COG Practical Skills Handbooks

Organic Field Crop Handbook

Third edition

Brenda Frick
Laura Telford
Joanne Thiessen Martens

Janet Wallace
Editor

COG
Canadian Organic Growers
Cultivons Biologique Canada

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Canadian Organic Growers Inc.
Cultivons Biologique Canada Inc.
1145 Carling Ave, Suite 7519
Ottawa · Ontario · K1Z 7K4 · Canada
Tel.: 613-216-0741 888-375-7383 Fax: 613-236-0743
www.cog.ca

Production
Editor:
Janet Wallace
Writers:
Brenda Frick
Laura Telford
Joanne Thiessen Martens
Design and Layout:
Jean-Michel Komarnicki, JMK Image-ination
Cover photograph:
Laura Berman - GreenFuse Images.com
Golden Oats, Ontario.
Project Managers:
Ashley St Hilaire, Laura Telford

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Since COG's inception in 1975, changes in the organic sector have been dramatic. A movement then struggling to be noticed is now a multi-billion dollar industry with widespread consumer recognition and national standards backed by federal regulations and international equivalency arrangements.

COG has a significant positive impact on organic growing in Canada through its policy and communications work, educational outreach to farmers and consumers, production statistics, farmer training, market development, and the grassroots work of its chapters.

Organic agriculture:

- Produces food using energy-efficient methods.
- Increases soil organic matter and the diversity and number of living soil organisms.
- Improves water quality.
- Improves the health of soil, plants, animals, farm workers and consumers.
- Increases farm financial viability by reducing dependence on external inputs and by giving farmers a fairer return for their products.

COG is a federally registered charity (13014 0494 RR 0001). Members and supporters are farmers, gardeners, processors, retailers, researchers and consumers who share a vision of a sustainable bioregionally-based organic food system.

COG's mission is to lead local and national communities towards sustainable organic stewardship of land, food and fibre while respecting nature, upholding social justice and protecting natural resources.

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OUR NATURE IS ORGANIC

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Acknowledgments

The third edition of the Organic Field Crop Handbook is a testament to the evolution of organic farming in Canada and the progress of research and knowledge accumulated over years of field trials. From the first edition published in 1992 through to the third edition in 2016, this publication represents the efforts of hundreds of people. This important reference book would not exist without their work in the fields and in writing and reviewing the contents of this book.

On behalf of Canadian Organic Growers, our editor and writing team, we wish to extend our gratitude and appreciation to everyone who contributed to the most recent edition and to past editions. We apologize in advance to anyone whose name we have inadvertently missed from this list.

THIRD EDITION

Project Managers: Ashley St Hilaire, Laura Telford

Production Team: Nicole Chartrand (Proofreading), Michael Hutton (Proofreading), Jean-Michel Komarnicki (Layout and Design), Emily McTaggart (Proofreading), Kristine Swaren (Proofreading)

Editor and Writer:

Janet Wallace is a freelance writer, editor and organic grower with a M.Sc. in ecology. She writes magazine articles about farming, gardening, food and rural living. She also works and volunteers in rural community revitalization projects including school gardens, a community newsletter and the collection of local heirloom seeds. For a decade, Janet had an organic farm with sheep, goats, pigs and poultry. Now she grows vegetables, grain and pulses in her garden in New Brunswick, and saves seeds. Janet has edited several books for COG and was the editor of COG's magazine, *The Canadian Organic Grower,* for eleven years.

Writers:

Brenda Frick is a freelance organic specialist based in the Prairies. She is also an organic inspector, an avid community gardener, a K-12 substitute teacher, a *Western Producer* columnist and a partner in *Resilient Solutions Consulting.* She has a PhD in weed ecology and teaches an online organic weed-management course. She has worked with the organic community for more than 25 years, acting as a liaison between scientists and farmers, connecting organic research and experience.

Laura Telford has played a key role in the development of Canada's organic sector since 2003 when she became the director of Canadian Organic Growers. Laura has a Ph.D. in Psychology and has published numerous scientific articles. She now lives in rural Manitoba and works for Manitoba Agriculture as the organic sector development specialist where she enjoys working with the diverse organic agriculture community.

Joanne Thiessen Martens grew up on a mixed farm near Austin, Manitoba. She earned a B.Sc. in Agroecology at the University of Manitoba in 1999 and has since been working in the area of organic and ecological agriculture. For much of this time, Joanne has been part of the Natural Systems Agriculture research team at the University of Manitoba. She has also worked with organic market gardeners in Brazil and with the Organic Agriculture Centre of Canada. She lives in Winnipeg with her husband and two children.

Supporting Writers:

Janine Gibson, Amy Kremen, Hugh Martin, Gary Martens, Janet Wallace.

Contributors – Who provided information, photos, reviews, or other forms of assistance:

Chris Boettcher, Michelle Carkner, Linda Carlson, Nicole Chartrand, Ian Cushon, Loic Dewavrin, Martin Entz, Rochelle Eisen, Jeremiah Evans, Robert Goossen, Roger Henry, Michael Hutton, Nicolas Jobin, Anastasia Kubinec, Gary Lean, Anne Macey, Joanna MacKenzie, Larry Marshall, Jennifer McCombe, Alan McKenzie, Stuart McMillan, Ward Middleton, Aaron Mills, Kelly Monaghan, Larry Pollock, Pat Pollock, Cody Straza, Brian Unrau, Joanna White, Dwayne Woolhouse, Melisa Zapisocky.

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About this handbook

THIS HANDBOOK provides a road map to field crop producers who aspire to improve the environmental sustainability and profitability of their farming operations. It is intended for organic farmers as well as for producers who want to reduce their reliance on external inputs while improving knowledge of non-chemical weed management and natural methods to enhance soil fertility. Academics and extension workers will find these pages packed with the latest science (at the time of writing) and best management practices for organic field crop production. The handbook provides the theoretical foundation as well as practical production guidance for the cultivation of the key organic field crops grown in North America.

A lot has changed since the first edition of this handbook was published in 1992. In the early 90's, much of Canada's organic field crop production was based in Ontario and Quebec, as was much of the science and practical knowledge, scant though it was. This meant that the focus of early editions of the handbook was on the cropping systems, soils and climate of eastern Canada. Since then, organic field crop production in Canada has shifted dramatically; markets and acreage have expanded, the vast majority of organic field crop acreage has shifted westward to the Prairie region, and a greater variety of organic field crops are now grown. Along with the growing organic acreage, the sector is experiencing greater interest from agricultural researchers in studying the factors that contribute to successful organic field crop production and more relevant scientific research has been published.

Perhaps the most significant change is that organic field crop producers are no longer alone. In 1992 there were few successful organic producers with whom to share production information. There are now many organic field crop producers who have spent years fine tuning their crop rotations and who have learned how to successfully manage weeds and fertility in an organic system. Also, gone are the days when organic producers were embarrassed by weedy fields and ultra-low crop yields. Organic field crop producers across North America now proudly show off their fields to their neighbours (organic or not) and manage profitable farm enterprises. These producers, many of whom learned about organic agriculture the hard way through trial and error, have generously shared their knowledge with us, and, as with all of the handbooks published by Canadian Organic Growers, the pages of this handbook are imbued with this practical knowledge.

Although this handbook focuses on the principles and practical aspects of organic field crop production, there are references to the Canadian Organic Standards throughout. In Canada, Organic Standards consist of two documents: The General Principles and Management Standards (CAN/CGSB-32.310) and the Permitted Substances List (CAN/CGSB-32.311). These documents are referenced within the federal Organic Products Regulations and are thus a legal national standard of Canada. The Canadian Organic Standards are available electronically on the Canadian General Standards Board website [www.tpsgc-pwgsc.gc.ca], the Canadian Food Inspection Agency website [www.inspection.gc.ca] and on COG's website [www.cog.ca]. At the time of writing this book, Canada had signed equivalency arrangements with the United States (with critical variances), the European Union, Switzerland, Japan and Costa Rica, thereby harmonizing standards with its major trading partners. Equivalency does not mean that other standards are identical; only that their intent is similar.

This handbook is divided into five sections. Section One covers the principles upon which organic management practices are based, along with an overview of the organic certification process. Section Two focuses on soil management, Section Three covers weed and pest management, while Section Four is written to help producers to understand how to design an effective organic field crop rotation. Section Five provides practical tips for growing the key organic field crops of North America.

We hope that the information in this handbook will help producers across the continent to build more resilient, profitable and environmentally sustainable farm enterprises.

Section one

Principles and Certification

1 The foundations of organic agriculture

Organic farming is a holistic system based on the principles of health, ecology, fairness and care. The organic approach to agriculture goes beyond the avoidance of synthetic inputs and focuses on the sustainability of farming and food systems.

This handbook contains information on organic field crop production methods that can be used to create healthy and sustainable organic farm systems. The information is based on scientific research as well as the experience of farmers, and is guided by the general principles of organic agriculture and the specific requirements of the Canadian Organic Standards. The methods described are not meant to be recipes to be followed exactly, or a one-size-fits-all approach. Rather, farmers are encouraged to integrate the information contained in these pages with their own knowledge of local conditions and what works on their farms.

When building a healthy and sustainable organic farm system, it is helpful to know more than just the *methods* of organic farming. Knowing the general principles of organic agriculture, as well as the ecological principles on which organic farming is based, helps us to understand why we do things a certain way. A recognition of how organic agriculture contributes to environmental sustainability and where further improvements are needed helps us to continually improve our farming practices. Thinking of a farm as a whole system, with many interacting parts to be managed, also helps farmers plan and develop thriving and sustainable organic farms.

Principles of organic agriculture

Source: International Federation of Organic Agriculture Movements (IFOAM). www.ifoam.bio

PRINCIPLE OF HEALTH

Organic agriculture should sustain and enhance the health of soil, plants, animals, humans and the planet as one and indivisible.

This principle points out that the health of individuals and communities cannot be separated from the health of ecosystems – healthy soils produce healthy crops that foster the health of animals and people.

Health is the wholeness and integrity of living systems. It is not simply the absence of illness, but the maintenance of physical, mental, social and ecological well-being. Immunity, resilience and regeneration are key characteristics of health. The role of organic agriculture, whether in farming, processing, distribution, or consumption, is to sustain and enhance the health of ecosystems and organisms from the smallest in the soil to human beings. In particular, organic agriculture is intended to produce high quality, nutritious food that contributes to preventive health care and well-being. In view of this it should avoid the use of fertilizers, pesticides, animal drugs and food additives that may have adverse health effects.

PRINCIPLE OF ECOLOGY

Organic agriculture should be based on living ecological systems and cycles, work with them, emulate them and help sustain them.

This principle roots organic agriculture within living ecological systems. It states that production is to be based on ecological processes, and recycling. Nourishment and well-being are achieved through the ecology of the specific production environment. For example, in the case of crops this is the living soil; for animals it is the farm ecosystem; for fish and marine organisms, the aquatic environment.

Organic farming, pastoral and wild harvest systems should fit the cycles and ecological balances in nature. These cycles are universal but their operation is site-specific. Organic management must be adapted to local conditions, ecology, culture and scale. Inputs should be reduced by reuse, recycling and efficient management of materials and energy in order to maintain and improve environmental quality and conserve resources.

Organic agriculture should attain ecological balance through the design of farming systems, establishment of habitats and maintenance of genetic and agricultural diversity. Those who produce, process, trade, or consume organic products should protect and benefit the common environment including landscapes, climate, habitats, biodiversity, air and water.

PRINCIPLE OF FAIRNESS

Organic agriculture should build on relationships that ensure fairness with regard to the common environment and life opportunities.

Fairness is characterized by equity, respect, justice and stewardship of the shared world, both among people and in their relations to other living beings.

This principle emphasizes that those involved in organic agriculture should conduct human relationships in a manner that ensures fairness at all levels and to all parties – farmers, workers, processors, distributors, traders and consumers. Organic agriculture should provide everyone involved with a good quality of life, and contribute to food sovereignty and reduction of poverty. It aims to produce a sufficient supply of good quality food and other products.

This principle insists that animals should be provided with the conditions and opportunities of life that accord with their physiology, natural behavior and well-being.

Natural and environmental resources that are used for production and consumption should be managed in a way that is socially and ecologically just and should be held in trust for future generations. Fairness requires systems of production, distribution and trade that are open and equitable and account for real environmental and social costs.

PRINCIPLE OF CARE

Organic agriculture should be managed in a precautionary and responsible manner to protect the health and well-being of current and future generations and the environment.

Organic agriculture is a living and dynamic system that responds to internal and external demands and conditions. Practitioners of organic agriculture can enhance efficiency and increase productivity, but this should not be at the risk of jeopardizing health and well-being. Consequently, new technologies need to be assessed and existing methods reviewed. Given the incomplete understanding of ecosystems and agriculture, care must be taken.

This principle states that precaution and responsibility are the key concerns in management, development and technology choices in organic agriculture.

Science is necessary to ensure that organic agriculture is healthy, safe and ecologically sound. However, scientific knowledge alone is not sufficient. Practical experience, accumulated wisdom and traditional and indigenous knowledge offer valid solutions, tested by time.

Organic agriculture should prevent significant risks by adopting appropriate technologies and rejecting unpredictable ones, such as genetic engineering. Decisions should reflect the values and needs of all who might be affected, through transparent and participatory processes.

International Federation of Organic Agriculture Movements (IFOAM).

Ecological principles

Ecology is the relationship between living things and their environment. The ecological processes that occur in nature also occur on farms. As stated in the organic principles above, the goal of organic production is to work with and emulate natural ecosystems as much as possible. For this reason, organic field crop production requires a basic understanding of key ecological principles and processes.

Diversity

Diversity is the cornerstone of sustainability. High levels of diversity help to create systems that are resilient to both economic and environmental stress. Planting many different crops, maintaining natural areas and producing both crops and livestock are some ways to add and support diversity on organic farms.

Recycling

Nutrients and water move through ecosystems in cycles, and energy flows from the sun through all organisms carried by the carbon cycle. On organic farms, these cycles are closed as much as possible while still generating products for consumption off the farm. Nutrient cycling is promoted by growing legumes to fix nitrogen, maintaining high levels of soil biological fertility and integrating crops with livestock.

Soil building and natural plant nutrition

Healthy soil contains a large pool of soil organic matter and an active community of soil organisms. Organic matter is built up and maintained in the soil by adding plant material and composted manure, promoting root growth and minimizing tillage. Nutrients cycle through soil organic matter with help from soil life and become available to plants with minimal nutrient losses to the environment.

Natural weed, pest and disease management

Weeds, insects and plant diseases are naturally occurring parts of agroecosystems. On organic farms, pests are managed by using diverse rotations and other agronomic practices based on the knowledge of pest biology and by supporting natural biological controls. Mechanical methods such as tillage are used strategically when required.

Integration

In ecosystems, you can never just do one thing – a change in one part of the system affects all the other parts. On organic farms, connections between components, such as crops and livestock, are established and managed strategically so that synergies are created. Synergies are created when two or more components work together to produce benefits that are greater than the sum of their individual effects. For example, livestock grazing a legume green manure benefit from the high-quality forage (helping to earn money for the farmer) and, at the same time, cycle nutrients to the next crop in rotation.

Sustainable Agriculture: A whole-systems approach to food, feed, and fibre production that balances environmental soundness, social equity, and economic viability among all sectors of the public, including international and intergenerational peoples. Inherent in this definition is the idea that sustainability must be extended not only globally but indefinitely in time, and to all living organisms including humans.

Stephen Gliessman, www.agroecology.org

Environmental sustainability

Organic agriculture can promote environmental sustainability when it is based on sound ecological principles and adapted to local conditions. It is important to remember, however, that there is still much to learn about how various farming practices affect the environment. We must be willing to learn and adapt as our understanding of organic agriculture and the environment grows.

Biodiversity

In the farming landscape, organic farms are often hot spots of biodiversity, from the soil to the field to the hedgerow or shelterbelt. Even weeds help to support diverse populations of organisms both below and above ground. Not only do organic farmers create a more hospitable environment in crop fields by avoiding the use of synthetic pesticides, but they also create habitat for wildlife and other organisms through practices such as crop rotation, intercropping, conservation tillage and preservation of natural areas. This diversity lends stability and resilience to the farm system.

SOIL MANAGEMENT

Healthy soil is essential to the sustainability of an organic system. Soil health involves physical properties such as soil structure, chemical properties such as nutrient levels, and biological properties such as microbial diversity. Organic farming uses techniques that increase levels of soil organic matter and support abundant and diverse soil life. Organic farmers increase soil fertility without the use of synthetic fertilizers by using carefully designed crop rotations and applying compost. Avoiding highly soluble fertilizers and synthetic pesticides also supports soil life and allows nutrients to cycle naturally. Special attention to long-term soil fertility is required on organic farms to replace the nutrients that leave the farm in the forms of crops, hay, livestock and other products.

On organic farms, soil is protected from erosion by building soil organic matter, maintaining soil cover, and minimizing tillage as much as possible. Reducing tillage in organic systems remains an ongoing challenge that requires greater attention.

CLIMATE CHANGE, ENERGY UTILIZATION, AND GREENHOUSE GASES

Organic farming helps in the fight against global climate change. Greenhouse gas emissions are usually lower on organic farms than on conventional farms. In particular, nitrous oxide (N_2O) emissions are dramatically lower because synthetic nitrogen fertilizers are not used.

Energy use in organic field crop production is typically 30-50% lower per acre than in conventional production (Hoeppner et al., 2005; Pimentel et al., 2005; Zentner et al., 2011). This is mainly because synthetic fertilizers, which require large amounts of fossil fuels to manufacture, are not used. Even when adjusted for lower yields, organic crop production systems produce more crops per unit of non-renewable energy than do conventional systems. However, reducing non-renewable energy use even more should be a priority on organic farms. This could be achieved, in part, by using more perennial crops, reducing tillage, and integrating crops and livestock in innovative ways.

Lower energy use in organic production systems means that less carbon dioxide (CO_2) is emitted. In addition, CO_2 is removed from the atmosphere when soil organic matter is built up through planting of green manures, cover crops and perennial forages, as well as good crop productivity, conservation tillage and judicious use of livestock manure. High levels of soil organic matter, along with farm diversification and independence from external inputs, will also help organic farms adapt to the uncertainty caused by climate change (Scialabba and Müller-Lindenlauf, 2010).

WATER QUALITY AND QUANTITY

An abundant source of clean water is an essential part of a sustainable agriculture system.

Pollution of groundwater and surface water by nitrates, phosphates, pesticide residues, antibiotics and disease-causing bacteria is increasingly common in agricultural areas. In some areas, water supplies are threatened by excess use of water for irrigation and other purposes. Organic farmers help protect water supplies by avoiding practices that contribute to soil erosion and nutrient leaching and by using water judiciously and efficiently.

Use of legumes and other organic inputs for soil fertility, rather than synthetic fertilizers, maintains nutrients in more stable forms in the soil and reduces nutrient loss (Drinkwater and Snapp, 2007). Manure is stored carefully and preferably composted before being applied. Synthetic pesticides are not used on organic farms. Also, organic farmers help reduce the potential for soil erosion and nutrient leaching by using cover crops, leaving crop residue on the soil and designing crop rotations that keep the soil covered as much as possible.

WASTE MANAGEMENT

Organic farmers reduce waste by recycling many products. Manure, straw and other products that are often considered to be waste on other farms are valued as sources of nutrients and organic matter on organic farms. Screenings from organic grain are valued highly as a source of livestock feed. Plastic and non-biodegradable materials are avoided or recycled as much as possible.

PRODUCTIVITY

Productivity is an important aspect of environmental sustainability that is often overlooked. Organic systems do not aim to increase crop yield at all costs. However, a certain level of productivity is necessary – not only to produce food and other products and provide income for the farm, but also to support biological processes. Soil organisms need a steady supply of high-quality plant material so they can cycle nutrients and form soil organic matter. Organic crops that grow poorly because of lack of nutrients cannot provide the resources needed to support soil life, and may actually deplete soil organic matter (Bell et al., 2012; Liefeld, 2012). Healthy organic farms that harness the power of ecological processes, such as nutrient cycling, soil building, and predator-prey relationships, are both productive and environmentally sustainable (Halberg, 2012).

Creating a healthy and sustainable farm system

An organic farm is more than just a collection of products (e.g., crops, livestock) grown without the use of synthetic inputs. It's an ecosystem, which needs to be thought of as a whole system, with many interacting parts. Soil, crops, microbes, weeds, insects, and livestock affect each other through all sorts of ecological processes, many of which can be managed by the farmer. Wildlife, air and water are influenced by the farm as well.

The human element also needs to be considered in terms of human health, labour and relationships with neighbours, along with the market factors and farm finances.

Managing these components and their interactions is complex and may seem overwhelming! Developing a farm plan based on observation and adaptation will help clarify the interactions between farm components and find ways of managing them effectively. The plan rests on the principles of health, ecology, fairness and care.

Farm planning guidelines

Each farmer will have his or her own approach to farm planning, but it may be helpful to keep these guidelines in mind:

- Work with nature, rather than against it.
- Look for and promote synergies between farm components and practices.
- Discover and address the root cause of problems, rather than just treating the symptoms.
- Consider both short- and long-term effects of farm practices.
- Consider both small- and large-scale effects, including impacts beyond the borders of the farm.
- Strive to optimize various goals, rather than maximizing one at the expense of others.
- Remember that developing a healthy farm system is a process that takes time.

Appendices

Acronyms, abbreviations and conversion factors

Glossary

References

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Acronyms and abbreviations

Ca^{+2}	calcium
CB	certification body
CEC	cation exchange capacity
CO_2	carbon dioxide
C:N	carbon-to-nitrogen ratio
COG	Canadian Organic Growers
GE	genetically-engineered (equivalent to GMO)
GMO	genetically-modified organism (equivalent to GE)
K	potassium
K_2O	potash (a useable form of potassium)
N	nitrogen
NH_4^+	ammonium (a useable form of nitrogen)
NO_3^-	nitrate (a useable form of nitrogen)
OM	organic matter
P	phosphorus
P_2O_5	phosphate (a useable form of phosphorus)
ppm	parts per million
SOM	soil organic matter

Conversion factors

To convert From	To	Multiply by
Area		
hectares	acres	2.47
acres	hectares	0.405
sq feet	sq metres	0.093
sq metres	sq feet	10.8
sq yards	sq metres	0.836
sq metres	sq yards	1.20
Weight		
ounces	grams	28.3
grams	ounces	0.0353
pounds	kilograms	0.454
kilograms	pounds	2.20
tons	kilograms	1016
lb/ac	kg/ha	1.12
kg/ha	lb/ac	0.89
Length		
inches	centimetres	2.54
centimetres	inches	0.394
Temperature		
C (Celsius)	F (Farenheit)	(C x 1.8) + 32
F (Farenheit)	C (Celsius)	(F - 32) x $^5/_9$
Plant nutrients		
P	P_2O_5	2.29
P_2O_5	P	0.437
K	K_2O	1.2
K_2O	K	0.83

Glossary

Aerobic: a process that requires the presence of oxygen, or a condition in which oxygen is present.

Actinomycetes: type of bacterium with cells arranged in thread-like filaments. The bacteria help decompose organic matter and are responsible for giving healthy soil a sweet smell.

Aggregates: clumps or structures of soil produced by the interactions of soil life, organic matter and minerals.

Allelopathy: suppression of one plant species by another through secretion of phytotoxins. These chemical compounds are produced while the allelopathic crops are growing and/or decomposing.

Anaerobic: a process that does not require oxygen, or a condition in which oxygen is absent.

Anion: a negatively charged element or molecule (e.g., nitrate NO_3^-).

Arbuscular fungi: fungi in a symbiotic relationship with the roots of a host plant where carbon compounds from the plant are exchanged for nutrients absorbed from the soil by the fungi. The fungi live inside the plant roots; together, the roots and fungi are called mycorrhiza. Also known as AM and VAM.

Audit trail: documentation that allows tracking of a product from field to market.

Beneficial organism: a type of bird, insect or other organism which provides a useful function on the farm, such as pollinating crops or destroying pests.

Blind harrowing: harrowing a crop that has been seeded, but which has not yet emerged; also called pre-emergent tillage.

Break crop: crop (or green manure) used to break the life cycle of insect pests, weeds or disease.

Carbon-to-nitrogen ratio (C:N): the proportion of carbon to nitrogen by weight in organic matter.

Capillary action: action by which surface tension causes water to be drawn up a narrow channel or pore.

Catch crop: a cover crop planted to take up excess nutrients in the soil, thereby reducing nutrient leaching. The nutrients will be released when the catch crop is turned under.

Cation: a positively charged chemical element or molecule (e.g., calcium Ca^{+2}).

Cation exchange capacity (CEC): the capacity of the colloidal particles in a given soil to absorb positively charged ions; expressed in milliequivalents per 100 grams. The CEC quantifies the soil's ability to retain nutrients and to supply nutrients to plants.

Certification body: an organization that conducts organic certification.

Colloid: a mass of very fine particles having a high ratio of surface area to weight.

Corn heat unit (CHU): a term describing the amount of energy (from the sun) accumulated by a crop from planting to harvest date. Corn heat units are calculated using the daily maximum and minimum temperature for a certain area.

Cover crop: a crop (usually green manure) which covers soil and thereby reduces soil erosion.

Cultivation: to mechanically break up soil around growing crops to uproot weeds.

Denitrification: the conversion (by bacteria) of nitrate (NO_3) to nitrogen gas (NO_2), nitrous oxide (N_2O) and nitric oxide (NO). Denitrification occurs in anaerobic conditions (i.e., no oxygen) and results in a loss of nitrogen from the soil to the air.

Dockage: weed seeds, chaff, volunteer grains and other 'waste' material in a grain shipment; payment for grain is docked for this fraction.

Drilling: planting by a machine that places the seeds in rows at the required depth in the ground.

Ecology: the science that studies the interrelationships between living organisms and their environment.

Ecosystem: a community of organisms interacting with one another and the environment in which they live and with which they also interact.

Fertilizer: any material (organic or synthetic) added to the soil for the purpose of providing essential nutrients to the plants.

Fixation: the binding of a nutrient into a more stable form.

Friability: the tendency of the soil to crumble and maintain aggregation during tillage.

Frost-seeding: broadcasting seeds onto frozen ground in the spring before the last frost. The seeds are drawn into the soil by the freeze-thaw cycles.

Genetic engineering (GE): a breeding technique by which scientists change, or modify, plants or animals at the molecular level by inserting genes from other organisms, including those from different species or kingdoms.

Genetic modification (GM): see Genetic engineering

Genetically modified organism (GMO): see Genetic engineering

Green manure: a crop that is incorporated into the soil for the purpose of soil improvement, sometimes called a cover crop.

Hook stage: referring to pulses, when the stem is exposed and the cotyledons have not yet opened above the ground.

Horizontal resistance: a plant's ability to resist all strains of a specific disease or pest; the resistance is the effect of several traits.

Humus: the stable portion of soil organic matter resulting from the decomposition of plant, animal and microbial tissues.

Hydraulic conductivity: rate at which water drains through saturated soil.

Indeterminate growth: growth pattern in which the plants continue to grow after flowering has started.

Inoculant: spores of the desired strain of Rhizobia bacteria, applied to the legume seed when planted; or, any material of high microbial content added to the soil to stimulate biological activity.

Intercropping: planting different crops together in alternating rows, broadcast together or by overseeding one crop into an already established crop.

Leaching: downward movement through the soil of chemical substances (e.g., nutrients) dissolved in water.

Legume: a member of the plant family which includes clover, alfalfa, beans and peas, whose roots host nitrogen-fixing bacteria in a symbiotic relationship.

Macronutrient: a plant nutrient needed in substantial quantities; refers to nitrogen, phosphorus, sulphur, calcium, magnesium and potassium.

Metabolism: the sum of the biochemical processes of growth, maintenance and energy transformation carried out by a living organism.

Micronutrient: a plant nutrient needed in very small quantities including copper, zinc, iron, manganese, boron and molybdenum (also called trace elements).

Microorganisms: living organisms that are not easily seen by the naked eye, including bacteria, fungi, protozoa and viruses.

Mineralization: the release of soluble minerals and simple organic compounds from organic matter or rock particles by the action of enzymes and other substances produced by microorganisms.

Mucigel: a gelatinous substance surrounding the root, created by the root-soil-microbe complex.

Mycorrhizal association: a symbiotic relationship between mycorrhizal fungi and plant roots, in which soil phosphorus and other nutrients are made available to plants.

Nitrate (NO_3^-): a form of nitrogen which is readily available to plants.

Nitrogen cycle: the process by which nitrogen passes from a gaseous state, through living tissue in various organisms, and back into the atmosphere. Carbon and sulphur undergo similar cycles.

Nitrogen-fixation (N-fixation): the conversion of nitrogen gas to a useable form of nitrogen; this is accomplished by strains of bacteria (Rhizobia) living in the nodules of legumes.

Nodules: growths on the roots of legumes where N-fixation occurs.

Nurse crop: a cover crop planted to control weeds while another crop is becoming established (e.g., oats are often used as a nurse crop for clover).

Nutrient cycling: nutrients being continually recycled through the ecosystem; from the soil into the plants and animals and then returned to the soil by the decomposition of organic matter.

Organic matter: the living bodies, remains and waste products of living organisms. Organic matter includes the living organisms, active organic matter and humus.

Overseeding: planting seed into an existing crop or into a field that has just been planted (e.g., clover into cereal stands). Also called underseeding.

Pathogen: an organism (e.g., virus, fungus or bacterium) capable of causing disease in other living organisms.

pH: the concentration of hydrogen ions in a solution that determines its level of acidity or alkalinity. A pH of 7 is neutral; lower numbers indicate acid and higher numbers alkaline conditions.

Photosynthesis: synthesis of organic compounds from water and carbon dioxide using energy from sunlight absorbed by chlorophyll in green plants.

Phytotoxin: a substance toxic to plants, which may be produced by other plants (e.g., allelopathic compounds), by humans (e.g., herbicides) or by other processes.

Plowdown: incorporation into the soil of a green manure crop or the green manure crop itself. The term is still used although the plow is no longer considered the appropriate tool to use.

Resistance: ability of an organism to remain healthy after being infected by a pathogen.

Rhizobia: nitrogen-fixing bacteria that live in symbiosis with legumes and fix nitrogen.

Rhizome: a long underground stem, usually growing horizontally, that can produce new shoots and roots along the length (e.g., as found in quackgrass and Canada thistle).

Rhizosphere: the area immediately surrounding plant roots where the highest level of soil biological activity exists.

Ridge tillage: a form of tillage in which soil is formed into flat ridges and seeds are planted into the ridges. Ridge tillage protects the soil because the area between rows is not cultivated during planting.

Rogue: to remove certain individual plants from a field, often diseased plants, while scouting the field.

Scouting: inspecting the field for problems (e.g., diseased plants, weeds or pests) and then roguing.

Small grains: crops with small kernels including wheat, oats, barley and rye.

Smother crops: crops, usually green manures, with dense, rapid growth which effectively shade out weeds.

Soil amendment: any material added to the soil to enhance soil biological activity.

Stover: mature, dry stalks and leaves of corn plants after the ears have been harvested.

Strip cropping: a method of contour planting which results in alternating strips of crops across the slopes of fields.

Swathing: mowing or cutting the crop that is then left to dry on the ground.

Symbiosis: a mutually-beneficial relationship between two living organisms, such as plant roots and Rhizobia.

Texture: the relative proportions of silt, sand and clay in a soil.

Tillage: mechanical disturbance of the soil to prepare the seedbed, control weeds, incorporate soil amendments and loosen the soil.

Tiller: side shoot (of cereal crop) arising at ground level.

Tilth: the physical quality or condition of soil, similar to the health of a living organism. Used by farmers to describe how easy it is to till the soil.

Transpiration: loss of water vapour from plants mainly through stomata (pores) in the leaves.

Underseeding: planting seed into an existing crop or into a field that has just been planted (e.g., clover into cereal stands). Also called overseeding.

Vesicular arbuscular mycorrhiza (VAM): See Arbuscular fungi and Mycorrhizal association.

Volunteers: individual crop plants that are growing in unexpected places. Volunteers can result from a crop setting seed in the previous year, from seed remained dormant during the year it was planted, or from sowing seed contaminated with seed from other crops.

Windrow: a long row in which mown hay or crop is laid, before being made into bales or picked up by the combine (i.e., a row to be dried by the wind). Also used to describe the way in which compost piles can be laid out.

Winter annual: a crop which begins growing in the fall, lies dormant over the winter and flowers the following the spring.

Winter cereal (winter grain): a grain that is planted and grows in the fall and is harvested the following summer.

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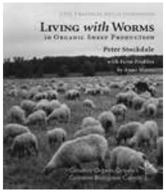

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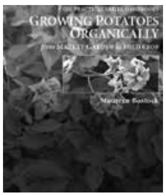
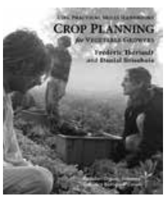
Written by Peter Stockdale, a sheep farmer and retired parasitologist,
this books guides you through raising sheep without chemicals.



GROWING POTATOES ORGANICALLY
***from* MARKET GARDEN *to* FIELD CROP**

Farmer Maureen Bostock addresses one of the most heavily pesticide-dependent field crops - potatoes.

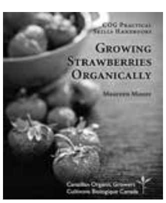


CROP PLANNING
***for* ORGANIC VEGETABLE GROWERS**

Authors Frédéric Thériault and Daniel Brisebois share their 11-step process for making money from a market garden (with templates and real life success stories).

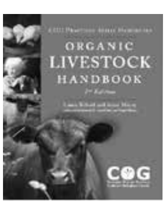
RECORD KEEPING
***for* ORGANIC GROWERS**

Making less work of paperwork is the mission of authors Kristine Swaren and Rowena Hopkins. Filled with examples, templates and practical advice.



GROWING STRAWBERRIES ORGANICALLY

Author Maureen Moore takes you through the process of growing strawberries without chemicals - from preparing the seed bed to harvest.



ORGANIC LIVESTOCK HANDBOOK, 2ND EDITION

Authors Laura Telford and Anne Macey have produced a fully revised, second edition to reflect the Canadian Organic Standards and latest research. Includes details on organic production, transition, and farmer interviews.

COG Practical Skills Handbooks

Organic Field Crop Handbook *Third edition*

GREAT YIELDS, HIGH-QUALITY CROPS AND ENVIRONMENTAL SUSTAINABILITY

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The trusted and highly regarded *Organic Field Crop Handbook* is an essential and invaluable reference that won't get dusty on your bookshelf.

"On our organic, family farm we've learned that our greatest resource is healthy soil. The *Organic Field Crop Handbook* is used regularly for principles of crop rotation, planting methods, and soil management and therefore has been a necessary reference to attain the ultimate goal of growing healthy food for families in western Canada."
David and Valerie Witzaney, New Life Organic Foods

"There are few 'must-have' books for the organic farm library and this is one. You turn to it countless times whether to check seeding rates or row spacing, or when you are thinking about implementing an innovative technique. More than just a practical manual, the *Organic Field Crop Handbook* weaves the integrity, the intent and the principles behind what makes organic farming so necessary for our collective food future."
Av Singh, PhD, PAg, Organic Extension Specialist

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