Dr Jeff Mitchell (UCD) – visit for workshops on new technologies and approaches to sustainable vegetable production

John McPhee
TIAR

Project Number: VG11700

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This report is published by Horticulture Australia Ltd to pass on information concerning horticultural research and development undertaken for the vegetables industry.

The research contained in this report was funded by Horticulture Australia Ltd with the financial support of Bayer CropScience Pty Ltd.

ISBN 0 7341 2764 2

Published and distributed by:
Horticulture Australia Ltd
Level 7
179 Elizabeth Street
Sydney NSW 2000
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Horticulture Australia

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Horticulture Australia Project Number: VG11700 (November, 2011)

John McPhee

Tasmanian Institute of Agricultural Research

Dr Jeff Mitchell (UCD) – visit for workshops on new technologies and approaches to sustainable vegetable production

Horticulture Australia Project Number: VG11700

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This is the final report of the above project. It covers the purpose and conduct of the project, observations recorded during the study tour, recommendations and includes media and technical summaries.

This project has been funded by HAL through the Vegetable levy, matched funds from the Australian Government and a Voluntary Contribution from Bayer Crop Science P/L.

November, 2011

Contents

1 Media Summary

Project VG11700 - Dr Jeff Mitchell (UCD) – visit for workshops on new technologies and approaches to sustainable vegetable production

In many environments and industry sectors, annual horticultural production systems rely on intensive tillage to try to repair soil compaction caused by harvest traffic and to prepare consistent seed beds. Apart from the direct costs of labour and fuel, intensive tillage regimes impose significant costs on growers in the form of capital overheads. Furthermore, and of key importance for the long term future of the industry, intensive tillage has a significant cost in terms of soil sustainability.

With support from Bayer Crops Science and Horticulture Australia Ltd, Dr Jeff Mitchell of University of California (Davis) visited Tasmania and New South Wales to present information on conservation agriculture techniques suitable for use in vegetable production. Dr Mitchell is an extension specialist in the area of water management and resource use efficiency, and has a long association with research and extension at UCD, including a number of farming systems projects which focus on reduced and zero-till techniques.

Dr Mitchell visited a number of vegetable farms in Tasmania and gave a seminar to growers and service providers in Devonport. This was followed by attendance and presentations at a Partnering with Innovation workshop and field day at Cowra in NSW. The workshop was attended by growers from Tasmania, Victoria, New South Wales, Queensland and Northern Territory. They represented a diverse range of sectors in the horticultural industry, from baby leaf lettuce and fresh market potatoes and onions, to tomatoes and tropical melons.

The workshop also featured other speakers from Tasmania and Queensland. Topics addressed included soil management for maintaining soil carbon, benefits of controlled traffic in the vegetable industry, use of biofumigant crops, cover crop selection in tropical environments, and conservation tillage techniques, equipment and economics in California. The field day part of the workshop featured demonstration of a machine imported from California for incorporating crop residue and reforming beds for leafy vegetable production under a raised bed controlled traffic system.

Those attending judged the workshop and field day to be very worthwhile and found great value in the interaction between growers from a range of different production sectors.

2 Dr Jeff Mitchell visit

2.1 Background

A two day soil health forum and field day was held in Tasmania in June 2010. It was initiated and supported financially by Bayer Crop Science, with organisational support from Serve-Ag and TIAR. The forum brought together a number of grower/managers from leading horticultural production businesses, industry and business development consultants and presenters to discuss issues surrounding soil management and soil health. The success of this initial event was the basis for the Partnering with Innovation II workshop, held in Cowra in August 2011.

Current vegetable production systems rely heavily on intensive tillage to relieve soil compaction caused by harvest traffic, and to prepare seed beds. The tillage regimes used in vegetable production are expensive in terms of direct labour and fuel costs, and capital overheads. There are also significant soil sustainability issues associated with intensive tillage.

There is growing interest in the vegetable industry in improved soil management practices. Practices known to improve soil sustainability, but which have limited adoption, particularly in temperate regions, include cover cropping, crop residue retention and controlled traffic. Not only do these practices improve soil sustainability, but they have been shown to reduce costs. The adoption of these practices is often hindered by the difficulty of changing conventional practices and equipment.

2.2 Tasmanian visit and seminar

Dr Jeff Mitchell's visit to Tasmania was brief but valuable. He visited 2 farms in the Cressy region, 3 farms around Devonport and the TIAR research farm at Forthside to gain a better appreciation of the local vegetable industry and the environments in which it works. His insights into residue and soil management were useful discussion points for those in the travelling group. A seminar as held on one afternoon which attracted some 45 attendees, including farmers and a large number of service providers, consultants and industry field advisors. The seminar gave those present an insight into the techniques being used in California to manage residue within conservation agriculture systems for vegetable and mixed crop production. An interview was also held with ABC Rural Radio. Discussions were also held with TIAR representatives regarding possible future collaboration with UCD in the area of conservation cropping for vegetables.

2.3 Partnering with Innovation II workshop

The Partnering with Innovation II workshop invited Dr Jeff Mitchell, University of California, Davis (UCD)) to come to Australia to present on the topic of conservation agriculture, particularly as it relates to vegetable production. Dr Mitchell is an extension specialist with a focus in the fields of water management and resource use efficiency. He has a long association with research and extension activities at UCD, including a number of farming systems projects which focus on reduced and zero-till techniques.

Other speakers were also invited to address the workshop on the topics of soil carbon, an update on controlled traffic research in vegetable production, and the use of biofumigant and cover crops in temperate and tropical production environments. The workshop program is given in Appendix A.

The growers attending the workshop represented a wide range of horticultural production enterprises and regions (see Appendix B). The growers were predominantly fresh market suppliers, although some are involved in the processed or semi-processed sector. All of the enterprises are leaders in their respective industry sectors, and the operators have a track record of implementing new techniques and strategies to enhance profitability and sustainability.

2.4 Aims and objectives

The aims of this project were two-fold:

- To bring Dr Jeff Mitchell to present information on vegetable production systems being used in California, with particular emphasis on topics such as cover crops and reduced till/zero-till techniques. His itinerary (see Appendix C) provided for speaking engagements in Tasmanian and NSW, although participants of the workshop came from all the eastern states.

- To bring together a diverse collection of growers from a range of sectors and growing environments to interact and discuss the suitability and application of alternative production techniques that enhance soil sustainability. Those attending the workshop represent a range of levels of adoption of more sustainable production practices, including permanent beds and cover crops in some sectors and regions.

2.5 Key information and outcomes

Key points from the presentations at the seminar and workshop are summarised below:

- Intensive tillage contributes to rapid loss of organic carbon in soils
- Less than 30% of green matter incorporated as cover crops or crop residue ends up as soil carbon
- Addition of 10 t/ha of dry matter will raise soil carbon levels by about 0.1%
- Controlled traffic allows a reduction in the frequency and intensity of tillage, and should therefore reduce the rate of carbon loss due to tillage
- The benefits of improved soil structure take time to accumulate, with increased productivity generally taking the longest to achieve
- Biofumigant crops need to be selected carefully to ensure the correct variety is used to address the specific pathogen problems that are present
- Biofumigant crops need to be macerated and incorporated at early flower bus set
- Plan biofumigant crops as an integral part of the rotation, not just an add on to cash crops
- Choose cover crops for the end purpose – grasses for high organic matter, legumes for nitrogen
- Cover crops need to be competitive to assist with weed control, but easy to kill to provide a mulch layer for the next crop
- The 3 E's of agriculture – Economics, Equipment, Ecology
- Take tillage out of the system. Replace it with sanitation and competition.
- It's not about the tillage practice. It is about managing the ecosystem. Tillage removes out ability to manage the system.
- There is no need for tillage unless it is to correct a problem you've created.
- Mother Nature is an Opportunist. If you have a problem, YOU have provided the opportunity somewhere in your system.
- Think twenty years ahead.
- Intensive tillage – no. 1 environmental enemy in production agriculture. Intensive tillage causes an accelerated downward spiral of soil degradation
- Soil organic matter is a mixture of residual plant material in various stages of decomposition and microbial biomass and all their bi-products. The "key" component is carbon.
- Soil carbon is interlinked to all measures of soil quality through a complex web of many factors.
- Intensive tillage enhances biological oxidation and decreases soil carbon irrespective of residue management.
- Soil carbon sequestration provides:
    - increased water holding capacity and use efficiency
    - increased cation exchange capacity
    - reduced soil erosion
    - improved water quality
    - improved infiltration, less runoff
    - decreased soil compaction

- improved soil tilth and structure
- reduced air pollution
- reduced fertilizer inputs
- increase soil buffer capacity
- increase biological activity
- increase nutrient cycling and storage
- increased diversity of microflora
- increase adsorption of pesticides
- gives soil aesthetic appeal
- increase capacity to handle manure and other wastes
- more wildlife

Copies of the presentations given at the workshop have been provided along with this report.

Soil pits on the host farm were viewed and discussed as part of the field day. The pits demonstrated the differences in soil structure between a long-term cropping site, a cleared grazing site and a site as close as possible to the original native vegetation condition of the region. This clearly demonstrated the impact of traffic and tillage on soil structure.

Information gained by the growers through the workshop and field day has been taken back to their respective production regions. Given the nature of the growers involved, in that they tend to be innovators and adopters of new ideas, a very important outcome of the workshop is how it will influence the on-going activities of those who participated. Not only have individual growers been exposed to a range of new ideas, but the connections made with other growers from diverse parts of the industry will allow them to follow up their own lines of enquiry in areas of interest to them.

Feedback since the workshop and field day indicates that a number of communication lines have been established between growers that would not otherwise have occurred. These include the sharing of information about equipment, growing practices and business arrangements between some growers.

3 Evaluation survey

Feedback from participants of the workshop, both through formal survey and informal comment, indicates that the workshop and field day was a very effective means of presenting information on soil health management. Perhaps just as important was the opportunity the event provided for a collection of growers from different horticultural sectors and production regions to mix and learn from each other in a non-competitive environment. All the feedback was positive and indicated that future events of a similar nature would be well supported. A summary of the feedback, presented in the same structure as the evaluation form, is provided in Appendix D.

4 Recommendations

The Australian horticultural industry is very diverse, and it is often difficult to develop a seminar or workshop program that is of interest and relevant to growers from a range of production sectors and environments. Soil health is clearly one area where this can be done, even though some of the management practices used will vary in applicability for different crops and regions.

Workshops of this nature could be an annual event, and held in a different region each year to allow exposure to different environments and farming systems. The content of the two workshops held so far is very much directed towards annual horticultural cropping, but applicable to a wide range of crops and growing environments within that sector.

The duration of the workshop is very important. Wherever possible, it should last a maximum of two days, with about half the time devoted to presentations and half to field visits. Even though the travel distances are large for most attendees, depending on where the event is held, keeping the total program short and concise encourages attendance. Most growers can accommodate an absence from their business of a few days, allowing for travel and attendance. Attendance at events lasting up to a week is much more difficult to organise. Holding the event in a place with ready access to field visit opportunities is very important.

5 Acknowledgements

The support of Bayer Crop Science is acknowledged as a key contribution to the success of this project. Those who participated in the Cowra workshop represented a wide diversity of sectors in the vegetable industry. Each participant brought a different perspective to the event, and this diversity was very valuable. Their personal contributions of time and meeting their own travel costs are greatly appreciated. The efforts of the presenters who provided valuable insights into various aspects of soil management and cropping sustainability is greatly appreciated. Lastly, thanks are given to Horticulture Australia Limited for matching the funds provided by Bayer Crop Science through the Voluntary Contribution scheme.

6 Appendix A – Partnering with Innovation II workshop program

8:00 a.m.	Partnering with Innovation II - Objectives and Agenda, Introduce Guest Speakers, **Tim O'Grady**	
8:15 a.m.	Mechanics of building and maintaining soil carbon - why maintaining ground cover and reducing tillage is critical for productive and sustainable vegetable production. **- Peter Aird & John McPhee**	Peter Aird (Serve-Ag) has more than 25 years agronomy experience in the Tasmanian vegetable industry and a keen interest in the practical adoption of sustainable soil management.
		John McPhee (Tasmanian Institute of Agricultural Research) started work in CTF in the Burdekin during the 1980's and has worked with Peter Aird for many years to progress CTF in Tasmania.
8:45 a.m.	Global trends with green manure crops in temperate vegetable production **- Jason Lynch**	Jason Lynch (Serve-Ag) has 15 years experience in the vegetable and flower industries in north-west Tasmania. He has extensive knowledge in the agronomic management of bio-fumigant crops.
9:30 a.m.	Selection and management of cover crops in dry tropics vegetable production **- Chris Monsour**	Chris Monsour (Prospect Ag.) is based in Bowen and provides pest management and agronomic services in a range of horticultural crops. Chris has considerable expertise in key aspects of dry tropics vegetable production systems.
10:00 a.m.	**Morning Tea**	
10:30 a.m.	Successes and failures with conservation tillage and cover crop management in the United States **- Dr. Jeff Mitchell**	Dr. Jeff Mitchell (University of California, Davis) is an extension specialist with expertise in techniques and equipment to enhance production sustainability in vegetables.
12:30 p.m.	**Lunch**	
1:30 p.m.	Farm tour of reduced tillage vegetables systems on 'Mulyan Farms', including '360 reformer'. Soil pits with and without intensive cultivation **- Ed Fagan & Ian Packer**	Ed and James Fagan (Mulyan Farms) manage a mixed broad acre, viticulture and vegetable farm, focused on processing lettuce & spinach.
		Ian Packer (Lachlan CMA) has over 30 years experience R&D on local soils and CTF in broad acre farming.
3:00 p.m.	**Afternoon Tea**	
3:30 p.m.	**Question and answer session**	

7 Appendix B – Participants

7.1 Growers

Grower	Location/s	Cropping focus	Crop rotation and production practices focus
Kayne Younghusband	Mataranka NT, Broome, WA	Seedless watermelon, pumpkin	Winter melon production with summer sorghum rotation during the wet season. Previous trial involvement with HAL permanent bed project. Progressive producer interested in new techniques.
Peter Greensil	Bundaberg, QLD	Seedless watermelon	Year-round melon production in rotation with sugarcane. Progressive adopter of new technologies. Yet to adopt any CTF practice.
Paul Windolf	Gatton, QLD	Potato, lettuce, broccoli, cucurbit	Winter rotation of lettuce, broccoli and potato with summer cucurbits. Aiming to reduce tillage and compaction impact in their intensive system.
Ray Taylor	Stanthorpe, QLD	Silverbeet, celery, lettuce, brassicas	Summer & autumn harvest on 7 lines. Using permanent beds to reduce soil compaction.
David DePaoli	Bundaberg, QLD	Chili	Year round chili production with sunflower rotation. Using conventional tillage with some permanent beds. Adopting CTF.
Andrew Phillip	Childers, QLD	Tomato	No designated crop rotation with production mainly on leased ground. Longer-term view to CTF on family owned land.
David Moon	Saint George, QLD	Onions, cotton	Onions planted in autumn followed by cotton over summer. Long-term use of compost to build soil health.
Ed Fagan	Cowra, NSW	Lettuce, spinach, beetroot.	Lettuce and spinach rotation with winter rye grass. Recent adoption of CTF and cover cropping strategies.
Jamie Jurgens	Bowen, QLD	Tomato, capsicum, sugarcane	Winter tomato production followed by one-year sugarcane rotation. Reducing tillage a key focus in production system.
Paul Villis	Burdekin, QLD	Sugarcane, mungbeans.	Sugarcane and mungbean rotation. Using zonal tillage and permanent beds. Developed broadacre CTF concepts for vegetable production
Dale Williams	Bowen, QLD	Tomato	Tomato production in permanent beds. Previous trial involvement with HAL permanent bed project. History of early adoption of new farming techniques.
Paul LeFerve	Burdekin, QLD	Zucchini, mango	Winter zucchini production with sorghum companion crop. Previous trial involvement with HAL project. Using innovative production techniques, with a focus on soil health.

Grower	Location/s	Cropping focus	Crop rotation and production practices focus
Mark Kable	Forth, TAS	Broccoli, green beans, onions, potatoes & various others	Over 80% of their crops are grown on beds with winter ryegrass cover cropping. Highly mechanized producer. Topography of land is a major limitation for CTF. Progressive adopter of new production technologies
Lawrence Cowley	Cambridge, TAS	Baby leaf lettuce, baby spinach	70% of farm is dedicated to raised permanent beds. Experimented with ryegrass & mustard cover crops but haven't pursued these due to crop demands.
Mark Schreurs	Devon Meadows, VIC	Leeks, lettuce, leafy brassicas	Intensive rotations with mustard or rye corn cover cropping every 2 years. Currently practicing minimum tillage across their operation. Composting to improve soil health. Highly innovative with a focus on IPM and improving soil health.
Colin Gazzola	Somerville, VIC	Bunching Asian vegetables, lettuce, broccoli, celery	Rye corn/oat cover crop rotation every 2-3 years. No set rotation. Limited at present with the mechanization of CTF. Would like to explore minimum till rotary bed former as the way forward.
Peter Covino	Longford, VIC	Lettuce, baby spinach, carrots, broccoli	No structured crop rotation. Very intensive production. Grows on light, sandy soils. No controlled traffic or conservation agriculture focus but recognizes the value in this approach.

7.2 Presenters, organisers and service provider representatives

Name	Company	Location	Name	Company	Location
Peter Aird	Serve-Ag	Devonport, TAS	Marc Hinderager	Elders	Cowra, NSW
Jason Lynch	Serve-Ag	Smithton, TAS	Graham Nicol	Bayer CropScience	Fingal Bay, NSW
Andrew Whitbourne	E.E Muir & Sons	Lindenow, VIC	Tim O'Grady	Bayer CropScience	Tallebudgera, QLD
Mike Titley	MHT Vegetable Consultancy Services	Sydney, NSW	Jeff Mitchell	University of California	Davis, CA
Chris Monsour	Prospect Ag.	Bowen, QLD	Damien Odgers	Bayer CropScience	Melbourne, VIC
John McPhee	Tasmanian Institute of Agricultural Research	Devonport, TAS	Ian Packer	Lachlan Catchment Management Authority	Cowra, NSW

8 Appendix C – Itinerary – Dr Jeff Mitchell

Date	Place	Activity
Sat 30 July	Arrive Sydney from California	Rest and recovery
Sun 31 July	Sydney – Launceston - Devonport	Travel, vegetable farm visits in Cressy area to inspect soil management and production practices
Mon 1 Aug	Devonport	Vegetable farm visits in Forth – Devonport area to inspect soil management and production practices. Seminar for growers, researchers and service providers. Final preparations for Cowra seminar. Discussions with TIAR regarding future collaboration with University of California (Davis).
Tue 2 Aug	Devonport – Canberra – Cowra	Interview with ABC Rural Radio. Farm visits in Wesley Vale area. Travel to Cowra
Wed 3 Aug	Cowra	Partnering with Innovation II workshop and field day
Thu 4 Aug	Cowra – Canberra - Sydney	Final review of Partnering with Innovation II workshop, travel
Fri 5 Aug	Sydney – Los Angeles	Return travel to California

9 Appendix D – Evaluation and feedback from attendees

Details below outline the questions and structure of the evaluation form which was sent to attendees after the event. The form was structured in two parts, the first seeking a rating score and comment on generic aspects of the event, and the second seeking comments about the specific topics covered, and how the information was received and will be used by those attending. Some of those responding gave only a rating, while others added further comment. Average evaluation scores and comments from the attendees are included.

Evaluation form for Partnering with Innovation II

Overall rating of the event:
Average score – 4.5

- Very good to have top growers from all over the country together
- Excellent in technical content especially data from Tasmanian researchers
- Well organised event with good speakers and field demonstrations

Value of the event content to your business:
Average score – 3.8

- Data on biofumigants, having Jeff Mitchell present, equipment shown by Fagan's all very valuable
- Apart from the learning side, always good to catch up with other growers to obtain fresh ideas

Value of the event to you professionally:
Average score – 4.8

- Gain understanding of practical methods (cover crops) to integrate biological focus with traditional practices (ag-chem, fumigants, synthetic fertilizers, etc.).
- Manures, composts, cover crops, strip tillage, will come into play more and more especially in horticulture.
- Being a private consultant, having interaction with key innovative farmers and fellow consultants was great

Quality and relevance of the speakers:
Average score – 4.3

- Good
- Everybody excellent, although a couple could have given better coverage to fewer points
- Good speakers who presented well

Participant interactivity:
Average score – 4.3

- Breaks, field demos, evenings gave opportunity to "interact".
- Perhaps could have been improved by going around all participants at the end as well as in the beginning
- Good to see that all the growers were open about their thoughts and ideas

Key points from attendee feedback

Topic & speaker	What did I learn, what are the opportunities	How can I put this into practice? What is the next step?
Building and maintaining soil carbon - *Peter Aird, John McPhee*	• ground cover is important • be very careful with tillage • how much OM needs to be added to raise OC by 1% • importance of soil carbon	• never leave soils bare • use compost • some real data needed, rather than testimonials – scope for a funded project?
Global trends with green manure crops in temperate vegetable production - *Jason Lynch*	• mostly brassicas • little effect on verticillium & sclerotinia • variety matters! • reduce nematicides, fertiliser inputs • rating of which pathogens are easiest to control by biofumigants	• get biofumigant data and other reliable reports presented to appropriate innovative growers
Selection and management of cover crops in dry-tropics vegetable production - *Chris Monsour*	• Range of grasses and legumes available - ryegrass, soybeans, cowpea, French millet, sorghums • adoption in the sub-tropics is ahead of temperate areas	• have southern growers visit the progressive northern growers
Successes and failures with conservation tillage and cover crop management in the US - *Dr. Jeff Mitchell*	• reduce volume of soil disturbed, improve depth of improved soil • broadacre agriculture ahead of horticulture in southern Australia • importance of getting the right machinery working properly	• more days like held at Cowra
Soil pits with and without intensive cultivation - *Ian Packer*	• presence of compaction layer with cultivation • message still not getting out into horticulture about looking after soil	• the innovators will bring the laggards along

Farm tour of reduced tillage vegetables systems on Mulyan Farms, and '360 reformer' demonstration - *Ed Fagan*	• it is possible to form beds and deal with trash without pulverising soil • testimonials and observations still driving what the Fagan's have achieved in 12 months • good opportunity to see the 360 reformer in action	• need for good supporting science

Other unsolicited feedack (received by email and personal contact)

- Congratulations on a very successful and informative workshop. Please pass on my appreciation to the presenters. I look forward to participating in another in the future.
- A massive thank you to you and the team for holding such an event and inviting me to attend. I thoroughly enjoyed it. I really appreciate all the effort you guys must have put into organising it.
- I didn't get a chance to properly thank you for inviting me to attend your "Partners in Innovation" day. I was honoured to be there and really enjoyed it.
- Just wanted to say well done on pulling together the PWI show. It was a very worthwhile trip from my point of view – to interact with a great group of growers and industry leaders and to meet Jeff who is an inspirational guy.
- Thanks very much for asking me to speak to the Partnering with Innovation event in Cowra. It was an excellent opportunity for me to promote biofumigation, and share my knowledge with such a successful and diverse group of growers. I really enjoyed the event, and I hope that it provided the growers with something new to think about in terms of improving soil health.
- There is enough in the soil health topic for similar meetings for the next 10 years. It is a broad area to cover, and everyone has a different approach, however, the true value is with a group of like- minded people sharing their ideas.

10 Appendix E – Budget summary

The total budget for the project was $29,168.33, of which $16,895.52 was provided by Bayer Crop Science as a voluntary contribution. The cost per attendee was $1,005. Each participating grower funded their own travel costs, which in many cases would have been in the order of $1000 each, and Bayer Crop Science also provided resources and workshop materials, outside the HAL budget, to a value of approximately $5000, not including staff time.

11 Appendix F– Photographs from the workshop, field day and farm visits

Visit to controlled traffic field site, Tasmania

Visit to Tasmanian vegetable farm to discuss soil management and cover crops

Presenting to the Partnering for Innovation II workshop

Soil pit discussions as part of the Partnering for Innovation II field day

Demonstration of '360 reformer' as part of the Partnering for Innovation II field day

Demonstration of '360 reformer' as part of the Partnering for Innovation II field day

THE QUEST FOR DIVERSE, LOW-DISTURBANCE CROPPING SYSTEMS: RECENT PROGRESS AND CHALLENGES IN THE IRRIGATED WESTERN US

Jeff Mitchell, Karen Klonsky, Will Horwath, Randy Southard, Wes Wallender
University of California, Davis

Dan Munk, Gene Miyao, Brenna Aegerter, Tom Turini and Kurt Hembree
University of California

Ron Harben
California Association of Resource Conservation Districts

Partnering with Innovation II Workshop
Mulyan Farms
Cowra, NSW

August 4, 2011

Special thanks to Tim O'Grady and Bayer CropScience for the invitation to be with you today.

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Tom Gohlke

Ron Harben

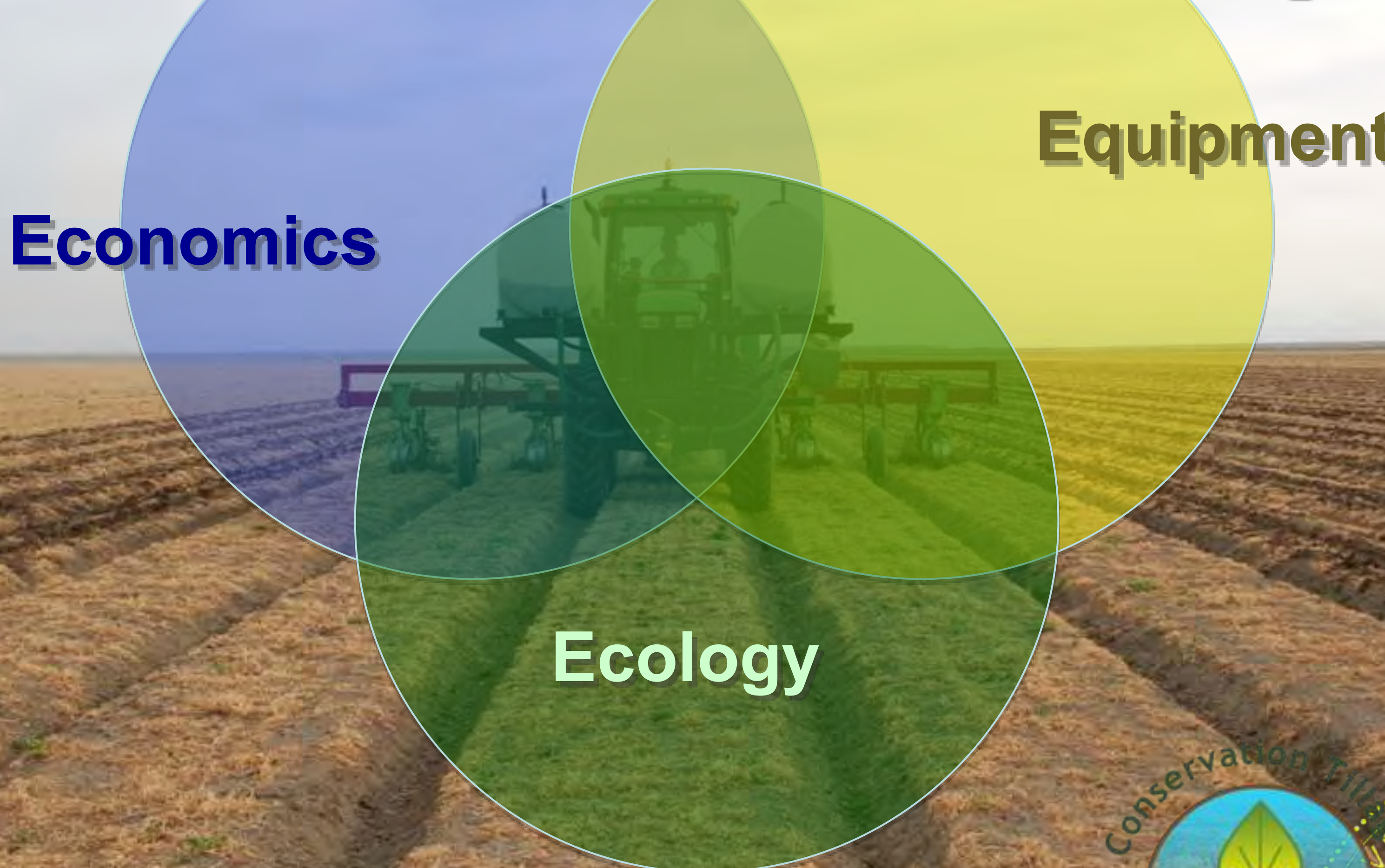
Ray Batten
Alan Wilcox
Pat Murray
Chuck Powell
Monte Bottens

Allen DuSault
Joe Choperena
Ladi Asgill

OVERVIEW OF PRESENTATION

- first principles - sources of motivation and inspiration
- development of conservation agriculture systems in CA - the research base
- scaling up with farm innovation
- examples from CA, WA and OR
- "putting the pieces together" into new production paradigms, and
- enabling change

The 3 E's of Farming



RESOURCE CONSERVATION DISTRICTS
Sustainable Conservation
NRCS
UC DAVIS PLANT SCIENCES
UC DAVIS COLLEGE OF AGRICULTURAL AND ENVIRONMENTAL SCIENCES
Conservation Tillage Workgroup
UC CE

1930s	Dryland Farming "Pump Era" - Advent of limited irrigation
1957	Shredder Bedder Ruozi, Interstate Mfg.
1963	California Aqueduct Central Valley Improvement Project (Expansion of irrigation)
1970s	Wide tractive "spanner" implement (Controlled traffic research) Carter, USDA
1980s	No-till dryland small grain production (Yolo, Tulare and San Luis Obispo) "zone tillage," Carter, USDA
1993	Hahn Bed Disk Wilcox *Performer* New World Tillage *Incorpramaster*
1998	CT Workgroup formed
2000	New World Tillage *Optimizer*
2003	No-till and strip-till cotton farm studies (Bob Prys, Riverdale, CA)
2004	Wilcox *Eliminator*
2005	Strip-till tomatoes
2008	Strip-till and no-till daily silage

RESOURCE CONSERVATION DISTRICTS

Sustainable Conservation

NRCS

UCDAVIS PLANT SCIENCES

UCDAVIS COLLEGE OF AGRICULTURAL AND ENVIRONMENTAL SCIENCES

Conservation Tillage WORKGROUP

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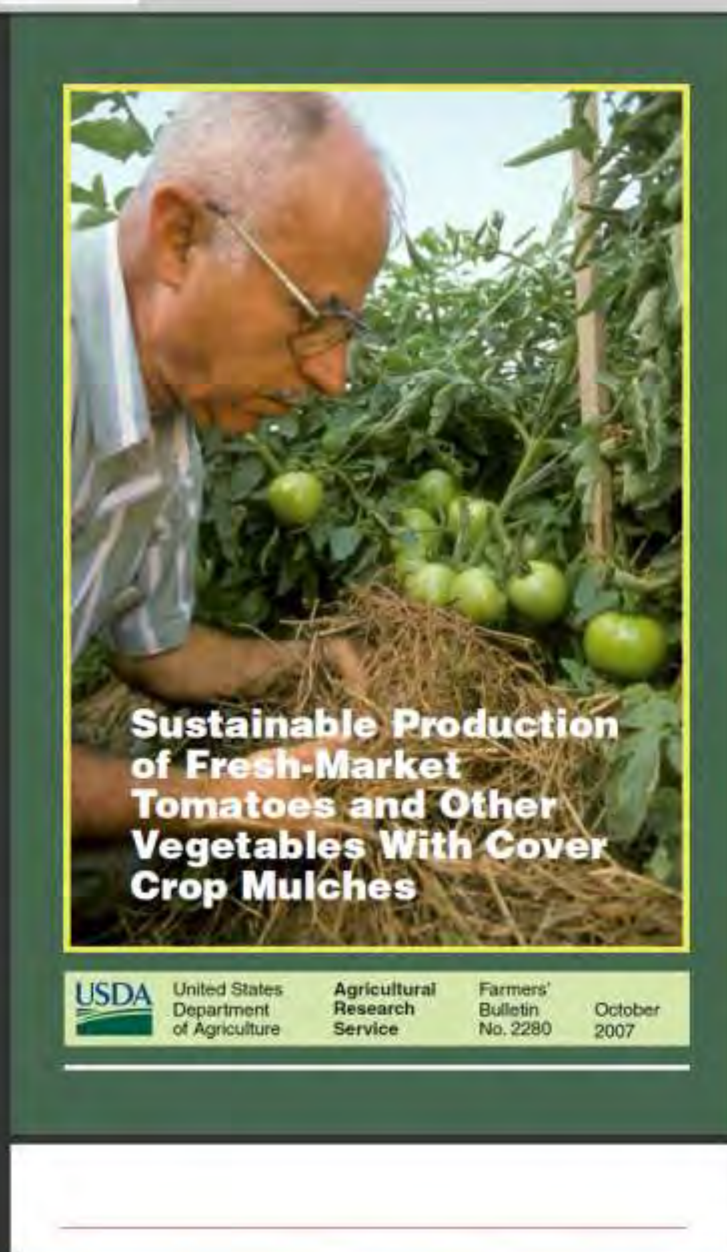

"Show me that it won't wo

Aref Abdul-Baki
USDA ARS
Beltsville, MD

Dwayne Beck, South Dakota State University
Dakota Lakes Research Farm, Pierre SD

New Horizons for Conservation Cropping for California Conference • March 2011

WELCOME!!

Dwayne Beck

Dakota Lakes Research Farm

What is your problem?

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American Farmland Trust

Conservation Tillage and Cropping Systems WORKGROUP

RESOURCE CONSERVATION DISTRICTS

Sustainable Conservation

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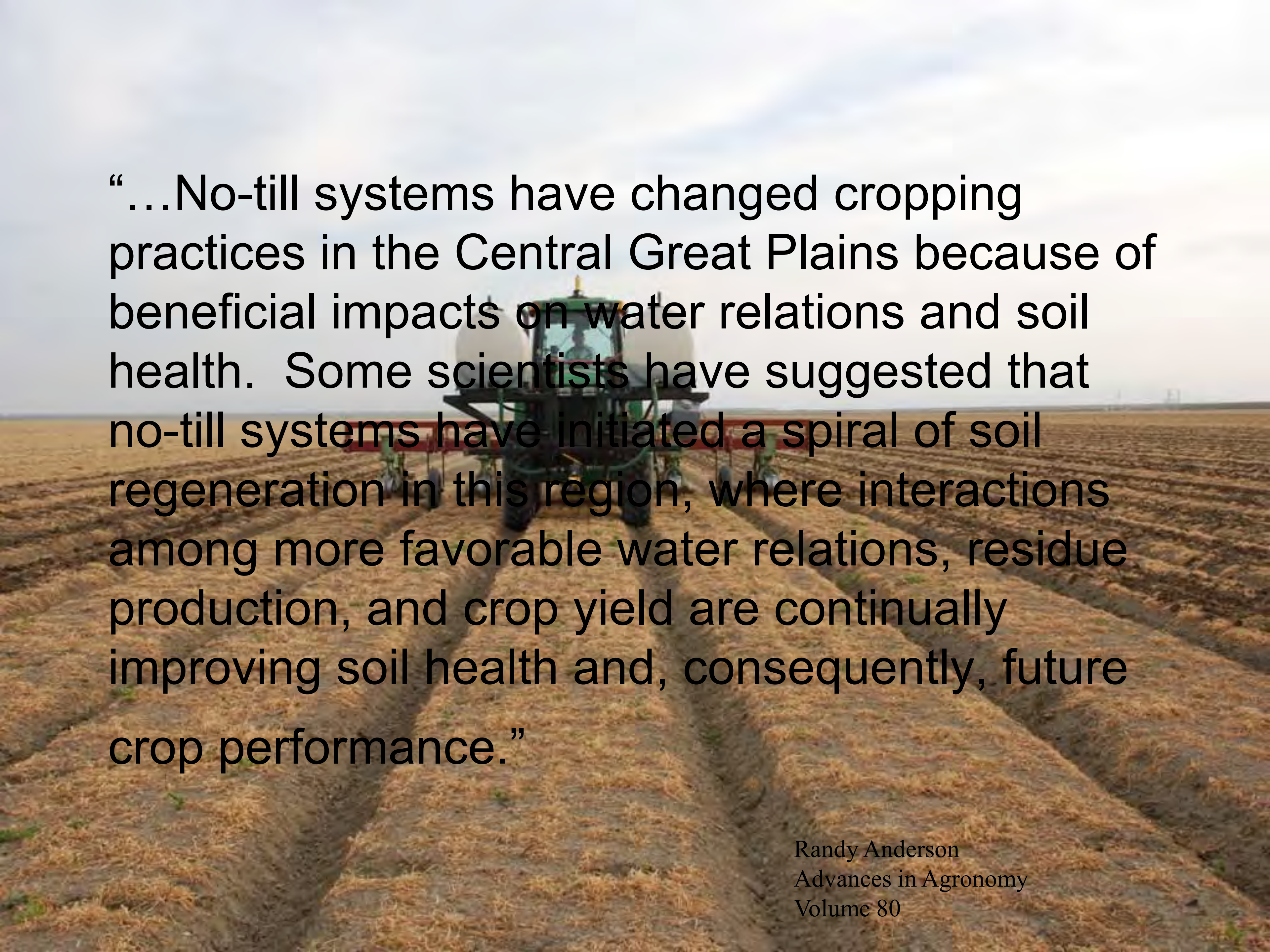
Agriculture and Natural Resources

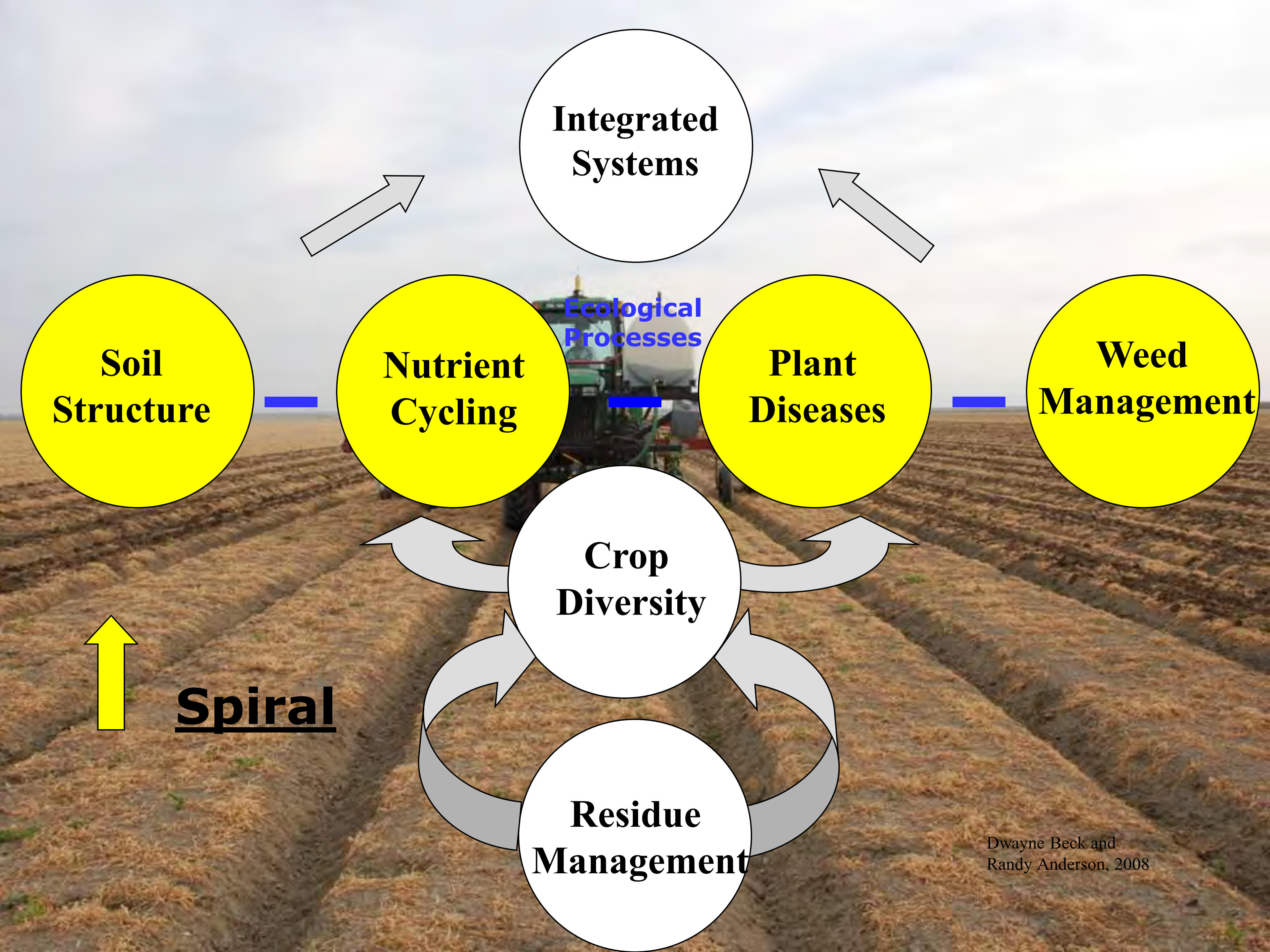
UCCE
Making a Difference for California


"…Take tillage out of the system.
Replace it by sanitation and competition."
Dwayne Beck
January 23, 2008
"…Tillage removes our ability to manage the system."
Dwayne Beck
March 7, 2006



"…No-till systems have changed cropping practices in the Central Great Plains because of beneficial impacts on water relations and soil health. Some scientists have suggested that no-till systems have initiated a spiral of soil regeneration in this region, where interactions among more favorable water relations, residue production, and crop yield are continually improving soil health and, consequently, future crop performance."

Randy Anderson
Advances in Agronomy
Volume 80



Integrated Systems
Ecological Processes
Soil Structure
Nutrient Cycling
Plant Diseases
Weed Management
Crop Diversity
Residue Management
Spiral
Dwayne Beck and
Randy Anderson, 2008

"…Mother Nature is an Opportunist. If you have a problem, YOU have provided the opportunity somewhere in your system."

Dwayne Beck
January 23, 2008

"…There is no need for tillage unless it is to correct a problem you've created."

Lyle Carter
2002


High residue no-till systems in Pierre, SD


CASE IH
2007
California
CONSERVATION TILLAGE
FARMER TOUR
Conservation Tillage
WORKGROUP
CARCD
NRCS
UCDAVIS
UCCE


“Take the „E’ out of „ET.’”
“Think twenty years ahead.”
“We have to be no-tillers. Let’s learn to do it right.”
Dwayne Beck
Dakota Lakes Research Farm
South Dakota State University
Pierre, SD

Conservation Agriculture is good for a lot of reasons. Carbon sequestration impacts on Climate change is just one of those reasons.

Global Policies and Perspectives

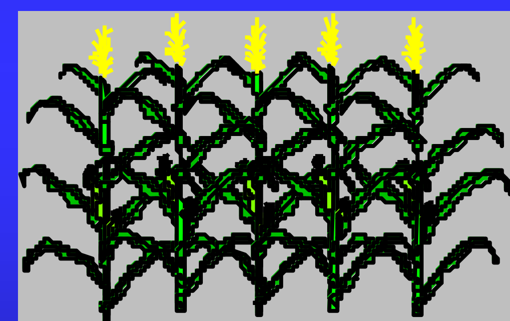
We have only one earth! Let's protect and nurture it.

MANAGEMENT'S DELICATE BALANCE TO MAINTAIN SOIL QUALITY

TILLAGE INTENSITY

OUR FOOD SUPPLY

RESIDUE INPUTS



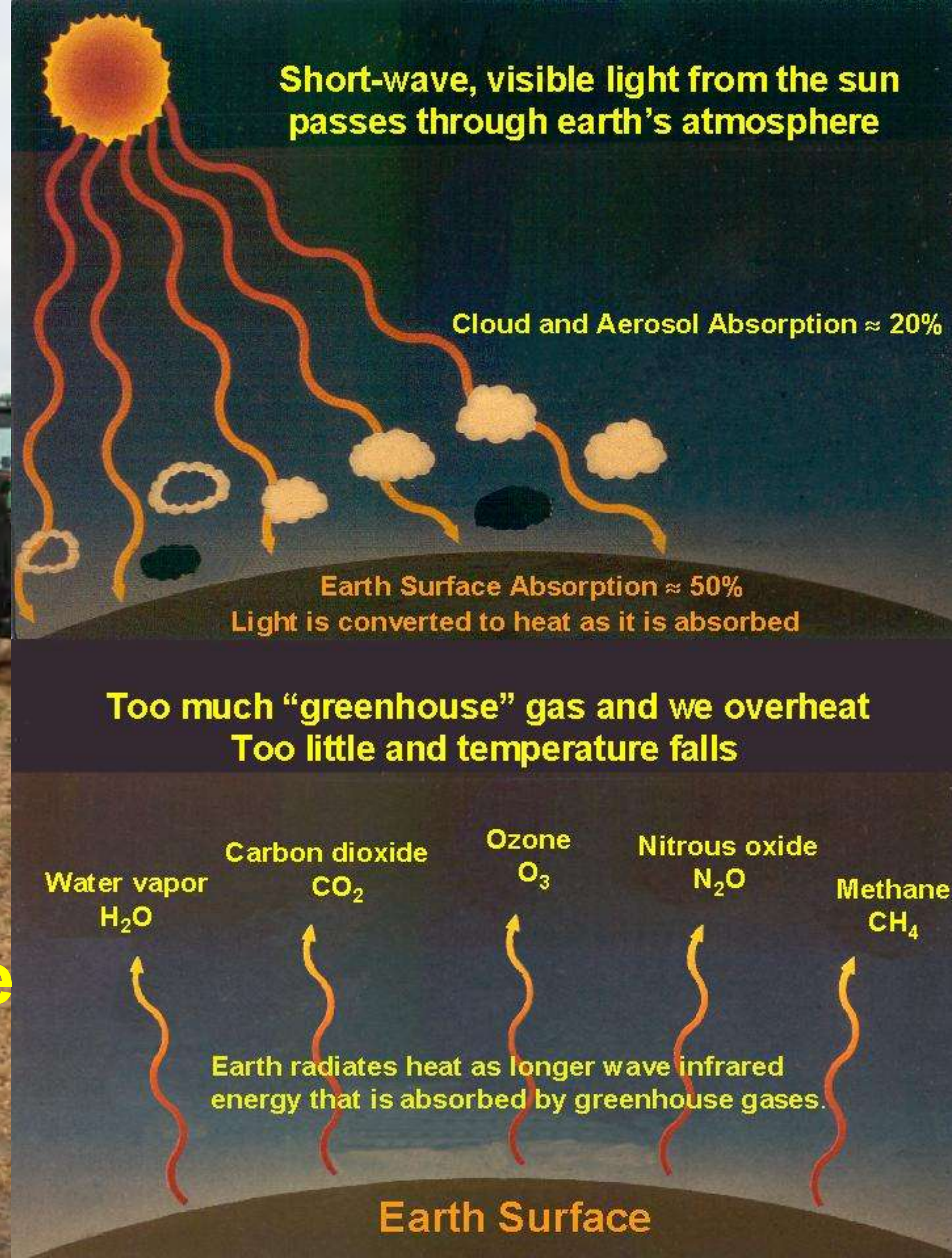
SUSTAINABLE AGRICULTURE

climate   vegetation   parent material   topography   age

SOIL ORGANIC CARBON

Reicosky,2000

Greenhouse Effect and Global Climate Change

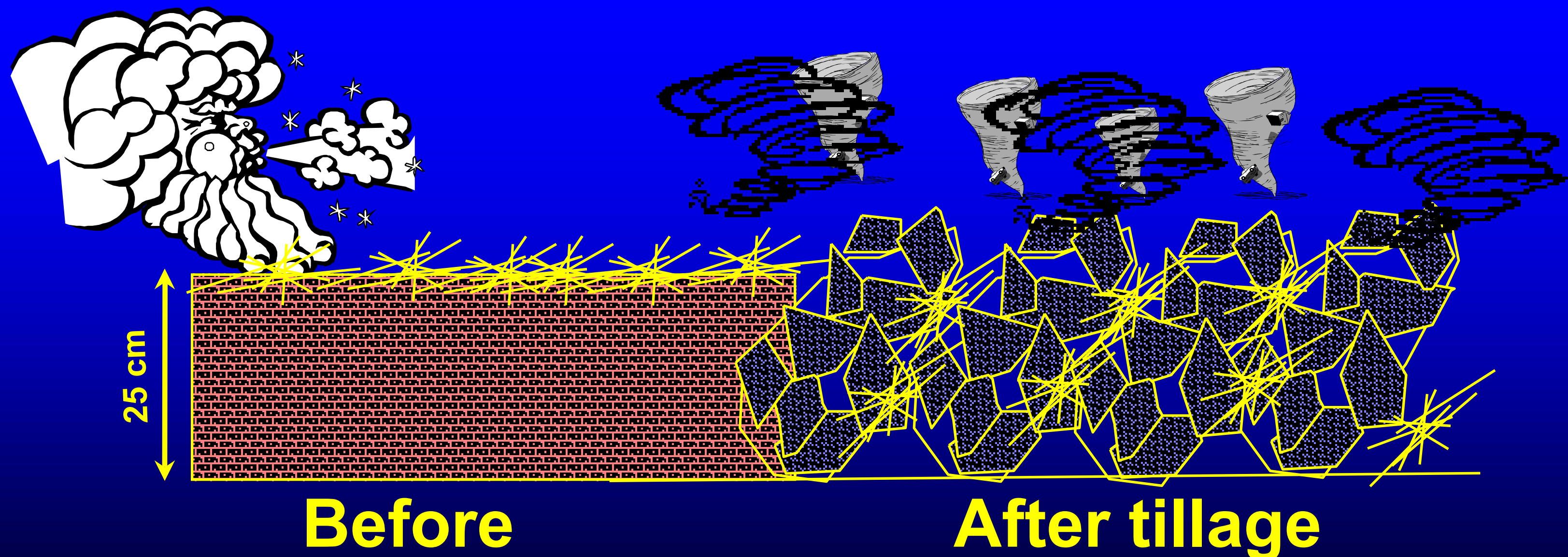


The role of intensive agricultural tillage and Soil Carbon

“Clear air turbulence”!

Invisible effects of invisible forces!

Normal wind with turbulent mixing creates gentle updrafts that enhances soil air exchange and carbon loss after tillage.

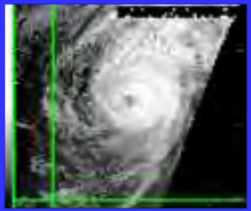


"Turmoil of Tillage"

The soil is a natural biological system that contains a lot of life and when tilled intensively is dramatically changed. It can be considered analogous to human reaction to a combination of:

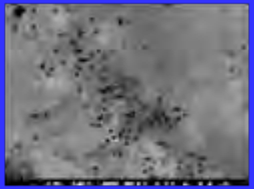
- earthquake

- hurricane



- tornado

- forest fire



all rolled into one perturbation event.

Reicosky,2000

No. 1 Environmental Enemy in Production Agriculture

Intensive Tillage

Intensive tillage causes an accelerated downward spiral of soil degradation.

Tillage Enhances Biological Oxidation.

Tame the "Invisible Flame"!

Use Conservation Tillage!

INTENSIVE TILLAGE, HOW MUCH IS NECESSARY?

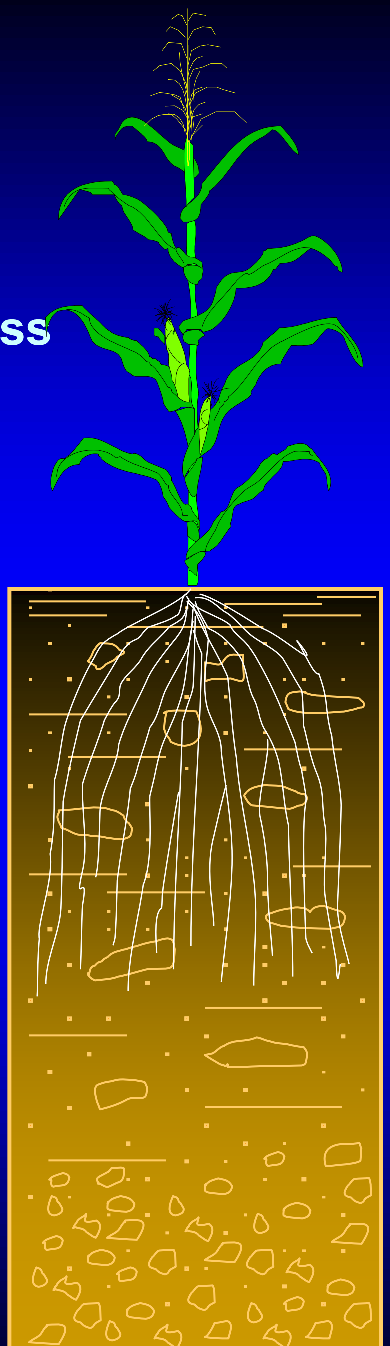
True Conservation is carbon management.

Conservation Agriculture provides beneficial ecosystem services:

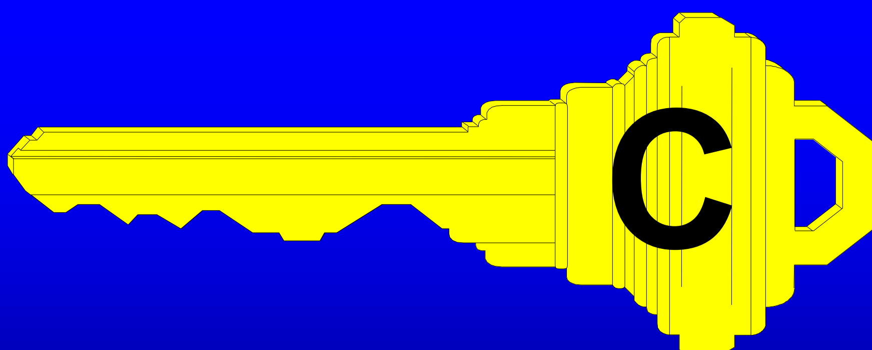
1. **Food, fiber and biofuels**
2. **Less erosion, less pollution, clean water, fresh air, healthy soil, natural fertility, higher production, carbon credits, beautiful landscape, sustainability etc., etc. ……**

Soil carbon is a priceless key to the planet's health and our environmental quality.

Soil organic matter is a mixture of residual plant material in various stages of decomposition and microbial biomass and all their bi-products.



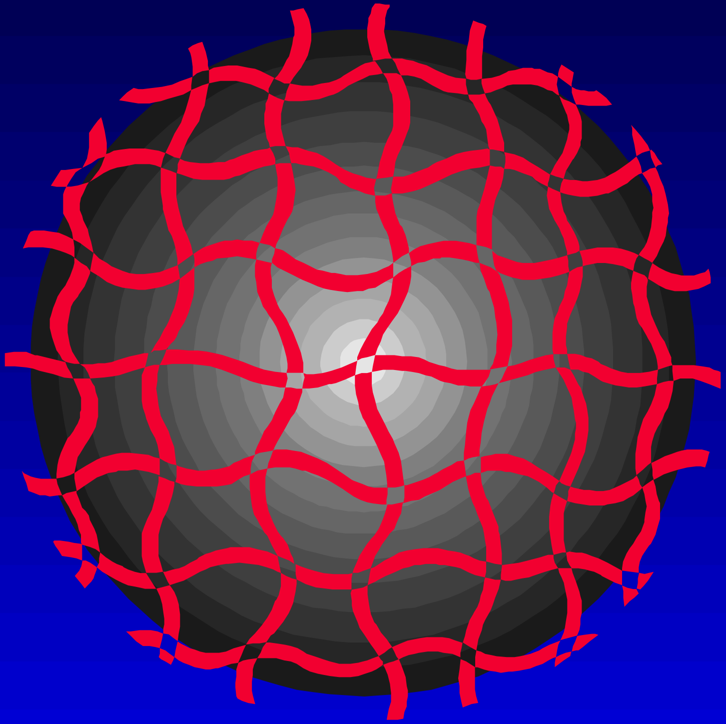
The "key" component is:



c a r b o n !

Soil carbon is interlinked to all measures of soil quality through a complex web of many factors.

Physical



Chemical

Biological

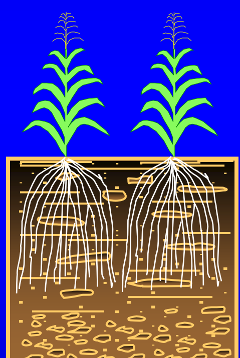
Carbon Cycle - a "fantastic voyage"

CO_2

Green plants

Crop Residue/Stubble Decomposition Cycle as a temporal continuum with carbon changing form and function as CO_2 is released through microbial respiration.

CO_2 CO_2 CO_2 CO_2 CO_2 Basic elements



Stubble residue

Organic matter --- humus

Humic fulvic acids

Active pools ---- Passive pools ---- Recalcitrant pools

Tillage flashes forth flames of fire!

Gaining Carbon

Improved management can make it easy to come with more cropping intensity and/or cover crops and result in net carbon sequestration.

Losing Carbon

Improved management can make it slow to go with residue management and/or less tillage and result in net carbon sequestration.

Agriculture has dug a “carbon hole” with intensive tillage.

Agriculture can now refill the “carbon hole” with less intensive tillage.

Tillage-induced Carbon Dioxide Loss

Soil Carbon Sequestration

Environmental benefits are spokes that emanate from the Carbon hub.

- increased water holding capacity and use efficiency
- increased cation exchange capacity
- reduced soil erosion
- improved water quality
- improved infiltration, less runoff
- decreased soil compaction
- improved soil tilth and structure
- reduced air pollution

Carbon

central hub of environmental quality.

- reduced fertilizer inputs
- increase soil buffer capacity
- increase biological activity
- increase nutrient cycling and storage
- increased diversity of microflora
- increase adsorption of pesticides
- gives soil aesthetic appeal
- increase capacity to handle manure and other wastes
- more wildlife

World plowing Record in 2003!

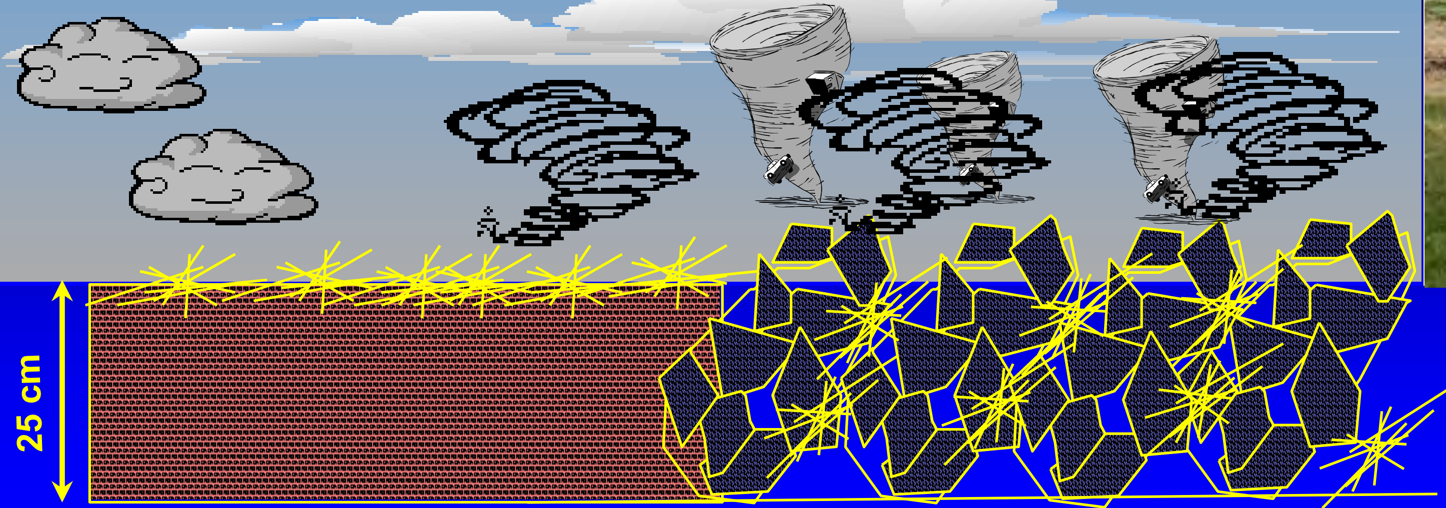
Massey Ferguson MF 8289 387 HP tractor

Setting world records degrading our resources!

Plowed 251.5 ha (621 ac) in 24 hours or 10.5 ha (24 acres) per hour!

Based on typical portable chamber measurements on moldboard plowed soil in Minnesota, at ~200 g CO_2 m^{-2} in 24 hours, they released about 503 tonnes of CO_2 (137 tonnes of carbon) in 24 hours!

Invisible forces of aerodynamics lifts carbon dioxide out of tilled soil.



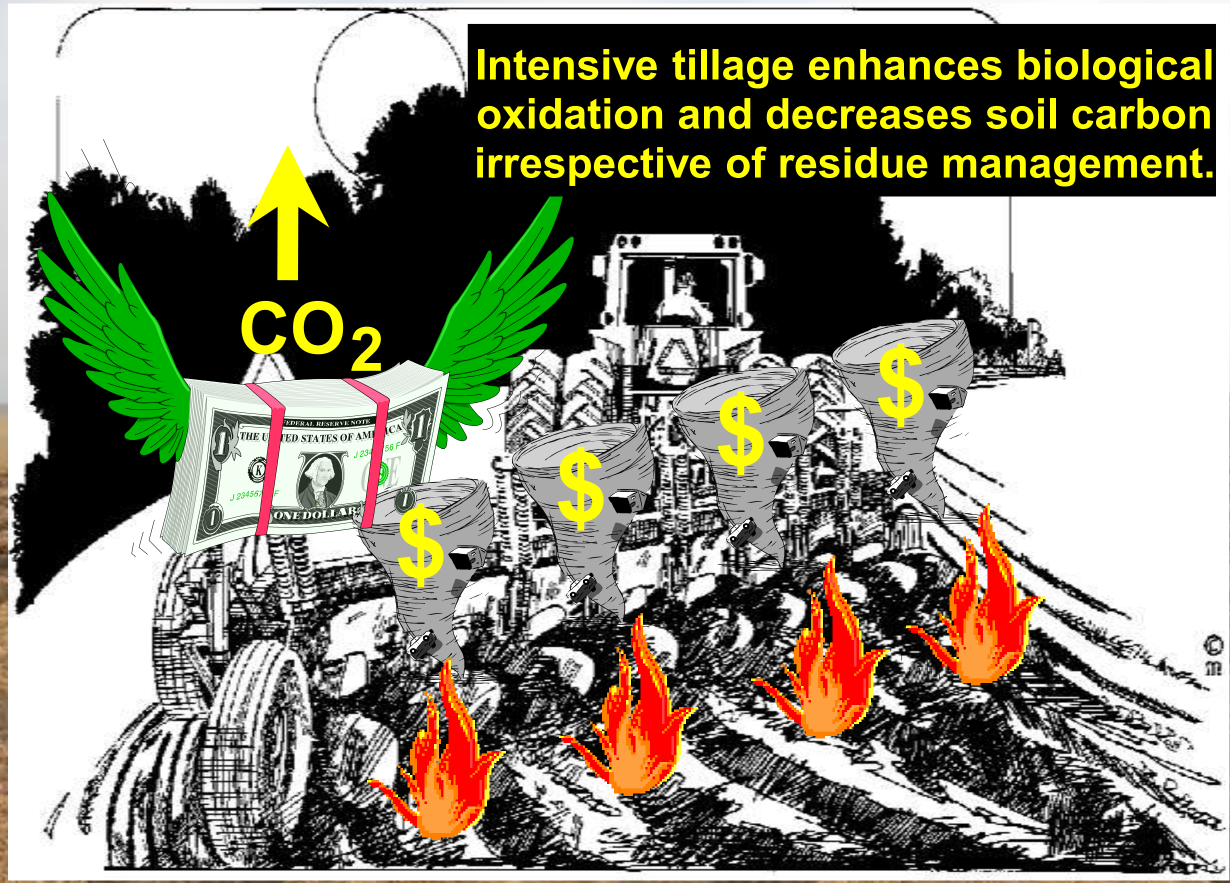
MOLDBOARD PLOW

BEFORE **AFTER**

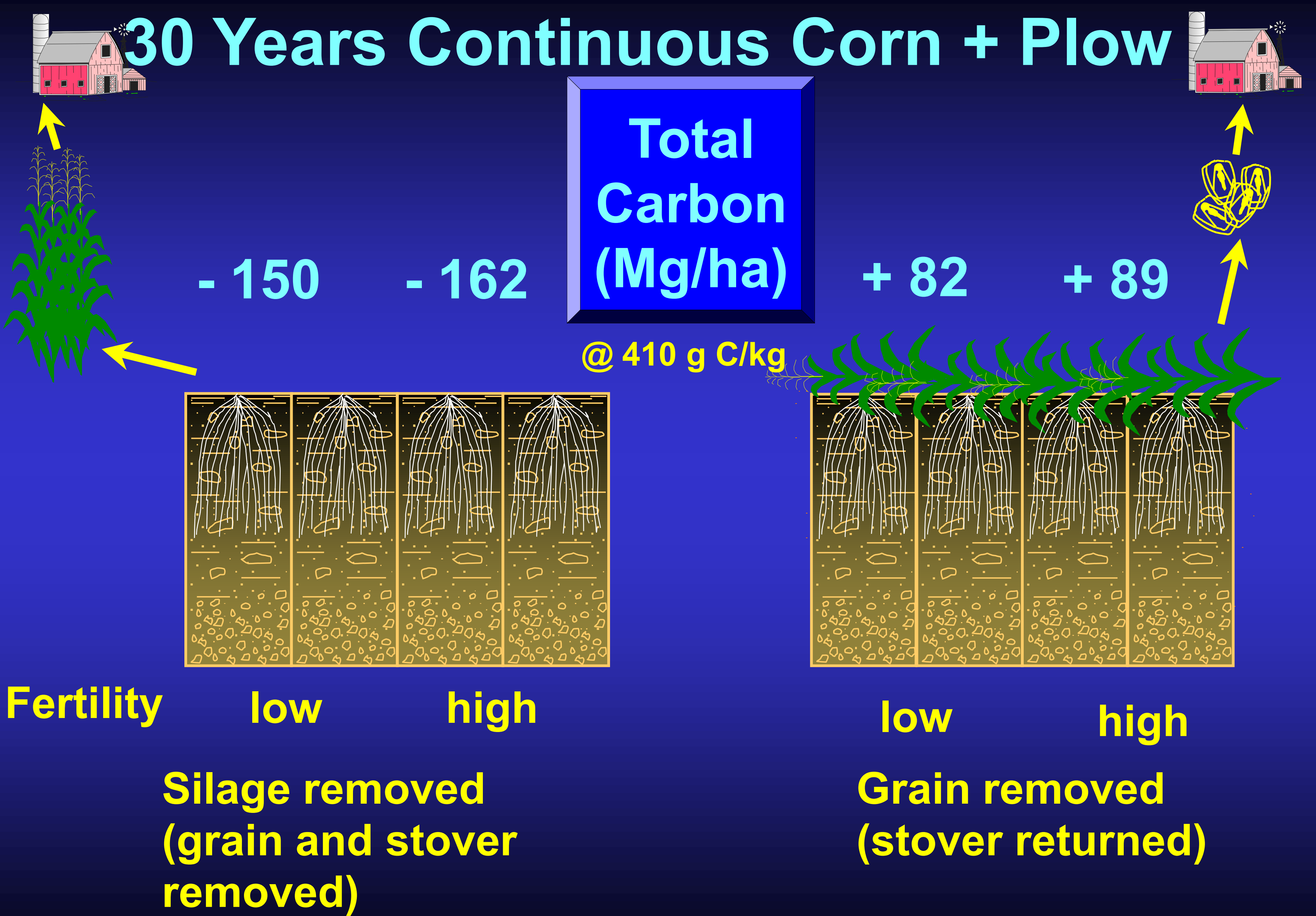
Tillage loosens the soil (i.e. changes soil air permeability) and enables rapid soil gas exchange. Soil carbon dioxide is sucked and swirled into turbulent eddies on into the atmosphere. Oxygen enters the large voids to enhance microbial activity.

Tillage unlocks the potential microbial activity by creating more reactive surface area for gas exchange on soil aggregates that are exposed to a higher ambient oxygen concentration (21%). Tillage also breaks the aggregates to expose "fresh" surfaces for enhanced gas exchange and perhaps more carbon loss from the interior that may have a higher carbon dioxide concentration.

Invisible effects of invisible forces!



Tillage very effectively facilitates biochemical degradation of organic matter.

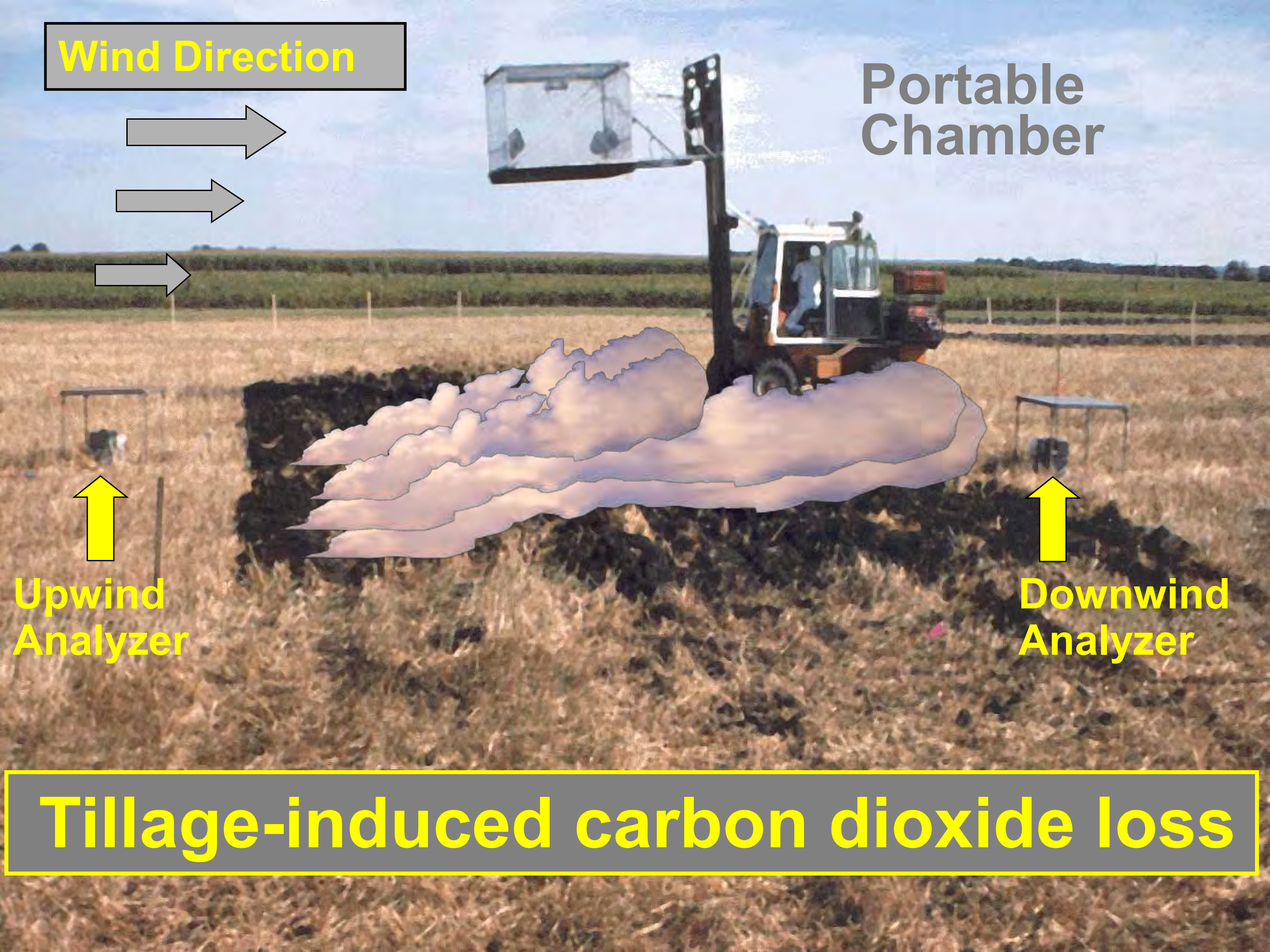

30 Years Continuous Corn + Plow
Total Carbon (Mg/ha)
@ 410 g C/kg
- 150
- 162
+ 82
+ 89
Fertility
low
high
low
high
Silage removed (grain and stover removed)
Grain removed (stover returned)

30 Years Continuous Corn + Plow

	Silage removed (grain and stover removed)			Grain removed (stover returned)	
			Total Carbon (ton/ac)		
	- 67	- 72		+ 37	+ 40
Fertility	low	high		low	high
	2.13	2.14	(0-6 in) Soil Carbon (%)	2.13	2.17

Results suggest intensive tillage common to all treatments overshadowed stover carbon removal or addition.

Reicosky,2000


Wind Direction
Portable Chamber
Upwind Analyzer
Downwind Analyzer
Tillage-induced carbon dioxide loss


Subsoil
Mole Knife
L128 Knife
Reicosky,2000

in an amicus brief supporting health care

federal health insurance program 321-1967

eagerly anticipated by those who would like to use the device, but are wary of the spotty reputation for quality gained by AT&T Inc.'s network.

AT&T is the only U.S. carrier now able to offer the iPhone on its network.

Crop disaster funds available for Fresno Co.

Fresno County farmers who experienced a crop disaster in 2009 can apply for assistance from the U.S. Department of Agriculture.

The USDA has made funds available through its Supplemental Revenue Assistance Payments program for the 2009 crop year. Farmers can apply to the program starting Monday.

The program provides financial help to farmers and ranchers who have experienced losses caused by natural disasters.

For information on the program's eligibility requirements, visit www.fsa.usda.gov/sure.

Borrowing rises in U.S. but still at low levels

Americans increased the amount of money they borrowed in November, mostly to buy cars and attend college. But the second straight month of gains barely raised consumer credit above its lowest point in four years.

Consumer debt rose $1.3 billion in November, the Federal Reserve said Friday. That follows a revised $7 billion increase in October.

The increase pushed overall borrowing to an annual rate of $2.4 trillion. That is not much higher than the $2.39 trillion rate from September — the lowest point since January 2007. It's 4.3% below the $2.58 trillion high point hit in July 2008.

AGRICULTURE

ASSOCIATED PRESS FILE

A farmer cultivates a recently harvested cornfield near Farmingdale, Ill., turning plants back into the soil. Sixty-eight percent of U.S. nitrous oxide emissions in 2008 came from farmland, according to an EPA report released last year.

Less plowing, lower emissions

No-till farming releases less of potent greenhouse gas, study finds.

By Rick Callahan
Associated Press

Crop land that's left unplowed between harvests releases significantly smaller amounts of a potent greenhouse gas than conventionally plowed fields, according to a new study that suggests no-till farming can combat global warming.

Those numbers are averages, he said. Researchers looked at fields where corn and soybeans were alternated from year to year and others that were planted each year from corn. Emissions in fields where crops were rotated were lower than in those where they weren't, he said.

Vyn said he was stunned by the large amounts of nitrous oxide his team detected in the air above the

Banks lose key home loan case

By Denise Lavoie
Associated Press

BOSTON — The highest court in Massachusetts ruled Friday against U.S. Bancorp and Wells Fargo & Co. in a widely watched mortgage foreclosure case that could have serious implications for the nation's largest banks.

The Supreme Judicial Court affirmed a lower court judge's ruling invalidating two mortgage foreclosure sales because the banks did not prove that they actually owned the mortgages at the time of foreclosure.

Last fall, the banking industry's foreclosure machine came under scrutiny with revelations low-level employees called "robo signers" powered through hundreds of foreclosure affidavits a day without verifying a single sentence.

Analysts warned the banks' allegedly fraudulent document procedures could imperil their ability to prove that they owned the mortgages.

The Supreme Judicial Court found that the banks, which were not the original mortgagees, did not make a required showing that they held the mortgages at the time of foreclosure. As a result, the court found, the banks did not show that the foreclosure sales were valid to convey title to the properties.

Attorney Paul

No-till farming more efficient, report says

Fewer greenhouse gases and reduced fertilizer use reported

INDIANAPOLIS (AP) — Cropland that's left unplowed between harvests releases significantly smaller amounts of a potent greenhouse gas than conventionally plowed fields, according to a new study that suggests no-till farming can combat global warming.

Researchers said the findings could also help farmers make more efficient use of the costly nitrogen-based fertilizers used to promote plant growth. No-till farming apparently slows the breakdown of fertilizers in the soil, they said.

David Simpson, district conservationist with the National Resource Conservation Service in Stockton, said no-till farming sees very limited use in California because of the vastly different climate, soil conditions and farm practices than in the Midwest.

"No-till is a tool that works in some areas and in some cropping systems, but it's not a panacea, it's not a solution for everyone," he said.

However, many Central Valley farmers are adopting new reduced-tillage systems, which cut down on the number of soil working operations in the field. Much of the focus is on new types of equipment that can do several jobs during a single pass through the field, cutting down on fuel use and air pollution.

"It's created a climate of entrepreneurial development in tillage instruments that I've never seen before in my career," Simpson said.

The three-year, federally funded Purdue University study looked at the amount of nitrous oxide released by no-till fields compared to plowed fields. No-till farmers don't plow under their fields between crops and disrupt the soil surface as little as possible, although they do cut into it to plant seeds and inject fertilizers.

The study found no-till fields released 57 percent less nitrous oxide than chisel tilling, in which plants are plowed back into the soil after harvest, said Purdue agronomist Tony Vyn, who led the research. They also produced 40 percent less gas than fields tilled with moldboard plows, which turn the dirt over onto itself.

Those numbers are averages, he said. Researchers looked at fields where corn and soybeans were alternated from year to year and others that were planted each year from corn. Emissions in fields where crops were rotated were lower than in those where they weren't, he said.

Vyn said he was stunned by the large amounts of nitrous oxide his team detected in the air above the plowed fields compared with those that had long been farmed using the erosion-fighting no-till approach.

The results are particularly disconcerting in light of the fact that nitrous oxide packs 310 times the heat-trapping power of carbon dioxide, the greenhouse gas largely blamed for climate change, he said.

The U.S. Environmental Protection Agency has determined that nitrous oxide can remain in the atmosphere for 120 years, adding to its global warming impact.

"Because it's so long lived, we need to do everything we can in terms of farming practices to reduce these releases," Vyn said. "Once it's released, it's going to be in the air for a long time — longer than anyone's lifetime."

His team's research results appear in the January-February issue of the Soil Science Society of America Journal.

Robert Horton, a professor of agronomy at Iowa State University who was not involved in the study, called the results exciting and said they highlight another potential benefit of no-till farming, which has already been shown to reduce erosion and improve soil quality.

"Now we can add an air quality advantage of no-till rotations to the list," he said.

Vyn's team conducted its research in fields Purdue maintains near the West Lafayette campus in rich soils that once were tall grass prairie. The university has farmed those fields for three decades using either no-till or one of the common plowing practices. The differences seen in the nitrous oxide emissions are likely due to variations in microbial life and soil chemistry created by the different farming practices, Vyn said.

Rodney Venterea, a soil scientist with the U.S. Department of Agriculture's research arm, said the Purdue study supports his research, which also found that scaling back on field plowing reduces nitrous oxide emissions.

But he said the release of the gas is complex and not simply a matter of one farming practice versus another. For example, he's found no-till fields release more nitrous oxide than plowed land when fertilizer is applied to the soil surface rather than injected into the dirt. The Purdue researchers injected the liquid nitrogen fertilizer a few inches into the soil.

Sixty-eight percent of the nitrous oxide emissions in the U.S. in [illegible] came from farmland, according to an EPA report issued last year. It said U.S. emissions of the gas grew about [illegible] percent between [illegible] and [illegible].

Mearl McCartney plants soybeans using a no-till drill near Bowling Green, Ohio, in April 2004. A new three-year study by Purdue University found that no-till farming, in which crops are planted into last year's field stubble without plowing, releases significantly less nitrous oxide than fields plowed using conventional methods.

Soil Nitrous Oxide Emissions in Corn following Three Decades of Tillage and Rotation Treatments

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Agronomy Dep.
Purdue Univ.
West Lafayette, IN 47907

Doug R. Smith
USDA-ARS
National Soil Erosion Lab.
Purdue Univ., West Lafayette, IN 47907

Anita Gál
Dep. of Soil Science and Agrochemistry
Szent István Univ.
Páter Károly utca 1
2103 Gödöllő, Hungary

Tony J. Vyn*
Agronomy Dep.
Purdue Univ.
West Lafayette, IN 47907

Few experiments have directly compared the long-term effects of moldboard, chisel, and no-till tillage practices on N_2O emissions from the predominant crop rotation systems in the midwestern United States. This study was conducted from 2004 to 2006 on a tillage and rotation experiment initiated in 1975 on a Chalmers silty clay loam (a Typic Endoaquoll) in west-central Indiana. Our objectives were to assess (i) long-term tillage (chisel [CP], moldboard plow [MP], and no-till [NT]), rotation (continuous corn [*Zea mays* L.] and corn–soybean [*Glycine max* (L.) Merr.]), and rotation × tillage interaction effects on soil N_2O emission, and (ii) how soil N_2O emission is related to environmental factors during corn production under identical N fertilizer management. Seasonal N_2O emissions were measured at intervals ranging from a few days to biweekly for up to 14 sampling dates in each growing season for corn. Nitrous oxide emissions during the growing season were significantly affected by tillage and rotation but not their interaction; however, 50% of total emissions occurred shortly after N application regardless of tillage or rotation practices. Seasonal cumulative emissions were significantly lower under NT but not statistically different for CP and MP. Overall, emissions under NT were about 40% lower relative to MP and 57% lower relative to CP. Rotation corn lowered N_2O emissions by 20% relative to continuous corn. Higher N_2O emission under MP and CP appeared to be driven by soil organic C decomposition associated with higher levels of soil–residue mixing and higher soil temperatures.

Abbreviations: CC, continuous corn; CP, chisel plow; MP, moldboard plow; NT, no-till; RC, rotation corn (corn following soybean); UAN, urea–ammonium nitrate.

Although the atmospheric concentration of N_2O is less than that of CO_2, the global warming potential of N_2O is about 310 times greater than CO_2 and accounts for about 5% of the total greenhouse effect (Smith et al., 2007; Mosier et al., 2004). On a global scale, agriculture contributed 10 to 12% of the 5.120 to 6.116 Pg CO_2 equivalent yr^{-1} global non-CO_2 anthropogenic emissions of greenhouse gases in 2005 (Intergovernmental Panel on Climate Change, 2007). Of this amount, N_2O emissions from agriculture accounted for 58% of the total anthropogenic emissions, with emission from soils constituting about 38% of the total N_2O emissions due to agricultural activities in 2005 (Smith et al., 2007; USEPA, 2010). Furthermore, global agricultural N_2O emissions are projected to increase by 35 to 60% by 2030 due to increased N fertilizer use and animal manure production (FAO, 2003).

In the United States, soil management activities, such as fertilizer application and other cropping practices, accounted for 67% of all N_2O emissions, equivalent to 5.8% of total greenhouse gas emissions. On average, N_2O emissions in the United States increased by 5% between 2000 and 2007 (USEPA, 2010; Franzluebbers and Follett, 2005). Corn and soybean production systems account for the highest N_2O emissions among major cropping systems in the United States (Del Grosso et al., 2005). Therefore, several soil management technologies including reduced tillage or no-till (NT) have been proposed as strategies to mitigate N_2O emissions to the atmosphere even as the net effects are inconsistent and have

Soil Sci. Soc. Am. J. 75:152–163
Published online 6 Dec. 2010
doi:10.2136/sssaj2009.0147
Received 15 Apr. 2009.
*Corresponding author (tvyn@purdue.edu).

Soil Resource Sustainability

Soil carbon is the hub of the wheel of sustainable soil properties and processes.

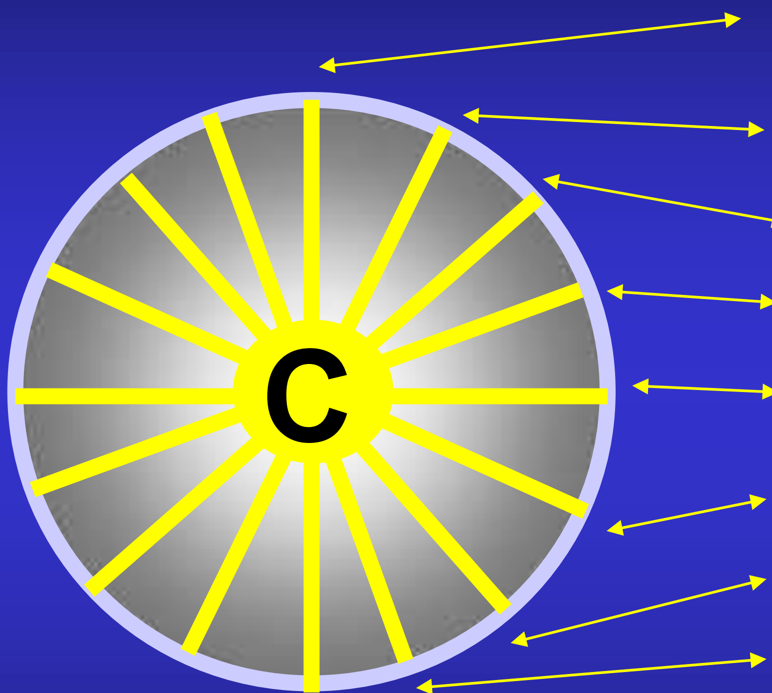
The wagon of sustainability is carried along on environmental wheels that have soil carbon as the hub.

Soil carbon is the hub of the wagon wheels that carry our food production system and economy along.

Soil carbon is the central hub of benefits for environmental quality

Strong spokes are required to maintain integrity and function of wheel.

Soil carbon is the central hub of the environmental sustainability wheel that supports secondary environmental benefits.



- increased water holding capacity and use efficiency
- increased cation exchange capacity
- reduced soil erosion
- improved water quality
- improved infiltration, less runoff
- decreased soil compaction
- improved soil tilth and structure
- reduced air pollution

Spokes are the incremental links of carbon to environmental improvement that support total soil resource sustainability.

What have you done to improve our world?

Put carbon thinking into Conservation Agriculture

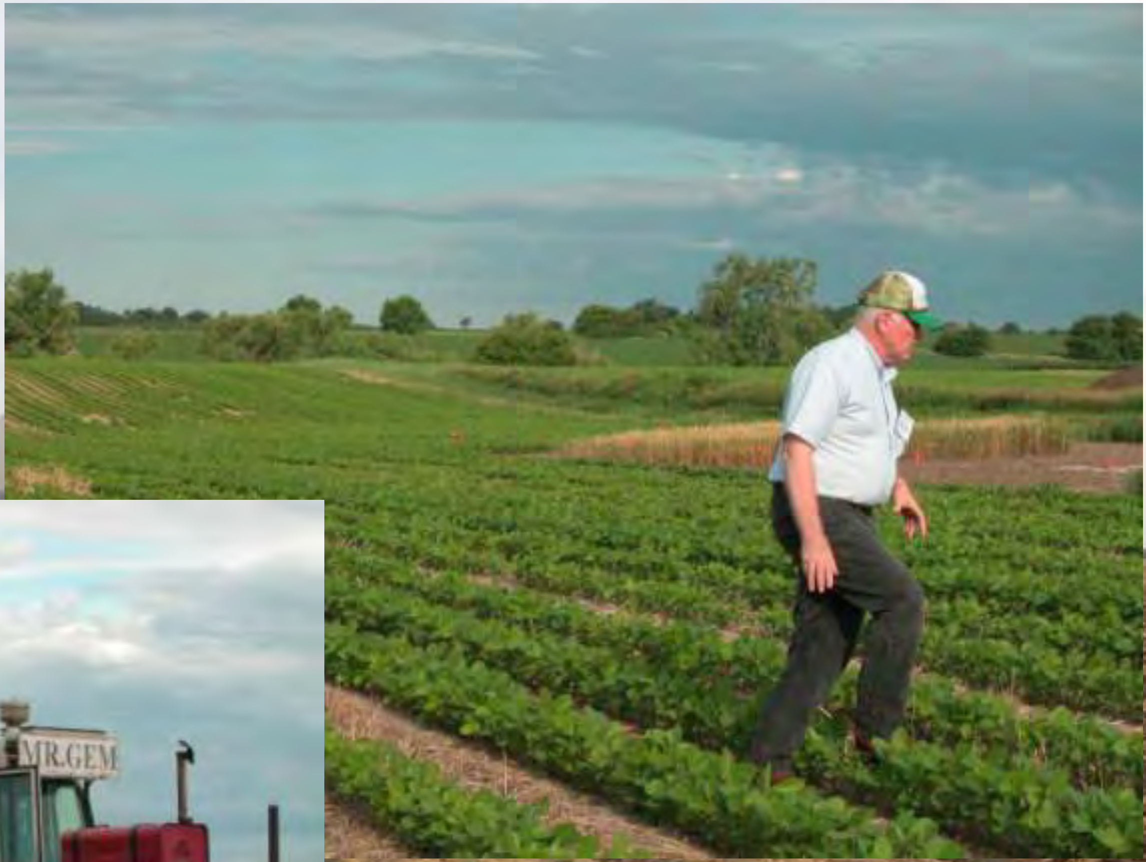
Put carbon on your agenda

Put carbon in your action plan

Lead development of global carbon policies and markets that includes farmers

Implement carbon management in Conservation Agriculture

Society will appreciate your efforts in providing a quality environment and a sustainable food supply.



"Reduce the volume of soil disturbed."

Don Reicosky
Retired
USDA ARS
Morris, MN

CARBON SEQUESTRATION WORKSHOP
September 8, 2005
WSREC • Five Points, CA
8:00 am to Lunch
Conservation Tillage
2005
WORKGROUP
Next Steps


SPECIAL REPORT:
FARMING WITH HIGH
FERTILIZER COSTS / 34
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FARMER
A FARM PROGRESS PUBLICATION MIDWEST GROUP EDITION
SECOND FEBRUARY 2001
CORN COSTS
RISE SHARPLY / 40
APPROACH BIOTECH
WITH CAUTION / 48
FARMERS — WHO
NEEDS THEM? / 54
Carbon farming
See page 12.
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THIS BARN UNIQUE / 14
PROFITS AHEAD WITH
WHITE CORN? / 18
INS AND OUTS OF
INOCULATING / 46
Cash for
carbon
The idea may not be as far-fetched or
as far off as it first seems — Page 12
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MORRIS MN 56267-9653


CONSERVATION AGRICULTURE
SYSTEMS ALLIANCE
Manitoba – North Dakota Zero Tillage Farmers Association
Reduced Tillage Linkages
Delta Conservation Demonstration Center
Georgia Conservation Tillage Alliance
Pennsylvania No-Till Alliance
Colonial Soil and Water Conservation District
Saskatchewan Soil Conservation Association
Southern Plains Agricultural Resources Coalition
Pacific Northwest Direct Seed Association
Ohio No-Till Council
USDA ARS National Soil Dynamics Lab
Mississippi State University
Auburn University
Pennsylvania State University
USDA Natural Resources Conservation Service
California Conservation Tillage Workgroup

Are you ready to learn how direct seed cropping systems will meet global supply challenges!

Two days packed with agronomics, technology and direct seed cropping systems information.

January 21 & 22, 2009

Three Rivers Convention Center, Kennewick, WA

The theme of this year's conference, Meeting Global Demand, was put forward in response to the UN challenge for agriculture to double global food production by 2050; a challenge that will meet the basic nutritional needs of an anticipated global population of 9.5 billion people.

To meet this demand there will be a strong emphasis on providing support to the small land holders of the developing world, however, the large scale agriculture production of the PNW will continue to be called upon to deliver more products with lower impact on available land and ecosystem resources.

The 2009 conference will deliver information and insight into how PNW agriculture will change and adapt to meet the demand within this challenge.

EFFICIENCY • PRODUCTIVITY • TECHNOLOGY • STEWARDSHIP • SUSTAINABILITY

2009 Direct Seed Conference Sponsors

McGregor – Registration Package

Western Farmer-Stockman – Official Publication

syngenta – Keynote Speaker

Great Plains – Two Concurrent Session Rooms

Gowan – The Go To Company – Keynote Speaker

Shepherd's Grain

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For more information: 208.883.0190

Alberta Reduced Tillage LINKAGES

Dedicated to improving the environmental and economic sustainability of farming in Alberta.

The Reduced Tillage LINKAGES (RTL) program is a unique partnership with broad-based farmer, industry, educational, wildlife and government support. The partners have pooled financial and in-kind resources to develop an extension program focused on improving the environmental and economic sustainability of farming in Alberta. Read More ...

2,342,135 hours of farm labour saved by direct seeding in Alberta this year

click for details

Coming Events

View All Events

- Peace Direct Seeding Workshop 1/7/2009
- Value Plus - A Workshop About A Quest for New Farm Value 1/16/2009
- Agronomy Update 2009 1/20/2009

The RTL Agronomy Library

Articles, papers and proceedings. View

The RTL Agronomy Library contains hundreds of articles from getting started in direct seeding to fine tuning no till systems. Topics include seeding equipment, residue management, weed control, crop rotations, soil quality and much more.

Latest Library Updates

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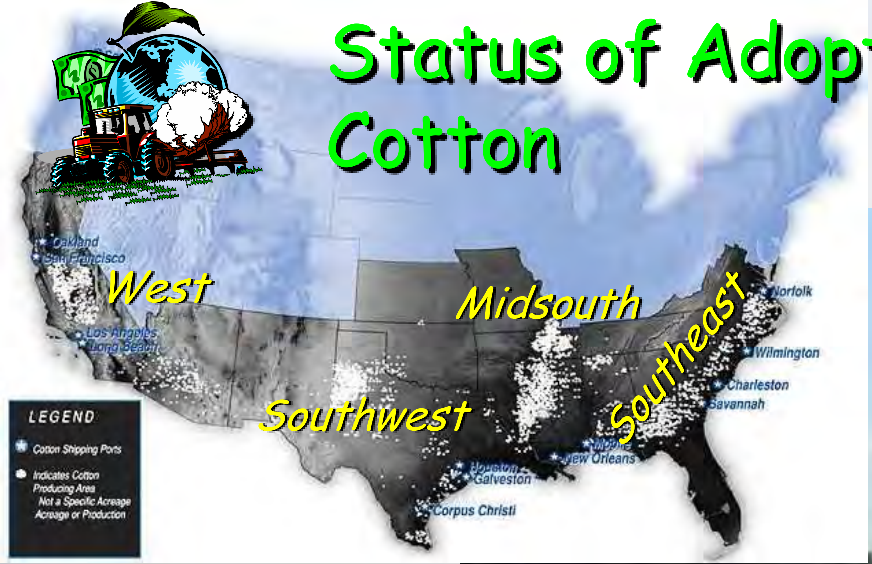
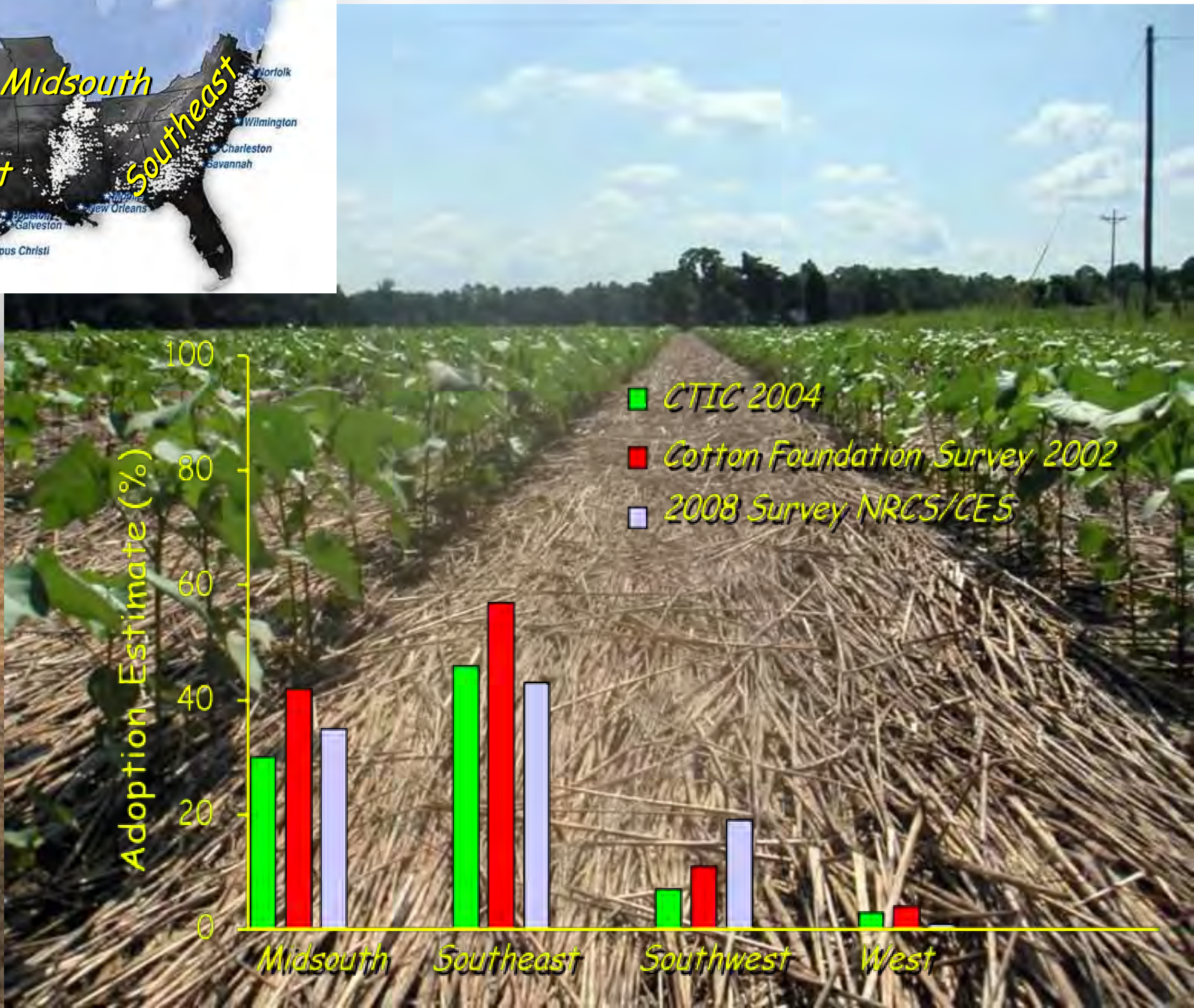
Reicosky, 1998


More Profit
With Less Tillage
Ernest E. Behn
Iowa, 2001
Iowa, 2001
IMPROVE
SOIL & WATER
NO-PLOW ZONE
Brazil, 2007
Nebraska, 2007
Georgia, 2001
Brazil, 2004

Status of Adoption: Conservation Tillage Cotton





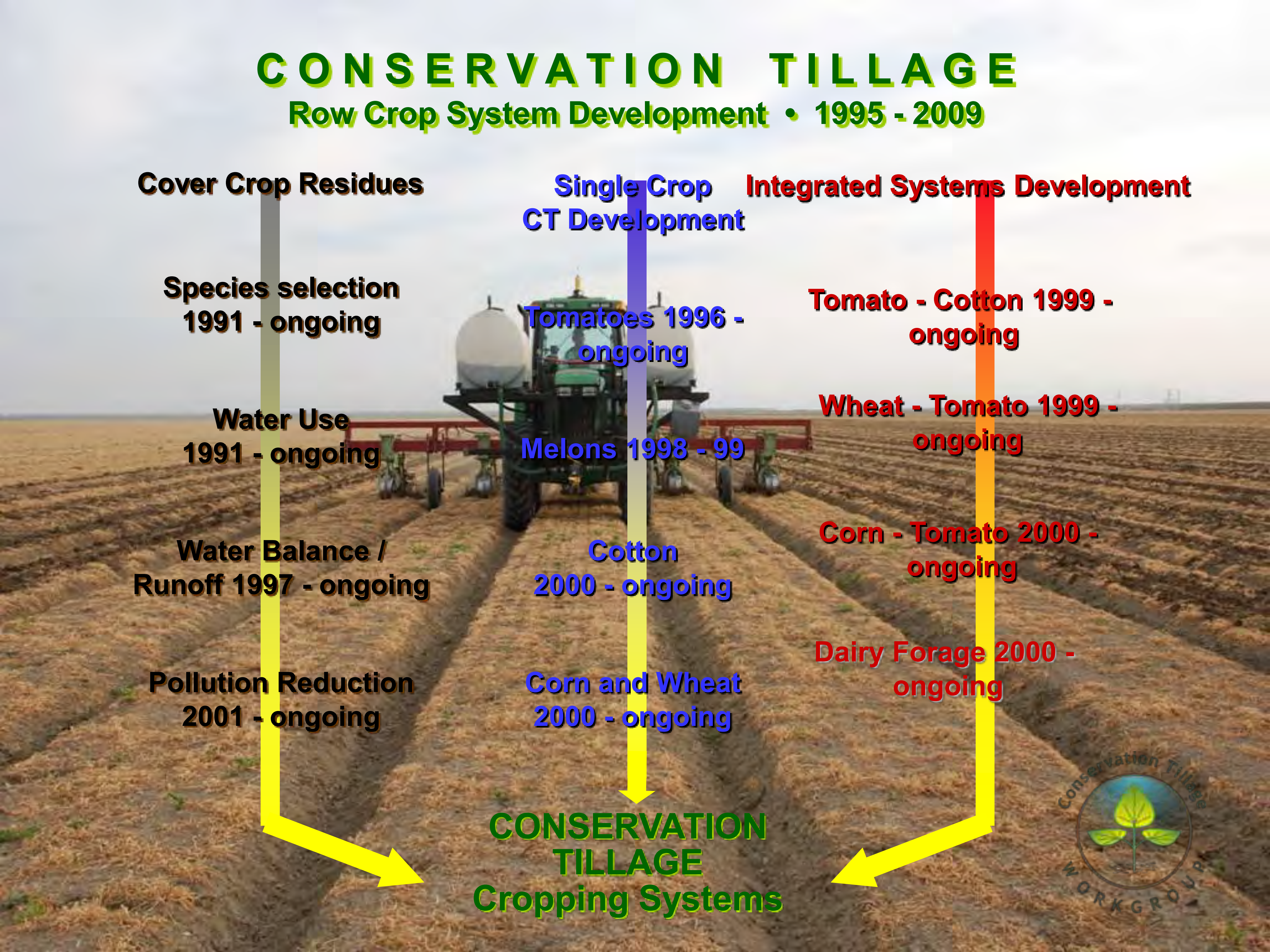
Dr. Wayne Reeves
Retired USDA ARS
Watkinsville, GA
2010 Cotton Beltwide Proceedings

Possible benefits of conservation tillage

- saves fuel
- saves soil
- saves time
- saves labor
- saves machinery
- permits timely planting
- reduces run-off
- increases soil moisture
- increases soil organic matter
- sequesters carbon
- improves habitat for beneficial organisms

Dr. Sharad Phatak, University of Georgia, 1997

- *dust (PM10 and PM2.5) emissions mitigation*
- *surface water (sediment, nutrient and pesticide) runoff reduction (?)*
- *reducing GHG emissions (?)*
- *enable greater forage production and nutrient removal (?)*


CONSERVATION TILLAGE
Row Crop System Development • 1995 - 2009
Cover Crop Residues
Species selection 1991 - ongoing
Water Use 1991 - ongoing
Water Balance / Runoff 1997 - ongoing
Pollution Reduction 2001 - ongoing
Single Crop CT Development
Tomatoes 1996 - ongoing
Melons 1998 - 99
Cotton 2000 - ongoing
Corn and Wheat 2000 - ongoing
Integrated Systems Development
Tomato - Cotton 1999 - ongoing
Wheat - Tomato 1999 - ongoing
Corn - Tomato 2000 - ongoing
Dairy Forage 2000 - ongoing
CONSERVATION TILLAGE Cropping Systems
Conservation Tillage WORKGROUP

Minimum Tillage Approaches

(Non-Permanent Bed Systems)

Minimum Tillage Implements, 2004

(Non-permanent Bed Systems)

University of California
Division of Agriculture and Natural Resources
http://anrcatalog.ucdavis.edu

UC PEER REVIEWED

PUBLICATION 8364 / FEBRUARY 2009

Classification of Conservation Tillage Practices in California Irrigated Row Crop Systems

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Tillage has been an integral component of crop production systems since the beginning of agriculture. The process of tilling or preparing the soil was greatly refined with the invention of the first plow by the Chinese in the sixth century b.c., and since then, various types of tillage equipment and systems have been developed for seedbed preparation and cultivation. In California, many of the modern tillage practices that became common with the expansion of irrigated agriculture in the 1930s changed little during the second half of the twentieth century. However, during the past 10 or so years, a number of new tillage implements and management approaches have been introduced in California, and this has created a need for more concise tillage terminology to replace the often confusing jargon.

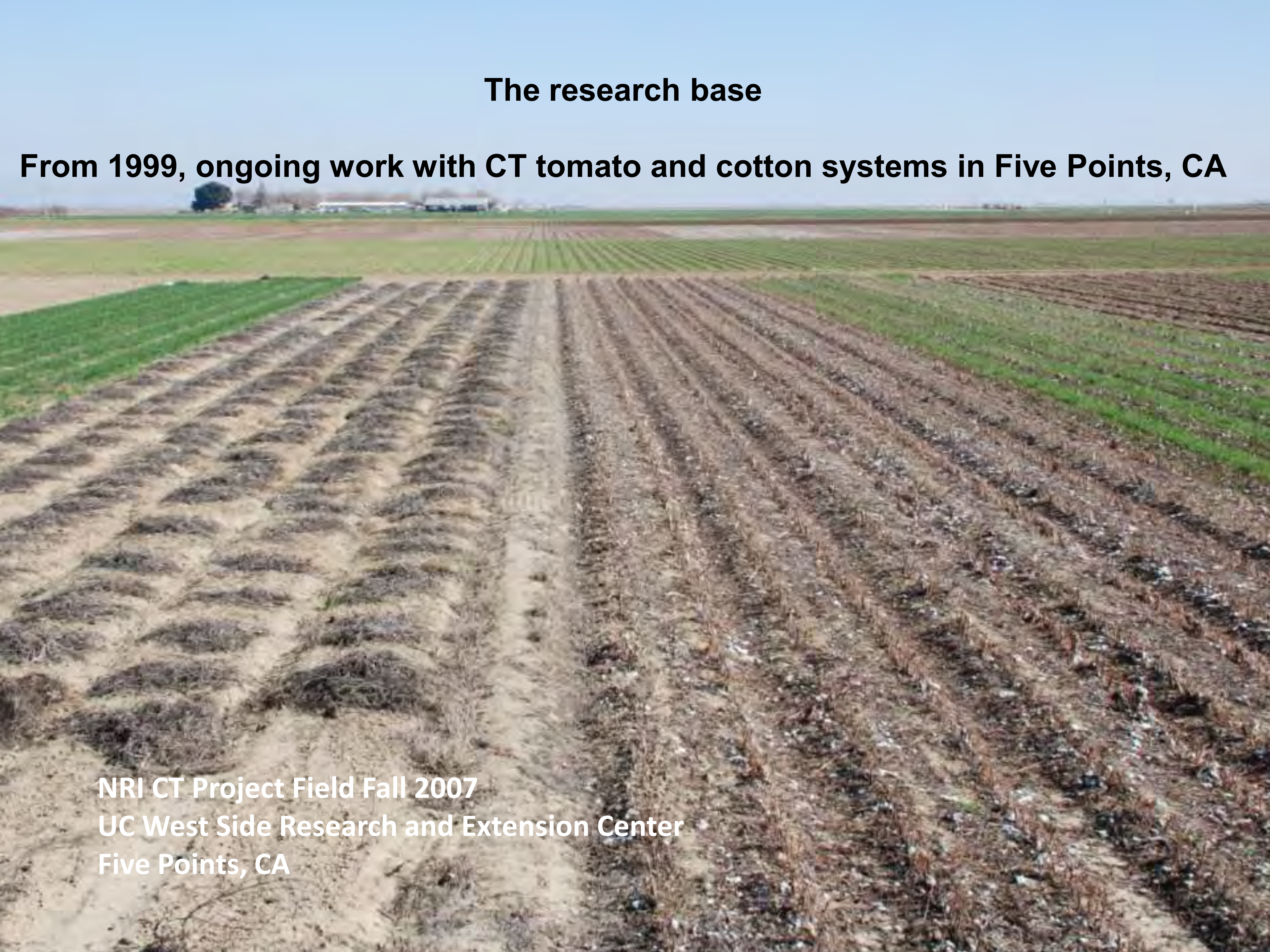
Some of the tillage systems that were recently introduced in California resemble well-known forms of conservation tillage (CT) such as no-tillage and strip-tillage, which were developed in other regions of the United States primarily to combat soil erosion. However, many of the new systems in California are quite different from these better-known forms. Compared with conventional plowing systems, these new approaches reduce the number of tillage operations or passes, the amount of diesel fuel that is used (Upadhyaya et al. 2001), the amount of dust that is generated (Baker et al. 2005; Madden et al. 2008), and the volume of soil that is disturbed (Mitchell et al. 2004; Reicosky and Allmaras 2003; Reicosky 2002). For this reason, the term "conservation tillage" is justified in characterizing them. However, compared with the familiar no-tillage systems, conservation tillage systems that reduce or combine passes do so generally with relatively high amounts of soil disturbance, and therefore do not protect the soil resource as well as do the no-tillage or strip-tillage approaches (Reicosky and Allmaras 2003). It is essential, therefore, to define the tillage system alternatives that constitute conservation tillage in California at this time and describe the extent of their use. This publication reports the terminology and classification of


After Performer 2
Conservation Tillage
WORKGROUP


WILCOX

The research base

From 1999, ongoing work with CT tomato and cotton systems in Five Points, CA

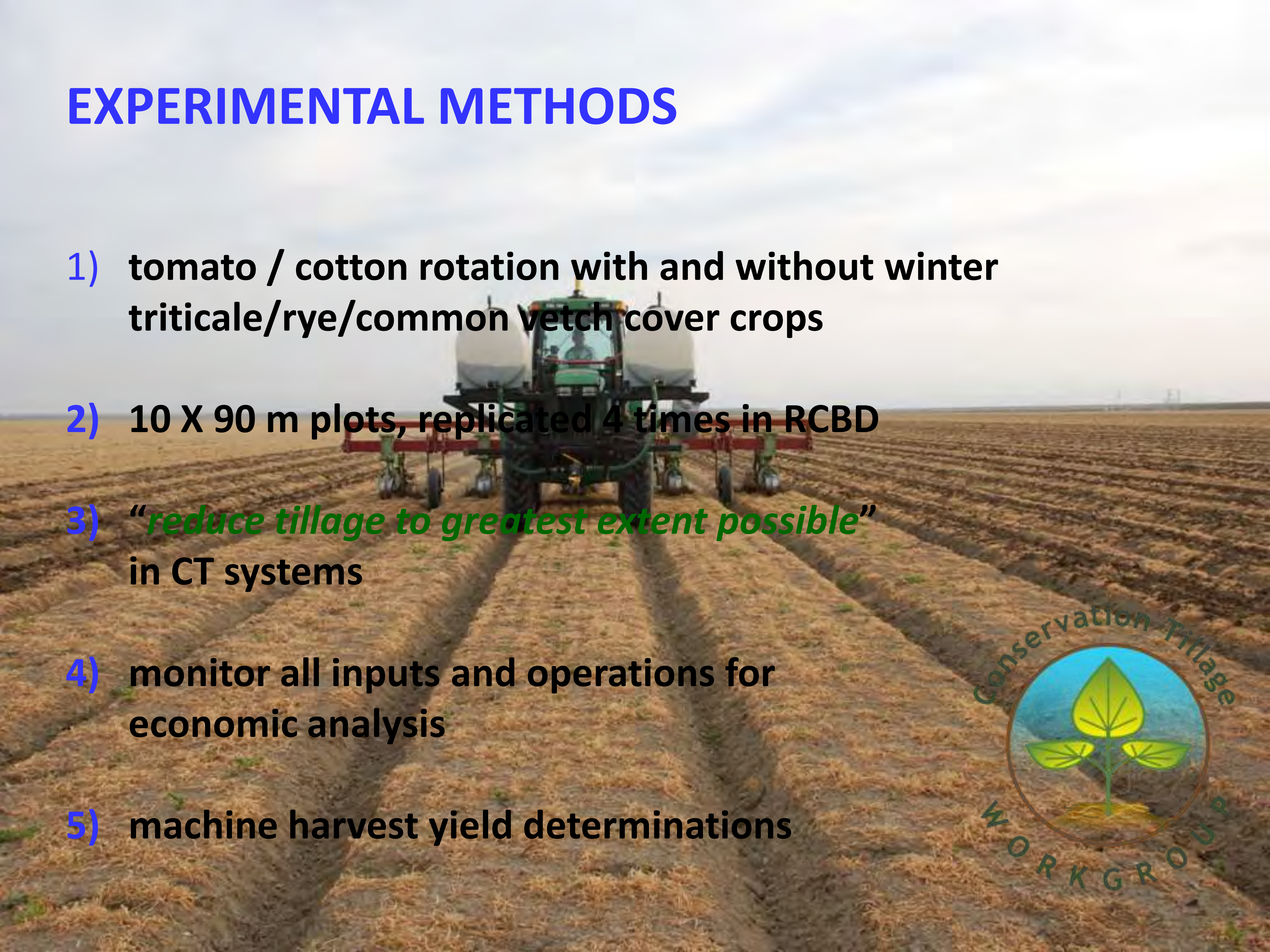


Conservation / Standard Tillage Comparison Study

(1999 – ongoing)

Standard Tillage
- With cover crop
- Without cover crop

Conservation Tillage
- With cover crop
- Without cover crop



EXPERIMENTAL METHODS

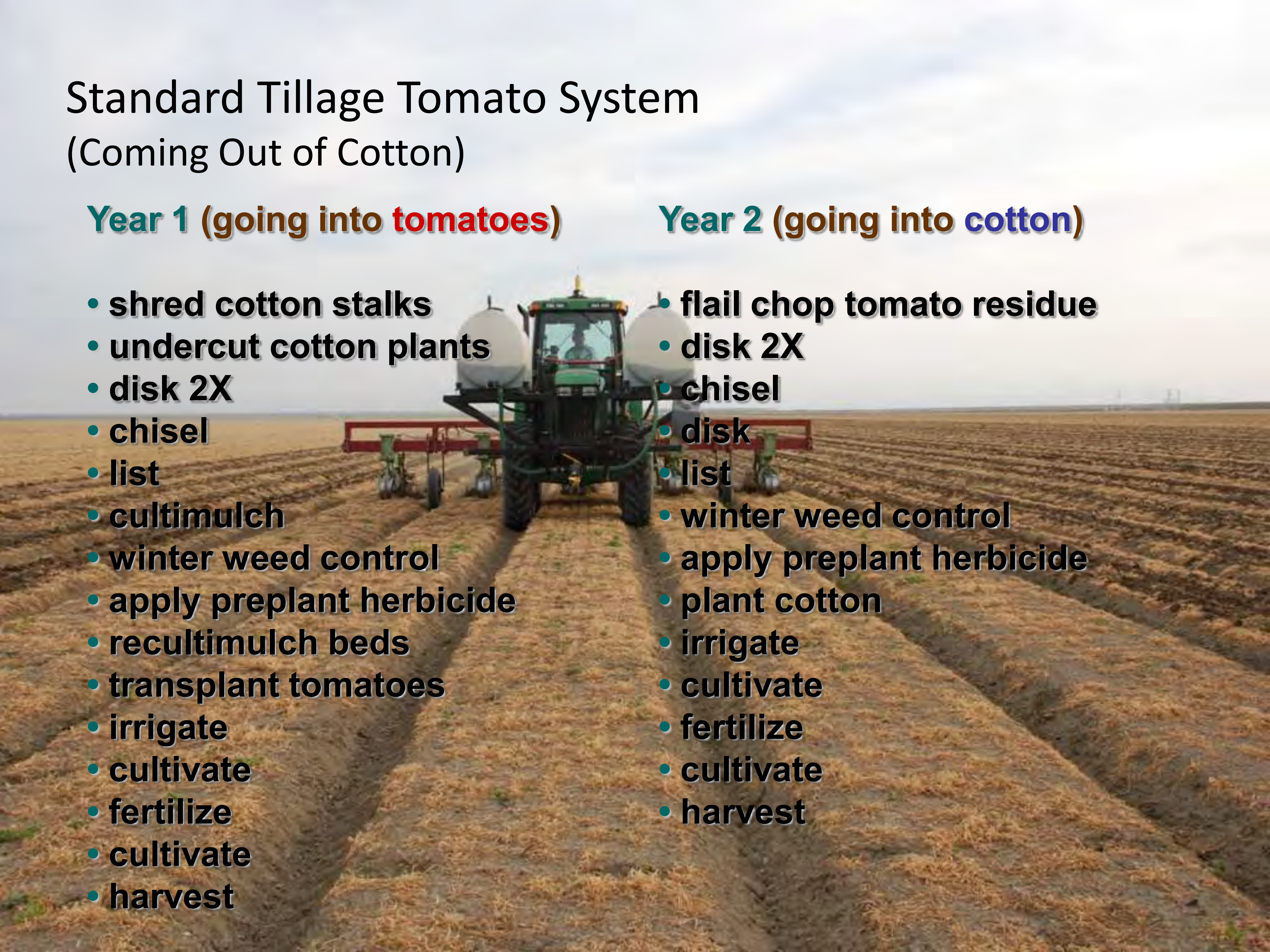
1) tomato / cotton rotation with and without winter triticale/rye/common vetch cover crops

2) 10 X 90 m plots, replicated 4 times in RCBD

3) "*reduce tillage to greatest extent possible*" in CT systems

4) monitor all inputs and operations for economic analysis

5) machine harvest yield determinations



Standard Tillage Tomato System

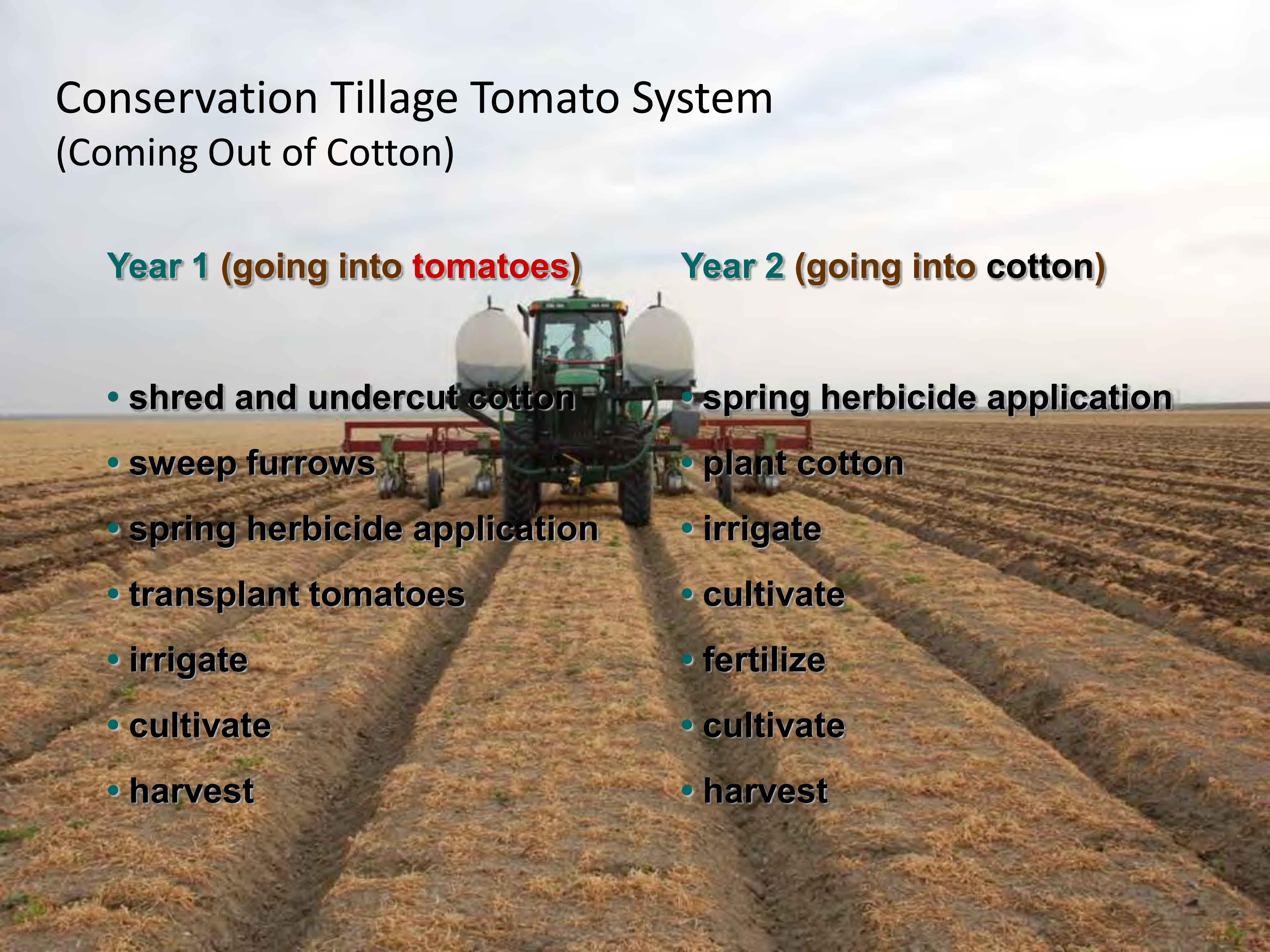
(Coming Out of Cotton)

Year 1 (going into tomatoes)

- shred cotton stalks
- undercut cotton plants
- disk 2X
- chisel
- list
- cultimulch
- winter weed control
- apply preplant herbicide
- recultimulch beds
- transplant tomatoes
- irrigate
- cultivate
- fertilize
- cultivate
- harvest

Year 2 (going into cotton)

- flail chop tomato residue
- disk 2X
- chisel
- disk
- list
- winter weed control
- apply preplant herbicide
- plant cotton
- irrigate
- cultivate
- fertilize
- cultivate
- harvest



Conservation Tillage Tomato System
(Coming Out of Cotton)

Year 1 (going into tomatoes)

- shred and undercut cotton
- sweep furrows
- spring herbicide application
- transplant tomatoes
- irrigate
- cultivate
- harvest

Year 2 (going into cotton)

- spring herbicide application
- plant cotton
- irrigate
- cultivate
- fertilize
- cultivate
- harvest

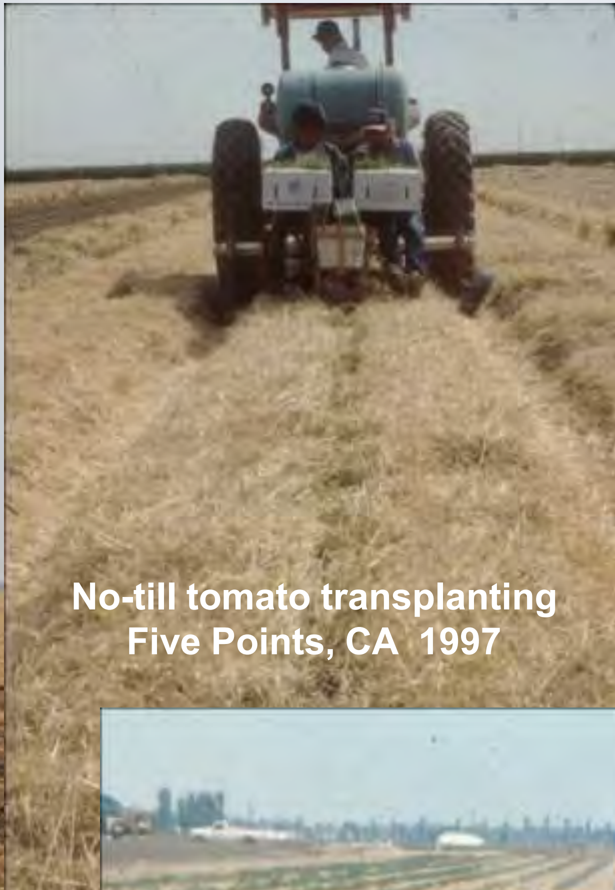
Rye / triticale / vetch cover
crop in CTCC system
Five Points, CA 2000

Surface residue in CTCC system
Five Points, CA 2003

Conservation Tillage Workgroup

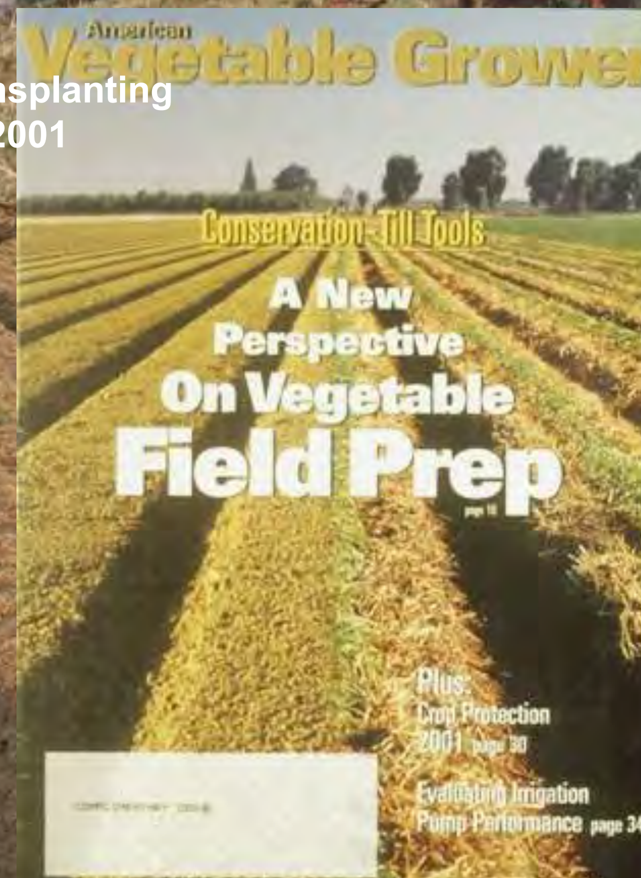
Development of no-till tomato transplant capability in California (1995 – 2004)

Acknowledgements: Ron Morse, Aref Abdul-Baki and Steve Groff



No-till tomato transplanting
Five Points, CA 1997

Strip-till tomato transplanting
Winters, CA 2001



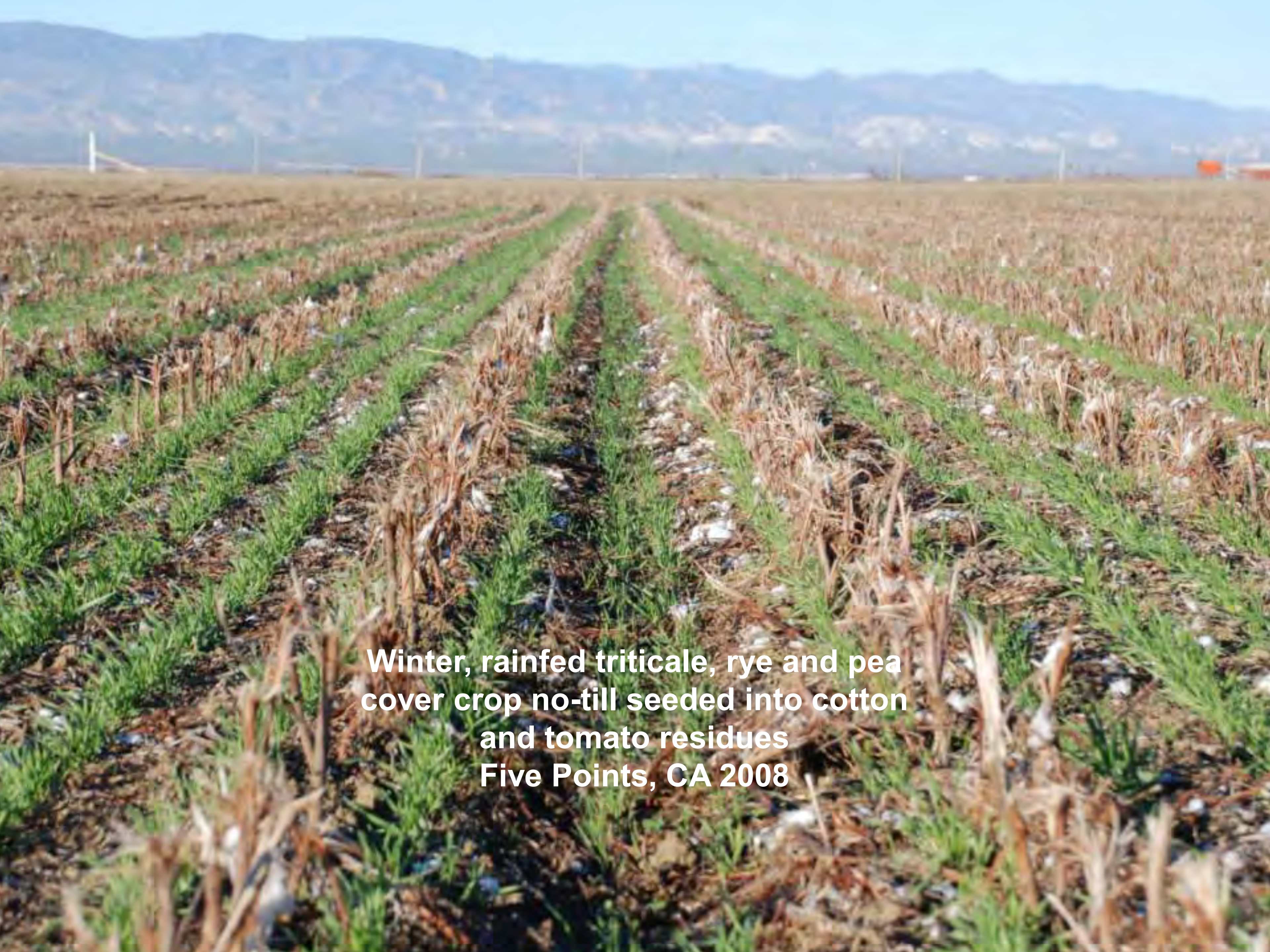
American
Vegetable Grower
Conservation Till Tools
A New Perspective On Vegetable Field Prep
Plus:
Crop Protection 2001 page 30
Evaluating Irrigation Pump Performance page 34

Cultivating no-till planted tomatoes
Tracy, CA 2000

Rainfed winter cover crop being seeded into cotton and tomato residue Five Points, CA 2007


Conservation tillage system
following tomato harvest and
before cotton planting
Five Points, CA 2000


Winter, rainfed triticale, rye and pea cover crop no-till
seeded into cotton and tomato residues
Five Points, CA 2008


Winter, rainfed triticale, rye and pea
cover crop no-till seeded into cotton
and tomato residues
Five Points, CA 2008

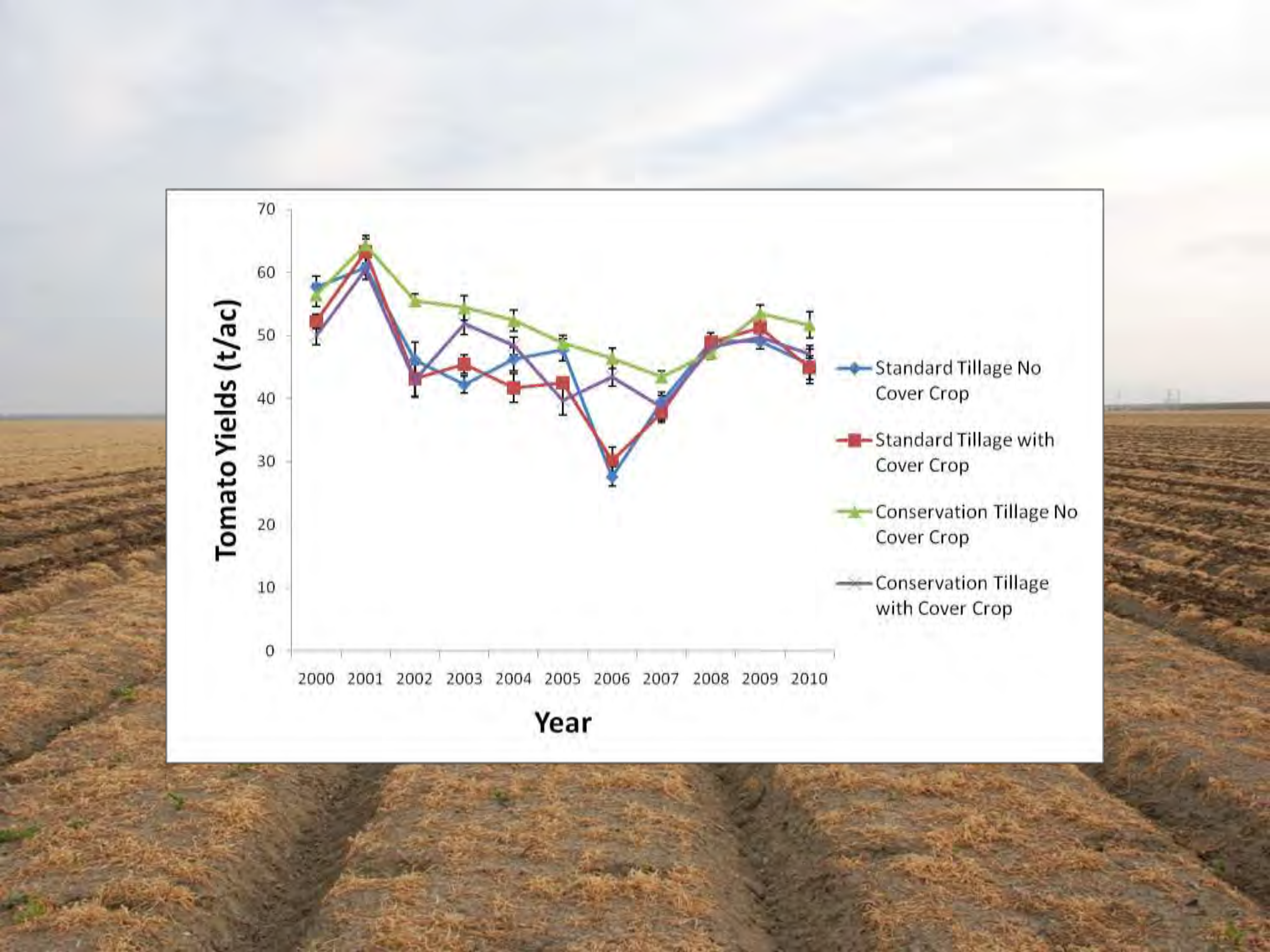

Standard tillage
no cover crop
7% + 3
Standard tillage
with cover crop
10% + 4
Conservation tillage
no cover crop
55% + 10
Conservation tillage
with cover crop
90% + 4
Following
2005 Tomatoes
November 2, 5005

Cover crop biomass in STCC and CTCC systems, 2000 – 2008

	2000	2001	2002	2003	2004	2005	2006	2007	2008
	(lbs/ac)								
South									
STCC	**8036 ± 205**	**3604 ± 169**	**1226 ± 213**	**2281 ± 188**	**1732 ± 246**	**6661 ± 401**	**1461 ± 239**	**28 ± 14**	**2894 + 295**
CTCC	**8344 ± 345**	**2798 ± 141**	**1895 ± 213**	**5063 ± 327**	**1744 ± 206**	**8327 ± 152**	**1282 ± 143**	**66 ± 18**	**2637 + 756**
North									
STCC	**7850 ± 656**	**4058 ± 96**	**3121 ± 407**	**2031 ± 286**	**2449 ± 100**	**5223 ± 228**	**3320 ± 196**	**10 ± 0**	**5112 + 180**
CTCC	**7889 ± 1326**	**3966 ± 55**	**4236 ± 223**	**3919 ± 638**	**3192 ± 124**	**5677 ± 228**	**3169 ± 185**	**58 ± 3**	**5328 + 403**

No-till cotton seeding
Five Points, CA 2009

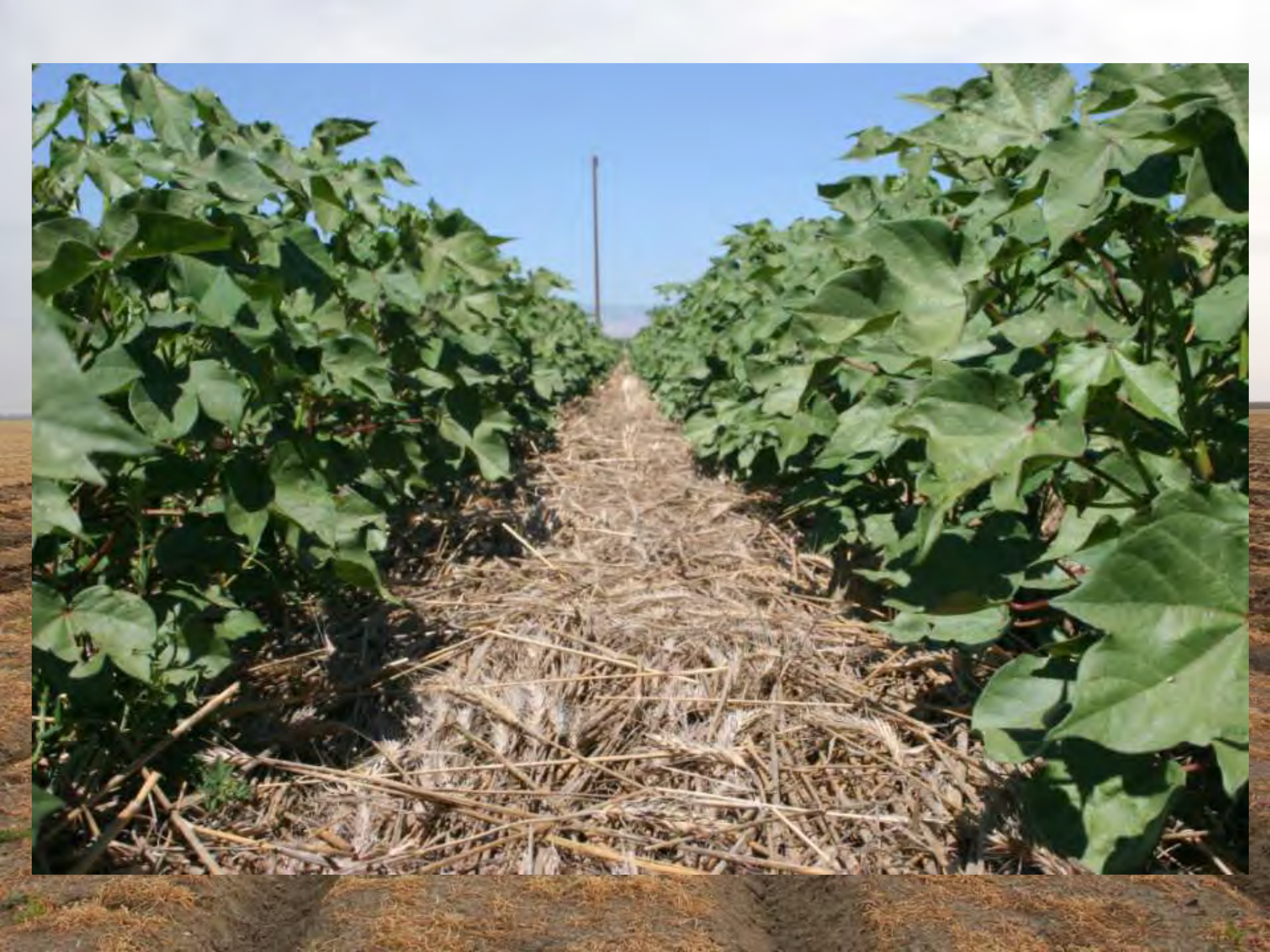
No-till processing tomato transplanting
Five Points, CA 2009



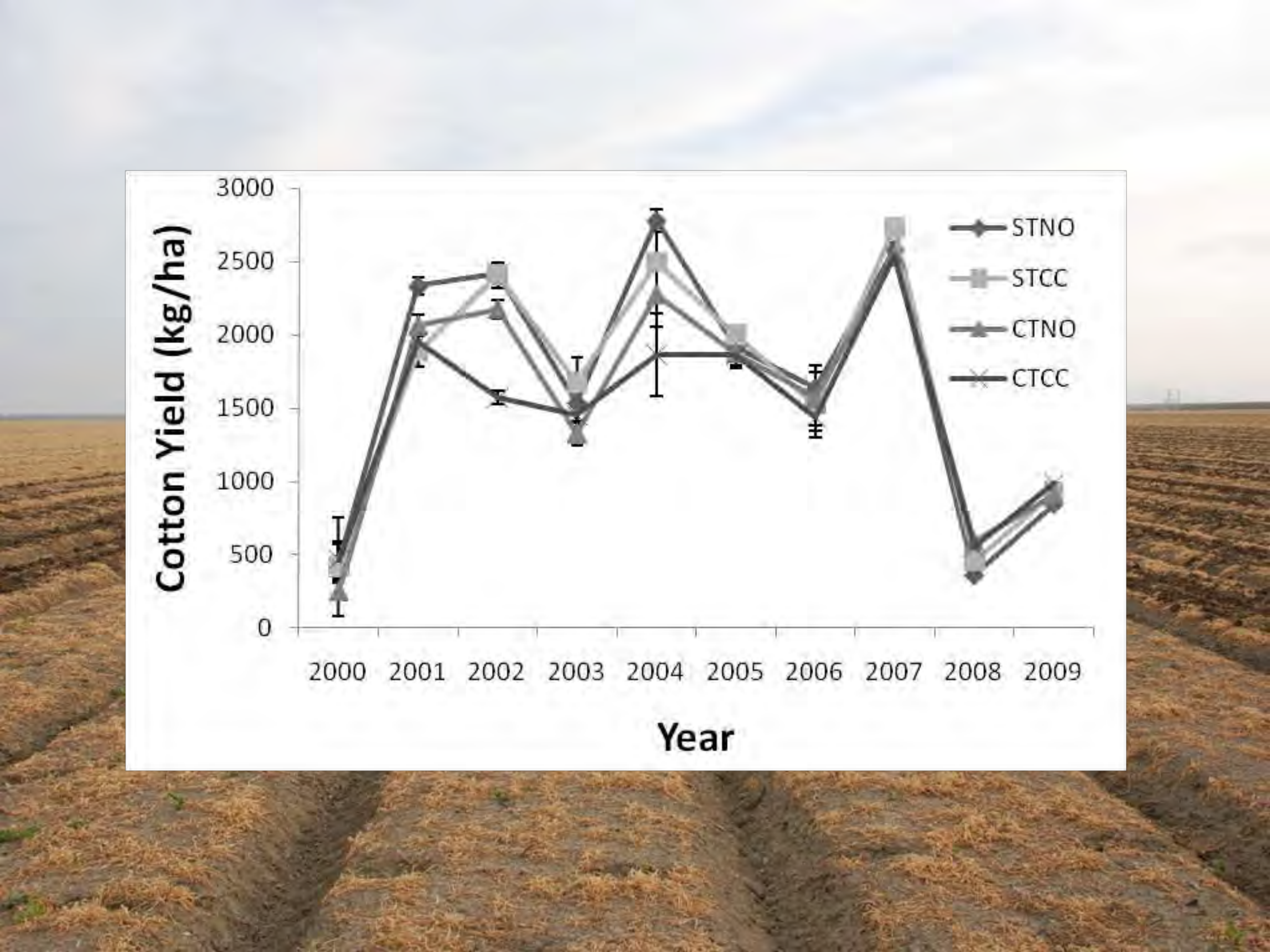
Tomato Yields (t/ac)
70
60
50
40
30
20
10
0
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
Year
Standard Tillage No Cover Crop
Standard Tillage with Cover Crop
Conservation Tillage No Cover Crop
Conservation Tillage with Cover Crop

2009 NRI Tomato Yields

Standard tillage no cover crop	49.1 ± 1.2
Standard tillage with cover crop	51.2 ± 1.9
Conservation tillage no cover crop	53.5 ± 1.3
Conservation tillage with cover crop	49.8 ± 0.8



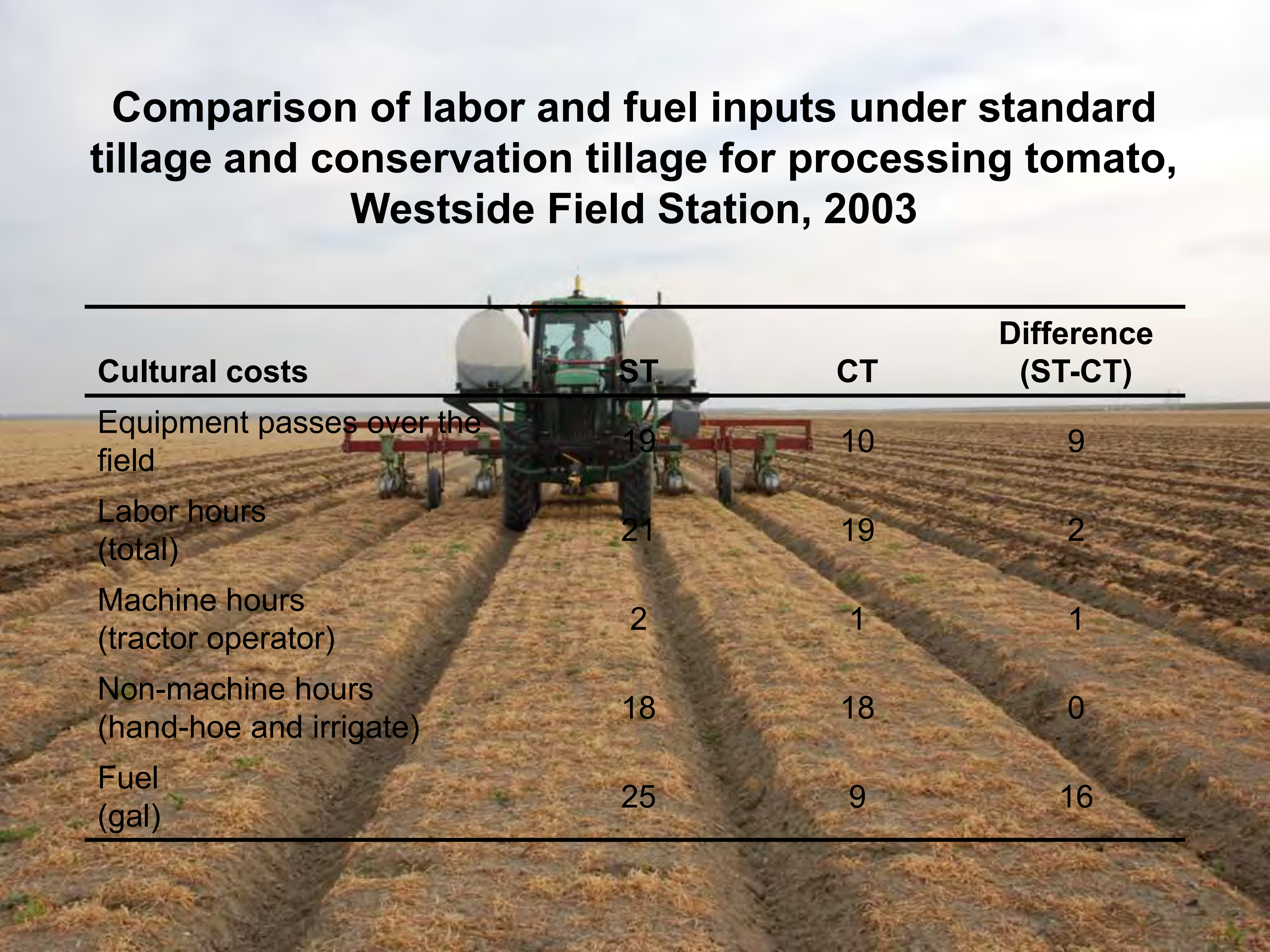

No-Till



Cotton Yield (kg/ha)
3000
2500
2000
1500
1000
500
0
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
Year
STNO
STCC
CTNO
CTCC

Cultural costs for standard tillage (ST) versus conservation tillage (CT) for processing tomato, Westside Field Station, 2003 (operations expensed at 2007 input prices)

Cultural costs	ST	CT	Difference (ST-CT)
Fertilizer	79	79	0
Seed	176	176	0
Herbicide	76	70	6
Insecticide	0	0	0
Water	163	163	0
Labor (machine)	36	19	17
Labor (irrigation)	110	110	0
Labor (hand weed)	84	84	0
Fuel	58	21	37
Lube and repair	34	16	18
Interest	36	31	5
Total cultural	**853**	**770**	**83**



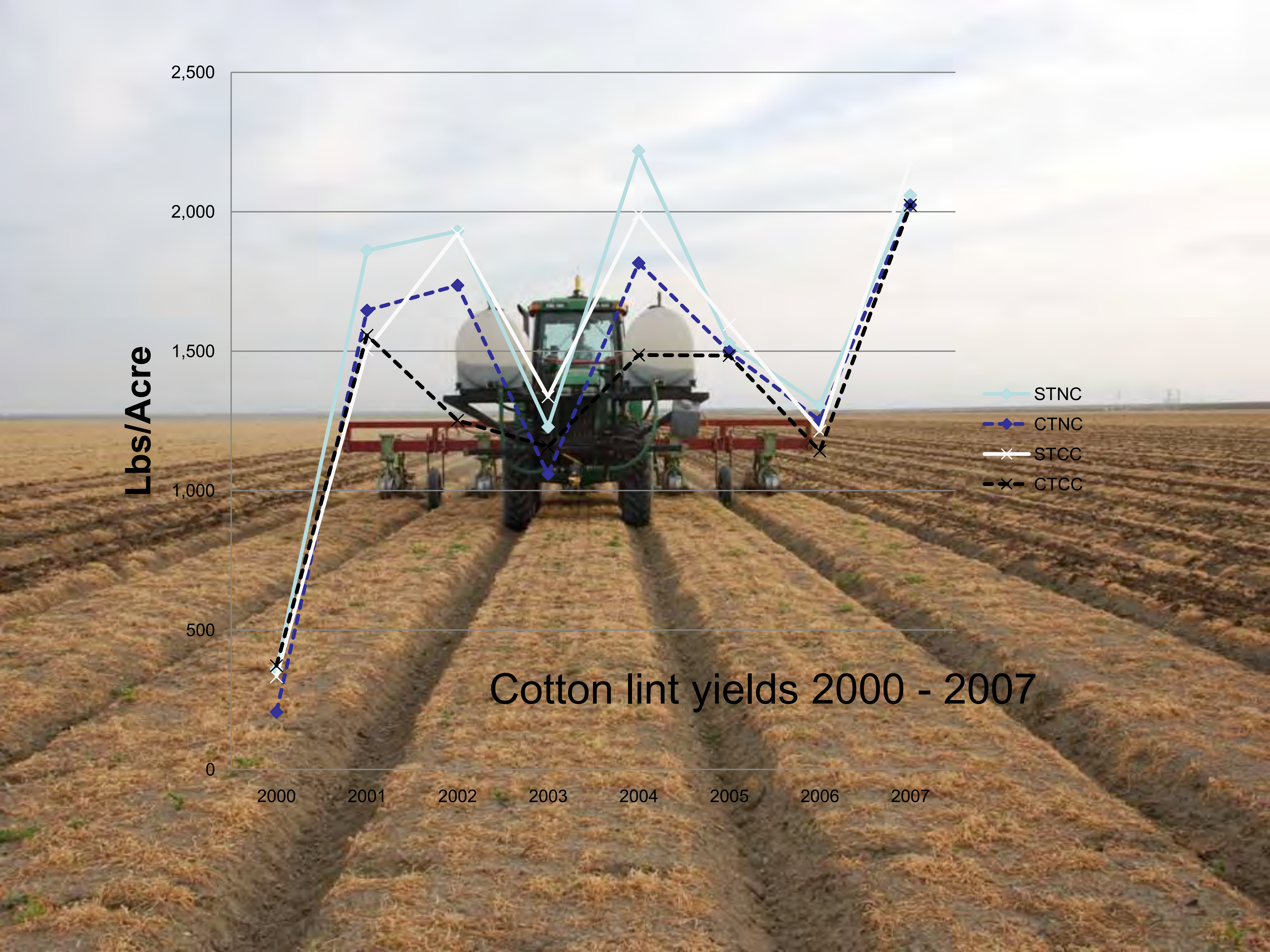
Comparison of labor and fuel inputs under standard tillage and conservation tillage for processing tomato, Westside Field Station, 2003

Cultural costs	**ST**	**CT**	**Difference (ST-CT)**
Equipment passes over the field	19	10	9
Labor hours (total)	21	19	2
Machine hours (tractor operator)	2	1	1
Non-machine hours (hand-hoe and irrigate)	18	18	0
Fuel (gal)	25	9	16

Tillage and cover crop system erosion estimates, soil condition index sub-factors, soil tillage intensity rating and estimates of diesel fuel use.

Cropping System*	Erosion Estimates RUSLE2 (Mg ha-1)	Soil Conditioning index	STIR Average Annual	Diesel fuel use	Fuel cost for entire simulation ($)
STNO	0.2	-0.71	261	32	128.6
STCC	0.07	-0.96	390	40	160.6
CTNO	0.04	0.43	30.6	9.3	36.8
CTCC	0.03	0.52	37.1	11	43.27

* STNO = Standard tillage no cover crop, STCC = Standard tillage with cover crop, CTNO = Conservation tillage no cover crop CTCC = Conservation tillage with cover crop.



Cotton lint yields 2000 - 2007
Lbs/Acre
2,500
2,000
1,500
1,000
500
0
2000
2001
2002
2003
2004
2005
2006
2007
STNC
CTNC
STCC
CTCC

Soil Disturbance Ratings

FIELD OPERATIONS	SOIL DISTURBING ACTIONS						SOIL DISTURBANCE RATING (SDR)
	INVERT	MIX	LIFT	SHATTER	AERATE	COMPACT	
Primary tillage							
Plow, moldboard, complete inversion	5	5	5	5	5	4	29
Plow, moldboard, incomplete inversion	4	5	5	5	5	4	28
Plow, deep chisel, twisted point	4	4	5	5	5	2	25
Plow, deep chisel, straight point	3	4	4	4	5	2	22
Plow, chisel, twisted point	3	4	5	5	5	2	24
Plow, chisel, straight point	2	3	4	4	4	2	19
Plow, chisel, sweeps	2	3	5	4	4	3	21
Plow, disk plow	4	5	5	5	5	4	28
Disk, offset	4	5	4	5	5	4	27
Disk, Tandem primary (> 6" depth)	4	5	4	4	5	4	26
Power rotary tiller	5	5	5	5	5	4	29
Ground driven rotary tiller	4	5	5	5	5	4	28
Paratill/paraplow	0	0	5	5	3	2	15
Undercutter (8-12" sweeps)	0	0	5	5	4	3	17
V-blade	0	0	5	5	3	3	16
Vee ripper/subsoiler	3	3	4	5	5	2	22
Bedder-ridger	5	5	5	5	5	3	28
Secondary tillage							
Disk, Tandem finishing (< 6" depth)	2	3	3	3	4	3	18
Field cultivator, straight point	3	3	3	4	3	2	18

Dust Production by Treatment and Operation (µg/L)

Treatment	STNO		STCC		CTNO		CTCC	
Size Fraction	Total	Resp.	Total	Total	Total	Total	Total	Total
Land Preparation								
Disc	98	14	81	10				
Chisel	20	1	11	1				
List Beds	12	3	11	2				
Ringroll Beds	44	7	39	24				
Power Incorporate	127	20	93	7				
Plant Cover Crop			4	trace*			21	4
Mow/Chop Cvr Crop			22	9			61	6
Compact Furrow			9	6				
Subtotal	300	44	270	58			82	9
In Season Operations								
Spray	12	3			5	2	2	1
Lilliston	92	4						
Cultivate Tomato	34	2	28	2	75	4	75	7
Cultivate Cotton	316	8	222	10				
Subtotal	455	17	250	12	80	6	77	8

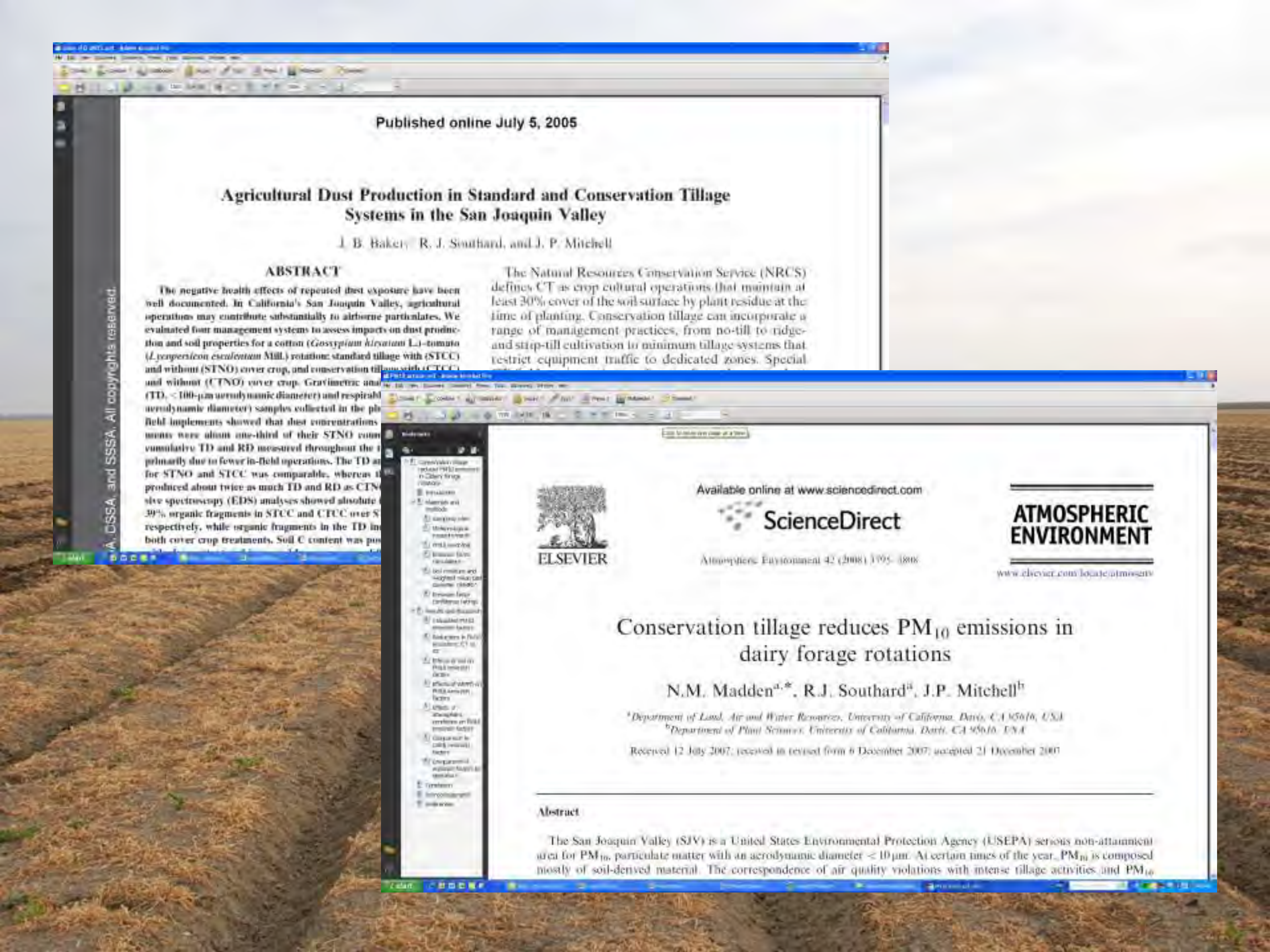
*There were detectable dust measurements for these operations, but they rounded to 0 with this number of significant figures.

Dust Production by Treatment and Operation (µg/L)
(continued)

	STNO		STCC		CTNO		CTCC	
Planting / Harvest								
Plant Cotton	1	trace*	5	1	4	1	14	1
Transplant Tomato	2	trace*	9	1	17	2	17	2
Clean Furrow							37	5
Shred-Bed					12	4	22	8
Mow	38	6	51	6				
Undercut	29	3	27	2				
Harvest Cotton	11	2	11	2	8	2	13	3
Subtotal	81	11	103	12	40	8	103	19
Cumulative Dust Production	837	72	623	82	120	14	262	36

*There were detectable dust measurements for these operations, but they rounded to 0 with this number of significant figures.

Baker, Southard and Mitchell
JEQ, 2004



Published online July 5, 2005

Agricultural Dust Production in Standard and Conservation Tillage Systems in the San Joaquin Valley

J. B. Baker,* R. J. Southard, and J. P. Mitchell

ABSTRACT

The negative health effects of repeated dust exposure have been well documented. In California's San Joaquin Valley, agricultural operations may contribute substantially to airborne particulates. We evaluated four management systems to assess impacts on dust production and soil properties for a cotton (*Gossypium hirsutum* L.)–tomato (*Lycopersicon esculentum* Mill.) rotation: standard tillage with (STCC) and without (STNO) cover crop, and conservation tillage with (CTCC) and without (CTNO) cover crop. Gravimetric ana (TD, < 100-μm aerodynamic diameter) and respirabl aerodynamic diameter) samples collected in the pl field implements showed that dust concentrations ments were about one-third of their STNO coun cumulative TD and RD measured throughout the primarily due to fewer in-field operations. The TD a for STNO and STCC was comparable, whereas t produced about twice as much TD and RD as CTN sive spectroscopy (EDS) analyses showed absolute 39% organic fragments in STCC and CTCC over S respectively, while organic fragments in the TD in both cover crop treatments. Soil C content was pos

The Natural Resources Conservation Service (NRCS) defines CT as crop cultural operations that maintain at least 30% cover of the soil surface by plant residue at the time of planting. Conservation tillage can incorporate a range of management practices, from no-till to ridge- and strip-till cultivation to minimum tillage systems that restrict equipment traffic to dedicated zones. Special

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Conservation tillage reduces PM_{10} emissions in dairy forage rotations

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Received 12 July 2007; received in revised form 6 December 2007; accepted 21 December 2007

Abstract

The San Joaquin Valley (SJV) is a United States Environmental Protection Agency (USEPA) serious non-attainment area for PM_{10}, particulate matter with an aerodynamic diameter < 10 μm. At certain times of the year, PM_{10} is composed mostly of soil-derived material. The correspondence of air quality violations with intense tillage activities and PM_{10}

Soil Carbon weights (t/ha)

Depth (cm)	Standard Till No Cvr Crop	Standard Till Winter Cvr Crop	Conservation Tillage No Cvr Crop	Conservation Tillage Winter Cvr Crop
0-15	10.74 (0.26)	13.68 (0.43)	14.51 (0.61)	15.95 (3.43)
15-30	11.59 (0.43)	13.69 (0.73)	11.69 (0.45)	12.89 (0.54)
Total	22.33 C	27.37 B	26.20 B	28.84 A

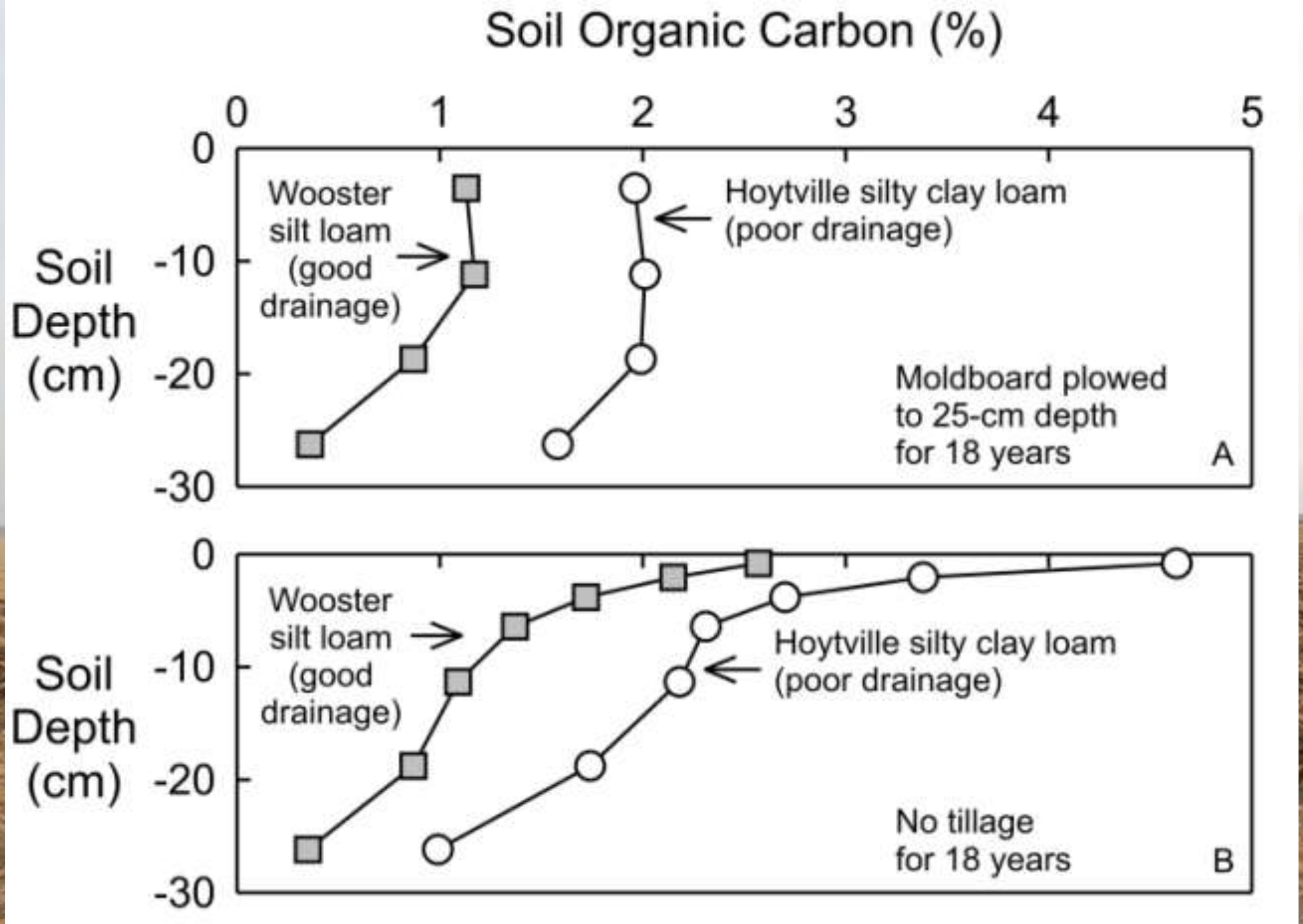
Values in parentheses are standard error of the means (n=8; north and south field mean averages were not significantly different therefore treatments combined for analysis). Letters represent significant differences among treatments using a one-way ANOVA analysis with Tukey HSD means comparison.

No-till cotton production following tomato

Five Points, CA • 2000 - 2010

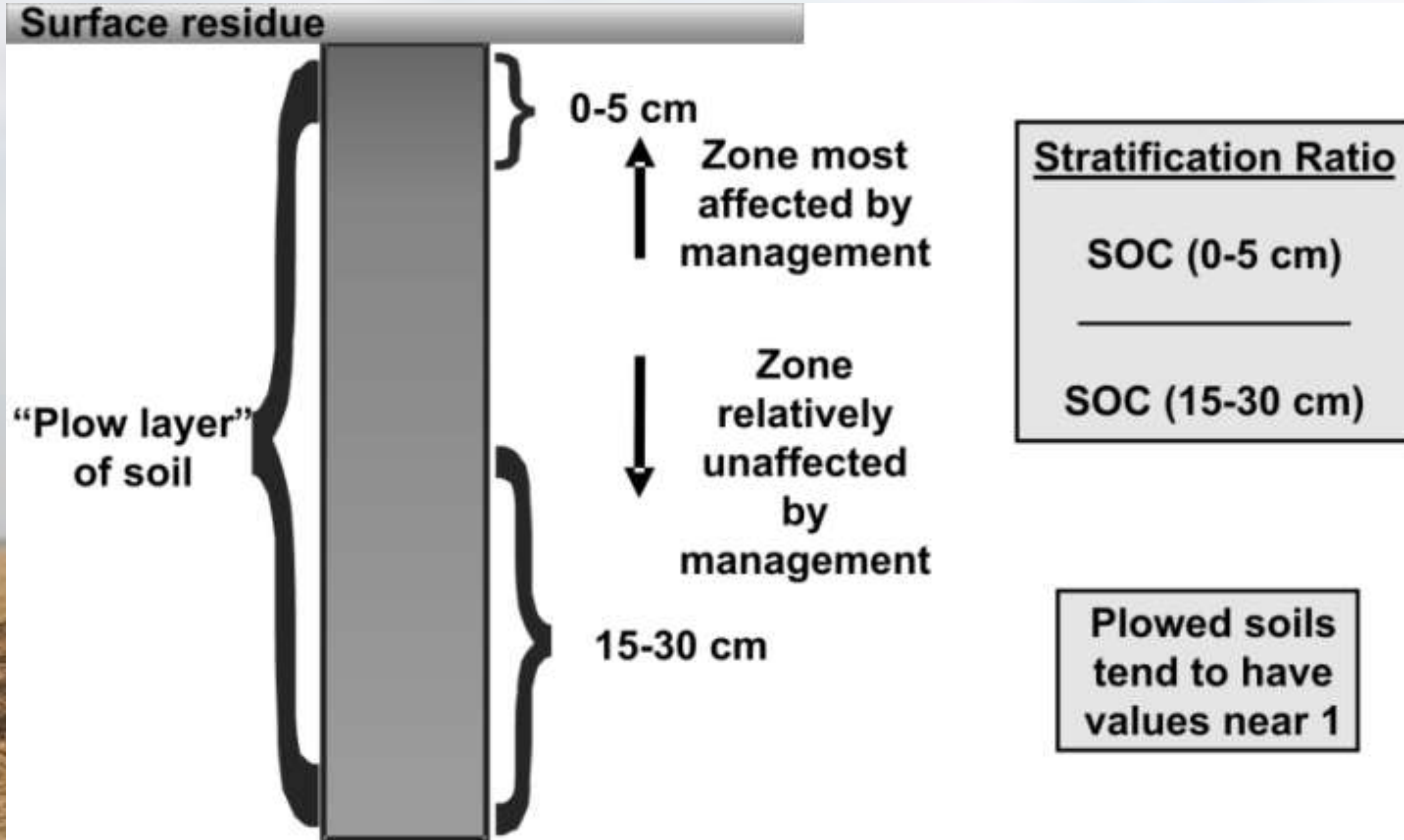
Conservation Tillage Workgroup

ANR · UCCE · UC Davis Plant Sciences · UC Davis College of Agricultural & Environmental Sciences · NRCS · Sustainable Conservation · Resource Conservation Districts · American Farmland Trust



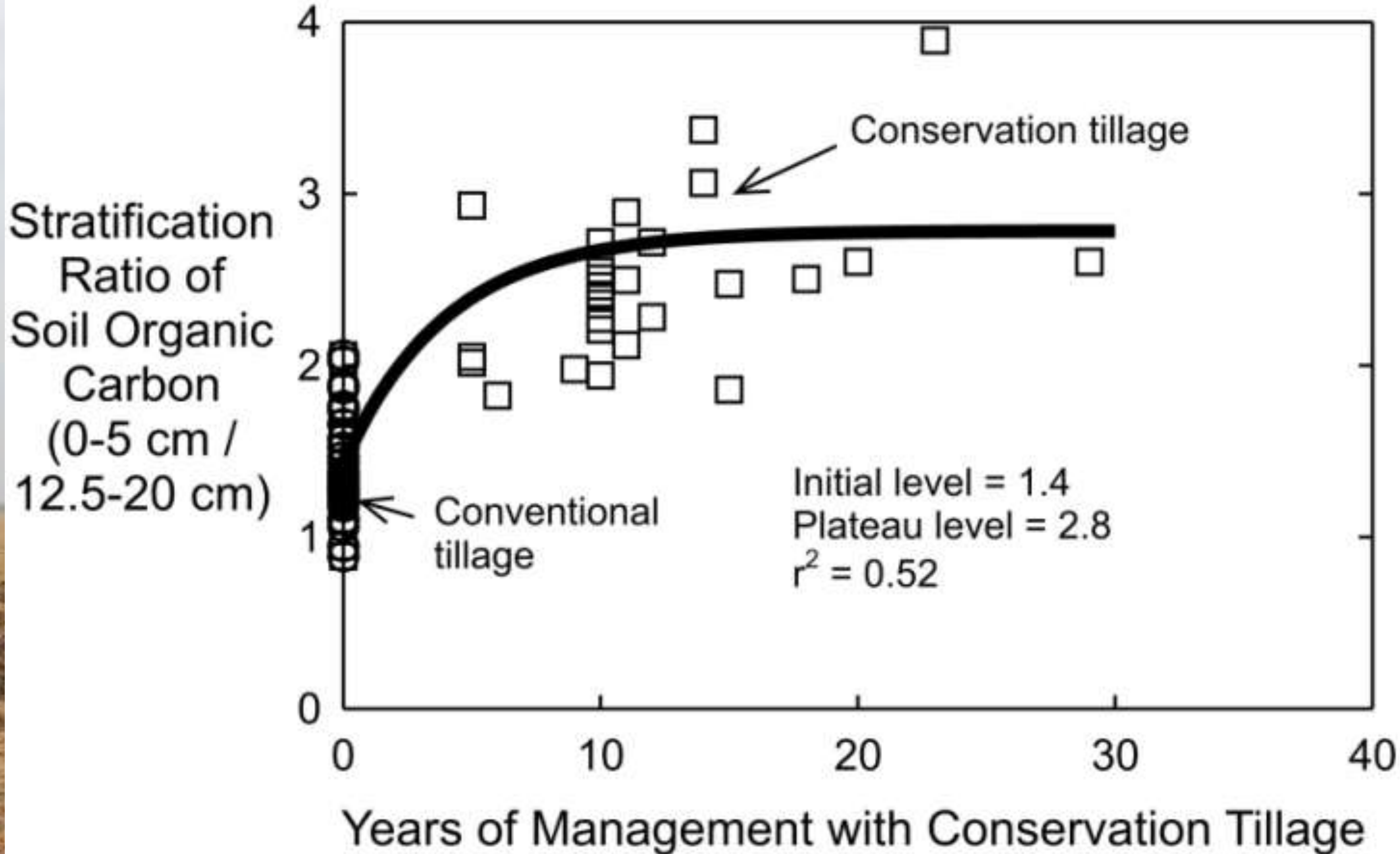
Organic carbon under conventional tillage (A) and under no tillage (B) in two contrasting soils in Ohio. Data from Dick WA (1983) Soil Sci. Soc. Am. J. 47:102-107.

Presented in Franzluebbers AJ. Surface soil organic matter as an indicator of soil quality, Winter Issue No. 58, 2010 Prairie Steward – Farming for Your Future Environment, the Newsletter of the Saskatchewan Soil Conservation Association Inc.



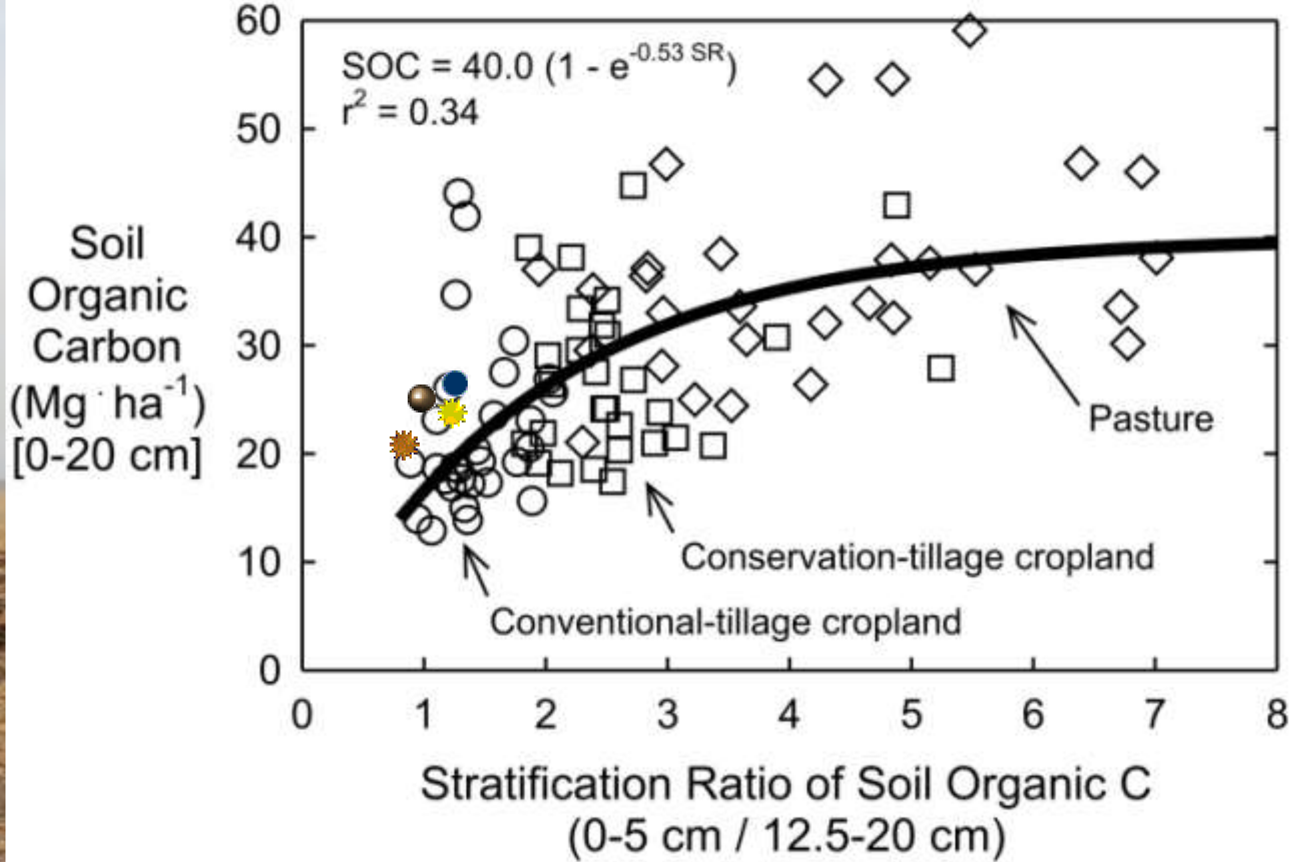
Conceptual diagram for the calculation of stratification ratio of soil organic matter.

Presented in Franzluebbers AJ. Surface soil organic matter as an indicator of soil quality, Winter Issue No. 58, 2010 Prairie Steward – Farming for Your Future Environment, the Newsletter of the Saskatchewan Soil Conservation Association Inc.



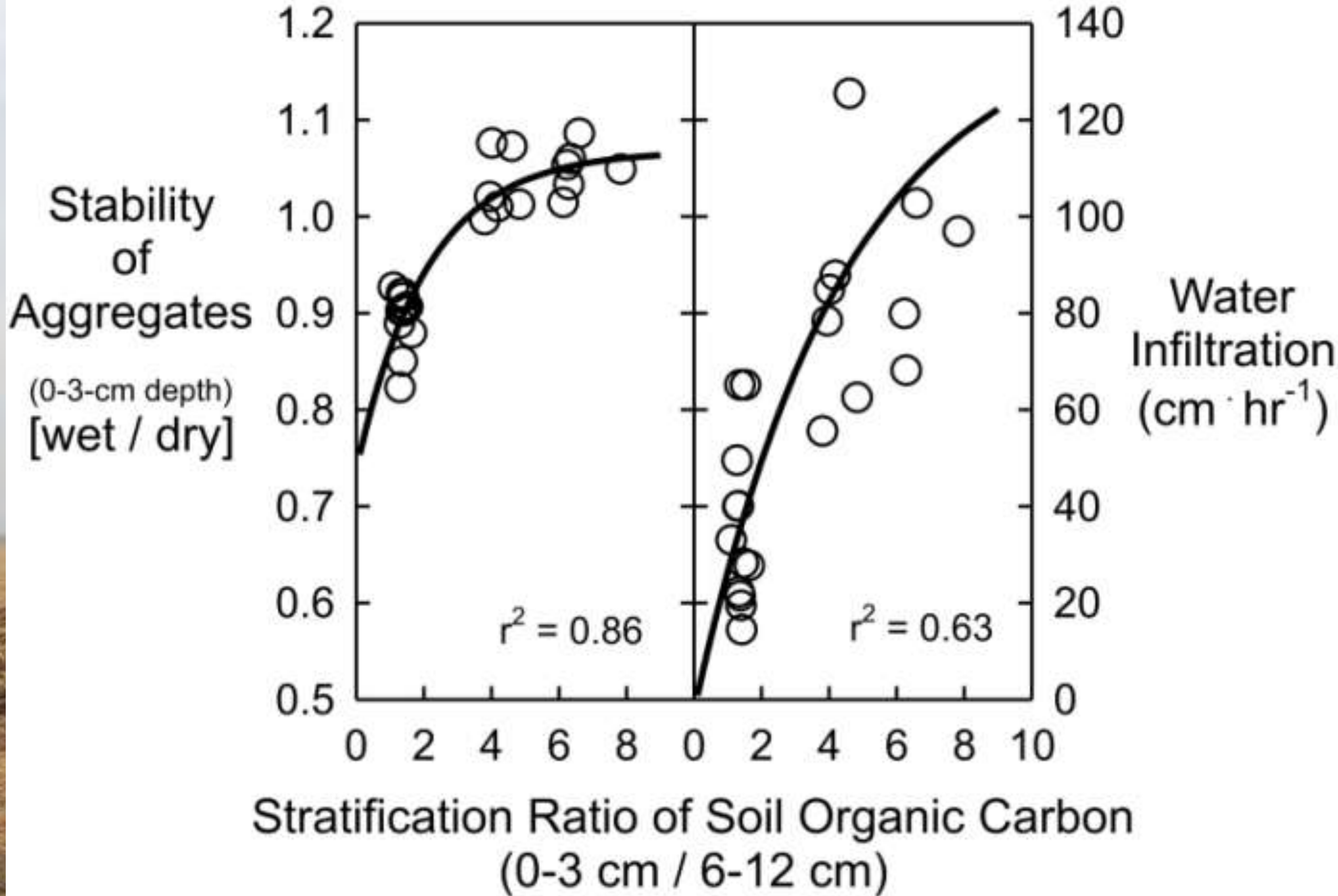
Changes in stratification ratio of soil organic carbon with time under conservation-tillage management in a survey of 89 farms in the southeastern USA.
Data from Causarano HJ, Franzluebbers AJ, Shaw JN, Reeves DW, Raper RL, Wood CW (2008) Soil Sci. Soc. Am. J. 72:221-230.

Presented in Franzluebbers AJ. Surface soil organic matter as an indicator of soil quality, Winter Issue No. 58, 2010 Prairie Steward – Farming for Your Future Environment, the Newsletter of the Saskatchewan Soil Conservation Association Inc.



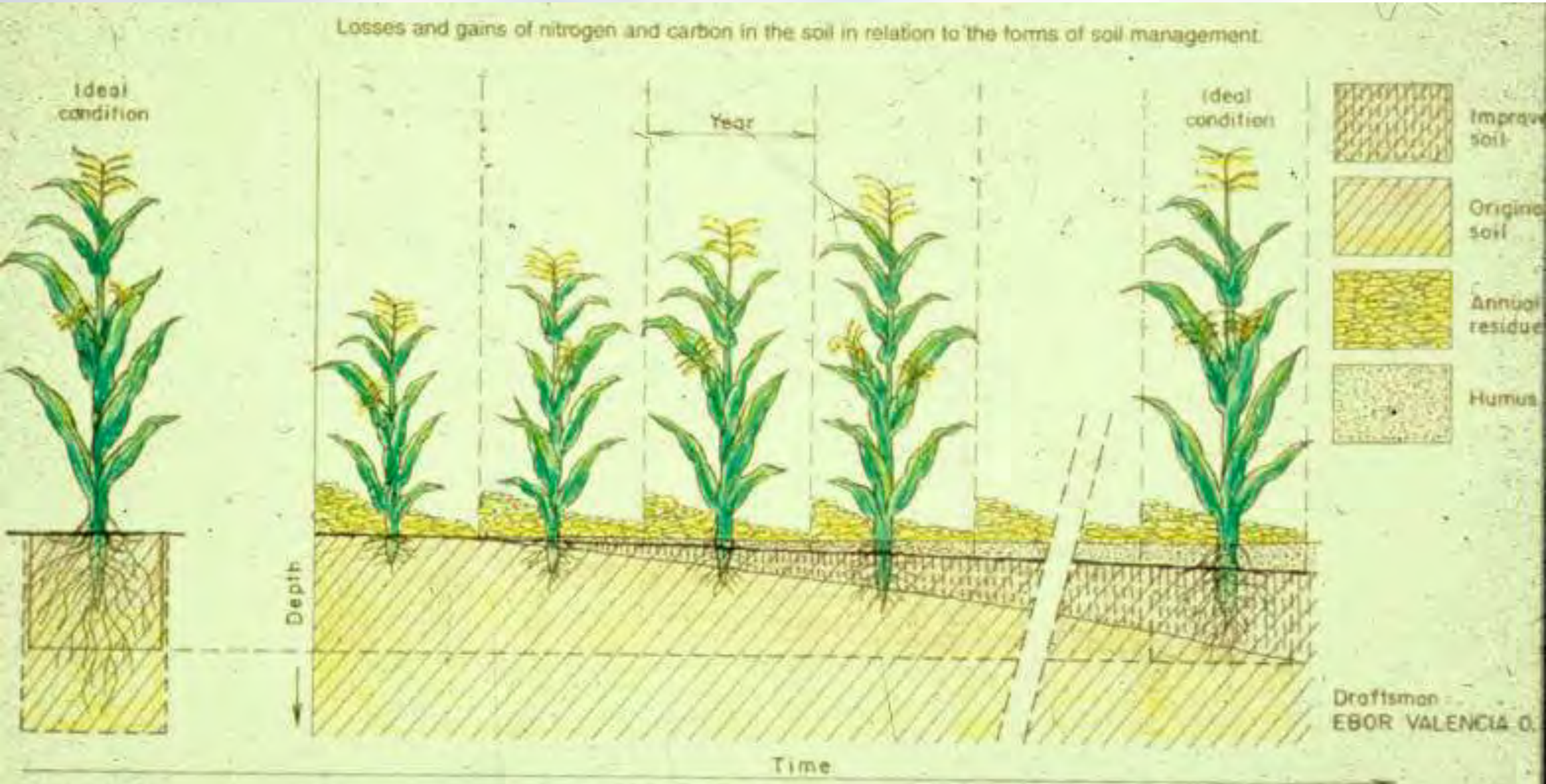
Stock of soil organic carbon to a depth of 20 cm in relation to the stratification ratio of soil organic carbon from a survey of 89 farms throughout the southeastern USA.
Data from Causarano HJ, Franzluebbers AJ, Shaw JN, Reeves DW, Raper RL, Wood CW (2008) Soil Sci. Soc. Am. J. 72:221-230.

Presented in Franzluebbers AJ. Surface soil organic matter as an indicator of soil quality, Winter Issue No. 58, 2010 Prairie Steward – Farming for Your Future Environment, the Newsletter of the Saskatchewan Soil Conservation Association Inc.



Relationship of water-stable aggregation and water infiltration to the stratification ratio of soil organic carbon in soils from Georgia.
Data from Franzluebbers AJ (2002) Soil Tillage Res. 66:197-205.

Presented in Franzluebbers AJ. Surface soil organic matter as an indicator of soil quality, Winter Issue No. 58, 2010 Prairie Steward – Farming for Your Future Environment, the Newsletter of the Saskatchewan Soil Conservation Association Inc.



Stubble Over the Soil
Carlos Crovetto
1996

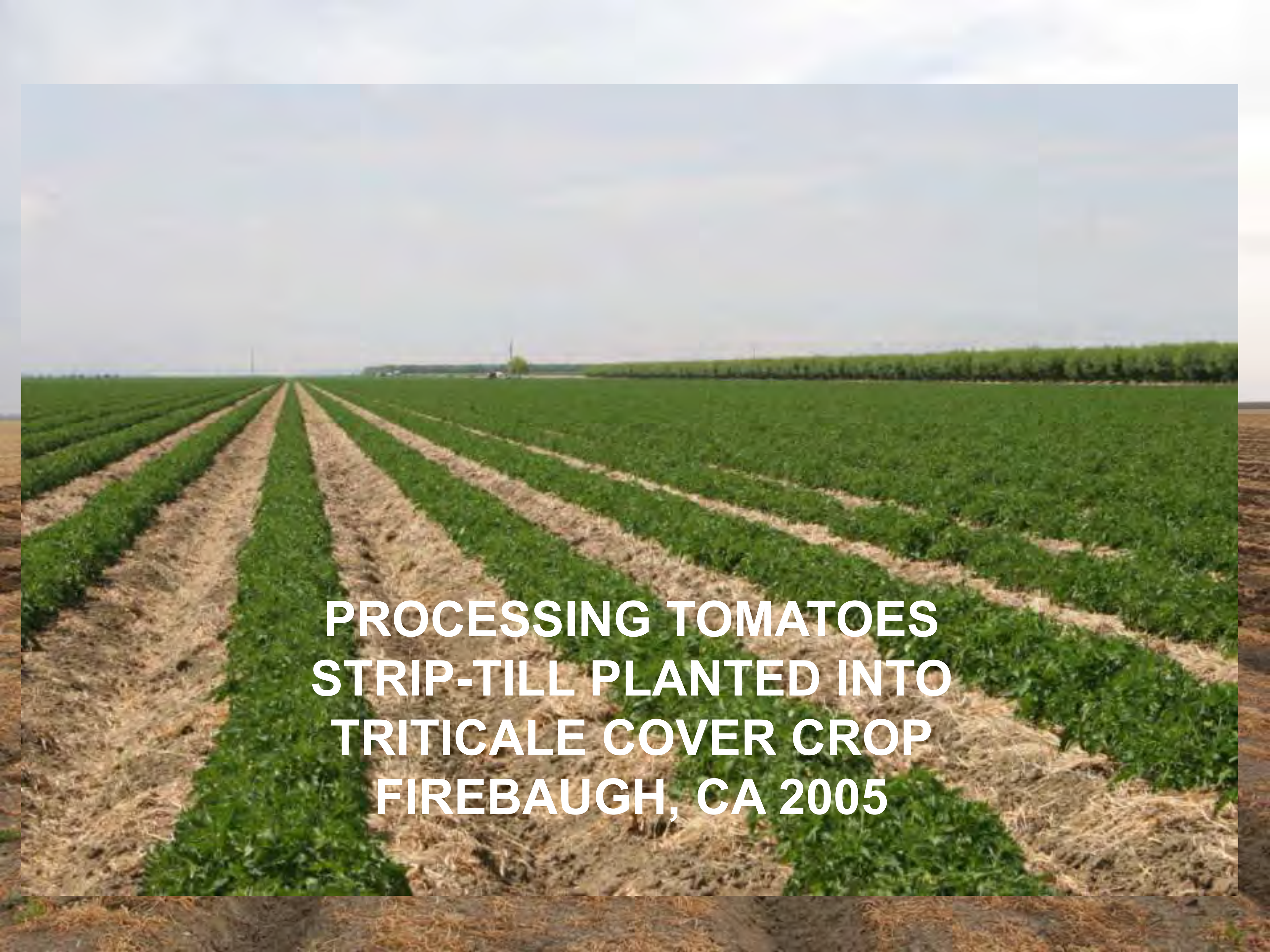
“Scaling up” conservation tillage techniques
at commercial processing tomato farm
Firebaugh, CA
2008


Short-season triticale cover crop
preceding processing tomatoes
Firebaugh, CA 2005

**Strip-till planted processing tomatoes
Firebaugh, CA 2006**

Strip-till planted processing tomatoes into Triticale cover crop residue
Sano Farms, Firebaugh, CA 2006


"This is the first worm I've seen in these fields in 30 years."
Alan Sano
Sano Farms
Firebaugh, CA
May 4, 2006


PROCESSING TOMATOES
STRIP-TILL PLANTED INTO
TRITICALE COVER CROP
FIREBAUGH, CA 2005


Subsurface drip coupled with permanent
beds and strip-till cover cropped fresh
market tomato production
Firebaugh, CA
2005

Rolling stalk chopper knocking down bell bean cover crop ahead of strip-tilling and transplanting processing tomatoes
Davis, CA
April 2006


Modified Orthman *1-tRIPr* strip-tiller
preceding tomato transplanting
Davis, CA May 2006

Costs by Item Table			
Operation	Standard	Intermediate	Sano
Machine Labor Hours	2.21	1.28	0.67
Machine Labor Costs	30.32	17.49	9.18
Non-Machine Labor Hours	0.00	0.00	1.00
Non-Machine Labor Costs	0.00	0.00	10.96
Diesel Gallons	29.10	13.42	6.64
Diesel Costs	59.36	27.38	13.56
Lube	8.90	4.11	2.03
Repair	20.14	10.61	8.44
Interest	7.46	4.67	9.70
Total Operation Costs	126.18	64.26	53.87
Cash Overhead	2.49	1.44	1.78
Non Cash Overhead	27.51	15.44	17.89
Total Costs	156.18	81.14	73.54
Add Materials			
Water	81.25	81.25	81.25
Roundup	32.28	32.28	32.28
Cover Crop	0.00	0.00	28.00
Total Materials	113.53	113.53	141.53
Total Costs	269.71	194.67	215.07

Cover cropping and conservation tillage in California processing tomato production systems

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and
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Introduction

California tomato producers seek technologies that are economically viable and environmentally sustainable. Production practices that are ultimately adopted by tomato

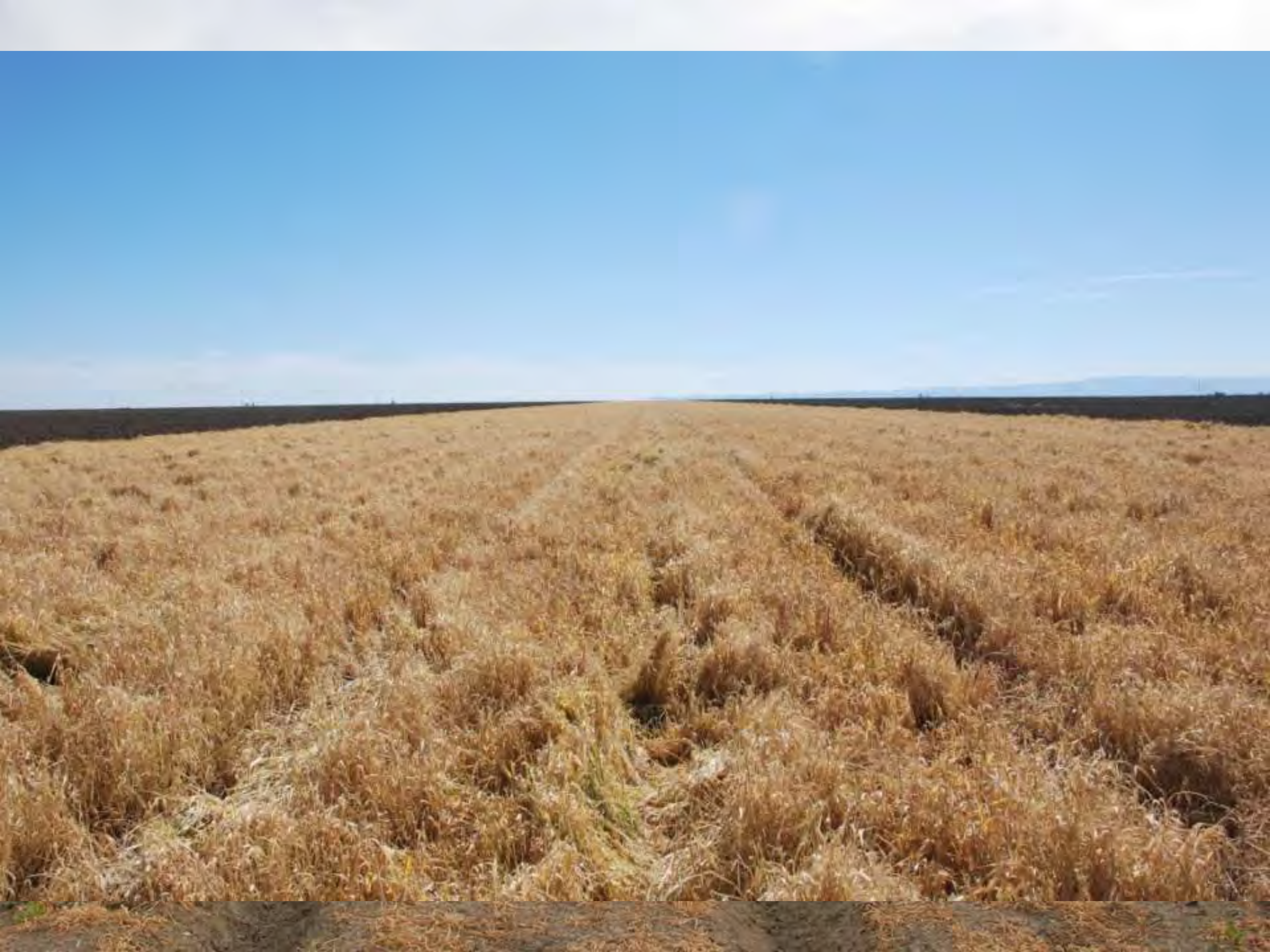

2011 Tomato Cover Crop and Strip-till Demonstration Evaluation Sites
Yolo County locations
San Joaquin County locations (2)
Merced County locations (2)
San Benito County locations (1)
Fresno County locations
Conservation Tillage
WORKGROUP
Modoc
Trinity
Shasta
Tehama
Mendocino
Glenn
Butte
Plumas
Lake
Colusa
Sierra
Nevada
Sonoma
Yolo
Placer
Napa
El Dorado
Solano
Alpine
Tuolumne
Mono
Stanislaus
Santa Clara
Merced
Fresno
Monterey
Kings
Tulare
Inyo
San Luis Obispo
Kern
Santa Barbara
Ventura
San Bernadino
Los Angeles

2011 Tomato CT and Cover Crop Demonstration Evaluations
Mid-Season Progress Discussion

Santa Nella, CA

June 30, 2011

Thanks for taking part!



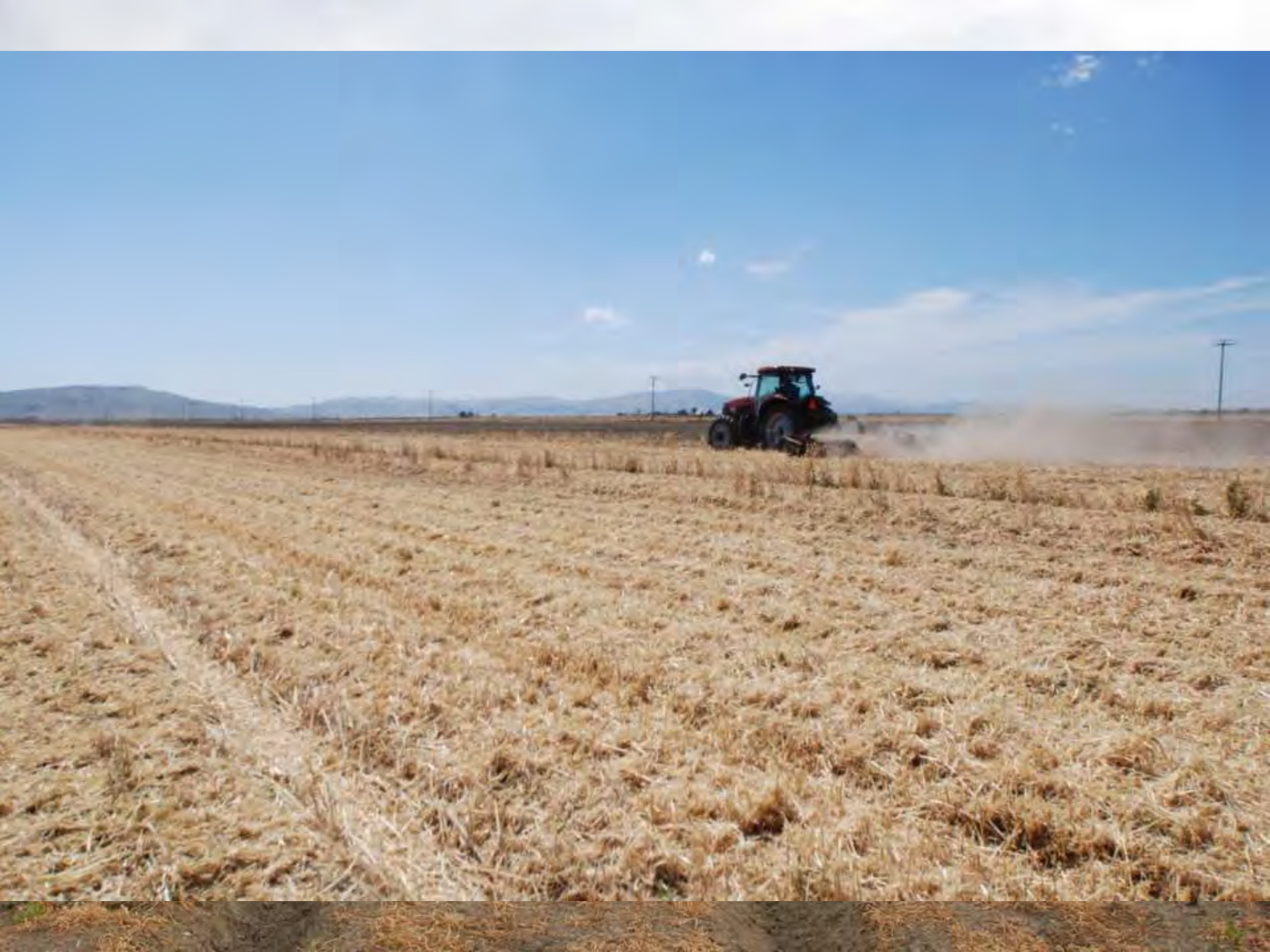
Coehlo

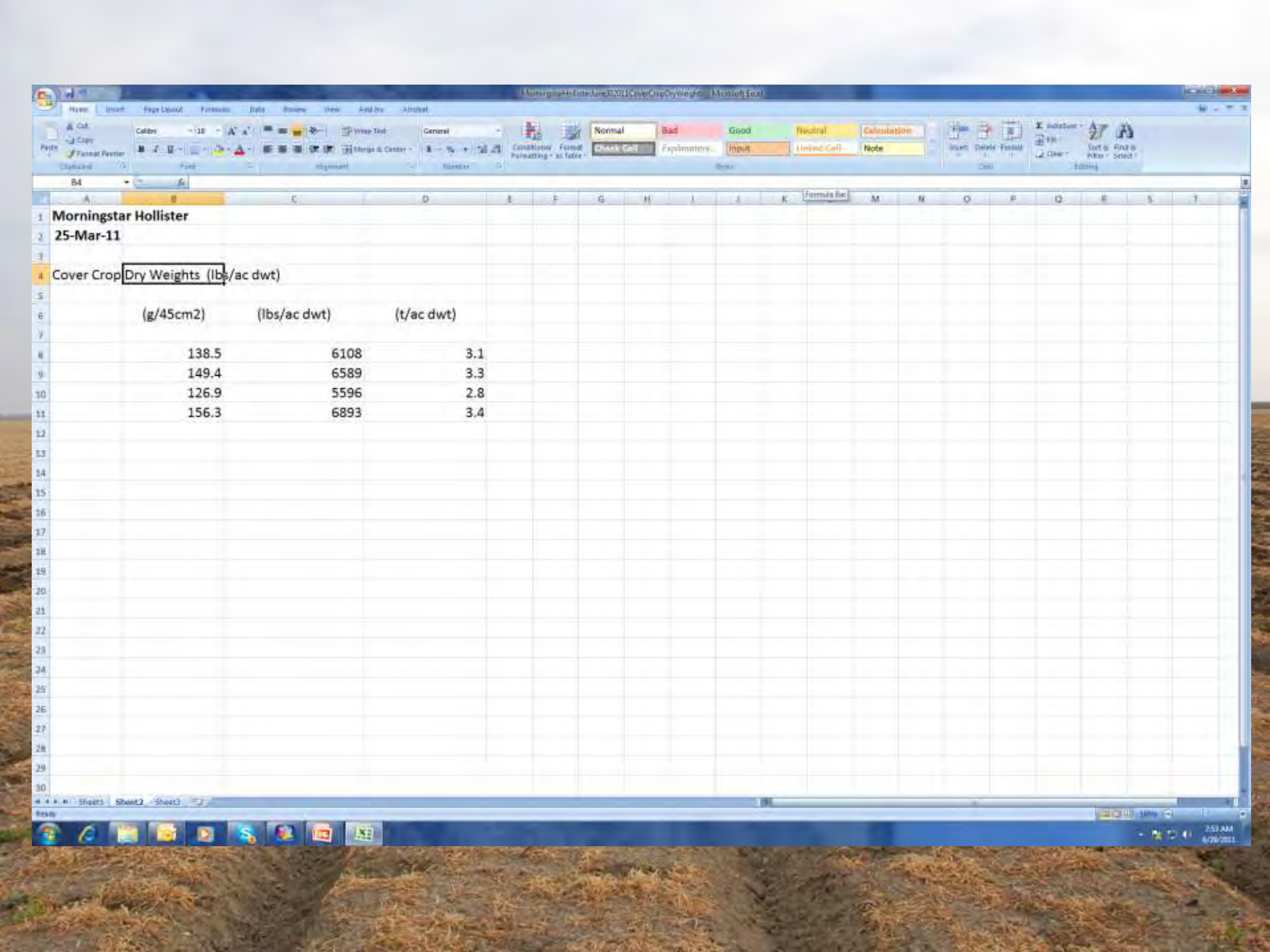
25-Mar-11

Range 4957 - 6628 lbs/ac

Cover Crop Dry Weights (lbs/ac dwt)

(g/45cm2)	(lbs/ac dwt)	(t/ac dwt)
124.7	5499	2.7
112.4	4957	2.5
150.3	6628	3.3





Morningstar Hollister

25-Mar-11

Cover Crop Dry Weights (lbs/ac dwt)

(g/45cm2)	(lbs/ac dwt)	(t/ac dwt)
138.5	6108	3.1
149.4	6589	3.3
126.9	5596	2.8
156.3	6893	3.4

Front-mounted roller rolling rye cover crop
Tipton, GA

Rolled rye cover crop
Lamar Black
Tipton, GA
1999

Strip-till planted cotton into rolled rye cover crop
Tipton, GA
1999

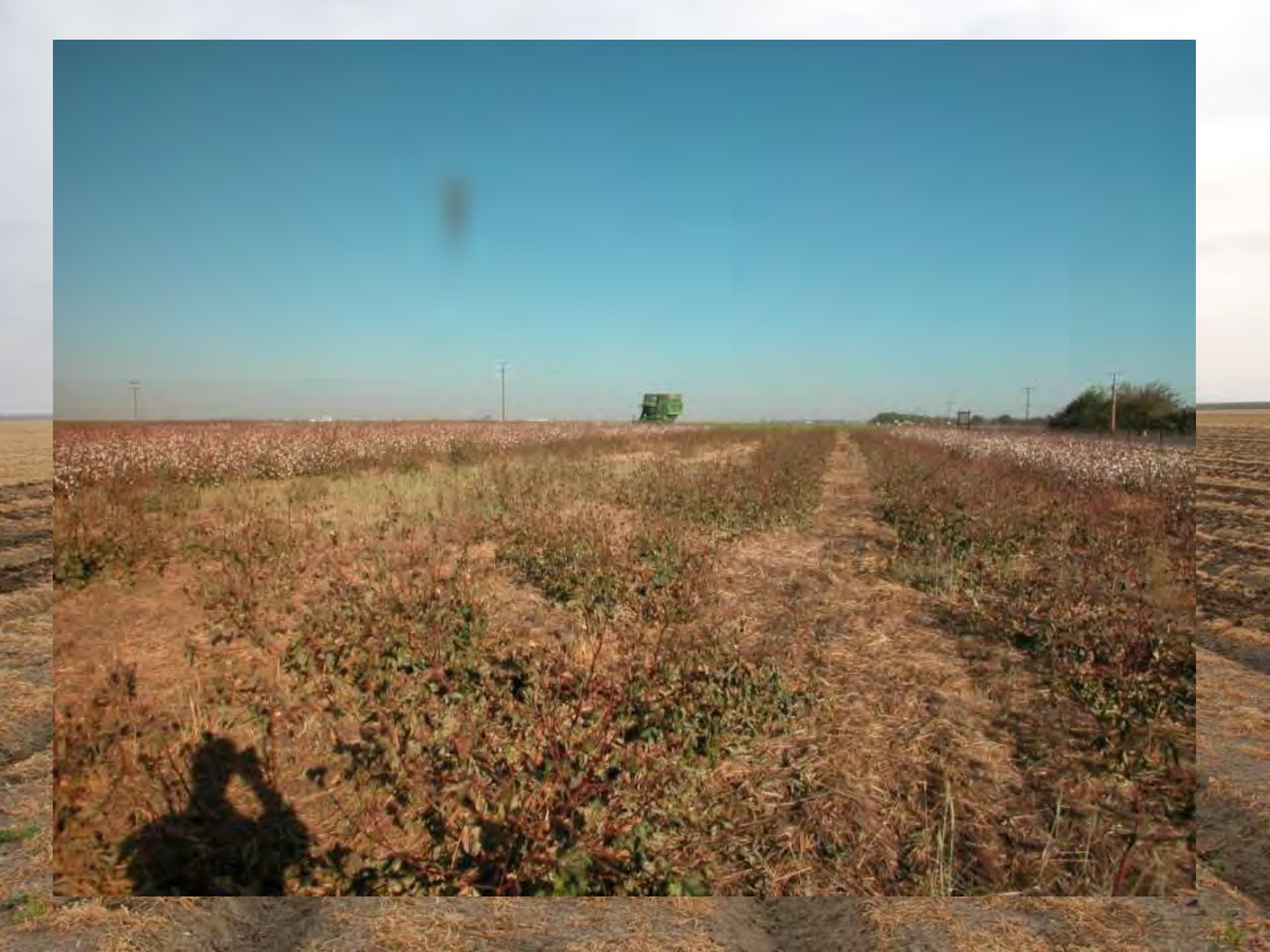
No-till planting into rolled cover crop
Parana, Brazil
1999

Rye cover crop being rolled at organic farm of Tom and Denesse Willey, Madera, CA
2006


Conservation Tillage
WORKGROUP


Conservation Tillage
WORKGROUP


Conservation



Submitted to: *Renewable Agriculture and Food Systems*

Category: Review Paper

June 15, 2011

Conservation tillage for organic agriculture:

Evolution toward hybrid systems

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Abstract

Organic farming has been historically dependent on conventional tillage operations to convert perennial pasture leys to annual crop rotations, incorporate crop residues, compost and cover crops, as well as to mechanically kill existing vegetation. Conventional tillage, however, has long been known to lead to soil degradation and erosion. A recently developed no-till organic production system which uses a roller-crimper technology to mechanically kill a cereal rye cover crop was evaluated in two states in the western United States. In Washington, pumpkins grown in a no-till roller-crimper rye system produced yields 80% of conventional tillage, but with fewer weeds. However, in California on-farm research trials in organic cotton, tomato, eggplant, and cowpeas, the no-till system produced virtual crop failure, or yields less than 30% of the standard production method. The major problems associated with rolled cover crops in California included reduced crop seedling emergence, planter impediment with excessive residue, lack of moisture and delay in transplanting of vegetable crops due to continued growth of cover crops, in-season crop competition from cover crop regrowth, and impracticability of using cultivators. Further, excessive dry residue during summer in California can present the risk of fire. In both California and Oregon, considerable success has been demonstrated with zone tillage (strip tillage) in conventionally-produced field and vegetable crops. In a replicated Oregon trial, the organic strip tillage treatment produced 85% of the broccoli yield compared to a reduced tillage treatment. We believe there are major agronomic constraints which limit adoption of no till organic agriculture. We suggest that zone tillage concept may offer opportunities to overcome many of the agronomic challenges facing no till.

Keywords: no till, strip till, zone tillage, conservation tillage, roller crimper, organic farming, *Secale cereale* L., *Phacelia tanacetifolia*

On Farm Experiment: Effects of deep *vs.* shallow minimum tillage on lettuce yield

- **Goal:** Examine changes in yield, Sclerotinia and corky root levels under three types of tillage that retain semi-permanent beds for several years
- **Cropley silty clay:** sprinkler and furrow irrigation
- **Three treatments started in Oct 1994**
  - Shallow minimum till ("Sundance")
  - Deep minimum till ("Chisel Only")
  - Deep minimum till ("Full Five-Step")
- **Lettuce crops every year (1995-1998)**
- **Sampling:** nitrate, ammonium, microbial biomass, bulk density, disease counts in the field

L.Jackson, 2011

Minimum Tillage Plots After Three Years

	n per plot*	'Deep' Full 5-Step Minimum Till	'Deep' Chisel Only (No Ripper)	'Shallow' Sundance Only
Fresh weight of lettuce (g/head)	10	903[a]	861[b]	842[c]
Sclerotinia (% of heads with wilt symptoms)	250	1.17[a]	1.94[a]	5.27[b]
Corky Root (% of taproot infected)	12	47[a]	43[a]	56[a]

*6 plots per treatment

Minimum Tillage Plots After Four Years

	n per plot*	'Deep' Full 5-Step Minimum Till	'Deep' Chisel Only (No Ripper)	'Shallow' Sundance Only
Fresh weight of lettuce (g/head)	12	955[a]	926[a]	856[ab]
Sclerotinia (% of heads with wilt symptoms)	600	0.63[a]	0.97[b]	1.89[c]
Corky Root (% of taproot infected)	12	4.7[a]	4.6[a]	5.5[a]

*6 plots per treatment

Summary of On-Farm Experiment: Effects of deep *vs.* shallow minimum tillage on lettuce yield

- After two years of shallow minimum tillage („Sundance'), yields decreased and Sclerotinia increased.
- Yields were highest when both chiseling and ripping were included in the operations for maintaining semi-permanent beds.
- Corky root disease was variable from year to year, but was not affected by the different tillage treatments.
- Other soil parameters did not show large differences between tillage treatments.

Conclusions:

- **SOM:** Increasing active soil organic matter (e.g., microbial biomass) is related to increased lettuce yield.
- **Organic matter management**: Addition of fresh, readily available organic matter (i.e., plant material) along with more recalcitrant forms (i.e., compost) seems to be an effective way to boost microbial biomass for an extended period.
- **Tillage management:** Shallow minimum tillage (e.g., Sundance) is only recommended for a short period in between use of deeper tillage methods.

Table 1. Tillage system effects on average sweet corn yield and tillage costs (Data from Luna and Staben, 2002).

Tillage System	Graded Yield[1] Tons/acre		Tillage Costs[2] $ / acre	
	1997-1998		1997-1998	
Strip-till	8.9		$20.90	
Conv.-till	8.6		$36.50	

[1]Number of on-farm trials for yield: 1997-1998 = 8; 1999-2000 = 12.

[2]Number of on-farm trials for estimating tillage costs: 1997-1998 = 6; 1999-2000 = 5.

Cooperating Farmers

Carl, Kenny and Jack Hendricks
Rod Chambers
Peter Kenagy
Mike and Mark Dickman
Rob Heater
Sam Sweeney
Alan and Steve Keudell
Ron Pearmine
Ray Stafford

2009 Strip tillage at Pearmine Farm

Cover crop effects on sweet corn yield in strip-till systems – 2003-2005

- 4 cover crop treatments:
  - Fallow
  - Oats
  - Oats + vetch
  - Oats + phacelia
- 2 farms each year; 3 year study: 6 fields total

Cover crop effects on sweet corn yield

Fuel and Energy Use comparison

Pearmine Farms, Gervais, OR

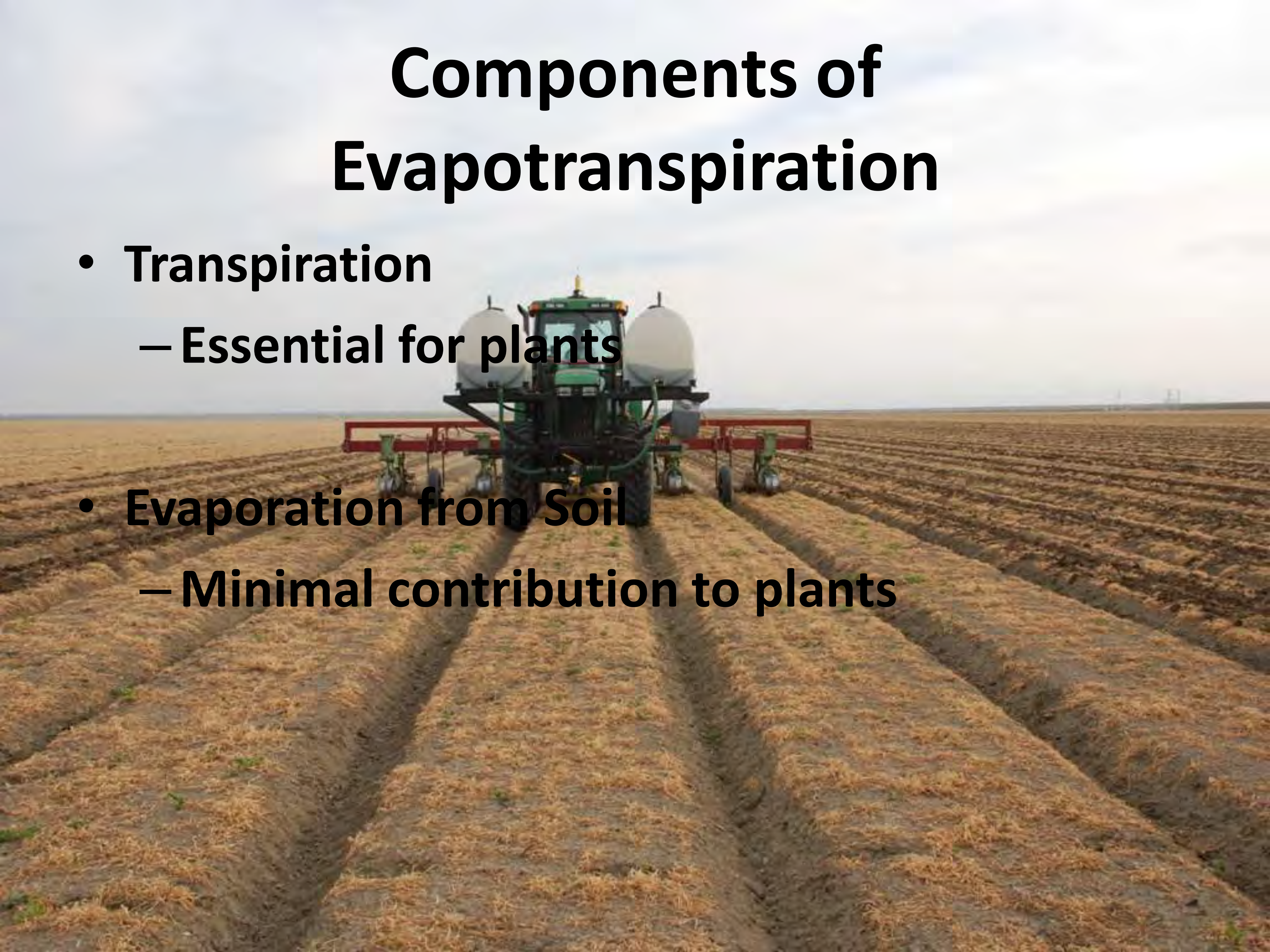
Strip-Till (Tractor - JD 7830 160 hp)

	Implement width (ft)	tractor speed (mph)	acres/hour	fuel used / hour (gal diesel)	fuel per acre	passes/acre	total fuel/acre	energy Equiv. (MJ)
Transtiller	15	5	8	4	0.5	1	0.5	83
Strip roller disk	15	6.5	10	4	0.4	1.7	0.7	112
						total fuel/acre	**1.2**	**195**
Conventional Till (Tractor - JD 7140 200 hp)								
Offset disk	30	6	16	16	1	2	2.0	330
Vibra-shank cultivator	30	6	16	16	1	2	2.0	330
Perfecta finish cultivator	25	6	13.3	16	1.2	1.0	1.2	198
						total fuel/acre	**5.2**	**858**


Irrigation Extra
November 2008
Free H_2O in no-till residue
By DON McCABE
Key points
WATER WISE
Pilot trials
Word of caution
Center Pivot Parts
Yesterday!
parts break, you can't afford to wait.
Nebraska Irrigation, Inc.
1.800.397.1100

Components of Evapotranspiration

- Transpiration
  - Essential for plants
- Evaporation from Soil
  - Minimal contribution to plants



Value of Crop Residue for Reducing Evaporation

- Frequent surface wetting with center pivots
- Crop residue insulates surface
- How much residue is needed?

Soil Water Evaporation and Crop Residues

N. L. Klocke, R. S. Currie, R. M. Aiken

Abstract. *Crop residues have value when left in the field and also when removed from the field and sold as a commodity. Reducing soil water evaporation (E) is one of the benefits of leaving crop residues in place. E was measured beneath a corn canopy at the soil suface with nearly full coverage by corn stover or standing wheat stubble. E was also measured from a soil surface that was partially covered with corn stover without crop shading. E was measured with mini-lysimeters that were 300 mm in diameter and 140 mm deep. Surface coverage and amount of dry matter of crop residues influenced E. E was reduced nearly 50% compared with bare soil E when corn stover and wheat stubble nearly covered the surface under a corn canopy during the growing season. Partial surface coverage, from 25% to 75%, with corn stover caused small reductions in E compared with bare soil when there was no crop canopy. Full surface coverage reduced energy limited E 50% to 65% compared with E from bare soil with no shading. No-till management, using crop residues to significantly reduce E, required soil surfaces to be nearly covered. Economic benefits of crop residues for E suppression during the growing season can be as much as $365 ha^{-1}.*

Keywords. *Corn, Crop residues, Irrigation, Irrigation management, Soil evaporation, Soil water, Soil water evaporation.*

Corn growers who irrigate in the Great Plains and other irrigated regions face water restrictions from decreased well capacity, water allocations imposed by water policy, and/or rising energy costs. These growers require water management practices that optimize grain production. When not enough water is available to produce full yields, the goal for water management is to

During the growing season, sprinkler irrigation wets soil surfaces up to twice per week, which causes most evaporation to be ELE. Management to reduce ELE is important when wet soil surfaces occur. Crop residues left in the field can conserve soil and water by increasing infiltration, reducing runoff, and reducing water and soil erosion. Crop residues also insulate the soil surface from radiant and advective energy,

Harvesting winter forage wheat, strip-tilling and planting corn, Tipton, CA, May 2005

Tom Barcellos addressing over 140
Tulare County dairymen
Tipton, CA
August 30, 2007


CONSERVATION TILLAGE
Saves time
Saves fuel
Saves money
Saves air quality
Saves equipment
NRCS
STRIP-TILL

Do's & Don'ts for Success in Con-Till / No-Till

Tom Barcellos

Barcellos Farms

Tipton, CA

IS THERE POTENTIAL?

YES THERE IS!

41 ton Silage

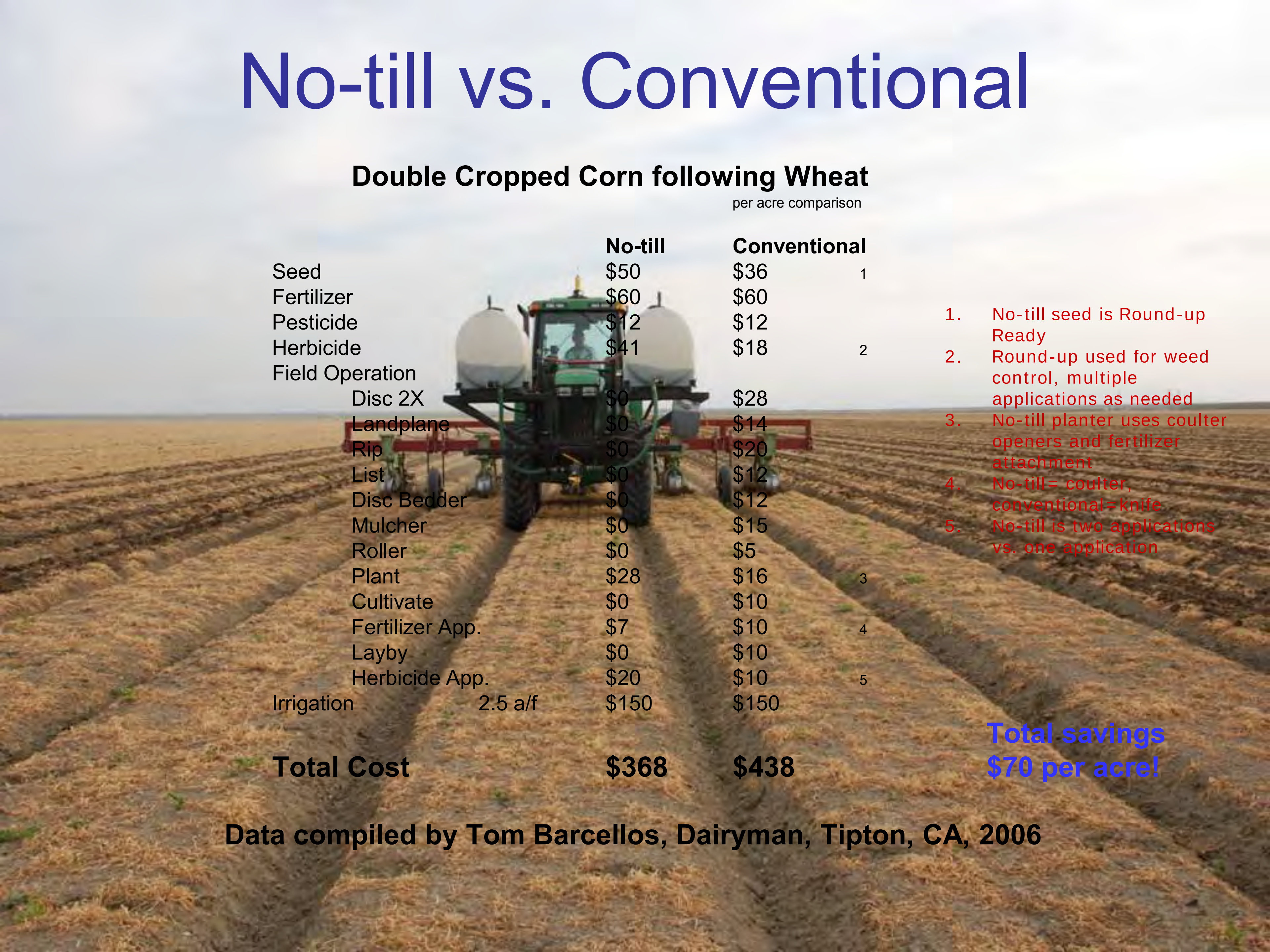
No-Till 6 years

35 ton Field Avg.

16-row strip-tiller used ahead of forage corn planting
Madera, CA
2007


Strip-till corn stand establishment
Iest Dairy, Chowchilla, CA 2007

No-till vs. Conventional



Double Cropped Corn following Wheat

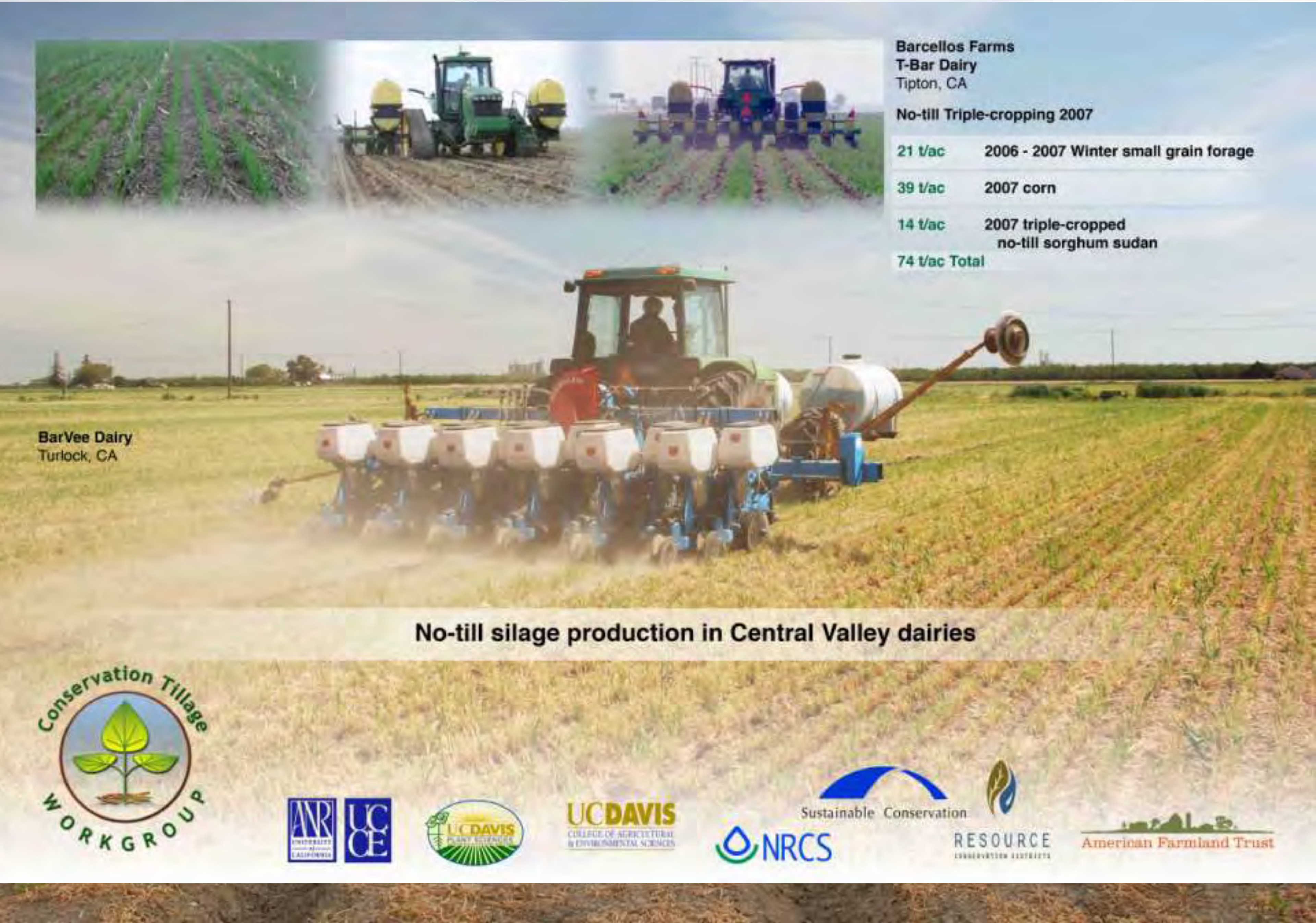
per acre comparison

		No-till	Conventional	
Seed		$50	$36	1
Fertilizer		$60	$60	
Pesticide		$12	$12	
Herbicide		$41	$18	2
Field Operation				
Disc 2X		$0	$28	
Landplane		$0	$14	
Rip		$0	$20	
List		$0	$12	
Disc Bedder		$0	$12	
Mulcher		$0	$15	
Roller		$0	$5	
Plant		$28	$16	3
Cultivate		$0	$10	
Fertilizer App.		$7	$10	4
Layby		$0	$10	
Herbicide App.		$20	$10	5
Irrigation	2.5 a/f	$150	$150	
Total Cost		**$368**	**$438**	

1. No-till seed is Round-up Ready
2. Round-up used for weed control, multiple applications as needed
3. No-till planter uses coulter openers and fertilizer attachment
4. No-till= coulter, conventional=knife
5. No-till is two applications vs. one application

Total savings $70 per acre!

Data compiled by Tom Barcellos, Dairyman, Tipton, CA, 2006


Barcellos Farms
T-Bar Dairy
Tipton, CA
No-till Triple-cropping 2007
21 t/ac 2006 - 2007 Winter small grain forage
39 t/ac 2007 corn
14 t/ac 2007 triple-cropped no-till sorghum sudan
74 t/ac Total
BarVee Dairy
Turlock, CA
No-till silage production in Central Valley dairies
Conservation Tillage Workgroup
UC Davis College of Agricultural & Environmental Sciences
Sustainable Conservation
NRCS
RESOURCE
American Farmland Trust

Tillage system estimates of soil condition index, soil tillage intensity rating, and diesel fuel use for Kimberline fine sandy loam soil, Hanford, CA

Cropping System*	Soil Conditioning Index ‡	STIR Average Annual ◊	Diesel Fuel use	Fuel cost for entire simulation ($)
Standard Tillage	-2.0	703	18	52.52
Strip-tillage/ no-till	0.84	12.7	3.9	11.69

* Corn silage and winter wheat with “standard” on strip=till/no-till.

‡ The **SCI** is the **Soil Conditioning Index** rating. If the calculated index is a negative value, soil organic matter levels are predicted to decline under that production system. If the index is a positive value, soil organic matter levels are predicted to increase under that system.

◊ The **STIR** value is the **Soil Tillage Intensity Rating.** It utilizes the speed, depth, surface disturbance percent and tillage type parameters to calculate a tillage intensity rating for the system used in growing a crop or a rotation. STIR ratings tend to show the differences in the degree of soil disturbance between systems. The kind, severity and number of ground disturbing passes are evaluated for the entire cropping rotation as shown in the management description.


Dairy forage triple-cropping
as a means to increase forage
production and nutrient
uptake

Documented benefits of CT

- **Cutting costs**
  Cal Ag 2006, 2008
- **Reducing dust emissions**
  J. Env. Qual. 2005, 2009, Atmos. Env. 2008
- **Cutting fuel use**
  Cal Ag 2006, 2008
- **Increasing soil carbon**
  Agron. J. In preparation

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Australian Journal of Experimental Agriculture, 2004, **44**, 213–222

Social principles for agricultural extension to assist in the promotion of natural resource management

F. Vanclay

Tasmanian Institute of Agricultural Research, University of Tasmania, Private Bag 98, Hobart, Tas. 7001, Australia; e-mail: Frank.Vanclay@utas.edu.au

Abstract. An understanding of social issues, the social nature of farming, and the social basis of adoption is needed if agricultural extension is to be effective in addressing natural resource management issues, and in promoting sustainability in its triple bottom line conceptualisation. Twenty-seven principles are presented here, with the key principles being: awareness of farming as a social activity; recognition of the social diversity of farmers and the social drivers in agriculture; and the socio-cultural basis of adoption.

Additional keywords: rural sociology, farming, barriers to adoption, social drivers.

Introduction

Agriculture has too long been thought of as a technical issue involving the application of science, and the transference of the outputs of that science via a top-down process of technology transfer. It is not. Agriculture is farming, and farming is people. The survival of agriculture is dependent on the survival of viable rural communities. Sustainability has multiple bottom line implications, containing environmental, social and economic dimensions. The criteria and indicators for sustainability in a physical sense are generally understood. The economic indicators are also well established, although rather limited. What is lacking is an awareness of the social issues. This paper seeks to outline the key social principles relevant to the promotion of natural resource management issues in agriculture. These social principles should augment technical and economic principles relevant to sustainable agriculture.

The principles were developed out of personal reflection on 20 years of research on the social dimensions of farming particularly as they relate to the promotion of natural resource management in agriculture. This research started with a Masters degree (Vanclay 1986), continued through a PhD (Vanclay 1994), and through subsequent supervision of management (Vanclay 1991*a*, 1991*b*, 1992*b*, 1999). Some of the publications that have come out of this research provide evidence for statements made in this paper. However, in most cases, the principles that are articulated cannot be substantiated easily with evidence of the sort that physical agricultural scientists are used to. This is partly because this is a review paper rather than original work, but it also reflects the different epistemological paradigm of the social sciences.

They are called 'principles' because they are intended to be regarded as 'a general law or doctrine that is used as a basis of reasoning or a guide to action or behaviour' (The Australian Oxford Paperback Dictionary 1989). This status may not be accorded to them by all agricultural scientists, but they do have that status from a rural sociological perspective. It is the argument of this paper that agricultural scientists should accept these statements as principles.

Principle 1. Farming is a socio-cultural practice

The first principle is to acknowledge that farming is a socio-cultural practice rather than just a technical activity. Farming becomes a way of life, a way of making a living, that acquires a meaning far deeper that almost any other

Adoption of conservation practices by rural landholders

***David J. Pannell*[A,F]*, Graham R. Marshall*[B]*, Neil Barr*[C,F]*, Allan Curtis*[D]*, Frank Vanclay*[E] *and Roger Wilkinson*[C,F]**

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[C]Department of Primary Industries, Bendigo, 3554 Victoria

[D]Faculty of Science and Agriculture, Charles Sturt University, Albury, 2640 NSW

[E]Tasmanian Institute of Agricultural Research, University of Tasmania, Hobart, 7001 Tasmania

[F]Cooperative Research Centre for Plant-Based Management of Dryland Salinity, University of Western Australia, Crawley, 6009 WA

Note: This is a summary of: Pannell, D.J., Marshall, G.R., Barr, N., Curtis, A., Vanclay, F. and Wilkinson, R. (2006). Understanding and promoting adoption of conservation practices by rural landholders. *Australian Journal of Experimental Agriculture* 46(11): 1407-1424. The full paper is available at the journal web site: http://www.publish.csiro.au/nid/72/paper/EA05037.htm

Much of the focus of government policy for land and water conservation is on changing the behaviour and management practices of rural landholders. However, these policies often neglect the large body of evidence about what it takes to achieve such changes. This paper is a selective review and interpretation of the literature, conducted by a team from three relevant disciplines: agricultural and resource economics, rural sociology and social psychology.

Adoption is based on subjective perceptions or expectations rather than on objective truth. These perceptions depend on three broad sets of issues: the process of learning and experience, the characteristics and circumstances of the landholder within their social and economic environment, and the characteristics of the practice. These three elements are considered in detail in the following three sections. The last section discusses the implications of the review for various stakeholders: researchers, extension agents, and policy makers.

The process of learning and experience to inform adoption decisions

Adoption is a learning process with two distinct aspects. One is the collection, integration and evaluation of new information to allow better decisions about the innovation. Early in the process, the landholder's uncertainty about the innovation is high, and the quality of decision making may be low

made (Marra *et al.* 2003). At least for relatively simple innovations, a landholder's probability of making a good decision - one that best advances their goals - increases over time with increasing knowledge of, and perhaps experience with, the practice.

The other aspect of learning is improvement in the landholder's skills in applying the innovation to their own situation (Tsur *et al.* 1990). Most farming innovations require a certain level of knowledge and skill to apply them in practice and there can be a wealth of choices in the method of implementation (e.g. timing, sequencing, intensity, scale). Through learning-by-doing, as well as by reading, listening and watching, the necessary skills can be established and enhanced.

The dynamic learning process has been broken down into stages or phases in a number of different (though similar) ways. One typical description of the sequence follows.

1. Awareness of the problem or opportunity
2. Non-trial evaluation
3. Trial evaluation
4. Adoption
5. Review and modification
6. Non-adoption or dis-adoption

Prior to trialing, the landholder's assessment of a technology or practice relies strongly on information from outsiders. At this stage, social and information networks would be important influences on the decision to proceed to trial, but after trialing has commenced, personal experience is likely to be the main influence on further decisions (Dong and Saha 1998; Marsh *et al.* 2000).

There is no guarantee that a landholder's subjective beliefs will ultimately lead them to a final decision that is actually the one most likely to best achieve their goals. Reasons include that some conservation practices are relatively complex and that the benefits and costs of some conservation practices are not clearly observable. An example of a prominent conservation-related learning failure is provided by Pannell *et al.* (2001). They noted that many landholders (as well as scientists and policy makers) came to believe that successful prevention of dryland salinity on a farm would generally depend on cooperation from neighbours. While this is true in some cases, in many it is not.

Social, cultural and personal influences on adoption decisions

Although, for convenience, we will often refer to the (singular) landholder or farmer, the reader should bear in mind that for many decisions, particularly larger ones, the decision-making unit can be a team, so that individual perceptions and goals influence a consensus rather than leading directly to a decision.

Phillips (1985) found that a typical dairy farmer may embark on anything up to 30 learning projects in one year. A landholder (or landholding family) has limited learning time, and each project must compete with the others for that limited time. A minor decision will receive minimal information time, sufficient to achieve an acceptable solution, which is not necessarily the best possible solution. For more important decisions, the dairy farmers in

Phillips (1985) study sought information from up to 40 people.

The goals of landholder families or individuals are heterogeneous, and can include the following (i)


RETURN ON INVESTMENT
ENVIRONMENTAL ISSUES
CARBON SEQUESTRATION
CAPITAL
WATER MANAGEMENT
NITROUS OXIDE EMISSIONS
QUALITY & QUANTITY
EQUIPMENT
FUEL CONSUMPTION
FARMING
NUTRIENT MANAGEMENT
ISSUES
RISK MANAGEMENT
LABOR
SOIL QUALITY
CASH FLOW


Costs
Time
Conservation
Fuel
Labor
Double crop
Water/power
Soil
McGuire, 2011


CONSERVATION
TILLAGE
ADOPTION GROUP
Thursday, March 24, 2005
8:00 a.m.

Conservation Cropping Systems Workgroup

STRATEGIC PLAN
for the
INCREASED ADOPTION OF CONSERVATION CROPPING SYSTEMS
in the
CENTRAL VALLEY OF CALIFORNIA

What is the Conservation Tillage and Cropping Systems Workgroup?

Established in 1998, the Conservation Cropping Systems Workgroup is a diverse group of over 1500 farmer, University of California, California State University, USDA - NRCS, Resource Conservation District, public agency, private sector and environmental group members that have come together to promote conservation cropping systems in California.

Vision of the Conservation Tillage and Cropping Systems Workgroup

Our vision is to have farmers in California adopt resource-conserving and economically viable conservation farming systems. These systems contribute to greater production efficiencies, reduce negative environmental impacts, ease labor requirements, and result in more vibrant farm economies.

Mission

Our mission is to accelerate the adoption of conservation cropping systems by California farmers.

Goals of the Conservation Cropping Systems Workgroup are:

1. To increase the sustained adoption of conservation cropping systems to more than 50% of cropping acreage by the year 2028,

2. To develop and deliver information on the economic and environmental benefits of conservation cropping systems,

3. To partner with national and international conservation organizations and serve as a clearing house for information to promote conservation cropping systems, and

4. To increase funding for conservation cropping systems research, education, and adoption in California.

Fostering Social Behavior flyer.pdf - Adobe Acrobat Pro

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1 / 1 198% Find

fostering sustainable behavior

BEYOND BROCHURES

The cornerstone of sustainability is behavior change. Sustainability requires individuals and businesses to act (e.g., alter transportation choices, increase energy efficiency). To date, most programs to achieve these changes have relied upon disseminating information. Research demonstrates, however, that simply providing information has little or no effect on what people or businesses do. But if not ads, brochures or booklets, then what?

ABOUT THE PRESENTER

For over twenty years Dr. McKenzie-M
environmental psychologist, has been incorp
scientific knowledge of behavior change int
delivery of community programs. He is t
community-based social marketing -- a
delivering environmental behavioral ch
that is used throughout the world. He
training internationally for over 50,00
program planners. Below are several
anonymous evaluations:

Conservation Tillage Practices Survey
Winter 2011

Conservation tillage involves no-till, strip-till, or minimum tillage systems that reduce overall tillage passes by at least forty percent relative to your region's conventional tillage practices.

1. Are you a farmer? ☐ Yes ☐ No
   If you are not a farmer, what is your connection to farming? (equipment dealer, chemical sales, etc.) ____________________

2. Does your farm currently use conservation tillage? ☐ Yes ☐ No

3. Have you ever used conservation tillage? ☐ Yes ☐ No

4. How much do you know about Conservation Tillage? (1 = Nothing; 7 = A great deal)

   1 2 3 4 5 6 7

5. Whether you use conservation tillage or not, please respond to the following statements based on what you "believe" about conservation tillage. Please rate these statements on a seven-point scale, where "1" is strongly disagree and "7" is strongly agree.

	Strongly Disagree	→				Strongly Agree		Don't Know
Conservation tillage is too risky.	1	2	3	4	5	6	7	DK
Converting to conservation tillage requires too much new equipment.	1	2	3	4	5	6	7	DK
Conservation tillage requires too many changes in what I'm currently doing.	1	2	3	4	5	6	7	DK
There is not enough demonstrated and successful experience with conservation tillage in California.	1	2	3	4	5	6	7	DK
Conservation tillage requires too much equipment "know how" and attention.	1	2	3	4	5	6	7	DK
There is not enough technical information and support available for conservation tillage in California.	1	2	3	4	5	6	7	DK
Conservation tillage will not work in California soils where there are no freeze-thaw conditions like in the Midwest.	1	2	3	4	5	6	7	DK

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University of California

Conservation Tillage and Cropping Systems Workgroup

Home
About us
Mission and strategic plan
About CT in CA
UC Delivers
Research
CT innovators
Getting started with CT
Video library
Photo gallery
Partners
CT vendors
Comments and inquiries
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CT innovators

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Jim Couto - 2007

This year's CT Farmer Innovator Award recipient is Jim Couto.

Jim Couto

Jim is the owner and manager of Couto Farms, a diversified cotton, corn, alfalfa and wheat farming operation south of Kerman, CA in Fresno County. During the past several years, he has excelled in developing innovative conservation tillage approaches for his farm and has become a true leader in the entire arena of CT in California's Central Valley. He also has become an invaluable and outspoken authority on issues related to CT and has committed his time and energy to forwarding his views via a number of public vehicles. He is supremely deserving of our workgroup's high public honor.

Jim is one of the most tenacious and driven examples of CT innovation that California can boast. He singlehandedly invented and refined a custom "one-pass" cotton stalk management tool that is now widely recognized as providing considerable reduced pass potential for cotton producers. Jim has worked hand-in-hand with Bigham Brothers, Inc. in Lubbock, TX and their California distributors to develop a "California specific" minimum disturbance subsoiler, cotton root cutter, and bed reshaper implement that performs cotton stalk management in full compliance with CDFA requirements for Pink Bollworm Management. A video of this implement in action can be viewed at our CT Workgroup's website http://groups.ucanr.org/ucct/Video_Clips/.

Other sources of information:

The Conservation Tillage Workgroup:

http://ucanr.org/sites/ct/

Jeff Mitchell
(559) 303-9689

Global Trends in Temperate Cover Crops

Experience and Innovation in Agriculture

Outline

- Cover crop trends
  - R&D
  - Crop developments
- Biofumigation
  - What is it?
  - Benefits
  - Critical success factors

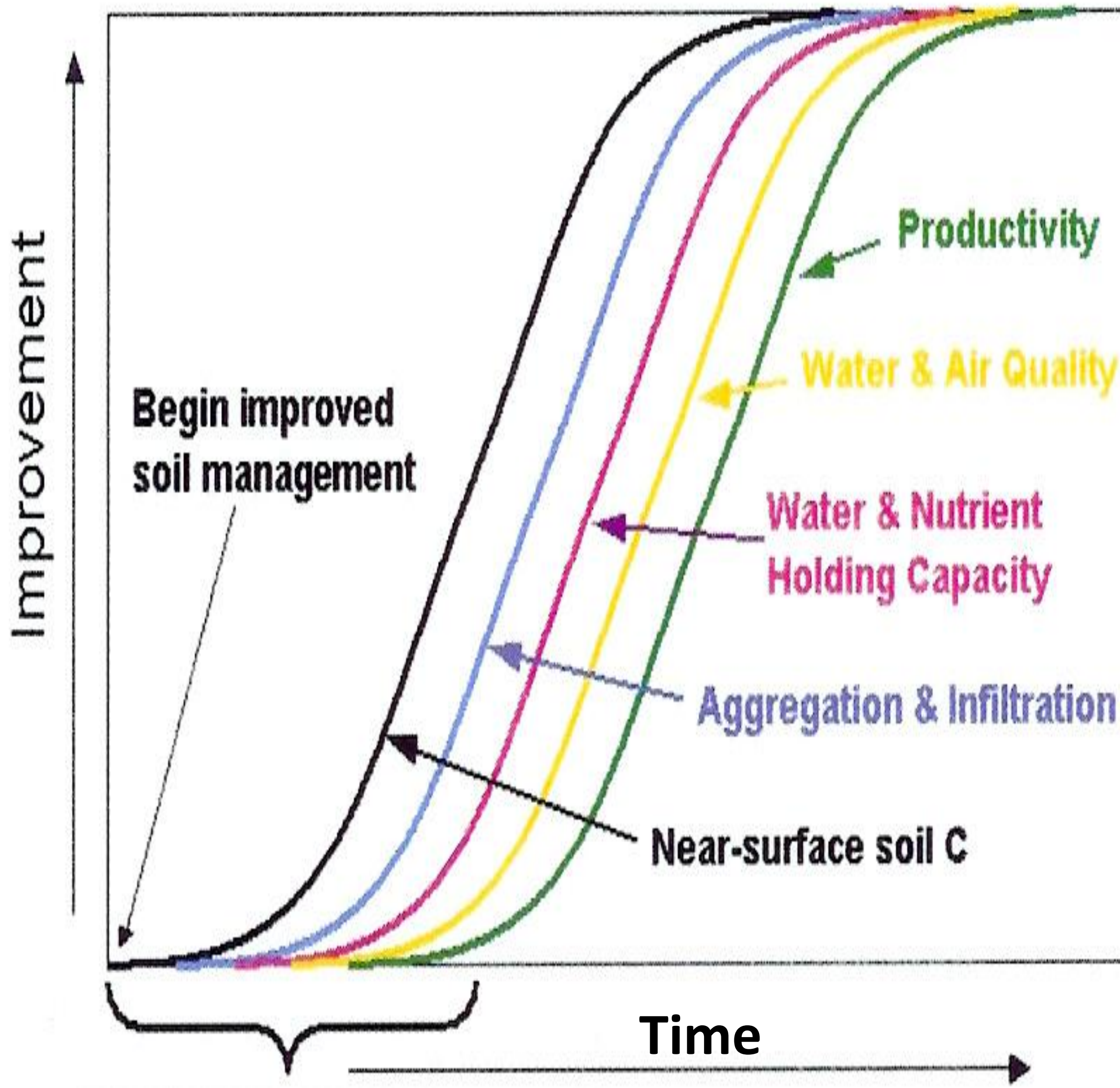
Cover Crop Trends

- Extensive R&D programs;
  - Plant breeding
  - Soil biology
  - Plant pathology
  - Nematology
  - Virus vector management
  - Agronomy
  - Biofumigation

Cover Crop Trends

- Cover crop developments;
  - Soil conditioners
  - Effective nematode control
  - Higher biomass yields
  - Plants with improved agronomic traits
  - Customised crop options available
  - New plant extract formulations

Cumulative Effects of Improved Soil Management



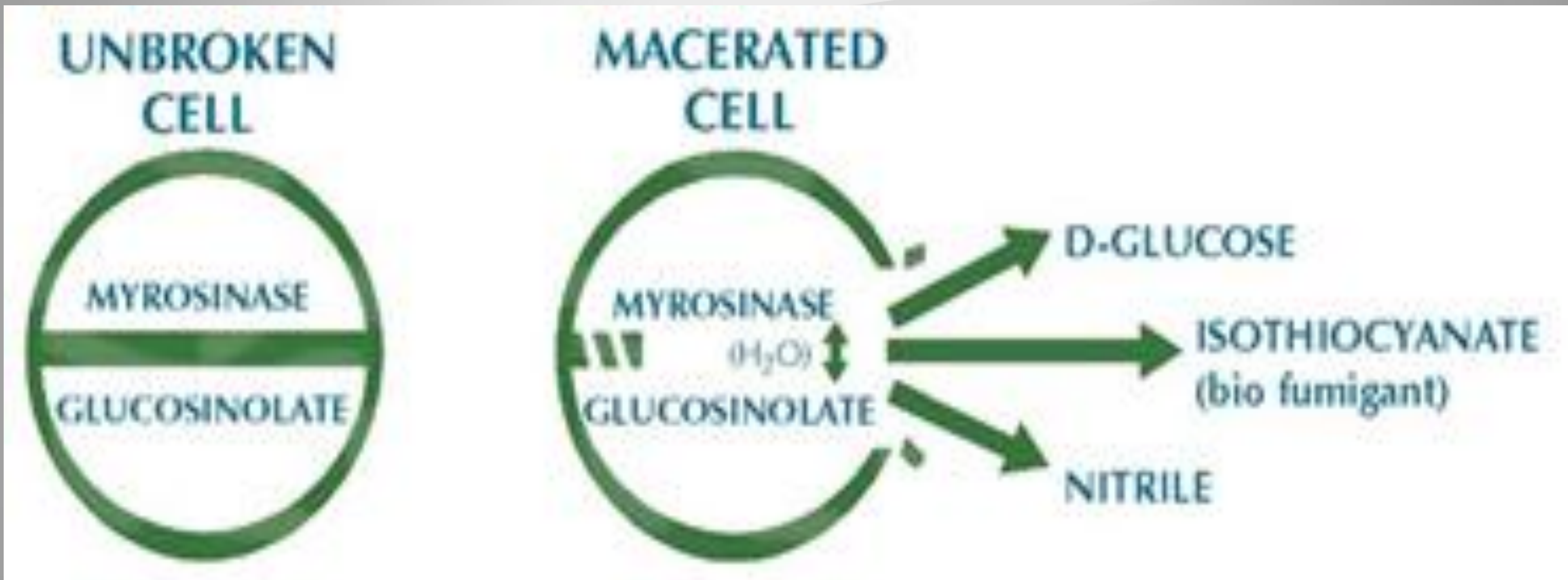
Biofumigation

Experience and Innovation in Agriculture

Biofumigation

- Brassica crops that produce naturally occurring chemical compounds that “sterilise” the soil
- Specific Glucosinulate compounds
- Significant soil health benefits if done correctly
- Pioneered in Australia (CSIRO, Dr Kirkegaard)

The Biofumigation Process

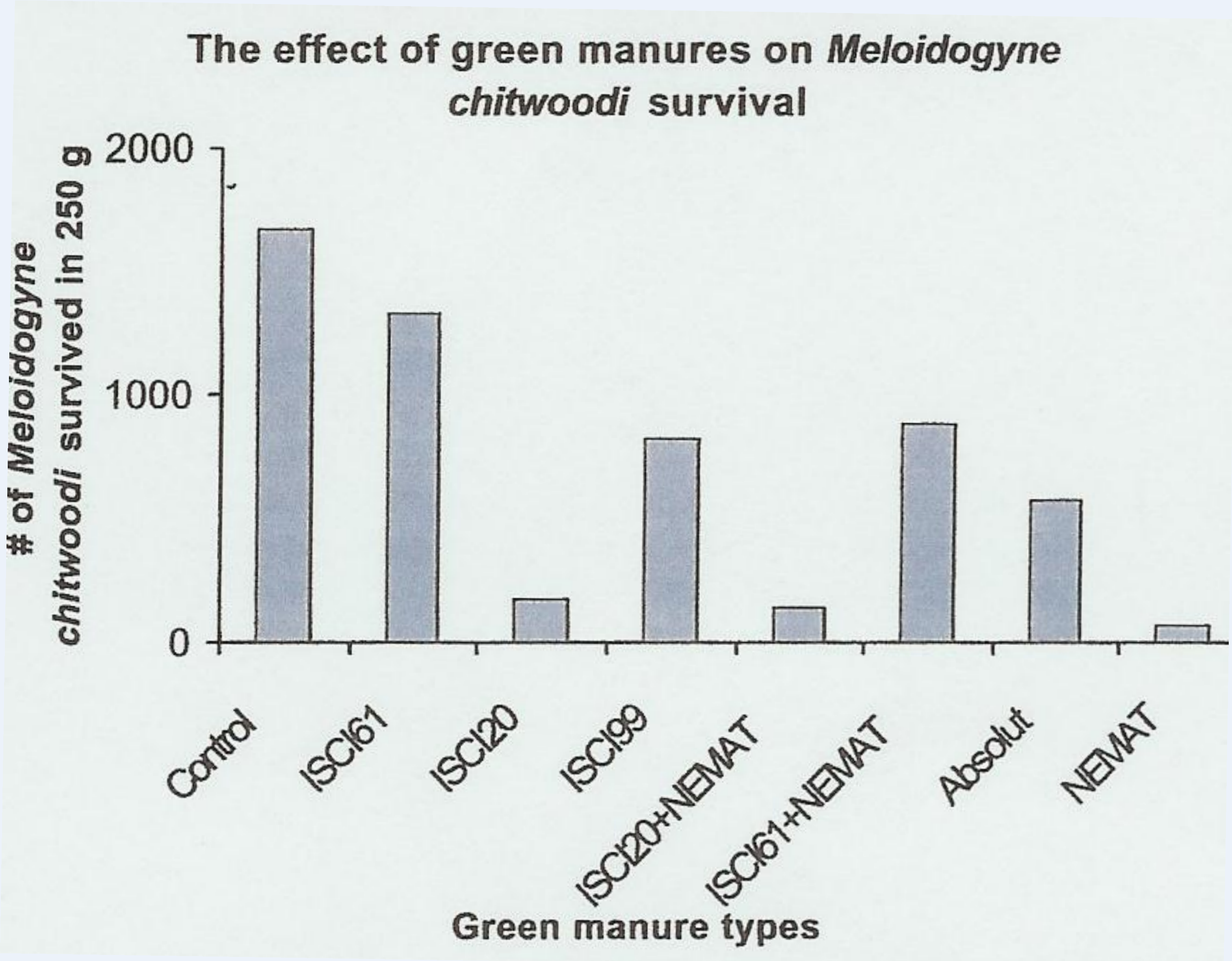


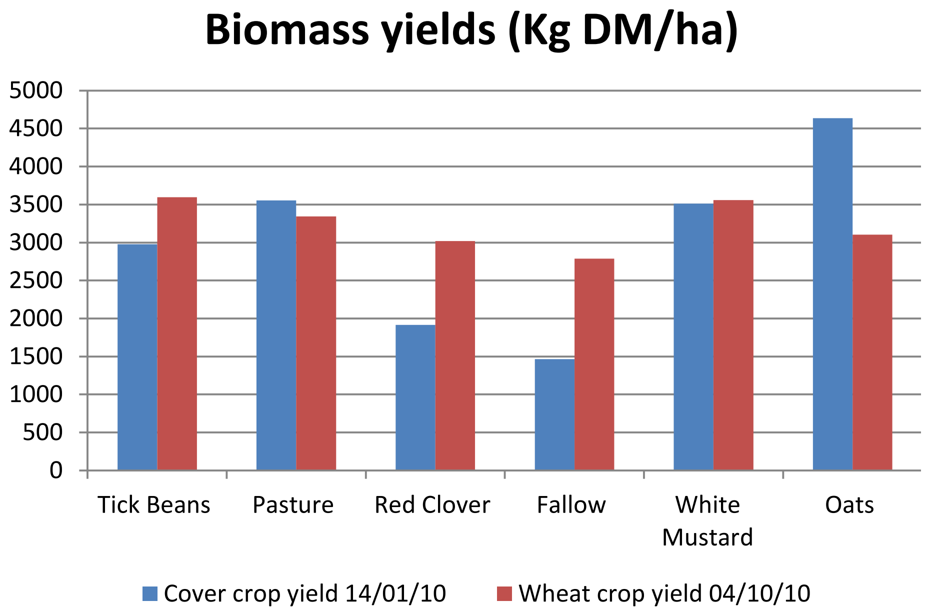
Biofumigation Benefits

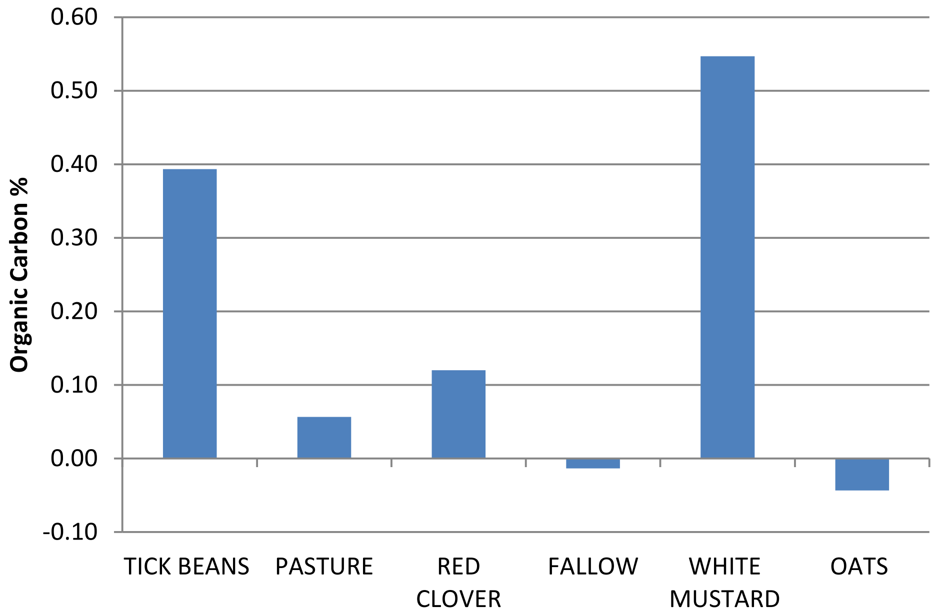
- Control of various soil borne diseases
  - *Rhizoctonia*, Scabs, Take All, *Fusarium* etc….
- Assists in the management of nematodes;
  - *Meloidogyne sp*., *Pratylenchus sp*. etc…
- Productive green manure crop
- Reduced reliance on farm inputs
  - Fungicides, nematicides, fertilisers

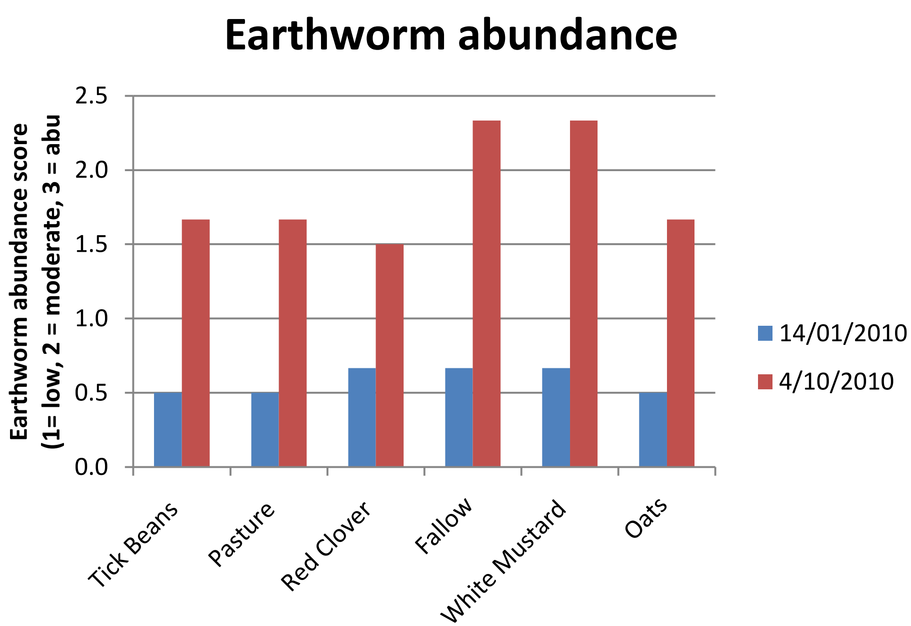
Sensitivity of some soilborne fungi to Thio-GL-DPs

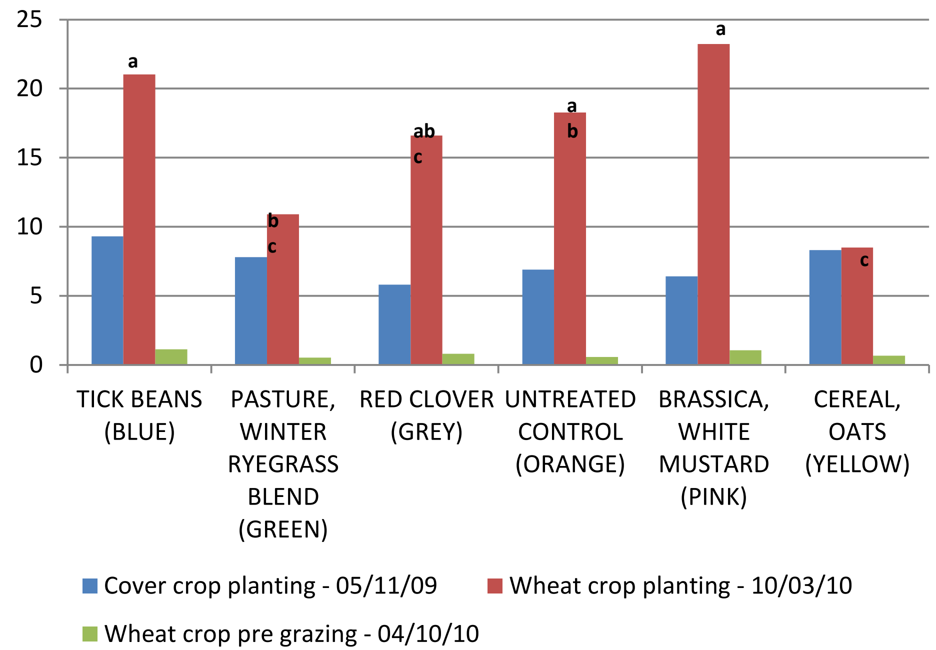
	IC_{50} (mM)	Sensitivity
Phytophthora cactorum *Phytophthora nicotiana* *Pythium irregulare* *Pythium ultimum*	0.005-0.05	High
Rhizoctonia solani *Sclerotium rolfsii*	0.05-0.1	Medium
Fusarium oxysporum *Verticillium dalhiae* *Sclerotinia sclerotiorum* *Pyrenochaeta lycopersici* *Trichoderma harzianum*	0.1-0.5	Low


The effect of green manures on *Meloidogyne chitwoodi* survival
of *Meloidogyne chitwoodi* survived in 250 g
2000
1000
0
Control
ISCI61
ISCI20
ISCI99
ISCI20+NEMAT
ISCI61+NEMAT
Absolut
NEMAT
Green manure types


Biomass yields (Kg DM/ha)
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
Tick Beans
Pasture
Red Clover
Fallow
White Mustard
Oats
Cover crop yield 14/01/10
Wheat crop yield 04/10/10


Organic Carbon %
0.60
0.50
0.40
0.30
0.20
0.10
0.00
-0.10
TICK BEANS
PASTURE
RED CLOVER
FALLOW
WHITE MUSTARD
OATS


Earthworm abundance
Earthworm abundance score (1= low, 2 = moderate, 3 = abu
2.5
2.0
1.5
1.0
0.5
0.0
Tick Beans
Pasture
Red Clover
Fallow
White Mustard
Oats
14/01/2010
4/10/2010


25
20
15
10
5
0
a
b c
ab c
a b
a
c
TICK BEANS (BLUE)
PASTURE, WINTER RYEGRASS BLEND (GREEN)
RED CLOVER (GREY)
UNTREATED CONTROL (ORANGE)
BRASSICA, WHITE MUSTARD (PINK)
CEREAL, OATS (YELLOW)
Cover crop planting - 05/11/09
Wheat crop planting - 10/03/10
Wheat crop pre grazing - 04/10/10

Biofumigation Success Factors

- Only use true Biofumigation crops
- Incorporate at early flower bud set (GS 8)
- Correct crop maceration and rapid incorporation
- Allow 2 weeks after incorporation before planting

Take Home Messages

- Plan ahead (crop rotations, planting window etc…)
- Adopt biofumigation if possible
- Treat cover & biofumigation crops as an integral component to horticultural production systems

Thank you

Cover Crops in Dry Tropics Vegetable Production

Partnering with Innovation II

Cowra

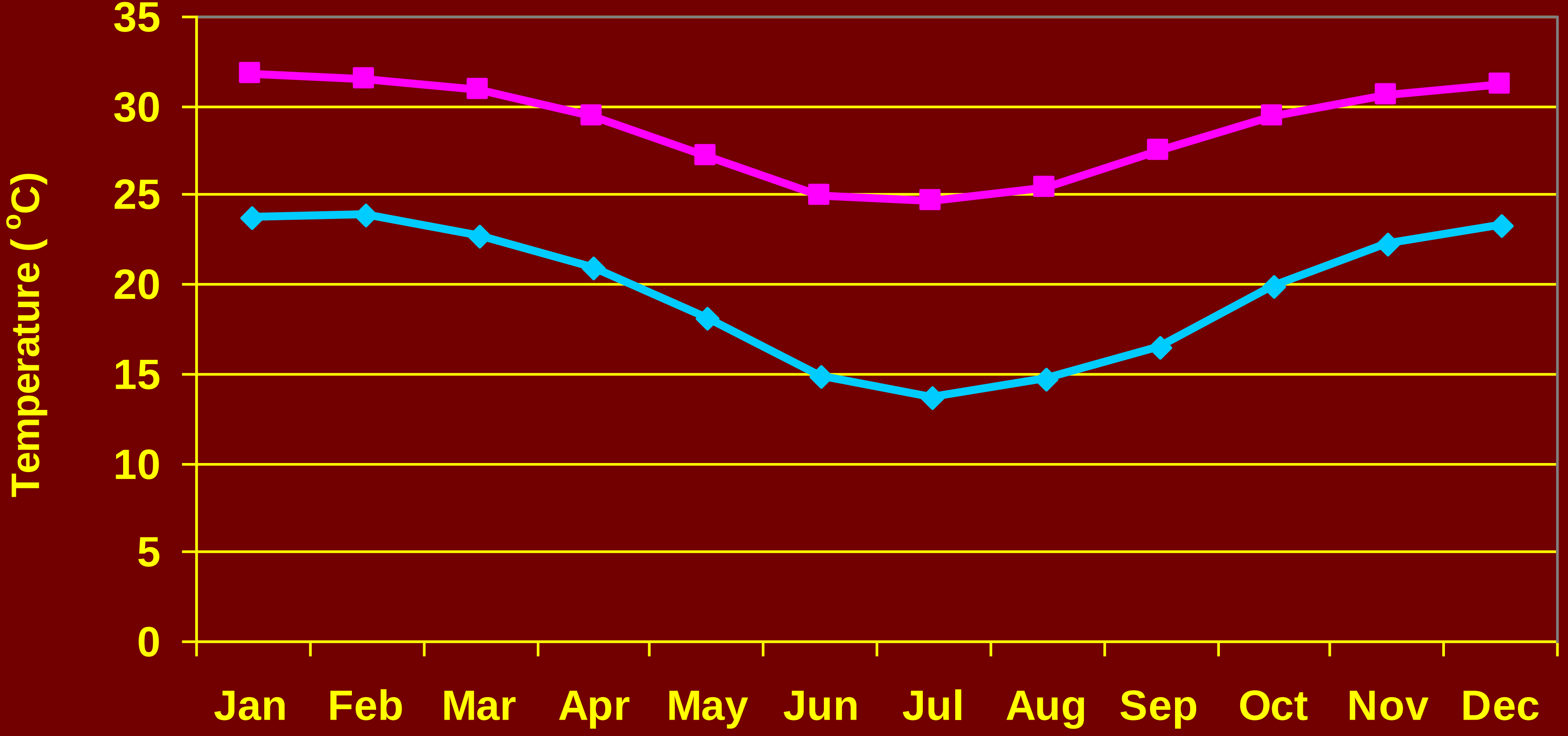
August 3, 2011

Chris Monsour

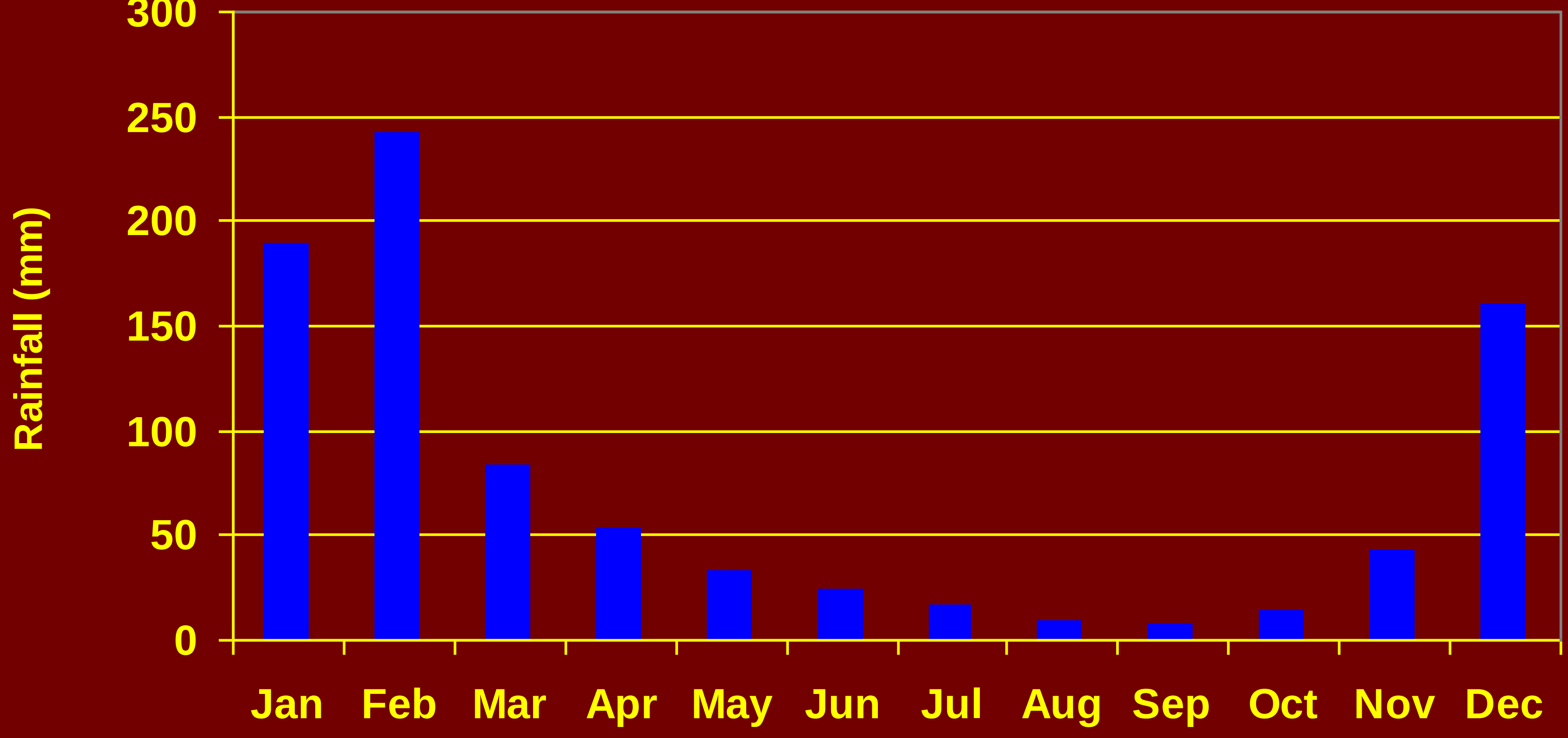
Prospect Agriculture Pty Ltd

The Dry Tropics of Queensland

Bowen's Climate



Bowen’s Rainfall



Dry Tropics Horticulture

- Premier winter production area for vegetables in Australia
  - Tomatoes – 78,000 tonnes worth $140 million
  - Capsicums
  - Melons
  - Sweet corn
  - Squash & zucchinis
  - Green beans
  - Mangoes

Emerging/Minor Crops

- Eggplant
- Table grapes
- Passionfruit
- Citrus (limes)
- Lychees
- Bananas

Soil Types

- Deep sandy soils
- Deltaic alluvials
- Red-brown earths
- Black earths
- Heavy clay soils

Organic Carbon

- Very low in organic carbon, particularly cultivated soils

- OC in Bowen sandy soils – 0.36 to 1.03%
- OC in Bowen clay soils - 0.76 to 1.36%

- Low till systems in the dry tropics
  - 1.55% in 8 year old system
  - 1.42% in 5 year old system
  - 1.40% in newly renovated low till site

Cover Crops in the Dry Tropics

- Green manure crops
- Mulches for permanent bed systems

Fallow Options

Bare fallow

•risk of erosion and the associated problems of offsite sediment, nutrient and pesticide movement

Weedy fallow

• potential to carry over insects and diseases to next season
• increase weed seed bank

Green Manure Crops

Legumes

• reduced reliance on chemical nitrogen fertiliser

• reduced ground exposure during periods of high rainfall and potential runoff

- Dolichos lablab
- Cowpea (Meringa)
- Soybean (Leichardt)

Green Manure Crops - Legumes

Soybeans

• more tolerant of wet soil conditions

• produce more organic matter

• fix more nitrogen than cowpea or lablab
• can provide a financial return through sale of grain

Cowpea and lablab

• more tolerant of high temperatures and low soil moisture than soybean

• provide better ground cover = better weed control

• provide more management flexibility

Green Manure Crops - Legumes

The best time to destroy a non-grain legume crop for maximum nitrogen and dry matter levels is when pods have formed but the seed is still immature.

Avoids unwanted germination that can occur if the seeds are left to mature.

Disc the crop in and leave it to decompose for a number of weeks.

Nitrogen contribution from legume crops

Legume crop	Fallow crop dry mass (t/ha)	N%	Total N contribution (kg N/ha)	N contribution if grain harvested (kg/ha)
Soybean	8	3.5	360	120
	6		270	90
	4		180	60
	2		90	30
Cowpea	8	2.8	290	100
	6		220	75
	4		145	50
	2		70	25
Lablab	8	2.3	240	80
	6		180	60
	4		120	40
	2		60	30

Green Manure Crops

French millet

- can struggle to compete with weeds in tropical conditions

Forage sorghum

- deep rooted
- high biomass
- outcompetes weeds
- suppresses diseases and nematodes

Green Manure Crops

Improve soil health:

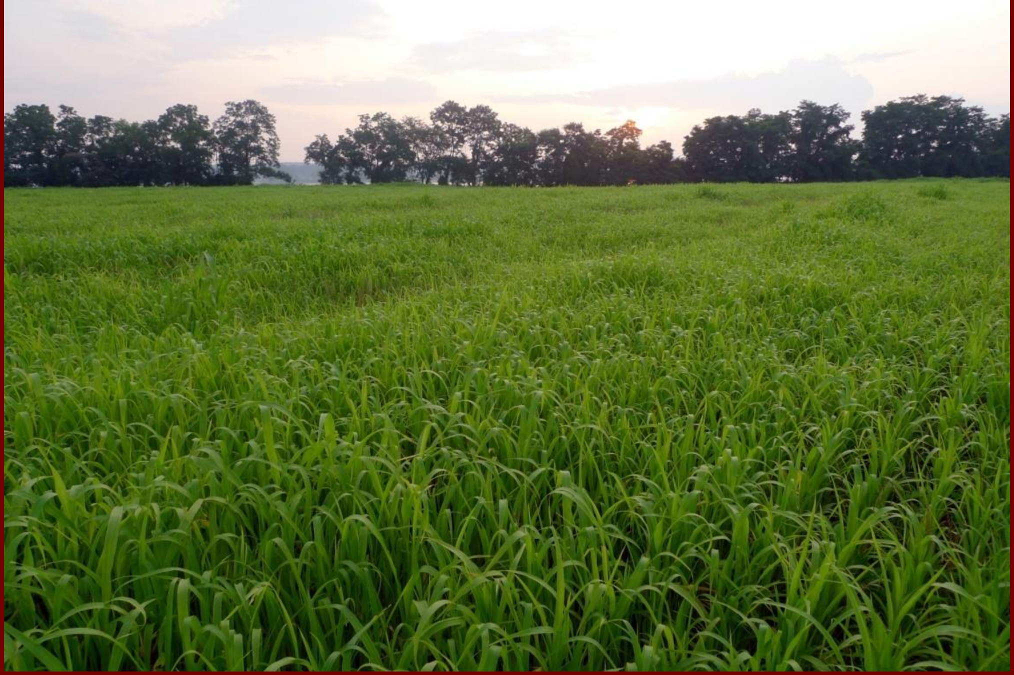
- Increase organic carbon levels
- Stimulate microbial activity

Cover Crops in the Dry Tropics

- Green manure crops
- Mulches for permanent bed systems

Desirable characteristics of cover crops

- Easily established
- Competes with weeds
- Readily killed
- Decomposes slowly
- Cost effective



Suitability of cover crops in dry tropics vegetable production

Cover crop	Establishment	Cover	Killing method	Mulch quality	Comments
Grasses					
Indian blue grass—Hatch	Good	Good	Spray	Good	Can be mowed; very high biomass
Indian blue grass—Keppel	Good	Good	Spray	Good	Expensive seed
Sorghum	Good	Good	Spray	Coarse	Cheap alternative, but coarse mulch
Shirohoe millet	Good	Early seed	Spray and roll	Good	Good winter cover crop
Rye grass	Good	Moderate	Spray and roll		Good winter cover crop
Japanese millet	Good	Early seed	Spray		Seeds too early for thick cover
Legumes					
Clovers	Poor	Poor	Spray	Poor	Poor competition with weeds
Centrosema	Slow	Good	Spray	Good	Excellent cover; hard to kill
Lucerne	Poor	Poor	Spray	No kill	Hard to kill
Verano stylo	Poor	Poor			Poor establishment
Sunn hemp	Good	Moderate	Spray and roll	Poor	Thin stalks, poor seed viability
Villosa mixes	Poor	Poor		Poor	Poor establishment
Biofumigants					
BQ mulch	Good	Good	Spray	Poor	Tissue too watery for good mulch
Rangi rape	Good	Good	Spray	Poor	Tissue too watery for good mulch
Brassica napus	Good	Good	Spray	Poor	Tissue too watery for good mulch
Fumus	Good	Early seed	Spray	Poor	Tissue too watery for good mulch
Mustards	Good	Early seed	Spray	Poor	Tissue too watery for good mulch

Source: Rogers (2001)

Lionel Williams – Euri Gold Farms

- Centrosema was the most effective cover crop for summer but was hard to kill

- Cereals (oats, rye) were effective in winter

- Also used Indian blue grass and forage sorghum

Cover crops are sprayed out with glyphosate, followed by rolling with a crimping roller within 7 days of herbicide application.

Lionel Williams – Euri Gold Farms

Cover crops are sprayed out with glyphosate, followed by rolling with a crimping roller within 7 days of herbicide application.

Lionel Williams – Euri Gold Farms

Transplanting seedlings into cover crop residue requires access to no-till transplanters, such as the Canadian manufactured RJV-600. Found to handle all conditions well, with the exception of wet mulch.

Lionel Williams – Euri Gold Farms

Paul LeFeuvre – Corrick Plains

- Developed a minimum tillage and mulch system for zucchini production

- Forage sorghum grown on permanent beds during summer, slashed regularly and killed with herbicide in autumn

- Produces a thick mulch that suppresses weeds and protects against the impact of heavy rain

- Zucchinis are transplanted through the mulch

Paul LeFeuvre – Corrick Plains

The minimum till production system:

- achieved OC levels well above 1% (high for this region and soil type)
- saves on inputs
- provides better management flexibility
- improves soil health

Limitations of cover crops on permanent beds

- Weed management
  - Need to control weeds in cover crop to prevent weeds seeding

- Soil temperature lower than plastic mulch
  - Lower than optimum 35% in Bowen winter
  - delayed harvest by up to 10 days

- Accumlation of salts in soil from ground water

THANK YOU

Some thoughts on Soil Carbon

– why it is important and how to keep it

Partnering with Innovation II

Cowra
August 4, 2011

Peter Aird, Serve-Ag
John McPhee, Tasmanian Institute of Agricultural Research

Soil Organic Carbon

Why focus on Soil Organic Carbon?

"The achievement of sustainable agriculture was 'let down' in the 20th Century when research focused strongly on soil chemical and physical factors and neglected biological factors".

Sherwood and Uphoff, 2000.

Soil Organic Carbon

Types of Soil Organic Carbon

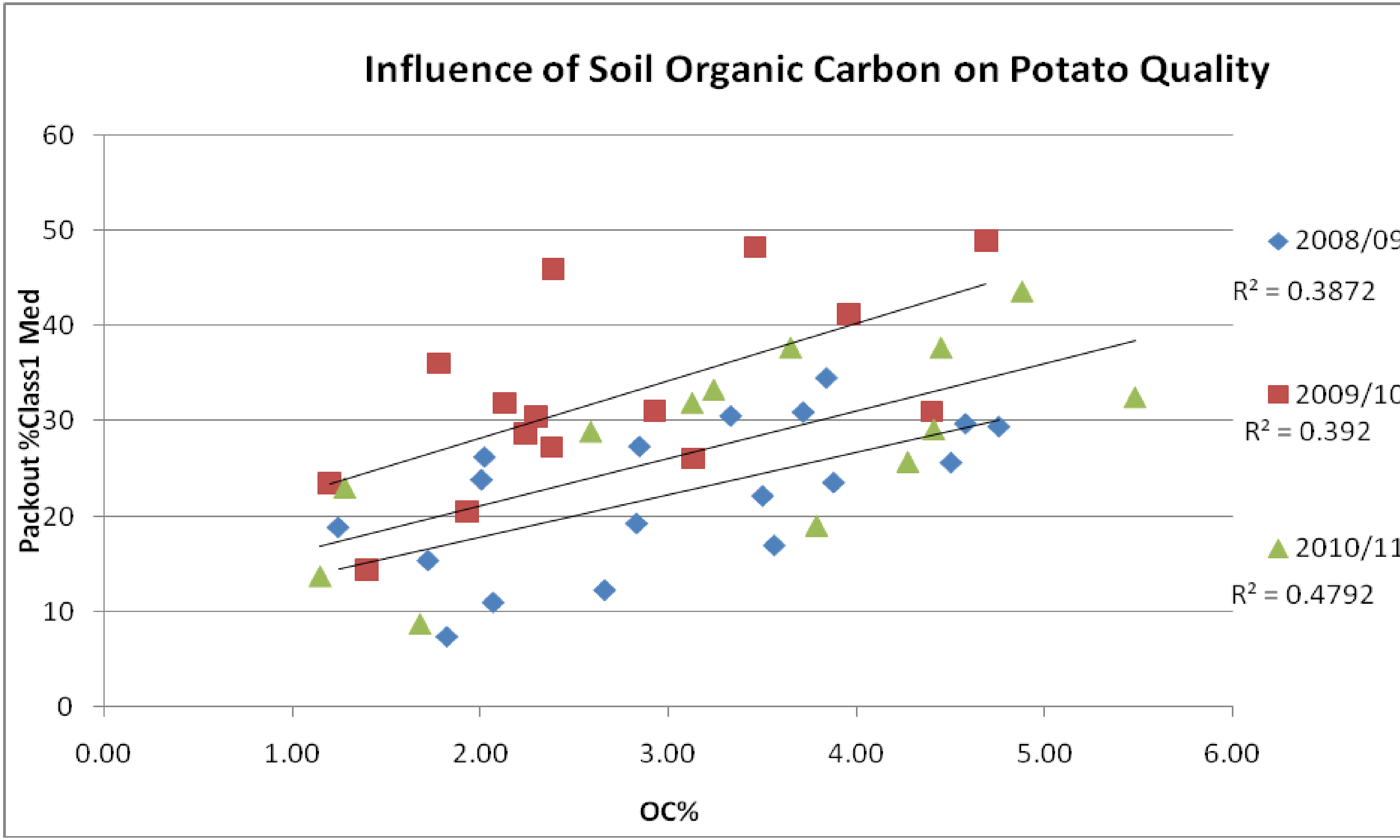
- **Crop residues** - *greater than 2mm in size*
- **Particulate Organic Carbon** - *plant material 0.053 - 2mm in size*
- **Humus** - u*sually the largest pool of organic carbon*
- **Recalcitrant Organic Carbon** - *usually charcoal*

Soil Organic Carbon

Why focus on Soil Organic Carbon?

- Improve drainage and soil water holding capacity
- Improve nutrient availability
- Suppress soil borne diseases
- Improve produce pack out

Soil Organic Carbon



Soil Organic Carbon

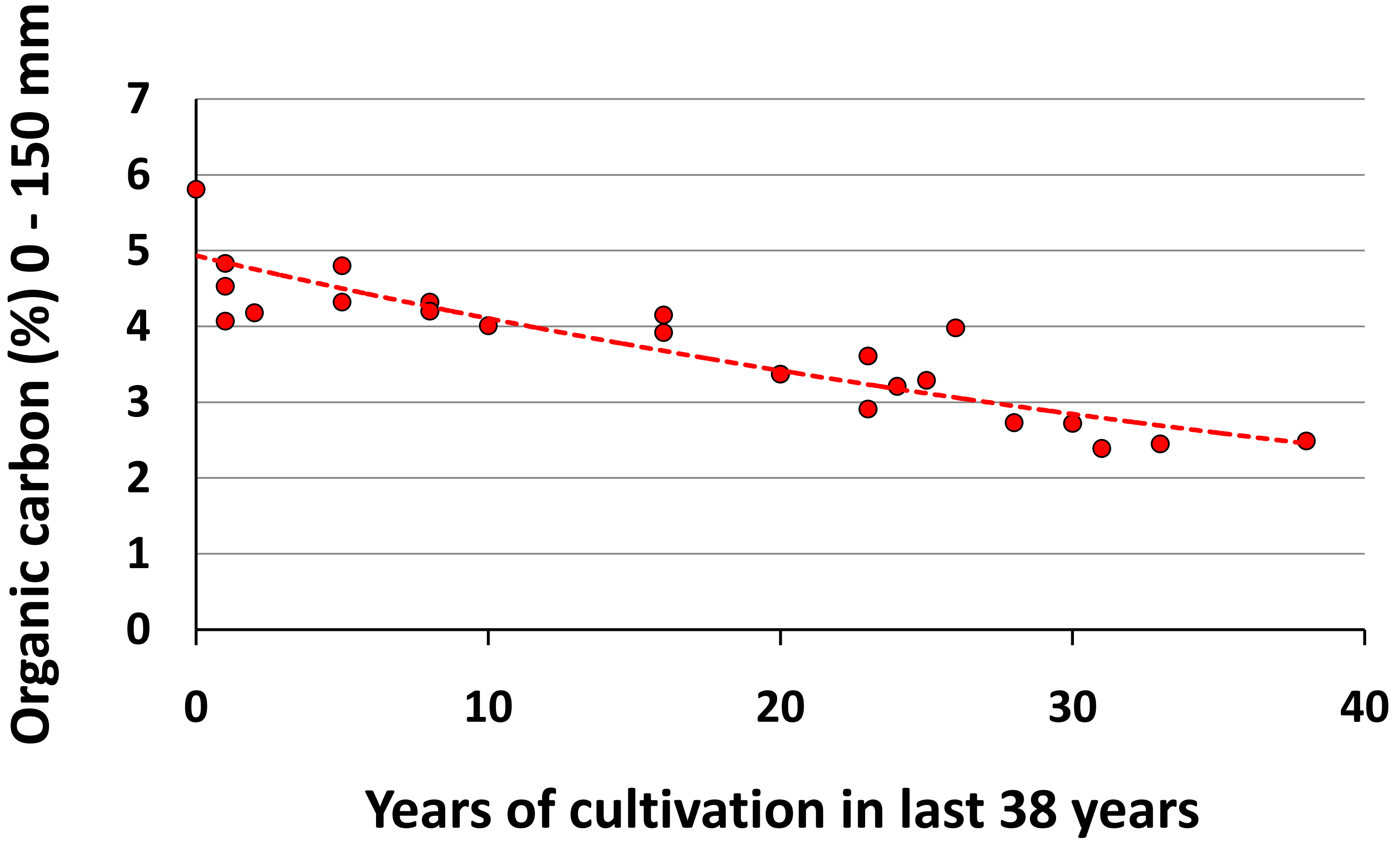
Major contributor to greenhouse gas emission

- UK study found a decline of 0.06% per year (1.5% over 25 years) contributed 8% of total industry greenhouse gas emissions

Decline in natural levels of Soil Organic Carbon

- Many examples of cropping soils with levels 10 times lower than natural levels

Soil Organic Carbon



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Soil Organic Carbon

Carbon content of Ferrosol topsoils in 2010

Continuously cropped paddocks	3.2%
Paddocks cropped 1-3 years in 5	4.0%
Pasture paddocks	4.8%

Soil Organic Carbon

Why have Soil Organic Carbon levels declined?

- Mouldboard plough
- Rotary implements
- Bare ground fallow

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Soil Organic Carbon

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Soil Organic Carbon

How much OC is in soils?

- OC level of 1.2%, bulk density of 1.2 g/cm³, depth 20 cm
  = 29 tonnes C/ha.

- **Less than 30%** of green matter incorporated
  ends up as Soil Organic Matter.

- **Approx 45%** of Organic Matter is C.

Soil Organic Carbon

How to increase Soil Organic Carbon levels

- To increase OC level by 0.1%, 10t of DM/ha is required.
- Incorporating green crops with a DM of 10 t/ha will take 10 years to increase OC levels by 1%

Soil Organic Carbon

What are the likely effects of the wet 2010 – 2011 season on Soil Organic Carbon levels?

- Anaerobic soils become bacteria dominant soils - accelerated Organic Carbon loss
- Soils will need aerating and active green matter to improve the balance
- Difficult to estimate time for soils to improve the balance between soil fungi and bacteria

Soil Organic Carbon

Take home messages:

- **Arrest the decline of OC levels**
- **Do not vigorously cultivate the soil**
- **Never leave the soil bare - always plant a green crop**

Tillage

- **A major contributor to soil OC decline**
- **Why do we till?**
  - **Compaction removal**
  - **Seedbed preparation**
  - **Crop residue management**
  - **Weed control**

Why do we have soil compaction?

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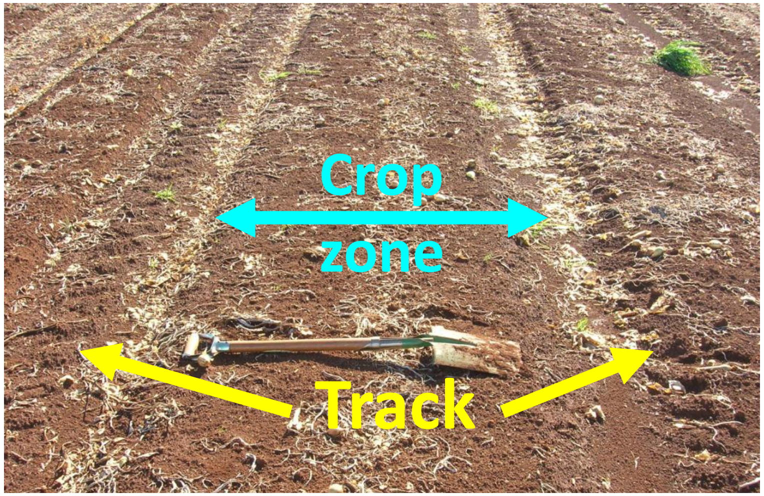
How can we reduce or avoid tillage?

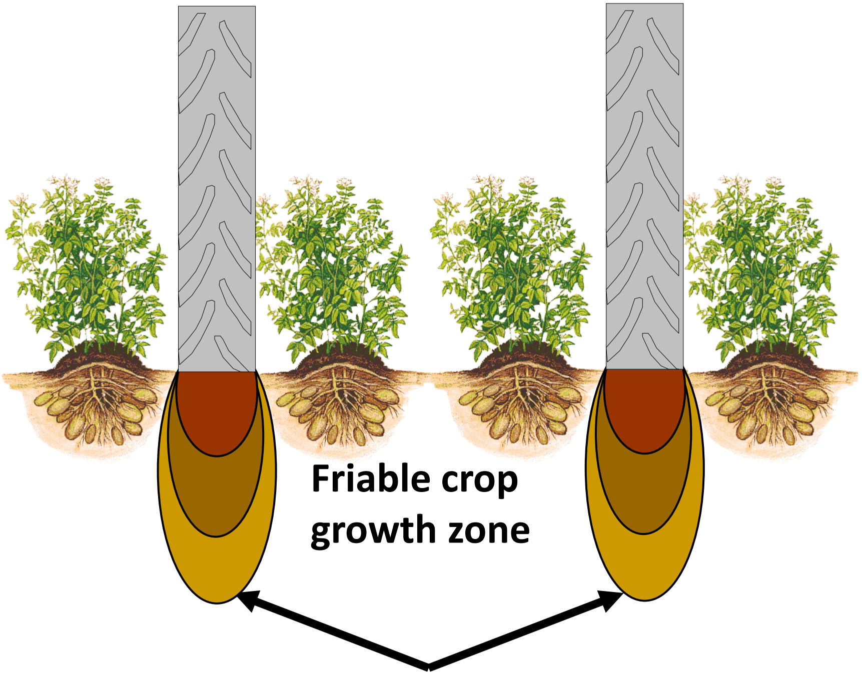
- **Better traffic management –** i.e. controlled traffic
- **Controlled traffic (permanent beds) reduces the need for tillage –** i.e. compaction removal is no longer a reason for tillage
- **Ultimate goal: control traffic to the minimum number and area of permanent wheel tracks –** i.e. maximise the area of soil with no wheel tracks

Controlled traffic - keeping all traffic in the same wheel tracks year after year

Plants grow better in soft soil

Wheels work better on roads





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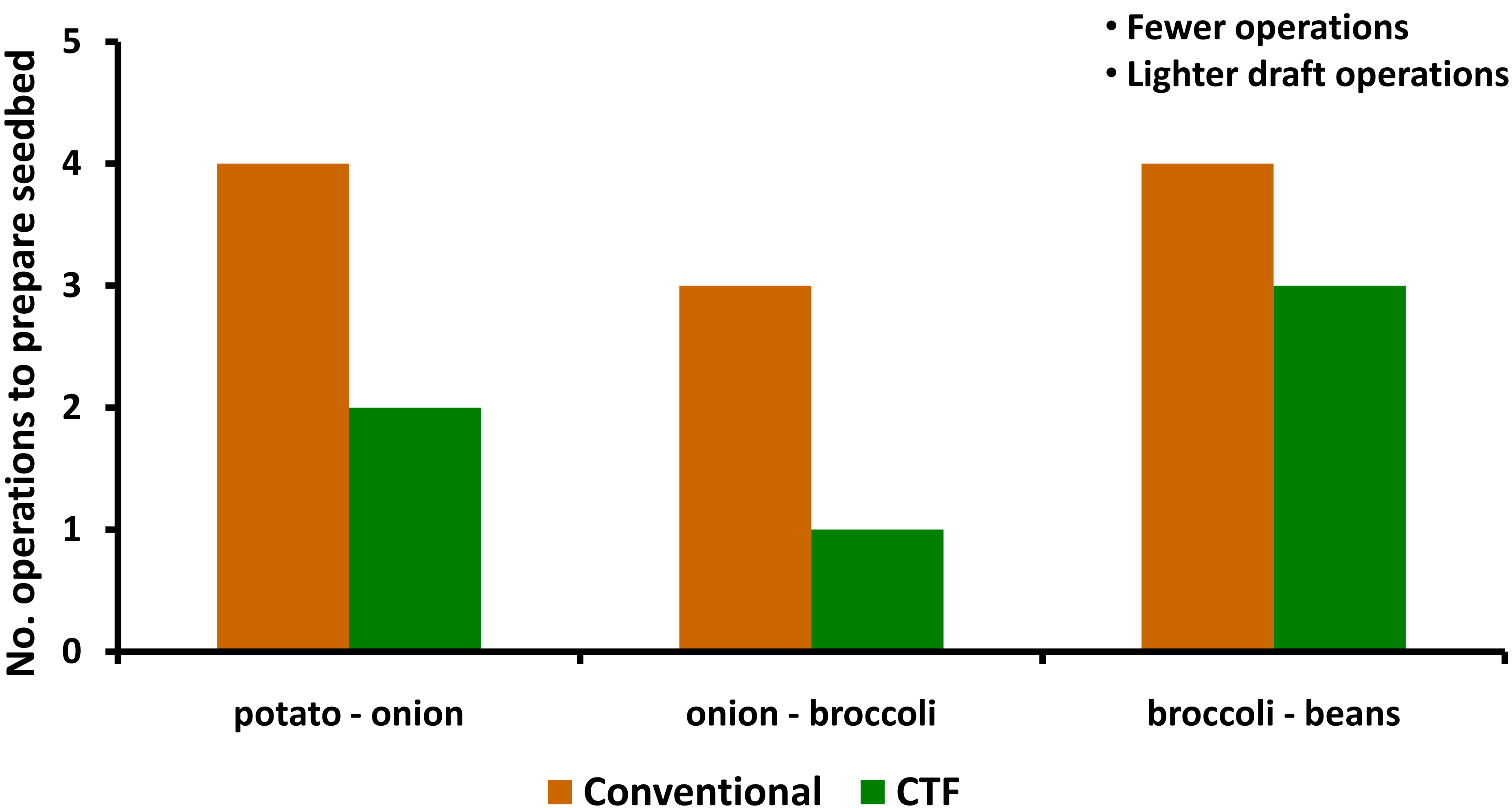
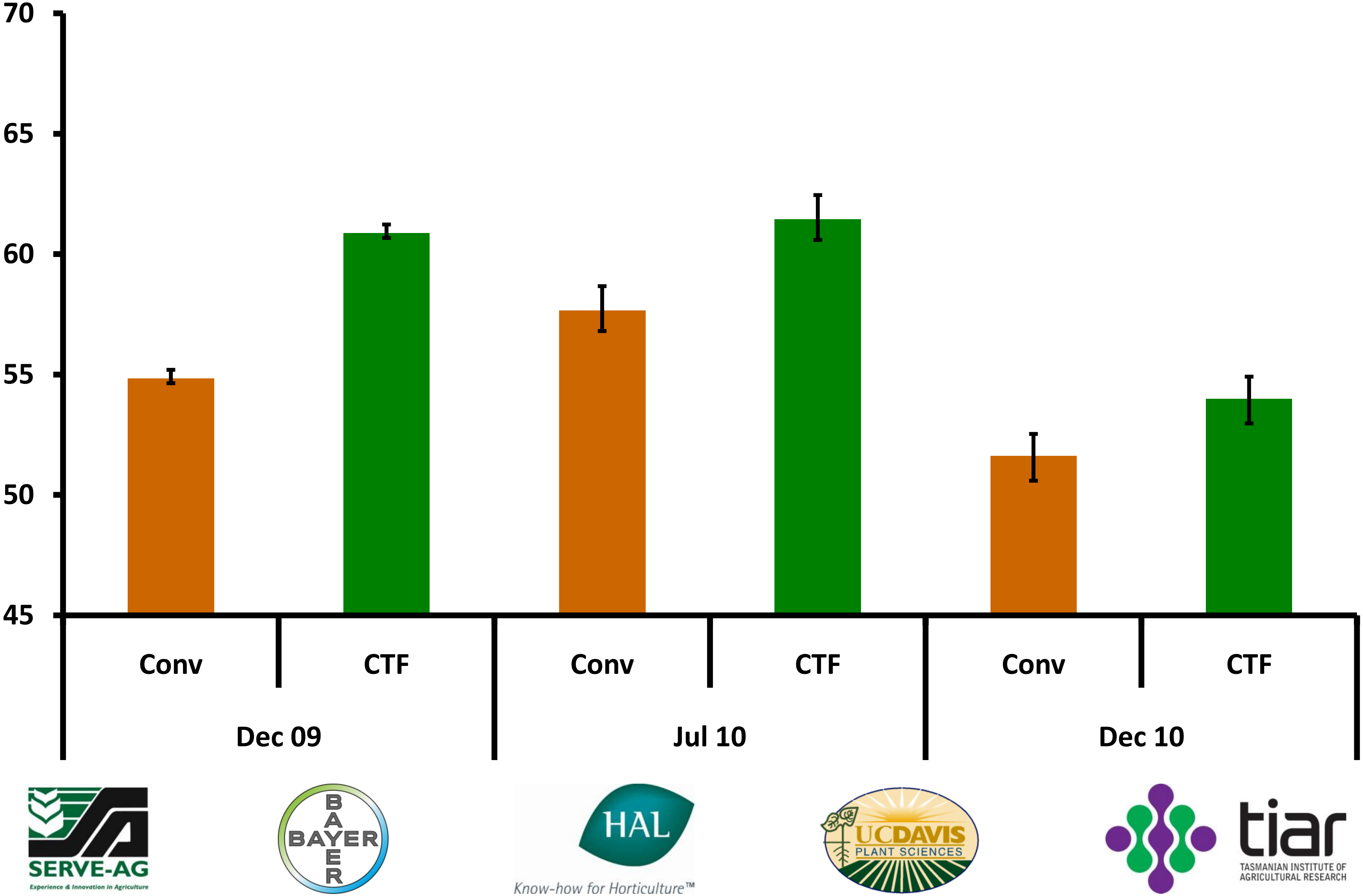
Benefits of controlled traffic

- **Lower energy use**
- **Improved soil structure**
- **Improved water use efficiency**
- **Improved yield**
- **Improved timeliness**
- **Improved economics**
- **Facilitates other farming techniques** – e.g. zero-till, strip tillage, inter-row drilling, relay cropping

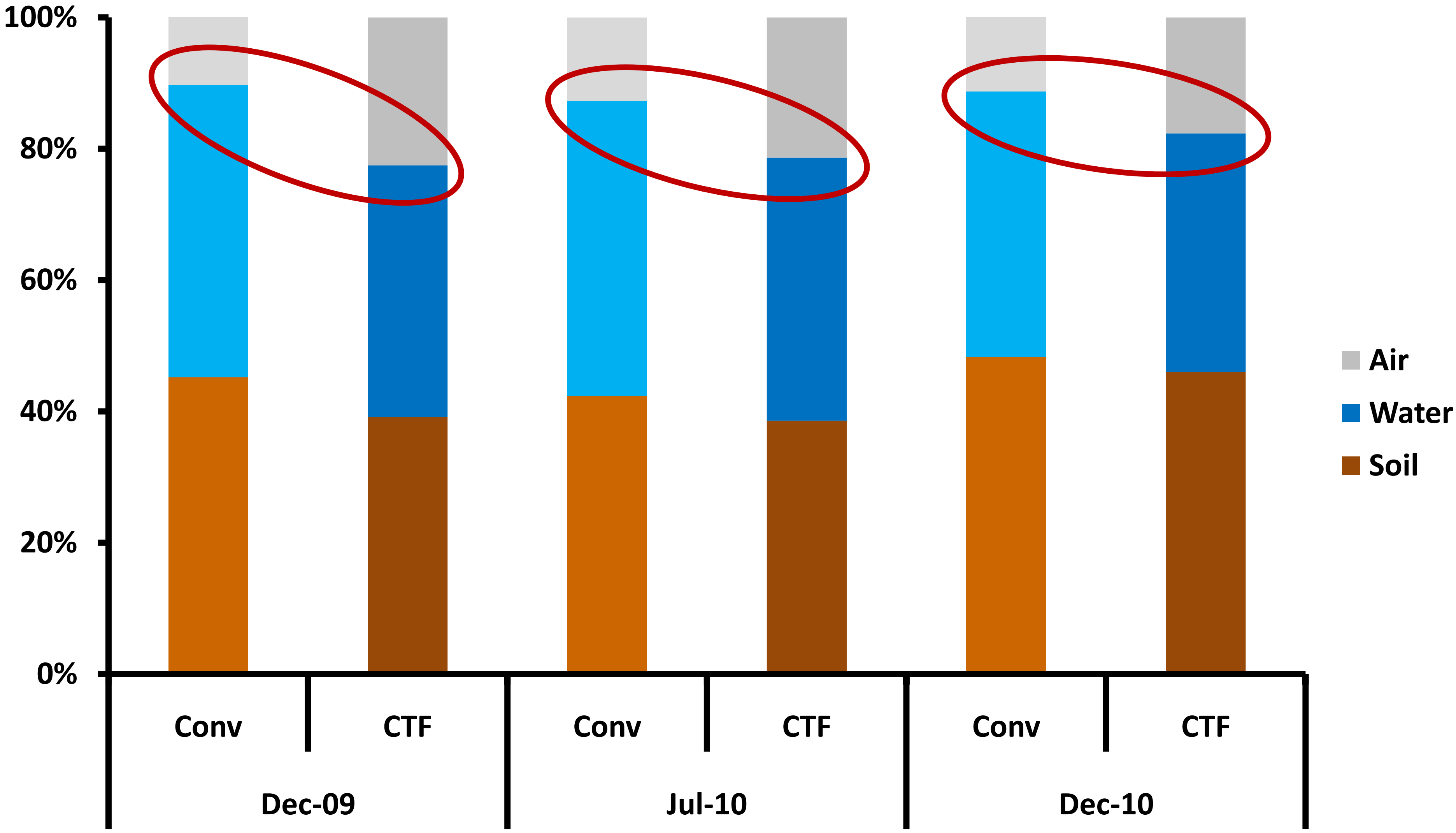
Reducing tillage through controlled traffic



Porosity (%) – 150 mm



Ratio of soil : water : air – 150 mm



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Impact of harvest traffic on infiltration

Conventional

Controlled traffic

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Infiltration test results (July 2010)

	Conventional	CTF
Duration of test (min)	30	90
Time to run-off (min)	4	not reached
Tillage operations prior to crop	Rip Rotary harrow Rotary harrow bed-form	Strategic rip Rotary harrow

Growing and retaining more ground cover

Controlled traffic presents opportunities for alternative residue and tillage management practices

Strip tillage

Inter-row sowing

Zero-till

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Summary

Soils managed using controlled traffic exhibit:

- Lower bulk density and higher porosity
- Better water:air ratio
- Greater infiltration and less run-off
- Reduced tillage requirements

which has the potential to:

- Improve plant growth and reduce soil borne disease
- Reduce erosion
- Improve soil water storage and drainage
- Retain more soil carbon