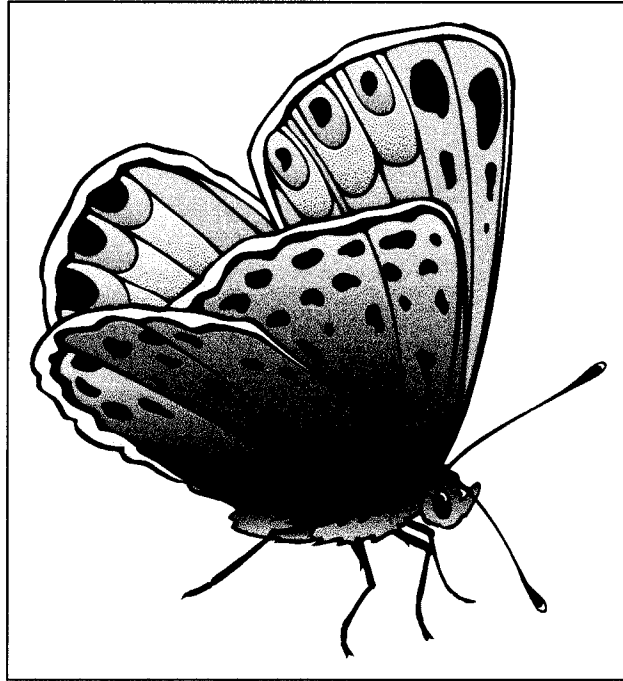


**Biological Control of Insect Pests
Using Pest Break Strips
A New Dimension to
Integrated Pest Management**



**Everett J. Dietrick
John M. Phillips
Joel Grossman**

**A Publication Of
The Naturfarm Conversion Project**

**Sponsored by the
California Energy Commission
and the
Nature Farming Research and Development Foundation
Lompoc, California
Copyright © 1995**

**Biological Control of Insect Pests
Using Pest Break Strips
A New Dimension to
Integrated Pest Management**

**Everett J. Dietrick
John M. Phillips
Joel Grossman**

**A Publication Of
The Naturfarm Conversion Project**

**Sponsored by the
California Energy Commission
and the
Nature Farming Research and Development Foundation
Lompoc, California
Copyright © 1995**

**Biological Control of Insect Pests
Using Pest Break Strips
A New Dimension to
Integrated Pest Management**

**Everett J. Dietrick
John M. Phillips
Joel Grossman**

**A Publication Of
The Naturfarm Conversion Project**

**Sponsored by the
California Energy Commission
and the
Nature Farming Research and Development Foundation
Lompoc, California
Copyright © 1995
All rights reserved.**

The authors and sponsors of this work make no representation, expressed or implied, with regard to the accuracy of the information contained in this publication, and cannot accept any legal responsibility or liability for any errors or omissions that may be made in this work or for any application or use of the information contained herein.

For more information, contact:

Nature Farming Research and Development Foundation
6495 Santa Rosa Road
Lompoc, California, U.S.A. 93436
Phone: 805-737-1536
Fax: 805-736-9599

Legal Notice: This report was prepared as a result of work sponsored by the California Energy Commission. It does not necessarily represent the views of the Energy Commission, its employees, or the State of California. The Energy Commission, its employees, contractors and sub-contractors, make no warranty, expressed or implied, and assume no legal liability for the information in this report; nor does any party represent that the use of this information will not infringe upon privately owned rights.

Foreword

The 1980 U.S. Department of Agriculture Report and Recommendations on Organic Farming indicated that there was a growing concern among farmers, consumers, environmentalists and society as a whole on the adverse effects of pesticides on human and animal health; environmental quality and biodiversity; and food safety and quality. Consequently, the Report urgently recommended that the U.S. agricultural research establishment seek to develop "new and improved techniques for control of weeds, insects and plant diseases using biological, non-chemical methods." The Report placed particular emphasis on "the development of pest control methods using parasites, predator insects, and other biological means to eradicate or control unwanted (i.e., harmful) species."

While this recommendation resulted in some renewed interest in biocontrol methods and Integrated Pest Management (IPM), there was little additional support for such research in the years which followed. That is, research continued to focus on ways of increasing the production of basic commodity crops in chemical-based, monoculture, conventional farming systems.

Nevertheless, by the late 1980's, consumer and environmental groups had become very prominent and vocal in expressing their concerns about the use of synthetic chemicals, i.e., fertilizers and pesticides, in our food production system. Subsequently, the impact of this movement led to two significant events with regard to U.S. agriculture. First, in June 1993, the National Academy of Sciences, National Research Council published a report entitled Pesticides in the Diets of Infants and Children which indicated that this particular age group could be at higher risk than adults from ingestion of fruits and vegetables containing pesticide residues. And second, also in June 1993, a joint statement was issued by the Secretary of Agriculture (USDA); the Administrator of the U.S. Environmental Protection Agency (USEPA); and the Commissioner of the U.S. Food and Drug Administration (USFDA) that officially committed these agencies to work together with U.S. farmers to reduce their use of, and dependence on, pesticides, and to promote the principles of sustainable agriculture.

The 1980 USDA Report also revealed that farmers who had converted abruptly from conventional, chemical-based agriculture to organic or nature farming systems without synthetic pesticides often experienced serious weed, insect and disease problems during the first three to four years after conversion had begun. Thus, in view of this and the two events cited in 1993, perhaps the most frequently asked question by U.S. farmers is "How can I accomplish such a conversion from conventional to organic or nature farming successfully and profitably, and with minimum risk?"

These historical and recent events are relevant because they underscore the goals and objectives of the California Energy Commission/Naturfarm Conversion Project, a five-year study which began in 1989. This report on the Biological Control of Insect Pests Using Pest Break Strips represents only one aspect of the overall project. The results of systems research and analysis of other components, including tillage, soil fertility, pest management and farm management, will be presented in other reports available from the Nature Farming Research and Development Foundation. Meanwhile, this report on pest break strip technology appears to offer a new and exciting approach to biological control, and an added dimension to Integrated Pest Management (IPM). The concept of pest break strips and their practical application should provide a more effective and reliable approach to the conversion from conventional agriculture to a nature/organic farming system. Moreover, when farmers realize that the Nature Farming Model can result in a substantial reduction in the energy needed for such production inputs as tillage, soil fertility, weed control, and insect pest management, their interest level will increase accordingly.

Certainly, additional research will help to refine the methods and techniques described in this report to a) enhance its adaptation over a wide range of agroecological and climatic conditions; and b) promote its acceptance and use by commercial farmers, both organic and conventional. Nevertheless, the results presented herein are scientifically-credible, convincing, and worthy of further on-farm testing and demonstration. The California Energy Commission/ Naturfarm Conversion Project is an excellent example and model of how resources can be integrated into more sustainable farming systems that are energy-efficient, environmentally-sound, and economically-viable. This report is both timely and innovative, and should be widely read by farmers, researchers and extension workers.

Dr. James F. Parr
President, Nature Farming Research
and Development Foundation
Lompoc, California
and
Collaborator,
U.S. Department of Agriculture,
Beltsville, Maryland

Preface: The Naturfarm Conversion Project

In 1989, the California Energy Commission (CEC) funded the Naturfarm Conversion Project to demonstrate the conversion process from an energy intensive farming system to a production system with less dependence on chemical and fuel energy use. The purpose of the CEC's Agricultural Energy Assistance Program (AEAP) is to promote the efficient use of energy resources in California's food and fiber industry. To achieve its purpose, the AEAP provides funding for applied research and demonstration projects to monitor and evaluate targeted technologies and farming practices that could help farmers reduce energy consumption.

The goal of the Energy Commission in funding the Naturfarm Conversion Project was to demonstrate energy conservation practices to reduce pesticide and fertilizer use, and achieve fuel use savings. Additional goals were set to achieve agricultural resource use efficiencies, reduce soil, air and water contamination, and limit worker exposure to harmful chemicals. The project was designed to document project results, assess benefits to the farmer, and develop educational materials.

The purpose of this technical report is to document the transition experience of converting a conventionally-farmed land area to a biologically-integrated farming system. In addition, it is hoped that the benefits of using the Naturfarm practices will become apparent and some of the successful methods described in this transition guide will be adopted by farmers. The results of this project should help to develop a greater appreciation of energy costs and how farming systems can become more energy efficient.

The Naturfarm has achieved a high level of energy efficiency by eliminating the use of chemical fertilizers and pesticides, and reducing diesel fuel consumption by eliminating pesticide applications and using conservation tillage practices. These results have been evaluated and summarized after four years of field research and test demonstrations. The project results reflect an overall improvement in the farm's effectiveness to control pest damage. Improvements also have been documented in crop quality and gross revenue, reduced pest problems, and better monitoring and management skills. Farm personnel have become more knowledgeable about insect ecology and biological control practices. Additional benefits have been measured in decreased fuel consumption, reduced soil compaction, and increased water infiltration and retention. Improved management skills have contributed to the development of a whole farm systems approach to decisions on production practices. We hope that reading this document will assist farmers as they strive to develop more energy efficient farming systems.

Ricardo Amon, Agricultural Energy Assistance Program
California Energy Commission

Acknowledgements

Support for this research by the Agricultural Energy Assistance Program of the California Energy Commission is gratefully acknowledged. The sponsorship of the Naturfarm and the Nature Farming Research and Development Foundation (NFRDF) by Sekai Kyusei Kyo and the International Nature Farming Research Center, Atami, Japan is gratefully acknowledged. Without their support, this project would not have been possible.

The contributions and dedication of those who served at various times as members of the CEC Naturfarm Conversion Project Team are acknowledged with sincere thanks and appreciation. Project Team Members were Ricardo Amon, Warren Bendixon, Everett Dietrick, Paul Dilger, Bill Gillette, Ron Gilman, Stephen Gliessman, Bill Liebhardt, Harlyn Meyer, James Meyer, Philip Northcraft, John C. Phillips, John M. Phillips, Thomas Ruehr, Louie Valenzuela, and Victor Wegrzyn.

Dr. Teruo Higa provided technical counsel throughout this project on Kyusei Nature Farming and the use of EM technology, and his assistance is sincerely appreciated with many thanks.

Harlyn and James Meyer designed and initiated the CEC Naturfarm Conversion Project and served as initial NFRDF Project Manager and Cooperating Farmer, respectively. Their contributions and service over many years, both to Nature Farming and to the organic farming movement in California, are recognized and appreciated.

Izuo Miyashita, President of NFRDF(1990-1994) gave wholehearted support to the CEC Naturfarm Conversion Project, which contributed immeasurably to its success. Dr. James F. Parr, President of NFRDF since 1995, has continued this support for the Project, and has served as Executive Editor of this Report. Dr. Sharon B. Hornick, Executive Director of NFRDF, contributed valuable comments and insights to this Report, and has fully supported this Project. Ann Mayse (UC-SAREP) reviewed and assisted in editing the Report and Susan E. Randall (NFRDF) also provided valuable comments and editorial assistance.

Lastly, Ricardo Amon, Project Manager for the California Energy Commission and John M. Phillips, Project Manager for NFRDF and the Naturfarm, have been instrumental in leading the CEC Naturfarm Conversion Project to a successful conclusion, which includes this Report. Sincere thanks and appreciation are extended to all who have contributed to the success of this Project.

Table of Contents

Foreword	iii
Preface: The Naturfarm Conversion Project	v
Acknowledgements	vi
I. Introduction	1
II. Historical Background	1
III. Function, Design and Operation of Pest Break Strips	4
A Habitat for Insect Wildlife.	4
Design and Layout.	4
Plant Selection and Blends	7
Economic Value and Benefit	10
IV. Management of Pest Break Strips	11
Establishment	11
Mowing and Strip-Cutting	11
Irrigation Methods and Practices	13
Other Management Practices for Pest Break Strips	14
Release of Commercial Insectary-Reared Beneficial Arthropods	14
Selective Insect Vacuuming and Re-Releasing	15
Classical Biological Control Agents	16
Ant Interference	17
Gopher Control	17
Replacement and Renovation	18
Management of Pest Break Strips to Enhance IPM	18

V. Results of the CEC Naturfarm Conversion Project	20
Biological Control of Insect Pests in Vegetable Crops	20
Energy and Cost Analysis	25
a. Projections at Start-up	25
b. Interim Results	27
c. Final Project Results	34
VI. Recommendations	36
VII. Summary	37
References	38
List of Tables	ix
List of Figures	x

List of Tables

Table 1.	Comparison of Numbers of Beneficial Arthropods in Strip-Cut and Full-Cut Alfalfa.	3
Table 2.	Plant Species Composition of Three Blends Tested for Use in Pest Break Strips at the Naturfarm (1990-1995).	8
Table 3.	Comparison of Insect Counts in Beneficial Blend and Naturfarm Blend No. 2.	9
Table 4.	Value in Dollars Per Acre of Some of the Beneficial Arthropods Produced in Pest Break Strips at the Naturfarm.	10
Table 5a.	Crops and Pests Responsive to Integrated Pest Management Using Pest Break Strips.	21
Table 5b.	Crops and Pests with Moderate to Good Response to Integrated Pest Management Using Pest Break Strips.	23
Table 5c.	Crops and Pests with Limited Response to Integrated Pest Management Using Pest Break Strips. Additional IPM Measures Required.	24
Table 6.	Summary of Per Crop-Acre Energy, Time and Cost Estimates for Conventional Farming Compared with the Naturfarm System.	26
Table 7.	Model of a 60-Acre Naturfarm: Cost Savings (\$) per Year.	26
Table 8.	Fuel Consumption at the Naturfarm in 1991-92 as Measured Using the Fluidyne Series 1020 Flow Meters.	27
Table 9.	Energy and Cost Comparison for Insect Pest Management for Three Annual Vegetable Crop Rotations Using Conventional Pesticides Compared to the Naturfarm System with Pest Break Strips.	35

List of Figures

Figure 1.	Layout of Pest Break Strips at the Naturfarm.	4
Figure 2.	Deke Dietrick Uses the Cycle-vac to Collect Insects from the Pest Break Strips at the Naturfarm.	15
Figure 3.	Deke and Karen Dietrick Greeley Use a D-vac to Sort Insects Collected by the Cycle-vac.	16
Figure 4.	A New Parasite of <u>Lygus</u> is Raised in a Screened Tent in the Pest Break Strip at the Naturfarm.	17
Figure 5.	Diagram of IPM Hierarchy of Responses to Insect Pest Management Using Pest Break Strips.	19
Figure 6.	Carrot: Comparative Costs, Gross Income and Yield for Naturfarm and Conventional Carrot in 1991. Total Costs and Costs for Individual Components of Tillage, Fertility, Weed and Pest Control Are Compared for Nature Farming and Conventional Agriculture Models.	28
Figure 7.	Leaf Lettuce: Comparative Costs, Gross Income and Yield for Naturfarm and Conventional Leaf Lettuce in 1991-92. Total Costs and Costs for Individual Components of Tillage, Fertility, Weed and Pest Control Are Compared for Nature Farming and Conventional Agriculture Models.	29
Figure 8.	Summer Squash: Comparative Costs, Gross Income and Yield for Naturfarm and Conventional Summer Squash in 1991. Total Costs and Costs for Individual Components of Tillage, Fertility, Weed and Pest Control Are Compared for Nature Farming and Conventional Agriculture Models.	30

Figure 9. Sweet Corn: Comparative Costs, Gross Income and Yield for Naturfarm and Conventional Sweet Corn in 1991. Total Costs and Costs for Individual Components of Tillage, Fertility, Weed and Pest Control Are Compared for Nature Farming and Conventional Agriculture Models. 31

Figure 10. Carrot: Energy Use for Various Operations in Gallons of Diesel Equivalents per Acre for Carrot Production in 1991 at the Naturfarm Compared with Conventional Farming Practices. 32

Figure 11. Leaf Lettuce: Energy Use for Various Operations in Gallons of Diesel Equivalents per Acre for Leaf Lettuce Production in 1991-1992 at the Naturfarm Compared with Conventional Farming Practices. 32

Figure 12. Summer Squash: Energy Use for Various Operations in Gallons of Diesel Equivalents per Acre for Summer Squash Production in 1991 at the Naturfarm Compared with Conventional Farming Practices. 33

Figure 13. Sweet Corn: Energy Use for Various Operations in Gallons of Diesel Equivalents per Acre for Sweet Corn Production in 1991 at the Naturfarm Compared with Conventional Farming Practices. 33

Biological Control of Insect Pests Using Pest Break Strips

A New Dimension to Integrated Pest Management

I. Introduction

Pest break strips are an essential part of the Naturfarm's transition strategy for enhancing the biological control of insect pests. They are a specialized form of strip-intercropping and provide a new dimension to integrated pest management (IPM). At the Naturfarm, pest break strips of an alfalfa-clover mixture are strip-intercropped with organic vegetables. Pest break strips have a dual role: 1) as trap crops, they divert pests away from market crops; and 2) as insectary crops, they grow beneficial insects helping to provide biological control of pests in adjacent rows of vegetable crops (Grossman and Quarles, 1993).

At the Naturfarm, a cultural practice known as strip-cutting maximizes the number of pests and the populations of natural enemies found in pest break strips. Strip-cutting is simply the practice of cutting only half the pest break strip at any one time. This allows half the pest break strip to flower prior to cutting, while the other half is in mainly a vegetative state. The young, lush uncut strips make excellent trap crops, catching incoming pests from cut strips, harvested crops and migrations. Beneficial insects are several-fold more numerous when pest break strips are strip-cut compared with simply cutting to a uniform height (Schlinger and Dietrick, 1960).

The exclusive reliance on natural biological control organisms and cultural practices like strip-cutting for sustainable insect pest management is rarely, if ever, attempted anymore. Such methods are almost unprecedented for vegetable crops. However, there have been times and places in California's agricultural history where such methods have provided all of the pest control needed for the production of major commercial crops such as citrus, cotton and alfalfa.

II. Historical Background

Everett J. "Deke" Dietrick, a registered entomologist and widely recognized authority on biological control of insect pests, served as the Naturfarm's Pest Control Advisor (PCA) on the CEC Naturfarm Conversion Project. Dietrick worked in southern California on cotton, citrus and alfalfa during a time when natural biological control techniques were the predominant methods used to control insect pests. Over the last 50 years, while a researcher at the University of California, Riverside, and later in private practice with Rincon-Vitova Insectaries, Inc., Dietrick helped develop, monitor and implement IPM techniques, such as strip-cutting and classical biological control releases, in unsprayed California cotton, citrus and alfalfa (Drlik, 1995). Dietrick drew upon his personal knowledge, based on decades of experience on biological control successes in southern California, to develop the IPM program for the Naturfarm.

A system similar to that designed for the Naturfarm's pest break strips and used for the production of vegetable crops was described by Marcovitch (1935). In those early experiments, strips of turnips, a good cabbage aphid host, were planted a month ahead of market cole crops as insectary plants to attract aphid natural enemies. The turnips were partially destroyed by aphid infestations by late spring or early summer. However, predators like lady beetles and parasitic wasps like Lysiphlebus testaceipes (Cresson) provided biological control of aphids for most of the season in the nearby market crops.

Naturfarm's pest break strips were designed to make this type of biological control a more permanent feature of vegetable farms. Part of making this system more permanent and effective is the use of strip-cut alfalfa which was first adapted for biological pest control in 1956 by Evert I. Schlinger and Everett J. Dietrick as part of the University of California's statewide effort to control the spotted alfalfa aphid.

Strip-cutting of alfalfa was devised in the 1950's as a means of maintaining beneficial insects in the field as a "defensive army" preventing population explosions of aphids and other pests from occurring in new crop growth (Dietrick, 1989-94). Strip-harvesting half of the field following each irrigation (12-to 14-day intervals), compared with complete harvesting of the field after the usual two irrigations (25 to 30 days), traps and protects the vast numbers of beneficial arthropods that were previously lost. When adapted to use in pest break strips, a 12-to 14-day cutting interval is also important because pests like adult Lygus bugs begin moving out of maturing hay when alfalfa reaches three-fourths maturity.

During the 1960's, University of California researchers Stern, van den Bosch and Leigh (1964) documented this added value of uncut alfalfa as a trap crop for Lygus, which can severely damage strawberries, cotton and vegetable seed crops. Continuously cutting the pest break strip before seed set prevents alfalfa and other pest break strip crops from becoming too favorable for seed feeders such as Lygus bugs and certain leafhoppers. If the entire pest break strip is cut and there is no nearby uncut alfalfa then Lygus and other pests typically migrate into nearby market crops. Besides "trapping" pests like Lygus, strip-cutting also retains beneficial insects, mites and spiders, which increase in number by feeding on small soft-bodied insects thriving in the young, tender strip-cut regrowth.

In their historic report on numbers of beneficial insects in strip-cut alfalfa in southern California, Schlinger and Dietrick (1960) counted 400 percent more natural enemies per acre in strip-cut alfalfa, compared with cutting and harvesting the whole stand. Alfalfa plants also yield 15 percent more biomass when managed by strip-cutting, which gives an extra ton of hay per acre per season. When the cut alfalfa is sheet-composted rather than removed from the field, an expanded food chain of decomposing organisms feeds an even more diverse and abundant fauna of beneficial