe disease that is not easily controlled with fungicides, as fungicide resistance develops quickly. Therefore a GSB-resistant melon is highly desirable. While the GSB material is considered to be "rough" germplasm (*i.e.*, it is not yet near to an acceptable commercial fruit type), in some cases it may combine GSB resistance with multiple virus resistance.

Field Trial Design. E-W Seed planted this material in January 2001, following the standard Indonesian production practices of planting on raised beds using a trellis system. To ensure the survival of the trial, the plants were sprayed to control for diseases and insects. For comparison, standard Indonesian cucumber and melon varieties were included in the trial. Observations were made in mid-March, 2001.

It should be emphasized that this was a simple trial. There were no replications within the trial or across different locations in Indonesia. The objective was to get a general idea of the acceptability, potential, and performance of the Cornell cucumber and melon germplasm from those used in North America. For example, in Indonesia cucumber is trellised to keep plants and fruit off the ground, which decreases the possibility of disease in a climate that is very wet for part of the year. In North America, cucumber is grown almost exclusively on the ground. Thus, the material is not adapted or bred for a trellis system.

Resistance. Various diseases were naturally present in the field trial. Virus symptoms were observed on both the Cornell and Indonesia material. Some symptoms were positively identified by (ELISA as CMV. Other virus symptoms could not be identified as the antisera needed was not

Table 5.1. Cornell Cucurbit Lines in Field Trials, East West Seed Company, Indonesia, 2001

Vegetable	Type	Putative Resistances			
		Virus		Fungal	
		Fixed	Segregating	Fixed	Segregating
Melon	Cantaloupe		CMV, PRSV WMV, ZYMV	PM	PM
Melon	Cantaloupe		CMV, PRSV WMV, ZYMV	PM	PM, GSB
Melon	Honeydew		CMV, PRSV, WMV, ZYMV	PM	PM
Cucumber	Beit alpha	CMV, PRSV, WMV, ZYMV		PM, DM, anthracnose ALS, Scab.	Target leafspot, Ulocladium

⁸ Information provided by Mark Henning, Cornell University.

available. The presence of CMV does not indicate that the Cornell material is susceptible. CMV may be present in "resistant" material, but the plant still produces a normal crop of cucumbers. Tolerance is a better description of the plant's reaction—which means that although the plant shows CMV leaf symptoms, it still produces normally. This principle also applies to viruses that affect melon.

Regarding ZYMV, a year prior to this trial, E-W Seed carried out a controlled screen for ZYMV on related Cornell breeding material. All but one of the progenies were susceptible to ZYMV. Since Cornell considers the material to be resistant to ZYMV, these results suggest that E-W Seed may have used a different (local) ZYMV strain.

Anthrachnose, a leafspot disease, was also present on the Cornell and Indonesian material. As the beita alpha progenies have been developed using the backcross method, it is assumed that resistance to anthracnose has been retained. Thus, the disease observed on the Cornell material may have been caused by a different strain of anthracnose.

Market Acceptance. The fruit type of the Cornell progenies was different than the preferred Indonesian fruit type. While the Cornell progenies are of the beita alpha fruit type, Indonesian consumers prefer a very pale green (almost white) and smooth cucumber.

Minimum Time to Commercialize⁹. E-W Seed estimates that it will take 19 generations to incorporate virus resistance into a variety that is acceptable to Indonesian consumers. In addition, two generations will be required to carry out multi-locational testing (dry and wet season), and an additional year to produce seed. Thus, assuming three generations per year, six years will be required to develop a virus-resistant hybrid cucumber variety, and seven to eight years to introduce the variety into the market.

Conclusions. Although there was disease present and the Cornell cucumbers progenies are "off type" for the Indonesian market, potential exists to utilize these material's disease resistance (both virus and leafspot) in a backcrossing program. However, additional research is needed to determine which virus strains are prevalent in Indonesia. Cornell is continuing to transfer new material to E-W Seed.

5.2.2 Melon: Field Trial Results and Potential for Commercialization

The Cornell virus-resistant melon germplasm was generally later, less vigorous, and lower yielding than Indonesian types. This is to be expected for the same reasons cited for cucumber. They also had smaller fruit than Indonesian types, although there were some progenies that had good fruit size.

Resistance. ZYMV symptoms were observed in the trial, which is to be expected as the Cornell melon germplasm does not yet breed true for virus resistance. The GSB-resistant melons performed very well, in terms of standing up to the GSB pressure present in the trial. While Indonesian types were susceptible to GSB, the Cornell material was resistant.

Market Acceptance. As the Cornell material was similar to melon varieties grown in Indonesia, market acceptance is not a major issue.

Minimum Time to Commercialize². E-W Seed estimates that it will take about five years (three generations per year) to incorporate virus resistance into a melon variety. In addition, two generations will be required to carry out multi-locational testing (dry and wet season), and an additional year to produce seed. Thus, six to seven years will be required to introduce a hybrid

⁹ Mr. Aernoudt Aardse of East-West Seed provided this estimate, which he considers to be a conservative estimate.

melon variety into the market.

Conclusions. The Cornell germplasm can be used as a source of virus and GSB resistance in a backcross program. E-W Seed is very interested in the GSB-resistance in the Cornell germplasm. Cornell is continuing to transfer new material to E-W Seed.

5.3 South Africa Field Trials of Cornell Experimental Lines¹⁰

Collaboration between Alpha Seed company and Cornell's cucurbit program began in Fall 1999, independent of ABSP. When ABSP began organizing international trials of Cornell's cucurbit lines in 2001, Cornell recommended Alpha Seed as a collaborator. Alpha Seed subsequently agreed to field test various Cornell lines in Spring 2001.

Field Trial Design. In February 2001, squash, cucumber, and melon breeding lines (Table 5.2) that Cornell sent to South Africa were planted by Alpha Seed in Henley-on-Klip (60 km south of Johannesburg) at the end of the regular growing season when disease and insect pressure was extreme (at a time when no farmer would plant). No chemical sprays were applied during the trials. Earlier in the summer, at a more typical planting date, Alpha Seed planted the following control varieties:

- 1) Eskandarandy squash: standard commercial varieties of Marrow
- 2) Melon: Commercial varieties Picasso, Idesto, Athena, Saticoy, and Eclipse (Fusarium wilt resistant, some PM tolerance)
- 3) Butternut squash: Nicklow's Delight (GSB tolerance), Waltham (none)
- 4) Cucumber: Commercial Dutch Greenhouse (many fungal "resistances", but no viral resistance).

Table 5.2. Cornell Cucurbit Lines in Field Trials, Alpha Seed Company, South Africa, 2001

Vegetable	Type	Putative Resistances			
		Virus		Fungal	
		Fixed	Segregating	Fixed	Segregating
Squash	Eskandarandy (zucchini)		CMV, PRSV, WMV, ZYMV	PM	PM
Melon	Cantaloupe		CMV, PRSV WMV, ZYMV	PM	PM
Melon	Cantaloupe		CMV, PRSV WMV, ZYMV	PM	PM, GSB
Melon	Honeydew		CMV, PRSV, WMV, ZYMV	PM	PM
Squash	Butternut				PM
Squash	Butternut	ZYMV			
Cucumber	Beit alpha	CMV, PRSV, WMV, ZYMV		PM, DM, anthracnose, ALS, Scab	Target leafspot, Ulocladium

¹⁰ Based on information provided by George Moriarty, Cornell University.

The trial was not designed as a formal yield trial. Rather, it was carried out simply to see how the Cornell sources of viral and fungal resistance¹¹ would fare against the viruses and fungi present in South Africa. Thus, given the differential timing of planting between the controls and the Cornell lines, the absence of normal insect and fungicide control, as well as the trial design, this trial does not give any indication as to the yield gain potential of the Cornell sources of resistance. However, the trials did demonstrate the resistance potential in the Cornell lines.

5.3.1 Zucchini: Trial Results and Potential for Commercialization

Resistance. Alpha Seed had planted standard zucchini varieties during the main growing season, which received pesticide and fungicide protection. These varieties behaved as expected and produced a crop. However, when the Cornell Eskandarany was planted, the control lines were nearly at the end of their life cycle and were all showing virus and disease symptoms. When the ABSP team visited Alpha Seed's trial sites in April 2001, the Cornell material was still fairly young. While many plants were showing mild-to-moderate virus symptoms, some plants survived the disease pressure to produce marketable fruit. Bill Kerr of Alpha Seed and George Moriarty of Cornell assumed that perhaps the WMV-M strain was to blame, although no ELISA was performed to determine what viruses or strains of virus were present.

The field trial demonstrated that the Cornell Eskandarany material was not sufficiently resistant to virus to prevent at least some fruit from becoming unmarketable. While it is likely that the Cornell materials could benefit farmers due to its resistance to other viruses, in the long term, resistance to WMV-M will also be required. This is because even assuming that a stable Cornell/Alpha Seed marrow variety is actually resistant to the other four viruses in South Africa, and assuming there is widespread adoption of such a variety, key informants suggest that it is likely that as resistance to other viruses increases, WMV-M will simply displace the other viruses. With this in mind, Cornell is currently engaged in collaborative trials with ARC-Roodeplaat to test a potential source of resistance to WMV-M (Nigerian Local) under local disease pressure.

Market Acceptance. Eskandarany is a tapered zucchini type that does not fit into any market classes of marrow that is grown in South Africa. The Cornell multiple virus-resistant Eskandarany was developed under the Egypt/AGERI project, as it is a popular summer squash in the Middle East. However, Cornell currently has ZYMV-tolerant zucchini and yellow squash, as well as PM-resistant acorn, delicata, zucchini, and yellow squash. Cornell is in the process of trying to move additional viral and fungal resistances into the Eskandarany (from Nigerian Local, *cucurbita moschata*) into zucchini and yellow squash.

Minimum Time to Commercialization. Since the ABSP team's visit, Cornell has sent ZYMV-tolerant zucchini and yellow squash material to two South African seed companies (Alpha Seed and Starke Ayres), as well as PM-resistant acorn¹², delicata, zucchini, yellow squash, and butternut.

¹¹ The definition of resistance and tolerance is hotly contested among plant pathologists and plant breeders. Some define resistance to a disease as absence of that disease within the plant, while others focus on whether or not the disease causes any noticeable changes in yield or fruit. Using Cornell's definition, this analysis assumes tolerance implies that a plant may sustain some damage to yield and fruit, but not complete loss.

¹² Cornell also has sent some PM-resistant acorn squash material, which at least one seed company hopes to incorporate into gem squash. If this is possible, it could result in even larger potential benefits from ABSP/Cornell cucurbit research, given that the crop value of gem squash is equal to that of the combined value of honeydew melon and cantaloupe.

As noted above, Cornell is also in the process of moving more resistances into zucchini and yellow squash. While moving traits from *C. moschata* to *C. pepo* is not an easy task, Cornell estimates that they can have OP varieties of zucchini and yellow squash with resistance or tolerance to the four main viruses, PM, and possibly WMV-M, in about three years. It would take a South African seed company an additional one to two years to true up¹³ and certify a variety, once the new source of resistance is received from Cornell. Thus, assuming that Cornell can move the resistances in the Eskandarany into zucchini and yellow squash, it would take about five years for a multiple virus- and fungus-resistant variety to be commercialized in South Africa. If this transfer is unsuccessful, the ZYMV-tolerant and PM-resistant zucchini and yellow squash should still result in sizeable (although smaller) benefits for farmers.

5.3.2 Melon: Trial Results and Potential for Commercialization

Resistance. All of the Cornell melon varieties in the field trial were severely damaged by Fusarium wilt because none of these varieties had Fusarium wilt resistance. Since none of the Cornell melons survived to maturity, the material's resistance to the target fungi could not be assessed.

Market Acceptance. The Cornell lines of western shipper, honeydew, and eastern cantaloupe are all popular and acceptable in South African markets.

Minimum Time to Commercialization. Several leading varieties in South Africa have Fusarium wilt resistance. For this reason, and given that incorporating this resistance should not be difficult, this summer Cornell started a program to incorporate Fusarium wilt resistance into their multiple virus- and PM-resistant material. A South African seed company could true up and certify a multiple virus- and PM-resistant melon variety (without Fusarium wilt resistance) in about two years. It will take approximately five years for Cornell to incorporate Fusarium wilt resistance and for a South African seed company to true up and certify a melon variety.

5.3.3 Butternut Squash

Resistance. Cornell has butternut lines with PM-resistance and ZYMV-resistance that are equal in maturity and yield to Waltham (one of the major varieties grown in South Africa). Cornell is sending additional butternuts that have resistance to various viruses, as well as to PM.

Market Acceptance. The Cornell lines in the field trial were somewhat small for consideration for the South African market, which is moving to fruit larger than Waltham. However, Cornell has sent new material to Alpha Seed that is larger and should be more acceptable to the market. Also, Cornell has sent material for the baby butternut market.

Minimum Time to Commercialization. It will take approximately three years for Cornell and a South African seed company to certify a butternut squash variety with PM resistance.

5.3.4 Cucumber

Resistance. Two of the Cornell lines did very well, one American slicer and one beit alpha type. This suggests that the Cornell sources of resistance are robust to the South African environment.

Market Acceptance. Seed companies and market traders concur that the American slicer is fading in consumer acceptance, and that the dominant fresh cucumber type is Dutch/English style. Thus, the Cornell American slicer materials would be acceptable in only a very small and declining

¹³ The process of growing out material and selecting for fixed traits is termed "to true up a line".

market. While the Cornell beit alpha materials (developed for the Middle Eastern market, where it is the dominant market class) are shorter than most English varieties, some key informants suggest that it is possible that a longer (20-25 cm), spineless beit alpha cucumber could break into the market as it could be produced outdoors—without the large fixed cost of tunnels—and therefore be produced more cheaply. Some of the Cornell material is moving in this direction and could have potential in the English market. However, during the ABSP team’s visit it was impossible to assess consumer/trader reaction to such a cucumber because none were available to take to a market. In light of consumer preference concerns, Cornell recently crossed their beit alpha with a popular Dutch type and will send this to South Africa for selections. Neither the American slicer nor the beit alpha types will be of use to the pickling industry.

Minimum Time to Commercialization. Because the major produce markets are currently selling commercial varieties that have little or no resistance, Cornell’s cucumber material could be used now. However, the key question is whether or not the market will accept a beit alpha type cucumber that is “similar” in appearance to the Dutch/English cucumber. This analysis conservatively assumes that only an English-style cucumber will be accepted.

In fall 2001, Cornell crossed its multiple virus- and fungal-resistant beit alpha material to the most popular English type and will select for resistances in the English fruit type. Cornell plans to send segregating populations to its collaborators in South Africa, so that they can select under their conditions until resistances are fixed. This analysis assumes that at two generations a year, Cornell and a South African collaborator could release a marketable English-type cucumber in three years.

6. Potential Farm-Level Effects of Disease-Resistant Cucurbits

6.1 Introduction

Potential technology effects on the cost and income of cucurbit production at the individual farm level are analyzed by comparing currently observed crop enterprise budgets with hypothetical ones, where the use of new disease-resistant variety is assumed¹⁴. The new technology (disease-resistant variety) is part of a technology package that includes assumed changes in other inputs and production factors. Thus, the evaluation of farm-level impacts consists of estimating not only the effects of a new variety on crop yields, but also its effect on the cost of production.

General Assumptions. For each crop, a single “representative” crop enterprise budget is estimated. Only variable costs are included because it is assumed that fixed costs (*e.g.*, land/land rental, machinery, tools, irrigation infrastructure, truck/truck rental) would be the same in both the “without” and “with” disease-resistant varieties scenario. In general, the assumptions made in the following farm-level analysis are on the conservative ends of the range of estimates obtained from key informants with respect to yield gain (yield loss avoided), adoption of resistant varieties, and decreases in insecticide and/or fungicide costs. In other words, costs are assumed to be at the high end of expected costs, while benefits are assumed to be near the low end of expected benefits. This is standard practice in impact analysis based only upon experimental or hypothetical results.

¹⁴ The figures used in the following crop budgets were obtained from key informants and national/regional government crop budgets, as well as phone interviews with farmers (South Africa). Average yields reported in these budgets, as well as estimates of yield loss from viruses and fungi, are based upon information from the government crop budgets, phone interviews with farmers (South Africa), and information obtained from seed company representatives and local scientists.

Increase in Seed Cost. Predicting how much seed companies will charge for new disease-resistant cucurbit varieties is quite difficult for a variety of reasons. First, while each seed company interviewed said that while they would charge a price higher than the price of their current premium variety, they could not estimate the actual price that they would charge until they saw the performance of the finished variety. In addition, the price they would be able to charge would depend upon whether or not other companies develop/release varieties with resistance traits similar to the Cornell material. Given this uncertainty, we assume (based on preliminary estimates from the respective seed companies) that farmers who adopt a disease-resistant variety would face a 30-50% increase in seed costs, depending upon the specific cucurbit and country. This premium is based on the estimated average premium for disease-resistant hybrid seed, compared to non-resistant hybrid seed or OP seed—depending on the crop and country.

Other Cost Increases. Using the example of melons in South Africa, we assume that a disease-resistant variety would increase a farmer's yield by an average of 20%. It follows that the farmer's harvest and post-harvest expenditures would therefore be 20% higher (assuming no economies of scale from increasing production by this factor). This includes rather substantial budget items such as harvest labor and packaging material. In addition, we assume that a disease-resistant melon grower could cut his preventative and active fungicidal spraying for powdery mildew, thereby reducing his spending on fungicide and application labor costs by 50%.

6.2 Potential Farm-Level Impact of Disease-Resistant Cucumber (Indonesia)

Choice of Budget Data. For the following farm-level analysis of cucumber, we use the cost of production and yield estimates derived from our farmer survey of 45 cucumber farmers in West Java, as this budget (Table 3.8) is likely more representative of farmers' conditions than the budget from E-W Seed (Table 3.7).

Variable Factors of Production. In Indonesia, the cost of seed accounts for 3% of total cucumber variable costs; other purchased inputs (*e.g.*, fertilizers, insecticide, fungicide, herbicide, irrigation payments, land rent) account for 49%; and labor accounts for 48% (629 person-days/ha). Clearly, seed is not a major variable factor of production, and that any costs savings from reduced insecticide/fungicide applications would not have a large effect on variable costs.

Cost Assumptions. The surveyed farmers, who all planted OP varieties, paid Rp.333,582/ha for seed (1 kg/ha). Currently, E-W sells hybrid seed for Rp.600,000/kg and reported that they would charge 20-40% more for a disease-resistant hybrid. Thus, assuming a 30% markup, farmers would pay Rp.780,000/ha for disease-resistant hybrid seed. Key informants reported that adopters would reduce pesticide and fungicide use by only a modest 15%. This is because most farmers do not understand that viruses are transmitted by insects; they also spray to prevent damage from insect feeding on the cucurbit plant; and farmers typically spray on a schedule, rather than in reaction to pest counts or scouting.

Change in Costs and Benefits. With respect to costs per hectare, adoption of disease-resistant cucumber would increase variable costs/ha by 1.5% (Table 6.1). Farmers who adopt a disease-resistant hybrid will experience a yield gain due to: a) switching from an OP to a hybrid variety, and b) the disease-resistance embodied in the new hybrid. The survey farmers, who planted OP varieties, averaged of 26,000 kg/ha (Table 3.8). E-W Seed estimates that hybrids yield 20% more than OPs. Thus, we assume that the survey farmers' yield would increase to 31,200 kg/ha, if they adopted a hybrid—which is close to E-W Seeds' yield estimate (32,000 kg/ha) for hybrid cucumbers (Table 3.7). Thus, in the analysis that follows, we assume that the yield of farmers who adopt a disease-resistant hybrid will increase by 15% above the estimated hybrid yield ($31,200 \text{ kg/ha} * 1.15 = 35,900 \text{ kg/ha}$). While OP farmers' yields would likely increase by 20% due

Table 6.1. Farm-level Economic Analysis for Cucumber, Indonesia, 2000

Cost/Revenue Item	Without	With	% Change without to with
Variable costs: Inputs (Rp/ha)			
Seed	600,000	780,000	30.0%
Insecticide	570,415	484,853	-15.0%
Fungicide	210,277	178,735	-15.0%
Other	4,646,112	4,646,112	0.0%
Total inputs	6,026,804	6,089,700	1.0%
Variable costs: Labor (Rp/ha)			
Labor-spraying	413,452	351,434	-15.0%
Labor-harvesting	1,143,905	1,315,491	15.0%
Other labor	3,734,594	3,734,594	0.0%
Total labor	5,291,951	5,401,519	2.1%
Variable cost of production (Rp/ha)	11,318,755	11,491,219	1.5%
Input cost per unit (Rp/mt)	362,781	320,268	-11.7%
Gross Revenue (Rp/ha)			
Yield (mt/ha)	31.2	35.9	15.0%
Farmgate Price (Rp/mt)	560,000	560,000	0.0%
Gross Revenue	17,472,000	20,092,800	15.0%
Net Revenue (Rp/ha)	6,153,245	8,601,581	39.8%

to switching to a hybrid and an additional 15% due to disease resistance, only the yield gain associated with disease-resistance is credited to ABSP. Therefore, the representative cucumber farm-level budget (Table 6.1) uses the cost structure obtained from our survey of cucumber farmers (Table 3.8)—who grew OPs—yet replaces their seed costs and yields with those of hybrid farmers. This enables us to approximate the changes in farm-level costs and benefits due to disease resistance seed (directly related to ABSP’s investment), separated from those attributable to moving from an OP to a hybrid (not ABSP-related).

Given the 15% yield gain expected and the low increase in variable costs, a 11.7% decrease in cost per mt is expected. With respect to benefits per hectare, these budgets show that adopters would enjoy a potential increase in net revenues of 39.8%. With respect to labor, adoption is expected to increase labor required by 26 person-days/ha. (See Appendix I. Table 3 for detailed “without” and “with” budgets.)

6.3 Potential Farm-Level Impact of Disease-Resistant Melon (Indonesia)

Choice of Budget Data. For the following farm-level analysis of melon, we use the 1999 Directorate of Horticulture budget (Table 3.11). However, we adjust downward several of the values reported in the Directorate of Horticulture budget, including the output price¹⁵, yield¹⁶, and

¹⁵ Output price is calculated, as described in section 3.6.10.

¹⁶ BPS’s melon budget (Table 3.10) reports a yield of 13.7 MT/ha, which appears to be too low, as is BPS’s yield estimate for Java (14 MT/ha, Table 3.9). Comparing the yield reported in BPS’s cucumber budget (14.3 MT/ha, Table 3.6) to the yield reported by the surveyed cucumber farmers (26.6 MT/ha, Table 3.8) suggests that BPS underestimates farmers’ yields (*i.e.*, survey farmers’ yield is 86% higher than the yield reported by BPS). Thus, the “without” melon yield used in Table 6.2 (26 MT/ha) is an “adjusted” yield, which was estimated by increasing the BPS melon yield by 86%. Given that the

several input cost line items¹⁷. The BPS 1997 budget is not used, as all input and output figures appear to be too low--which is likely due to the fact that prior to 1999, BPS collected data on melons and watermelon combined.

Variable Factors of Production. The cost of seed accounts for about 16% of total melon variable costs of production; other purchased inputs (*e.g.*, fertilizer, insecticide, fungicide, herbicide, irrigation payments) account for 48%; and labor accounts for 36%. Potential cost savings for reduced insecticide/fungicide application could moderately affect variable costs.

Cost Assumptions. E-W Seed estimates that they would sell hybrid disease-resistant hybrid melon seed for 33% above the current price at which hybrid melon seed is being sold. Thus, we assume that an adopter would face a 33% increase in seed costs, and would likely reduce insecticide and fungicide use by 15%, as suggested by key informants.

Change in Costs and Benefits. With respect to costs per hectare, adoption of disease-resistant melon would entail an increase in variable costs/ha of 5.3% (Table 6.2). Given the 15% yield gain expected, an 8.5% decrease in cost per mt is expected. With respect to benefits per hectare, adopters would enjoy a potential increase in net revenues of 34.7%.

Table 6.2. Farm-level Economic Analysis for Melon, Indonesia, 2000

Cost/Revenue Item	Without	With	% Change without to with
<i>Variable costs: Inputs (Rp/ha)</i>			
Seed	3,750,000	5,000,625	33.4%
Insecticide	1,740,000	1,479,000	-15.0%
Fungicide	625,000	531,250	-15.0%
Other	8,815,294	8,890,294	0.9%
Total inputs	14,930,294	15,901,169	6.5%
<i>Variable costs: Labor (Rp/ha)</i>			
Labor-spraying	600,000	510,000	-15.0%
Labor-harvesting	1,325,000	1,523,750	15.0%
Other labor	6,312,500	6,455,000	2.3%
Total labor	8,237,500	8,488,750	3.1%
<i>Variable cost of production (Rp/ha)</i>	23,167,794	24,389,919	5.3%
<i>Input cost per unit (Rp/mt)</i>	891,069	815,716	-8.5%
<i>Gross Revenue (Rp/ha)</i>			
Yield (mt/ha)	26.0	29.9	15.0%
Farmgate Price (Rp/mt)	1,331,000	1,331,000	0.0%
Gross Revenue	34,606,000	39,796,900	15.0%
<i>Net Revenue (Rp/ha)</i>	11,438,206	15,406,981	34.7%

Directorate of Horticulture's melon budget (Table 3.11) reports a yield of 38,475 kg/ha, this adjustment is realistic.

¹⁷ The Directorate of Horticulture's (DH) melon budget estimates of the cost per hectare of stakes and fertilizer are more than five times greater than those reported by the surveyed cucumber growers. Thus, we replaced these line items with figures from our cucumber grower survey (Table 3.8). The DH budget cost for rent was twice that found in our cucumber grower survey. Thus, we reduced the DH rent by one-half. In addition, several other line items in the DH budget were excluded (*i.e.*, shelter, guard, other).

6.4 Potential Farm-Level Impact of Disease-Resistant Zucchini (South Africa)

Variable Factors of Production. The cost of seed accounts for 15% of total zucchini variable costs of production; other purchased inputs (*i.e.*, fertilizers, insecticide, fungicide, herbicide, and irrigation payments) account for 44%; labor accounts for 35%; and packaging accounts for 6%. Zucchini generates 358 person-days/ha in labor (principally black women).

Cost Assumptions. This analysis assumes that an adopter of multiple-virus- and PM- resistant zucchini would face a 50% increase in seed costs, and would be able to reduce insecticide and fungicide use by 50%. Growers will not stop using insecticide altogether because some insect pests damage the plants—although they may not carry viruses. In addition, although it is possible to assume that cucurbit growers in South Africa are well educated, even these growers typically spray without monitoring pests. Likewise, growers will not cut fungicide application completely because they will continue to spray for DM and anthracnose. The “with” scenario implies adoption of a disease-resistant variety.

Change in Costs and Benefits. With respect to costs per hectare, adoption of disease-resistant zucchini would entail an increase in variable costs/ha of 8.1%, although given the average expected 30% yield gain, the cost/MT of zucchini would decrease 16.8% (Table 6.3). More significantly, the labor and chemical savings from using less insecticides and fungicides is much less than the increase in expenditures on harvest labor and packaging that arise from higher yields. With respect to benefits per ha, the budgets show that adopters would enjoy an increase in net revenues of 39%. Thus, the principal benefit to farmers of disease resistance is the increase in revenues due to higher yields, and not cost savings on sprays. With respect to labor, adoption is expected to increase labor required by 72 person-days/ha.

Table 6.3. Farm-level Economic Analysis for Zucchini, South Africa, 2000

Cost/Revenue Item	Without	With	% Change without to with
Variable costs: Inputs (Rd/ha)			
Seed	2,625	3,938	50.0%
Insecticide	2,500	1,250	-50.0%
Fungicide	500	250	-50.0%
Packaging	1,280	1,664	30.0%
Other	4,829	4,829	0.0%
Total inputs	11,734	11,931	1.7%
Variable costs: Labor (Rd/ha)			
Labor-spraying	462	231	-50.0%
Labor-harvesting	4,998	6,498	30.0%
Other labor	847	847	0.0%
Total labor	6,307	7,576	20.1%
Variable cost of production (Rd/ha)	18,042	19,507	8.1%
Input cost per unit (Rd/mt)	902	750	-16.8%
Gross Revenue (Rd/ha)			
Yield (mt/ha)	20.0	26.0	30.0%
Farmgate Price (Rd/mt)	3,103	3,103	0.0%
Gross Revenue	62,064	80,683	30.0%
Net Revenue (Rd/ha)	44,022	61,176	39.0%

6.5 Potential Farm-Level Impact of Disease-Resistant Melon (South Africa)

Variable Factors of Production. The cost of seed accounts for only 3% of total melon variable costs of production; other purchased inputs (*i.e.*, fertilizers, insecticide, fungicide, herbicide, irrigation payments) account for 33%; labor accounts for 10%; and packaging accounts for 57%. Melon generates 124 person days/ha in labor (principally black women). Harvested melons are packaged in 10 kg cartons, which are very expensive relative to the bags or wraps used for other cucurbits.

Cost Assumptions. This analysis assumes that an adopter of multiple-virus and PM- resistant melon would face a 50% increase in seed costs, and would be able to reduce insecticide and fungicide use by 50%. Growers will not stop using insecticide altogether, and although they would be able to eliminate some fungicide applications (such as preventative), they will still spray for DM and anthracnose.

Change in Costs and Benefits. With respect to costs per hectare, adoption of disease-resistant melon would entail an increase in variable costs/ha of 6.6%. However, given the average expected 25% yield gain, the cost/mt of melon would decrease by 14.7% (Table 6.4). It is clear from the detailed budgets (Appendix I. Table 4) that the increase in seed cost does not have a large effect on cost because this line item is quite small. As with zucchini, the labor and chemical savings from using less insecticides and fungicides is much less than the increase in expenditures on harvest labor and packaging that result from higher yields. With respect to benefits per hectare, adopters would enjoy an increase in net revenues of 64.2%. Again, the principal benefit to farmers of disease resistance is the increase in revenues due to higher yields, and not cost savings on sprays. Adoption is expected to increase labor required by four person-days/ha.

Table 6.4. Farm-level Economic Analysis for Melon, South Africa, 2000

Cost/Revenue Item	Without	With	% Change without to with
Variable costs: Inputs (Rd/ha)			
Seed	686	1,028	50.0%
Insecticide	2,000	1,000	-50.0%
Fungicide	2,000	1,000	-50.0%
Packaging	11,840	14,800	25.0%
Other	2,054	2,054	0.0%
Total inputs	18,580	19,882	7.0%
Variable costs: Labor (Rd/ha)			
Labor-spraying	462	231	-50.0%
Labor-harvesting	1,199	1,499	25.0%
Other labor	516	516	-0.0%
Total labor	2,177	2,246	3.2%
Variable cost of production (Rd/ha)	20,756	22,128	6.6%
Input cost per unit (Rd/mt)	1,038	885	-14.7%
Gross Revenue (Rd/ha)			
Yield (mt/ha)	20.0	25.0	25.0%
Farmgate Price (Rd/mt)	1,525	1,525	0.0%
Gross Revenue	30,494	38,177	25.0%
Net Revenue (Rd/ha)	9,737	15,989	64.2%

6.6 Potential Farm-Level Impact of Disease-Resistant Butternut (South Africa)

Variable Factors of Production. The cost of seed accounts for 26% of total butternut variable costs of production; other purchased inputs (*i.e.*, fertilizers, insecticide, fungicide, herbicide, irrigation payments) account for 36%; labor accounts for 16%; and packaging accounts for 22%. It is clear that seed is a major variable factor of production. Butternut generates 77 person-days/ha in labor (principally black women).

Cost Assumptions. Given the high cost of seed, relative to total variable costs, and the fact that the expected yield increase is only 12.5%, this analysis assumes that an adopter of PM-resistant butternut would face a 30% increase in seed costs, and would be able to reduce fungicide use by 50%. Growers will likely continue to spray for DM and other fungi.

Change in Costs and Benefits. With respect to costs per hectare, adoption of PM-resistant butternut would entail an increase in variable costs/ha of 6.9% (Table 6.5). Only a 12.5% yield gain is expected, given that butternut are a fairly disease-tolerant crop, and given that butternut also has losses to other fungi. Because this yield increase is not large, the cost per mt of butternut falls only 4.9%. It is clear from the detailed budgets (Appendix I. Table 4) that the increase in seed cost has a large effect on cost because this line item is fairly large. The labor and chemical savings from using less insecticides and fungicides are essentially the same as the increase in expenditures on harvest labor and packaging that result from higher yields. With respect to benefits per hectare, the budgets show that adopters would enjoy an increase in net revenues of 20.5%. With respect to labor, adoption is expected to reduce labor required by two person-days/ha.

Table 6.5. Farm-level Economic Analysis for Butternut, South Africa, 2000

Cost/Revenue Item	Without	With	% Change without to with
Variable costs: Inputs (Rd/ha)			
Seed	2,163	2,812	30.0%
Insecticide	230	230	0.0%
Fungicide	500	250	-50.0%
Packaging	1,840	2,070	12.5%
Other	2,365	2,365	-0.0%
Total inputs	7,098	7,726	8.9%
Variable costs: Labor (Rd/ha)			
Labor-spraying	308	198	-35.7%
Labor-harvesting	550	619	12.5%
Other labor	504	504	0.0%
Total labor	1,362	1,321	-3.0%
Variable cost of production (Rd/ha)	8,459	9,047	6.9%
Input cost per unit (Rd/mt)	414	393	-4.9%
Gross Revenue (Rd/ha)			
Yield (mt/ha)	20.4	23.0	12.5%
Farmgate Price (Rd/mt)	700	700	0.0%
Gross Revenue	14,302	16,090	12.5%
Net Revenue (Rd/ha)	5843	7043	20.5%

6.7 Potential Farm-Level Impact of Disease-Resistant Cucumber (South Africa)

Variable Factors of Production. The cost of seed accounts for 20% of total cucumber variable costs of production; other purchased inputs (*i.e.*, fertilizers, insecticide, fungicide, herbicide, irrigation payments) account for 40%; labor accounts for 20%; and packaging accounts for 20%. Cucumber production generates 87 person-days/ha of labor (predominantly black women). It is clear that seed is a major variable factor of production. It should be noted that English cucumber production entails the use of tunnels, which are very high fixed costs. While it is possible that disease-resistant cucumber could be grown in the field and thus save the expense of the tunnels (certainly a large benefit), this analysis conservatively assumes that the new variety would still be grown in tunnels. To assume that English cucumber would be grown in the field would entail assuming a lower yield (if not gynoecious cucumber¹⁸) and that growers would move to a field-growing system.

Cost Assumptions. Given the high cost of seed relative to total variable costs, this analysis assumes that an adopter of multiple virus- and fungi-resistant cucumber would face a 30% increase in seed costs, and would be able to reduce insecticide and fungicide use by 50%. This reduction may be a conservative estimate, given the many resistances in the Cornell cucumber, although, on the other hand, these multiple traits have yet to be transferred from a beet alpha to an English type.

Change in Costs and Benefits. With respect to costs per hectare, adoption of disease-resistant cucumber would enable a decrease in variable costs/ha of 0.4% (Table 6.6). Given the 20% yield

Table 6.6. Farm-level Economic Analysis for English Cucumbers, South Africa, 2000

Cost/Revenue Item	Without	With	% Change without to with
Variable costs: Inputs (Rd/ha)			
Seed	2,020	2,626	30.0%
Insecticide	1,000	500	-50.0%
Fungicide	1,000	500	-50.0%
Packaging	2,240	2,688	20.0%
Other	1,830	1,830	0.0%
Total inputs	8,090	8,144	0.7%
Variable costs: Labor (Rd/ha)			
Labor-spraying	440	220	-50.0%
Labor-harvesting	614	737	20.0%
Other labor	829	829	-0.0%
Total labor	1,883	1,786	-5.2%
Variable cost of production (Rd/ha)	9,973	9,930	-0.4%
Input cost per unit (Rd/mt)	285	236	-17.0%
Gross Revenue (Rd/ha)			
Yield (mt/ha)	35.0	42.0	20.0%
Farmgate Price (Rd/mt)	2,879	2,879	0.0%
Gross Revenue	100,764	120,917	20.0%
Net Revenue (Rd/ha)	90,791	110,987	22.2%

¹⁸ In South Africa, English cucumber gynoecious. While this seed is a more expensive than field cucumber seed, it produces nearly double the yield of field cucumber.

gain expected, and the negligible increase in variable costs, a 17% decrease in cost per mt is expected. The labor and chemical savings from using less insecticides and fungicides are essentially the same as the increase in expenditures on harvest labor and packaging that result from higher yields. With respect to benefits per hectare, the budgets show that adopters' net revenues would increase by 22.2% and that labor use would decline by six person-days/ha.

6.8 Section Summary

There are several generalizations that can be made from the representative farm-level budgets constructed in this section. With the aforementioned caveats concerning the nature of *ex ante* analysis¹⁹, there are several generalizations that can be made about the expected farm-level costs and benefits of adoption (Table 6.7). Regarding changes in production costs, adoption of disease-resistant cucurbit varieties in Indonesia and South Africa involves an increase in variable production costs, typically from increased labor for harvest and packaging materials. The financial savings from reduced insecticide and fungicide use are not large (we are not valuing the potential health benefits to workers and consumers). Because the cost of seed for most of the cucurbits does not account for a large share of total variable production cost, it does not appear that higher seed costs would deter adoption—at least not for those producers with access to some form of credit.

Regarding changes in net benefits, it is clear that under the assumptions made, each of the cucurbits is expected to significantly increase farmers' net revenue per hectare, not to mention that risk averse farmers would also benefit from more stable yields (although the benefits of risk reduction are not modeled here).

Table 6.7. Summary of *Ex Ante* Farm-Level Economic Analysis of Disease Resistant Cucurbits in Indonesia and South Africa, 2000

Assumed % change at farm-level given adoption of resistant variety ^a	Indonesia		South Africa			
	Cucumber	Melon	Marrow	Melon	Butternut	Cucumber
Cost of Seed	30.0%	33.4%	50.0%	50.0%	30.0%	30.0%
Insecticide Use	-15.0%	-15.0%	-50.0%	-50.0%	0.0%	-50.0%
Fungicide Use	-15.0%	-15.0%	-50.0%	-50.0%	-50.0%	-50.0%
Yield	15.0%	15.0%	30.0%	-25.0%	12.5%	20.0%
Resulting % changes in costs and returns given adoption						
Purchased input costs/ha	1.0%	6.5%	1.7%	7.0%	8.9%	0.7%
Labor costs/ha	2.1%	3.1%	20.1%	3.2%	-3.0%	-5.2%
Total Variable costs/ha	1.5%	5.3%	8.1%	6.6%	6.9%	8.1%
Input cost/unit of output	-11.7%	-8.5%	-16.8%	-14.7%	-4.9%	-17.0%
Net revenue/ha	39.8%	34.7%	39.0%	64.2%	20.5%	22.2%
Incremental labor generated (persondays/ha)	26	na	72	4	-2	-6

^aChange from base of current variety to resistant variety.

¹⁹ The cost figures in these budgets are approximate, as they are based on estimates from government crop budgets and key informants (seed companies, farmers). Also, the assumed yield benefits (yield loss avoided from diseases) from disease-resistant cucurbit varieties are based on key informant estimates of average yield loss to disease, as well as assumptions as to the potential value of resistance embodied in the Cornell materials, which is based upon one field trial in each country.

7. Potential Market Effects of Disease-Resistant Cucurbits

7.1 Market-Level Analysis Model

Model Choice. To aggregate benefits from the farm to the market-level, a combination of “Open Small Economy” and “Closed Economy” Economic Surplus models are used (Alston, Norton, and Pardey, 1995). In South Africa, the open small-economy model is used for zucchini and melon, while a closed economy model is used for cucumber and butternut. In Indonesia, a closed economy model is employed for both cucumber and melon.

The choice of which model is used for a given crop depends upon which best represents the closest approximation to the real-world trading situation of each commodity subsector in this study²⁰. The open small-country model assumes: a) that the domestic price of the given commodity is determined by the international price; b) that any additional production of that commodity is assumed to be exported; and c) that the country’s export volume is not large enough to influence the international price. By contrast, the closed economy model assumes that the country does not import or export the commodity²¹. Thus, any additional production of the commodity will increase its domestic supply, resulting in lower consumer prices (assuming competitive markets).

As there is no direct government involvement in the marketing of ABSP’s target cucurbits in either Indonesia or South Africa, and given the relatively non-concentrated structure of wholesale and retail marketing in each country, this analysis assumes that the domestic markets of these crops are competitive in each country. Both the open and the closed model are derived from a relatively simple surplus model which calculates the benefits of adoption of a specific commodity as follows:

Benefits. Societal benefits are defined as a time series of farm-level benefits, aggregated to the market level.

In the *open model*, the benefits for a given year are computed as:

$$\text{Benefits}_t = K_t * P_t * Q_t * [1 + 0.5 * K_t * \epsilon]$$

Where:

$$K_t = [E(Y) / \epsilon - E(C) / (1 + E(Y))] * R_t$$

K_t = Proportionate shift in supply curve (in year t); which is the net cost change (US\$/mt) multiplied by the adoption rate

²⁰ The real-world situation of both South Africa and, to a lesser extent, Indonesia, would likely be somewhere between an open and a closed economy model. The reason is because exporting cucurbits requires both competitive pricing as well as institutional and technological capacity to coordinate production and marketing of highly perishable crops. While South Africa has the technological capacity to export fresh cucurbits to Europe, these exports are low or non-existent for cucumber, butternut, and melon, given the high cost of airfreight, as well as strong competition from Brazil, Spain, and other countries. By contrast, Indonesian agribusiness firms lack the informational and technological capacity to coordinate exports to large markets such as Singapore and Shanghai (DAI, 1993). How much of a decline in production costs in South Africa, and how much additional technological capacity in Indonesia would enable these countries to become competitive in European or Asian cucurbit export markets would require a formal marketing study that is beyond the scope of this analysis.

²¹ A country may not import or export a given commodity due to domestic or foreign trade barriers, high transport and/or transaction costs, or lack of sufficient consumer demand for the commodity inside or outside the country.

$E(Y)$ = expected proportionate yield change per hectare
 ε = price elasticity of supply
 $E(C)$ = expected proportionate change in variable input costs per hectare
 R_t = adoption rate
 P_t = farm-level price of the commodity
 Q_t = total domestic production of the commodity (mt)

In the *closed model*, the policy and market environment enables quantity increases to reduce domestic prices, thus enabling consumers to directly benefit from technological change:

$$\text{Benefits}_t = K_t * P_t * Q_t * [1 + 0.5 * Z_t * \eta]$$

Where:

$Z_t = [(K_t * \varepsilon) / (\varepsilon + \eta)]$
 Z_t = proportionate decrease in price (in year t)
 η = price elasticity of demand

The annual benefits calculated by the surplus model for each commodity are aggregated and then compared with the costs of the technology development.

Costs. Costs are the time series of investments by the public and private sector in the development of the technology.

Adjustments for Inflation and Time. Benefits and costs prior to 2001 are converted to real values to adjust for inflation, and all benefits and costs are adjusted for the time value of money using a discount rate²².

Investment Performance Indicators. Several different indicators or measures of the return on the investment may be employed. One is net present value (NPV), which is simply the sum of discounted costs and benefits over time. The internal rate of return (IRR) is another such measure, defined as the interest rate that equates the net present value of benefit and cost flows to zero, as calculated by the equation:

$$\sum_{t=1}^n \frac{B_t - C_t}{(1 + r)^t} = 0$$

where “ B_t ” and “ C_t ” are the values of the benefit and cost streams in each time period from $t = 1$ to n , and “ r ” is the interest rate that solves the equality (the IRR).

The IRR is the “rate of return on capital outstanding per period while it is invested in the project (Gittinger, 1982);” in other words, the return to the money invested in the project. For example, an IRR of 18% means that project returns are large enough to cover all operating costs, pay back the principal on the capital invested in the project, and return an average 18% annually for the use of the money in the meantime. A project with an IRR that exceeds the average real

²² The time value of money states that \$100 received in 1993 is not equivalent to \$100 received in 2001. This is because the \$100 received in 1993 could be invested (assume at 10 percent per year) and would be expected to value approximately \$214 by 2001. In this manner, discounting values over time has the effect of inflating past values and deflating future values.

market interest rate during the project life is deemed “profitable.”

7.2 Costs of Developing Disease-Resistant Cucurbits

The costs involved in the development and transfer of disease-resistant cucurbit varieties for Indonesia and South Africa includes ABSP’s past, present, and future expenditures in the Cornell cucurbit program, as well as future expenditures by collaborating seed companies in each of the two countries. Cornell’s germplasm that is now being field-tested in South Africa and Indonesia is the result of years of investment by the State of New York, the USDA, and the U.S. vegetable seed industry in Cornell’s cucurbit research program. However, this analysis only considers as investment the costs that ABSP and Cornell incurred in developing material specifically for South Africa and Indonesia during 1993-2004²³. This premise is based on the assumption that Cornell would have maintained a disease-resistance cucurbit program with or without ABSP funds—given that Cornell’s principal clients (and donors) are the U.S. public and private agricultural sector, who seek varieties resistant to many of the same diseases as those of interest to ABSP.

Cornell Research Costs. ABSP Phase I provided support to Cornell to develop disease-resistant cucurbits for Egypt in collaboration with AGERI. Phase II funds were intended to help Cornell extend this effort beyond Egypt to other countries. To the best of the authors’ knowledge, the materials currently in South Africa and Indonesia have benefitted directly or indirectly from the Phase I work in Egypt. Therefore, this analysis assumes that all ABSP investments in the Cornell cucurbits program since 1993 have contributed to the development of the materials that have been transferred to seed companies in Indonesia and South Africa.

ABSP investments in the Cornell program fall into two main categories: funds from USAID/Cairo and funds from the ABSP Core, as shown in Table 7.1²⁴. In this table, italicized values are estimates of future funding levels, based upon prior funding levels. Appendix I. Table 5 contains further details concerning these accounts.

Seed Company Research Costs. The collaborating seed companies in Indonesia and South Africa will incur expenses during the process of breeding, testing, and certifying cucurbit varieties which incorporate Cornell’s sources of resistance. These private sector expenditures are included as technology development costs in addition to the public sector expenditures made by USAID/ABSP. Estimates of these expenditures, which were made by E-W Seed in Indonesia and by one seed company in South Africa, include the costs of sourcing the line (transport, travel, importation of samples), testing the line, introduction and registration, and initial marketing and promotion.

This analysis assumes that E-W Seed will invest US\$10,000 per year from 2001 to 2007, when they expect to release disease-resistant cucumber and melon varieties. For South Africa, the analysis assumes that at least two South African seed companies will each invest US\$10,000 per year until the last of their varieties are released in 2006. As the seed firms found it extremely difficult to estimate these future costs, these are rough estimates of private sector varietal development costs in Indonesia and South Africa. Combining the public and private sector investments yields a cost stream from 1993 to 2007 (Table 7.1)

²³ As continued collaboration will be required to move the material that Cornell has sent to Indonesia and South Africa into finished varieties, this analysis assumes that Cornell will continue to receive funding from ABSP through 2004.

²⁴ Expenditures noted in Table 7.1 are nominal values.

Table 7.1. Projected Public and Private Sector Investment in Disease-Resistant Cucurbits, Indonesia and South Africa, 1993-2006 (US\$ Nominal)

Year	Cornell ABSP	Cornell USAID/ Cairo	Cornell Total	Indonesia East-West Seed	A. Africa Seed Companies	Private Sector Total	Public and Private Total
1993	\$70,000	\$0	\$70,000	\$0	\$0	\$0	\$70,000
1994	\$0	\$40,818	\$40,818	\$0	\$0	\$0	\$40,818
1995	\$0	\$71,788	\$71,788	\$0	\$0	\$0	\$71,788
1996	\$0	\$21,493	\$21,493	\$0	\$0	\$0	\$21,493
1997	\$0	\$53,678	\$53,678	\$0	\$0	\$0	\$53,678
1998	\$0	\$49,218	\$49,218	\$0	\$0	0	\$49,218
1999	\$47,861	\$39,202	\$87,063	\$0	\$0	\$0	\$87,063
2000	\$105,962	\$60,297	\$166,259	\$0	\$0	\$0	\$166,259
2001	\$47,881	\$34,586	\$82,467	\$10,000	\$20,000	\$30,000	\$112,467
2002	\$108,639	\$50,000	\$158,639	\$10,000	\$20,000	\$30,000	\$188,639
2003	\$100,000	\$50,000	\$150,000	\$10,000	\$20,000	\$30,000	\$180,000
2004	\$100,000	\$50,000	\$150,000	\$10,000	\$20,000	\$30,000	\$180,000
2005	\$0	\$0	\$0	\$10,000	\$20,000	\$30,000	\$30,000
2006	\$0	\$0	\$0	\$10,000	\$20,000	\$30,000	\$30,000
2007	\$0	\$0	\$0	\$10,000	\$0	\$10,000	\$10,000

ABSP italicized figures are estimates based upon funding received in prior years. Private sector figures are estimates received from seed companies.

While these private sector cost estimates may seem low, it should be noted that the real expense in breeding typically is the search for sources of desirable traits—which Cornell has already accomplished. In the case of several of the Cornell materials, these companies only need to select the most resistant and stable lines. In other cases, Cornell or the companies themselves have since crossed the Cornell materials with local cucurbits in order to combine the Cornell resistance traits with local market traits.

7.3 Potential Benefits of Disease-Resistant Cucurbits

Yield Gain and Change in the Cost of Production. The potential benefits of disease-resistant cucurbits in Indonesia and South Africa derive from benefits at the farm level. The assumptions related to farm-level *yield gain* and *change in the cost of production* for each crop are discussed in detail in sections 3, 4 and 6, and are summarized in Table 7.2.

Price. Indonesian prices used in the market model are wholesale prices from the largest wholesale fresh produce market, Pasar Induk in Jakarta. The price used in this model is the monthly average price from 2000.

Prices for South African cucurbits in the market model are wholesale prices from the four largest wholesale fresh produce markets²⁵. For each commodity, a five-year real price series was constructed by taking total annual sales value of the four markets combined, and dividing this amount by the total annual volume traded on these markets. The price for a given commodity in the model is the 5-year average of this wholesale price series from 1995 to 2000. Because only five

²⁵ The choice of which price level in the marketing chain is used does not influence the net present value or the rate of return. The choice merely determines who is considered to be a producer and who is considered a consumer within the reporting of producer and consumer surplus.

Table 7.2. Principal Farm and Market Level Assumptions in the Economic Surplus Models, South Africa and Indonesia, 2004-2018

Crop	Farm-Level			Market-Level		
	Average Yield ^a (mt/ha)	Expected Yield Gain ^b (%)	Input Cost Change per ha ^c (%)	Total Domestic Production ^d (mt)	Wholesale Market Price ^d (US\$/mt)	Adoption Ceiling ^d (%)
South Africa						
Zucchini	20.0	30.0%	15.3%	75,000	443	70%
Cucumber	35.0	20.0%	11.6%	16,625	411	60%
Melon	20.0	25.0%	6.6%	80,000	218	70%
Butternut	20.4	12.5%	8.0%	204,444	100	40%
Indonesia						
Cucumber	31.2	15.0%	1.5%	247,000	56	20%
Melon	26.0	15.0%	5.3%	40,222	133	70%

^aAverage Yield under disease pressure (Sections 3 & 4)

^bExpected farm-level yield gain of a disease-resistant variety adopter (Sections 3 & 4)

^cExpected input cost change per hectare of a disease-resistant variety adopter (Section 6)

^dTotal domestic production, wholesale market price, and adoption ceiling (Section 7)

years of wholesale price data are available, no test for a price trend was completed, and no assumption of a price trend is made.

Crop Area and Production. For Indonesia, the cucumber analysis (Table 7.2) uses BPS's estimate of cucumber area (22,626 ha) and production (247,000 mt) for Java only, which accounts for 47% of Indonesia's harvested area and 57% of national production [Appendix I. Table 1 (d)].

While E-W Seed may be able to market a disease-resistant cucumber in other provinces, the analysis conservatively limits adoption to Java because this is where E-W Seed's marketing network is concentrated.

Similarly, the estimate of the melon area includes only hectares planted in Java (72% of the melon area; 1,547 ha). While BPS's harvested area estimate for melon (Table 3.9) appears sound, the production and yield estimates appear quite low. Thus, this analysis assumes that Java's total production is 40,222 mt, which is derived by multiplying the BPS area (Java) estimate by the "adjusted" BPS melon budget yield of 26 mt/ha (see section 6.3 for details regarding this adjustment).

The South African government does not collect or report either total production or area planted/harvested for any of the cucurbits supported by ABSP research. Therefore, for each South African crop in this analysis, area and production estimates are estimated from a combination of information (by crop), including: total private sector seed sales and seed planting densities (from seed companies and government production budgets), production marketed through wholesale markets (from published wholesale market reports), estimates of the percentage of total production channeled through wholesale markets (from key informant interviews at wholesale markets, supermarket procurement personnel, and seed companies), and average yields (from government production budgets, farmers, and seed companies). This information was used to construct a range of production estimates. Estimates of domestic production that are used in the market model are based on the lower end of this range of estimates (Table 7.2). Because no data exists on total production, it is not possible to discern whether there is an upward or downward trend in area or production for any of the crops.

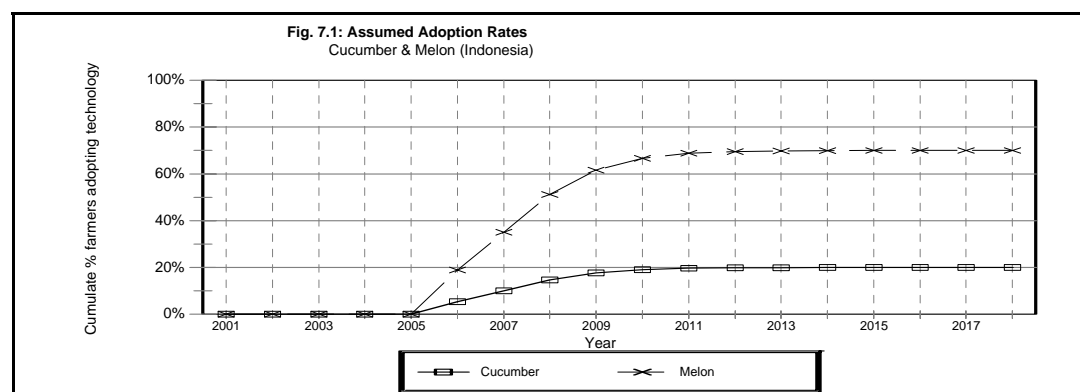
Adoption Rates: General. Expected rates of adoption of disease-resistant varieties by crop are estimated using the subsector background information obtained for each crop. For each crop, the adoption curve is a logistic function which utilizes information with respect to three variables: the year of varietal release, the ceiling (maximum) level of adoption, and how quickly the ceiling is reached. For each crop, the year of variety release is based upon the assumptions in Section 4, regarding the minimum time to commercialization. Following the standard practice for benefit-cost studies, we use a logistic model to project the adoption rate for each crop for approximately 15 years into the future (2002-2018).

The choice of functional form of the adoption curve over time (logistic function) models the typical dynamics in farmer adoption of agricultural technologies: a few progressive, risk-taking farmers adopt a new technology immediately; followed by many relatively risk-averse neighbors, followed by highly risk-averse or resource-poor laggards who either could not access the new technology earlier or simply do not trust it until seeing several years of results. The first two groups constitute a portion of the curve in which the adoption rate increases at an increasing rate, whereas the last group constitutes the portion of the curve in which adoption increases at a decreasing rate. For the South African farmers, this curve is probably a conservative estimate of the potential rate of adoption, considering their high education and input levels. These farmers would likely adopt a profitable technology quite quickly, given their familiarity with new technologies and regular contact with input dealers.

Adoption Rates: Indonesia. Estimates of the ceiling level of adoption, as well as the speed of adoption, are based upon the current nature of each crop's seed market and the type of farmers who grow each crop. In Indonesia, only 10% of cucumbers area is currently planted to hybrid. Thus, we assume a ceiling (20%), which is reached in about seven years (Figure 7.1). This assumes that all 10% of current hybrid growers will adopt the new disease-resistant hybrid, and that another 10% of OP growers will also adopt the new hybrid.

In sharp contrast, the melon seed market is already totally hybrid. Thus, we assume that a new hybrid would be both widely and rapidly adopted and a ceiling of 70% would be reached in five to six years. Although E-W Seed does not currently market a melon variety, we assume that they would face minimum difficulty in marketing a disease-resistant melon variety, given their dominant position in the seed markets of many other vegetables.

Adoption Rates: South Africa. Because the South Africa seed market for melon, zucchini, and cucumber is primarily hybrids or premium seed and these farmers are all large and highly



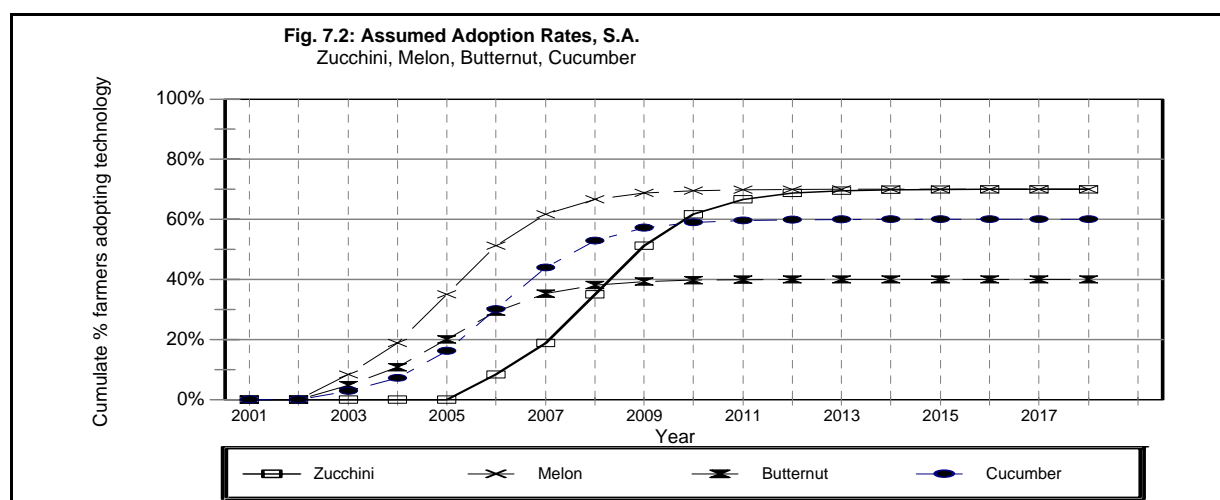
commercial, we assume that a new technology with high average yield gains plus insecticide and/or fungicide reduction would be both widely and rapidly adopted. Thus, this analysis assumes a ceiling adoption rates of 70% (of total estimated crop area) for melon and zucchini, and an adoption rate of 60% for cucumber (Figure 7.2). By contrast, the butternut market consists of both large-scale (white) commercial growers and small-scale (black) semi-subsistence growers. Because blacks seldom buy seed from the formal seed sector, we posit that this trend will continue and assume a ceiling adoption rate of 40% for disease-resistant butternut [*i.e.*, only the large-scale (white) commercial growers are expected to adopt a resistant butternut in the near future].

As data on actual seed sales (by crop) are not available for the seed companies in South Africa and because the principal ABSP collaborating seed firm in South Africa does not market its own seed, these adoption rate estimates are not based upon current seed sale of a given firm. Rather, they are based on the assumption that disease-resistant traits would be quite valuable and would be quickly incorporated into the varieties of more than one seed firm.

Elasticities. Elasticities indicate how producers/consumers are expected to change the quantity of that commodity supplied/demanded, given changes in the commodity price. As no published elasticity estimations exist for these crops in either country and due to a lack of data to estimate elasticities for these crops, we assume a standard vegetable supply elasticity of 1. This implies that, given a 1% decrease in the farm-level vegetable price, a vegetable producer will decrease his/her production of that vegetable by 1%. Likewise, as the demand elasticity for vegetables in Indonesia or South Africa has not been published and it is impossible to estimate one (given data limitations), we assume a typical vegetable demand elasticity of 1. This implies that, given a 1% decrease in the retail price of a vegetable, consumers will demand 1% more of the vegetable.

Exchange Rates. To compare monetary values of various countries, exchange rates are used to convert the Indonesia and South African currency values to U.S. dollars. For Indonesia, the exchange rate used is US\$=Rp10,000; and for South Africa, the exchange rate used is US\$1= Rand 8, which are “representative” of recent exchange rates.

Discount Rate. This analysis uses 10% as the discount rate, which is in the middle of the range suggested by Gittinger (1982) to represent the real opportunity cost of capital in developing countries.



Present Value of Benefits by Crop. The present value²⁶ (PV) of potential benefits from 2004-2018 (Table 7.3) is US\$48.8 million. This PV is the expected producer and consumer surplus, and not the NPV of the ABSP investment (net surplus to society). The NPV of the ABSP investment is lower than this figure because the ABSP and private sector costs are also considered (*i.e.*, deducted from the PV values) in the NPV calculation.

As shown in Table 7.3, South Africa accounts for 94% of the estimated PV. This is due to three factors. First, in Indonesia only approximately 10% of the cucumber area is currently planted to hybrid varieties and we estimate that the area will only increase to 20% by 2018. In contrast, in South Africa almost all of the farmers who plant the targeted crops use hybrid seed. Second, in South Africa three of the target crops are primarily consumed by whites, who have relatively high incomes and are willing to pay premium prices for these crops. For example, in South Africa the wholesale price of cucumber is US\$411/mt, compared to only US\$56/mt in Indonesia. However, it should be noted that the cucumber sold by Indonesian and South African farmers are not the same in form (market class or level of processing) or space (location). For example, in Indonesia, farmers sell cucumber (unpacked) at their farm-gate, while in South Africa, farmers wrap and box the cucumbers and transport them to either a wholesale market or supermarket depot. Finally, as a result of the Asian economic crisis, the value of the Rupiah fell by about 80% between 1997 and 2001. Thus, when the value of Indonesia's cucumber and melon production is converted to US\$ at the 2001 exchange rate, their value is reduced by about 80%—compared to what it would have been if the study had been carried out in early 1997.

Distribution of Benefits. For those crops with an open economy model (South African zucchini and melon), producers (farmers/wholesalers) obtain all the benefits of incremental production. For those crops with a closed economy (no trade) market model (all others crops considered), the benefits will be split evenly between producers (farmers/wholesalers) and consumers (retailers and consumers). Consumers benefit because prices are lower. Although retail and farm-level prices are lower, farmers' production costs decrease by a larger amount, thus producers' net returns increase.

Considering the distribution of benefits with respect to poverty alleviation, it is clear that in Indonesia, the benefits will go to small-scale producers and to all consumers. Cucumbers in Indonesia are produced exclusively by small-scale growers, and eaten by consumers of all income

Table 7.3. Potential Benefits from Cornell Disease-Resistant Cucurbit Varieties, South Africa and Indonesia, 2004-2018

Country	Crop	Present Value of Potential Benefits, 2004-2018 (million US\$)	Share of Total Present Value of Potential Benefits 2004-2018
South Africa	Zucchini	15.4	31.4%
	English Cucumber	3.5	7.2%
	Melon	16.8	34.4%
	Butternut	10.2	20.9%
Indonesia	Cucumber	1.4	2.9%
	Melon	1.5	3.2%
Total		48.8	100.0%

²⁶ To estimate a NPV, costs must be subtracted from the PV. Given that is impossible to allocate costs to specific countries/crops, the PV estimate is presented here.

levels. For melon in Indonesia, the benefits will go to small-scale farmers who produce melons and higher-income consumers. In contrast, the benefits in South Africa will go principally to large-scale (white) farmers and to white consumers (higher income consumers). This reflects the fact that only one of the ABSP-supported cucurbits (butternut) is produced or consumed by blacks. In the case of butternut, we are assuming that both white and black consumers will receive lower prices for butternut, but black butternut producers will not enjoy benefits because there is no reason to believe that they will purchase seed from the formal sector in the near future (without more state or NGO intervention in agriculture on black farmers' behalf).

Returns to Seed Companies. Using the assumed baseline adoption rates (Table 7.2), seed planting densities, and farm-level seed premiums (Section 6), it is possible to estimate the potential incremental revenues (discounted) that seed companies could generate from marketing disease-resistant cucurbit varieties (Table 7.4).

Given the baseline adoption and seed premium assumptions, the three seed companies' (E-W Seed, Alpha Seed, and Starke Ayres) gross revenues may increase by as much as NPV US\$4.5 million from 2004-2018. The companies' expected profits generated from these new varieties could only be calculated if we knew their overhead expenditures, as well as their actual investments in varietal testing and certification.

Benefits Not Considered. This analysis only considers potential benefits from South Africa and Indonesia, although ABSP/Cornell are in the process of transferring this germplasm to Brazil and Egypt. Since this analysis is considering the total ABSP investment in the Cornell program²⁷, ideally, these costs should be analyzed against the total potential benefits. Other Indonesian and South African benefits not considered in this analysis include the worker and consumer health benefits of lower insecticide/fungicide applications, as well as potential product value benefits for both producers and consumers due to a decrease in the amount of virus-affected produce in the market. The latter benefits are not estimated since it was impossible to gather data on the market

Table 7.4. Potential Incremental Gross Revenues of Seed Companies, Indonesia and South Africa, 2004-2018

Crop	Seed Premium per hectare ^a (US\$/ha)	Maximum Potential Area Adopted ^b (ha)	Total Discounted Incremental Gross Revenue ^c (US\$)
South Africa			
Zucchini	\$164	2,625	\$1,478,782
Cucumber	\$76	285	\$85,814
Melon	\$43	2,800	\$614,959
Butternut	\$81	4,000	\$1,663,215
Indonesia			
Cucumber	\$18	1,900	\$127,419
Melon	\$125	1,083	\$527,003
Total			\$4,497,192

^aDifference between resistant seed cost/ha and previous seed cost/ha

^bBased upon assumed adoption rates (Section 7)

^c2004 to 2018

²⁷ There exists no standard method for deciding what share of program costs should be assigned to a given country and we have no information on the specific details of Cornell's expenditures—only the total amounts.

price discount for virus-damaged fruit. In addition, there is no way to estimate how much fruit in each country is damaged by virus, and how much of the damaged fruit is acceptable in a market.

7.4 Rates of Return to ABSP Investment

Aggregate Results. The *ex ante* rates of return to ABSP Investment (Table 7.5, Appendix I, Table 6) indicate that this will be a profitable investment²⁸, given the caveat that these potential returns to the investment are based upon many strong assumptions. It should be emphasized that these materials are now only in the field-testing stage and have yet to be marketed to and adopted by farmers.

Sensitivity of Results to Assumptions. Sensitivity analysis is carried out to determine how sensitive the results are to the assumptions used in this analysis. Varying our baseline cost, adoption, and yield gain assumptions (Table 7.5) demonstrates that if these materials achieve only one-half of our initial estimate, in terms of farm-level yield gain, and are adopted by even one-half of our initial estimate of adopters, then the ABSP investment will still be profitable. Thus, if these materials actually reach the market and are adopted, it is very likely that the return to the ABSP investment will be positive.

It cannot be overstated that one of the strongest assumptions made in this analysis is that future cucurbit varieties that are released in Indonesian and South Africa will embody the resistances apparent from initial field tests. This assumption is quite strong, given that this material has only been field-tested once in each country and only one-half of these materials are close to market-readiness (*i.e.* don't require additional crosses to add desired resistance or market characteristic traits)—butternut and melon in South Africa and melon in Indonesia. Therefore, the assumptions concerning the farm-level yield gain of these material drives these results. Market-level assumptions such as certification by seed companies, and wide adoption by farmers would certainly follow, if future releases actually embody the expected disease resistances—given that current varieties have few resistances. Other variables in the market model, such as elasticities and the change in the cost of production for each crop, have a minimal effect on the aggregate results. Finally, the elasticity assumptions only have a significant effect on the distribution of benefits between producers and consumers.

Table 7.5. *Ex Ante* Rates of Return to ABSP Investment in Cucurbits for South Africa and Indonesia, 1993-2018

Adoption Assumption for each crop	Yield Gain Assumption for each crop	Internal Rate of Return	Net Present Value (US\$ million)
Baseline ^a	Baseline ^a	46.5%	47.3
50% of baseline	Baseline	38.2%	22.3
Baseline	50% of baseline	34.7%	15.5
50% baseline	50% of baseline	27.1%	6.9

^aBaseline assumption refers to adoption and yield gain assumptions described in Sections 3, 4, 5 & 6, and presented together in Table 7.2.

²⁸ An investment with a rate of return higher than the opportunity cost of capital—the discount rate used in the analysis—is considered a profitable investment.

Model Choice. The choice of an open or closed model has a minimal influence on the rate of return to the investment. Employing an open small economy model for any of the target cucurbits results in a 3% higher NPV than that for the same commodity under a closed economy model. What the model choice significantly affect is whether or not domestic consumers will benefit from lower production costs in the given country. For example, in the case of zucchini, it is assumed that all additional zucchini production in South Africa will be exported (open model). Thus, the domestic zucchini price will not fall, consumers will see no direct benefit, and South African zucchini producers who adopt the new technology will reap all of the benefits. In contrast, we assume that for butternut in South Africa, additional production will not be exported. Thus, consumer prices will fall as domestic supply increases. In general, because most of the commodities in this study are not currently traded, we assume that they will not be traded in the near future. Thus, we expect that South African and Indonesian consumers would enjoy the benefits of lower retail cucurbit prices that would result from increased domestic production.

Distributional Results. In Indonesia, small-scale farmers and all consumers would benefit from disease-resistant cucumber varieties. Small-to-medium-scale farmers and higher-income consumers would benefit from disease-resistant melons. In addition, the incremental labor requirement generated by disease-resistant cucumber and melon production would be quite high, with much of the labor provided by women.

In South Africa, with the exception of butternut squash, the ABSP cucurbits are grown exclusively by large-scale (white) commercial farmers and consumed by white (high-income) South Africans. Thus, the majority of benefits in South Africa would go to higher-income producers and consumers. However, it is important to note that black laborers (principally women) would benefit from the increased employment that would be generated from an increase in the production of all the cucurbits and that black consumers would benefit from lower butternut retail prices.

Conclusions. The primary focus of this analysis was to use a simple model (which incorporates the most reliable and quantifiable benefit of yield gain, production cost savings, and adoption rates) to assess whether or not the potential benefits from developing disease-resistant cucurbit varieties for Indonesia and South Africa would generate a positive rate of return to the entire ABSP/Cornell cucurbits investment. These results—given the caveat of the level of uncertainty underlying the farm-level and market-level assumptions—indicate an affirmative answer to this research question. The secondary focus of this analysis was to use subsector analysis to investigate the potential distribution of these aggregate benefits among different types of producers and consumers. From the perspective of poverty reduction, it is clear that the distribution of potential benefits in Indonesia is ideal. The new disease-resistant cucurbit varieties will increase income and generate employment for small-scale farmers, and reduce the retail price for all cucumber consumers and higher-income melon consumers. On the other hand, the distribution of potential benefits in South Africa is less than ideal. The new disease-resistant varieties will increase the income of large-scale (white) growers and primarily reduce retail prices for high-income whites. Benefits for blacks would lie principally in labor generation for black women and lower retail prices for black consumers of butternut. The following section addresses the third focus of this analysis, which is to investigate lessons for sustaining and improving ABSP's investment impact and its distribution.

8. Institutional Issues in Technology Transfer

8.1 Introduction

As emphasized in the World Bank's *World Development Report 2002*, the development community is increasingly recognizing that strong institutions are required to improve market performance and to realize the potential benefits of new technologies. This section summarizes the institutional lessons emerging from ABSP-Cornell collaboration to date and provides suggestions as to how ABSP and Cornell can improve the potential aggregate and distributional impacts of their collaborative efforts.

8.2 ABSP-Cornell Collaboration

By supporting the Cornell cucurbits breeding program, ABSP has gained access to the human capital resources and wealth of genetic material embodied in Cornell's ongoing cucurbit-breeding program by paying only the marginal costs associated with transferring these breeding materials to developing countries.

A critical, yet challenging, task in impact analysis is formulating a hypothetical state of nature that "would" have occurred in the absence of an historic investment, program intervention, *etc.*, which has, in fact, been made. Thus, first, it is reasonable to ask whether or not the germplasm transfers that Cornell has made to several countries since 1997 would have occurred without ABSP funding. A second hypothetical question is—what has ABSP been funding Cornell to do? For example, if ABSP is simply sending funds to Cornell each year in order to gain access to Cornell's unparalleled collection of cucurbit germplasm, then ABSP could simply liaise between developing country seed companies and Cornell, and fund the additional cost required to transfer Cornell's breeding material to these countries. However, if ABSP is both gaining access to breeding material for transfer to developing countries and collaborating with local private seed companies to facilitate greater access to Cornell's extensive cucurbit-breeding experience (which helps to match the needs of seed companies with Cornell's genetic possibilities), it is clear that ABSP's support to Cornell strengthens and facilitates collaboration between Cornell and these private seed companies.

While some of the linkages between Cornell and private seed companies in the target countries were established prior to 1997, the additional funding provided by ABSP has enabled Dr. Jahn to extend the impact of her research on cucurbits to these (and other) developing countries. According to Dr. Jahn, without this additional funding, her program would not have been able to hire Mark Henning, who has coordinated the time-consuming arrangements required to establish international trials; thereby enabling Cornell to more effectively collaborate with private companies in the target countries. In addition, Dr. Jahn contends that as a result of ABSP funding, Cornell has been able to intensify its disease-resistance breeding efforts and thereby produce the multi-disease resistant lines that private companies need.

Thus, ABSP investment in Cornell's cucurbit program represents a marginal expense that has enabled ABSP to gain access to both Cornell's genetic and intellectual resources. While Cornell liaised with private seed companies in developing countries before ABSP began to fund these activities, ABSP's investment has enabled Cornell to expand this collaboration beyond the level that would have been possible without ABSP's investment. In this sense, ABSP's investment in the Cornell program has characteristics of a public good. Given the absence of perfect information concerning the genetic material available for cucurbit breeding, ABSP helps to alleviate this information gap by facilitating collaboration between Cornell and private sector seed companies in developing countries.

8.3 Linkages with Private Sector Companies

A key characteristic of Cornell's collaboration with developing countries has been its efforts to link with private sector seed companies in order to increase their capacity to develop and transfer improved cucurbits, as well as Cornell's willingness to share their genetic resources at no cost—unless the collaborator incorporates a trait in a commercial variety. To inform the private sector about the availability of their materials, Cornell invites vegetable seed companies from around the world to their annual field-day in August.

Importance of Working with the Private Sector. Throughout the world, the private sector is the dominant player in vegetable seed markets. However, U.S. public institutions still have a role to play in vegetable research. In both Indonesia and South Africa, the public sector is investing limited resources in cucurbit breeding, and often private sector companies have limited capacity to maintain a strong cucurbit-breeding program. Thus, by strengthening private sector breeding programs in developing countries, ABSP's support of Cornell's efforts creates large spillover benefits in the target countries.

Importance of Openness. Over the past 50 years, Cornell's cucurbit breeding program has shared its germplasm with private sector seed companies in the U.S. and in developing countries. For most of this period, Cornell has simply shared lines of interest with these companies and entrusted them to pay Cornell a small royalty fee, if the materials are incorporated into a commercial variety. These “handshake” agreements were often enforceable, given the personal relationships between Dr. Munger, Dr. Jahn and the seed companies' management and breeders.

However, in recent years, many seed companies have been bought by larger input firms and/or life sciences companies, whose personnel changes and strategic behavior have subsequently weakened these bonds of trust. In response to these changes, Cornell has formalized their relationship with collaborators by requiring them to sign a Material Transfer Agreement (MTA) before sharing promising cucurbit lines with private sector companies. In addition to helping Cornell protect its intellectual property, the MTAs ensure that Cornell receives financial compensation from material that is used by the private sector, which is increasingly important given decreases in federal and state funding for agricultural research in the U.S..

Currently, to access Cornell's material, companies must sign an MTA that specifies that if the company incorporates a Cornell line into a variety, it will pay Cornell a royalty that is based on sales (typically 5%, if one parent is from Cornell, and 10%, if two parents are from Cornell). Once a company signs an MTA, Cornell will share its cucurbit-breeding materials with the company.

8.4 Strengthening the ABSP/Cornell Private Sector Technology Development and Transfer Model

This study identifies four lessons for strengthening ABSP's and Cornell's efforts to develop and transfer new technology to the private sector in developing countries.

Socioeconomic Impact and Technology Transfer Should be Considered in the Planning Stage of a Project. In Indonesia, Cornell is collaborating with the country's strongest private sector vegetable seed company, and a company that gives priority to crops grown by small farmers—although this was not an explicit criteria for selecting E-W Seed as their collaborator. On the other hand, in South Africa, only one of the targeted crops is grown by what USAID considers to be resource-poor farmers.

This suggests that prior to initiating future collaborations, both a socio-economist and a Cornell breeder/plant pathologist should visit the “prospective” target country to identify the companies with which Cornell will collaborate, the crops that should be given priority, and the

relative importance of various disease constraints.

Sign MTAs with Multiple Companies in Each Country. Working with multiple companies in each country helps to ensure that one company doesn't have the market power to set monopoly prices on new varieties with valuable new traits which are unavailable to other domestic companies²⁹.

In Indonesia, Cornell is collaborating with a single company. While E-W Seed is the dominant seed company in Indonesia and an excellent partner, collaborating with a single firm creates the potential that the company may set monopoly prices for new varieties that incorporate the disease resistance embodied in Cornell's breeding material.

In South Africa, Cornell initially collaborated exclusively with Alpha Seed. However, in 2001, Cornell also established a collaborative relationship with Starke Ayres (Pannar). During the ABSP team's visit to South Africa in April 2001 (which included a Cornell program technician), the team met with representatives from the three largest vegetable seed companies in South Africa: Starke Ayres, Mayford, and Hygrotech. As a result of these contacts, it is likely that Cornell will expand collaborative linkages in South Africa. Cornell has already taken steps to maintain and increase its collaboration with Alpha Seed and Starke Ayres (Pannar) and has agreed to provide these seed companies any material in which they are interested.

In the future, ABSP/Cornell should identify more than a single seed company collaborator in each target country. Given Cornell's policy of being willing to share its cucurbit germplasm with any country that is willing to sign an MTA, this recommendation should not be difficult to implement.

Specify Technology Transfer Facilitation as an Activity in the Next Scope of Work. Although ABSP has done exemplary work in facilitating institutional capacity building for biotechnology, the most recent cucurbit scope of work for Cornell (Phase II in 1998) focuses on the science behind the proposed breeding work and gives only passing reference to technology transfer. This SOW does not discuss technology transfer, other than to say that Cornell has linkages with Seminis and E-W Seed, and that Egypt and Indonesia have an interest in cucumber.

In the future, ABSP should allocate funds to support a business development specialist/socio-economist who would be responsible for:

- a) Contacting private sector companies in the target countries to increase their awareness of the availability of Cornell germplasm,
- b) Traveling to the target countries to make private sector contacts, and
- c) Conducting an *ex-ante* socioeconomic assessment, prior to country selection, in order to assess the relative importance of alternative target crops and which socioeconomics groups would benefit from incorporating disease-resistance into these crops.

Understand the Limits and Challenges of Collaboration. The key to developing strong collaboration is that each partner recognizes its mutual responsibilities. For example, Cornell assisted AGERI (Egypt) by performing many crosses and sent them breeding material. However, due to institutional constraints, these materials were tested but not moved forward into their

²⁹ However, given the extensive international linkages of Indonesian and South African seed companies, competitor companies may gain access to disease-resistant cultivars by importing varieties with disease resistance. Thus, domestically-bred varieties are not the only source of competition the national seed market.

breeding program.

In contrast, the performance of Cornell's private sector partners in Indonesian (E-W Seed) and South African (Alpha Seeds) has been exemplary. Both companies provide detailed and timely status reports on field tests of Cornell materials, which better enables Cornell to respond to the specific needs and requirements of cucurbit production in the respective country.

Thus, the difficulty of assessing the capacity and willingness of a potential seed firm to be a strong collaborator further supports the recommendation that ABSP/Cornell should identify more than one collaborator in each target country.

8.5 Indonesia

It is appropriate for Cornell to collaborate with a private seed company in Indonesia, both because the government encourages private seed industry development and because there is a growing demand for vegetables.

In addition, the crops that Cornell has targeted are highly appropriate. First, viruses are a significant constraint to increasing cucumber and melon production. Second, as both crops are very labor intensive, they generate considerable employment in rural areas. Third, both crops are grown by small/landless farmers, thereby contributing to reducing income inequality. Finally, cucumber is consumed by all Indonesians, and although melon is primarily consumed by higher-income families, the government has targeted melon as a priority crop for export.

E-W Seed is a strong collaborative partner for Cornell. First, E-W Seed is one of the few vegetable seed company in Indonesia that has an in-country breeding program that breeds varieties for local conditions. Second, E-W Seed has an excellent research farm and strong technical and managerial capacity. Finally, E-W Seed has established an extensive seed marketing network, especially in Java—which will insure that new varieties will be widely disseminated.

However, opportunities exist for Cornell/ABSP to increase the impact of vegetable research in Indonesia. While E-W Seed has considerable capacity in breeding, its capacity in applied research (e.g., virology, entomology, socioeconomics) is less strong. In contrast, Indonesia's Vegetable Research Institute (VRI) has strong technical capacity in applied research, but it faces severe funding constraints. Thus, Cornell/ABSP should explore opportunities to provide a modest level of support to the VRI and to develop stronger linkages between VRI and E-W Seed, which has the potential to accelerate the rate of technology development of improved cucurbit varieties. Finally, in order to insure competition in the seed market, ABSP/Cornell should identify a second seed firm with whom the project could collaborate.

8.6 South Africa

In South Africa, Cornell has collaborated with several seed companies and has targeted high-value crops that generate good returns and employment—especially for black women. However, with the partial exception of butternut squash, the target ABSP crops are grown exclusively by relatively wealthy white farmers, and consumed entirely by whites (high-income consumers).

Thus, in South Africa, there exist opportunities to improve the distributional impacts of Cornell's breeding efforts. The best way for ABSP/Cornell to target black farmers is to work with cucurbits that they traditionally produce and consume by the black population—primarily pumpkins³⁰. While Cornell does not currently have a pumpkin breeding program, Dr. Robinson—a

³⁰ In the South African context, “pumpkin” refers to *Cucurbita maxima*. In contrast, the “Halloween pumpkin” grown in North America is *Cucurbita pepo*.

scientist in the Cornell research system—has such a program (he recently retired, and the status of his program is undecided). As explained in detail in Section 4, the idea that disease-resistant varieties will enable black farmers to participate in the zucchini, melon, and cucumber markets simply by providing varieties that don't require high fungicide and insecticide expenditures ignores two important facts. First, for all of the cucurbits, fungicide and insecticide expenditures do not make up a large portion of total costs. Second, viruses or fungi are not preventing blacks from participating in high-value vegetable markets in South Africa—rather, decades of apartheid have prevented their participation. The primary constraints faced by black farmers at the macro-level (*e.g.*, poor roads, geographic displacement) and micro-level (*e.g.*, knowledge, consumption preferences, capital, credit, prejudice) are beyond the scope of plant breeding. However, to better meet the need of black farmers, Cornell/ABSP *can* liaise with existing Agricultural Research Council projects (such as the Sustainable Rural Livelihoods Project) that target black farmers, as the private sector has so far only “talked” about targeting resource-poor farmers.

9. Summary and Recommendations

This study provides several key insights with respect to the characteristics of the cucurbit sub-sector in Indonesia and South Africa, the performance of Cornell's disease-resistant germplasm, the potential farm- and market-level economic impacts of this germplasm, institutional lessons, and opportunities to increase the impact of Cornell's collaboration with seed firms in these countries, as summarized below.

9.1 Summary

Subsector Analysis. The cucurbit subsectors in Indonesia (Section 3) and South Africa (Section 4) are important contributors to economic development and poverty alleviation in each country, as they are relatively high-value crops which employ substantial amounts of labor.

Subsector analysis shows that in *Indonesia*, cucumber is produced by small farmers throughout the country, and consumed by all Indonesians. While melon is produced by small yet higher-resource farmers, it is consumed primarily by higher-income Indonesians.

By contrast, in *South Africa*, zucchini, cucumber and melon are produced by large-scale (white) farmers and consumed by high-income whites. While these crops do generate labor for black women, they are not traditionally grown by small farmers, and the constraints faced by these farmers to produce these high-value crops cannot be alleviated solely through varietal improvement. An exception to this is butternut squash³¹, which is grown by both white and black farmers and consumed by all South Africans.

ABSP Field Trials. Recent field tests of the Cornell germplasm demonstrate that their sources of resistance appear to be valuable in the Indonesian and South African growing environments (Section 5). However, it is very difficult to estimate the potential yield gain from these resistant materials due to large uncertainty regarding the level of resistance of the Cornell materials in-country, the current disease incidence in each country, and the actual yield loss due to disease. Notwithstanding these uncertainties, estimates of the average yield loss to disease for each crop were constructed, based upon information from key informants as well as existing studies.

³¹ Black farmers traditionally produce pumpkins, although they have recently also begun to produce butternuts. Both of these cucurbits can be stored for months before consumption.

Farm- and Market-Level Analysis. Analysis of the farm-level benefits of disease-resistant cucurbits show that adopting farmers in both countries would likely pay higher input costs, but would enjoy higher net revenues (Section 6). Using assumed adoption rates—based upon subsector analysis of each cucurbit—the farm-level benefits are aggregated to the market level using a standard economic surplus model (Section 7). These aggregate benefits are then compared in a benefit-cost framework with past and (assumed) future investment costs borne by ABSP and private sector seed companies in the development of these varieties. Under various scenarios—each with strong assumptions (*i.e.*, minimal empirical data are available to estimate potential farmlevel benefits) regarding actual farm-level benefits as well as adoption rates—the rate of return to ABSP investment is positive. Under the baseline scenario, the internal rate of return to ABSP's investment in Indonesia and South Africa is 46.5% and the net present value (discounted net social gains) is US\$47.3 million. The collaborating seed companies in Indonesia and South Africa could potentially increase their gross revenues by US\$4.5 million, as a result of incorporating disease-resistance into their future cucurbit varieties.

Sensitivity analysis demonstrates that when using 50% of the baseline adoption rates and 50% of the baseline farm-level expected yield gain from disease-resistant cucurbit varieties, the rate of return is still favorable at 27.1% and the net present value is US\$6.9 million. With respect to poverty alleviation, the distribution of benefits and labor generation in Indonesia is ideal. By contrast, the distribution of benefits in South Africa is less than ideal, although the ABSP target cucurbits do generate labor for black women.

9.2 Recommendations

Institutional Lessons to Date. There are several institutional lessons that can be drawn from the ABSP/Cornell model of technology development and transfer (Section 8). First, by supporting Cornell's cucurbits breeding program, ABSP has gained access to the human capital resources and wealth of genetic material embodied in Cornell's ongoing cucurbit program by paying only the marginal costs associated with transferring these breeding materials to developing countries. Second, a key characteristic of Cornell's collaboration with developing countries has been its effort to link with local private sector firms in order to increase these firms' capacity to develop and transfer improved cucurbit varieties. In both Indonesia and South Africa, the project has been very successful in developing collaborative linkages with private sector seed companies. Finally, Cornell has shared its genetic resources with private seed companies at no cost and signs an MTA with each company, which only requires that it pay royalties to Cornell if the company incorporates a trait in a commercial variety. These policies are to be commended, as they encourage companies to test Cornell's breeding material, first, because it is readily available and, second, because the companies do not have to make any payment to Cornell unless they actually use it in a commercial variety.

Institutional Keys to Improving Potential Impact. There are several general institutional issues which could help ABSP to increase potential future impacts of improved cucurbit varieties. First, issues related to technology transfer and the socioeconomic impact of new technology should be considered in the initial stage of formulating the new project. In the future, ABSP should specify in the scope of work both socioeconomic evaluation and technology transfer facilitation, as specific activities. These activities should be conducted early in the project, in order to guide priorities with respect to target crops and potential private sector collaborators. Second, when building linkages with private sector firms, public institutions (like Cornell) should try to collaborate with more than

a single seed company³² in each target country. This is recommended to avoid the possibility of monopoly pricing and to increase the probability of developing a successful collaborative linkage in each country—given the difficulty of assessing a company’s capacity when selecting companies with whom to collaborate..

Country-Specific Issues. Finally, there are several key issues specific to Indonesia and South Africa that could increase the potential future impact of disease-resistant cucurbits, as well as the distribution of benefits from these technologies.

In Indonesia, ABSP is collaborating with both the largest vegetable seed firm, as well as the only firm with an in-country breeding program. The Indonesian crops (cucumber and melon) that Cornell has targeted are appropriate, given that viruses are a significant constraint to increasing production, both crops are very labor intensive, and both crops are grown by small/landless farmers. In addition, cucumber is eaten by all consumers, and although melon is primarily consumed by higher-income families, the government has targeted melon as a priority crop for export. However, opportunities exist for Cornell/ABSP to increase the impact of vegetable research in Indonesia. While E-W Seed has considerable capacity in breeding, its capacity in applied research is less strong. In contrast, Indonesia’s Vegetable Research Institute (VRI) has strong technical capacity in applied research, but faces severe funding constraints. Thus, Cornell/ABSP should explore opportunities to provide a modest level of support to the VRI and to develop stronger linkages between VRI and E-W Seed, which has the potential to accelerate the rate of progress in developing improved cucurbit varieties.

In South Africa, Cornell has collaborated with several seed firms, has targeted high-value crops that generate good returns but which are threatened by viruses and fungi, and these crops generate labor for black female laborers. However, with the partial exception of butternut squash (which is grown and consumed by both whites and blacks), the target ABSP cucurbits are grown exclusively by relatively wealthy white farmers, and consumed entirely by whites (high-income consumers). Thus, there exist opportunities to improve the distributional impacts of Cornell’s breeding efforts. The best way for ABSP/Cornell to target black farmers and consumers is to work with cucurbits that blacks traditionally produce and consume—primarily pumpkins. To do this, Cornell will need to liaise with existing Agricultural Research Council projects that target black farmers, as the private sector has yet to market seed to resource-poor farmers.

³² At the least, ABSP should ensure that the Cornell cucurbit program continues its informal policy of not granting an exclusive license for a given trait or line to one company in a country.

References

- Agribusiness Development Project. 1993. An Overview of the Fresh Vegetable Subsector in Indonesia. ADP Working Paper No. 12. Jakarta, Indonesia.
- Alston, Julian, George Norton, and Philip Pardey. 1998. *Science Under Scarcity: Principles and Practices for Agricultural Research and Priority Setting*. Cornell University Press, Ithaca, NY.
- Byerlee, Derek, and Steven Franzel. 1993. Institutionalizing the Role of Economists in National Agricultural Research Institutes. CIMMYT Economics Working Paper 93-01, CIMMYT, Mexico, D.F..
- Cradock, K.R.. 1998. Control of Insect-Transmitted Viruses in Cucurbits in Kwazulu Natal. Unpublished M.Sc. Thesis, University of Natal.
- East West Seed (P.T) Indonesia. 2001. Inovasi Baru...Benih Unggul Sayuran (New Innovation, Superior Vegetable Seed [seed catalogue]).
- Ferrari, Maria F. 1994. *20 Years of Horticulture in Indonesia: The Vegetable Sub Sector. Working Paper 15*, CGPRT Centre, Bogor Indonesia.
- Gittinger, J. Price. 1982. *Economic Analysis of Agricultural Projects*, The World Bank, Johns Hopkins University Press, Washington, D.C.
- Gunaeni, Neni, Uun Sumpena, dan Yenni Kusandriani. 2000. Evaluasi Plasma Nutfah Mentimun Terhadap Penyakit Zucchini Yellow Mosaic Virus (Evaluation of Cucumber Germ Plasm on Zucchini Yellow Mosaic Virus Disease). In *Prosiding Kongres Nasional XV dan Seminar Ilmiah PFI, Purwokerto, 16-18 September 1999*, 346-353. Purwokerto Universitas Jenderal Sudirman.
- Holtzman, J.S. 1986. Rapid Reconnaissance Guidelines for Agricultural Marketing and Food System Research in Developing Countries. International Development Working Paper No.30, Department of Agricultural Economics, Michigan State University, East Lansing, MI.
- Indonesia, Government of (GOI), Badan Pusat Statistics (Bureau of Central Statistics). 2001 (a). Area and Production of Melon by Province of Indonesia in 1999. Special data run.
- _____, _____. 2001(b). Area Harvested, Production, and Yield of Cucumber by Province in Indonesia, 1990-1999. Special data run.
- _____, _____. 2001 (c). Production of Cucumber Partly Harvested, Entirely Harvested, and Total by Month by Regency of West Java in 1999. Special data run.
- _____, _____. 2001 (d). Area of Cucumber Partly Harvested, Entirely Harvested, and Total by Month by Regency of West Java in 1999. Special data run.

- _____, _____. 2000 (a). *Statistik Indonesia, 1999 (Statistical Pocketbook of Indonesia, 1999)*. Jakarta, Indonesia, June.
- _____, _____. 2000 (b). *Survei Pertanian Produksi Tanaman Sayuran Dan Buah-Buahan 1999 (Agricultural Survey Production of Vegetables and Fruit Crops, 1999)*. Jakarta, Indonesia.
- _____, _____. 2000 (c). *Survei Struktur Ongkos USAHA Hortikultura, 1997 (Cost Structure Survey of Horticulture Production 1997)*, Jakarta, Indonesia.
- _____, _____. 1999. *Survei Pertanian Produksi Tanaman Sayuran Dan Buah-Buahan 1998 (Agricultural Survey Production of Vegetables and Fruit Crops, 1998)*. Jakarta, Indonesia.
- _____, _____. 1998. *Survei Pertanian Produksi Tanaman Sayuran Dan Buah-Buahan 1998 (Agricultural Survey Production of Vegetables and Fruit Crops, 1997)*. Jakarta, Indonesia.
- _____, Departmen Pertanian. 1998. License of Cultivated Seed Production, License of Seed Imports, and Cultivated Seed Exports. *Decree of the Minister of Agriculture: No. 1017/Kpts/TP.120/12/98*, Jakarta, Indonesia.
- _____, Direktorat Jenderal Bina Produksi Hortikultura (Directorate General for Horticulture Production). 2001. *Pedoman Pengembangan Sentra Agribisnis Berbasis Melon (Guideline for Developing the Center for Agribusiness for Melons)*, mimeo (draft).
- _____, Pusat Tanaman Pangan (National Seed Board). 2001. *Seed Import Data for Cucumber and Melon in 2000 (fax)*.
- Menegay, Merle, R., Budiman Hutabarat, Masjidin Siregar, and P.T. Intersys Kelola Maju. 1993. *An Overview of the Fresh Vegetable Subsector in Indonesia*. Indonesia Agribusiness Development Project, ADP Working Paper No. 12, Development Alternatives International, Jakarta, Indonesia.
- Pasar Induk. 2001 (a). *Panduan Bisnis dan Belanja di Pasar Induk Kramat Jati Jakarta Timur (Buying and Selling Guideline in Central Market of Kramat Jati)*, Jakarta, Indonesia.
- Pasar Induk. 2001 (b). *Daily Wholesale Prices of Vegetables (data base obtained from the market manager at Pasar Induk with data for January 1999-March 2001)*.
- Shaffer, James D. 1973. On the Concept of Subsector Studies. *American Journal of Agricultural Economics*, 5: 333-335.
- Singh, S.B. 1994. Indonesian Country Report No. 5. Asian and Pacific Seed Association, Bangkok, Thailand.
- South Africa, Government of (GOSA). 2001. National Department of Agriculture (NDA), *Abstract of Agricultural Statistics*.

_____, _____. 2000. National Department of Agriculture (NDA). *Employment Trends in Agriculture*.

_____, _____. Statistics South Africa. 1999. *The People of South Africa Population Census, 1996*. Pretoria.

Survey. 2001. Survey of 45 Irrigated Cucumber Farmers in Bekasi and Perwakarta, West Java. March.

Sutarya, Rakhmat. 1994. Deteksi Penyakit Yang Disembabkan Oleh Virus Pada Tanaman Ketimun Di KP Subang, Kabupaten Brebes an Tegal (Detection of Virus Diseases on Cucumber in KP Subang, Kabupaten Brebes and Tegal). *Buletin Penelitian Hortikultura*, Vol XXVII No. 1, 99-105.

Sutarya, R. dan U. Sumpena. 1994. Studi Kehilangan Hasil Yang Disebabkan Oleh ZYMV (Zucchini Yellow Mosaic Virus) Pada Tiga Kultivar Mentimun [Study of Yield Loss due to ZYMV (Zucchini Yellow Mosaic Virus) on Three Cucumber Cultivars]. *Buletin Penelitian Hortikultura*, Vol XXVII No. 1, 170-175.

Sutarya, R., and A.S. Duriat. 1997. Pengaruh Waktu Inokulasi ZYMV (Zucchini Yellow Mosaic Virus) Terhadap Pertumbuhan Dan Hasil Pada Tanaman Mentimun [Effect of ZYMV (Zucchini Yellow Mosaic Virus) Inoculation Time on Cucumber Growth and Yield]. In *Kongres Nasional XII dan Seminar Ilmiah PFI, Mataram*, 27-29 September 1995, Mataram: Perhimpunan Fitopatologi, 449-452.

Takagi, Chifumi. 2001. Study of the Vegetable Farmers Marketing Models: A Case Study of West Java. Unpublished M.Sc. Thesis, University of Ryukyus, Okinawa, Japan. March 1.

van der Meer, F.W. 1995. Identification, Characterization and Strain Differentiation of WMV in South Africa. Unpublished M.Sc. Thesis, University of Witvatersrand.

von Wechmar, M.B., M.A. Jaffer, and M. Purves. 1994. ZYMV and Other Cucurbit-Infecting Viruses in South Africa: 1989-1993. 32nd Congress, South African Society of Plant Pathology.

Williamson, Oliver. 1985. *The Economic Institutions of Capitalism*. Free Press.

World Bank (IADB). 2002. *World Development Report 2002*. Oxford University Press.

World Bank (IBRD). 1997. *World Development Report 1997*. Oxford University Press.

Appendix I. Tables

Appendix Table 1 (a). Area Harvested, Production, and Yield of Cucumber, by Province, Indonesia, 1990-1992

Province	1990			1991			1992		
	Harvested area (ha)	Production (mt)	Yield (kg/ha)	Harvested area (ha)	Production (mt)	Yield (kg/ha)	Harvested area (ha)	Production (mt)	Yield (kg/ha)
Sumatra									
Aceh	2,528	6,259	2,476	4,430	10,007	2,259	4,026	5,949	1,478
North Sumatra	2,721	17,967	6,603	2,806	21,912	7,809	2,241	16,043	7,159
West Sumatra	999	1,948	1,950	1,046	2,275	2,175	801	1,714	2,140
Riau	1,402	4,169	2,974	1,369	9,909	7,238	1,340	5,590	4,172
Jambi	810	1,066	1,316	653	1,082	1,657	673	784	1,165
South Sumatra	1,435	3,318	2,312	2,717	5,734	2,110	2,468	5,216	2,113
Bengkulu	2,750	55,987	20,359	3,722	47,226	12,688	5,169	62,989	12,186
Lampung	1,268	1,643	1,296	1,234	2,483	2,012	22	106	4,818
Java & Madura									
Jakarta	435	3,328	7,651	332	2,808	8,458	269	1,684	6,260
West Java	20,144	96,265	4,779	19,256	102,649	5,331	20,780	111,569	5,369
Central Java	2,474	9,783	3,954	3,032	15,005	4,949	3,050	11,205	3,674
Yogyakarta	143	347	2,427	175	528	3,017	240	1,221	5,088
East Java	3,509	12,495	3,561	3,087	10,509	3,404	3,022	11,762	3,892
Bali & Nusatenggara									
Bali	1,141	8,089	7,089	891	4,492	5,042	590	2,368	4,014
West Nusa Tenggara	904	2,212	2,447	918	1,511	1,646	847	1,643	1,940
East Nusa Tenggara	528	1,097	2,078	488	687	1,408	440	1,002	2,277
East Timor	18	9	500	N/A	N/A	N/A	7	5	714
Kalimantan									
West Kalimantan	2,386	5,644	2,365	2,384	6,744	2,829	2,237	6,297	2,815
Central Kalimantan	801	4,608	5,573	709	2,009	2,834	812	3,664	4,512
South Kalimantan	1,125	4,209	3,741	1,141	3,737	3,275	1,082	3,847	3,555
East Kalimantan	1,181	6,585	5,576	1,109	3,853	3,474	1,198	4,846	4,045
Sulawesi									
North Sulawesi	424	303	715	633	1,766	2,790	284	540	1,901
Central Sulawesi	986	2,137	2,167	854	983	1,151	1,057	636	602
South Sulawesi	1,090	2,225	2,041	1,489	3,452	2,318	1,030	3,320	3,223
Southeast Sulawesi	302	628	2,079	454	628	1,383	576	1,200	2,083
Maluku & Irian Jaya									
Maluku	270	1,562	5,785	370	1,938	5,238	215	818	3,805
Irian Jaya	469	1,273	2,714	493	4,274	8,669	568	2,418	4,257
Total	52,243	255,156	4,884	55,792	268,201	4,807	55,044	268,436	4,877

Source: GOI, BPS, 2001 (b).

Appendix Table 1 (b). Area Harvested, Production, and Yield of Cucumber, by Province, Indonesia, 1993-1995

Province	1993			1994			1995		
	Harvested area (ha)	Production (mt)	Yield (kg/ha)	Harvested Area (ha)	Production (mt)	Yield (kg/ha)	Harvested area (ha)	Production (mt)	Yield (kg/ha)
Sumatra									
Aceh	3,163	6,712	2,122	2,497	5,256	2,105	2,405	6,360	2,644
North Sumatra	2,561	10,505	4,102	2,352	9,345	3,973	3,513	25,761	7,333
West Sumatra	679	1,699	2,502	1,087	3,298	3,034	1,069	3,400	3,181
Riau	769	4,143	5,388	1,278	5,485	4,292	1,168	4,127	3,533
Jambi	661	3,061	4,631	936	1,660	1,774	942	2,400	2,548
South Sumatra	2,468	5,216	2,113	1,513	2,528	1,672	1,790	2,134	1,192
Bengkulu	5,721	70,809	12,377	4,237	43,273	10,213	4,375	50,947	11,645
Lampung	1,474	2,912	1,976	1,215	1,869	1,538	2,438	3,436	1,409
Java & Madura									
Jakarta	156	952	6,103	50	312	6,240	N/A	N/A	N/A
West Java	20,306	108,025	5,320	20,821	148,898	7,151	N/A	N/A	N/A
Central Java	3,099	13,686	4,416	2,779	12,719	4,577	N/A	N/A	N/A
Yogyakarta	178	1,035	5,815	180	598	3,322	N/A	N/A	N/A
East Java	12,307	7,470	3,238	2,384	10,469	4,391	N/A	N/A	N/A
Bali & Nusa Tenggara									
Bali	484	4,572	9,446	757	11,906	15,728	439	3,535	8,052
West Nusa Tenggara	587	1,608	2,739	922	2,356	2,555	1,052	3,952	3,757
East Nusa Tenggara	239	834	3,490	402	927	2,306	516	2,260	4,380
East Timor	66	247	3,742	18	20	1,111	80	61	763
Kalimantan									
West Kalimantan	2,021	5,733	2,837	1,980	4,996	2,523	2,461	6,910	2,808
Central Kalimantan	826	2,528	3,061	778	840	1,080	1,209	1,707	1,412
South Kalimantan	1,157	2,637	2,279	1,072	2,082	1,942	1,123	2,480	2,208
East Kalimantan	1,235	7,535	6,101	1,218	3,730	3,062	1,460	8,176	5,600
Sulawesi									
North Sulawesi	250	955	3,820	290	456	1,572	269	1,938	7,204
Central Sulawesi	1,084	1,885	1,739	2,006	1,702	848	1,057	2,330	2,204
South Sulawesi	1,101	2,837	2,577	994	2,857	2,874	1,148	3,409	2,970
Southeast Sulawesi	301	403	1,339	369	439	1,190	438	760	1,735
Muluku & Irian Jaya									
Maluku	250	967	3,868	729	1,301	1,785	646	2,908	4,502
Irian Jaya	400	1,119	2,798	574	1,611	2,807	487	1,357	2,786
Total	53,543	270,085	5,044	53,438	280,934	5,257	NA	NA	NA

Source: GOI, BPS, 2001 (b).

Appendix Table 1 (c). Area Harvested, Production, and Yield of Cucumber, by Province, Indonesia, 1996-1998

Province	1996			1997			1998		
	Harvested area (ha)	Production (mt)	Yield (kg/ha)	Harvested area (ha)	Production (mt)	Yield (kg/ha)	Harvested area (ha)	Production (mt)	Yield (kg/ha)
Sumatra									
Aceh	2,555	10,068	3,941	2,584	6,020	2,330	1,799	4,547	2,528
North Sumatra	4,230	23,329	5,515	3,677	17,180	4,672	4,574	25,439	5,562
West Sumatra	1,146	3,476	3,033	997	2,711	2,719	950	2,339	2,462
Riau	1,497	4,800	3,206	1,405	4,050	2,883	1,390	3,766	2,709
Jambi	979	3,731	3,811	674	1,344	1,994	1,239	2,584	2,086
South Sumatra	1,928	4,375	2,269	2,463	5,055	2,052	2,937	5,219	1,777
Bengkulu	4,779	48,495	10,148	3,370	36,578	10,854	3,475	41,889	12,054
Lampung	1,936	13,807	7,132	1,593	2,751	1,727	1,904	1,905	1,001
Java & Madura									
Jakarta	79	165	2,089	24	113	4,708	84	269	3,202
West Java	19,169	63,173	3,296	18,843	155,375	8,246	19,470	146,150	7,506
Central Java	3,078	9,934	3,227	3,089	16,278	5,270	2,609	11,947	4,579
Yogyakarta	338	528	1,562	270	1,067	3,952	246	1,056	4,293
East Java	2,511	6,897	2,747	2,466	12,209	4,951	2,803	13,285	4,740
Bali & Nusantara									
Bali	390	2,052	5,262	355	1,497	4,217	444	2,652	5,973
West Nusa Tenggara	890	2,801	3,147	629	1,925	3,060	533	860	1,614
East Nusa Tenggara	428	2,211	5,166	422	668	1,583	472	1,046	2,216
East Timor	60	54	900	62	72	1,161	129	135	1,047
Kalimantan									
West Kalimantan	2,641	8,225	3,114	3,251	10,692	3,289	2,550	6,579	2,580
Central Kalimantan	1,024	2,582	2,521	1,029	2,219	2,156	1,532	2,061	1,345
South Kalimantan	878	1,762	2,007	910	1,381	1,518	1,016	1,982	1,951
East Kalimantan	1,545	8,394	5,433	1,297	4,974	3,835	1,523	5,022	3,297
Sulawesi									
North Sulawesi	216	364	1,685	218	315	1,445	127	358	2,819
Central Sulawesi	784	2,385	3,042	658	2,306	3,505	694	1,938	2,793
South Sulawesi	1,431	4,541	3,173	1,309	3,826	2,923	1,204	2,516	2,090
Southeast Sulawesi	410	756	1,844	574	1,049	1,828	635	600	945
Muluku & Irian Jaya									
Maluku	648	3,536	5,457	410	1,656	4,039	220	152	691
Irian Jaya	485	1,128	2,326	270	400	1,481	342	469	1,371
Total	56,055	233,569	4,167	52,849	293,711	5,558	54,901	286,765	5,223

Source: GOI, BPS, 2001 (b).

Appendix Table 1 (d). Area Harvested, Production, and Yield of Cucumber, by Province, Indonesia, 1999

Province	Entirely Harvested Fields			Partly Harvested Fields		Total			
	Harvested area (ha)	Production (mt)	Yield (kg/ha)	Harvested area (ha)	Production (mt)	Harvested area (ha) ^a	Production (mt) ^b	Percent of Production	Adjusted Yield (kg/ha)
Sumatra									
Aceh	2,514	8,535	3,395	1,861	6,069	2,514	14,604	3.4	5,809
North Sumatra	3,653	20,285	5,553	2,347	17,287	3,653	37,572	8.7	10,285
West Sumatra	823	2,213	2,689	508	1,174	823	3,387	0.8	4,115
Riau	1,273	4,079	3,204	1,347	3,373	1,273	7,452	1.7	5,854
Jambi	1,054	3,034	2,879	1,078	2,254	1,054	5,288	1.2	5,017
South Sumatra	2,063	3,590	1,740	2,903	9,339	2,063	12,929	3.0	6,267
Bengkulu	2,460	29,689	12,069	667	1,731	2,460	31,420	7.3	12,772
Lampung	1,456	3,424	2,352	1,826	2,403	1,456	5,827	1.3	4,002
Java & Madura									
Jakarta	117	369	3,154	227	1,079	117	1,448	0.3	12,376
West Java	17,136	120,012	7,004	13,672	79,604	17,136	199,616	46.2	11,649
Central Java	2,747	13,797	5,023	2,320	10,492	2,747	24,289	5.6	8,842
Yogyakarta	259	690	2,664	243	700	259	1,390	0.3	5,367
East Java	2,377	9,994	4,204	2,870	9,743	2,377	19,737	4.6	8,303
Bali & Nusatenggara									
Bali	464	2,897	6,244	353	5,669	464	8,566	2.0	18,461
West Nusa Tenggara	546	1,031	1,888	589	1,639	546	2,670	0.6	4,890
East Nusa Tenggara	605	793	1,311	394	911	605	1,704	0.4	2,817
East Timor	NA	NA	NA	NA	NA	NA	NA	NA	NA
Kalimantan									
West Kalimantan	2,023	6,275	3,102	2,003	4,891	2,023	11,166	2.6	5,520
Central Kalimantan	979	1,924	1,965	1,494	2,296	979	4,220	1.0	4,311
South Kalimantan	845	1,884	2,230	509	1,130	845	3,014	0.7	3,567
East Kalimantan	1,372	7,487	5,457	1,339	5,720	1,372	13,207	3.1	9,626
Sulawesi									
North Sulawesi	133	575	4,323	112	382	133	957	0.2	7,195
Central Sulawesi	1,084	5,458	5,035	827	3,816	1,084	9,274	2.1	8,555
South Sulawesi	1,109	2,996	2,702	1492	4,520	1,109	7,516	1.7	6,777
Southeast Sulawesi	718	1,349	1,879	902	1,737	718	3,086	0.7	4,298
Muluku & Irian Jaya									
Maluku	44	245	5,568	28	105	44	350	0.1	7,955
Irian Jaya	267	824	3,086	171	437	267	1,261	0.3	4,723
Total	48,121	253,449	5,267	42,082	178,501	48,121	431,950	100.0	8,976

^aTotal Harvested Area is equal to the harvested area of the "Entirely Harvested fields". ^bTotal Production is equal to the equal to the sum of production on "Entirely Harvested Fields" plus "Partly Harvested Fields".

Source: GOI, BPS, 2001 (b); GOI, BPS, 2001 (c); and GOI, BPS, 2001 (d).

Appendix Table 2 (a). Production of Cucumber (quintal) Entirely Harvested, by Month and Regency, West Java, Indonesia, 1999

Regency	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Bandung	5,565	2,208	315	1,629	658	875	2,239	415	208	1,462	532	2,042	18,148
Bekasi	6,698	11,602	3,500	3,595	1,818	4,672	5,530	2,324	7,665	6,859	4,900	7,123	66,286
Bogor	9,533	6,612	7,718	7,587	8,412	12,570	12,317	7,938	11,976	12,226	6,997	10,331	114,217
Ciamis	3,049	1,798	1,001	1,794	4,588	3,609	3,132	4,470	3,325	1,867	2,126	1,406	32,165
Cianjor	11,568	9,284	9,073	8,058	10,992	13,775	15,057	14,860	8,717	9,585	6,265	11,959	129,193
Cirebon	1,554	690	1,661	1,836	2,208	2,133	7,862	2,449	1,913	3,804	2,617	799	29,526
Garut	15,469	4,257	15,799	3,247	5,306	7,102	6,056	10,549	4,784	16,689	5,801	6,788	101,847
Indramayu	764	486	3,836	585	21,507	1,247	1,594	803	821	8,169	3,040	2,040	44,892
Karawang	3,295	2,537	4,236	2,461	3,925	3,829	3,378	1,683	9,865	5,580	10,043	3,067	53,899
Kuningan	75	0	120	40	150	200	96	90	30	87	140	0	1,028
Lebak	4,932	8,194	4,939	1,436	3,543	4,165	4,823	3,502	4,324	6,164	5,661	9,289	60,972
Majalengka	11,460	350	1,396	8,876	8,699	3,509	1,437	19,448	7,490	4,769	1,530	10,275	79,239
Pandeglang	2,368	2,424	698	314	750	2,861	1,516	840	998	1,568	891	1,877	17,105
Purwakarta	2,304	2,549	1,183	1,810	2,412	993	2,790	3,279	1,958	3,723	3,033	3,060	29,094
Serang	11,045	6,631	6,618	3,643	6,513	7,236	6,308	7,033	6,091	3,441	2,238	3,368	70,165
Subang	8,662	7,906	7,962	7,679	12,531	7,123	9,274	6,836	9,006	39,965	11,839	2,687	131,470
Sukabumi	4,130	3,294	5,029	2,963	1,986	3,529	3,450	5,128	4,737	4,610	4,350	5,604	48,810
Sumedang	2,742	3,073	6,362	2,080	4,038	138	2,060	4,372	4,388	3,997	1,188	814	35,252
Tangerang	12,379	13,076	6,022	5,129	6,157	6,597	9,237	5,641	6,129	4,501	20,239	5,718	100,825
<u>Tasikmalaya</u>	<u>3,907</u>	<u>4,651</u>	<u>1,886</u>	<u>2,659</u>	<u>2,441</u>	<u>1,800</u>	<u>3,088</u>	<u>3,280</u>	<u>3,107</u>	<u>3,502</u>	<u>3,484</u>	<u>2,181</u>	<u>35,986</u>
Total	121,499	91,622	89,354	67,421	108,634	87,963	101,244	104,940	97,532	142,568	96,914	90,428	1,200,119

1 quintal = 100 kg

Source: GOI, BPS, 2001 (c).

Appendix Table 2 (b). Production of Cucumber (quintal) Partly Harvested, by Month and Regency, West Java, Indonesia, 1999

R e g e n c y	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Bandung	711	204	39	118	1,144	188	657	840	606	310	0	868	5,685
Bekasi	5,329	674	936	1,101	1,966	993	726	6,394	2,846	4,143	3,626	2,176	30,910
Bogor	7,641	6,369	5,859	6,487	6,338	6,685	5,529	7,285	7,267	6,450	9,727	11,106	86,743
Ciamis	1,598	1,133	747	2,218	3,085	1,777	1,932	2,613	2,387	1,170	382	2,906	21,948
Cianjor	1,236	982	970	866	904	1,406	1,815	902	1,672	1,294	908	638	13,593
Cirebon	452	1,077	628	965	1,357	5,184	822	1,320	2,494	510	120	516	15,445
Garut	10,900	6,191	2,114	5,057	11,170	6,543	11,187	11,522	12,064	6,736	4,181	55,994	143,659
Indramayu	4,439	5,168	2,050	22,884	2,520	1,732	1,237	3,186	2,729	2,090	604	632	49,271
Karawang	2,628	6,266	3,600	6,461	4,031	5,119	3,885	14,269	4,126	6,659	701	2,290	60,035
Kuningan	0	0	25	0	18	18	0	36	46	18	0	150	311
Lebak	5,033	7,755	1,794	2,128	2,661	6,337	3,985	2,572	4,778	5,413	6,432	10,477	59,365
Majalengka	1,442	125	9,561	6,670	3,296	1,699	3,746	6,489	1,969	4,380	3,900	9,852	53,129
Pandeglang	430	167	556	478	976	712	1,451	1,395	734	865	592	2,092	10,448
Purwakarta	2,548	1,064	1,227	2,328	1,518	1,437	2,335	1,355	3,877	675	818	1,190	20,372
Serang	2,799	2,941	1,316	1,602	3,126	2,041	4,836	4,949	1,957	1,680	1,339	5,516	34,102
Subang	3,901	5,317	3,475	3,927	4,240	4,212	3,556	7,176	8,245	919	695	1,720	47,383
Sukabumi	2,515	1,427	3,266	2,476	1,758	2,489	1,732	2,470	2,834	1,021	2,848	2,230	27,066
Sumedang	3,058	3,366	2,984	8,243	1,387	3,318	4,630	3,944	3,731	1,634	216	2,698	39,209
Tangerang	4,285	4,145	5,088	3,637	3,130	4,632	5,096	5,092	2,420	1,215	4,868	4,890	48,598
<u>Tasikmalaya</u>	<u>1,141</u>	<u>2,395</u>	<u>2,326</u>	<u>2,412</u>	<u>2,200</u>	<u>3,708</u>	<u>3,335</u>	<u>2,458</u>	<u>700</u>	<u>2,712</u>	<u>2,233</u>	<u>3,150</u>	<u>28,770</u>
Total	62,086	56,766	48,561	80,058	56,825	60,230	62,492	86,267	67,482	49,894	44,290	121,091	796,042

1 quintal = 100 kg

Source: GOI, BPS, 2001 (c).

Appendix Table 3. Budgets for Without and With Diseases-Resistant Varieties, Indonesia

Cucumber		WITHOUT					WITH				
2000 Indonesia		Unit	Rupiah per unit	Quantity	Rp / ha	% total Var cost	Unit	Rupiah per unit	Quantity	Rp / ha	% total Var cost
Gross Revenue											
	Product Income	MT	560,000	31.2	17,472,000			560,000	35.9	20,092,800	
Gross Revenue less Marketing Costs					17,472,000					20,092,800	
Inputs	Seed				600,000	5.3%				780,000	6.8%
	Fertilizer				1,773,294	15.7%				1,773,294	15.4%
	Folial fertilizer				171,877	1.5%				171,877	1.5%
	Manure				281,883	2.5%				281,883	2.5%
	Plastic mulch				275,000	2.4%				275,000	2.4%
	Stakes				466,973	4.1%				466,973	4.1%
	Insecticide				570,415	5.0%				484,853	4.2%
	Herbicide				181,339	1.6%				181,339	1.6%
	Fungicide				210,277	1.9%				178,735	1.6%
	Ropes				127,032	1.1%				127,032	1.1%
	Sacks				272,100	2.4%				272,100	2.4%
	Other				111,000	1.0%				111,000	1.0%
	Rent				985,614	8.7%				985,614	8.6%
					6,026,804	53.2%				6,089,700	53.0%
Labor	Land Preparation		81.5		1,142,049	10.1%		81.5		1,142,049	9.9%
	Planting		29		786,094	6.9%		29		786,094	6.8%
	Bedding		56		367,722	3.2%		56		367,722	3.2%
	Fertilizing		52		272,513	2.4%		52		272,513	2.4%
	Watering		65		632,759	5.6%		65		632,759	5.5%
	Staking		28		197,321	1.7%		28		197,321	1.7%
	Spraying		40		413,452	3.7%		34		351,434	3.1%
	Roping		64		336,136	3.0%		64		336,136	2.9%
	Havesting		214		1,143,905	10.1%		246.1		1,315,491	11.4%
			629.5		5,291,951	46.8%		655.6		5,401,519	47.0%
Total Variable Costs					11,318,755					11,491,219	
Net Revenue					6,153,245					8,601,581	

Melon		WITHOUT						WITH					
2000 Indonesia		Unit	Rupiah per unit	Quantity	Rp / ha	% total Var cost		Unit	Rupiah per unit	Quantity	Rp / ha	% total Var cost	
Gross Revenue													
	Product Income	MT	1,331,000	26	34,606,000				1,331,000	29.9	39,796,900		
Gross Revenue less Marketing Costs					34,606,000			39,796,900					
Inputs	Seed			3,750,000	3,750,000	16.2%					5,000,625	20.5%	
	Fertilizer			5,117,400	1,773,294	7.7%					1,773,294	7.3%	
	Insecticide			1,740,000	1,740,000	7.5%					1,479,000	6.1%	
	Fungicide			625,000	625,000	2.7%					531,250	2.2%	
	Stakes			1,790,000	467,000	2.0%					467,000	1.9%	
	Plastic for beds, seedlings, transplants			2,325,000	2,325,000	10.0%					2,325,000	9.5%	
	Other			2,750,000	2,750,000	11.9%					2,750,000	11.3%	
	Rent for land			2,000,000	1,000,000	4.3%					1,000,000	4.1%	
	bags for marketing			<u>500,000</u>	<u>500,000</u>	<u>2.2%</u>					<u>575,000</u>	<u>2.4%</u>	
				20,597,400	14,930,294	64.4%					15,901,169	65.2%	
Labor	Plowing & Land Preparation			2,150,000	2,150,000	9.3%					2,150,000	8.8%	
	Spraying			600,000	600,000	2.6%					510,000	2.1%	
	Fertilizer application			1,600,000	1,600,000	6.9%					1,600,000	6.6%	
	Seeds Preparation and Planting			1,612,500	1,612,500	7.0%					1,612,500	6.6%	
	Pruning & Other			1,325,000	1,325,000	5.7%					1,523,750	6.2%	
	Harvesting			<u>950,000</u>	<u>950,000</u>	<u>4.1%</u>					<u>1,092,500</u>	<u>4.5%</u>	
				8,237,500	8,237,500	35.6%					8,488,750	34.8%	
Total Variable Costs					23,167,794			24,389,919					
Net Revenue					11,438,206			15,406,981					

Appendix Table 4. Budgets for Without and With Disease-Resistant Varieties, South Africa

		seed premium	0.5	yield with	26.0	% cost incr.	15.3%					
		Pesticide reductio	0.5	Yield loss	30%	% net rev incr	39.0%					
		Fungicide reductic	0.5	yield without	20							
Zucchini		WITHOUT					WITH					
2000 South Africa		Unit	Rand	Quantity	Rand / ha	% total	Unit	Rand	Quantity	Rand / ha	% total	
			per unit			Var cost		per unit			Var cost	
Gross Revenue												
	Product Income	MT	3,547	20.0	70,930		MT	3,547	26	92,209		
Marketing Costs												
	Agent commission	%	7.5	70,930	5,320		%	7.5	92,209	6,916		
	Market commission	%	5	70,930	3,547		%	5	92,209	4,610		
											% total	
Gross Revenue less Marketing Costs					62,064		80,683					Var cost
Inputs	Seed	kg	1750	1.5	2,625	14.5%	kg	2625	1.5	3,938	20.2%	
	Fertilizer				1,814	10.1%				1,814	9.3%	
	Pesticide				2,500	13.9%				1,250	6.4%	
	Fungicide				500	1.1%				250	0.4%	
	Herbicide				600	3.3%				600	3.1%	
	Irrigation				415	2.3%				415	2.1%	
	other				2,000	11.1%				2,000	10.3%	
	bags for harvest	10 kg	0.64	2000	1,280	7.1%	10 kg	0.64	2600	1,664	8.5%	
					11,734	65.0%				11,931	61.2%	
Labor	cultivate	Rd/hr	2.2	150	330	1.8%	Rd/hr	2.2	150	330	1.7%	
	pesticide	Rd/hr	2.2	170	374	2.1%	Rd/hr	2.2	85	187	1.0%	
	fungicide	Rd/hr	2.2	40	88	0.5%	Rd/hr	2.2	20	44		
	fertilizer	Rd/hr	2.2	40	88	0.5%	Rd/hr	2.2	40	88	0.5%	
	irrigation	Rd/hr	2.2	165	363	2.0%	Rd/hr	2.2	165	363	1.9%	
	watering/plant	Rd/hr	2.2	30	66	0.4%	Rd/hr	2.2	30	66	0.3%	
	harvest	Rd/hr	2.2	2272	4,998	27.7%	Rd/hr	2.2	2,954	6,498	33.3%	
				358	6,307	35.0%			430	7,576	38.8%	
Total Variable Costs					18,042		19,507					
Net Revenue					44,022		61,176					

		seed premium	0.5	yield	25	% cost incr.	6.6%	1.04			
		Pesticide	0.5	Yield loss	25%	% net rev incr	64.2%	0.89			
W.Cape		Fungicide	0.5	yield without	20						
Melon		WITHOUT					WITH				
2000 South Africa		Unit	Rand per unit	Quantity	Rand / ha	% total Var cost	Unit	Rand per unit	Quantity	Rand / ha	% total Var cost
Gross Revenue											
Product Income		ton	1743	20	34,850		ton	1743	25	43,563	
Marketing Costs											
Agent commission		%	7.5	34,850	2,614		%	7.5	43,563	3,267	
Market commission		%	5	34,850	1,743		%	5	43,563	2,178	
Gross Revenue less Marketing Costs					30,494		38,117				
Inputs	Seed	kg	457	1.5	686	3.3%	kg	685.5	1.5	1,028	4.6%
	Fertilizer				1,271	6.1%				1,271	5.7%
	Pesticide				2,000	9.6%				1,000	4.5%
	Fungicide				2,000	9.6%				1,000	4.5%
	Irrigation				415	2.0%				415	1.9%
	Other				368	1.8%				368	1.7%
	Packaging		5.92	2,000	11,840	57.0%		5.92	2,500	14,800	66.9%
					18,580	89.5%				19,882	89.8%
Labor	plant	rand/hr	2.2	16	35	0.2%	rand/hr	2.2	140	308	1.4%
	fertilizer	rand/hr	2.2	32	70	0.3%	rand/hr	2.2	40	88	0.4%
	pesticide	rand/hr	2.2	40	88	0.4%	rand/hr	2.2	20	44	0.2%
	fungicide	rand/hr	2.2	170	374	1.8%	rand/hr	2.2	85	187	0.8%
	weed control	rand/hr	2.2	16	35	0.2%	rand/hr	2.2	0.4	1	0.0%
	irrigation	rand/hr	2.2	165	363	1.7%	rand/hr	2.2	51	112	0.5%
	machinery	rand/hr	3	4	12	0.1%	rand/hr	3	4	12	0.1%
	harvest	rand/hr	2.2	545	1,199	5.8%	rand/hr	2.2	681	1,499	6.8%
				124	2,177	10.5%			128	2,251	10.2%
Total Variable Costs					20,756		22,133				
Net Revenue					9,737		15,984				

		seed premium	0.3	yield	23	% cost incr.	8.0%	0.41			
		Pesticid	1	Yield loss	0.125	% net rev incr	20.5%	0.39			
W.Cape		Fungicid	0.5	yield without	20.444						
Butternut		WITHOUT				WITH					
2000 South Africa		Unit	Rand	Quantity	Rand / ha	% total	Unit	Rand	Quantity	Rand / ha	% total
			per unit			Var cost		per unit			Var cost
Gross Revenue											
	Product Income	ton	800	20.4	16,345		ton	800	23	18,389	
Marketing Costs											
	Agent commission	%	7.5	16,345	1,226		%	7.5	18,389	1,379	
	Market commission	%	5	16,345	817		%	5	18,389	919	
Gross Revenue less Marketing Costs					14,302					16,090	
Inputs	Seed	kg	1236	1.75	2,163	25.6%	kg	1606.8	1.75	2,812	31.1%
	Fertilizer				1,814	21.4%				1,814	20.1%
	Herbicide				136	1.6%				136	1.5%
	Pesticide				230	2.7%				230	2.5%
	Fungicide				500	5.9%				250	2.8%
	Irrigation				415	4.9%				415	4.6%
	Bags for Harvest		0.9	2044.44	1,840	21.8%		0.9	2300	2,070	22.9%
					7,098	83.9%				7,726	85.4%
Labor	plant	rand/hr	2.2	16	35	0.4%	rand/hr	2.2	16	35	0.4%
	fertilizer	rand/hr	2.2	32	70	0.8%	rand/hr	2.2	32	70	0.8%
	pesticide	rand/hr	2.2	40	88	1.0%	rand/hr	2.2	40	88	1.0%
	fungicide	rand/hr	2.2	100	220	2.6%	rand/hr	2.2	50	110	1.2%
	weed control	rand/hr	2.2	16	35	0.4%	rand/hr	2.2	16	35	0.4%
	irrigation	rand/hr	2.2	165	363	4.3%	rand/hr	2.2	165	363	4.0%
	harvest	rand/hr	2.2	250	550	6.5%	rand/hr	2.2	281	619	6.8%
				77.375	1,362	16.1%			75.031	1,321	14.6%
Total Variable Costs					8,459					9,047	
Net Revenue					5,843					7,042.94	

		seed premium	0.3	yield	42	% cost incr.	11.6%								
		Pesticide	0.5	Yield loss	20%	% net rev incr	22.2%								
		Fungicide	0.5	yield without	35		-5.525								
English Cucumber		WITHOUT					WITH								
2000 South Africa		Unit	Rand	Quantity	Rand / ha	% total	Unit	Rand	Quantity	Rand / ha	% total				
			per unit			Var cost		per unit			Var cost				
Gross Revenue															
	Product Income	MT	3,290	35	115,158.75		ton	3,290	42	138,190.50					
Marketing Costs															
	Agent commission	%	7.5	115,159	8,636.91		%	7.5	138,191	10,364.29					
	Market commissio	%	5	115,159	5,757.94		%	5	138,191	6,909.53					
Gross Revenue less Marketing Costs					100,763.91					120,916.69					
Inputs	Seed	kg	2020	1	2,020.00	20.3%	kg	2626	1	2,626.00	26.4%				
	Fertilizer				1,460.00	14.6%				1,460.00	14.7%				
	Pesticide				1,000.00	10.0%				500.00	5.0%				
	Fungicide				1,000.00	10.0%				500.00	5.0%				
	Herbicide				370.00	3.7%				370.00	3.7%				
	bags for harvest	10 kg	0.64	3500	2,240.00	22.5%		0.64	4200	2,688.00	27.1%				
					8,090.00	81.1%						8,144.00	82.0%		
Labor	cultivate	rand/hr	2.2	140	308.00	3.1%	rand/hr	2.2	140	308.00	3.1%				
	pesticide	rand/hr	2.2	100	220.00	2.2%	rand/hr	2.2	50	110.00	1.1%				
	fungicide	rand/hr	2.2	100	220.00	2.2%	rand/hr	2.2	50	110.00	1.1%				
	fertilizer	rand/hr	2.2	40	88.00	0.9%	rand/hr	2.2	40	88.00	0.9%				
	load	rand/hr	2.2	0.4	0.88	0.0%	rand/hr	2.2	0.4	0.88	0.0%				
	load	rand/hr	2.2	0.4	0.88	0.0%	rand/hr	2.2	0.4	0.88	0.0%				
	make holes	rand/hr	2.2	75	165.00	1.7%	rand/hr	2.2	75	165.00	1.7%				
	make holes	rand/hr	2.2	40	88.00	0.9%	rand/hr	2.2	40	88.00	0.9%				
	irrigation	rand/hr	2.2	51	112.20	1.1%	rand/hr	2.2	51	112.20	1.1%				
	watering/plant	rand/hr	2.2	30	66.00	0.7%	rand/hr	2.2	30	66.00	0.7%				
	harvest	rand/hr	2.2	279	613.80	6.2%	rand/hr	2.2	335	736.56	7.4%				
					107	1,882.76	18.9%						101	1,785.52	18.0%
Total Variable Costs					9,972.76		9,929.52								
Net Revenue					90,791.15		110,987.17								

Appendix Table 5. ABSP Investments in Technology Development and Dissemination, 1993-2002

ABSP Investments in Cornell Cucubit Program, 1993-2002									
Account No. 61-2820 Cornell					Account No. 61-2814 Cornell				
Egypt Phase I					Core Phase I				
Year	Amount	Cumulative	Amount	Cumulative	Year	Amount	Cumulative	Amount	Cumulative
Ending	Obligated	Obligated	Expended	Expended	Ending	Obligated	Obligated	Expended	Expended
Sept 93	\$72,000	\$72,000	\$0	\$0	Sept 93	na	\$70,000	\$70,000	\$70,000
Sept 94	\$25,000	\$97,000	\$40,818	\$40,818	Sept 94	na	\$0	\$0	\$0
Sept 95	\$37,100	\$134,100	\$71,788	\$112,606	Sept 95	na	\$0	\$0	\$0
Sept 96	\$0	\$134,100	\$21,493	\$134,099	Sept 96	na	\$0	\$0	\$0
Account No. 61-2829 Cornell / OSP 26430					Account No. 61-2897 Cornell / OSP 34386				
Egypt Phase II					Core Phase II				
Year	Amount	Cumulative	Amount	Cumulative	Year	Amount	Cumulative	Amount	Cumulative
Ending*	Obligated	Obligated	Expended	Expended	Ending**	Obligated	Obligated	Expended***	Expended
Sept 97	\$98,061	\$98,061	\$53,678	\$53,678	Sept 97	\$0	\$0	\$0	\$0
Sept 98	\$19,037	\$117,098	\$49,218	\$102,896	Sept 98	\$0	\$0	\$0	\$0
Sept 99	\$25,000	\$142,098	\$39,202	\$142,098	Sept 99	\$112,706	\$112,706	\$47,861	\$47,861
Sept 00	\$95,000	\$237,098	\$60,297	\$202,395	Sept 00	\$89,153	\$201,859	\$105,962	\$153,823
Sept 01	\$0	\$237,098	\$34,586	\$236,981	Sept 01	\$46,353	\$248,212	\$47,881	\$201,704
					Sept 02	\$226,875	\$475,087	\$108,639	\$310,343
* Contract	Amount	Cumulative			** Contract	Amount	Cumulative		
Date	Obligated	Obligated			Date	Obligated	Obligated		
07/05/96	\$47,697	\$47,697			02/04/99	\$56,353	\$56,353		
12/05/96	\$50,364	\$98,061			11/01/99	\$56,353	\$112,706		
04/22/98	\$19,037	\$117,098			05/05/00	\$89,153	\$201,859		
07/12/99	\$25,000	\$142,098			06/26/01	\$32,800	\$234,659		
10/26/99	\$42,500	\$184,598			08/13/01	\$13,553	\$248,212		
03/09/00	\$52,500	\$237,098			01/15/02	\$226,875	\$475,087		
Source: ABSP Management office, Michigan state University					*** Amount expended through March, 2002				

Appendix Table 6. Combined Impact of Disease-Resistant Varieties in Indonesia and South Africa

Cost-Benefit Analysis of Virus and Fungal Resistance in Cucurbits in South Africa and Indonesia, 1993-2018						
				Discount Rate		10%
				Exchange Rate (SAfrica)		8
				Exchange Rate (Indonesia)		10,000
				eS (price elasticity of S)		1
				eD (price elasticity of D)		1
Project-level Economic Analysis						
Year	Real Benefits (\$US)	Nominal Costs (\$US)	Real Costs (\$US)	Real Net Social Gain (\$US)	Discounted Net Social Gain (\$US)	Discount Factor
1993		(70,000)	(80,571)	(80,571)	(172,710)	2.1436
1994		(40,818)	(45,865)	(45,865)	(89,378)	1.9487
1995		(71,788)	(78,374)	(78,374)	(138,845)	1.7716
1996		(21,493)	(22,817)	(22,817)	(36,748)	1.6105
1997		(53,678)	(55,524)	(55,524)	(81,293)	1.4641
1998		(49,218)	(50,158)	(50,158)	(66,760)	1.3310
1999		(87,063)	(87,063)	(87,063)	(105,346)	1.2100
2000		(166,259)	(166,259)	(166,259)	(182,885)	1.1000
2001		(112,467)	(112,467)	(112,467)	(112,467)	1.0000
2002		(188,639)	(188,639)	(188,639)	(171,490)	0.9091
2003		(180,000)	(180,000)	(180,000)	(148,760)	0.8264
2004	1,367,918	(180,000)	(180,000)	1,187,918	892,500	0.7513
2005	2,680,449	(30,000)	(30,000)	2,650,449	1,810,292	0.6830
2006	4,667,717	(30,000)	(30,000)	4,637,717	2,879,658	0.6209
2007	6,625,670	(10,000)	(10,000)	6,615,670	3,734,373	0.5645
2008	8,438,761			8,438,761	4,330,419	0.5132
2009	9,910,495			9,910,495	4,623,319	0.4665
2010	10,793,124			10,793,124	4,577,338	0.4241
2011	11,205,198			11,205,198	4,320,089	0.3855
2012	11,372,694			11,372,694	3,986,060	0.3505
2013	11,436,743			11,436,743	3,644,099	0.3186
2014	11,460,650			11,460,650	3,319,742	0.2897
2015	11,469,493			11,469,493	3,020,276	0.2633
2016	11,472,752			11,472,752	2,746,486	0.2394
2017	11,473,952			11,473,952	2,497,066	0.2176
2018	11,474,375			11,474,375	2,270,144	0.1978
Economic Rate of Return				46.5%		
Net Present Value					\$47,345,178	

Melon (Indonesia)				Supply elasticity 1 Demand elasticit 1 Yield Change 0.15 Input cost chang 0.05												
			Max	Gross cost	Input cost	Input cost	Net	prob	Adoptior	Depr				Quantity	undiscounted change in	Indo Melon Total surplus
	Supply	Demand	Yield	change	change	change	cost	succes	Rate	Rate	Kt	Price	Zt	produced	Total Surplus	discounted
Year	Elasticity	Elasticity	Change	per ton	per ha	per ton	change					(\$/MT)		(MT)	(\$)	(\$)
2004	1.00	1.00	1.00	1.00	1.00	0.500	0.500	1.000	0%	1	0	133	0	40,222	0	0
2005	1.00	1.00	1.00	1.00	0.15	0.075	0.925	1.000	0%	1	0	133	0	40,222	0	0
2006	1.00	1.00	0.15	0.15	0.05	0.046	0.104	1.000	19%	1	0.02	133	0.0098	40,222	105,462	65,483
2007	1.00	1.00	0.15	0.15	0.05	0.046	0.104	1.000	35%	1	0.036	133	0.0182	40,222	196,890	111,139
2008	1.00	1.00	0.15	0.15	0.05	0.046	0.104	1.000	51%	1	0.053	133	0.0266	40,222	289,077	148,342
2009	1.00	1.00	0.15	0.15	0.05	0.046	0.104	1.000	62%	1	0.064	133	0.0321	40,222	349,225	162,916
2010	1.00	1.00	0.15	0.15	0.05	0.046	0.104	1.000	67%	1	0.069	133	0.0347	40,222	378,169	160,381
2011	1.00	1.00	0.15	0.15	0.05	0.046	0.104	1.000	69%	1	0.072	133	0.0358	40,222	390,063	150,386
2012	1.00	1.00	0.15	0.15	0.05	0.046	0.104	1.000	70%	1	0.072	133	0.0362	40,222	394,628	138,315
2013	1.00	1.00	0.15	0.15	0.05	0.046	0.104	1.000	70%	1	0.073	133	0.0364	40,222	396,335	126,284
2014	1.00	1.00	0.15	0.15	0.05	0.046	0.104	1.000	70%	1	0.073	133	0.0364	40,222	396,966	114,987
2015	1.00	1.00	0.15	0.15	0.05	0.046	0.104	1.000	70%	1	0.073	133	0.0364	40,222	397,199	104,595
2016	1.00	1.00	0.15	0.15	0.05	0.046	0.104	1.000	70%	1	0.073	133	0.0364	40,222	397,285	95,107
2017	1.00	1.00	0.15	0.15	0.05	0.046	0.104	1.000	70%	1	0.073	133	0.0364	40,222	397,316	86,468
2018	1.00	1.00	0.15	0.15	0.05	0.046	0.104	1.000	70%	1	0.073	133	0.0364	40,222	397,328	78,609

Zucchini (S.Africa)			Supply elasticity	1												
			Demand elasticit	1												
			Yield Change	0.3												
			Input cost chang	0.15												
			Max	Gross	Input	Input	Net	prob	Adoptior	Depr				Quantity	undiscounted	ZUCCHINI
	Supply	Demand	Yield	cost	cost	cost	cost	Adopt	Rate	Rate	Kt	Price	Zt	produced	change in	Total surplus
Year	Elasticity	Elasticity	Change	change	change	change	change	Rate				(\$/MT)		(MT)	Total Surplus	discounted
				per ton	per ha	per ton									(\$)	(\$)
2004	1.00	1.00	0.30	0.30	0.15	0.118	0.182	1.000	0%	1	0	443		75,000	0	0
2005	1.00	1.00	0.30	0.30	0.15	0.118	0.182	1.000	0%	1	0	443		75,000	0	0
2006	1.00	1.00	0.30	0.30	0.15	0.118	0.182	1.000	8%	1	0.015	443		75,000	510,914	317,237
2007	1.00	1.00	0.30	0.30	0.15	0.118	0.182	1.000	19%	1	0.034	443		75,000	1,162,907	656,431
2008	1.00	1.00	0.30	0.30	0.15	0.118	0.182	1.000	35%	1	0.064	443		75,000	2,191,173	1,124,418
2009	1.00	1.00	0.30	0.30	0.15	0.118	0.182	1.000	51%	1	0.093	443		75,000	3,246,220	1,514,386
2010	1.00	1.00	0.30	0.30	0.15	0.118	0.182	1.000	62%	1	0.112	443		75,000	3,944,172	1,672,714
2011	1.00	1.00	0.30	0.30	0.15	0.118	0.182	1.000	67%	1	0.121	443		75,000	4,282,685	1,651,161
2012	1.00	1.00	0.30	0.30	0.15	0.118	0.182	1.000	69%	1	0.125	443		75,000	4,422,267	1,549,977
2013	1.00	1.00	0.30	0.30	0.15	0.118	0.182	1.000	70%	1	0.127	443		75,000	4,475,925	1,426,168
2014	1.00	1.00	0.30	0.30	0.15	0.118	0.182	1.000	70%	1	0.127	443		75,000	4,495,993	1,302,329
2015	1.00	1.00	0.30	0.30	0.15	0.118	0.182	1.000	70%	1	0.127	443		75,000	4,503,421	1,185,892
2016	1.00	1.00	0.30	0.30	0.15	0.118	0.182	1.000	70%	1	0.127	443		75,000	4,506,160	1,078,739
2017	1.00	1.00	0.30	0.30	0.15	0.118	0.182	1.000	70%	1	0.127	443		75,000	4,507,168	980,891
2018	1.00	1.00	0.30	0.30	0.15	0.118	0.182	1.000	70%	1	0.127	443		75,000	4,507,539	891,793

English Cucumber (S.Africa)				Supply elasticity	1											
				Demand elasticity	1											
				Yield Change	0.2											
				Input cost change	0.12											
Year	Supply Elasticity	Demand Elasticity	Max Yield Change	Gross cost change per ton	Input cost change per ha	Input cost change per ton	Net cost change	prob succes	Adoption Rate	Depr Rate	Kt	Price (\$/MT)	Zt	Quantity produced (MT)	undiscounted change in Total Surplus (\$)	E.CUCUMBER Total surplus discounted (\$)
2004	1.00	1.00	0.30	0.30	0.12	0.090	0.210	1.000	0%	1	0	411	0	16,625	0	0
2005	1.00	1.00	0.30	0.30	0.12	0.090	0.210	1.000	7%	1	0.015	411	0.0076	16,625	103,711	70,836
2006	1.00	1.00	0.30	0.30	0.12	0.090	0.210	1.000	16%	1	0.034	411	0.017	16,625	234,943	145,881
2007	1.00	1.00	0.30	0.30	0.12	0.090	0.210	1.000	30%	1	0.063	411	0.0316	16,625	439,521	248,098
2008	1.00	1.00	0.30	0.30	0.12	0.090	0.210	1.000	44%	1	0.092	411	0.0462	16,625	646,605	331,810
2009	1.00	1.00	0.30	0.30	0.12	0.090	0.210	1.000	53%	1	0.111	411	0.0556	16,625	782,136	364,872
2010	1.00	1.00	0.30	0.30	0.12	0.090	0.210	1.000	57%	1	0.120	411	0.0602	16,625	847,472	359,411
2011	1.00	1.00	0.30	0.30	0.12	0.090	0.210	1.000	59%	1	0.124	411	0.062	16,625	874,339	337,096
2012	1.00	1.00	0.30	0.30	0.12	0.090	0.210	1.000	60%	1	0.125	411	0.0627	16,625	884,656	310,067
2013	1.00	1.00	0.30	0.30	0.12	0.090	0.210	1.000	60%	1	0.126	411	0.063	16,625	888,513	283,108
2014	1.00	1.00	0.30	0.30	0.12	0.090	0.210	1.000	60%	1	0.126	411	0.0631	16,625	889,941	257,784
2015	1.00	1.00	0.30	0.30	0.12	0.090	0.210	1.000	60%	1	0.126	411	0.0631	16,625	890,467	234,488
2016	1.00	1.00	0.30	0.30	0.12	0.090	0.210	1.000	60%	1	0.126	411	0.0631	16,625	890,661	213,217
2017	1.00	1.00	0.30	0.30	0.12	0.090	0.210	1.000	60%	1	0.126	411	0.0631	16,625	890,732	193,849
2018	1.00	1.00	0.30	0.30	0.12	0.090	0.210	1.000	60%	1	0.126	411	0.0631	16,625	890,758	176,232

Melon (S.Africa)				Supply elasticity	1											
				Demand elasticit	1											
				Yield Change	0.25											
				Input cost chang	0.07											
			Max	Gross	Input	Input	Net	prob	Adoptior	Depr				Quantity	undiscounted	Melon
	Supply	Demand	Yield	cost	cost	cost	cost	succes	Rate	Rate	Kt	Price	Zt	produced	change in	Total surplus
Year	Elasticity	Elasticity	Change	change	change	change	change					(\$/MT)		(MT)	Total Surplus	discounted
				per ton	per ha	per ton									(\$)	(\$)
2004	1.00	1.00	0.30	0.30	0.07	0.051	0.249	1.000	19%	1	0.047	218		80,000	839,233	630,528
2005	1.00	1.00	0.30	0.30	0.07	0.051	0.249	1.000	35%	1	0.087	218		80,000	1,589,431	1,085,603
2006	1.00	1.00	0.30	0.30	0.07	0.051	0.249	1.000	51%	1	0.128	218		80,000	2,366,424	1,469,363
2007	1.00	1.00	0.30	0.30	0.07	0.051	0.249	1.000	62%	1	0.154	218		80,000	2,884,191	1,628,051
2008	1.00	1.00	0.30	0.30	0.07	0.051	0.249	1.000	67%	1	0.166	218		80,000	3,136,335	1,609,436
2009	1.00	1.00	0.30	0.30	0.07	0.051	0.249	1.000	69%	1	0.171	218		80,000	3,240,492	1,511,713
2010	1.00	1.00	0.30	0.30	0.07	0.051	0.249	1.000	70%	1	0.173	218		80,000	3,280,562	1,391,278
2011	1.00	1.00	0.30	0.30	0.07	0.051	0.249	1.000	70%	1	0.174	218		80,000	3,295,552	1,270,578
2012	1.00	1.00	0.30	0.30	0.07	0.051	0.249	1.000	70%	1	0.174	218		80,000	3,301,101	1,157,016
2013	1.00	1.00	0.30	0.30	0.07	0.051	0.249	1.000	70%	1	0.174	218		80,000	3,303,147	1,052,484
2014	1.00	1.00	0.30	0.30	0.07	0.051	0.249	1.000	70%	1	0.174	218		80,000	3,303,900	957,022
2015	1.00	1.00	0.30	0.30	0.07	0.051	0.249	1.000	70%	1	0.174	218		80,000	3,304,177	870,093
2016	1.00	1.00	0.30	0.30	0.07	0.051	0.249	1.000	70%	1	0.174	218		80,000	3,304,279	791,018
2017	1.00	1.00	0.30	0.30	0.07	0.051	0.249	1.000	70%	1	0.174	218		80,000	3,304,317	719,116
2018	1.00	1.00	0.30	0.30	0.07	0.051	0.249	1.000	70%	1	0.174	218		80,000	3,304,330	653,744

Butternut (S.Africa)				Supply elasticity	1											
				Demand elasticit	1											
				Yield Change	0.125											
				Input cost change	0.08											
			Max	Gross cost	Input cost	Input cost	Net	prob	Adoptior	Depr				Quantity	undiscounted	Butternut
	Supply	Demand	Yield	change	change	change	cost	success	Rate	Rate	Kt	Price	Zt	produced	Total Surplus	Total surplus
Year	Elasticity	Elasticity	Change	per ton	per ha	per ton	change					(\$/MT)		(MT)	(\$)	discounted (\$)
2004	1.00	1.00	0.30	0.30	0.08	0.062	0.238	1.000	11%	1	0.026	100	0.0129	204,444	528,685	397,209
2005	1.00	1.00	0.30	0.30	0.08	0.062	0.238	1.000	20%	1	0.048	100	0.0239	204,444	987,307	674,344
2006	1.00	1.00	0.30	0.30	0.08	0.062	0.238	1.000	29%	1	0.07	100	0.0349	204,444	1,449,974	900,320
2007	1.00	1.00	0.30	0.30	0.08	0.062	0.238	1.000	35%	1	0.084	100	0.042	204,444	1,751,955	988,933
2008	1.00	1.00	0.30	0.30	0.08	0.062	0.238	1.000	38%	1	0.091	100	0.0454	204,444	1,897,306	973,618
2009	1.00	1.00	0.30	0.30	0.08	0.062	0.238	1.000	39%	1	0.094	100	0.0468	204,444	1,957,033	912,970
2010	1.00	1.00	0.30	0.30	0.08	0.062	0.238	1.000	40%	1	0.095	100	0.0473	204,444	1,979,963	839,697
2011	1.00	1.00	0.30	0.30	0.08	0.062	0.238	1.000	40%	1	0.095	100	0.0475	204,444	1,988,533	766,666
2012	1.00	1.00	0.30	0.30	0.08	0.062	0.238	1.000	40%	1	0.095	100	0.0476	204,444	1,991,705	698,081
2013	1.00	1.00	0.30	0.30	0.08	0.062	0.238	1.000	40%	1	0.095	100	0.0476	204,444	1,992,875	634,991
2014	1.00	1.00	0.30	0.30	0.08	0.062	0.238	1.000	40%	1	0.095	100	0.0476	204,444	1,993,305	577,389
2015	1.00	1.00	0.30	0.30	0.08	0.062	0.238	1.000	40%	1	0.095	100	0.0476	204,444	1,993,464	524,941
2016	1.00	1.00	0.30	0.30	0.08	0.062	0.238	1.000	40%	1	0.095	100	0.0476	204,444	1,993,522	477,233
2017	1.00	1.00	0.30	0.30	0.08	0.062	0.238	1.000	40%	1	0.095	100	0.0477	204,444	1,993,543	433,853
2018	1.00	1.00	0.30	0.30	0.08	0.062	0.238	1.000	40%	1	0.095	100	0.0477	204,444	1,993,543	394,412