SMALL-SCALE GARDENING TECHNOLOGY
at the Kerr Center’s Cannon Horticulture Project

By George Kuepper
Horticulture Program Manager-Retired

TABLE OF CONTENTS

Introduction ......................................................... 1
Spades and Digging Forks ........................................... 3
Choosing the Best Tool for the Job ............................... 7
Broadforks ........................................................... 8
Hand Hoes .......................................................... 11
The Stale Seedbed Technique ................................. 18
Soil Rakes, Cultivators, and Hay Rakes .................... 19
Wheel Hoes and Push Cultivators ............................. 22
Appendix 1: Instructions for Double-Digging ............... 26
Appendix 2: Sources for Garden Tools ...................... 28
Endnotes .......................................................... 29
About the Author

GEORGE KUEPPER was Horticulture Manager at the Kerr Center for Sustainable Agriculture. He has over 30 years of experience with sustainable and organic agriculture.

From 2008 until his retirement in 2016, he directed the development of the Kerr Center’s organic horticulture program, the Cannon Horticulture Project. He also managed the Center’s horticulture interns, taught in the Center’s Beginning Farmer and Rancher program, and conducted a series of heirloom vegetable variety trials.

His Kerr Center publications include *Heirloom Vegetables, Genetic Diversity, and the Pursuit of Food Security* (along with an accompanying series of reports on variety trials of various heirloom crops); *A Brief Overview of the History and Philosophy of Organic Agriculture; Small Scale Organics: A Guidebook for the Non-certified Organic Grower; Farm Made: A Guide to On-Farm Processing for Organic Producers; Sweet Sorghum: Production and Processing*; and a series of reports on the Cannon project’s establishment and refinement of an organic bio-extensive management system, culminating in *Organic Bio-Extensive Management Revisited*.

Kuepper has spent his career mostly in the non-profit sector as a researcher, educator, producer, and consultant, including an earlier stint with the Kerr Center in the late 1980s. Before rejoining Kerr Center, he worked for NCAT (the National Center for Appropriate Technology) on the ATTRA Project and served as NCAT’s Midwest Office Director in Lewis, Iowa. There he focused on organic agriculture, specializing on compliance, certification, and transition issues.

George now makes his home in Fayetteville, Arkansas, where he lives with his wife, Dee, and an ever-changing number of pets. He continues to use his walk-behind tractor to manage his Biodynamic garden.
Introduction

The Cannon Horticulture Project is a demonstration, education, and practical research farm for organic horticulture. From 2007 until the present, we have explored organic systems design, cover crops, composting, biochar, heirloom vegetables, seed-saving, and alternative crops such as elderberries and lavender.

The Cannon Project occupies six acres, with about two-and-one-half under production and trials. Its small size, less-than-optimal soil fertility, and poor drainage, are features it shares with many market farms and home gardens in eastern Oklahoma, western Arkansas, and portions of surrounding states. Thus, our findings, successes, and failures are relevant to many of the farmers, gardeners, and the specialists who serve them, throughout this bioregion.

Bio-Extensive Management

The Cannon Project was certified organic by the Oklahoma Department of Agriculture, Food and Forestry (ODAFF) in 2011. Organic certification was allowed to lapse in 2017, but organic management techniques continue to be used. In addition to following the basic requirements of organic regulation, we manage our land using a specific sustainable strategy characterized by crop rotations, cover crops, green manures, and beneficial insect habitats. We refer to this approach as bio-extensive. Furthermore, we use organic no-till practices whenever possible. Organic no-till relies on natural mulch materials to suppress weeds and cover the soil, thus conserving moisture, protecting soil microbes, preventing crusting, and moderating soil temperature.


Small Farm Tools & Technology

Our market-farm scale leads naturally to using the same scale of tools and technologies that many small farmers and gardeners evaluate and adopt. As a foundation, however, we can experiment more widely with fewer consequences to our bottom line. With that freedom comes the obligation – willingly given – to share what we have learned.
Our first report on small-farm technology focuses on tools and methods we used for growing and trialing sweet potatoes under a three-year Specialty Crops Grant from ODAFF. Entitled Small-Scale Technology and Practices for Sweet Potato Growing in Southeast Oklahoma, it delves into a number of human-scale technologies suited to growing and harvesting. This publication is available at http://kerrcenter.com/publication/small-scale-technology-practices-sweet-potato-growing-southeast-oklahoma/.

Later, we published a summary of our work with walk-behind tractors, entitled Farming with Walk-Behind Tractors at Kerr Center’s Cannon Horticulture Project. It is available at http://kerrcenter.com/publication/farming-walk-behind-tractors/. The publication looks not only at our experiences at the Kerr Center, but also at ongoing use of two-wheel tractors at my personal garden near Fayetteville, Arkansas. Similarly, this document combines experiences from both locations over the past dozen or so years.

We evaluate small farm technologies under a variety of cultural conditions. Under bio-extensive management and organic no-till conditions, the soil surface is naturally trashy with plant residues and mulch. Many of the tools we discuss perform well under these conditions; some, however, are best suited only for clean cultivation.

Clean Cultivation

In the purest sense, clean cultivation is characterized by fields and gardens that are essentially mulch- and residue-free. Weeds are controlled by chemical and/or mechanical means, and soil is bare except for the crops being grown. To achieve this organically, frequent tillage and cultivation are necessary. This is the traditional approach to organic growing. Many – probably most – gardeners practice it. Some, though, also integrate a few non-clean culture techniques, such as plastic mulch (i.e. plasticulture), a bit of organic mulching, and mowing.

On the Cannon Plots, we use clean cultivation when it is best suited to our needs; growing sweet potatoes is one of the most obvious examples. It is hard to grow root and tuber crops without tillage. Clean cultivation is also appropriate when growing small-seeded crops, especially those that emerge slowly. It is also desirable for loose greens which would be unmarketable if contaminated with loose straw or other plant residues.

Clean culture by no means precludes soil-building organic practices. Crop rotations, cover crops, green manures, animal manures, compost, and the like work exceptionally well with clean culture. Our research into bio-extensive culture is our effort to find new strategies for organic management that are more sustainable. We admit that the methods we are researching may not suit, or even interest, all growers. That is not important here. What is more important is that you realize there are many ways to grow food and that you should find your own path. Choose whatever style, method, or tool that works for you!
Spades and Digging Forks

Many home gardeners use spades and digging forks to break, loosen, and turn garden soil. It is a traditional approach to breaking ground on new gardens, and one means of keeping it in production.

Figure 1. Two Men Turning Over the Soil. Jean Francois Millet (1814-1875). French. Digital image courtesy of the Getty’s Open Content Program.

Calling a Spade a Spade

Gardeners and farmers are sometimes confused about the differences between shovels and spades. Some use the terms interchangeably, though they really do refer to different tools. Shovels have concave blades with rounded or pointed tips. By contrast, the blades of garden spades are flat and straight-edged. Shovels are more likely to have long, straight shafts; spade shafts are usually shorter with T- or D-shaped handles. Both tools are used for digging and moving soil. However, the square blade of garden spades is far superior for slicing through soil and roots, as well as squaring up beds and borders. Hence, we prefer spades for most horticultural work.

Figure 2. A photo comparison between a shovel (left) and a spade (right). Shovels are usually longer than spades, about 56-60”; spades are typically shorter, with 40-45” of overall length. However, it is possible these days to find shovels and spades of varying lengths.
Double-Digging

Spades and digging forks are the tools of choice for growers practicing bio-intensive culture. (Bio-extensive management, and bio-intensive culture, are not the same thing. Bio-extensive management is explained in the publications mentioned on page 1. For a description of bio-intensive culture, see the text box on page 5.)

In 2012, Kerr Center’s student interns Katie Kilpatrick and Jacob Delahoussaye established a bio-intensive garden demonstration under the guidance of Luke Freeman, our horticulture program assistant. They followed the guidelines set forth by John Jeavons and Ecology Action of the Mid-Peninsula, doing deep seedbed preparation using spades and digging forks – a process called double-digging.

Double-digging is a gardening technique designed to deepen the rooting zone by increasing soil aeration, improving drainage, and distributing organic amendments and fertilizers more deeply. The gardener begins by spading off the top layer of the soil, leaving a shallow trench. He or she then switches to a digging fork to loosen the underlying layer. This alternating process continues until a planting bed is completed. (See Appendix 1.)

Double-dug beds are typically four to five feet in width and about 20 feet or more in length. Bio-intensive gardens feature one or more such beds, which are intended to be permanent. Foot traffic is confined to paths that surround the beds. Eliminating walking on the beds reduces compaction.

Eliminating compaction is a goal from the outset. Practitioners generally stand on a piece of plywood while double-digging. Jacob and Katie are standing on such a board in Figure 3.

Double-digging is an innovation of 19th-century European horticulture. Sources trace it to a successful market garden near Paris, France, that operated in the 1890s. The technique gained attention in the United States during the 1960s and 1970s due to the influence of British actor and horticulturist, Alan Chadwick.

One agronomic study of double-digging showed no real advantage when compared to both shallow surface cultivation and single-digging. This study was done on moderately fertile soil in the eastern Corn Belt. Deep tillage may be of less value on such soils. That said, double-digging remains an integral part of the bio-intensive approach and it is best to judge it within the context of all of its protocols and practices (see text box).
Bio-intensive Mini-Farming

Bio-intensive Mini-Farming is a comprehensive approach to resource-conserving, small-scale agriculture that relies mostly on hand tools. Bio-intensive Mini-Farms are large gardens with permanent, hand-dug, raised beds surrounded by pathways.

Bio-intensive culture is structured around eight principles that help growers to produce healthy food in an environmentally-benign manner. The eight principles include:

1. DEEP SOIL PREPARATION
   This is exemplified by double-digging.

2. COMPOSTING
   Compost is the principal fertilizer in biointensive culture.

3. INTENSIVE PLANTING
   Crops are seeded or transplanted as close as possible in an offset pattern to maximize production and suppress weeds.

4. COMPANION PLANTING
   Combining crop plants that are mutually beneficial

5. CARBON FARMING
   Crop mix should include grain and seed crops that also produce carbonaceous residues that serve as compost feedstocks.

6. CALORIE FARMING
   A major objective of Biointensive Mini-Farming is production of a balanced diet.

7. OPEN-POLLINATED (OP) SEEDS:
   OP varieties allow the grower to save seeds and, over time, select the most acclimatized plants for the garden.

8. WHOLE-SYSTEM APPROACH
   Proponents argue that all of the principles must be integrated to ensure development of a closed and truly sustainable system.

Quality and Maintenance of Spades and Forks

We recommend purchasing good-quality spades and digging forks, especially if you plan to double-dig. The most obvious indicator of a better-quality digging tool is the collar. In higher-quality forks and spades the collar and the blade (or tines) are forged as a single piece (see Figure 4).

In the real world, however, many gardeners and small farmers are on limited budgets and can’t always afford high-quality tools. They must use whatever happens to be in the shed, whether it be good, bad, or ugly. It never hurts, though, to be able to recognize good tools when you see them and, perhaps, acquire them in the future.

At least a minimal amount of maintenance of spades and forks is strongly encouraged – especially if you spent those extra dollars to buy higher-quality tools. Make sure they are free of soil after use; and cover the metal surfaces with a light coating of oil to prevent rust before storing. This advice applies to virtually all of the gardening tools we discuss in this publication.

Figure 4. The high-quality spade and garden fork used for double-digging on Kerr Center’s bio-intensive demonstration. Note that the tines and the blade are each forged as single pieces with their respective ferrules. This is typical of better-quality digging tools.

Figure 5. In contrast with the better-crafted spade and garden fork shown in Figure 4, less-sturdy digging tools are constructed with separate ferrules and tangs, as shown here.

Figure 6. The photo shows a spade and digging fork stored in a pail full of oil-saturated sand to prevent rust. I use this method at home.
Truly diligent gardeners sharpen their spades occasionally, especially if they’ve been working rocky and/or sandy soils. It’s a good idea and will make all digging tasks a lot easier. Begin by removing dirt and rust. To do the actual sharpening, you can choose a powered bench or hand-held grinder if you have them. Alternatively, you can use a standard mill bastard hand-file. You will want to maintain a single 45° bevel edge on the top side of the blade. At this angle it will be sharp enough to readily slice through sod and weeds, but not so sharp that you easily cut yourself.

Figure 7. Sharpen a garden spade at roughly a 45° angle with the bevel on the top side of the blade. When done, pass the file lightly on the back side of the bevel to remove any burrs.

Choosing the Best Tool for the Job

Many of the tools we discuss here are suited to a variety of purposes; others are quite specialized. The following table gives you an idea of where and when basic tillage and cultivation tools are best suited. It is only a general guide. Circumstances and soil conditions vary and, as we point out, you sometimes have to work with whatever tools you have at hand.

<table>
<thead>
<tr>
<th>Task</th>
<th>Best-Suited Tools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary Tillage: Breaking New Ground</td>
<td>Spades, Garden Forks, Broadforks, Heavy Duty, Grubbing Hoes</td>
</tr>
<tr>
<td>Primary Tillage: Previously Broken Ground</td>
<td>Spades, Garden Forks, Broadforks, Heavy or Light Duty, Grubbing Hoes</td>
</tr>
<tr>
<td>Secondary Tillage: Final Seedbed Preparation</td>
<td>Draw Hoes, Garden Rakes, Garden Cultivators, Specialty Wheelhoes</td>
</tr>
<tr>
<td>Cultivation: Both Inter-row and Inter-plant</td>
<td>Draw Hoes, Scuffle Hoes, Garden Cultivators, Wheelhoes</td>
</tr>
</tbody>
</table>
Broadforks

A broadfork is essentially a large spading fork, with two shafts on opposite ends of a rack bearing about four to eight tines. The tines typically range from eight to eighteen inches in length. Also called U-bars or U-forks, broadforks trace back to the grelinette – a tool invented during the 1960s in France by André Grelinin. Ecology Action of the Mid-Peninsula researched the concept around 1980 and produced their own tool design. A major proponent of broadforks, Eliot Coleman, discusses them in detail in his book, The New Organic Grower.

Broadforks accomplish deep tillage with little to no mixing of soil strata. They are commonly used to maintain bio-intensive beds that were originally created using double-digging. This is a major selling point for broadforks. Instead of double-digging the same beds every year, you can use a broadfork and reduce bed preparation time by 75% or more. Previously tilled soil will work easily with a broadfork, and relatively light models serve well. However, if soils are heavy, compacted, or have never been tilled before, you should consider one of the heavy-duty designs.
While at the Kerr Center, I used the heavy-duty broadfork to prepare planting rows for an elderberry trial. I wanted to till deeply to give this perennial lots of room for root growth and to ensure good water penetration and drainage. I consider broadforking particularly beneficial for all perennials, including vegetables like asparagus and horseradish. It is also appropriate for root crops like sweet potatoes and carrots. And because broadforks cause minimal soil disturbance, and because they work fine in sod and trashy soils, they can fit well into mulch-based gardening systems.

Try not to buy a broadfork heavier than you need. If you will be using it in already-tilled soils or to maintain bio-intensive beds, light and medium duty models should be fine. If you believe you need a heavy duty broadfork, then you probably do. You will discover, though, that it is probably constructed entirely of steel and is quite heavy and clumsy.

Broadforking can make intensive tillage much easier, especially when you substitute it for the rigors of spading and forking. Still, unless you understand the how-to basics, broadforking can be exhausting. Figures 12 through 16 illustrate how I’ve used the heavy-duty model and offer a few tips.

Figure 12. When I have to carry a broadfork, I’ve found it most comfortable to do what you see in the photo. The tool is well balanced to reduce strain. I also have good control of it. The tines are unusually sharp and can be hazardous to people, animals, and inflatable tires if you are not careful!

Figure 13. I move backwards when broadforking, much as I would when spading. I position the broadfork upright about six to twelve inches from the end of the bed or row.
Figure 14. I climb onto the cross-bar and rock the tool forward and backward – not side-to-side – until it goes as deep as possible.

Figure 15. Stepping backwards, I pull the handles downward. If necessary, I shake them up and down a bit to work the tines free from the soil.

Figure 16. Without lifting the broadfork, I drag it backwards far enough to take the next “bite” of soil and repeat the process. Simply dragging the tool backwards is so very much easier than lifting it. It is time-saving as well.
**Hand Hoes**

Hoe farming is the earliest form of agriculture, originating in Neolithic times. During this period much of humankind changed from nomadic hunting and gathering to growing crops and living in permanent settlements. Hoe farming began with sharpened stick and bone tools, but rather early on, the implement we recognize today as a hoe evolved. Today, hoe farming is still common in areas where subsistence agriculture is practiced, and hoes remain an important tool. In developed countries, hoes are also common in gardening and farming, and innovation and specialization have afforded us a multitude of different designs and applications.

**Grubbing and Grape Hoes**

Millet’s 19th-century painting, *Man with a Hoe* (Figure 17), depicts a farm worker taking a breather from breaking ground with a grubbing or grub hoe. The modern grub hoes (also called “chopping hoes”) are direct descendants of such tools. They are still used worldwide for primary tillage, as well as for subsequent cultivation and weed control. Survivalists and others committed to off-the-grid lifestyles are a contemporary market for grubbing hoes. This makes good sense. Like garden spades and digging forks, grub hoes can be readily used to prepare a good-sized food garden, keep it free of weeds, and do this without reliance on gasoline or diesel engines. They are also built for the long haul and are easily maintained.

Grubbing hoes are a kind of draw hoe. A draw hoe has a blade set at approximately a right angle to the shaft. The user chops into the ground and then pulls or “draws” the blade towards him or herself. Grub hoes are more stoutly constructed than common draw hoes, which we describe later. Grub hoes need to be strongly built. We use them to break ground, root out large weeds, dig trenches, and hill potatoes – all activities where considerable amounts of soil must be shifted. We can use grub hoes for inter-row weeding as well, and sometimes for cultivating between plants within a row. However, there are better tools for these purposes.

Figure 18. David holds a well-designed and sturdy grub hoe, with its parts properly named. Rogue hoes are manufactured from recycled agricultural disk blades.
When using grubbing hoes to break ground, it will be natural to bend your spine somewhat, as shown in Figure 19. The upright posture we recommend for weeding crop rows – something we discuss in the next chapter – does not work very well here, and might even be a bit dangerous. When standing upright, the chopping action occurs much closer to where you stand. The long, hard swings you make could miss the target and slice into your foot or ankle.

Grape hoes resemble grubbing hoes, though their design is somewhat different and their use more specialized. Grape hoes are designed primarily for weeding, particularly in perennial grape, berry, and orchard plantings. In contrast to a grub hoe, a grape hoe blade is mounted at a sharper angle relative to the shaft, to facilitate scraping and weeding the soil surface, as opposed to the digging action of grub hoes. Traditional grape hoes are often fitted with specially-curved shafts that are designed to aid further in weeding. Grape hoes are also distinguished by the iconic shape of the blade as shown in Figure 20.

In late summer of 2018, I used my grape hoe to slice through light mulch and some large weeds while making space for some fall crops. Well-sharpened, it worked quickly and easily. For some of the task, I found I could hold an upright posture and not strain my back, but I did take notice of the closer proximity to my feet and ankles!

You should sharpen a grub hoe in the same manner as a common draw hoe. We show this later, in Figure 27. I have noticed, however, that my Austrian-made grape hoe is beveled on the inside of the blade. This might or might not be a standard characteristic of grape hoes. Whether it is or not, I need to use a different and somewhat clumsier approach to sharpening the grape hoe, as you can see in Figure 21.
The Common Draw Hoe

The standard draw hoe is a multi-purpose tool. We can use it to mix potting soil, dig shallow trenches, mix concrete, and, of course, to kill weeds. Even though there are superior hoe designs for easy and effective weed control, this is the only kind many gardeners might be able to afford or have access to. If this applies to you, use what you’ve got! It will still get the job done.

It is helpful to distinguish cultivation or “weed-hoeing” from the ground-breaking, trenching, and other heavy-duty tasks best suited to grub hoes. Cultivation is typically done in loosened soil, and the weeds are small. (They should be, anyway!) Weed-hoeing strokes are shorter, better-controlled, and require less force than those used to break ground. This allows you to assume a more comfortable posture.

Too often, gardeners use the same bent-over position they would use with a grub hoe when breaking ground or hoeing out very large weeds, as David demonstrates in Figure 23. At times this posture might be needed, but you shouldn’t use it all the time!

When cultivating, it is recommended that you stand upright and hold the shaft in a cross-grip – the lower hand with palm towards the body and the upper hand facing away with your thumb pointing upwards (Figure 24). This posture is far easier on your back and neck, making the task far easier. Furthermore, because row weeding involves precise, short and controlled strokes, you can stand much closer to the action and are much less likely to injure your feet as you might when trying to break ground with a grub hoe.
You want to avoid poor posture as much as possible. There are two common excuses that gardeners often cite to explain why they stay bent over while weed-hoeing:

1) My hoe’s shaft is too short!

The solution here is to fit a longer shaft to your hoe… or buy another hoe.

2) My weeds grow too big!

While keeping your hoe blade sharp will help, timing is the most important consideration. The best time to control weeds, whether you use a tractor-cultivator, rototiller, wheel-hoe, or hand-hoe, is to catch them at the seedling stage. There are several good reasons:

- You can control seedling weeds using shallow cultivation, which causes less damage to crop roots and brings fewer new weed seeds to the surface.
- Seedling weeds are not yet competitive with your crops. If allowed to grow, however, they will soon grab nutrients, water, and sunlight your plants need.
- In the seedling stage, you’ll require less physical energy and time to root them out.
- Even if perennial weeds are your challenge, catching them when they are smaller is still a better strategy. At the very least, it slows the proliferation of roots, stolons, and rhizomes that require more draconian digging later on.
- Early cultivation at the seedling stage does not necessarily mean you must weed more often! Early control allows the crop to become more competitive and, in many cases, it suppresses late-emerging weeds with little or no additional hand labor. Even if additional hand-hoeing is needed, as it well might be on less competitive crops like carrots and onions, it can be done using the healthier and more efficient cultivation posture we’ve described.

**Specialty Draw Hoes**

Some draw hoes have been specially designed either to enhance their effectiveness for weeding or for other horticultural purposes. We used several of these at the Kerr Center.

The warren hoe (Figure 25) is a draw hoe with a pointed blade. It is best used for shallow trenching when hand-planting vegetables and flowers without a mechanical seeder. That said, it will still work well as a weeding hoe. But be forewarned: warren hoes are often sold with short shafts that require you to bend over no matter what the task.

The trapezoid hoe (Figure 25) is so named for the shape of the blade. The sharper angles on the bottom allow cultivating close to crop plants. While I prefer a stirrup hoe (Figure 30) for general inter-row weeding, I usually choose a trapezoid hoe when I want to get close to crop stems. Also, the especially sharp blade works well for the occasional larger weeds that I may have missed the previous time I hoed.

Collinear hoes (Figure 26) are excellent weeding tools, designed to “skim” weed seedlings from the soil surface rather than dig them out. I found them ineffective on the Kerr plots, however. The Cannon site has relatively low soil organic matter levels, and Oklahoma’s heavy rains often lead to crusting. The collinear hoe we tried was not robust enough to work well under these conditions. It is not hard to understand, however, that it would work much better on improved, higher organic matter soils.
Figure 26. A collinear hoe, viewed from front and back

Figure 27. Here I’m sharpening a swan-neck hoe – a specialized draw hoe imported from Europe. It is intended for very close crop weeding. As with all draw hoes, you want a 45° bevel on the back side of the blade. Remove any burrs by holding the file parallel to the front side of the blade and swiping it lightly two or three times.

To sharpen a draw hoe, use a mill bastard file to create a bevel of roughly 45° on the back side of the blade, as shown in Figure 27.

Scuffle Hoes

Scuffle hoes have all their blade edges sharpened, so that they can be either pushed forward or drawn back (Figure 28). 24,25 Many growers have a strong preference for scuffle hoes, finding them faster to use, especially when pushed. I prefer them myself, especially when I’m able catch weeds at that vulnerable seedling stage. Under such circumstances, they are much faster than a draw hoe. Scuffle hoes will still work when weeds grow larger, but I prefer draw hoes under those circumstances, especially for perennial weeds.

Figure 28. Two different scuffle hoe blades: triangular (top left); the Hooke ‘n Crooke™ (bottom right)

I mentioned previously that I prefer draw hoes when working especially close to vulnerable crop plants. I find I have better control with them. There are a few exceptions. The Hooke ‘n Crooke™ line of scuffle hoes feature a notched blade that allows for very precise hoeing. 26
Figure 29. In photo A, David demonstrates the relaxed posture that can be used when using a scuffle hoe in relatively loose soil if weeds are small. When soil is compacted and/or weeds are large, two hands might be required, as in photo B. In both instances, however, David is able to avoid the strain of bending over.

Stirrup hoes\textsuperscript{27} are a kind of scuffle hoe with added mechanical action due to a hinged blade (see Figure 30). A superior stirrup hoe, such as the one shown, has a convex, rather than flat, blade. The convex shape cuts somewhat deeper in the soil, allowing you to better slice the weed’s crown free of its root. At the same time its outer edges run shallow, doing less damage to crop roots. This is the design of scuffle hoe that I have used, and appreciated, the most. I am able to hoe quite rapidly and efficiently, using the same upright postures that David shows in Figure 29.

Figure 30. A Swedish-made stirrup hoe.

Figure 31. Scuffle hoe blades are sharpened so that the beveled edge is on top of the blade. This encourages the blade to cut downwards into the soil rather than skimming over the top. \textit{Draw-filing} – pulling the file backwards over the bevel – is recommended when sharpening stirrup hoes.\textsuperscript{28}
Weeds, Hoes, Tillage and Timing

We can become so enamored of farm and garden technologies and what they promise that we forget the fundamentals. This is true, even with something as mundane as mechanical weeding. For this reason, I have long treasured a magazine article by farmer and consultant Josh Volk, who assembled much of the art and science of mechanical weeding in a single written piece. Much of what I’ve written here is adapted from his article. Some of it repeats information covered earlier. That is by intention; it is worth repeating!

Whether you use a hoe, a cultivator, or a wheel-hoe, cultivating early and more often is easier and less damaging to the crop than waiting for weeds to grow in size before tackling them. You might be surprised to find it more time efficient as well. This is possible because there is less physical resistance from large, stubborn weeds and from crusted soil, allowing you to move up and down crop rows more quickly. And because each hoeing operation is quicker and easier, your total time with hoe in hand may be less, even if you have do it one extra time before the end of the season.

You can actually do your most effective weeding before the weeds are even visible! Shallow stirring of the soil readily kills tiny, thread-like weed seedlings. It is true that you won’t get them all by cultivating at this stage, but so can your crop. Be careful and cultivate as shallowly as possible to avoid pruning crop roots. Crops will wilt following mechanical cultivation if roots are damaged – a condition laughingly called “hardware disease.” But you won’t chuckle about it if it’s your crop!

Conversely, avoid cultivating just ahead of overhead irrigation or rain. Weeds that would otherwise be killed might simply re-root. If possible, cultivate about one to two weeks after rain or overhead irrigation, once the soil is dry enough. Volk explains that, following a good watering, it takes less than a week for weeds to germinate, and about seven to ten more days for the seedlings to develop true leaves.

Cultivation can provide a growth spurt for your crop. This results from a sudden release of soil nitrogen. Cultivation aerates the soil, which stimulates soil bacteria. Bacteria then break down organic matter, releasing nitrogen to crop roots. This sounds like a good thing. It is, but only in the short term. In the long term, repeated soil aeration depletes soil humus. Soil humus is the dark, relatively stable organic material that forms when plant and animal matter decays. It is a reservoir of plant nutrients, and positively influences water-holding capacity, gas exchange, and friability.

Tillage and cultivation, even in their most conservative forms, disrupt soil-building fungal and macro-organism communities (e.g. earthworms) and stimulate humus-depleting bacteria, eventually exhausting the soil fertility “bank account.” Traditional organic soil-building practices, such as manuring, green-manuring, composting, and mulching, are used to re-build humus levels by returning organic matter. In the parlance of the organic community, this is referred to as “the law of return.” In this light, many organic soil management strategies are basically compensatory, with measured soil-building practices employed largely to counterbalance the destructive actions of tillage and clean cultivation. This is a reasonable and relatively sustainable strategy. However, we know we can do better. Perhaps this helps explain why we are experimenting with bio-extensive management and organic no-till.
The Stale Seedbed Technique

The stale or “false” seedbed technique[^32] is a specialized clean cultivation technique that few gardeners and small farmers understand or use. It is best explained through a simple example:

1. The grower prepares a good seedbed using standard organic practices.
2. Instead of immediately seeding, he or she waits about a week for weed seeds to germinate.
3. The grower then kills this first flush of weeds while trying to disturb the soil as little as possible. The best tools for this are either a flame weeder or an organically-acceptable herbicide such as concentrated vinegar. Lacking these, cultivation is done using a scuffle hoe, hand cultivator, weeding rake, or any tool that works as shallow as possible.
4. The gardener can then plant, still taking care not to disturb the soil more than necessary.

Variations on this basic strategy are common. For example, you can seed before killing the weed flush (i.e. doing step 4 ahead of step 3). You will then kill the weeds before the crop emerges. The objectives, in either case, are the same: a) to force early weed germination so they can be killed and give the crop a head start and, b) to avoid bringing new weed seeds to the surface.

Hoes and Mulch Gardens

Generally speaking, mulch gardening should make hoeing and other forms of cultivation redundant. It largely does. However, a few weeds still tend to make their way through the mulch cover. This is especially so in the early years of a garden plot, when there is an abundant weed-seed bank in the upper topsoil. In my experience, these weeds are usually widely spaced, but they grow vigorously.

Under these conditions, I’ve found that the grape hoe works quite well, but so does the oscillating hoe. I suspect most kinds of hoes will work to some degree or another, though not as easily as they do under clean cultivation. The key to success seems to be keeping the blade sharp.

[^32]: Reference or citation is needed for the stale seedbed technique.
Soil Rakes, Cultivators, and Hay Rakes

We did very little work with soil rakes and hand-held cultivators, since they are primarily used in clean cultivation. Still, we’d be negligent not to mention them in this publication.

Soil Rakes

Soil rakes are simple tools (Figures 33, 34). Gardeners use soil rakes for secondary tillage – to put the final touches on beds and plots by shaping them, removing stones, crushing clods, and rounding or leveling the surface. The most common soil rakes on the market appear to be bow rakes with tang and ferrule construction. These are suitable for most soil applications.

Soil rakes can also do light weeding when the weeds are just barely emergent. Some are specifically designed for this purpose and are called weeding rakes. Actually, there are also several specialized designs for landscape and garden bed work.

Figure 32. Italian girl with rake. Frank Duveneck (1848-1919). American.

Figure 33. The photo on the left shows a common bow rake of tang and ferrule construction. The rake on the right is a common leaf rake. Leaf rake tines are usually too “springy” to work soil effectively, though they might serve as weeding rakes. They are good for their stated purpose, however – raking leaves.

Figure 34. A specialized soil rake – suited for intensive vegetable production. Special “fingers” can be fitted over individual tines to mark planting rows.
Hand Cultivators

Cultivators are intended for two main purposes: killing seedling weeds and aerating the soil. The latter can be especially important on soils that crust easily. In a pinch, garden cultivators, like that shown in Figure 35, can be used for the same purposes as soil rakes, but they are far less efficient because the spread of the tines is so small.

Hay Rakes

Organic no-till is characterized by organic mulch covers that suppress weeds, protect the soil, conserve moisture, and add to fertility. One way of obtaining organic mulch is to grow, cut, and harvest it from nearby fields and waste areas. We describe this in detail in Market Farming with Rotations and Cover Crops: An Organic Bio-Extensive System.33 Specialized hay rakes are helpful here; they are specifically designed for gathering cut and dried hay and straw – the sorts of materials that make good mulch. I found that soil rakes – including the one shown in Figure 34 – worked poorly. They do not gather as much vegetation with each stroke and the inward curve of the tines tends not to release it. This makes the job harder and more frustrating. Leaf rakes are totally unsuited for gathering vegetation cut with a sicklebar. Again, it is too “springy.” A leaf rake might work well however, if the vegetation has been finely cut.

Figure 35. This cultivator head has been fashioned from a single piece of steel, combining the ferrule and tines. You will find that most such tools on the market are of tang and ferrule construction.

Figure 36. Called a “garden weasel,” this cultivator is a novel design that some gardeners like.

Figure 37. Peasant Woman Raking. Jean Francois Millet (1814-1875). French.
With a few exceptions, hay rakes are lightly constructed (Figures 38, 39). The ones I’ve seen and used are made mostly from wood, with a few bits of hardware. It makes them pleasantly light and easy to handle. The tines are wood pegs, which do break on occasion, but they are easily replaced.
**Wheel Hoes and Push Cultivators**

**Wheelhose**

Wheel hoes have been a feature of small-scale farming since the latter half of the 19th century. The Philadelphia manufacturer, S.L. Allen and Company, was a key developer and promoter. S.L. Allen created the Planet Jr. equipment line, which included single-horse-drawn implements, as well as hand-pushed cultivators and seeders. The firm claimed that gardeners and small farmers could plant and maintain up to four times as much land using hand-pushed equipment as was possible using hoes and other hand tools.34

The original Planet Jr. and its modern equivalents have small wheels – typically twelve to fifteen inches in diameter (Figures 40, 41). In the late 1800s and early 1900s, however, high-wheel wheelhoses also entered the market, sporting wheels two or more feet in diameter. Some writers suggest that America’s turn-of-the-century infatuation with bicycles prompted this new development. By the 1920s, the two designs were about equally popular among gardeners.35

High-wheel wheelhoses are easier to push, but are not as easy to control during close cultivation. When you push a high-wheel wheelhoe, your body force is directed to the wheel, and only indirectly to the tillage attachment (Figure 42). By contrast, small-wheel wheelhoses are designed so that your body force is directed to the cultivation tool (Figure 43).36,37 This is a major reason why the small-wheel design is preferred by market growers today. Another factor, though, is the far greater number of tilling and planting attachments that are designed for them.
As mentioned, low-wheeled wheel hoes can mount a wide variety of implements (Figures 47-49). This flexibility goes back to the early days of the Planet Jr., as shown in Figure 45. You can also configure them with either one or two wheels, allowing you to straddle short-growing crops or cultivate close to the crop in the inter-row area. Vine-lifters – a common feature with early models – can still be found. These are simple pieces of metal that project a few inches beyond the wheel(s) to reduce damage to above-ground parts of the crop.

There are relatively few implements marketed for high-wheel wheelhoes. The five-prong cultivator is perhaps the most popular attachment (Figure 44). It truly does an excellent job of cultivation when weeds are small. If you were to purchase a high-wheel wheelhoe today, you would likely receive, along with the five-prong cultivator, a furrow shovel and a turning shovel, suitable for light plowing under clean cultivation. While researching this publication, however, I did discover one source selling an oscillating hoe blade specifically made for high-wheel hoes (Figure 46).
Note that the Glaser hoe shown in Figure 46 has a rather interesting attachment plate for mounting the various cultivating tools. The plate features several bolt holes, plus a pair of slots allowing you to slide cultivating tools closer together or further apart depending on need. This plate pattern appears to have originated with the Planet Jr. and remained unchanged on the Jupiter wheelhoe, which followed it. It continues today on Glaser and Hoss wheelhoes, as well.

Figure 47. Hoss Tools markets the split shovel shown in these photos. The configuration in photo A makes it into a furrower. Under clean cultivation, I have used this to create a shallow trench for planting white potatoes. By reverse-mounting the shovels, as shown in photo B, I used them to cover the potatoes after they had been placed in the trench. Note that the wheelhoe is in the two-wheel configuration. This might not be necessary for trenching, but is needed when covering the potatoes. Otherwise, the single wheel would run right over the just-planted spuds. I have also used the reverse mount to build a small raised planting ridge for sweet potatoes.

Figure 48. Another option from Hoss Tools is the disk gang. It can be used for careful cultivation and hilling while straddling a crop. Like the reverse-mounted shovels shown in Figure 47, it can also be used to create low planting ridges. That is what I am doing in the top photo. This small field was planted to sweet potatoes later that day.

Figure 49. A small moldboard plow implement was once standard with Planet Jr. and Jupiter wheelhoes. I find mine suitable for turning soil that is loose and largely free of litter. Trust me, it will not break sod or bury corn stalks. Eliot Coleman has commented that he found this implement useful for burying the edges of plastic mulches and row covers.
**Wheelhoes and Mulch Gardening**

A wheelhoe is a godsend when you practice clean cultivation. I absolutely recommend them for such systems. However, the more reliant you become on organic mulches, the less helpful they become. While I have not done much work with small-seeded crops, which require clean cultivation, it seems to me that this is where wheelhoes have a long and healthy future (Figure 50).41

**Push Cultivators**

I am using the term “push cultivators” to describe self-contained tillage tools that resemble wheelhoes, but are single-purpose and generally lack the flexibility to mount different tools. There are a few different kinds of push cultivators on the market these days, but I have not seen very many.

There is one particular push cultivator, built and marketed by Lehman’s Hardware, which we used on the Cannon Plots. Lehman’s Hand Rotary Cultivator is a re-design of a traditional tool called the Ro-Ho cultivator (Figure 51). The Ro-Ho was built by Rowe Manufacturing, Galesburg, Illinois. I’m not certain when production began, but it ended sometime in the early 1990s.42 The cultivator is still favored by many Amish gardeners.43 It is excellent for breaking soil crusts and cultivation when weeds are in the seedling stage. I frequently used it to incorporate cover crop seeds between crop rows when we experimented with living mulches. It worked well for that. This is one innovation that is suited only for clean cultivation systems. Even small amounts of trash clog it.
Appendix 1: Instructions for Double-Digging

The following sequence of drawings (Figures 52-58) illustrates the steps in double-digging from start to finish.44

Figure 52. **Step 1.** After marking out the boundaries of the bed, dig a four-to-five foot trench along one end using a spade. Place the soil in a wheelbarrow or garden cart, or into buckets.

Figure 53. **Step 2.** Switching to your digging fork, loosen the soil or subsoil level beneath the top layer you just piled into your garden cart.

Figure 54. **Step 3.** Slide your digging board backwards a step and, taking up your spade again, dig the next trench. Place the soil on top of the soil previously loosened in step 2 (i.e. Figure 53).

Figure 55. **Step 4.** As in step 2, use your digging fork to loosen the soil or subsoil level beneath the topsoil layer that you just shifted.

Figure 56. **Step 5.** Now, repeat the same action as in step 3. Move the digging board back a step back and dig the next trench with your spade. Place the soil on top of the soil previously loosened in step 4.

Figure 57. **Steps 6-22.** By now, the process should be clear. Repeat the same alternating steps of loosening subsoil with the digging fork and covering it with topsoil spaded from the next trench.
Figure 58. Step 23. In the final step, return to the soil originally removed in step 1 and held in your garden cart. Place it on top of the last subsoil layer you loosened in step 22. You have just double-dug your first garden bed. Finish by using a soil rake to shape and smooth it.

The Royal Horticulture Society (RHS) of Great Britain recommends double-digging for new garden beds where soils are compacted, or where an especially deep seedbed is needed, such as when growing asparagus. They advise repeating the process every three to five years if soils are particularly heavy. Under average circumstances, however, the RHS feels that single-spading and standard soil cultivation practices are adequate. This is especially so if the land has been tilled previously. Should you decide to double-dig, you can do it at any time of the year. However, RHS encourages fall or winter spading, when the ground is moist, but not frozen. This allows subsequent frosts to break down clods. It also lets the soil settle before planting.45

Double-digging is hard work. Ecology Action has produced a DVD featuring John Jeavons that shows the process.46 It not only illustrates double-digging, but details economies of movement to reduce the strain of digging. I have tackled double-digging on my own and found it quite demanding. This DVD can be exceptionally valuable to anyone using or planning to use this technique. I strongly recommend it.
Appendix 2: Sources for Garden Tools

EARTH TOOLS
1525 Kays Branch Rd.
Owenton, KY 40359
502-484-3988
www.earthtoolsbcs.com/
Spades, Digging Forks, Broadforks, Hoes, Grub & Grape Hoes, Hand Cultivators, Soil Rakes, Hay Rakes, Hoss Wheelhoes

EARTHWAY PRODUCTS, INC.
1009 Maple St.
Bristol, IN 46507
800-294-0671
https://earthway.com
High Wheelhoes

EASY DIGGING
1400 Forum Blvd. #585
Columbia, MO 65203
573-823-3539
www.easydigging.com/
Spades, Broadforks, Hoes, Grub & Grape Hoes, Hoss Wheelhoes

GARDENER’S SUPPLY COMPANY
128 Intervale Rd.
Burlington, VT 05401
888-833-1412
www.gardeners.com/
Spades, Digging Forks, Hoes, Hand Cultivators, Soil Rakes

GEMPLERS
P.O. Box 5175
Janesville, WI 53547-5175
800-382-8473
www.gemplers.com
Spades, Digging Forks, Broadforks, Hoes, Grub Hoes, Hand Cultivators, Soil Rakes

HOLDREDGE ENTERPRISES, LLC
2533 State Hwy. 80
West Burlington, NY 13482
607-965-6423
http://holdredgeenterprises.com/
Hooke’n Crooke™ Hoes

HOSS TOOLS
P.O. Box 429
Norman Park, GA 31771
888-672-5536
229-769-3999
hosstools.com/
Spades, Digging Forks, Hoes, Soil Rakes, Hand Cultivators, Hoss Wheelhoes

JOHNNY’S SELECTED SEEDS
955 Benton Ave.
Winslow, ME 04901-2601
877-564-6697
www.johnnyseeds.com
Spades, Digging Forks, Broadforks, Hoes, Soil Rakes, Hand Cultivators, Glaser & Terrateck Wheelhoes, Push Cultivators

LEE VALLEY TOOLS LTD.
P.O. Box 1780
Ogdensburg, NY 13669-6780
800-513-7885
www.leevalley.com/us/garden
Spades, Digging Forks, Broadforks, Hoes, Soil Rakes, Hand Cultivators, Hoss Wheelhoes

LEHMAN’S HARDWARE
289 Kurzen Rd.
N. Dalton, OH 44618
800-438-5346
lehmans.com
Broadforks, Hoes, Grape Hoes, Hand Cultivators, High-Wheelhoes, Push Cultivators

MEADOW CREATURE
P.O. Box 2112
Vashon, WA 98070
360-329-2250
meadowcreature.com
Meadow Creature Broadforks

MORGAN COUNTY SEEDS
18761 Kelsay Rd.
Barnett, MO 65011-3009
573-378-2655
www.morgancountyseeds.com
Spades, Digging Forks, Rogue Hoes, High-Wheelhoes

PEACEFUL VALLEY FARM AND GARDEN SUPPLY/GROW ORGANIC
P.O. Box 2209
Grass Valley, CA 95945
530-272-4769
www.groworganic.com
Spades, Digging Forks, Broadforks, Hoes, Grape Hoes, Soil Rakes, Hand Cultivators, Glaser Wheelhoes

PROHOE MANUFACTURING
P.O. Box 87
Munden, KS 66959
800-536-5450
www.prohoe.com
Rogue Hoes, Soil Rakes, Hand Cultivators

RED PIG GARDEN TOOLS
12040 SE Revenue Rd.
Boring, OR 97009
503-479-5571
www.redpigtools.com
Broadforks, Hoes, Grub Hoes

SCYTHE SUPPLY
496 Shore Rd.
Perry, ME 04667
207-853-4750
scythesupply.com/rakes.html
Hay Rakes

VALLEY OAK TOOL COMPANY
P.O. Box 301
Chico, CA 95927
530-342-6188
www.valleyoaktool.com
Broadforks, Valley Oak Wheelhoes
Endnotes

1 This is a familiar expression for most of us. It means that one should be straightforward and call things by their right names, without euphemisms. While many believe the term comes from the card game of poker, it is actually traced back to ancient Greece, around 300 BCE. It truly did refer to garden spades.


3 Ecology Action is a 501(c)3 non-profit, established in 1971, and committed to “teach(ing) people worldwide to better feed themselves while building and preserving the soil and conserving natural resources.”

   http://www.growbiointensive.org/index.html


11 The tang is the projection of metal from a blade (or set of tines) by which it is fastened to a shaft or handle; the ferrule is the metal ring, cap, or sleeve that surrounds the tang and shaft to join and strengthen them, and to prevent the shaft from splitting or wearing.


19 Meadow Creature LLC. www.meadowcreature.com


23 Prohoe Manufacturing, LLC. www.prohoe.com


Holdredge Enterprises, LLC
http://holdredgeenterprises.com/


Anon. No date. The Secret of Easy Weeding.
https://www.easydigging.com/guide/easy-weeding.html


http://www.easydigging.com/Garden_Cultivator/wheel_hoe_push_plow.html

Ibid.