

Tractor Primer for the Market Farm

Wisconsin School for Beginning Market Growers

Much can be said for the small market garden that relies on hand labor and a sturdy rototiller. These market gardeners prove that it does not require a significant investment in tools to grow a good deal of vegetables (and generate significant gross sales) on an acre or less. Some growers even manage to cultivate two or three acres of vegetables without a tractor. A quality, heavy duty, rear-tine tiller can incorporate cover crops and even sod (with adequate weight and horsepower) and prepare a seedbed for direct seeded crops or setting transplants. However, this does require a good deal of time and can put undo wear and tear on the grower, the soil, and the tiller.

Rototilling can be overdone and have deleterious effects on soil structure, tilth, and soil biology. Some growers ameliorate these effects by extensive cover cropping, mulching, and finding neighboring farmers or retired farmers to perform disking, chisel plowing, or sub-soiling. This can be a very economical option, allowing the small-scale farmer to not buy and maintain larger-scale equipment. One challenge is that a neighboring farmer is most likely going to do plowing work on *their* schedule not the market grower's. This can mean lost planting opportunities and tilling the soil under less than ideal conditions. When it is time to till and plant on the market farm, a day delay (or even hours) can have significant impacts. Some growers rent a tractor and implements periodically to conduct primary tillage and handle large tasks. There comes a time for most growers, however, when—due to age, acreage or efficiency—the services of a tractor are most welcome to ease some of the hard manual labor and long hours involved in producing vegetables. Farming with horses is another viable option but will not be discussed here.

The following is meant to introduce some essential basics about tractors for the new and beginning grower who is ready to purchase a tractor. This is not meant to be a complete or detailed treatise. It is wise for growers to gather information from a variety of sources including neighboring farmers, other fresh market vegetable growers, books, reputable dealers, and elsewhere. Increasingly, there is information available on the Internet and such resources are listed in the reference section.

Tractor and implement advice can vary significantly depending on who is giving it. Most growers have their favorites and color bias (such as John Deere green or International red) when it comes to tractors! Given that advice is likely to vary, it is best to do plenty of research before making a purchase. This publication aims to provide a foundation in understanding basic terms and issues from a small farm perspective.

The remainder of this publication endeavors to provide some practical information and advice about tractors, including:

- Perspective on the number and type of tractors needed
- Recommended tractor features
- Advice on looking for and purchasing a used tractor
- Buying a new or grey market tractor
- Factoring in annual maintenance and repair costs
- Basic descriptions of various implements and their horsepower requirements
- Glossary of common terms and abbreviations

Tractors on the Market Farm

It is perhaps wise to first remind new growers that while a good tractor is invaluable, there are other equipment needs on a market farm. It is tempting to make a tractor the first major investment. After all, the tractor allows the grower to quickly and efficiently prepare soil for planting, pull a wide variety of implements, and, with a front-end loader, handle manure, compost or other heavy or bulky materials. Unless one chooses

to farm with horses, the tractor will be the central, crucial piece of equipment at the “front end” of the vegetable farm—along side the greenhouse for producing transplants. However, it is easy for many new growers to focus on tractors and tillage when developing and expanding a market farm, while neglecting to adequately capitalize the “back-end” of the farm in terms of walk-in coolers and post harvest handling facilities and equipment. Indeed, a walk-in cooler is, in most cases, a more important early purchase than a tractor. The successful small market farm most often relies on producing premium quality produce and adequate storage facilities are absolutely vital. Another important area to invest in is adequate irrigation. Of course, walk-in coolers and irrigation equipment are not nearly as fun as tractors! A walk-in cooler and irrigation are very likely to help you earn more money, however.

As mentioned above, it is possible to farm an acre or two without a tractor (or other form of horsepower) but this demands a great deal of manual labor. Even many one-acre market gardens utilize a garden tractor or other small utility (compact) tractor. Obviously, as scale increases the need for multiple tractors increases because there is more work to be done and more varied tasks. The book How to Make \$100,000 Farming 25 Acres by Booker T. Whately (out of print) contains some practical advice on tractors for the diversified vegetable grower. Whately advocated a three-tractor vegetable growing system featuring a “big” tractor in the 40 to 50 horsepower range (small by modern farming standards), a secondary tractor in the 30-45 horsepower range, and a small cultivating tractor.

In this system, the big tractor handles primary tillage, manure handling, and helps with secondary tillage. The mid-sized tractor is a real workhorse, performing secondary tillage, seeding, transplanting, cultivation, and the operation of various specialty implements (potato harvesters, plastic mulch layers, etc.). The cultivating tractor, at 18-30 horsepower, is devoted to weed cultivation.

For farms less than 10 acres or for beginning operations, Whately suggests a two-tractor system consisting of the secondary, mid-sized tractor and the cultivating tractor. Primary tillage can still be accomplished using a slightly lower horsepower tractor or it might be contracted to a neighbor. At very small scales or for those just starting out, a one-tractor system would feature only the mid-sized tractor. A one-tractor farm is certainly viable; the biggest hazard is what happens when that tractor breaks down and there is no backup.

To update Whately's book, most vegetable growers growing 25 acres of vegetables today would likely recommend that the “large” primary tractor have perhaps 75 horsepower. Also, many vegetable growers above 15-20 acres appreciate having more than one cultivating tractor in order to leave specialized cultivating tools in place and ready to go. When the time is ripe for weed cultivation it pays to have equipment ready without time-consuming mounting and adjusting.

A tractor purchase can feel daunting but it is important to put the cost into perspective. Tractors can accomplish a multitude of tasks and should easily pay for themselves relatively quickly. As George DeVault writes for New Farm: “A grower's time and the physical wellbeing are two of the most precious resources around a farm. What a tractor saves in time and physical—and emotional—wear and tear on (a) farmer is priceless.” Many growers advise others to “buy as much of a tractor as you can afford.” That said, a first tractor does not have to have all the bells and whistles. The next section discusses desired tractor features.

Recommended Tractor Features

Before buying a tractor, it is very wise to make a list of all the tasks you want the tractor to perform and the implements you anticipate using. To encourage thinking about future needs, make two lists: one of all the things you definitely plan to do with a tractor right away and a second list of things you might want to possibly add in the future. These lists will help determine the right size for your tractor in terms of horsepower as different types of equipment demand different levels of horsepower and traction. Table 1, at the end of this publication lists horsepower requirements for various implements. Another important fundamental decision that will influence tractor model options is your planting scheme. Although wheel width is adjustable on most

tractors, the width of your beds will impact which tractors are best suited to your farming system—or vice versa: the footprint of your existing or desired tractor may impact the width of your vegetable beds.

The two most basic and important features to look for are a three-point hitch and power take-off (PTO).¹ Without these, a tractor is very limited in what it can do. The three-point hitch allows you to mount a wide variety of implements securely and efficiently. While older implements may only require a draw bar, virtually all modern implements used in vegetable production are based on the three point hitch. The three point hitch became common on tractors in the 1940s and 50s but was not standardized until after 1960.

The standardization of the three-point hitch involved classifying hitches in a series of categories. Each category of three-point hitch is designed for a specific range of tractor horsepower. As seen in table 1, below, each progressive category accommodates heavier pins in the mounting hardware of the implements to be mounted on the tractor. In most cases, a small to medium sized market farm will use a tractor and implements with a category 2 three-point hitch. See the diagram and table below. A PTO (power take-off) is necessary to transfer mechanical power from the tractor to implements such as tillers and mowers.

Figure 1: Three-point Hitch and PTO Diagram

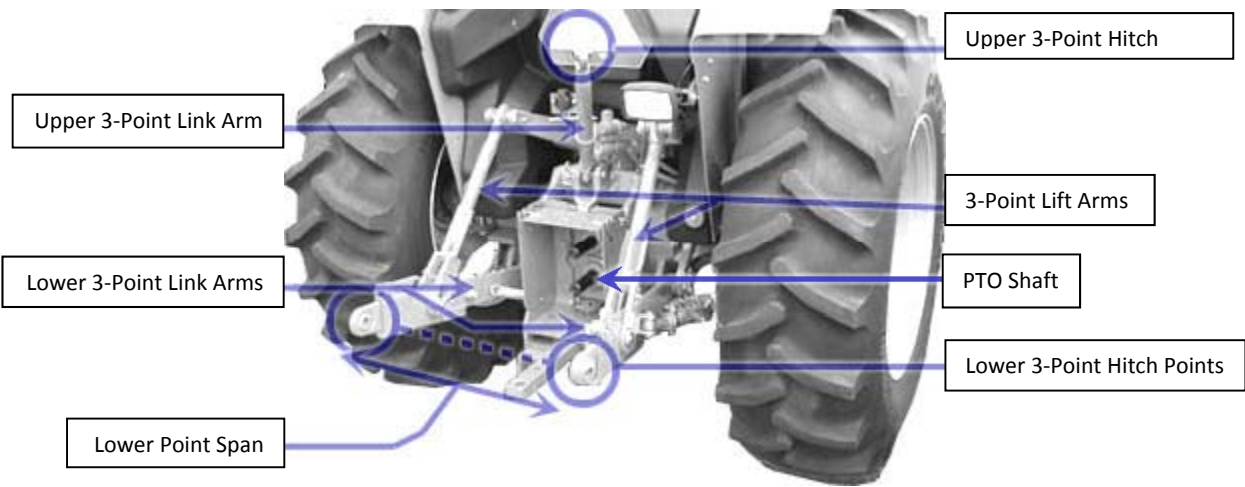


TABLE 1: Three Point Hitch Categories

Category	Hitch pin size		Lower hitch span	Tractor drawbar power
	Upper link	Lower links		
0	5/8 inch	5/8 inch	20 inches	Less than 20 hp
1	3/4 inch	7/8 inch	26 inches	20 to 45 hp
2	1 inch	1 and 1/8 inch	32 inches	40 to 100 hp
3	1 and 1/4 inch	1 and 7/16 inch	38 inches	80 to 225 hp
4	1 and 3/4 inch	2 inch	46 inches	180 to 400 hp

A wide front end is requisite on a vegetable farm in order to straddle crops and raised beds. Auction announcements and ads use the abbreviation WF to refer to tractors with the front wheels spaced so that they straddle a crop as opposed to narrow front (NF) or "tricycle" tractors that have the front wheel or wheels directly beneath the engine. Narrow front tractors are not only ill-suited to vegetable production but are dangerous as they are more prone to roll over accidents (more on safety issues and features below).

¹ See the glossary for an explanation of common tractor and implement names, terms, and abbreviations.

Other strongly desirable features include live hydraulics, low range or a creeper gear, and a front end loader. "Live" hydraulics refers to the ability to raise and lower implements when the clutch is engaged. A creeper gear permits driving the tractor at very low speeds, a useful feature when using a transplanter or certain types of tillage. Hydrostatic drive is another alternative that allows for very slow speeds. A front end loader is a bucket that can be raised and lowered and has many uses on the farm, most notably moving and handling compost, manure, gravel, or other heavy items. Power steering is very nice to have, especially for tractor operators with less upper body strength. Four wheel drive and hydrostatic drive are nice features indeed but can be pricey.² A four wheel drive tractor will boost the tractor's traction and allow it to handle bigger tasks than a two wheel drive tractor of the same horsepower. A quick word of caution on four wheel drive tractors, however is that they can cause a great deal of damage to soils if used in wet soil conditions. Last but not most importantly, safety features such as rollover protection (ROPS), PTO guards, and seatbelts are **strongly** recommended. ROPS became standard on newly manufactured tractors in 1985 so tractors built before then are unlikely to have this safety feature.

Looking for and Purchasing a Used Tractor

The first basic question to answer is whether you're going to buy new or used. There is also the important corollary: how used or how new? Tractors pre-dating 1940 are unlikely to have the horsepower and features to be satisfactory. An exception may be the common and relatively easy to find Ford 8n or 9n. These tractors have enough horsepower to pull two bottom plows and a variety of other small-scale implements and can be used effectively on 1-4 acre farm. They have their limitations, however, such as being quite low to the ground (thereby limiting their use and versatility on a diversified vegetable operation). They also will not have ROPS and other safety features.

One thing for beginners to note is that, unlike cars, a tractor's use and life is measured in hours, not miles. However, checking the hour meter is not like checking an odometer. What is considered heavy use in terms of hours depends in part on **what** the tractor was doing during those hours than the time itself. Tractors used extensively for front-end loader work are more likely to have more significant wear and tear. An even bigger factor is how the tractor was maintained over its hours of use. Depending on the farm, tractors may be used from 100 to 600 hours per year. The useful life of most tractors is generally around 12,000 hours, although this can vary substantially depending on how the tractor is used and maintained.

See Appendix A for a checklist of things to examine and consider when evaluating a used tractor.

When looking for a used tractor, be prepared to spend some time looking as it may take a while to find the right tractor in the right condition. One thing to keep in mind is the availability of parts and service. While there are some really neat looking older tractors around, if the manufacturer is no longer in business or is overseas, finding replacement parts and getting the tractor repaired may be difficult and expensive. It is best to stick with brands common and popular in your state or region.

There are generally three ways to buy a used tractor: at auctions, at dealerships, or classified ads. Generally, auctions may afford the opportunity for the best deals but finding the right tractor can be time consuming and requires the ability to quickly assess tractor condition and value. Newcomers to farming would be advised to find experienced friends and neighbors to help them evaluate tractors and make wise bids at auctions. Shopping via classified ads does not require traveling to auctions and, if you know what you are looking for, a wanted ad can be a good way to locate equipment. Buying from a known, reputable dealer may be the safest route because you can have assurance that the tractor has been examined and serviced. Finally, there are a number of websites where one can locate used tractors and implements. See the Resource section.

² When considering the price of tractors and features one may want to consider Joel Salatin's advice in his book [You Can Farm](#): the price difference between a slightly larger, more powerful, or 2 versus 4-wheel drive tractors is not that high compared to the overall purchase price.

Grey Market Tractors

The grey market refers to the trade of a commodity through distribution channels which, while legal, are unofficial, unauthorized, or unintended by the original manufacturer. In general, grey market tractors are used, possibly reconditioned tractors imported from foreign countries. There are many importers in the grey market business, mostly on the West coast. Many grey market tractors come from Japan. An Internet search for "grey market tractors" will yield various options. The main drawbacks to the grey market are that this typically involves tractors that were not built to U.S. safety standards, a lack of availability of parts and service, and—unless you are willing to travel to the West Coast to shop for such a tractor—you are likely going to be buying something based only on photographs and the word of a grey market salesperson. As the saying goes: 'buyer beware.'³

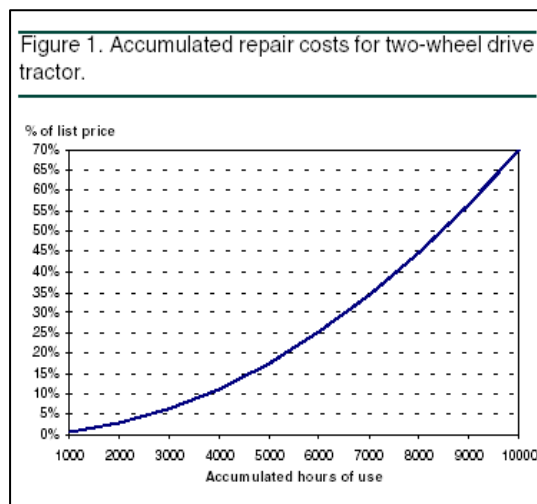
Buying a New Tractor

Some people buy new tractors. The price will be high but you will certainly know more about what you are getting as opposed to trying to evaluate a used tractor. Beginning growers with less mechanical experience sometimes find it appealing to buy new for this reason. One very nice feature of buying new is the potential for a warranty and service agreement with the dealer as well as the option of financing. Kubota, Case-International, and John Deere are likely to be three of the more likely options when buying new.

Maintenance, Repair and Opportunity Costs

How much does it cost to own and operate a tractor? This will obviously depend greatly on the tractor you purchase (new versus used), what it is used for, how it is cared for (regular maintenance such as oil changes and lubrication), and your own mechanical know-how. Figure 1 (at right) is excerpted from "Estimating Farm Machinery Costs" by William Edwards, extension economist, Iowa State University Extension (pub. no. A3-29; April, 2002). This figure shows how repair costs are likely to accumulate over time. Not surprisingly, as the number of hours of use increases, repair costs increase as a percent of the original price of the tractor.

In general, a used tractor will likely need more frequent and perhaps costly repairs so it is wise to factor this into the cost of a used tractor versus the price of buying a new tractor. If you are mechanically inclined and can do repairs yourself, great...but you also need to factor in the TIME this will require of you and also the opportunity cost if you miss tilling, seeding and cultivating deadlines because a tractor was not up and running when needed.



³ The following is excerpted from the Kubota website: "Used Kubota tractors, originally sold in Japan, are being imported into this country. These "gray market" units were not designed for sale in the United States. They were designed and manufactured for the Japan market and imported into the United States by individuals or entities independent of Kubota and without Kubota's authorization. These "gray market" units are different in several important respects from the tractors that Kubota makes for the United States, and which Kubota Tractor Corporation sells in the United States. These tractors are not ordinarily equipped with important safety equipment such as ROPS and seatbelt, PTO shield, safety decals, or operator's manual. Neither Kubota Tractor Corporation nor its affiliated company Kubota Corporation of Osaka, Japan, provides parts, service or any warranty support for Kubota "gray market" units in the United States. There is no responsibility whatsoever either by Kubota or its authorized dealers for these "gray market" units. Please be advised that since April 30, 1997, the importation, distribution and sale in the United States of Kubota "gray market" units under 50 PTO horsepower has been prohibited by a General Exclusion Order of the United States International Trade Commission."

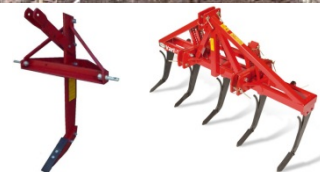
Primary Tillage Tools

Primary tillage refers to implements used for initial tillage of the soil following a cover crop or fallow period. There are 4 basic types of primary tillage tools in common use: the moldboard plow, chisel plow (or subsoiler), rotovator and spader.

The **moldboard plow** is a tool that turns under the top layer of soil. It has gotten a lot of bad publicity because it inverts the soil profile and leaves soil exposed to wind and rain and thus the risk of erosion. Used repeatedly without deeper tillage, it can also contribute to the development of a hardpan layer. These criticisms are certainly valid. Used properly, however, and in conjunction with other tools, a moldboard plow need not be viewed as necessarily negative. All tillage disrupts the soil in some way. The moldboard is certainly effective at turning under green manure crops and smaller plows can be found fairly cheaply. It is also possible to operate a moldboard plow and not completely turn the top layer under, a method sometimes referred to as ridge plowing. Growers on loose, sandy soils may find that the moldboard plow does not completely invert the soil.



The **chisel plow** (at right, top) is very unlike the moldboard plow. Rather than turning soil under, chisel plow shanks are narrow and "comb" through the soil with a lifting and slight rolling action. Chisel plowing improves soil drainage, breaks-up hard pan, and improves soil tilth. They are used prior to secondary tillage in areas where there is not significant material to incorporate or prior to moldboard plowing. A chisel plow does not fully incorporate residues. **Subsoiler** (2 photos at right, bottom) work even deeper than a chisel plow with an even more pronounced lifting of the soil but without any rolling or turning of the soil. Subsoilers require as much as 2.5 times more horsepower and good traction. They do not incorporate residue.



Rotovators are the tractor version of the rototiller. They feature a number of tines that revolve thereby pulverizing and mixing the soil. Rotovators quickly and thoroughly incorporate cover crops and cash crop residue, can cut through sod, and can also prepare a fine seedbed. They are the most common soil preparation tool on vegetable farms. That said, their use as a primary tillage tool should be limited because it is easy to overuse the rotovator. The pulverizing, mixing action is hard on soil structure and soil biology. The best approach is to consider the rotovator as a secondary tillage tool to prepare a seedbed rather than a primary tillage tool.



Spaders are becoming a more popular option for some growers concerned about the deleterious affects of rotovators. A true spader has a series of articulated shovels on a central crankshaft. Less horsepower is required because the shovels go into the soil one at a time opening and loosening the soil. The up-and-down action does not smear the soil unlike the rotovator. The articulated spader can invert the soil profile, and can be used to incorporate cover crops and other residue, although more than one pass might be required depending on soil type and amount of residue. It is relatively easy to use the spader to incorporate green material in more sandy soils. With clay soils it can be more difficult or impossible to achieve completely satisfactory results. In contrast, a rotary spader works more like a rototiller with the shovels revolving in a circle. This type of machine more quickly incorporates cover crops but can cause the same compaction and smearing as the rotovator.



Other Essential or Optional Implements

What is essential for you will depend on your situation and needs. Some implements to consider include:

Mower—This is likely the most frequently used of all tractor implements. A finishing mower is best for cutting a lawn while a rotary mower is good for more rugged use (field roads, edges, clearing brushy areas, etc.). For cover crops, a flail mower is most often ideal. Sickle bar mowers can be cheap but are not well suited for use on most vegetable farms. See the glossary for an explanation of these different types of mowers.

Seed drill—Many vegetable farmers have a seed drill (photo at right) to effectively plant and establish cover crops. At a small scale you can do this by hand or with a strap-on broadcast seeder. This might require having a simple harrow or cultipacker (see below) to lightly cover the seed and ensure good seed to soil contact unless you are at a very small scale and can simply rake in seed by hand.



Field digger, field cultivator, spring harrow—These are very useful for secondary tillage and working soil that is being prepared for cover crops or cash crops that do not require a fine seedbed. They can also be used to begin working an area that has been in cover crops and or cultivating weeds in an area that is in fallow. Newer units, like the Perfecta (at right), are very nice while older units can be easy and cheap to find.



Disk or disk-harrow—A very useful tool for working up ground and working in residue. Small, five to six foot, disks are not as effective as larger units so this may not be high on the priority list unless you have a decent sized tractor. Some growers decline to use the disk because, like the moldboard plow, they invert the soil profile and can contribute to hardpan. Used judiciously and in conjunction with chisel plows and subsoilers, they are a very effective way to cut-up and lightly incorporate residue from a previous crop or cover crops. On sandy soils, they may be all that is needed to prepare a decent seed bed.



Cultipacker—An implement with a set of meeker disks and/or shallow tines used to lightly incorporate cover crop seeds and compress the soil to ensure good seed to soil contact thus ensuring good germination and a good stand.



Spreader—Used for spreading manure, compost or other materials. Older models are ground driven (meaning that the wheels of the spreader drive the moving parts that discharge material) while newer models are most often PTO-driven. Spreaders are either rear discharge or side discharge. Some spreaders are especially designed to handle liquid manure. Unless you have animals on your farm, or make and spread lots of compost regularly, a spreader is likely an item that can be borrowed, rented or the spreading can be done by a neighbor who is bringing manure to your farm. A drop spreader is an implement designed to handle a range of finer fertilizer materials.

Mulch Layer—A mulch layer is a tool that lays plastic mulch. Two disks open furrows, the plastic is rolled out, and then another set of disks bury the edges. Most larger, commercial organic farms use plastic mulch extensively and this tool is relatively simple and inexpensive. Most will also lay irrigation drip tape at the same time.



Plastic Lifter—A lifter aids in removing plastic mulch but these tools also make excellent under-cutters for crop such as garlic, beets, and other root crops.

Potato Digger—Most Potato diggers are designed with a shoe or shovel at the front end to lift tubers out of the ground followed by a chain to convey and jostle soil off the potatoes before they are either deposited in a bin or simply on the ground behind the implement. Some diggers can handle additional crops such as onions, beets, etc. Manufacturers include: Willsie, Zaga, and many others.



Cultivators—There are many, many different types of cultivation tools to remove weeds. An excellent DVD is available called Farmers and Their Weed Control Machines available from the University of Vermont. The following on-line publications provide descriptions, uses, and sources:

<http://www.uvm.edu/vtvegandberry/factsheets/orgweedmgmt.html>

<http://www.hort.cornell.edu/bellinder/publications/CultTools1.pdf>

<http://www.hort.uconn.edu/IPM/weeds/htms/weeders.htm>

Spike Tooth Harrow—These are not very commonly used anymore unless they are part of a larger cultivating unit. These feature many short spikes that comb through the soil and break up clods of soil to prepare an area for planting. They can also be used to lightly work in broadcast cover crop seeds. Likely not a priority item but old small units can be very cheap if not free.



Scraper blade—usually rear-mounted, these are useful for many tasks including plowing snow and smoothing and leveling ground. A blade may not be required for vegetable farming but on a rural homestead they can be very nice to have around. Used ones are often available at auctions.



Post-hole digger—this is an item than can likely be rented when you need it rather than owned, unless you anticipate needing to do lots of fencing on a regular basis.

Tire Chains—Although not an implement, tire chains are practically essentially in any northern, snowy area if you'll be using your tractor to plow snow.

Glossary of Terms⁴

3-point hitch—A hitch for holding, lifting and lowering implements. As the name suggests, the implement is attached to the tractor at 3 points (a triangle) which offers stability and strength. A 3-point involves two side arms and a top link. On newer tractors, all three arms are adjustable allowing one to adjust where and how an implement trails behind the tractor. Adjusting the top link controls the level or horizontal pitch of the implement. There are two main types of 3-point hitches, Category 1 and Category 2. Smaller tractors usually have Cat I. It is important to know which you have in terms of matching them with implements. Some garden tractors have a category 0 hitch and very large agricultural machinery may have Category 4. The higher the number the larger the hitch and connecting pins and it will be made from stronger components.

PTO or Power Take-off—The PTO is the means by which a tractor transfers power to an implement. It is a drive shaft that sticks out the back of the tractor which can power implements with moving parts, such as a rototiller, manure spreader, mower or hay bailer. As noted by George DeVault, the PTO is likely "the most dangerous feature of any tractor. The PTO shaft on most tractors spins at 540 revolutions per minute. At that speed, hair, loose clothing or anything else that gets tangled can wrap itself around the shaft nine times in just one second." PTOs on older tractors deserve extreme caution as they are often not fitted with the safety features standard on newer tractors.

Hardpan—a smeared and/or compacted layer of soil caused by repeated use of the same type of tillage implement over time that prevents moisture and roots from penetrating deeper into the soil.

Hydraulics and Live Hydraulics—Hydraulic arms are used on tractors to raise and lower hitches, belly-mounted cultivators, and front-end loader buckets. Pistons and cylinders filled with pressurized oil provide the lifting power. The term "live hydraulics" refers to the ability to operate hydraulics without having the PTO engaged. Older tractors utilize the power from the PTO to create oil pressure to operate hydraulic arms. Thus, on a

⁴ Some of this material was adapted from "the Small Tractor FAQ" <http://www.andrew.cmu.edu/user/kb13/glossary.htm>

tractor with live hydraulics, the lift arms can operate even when the clutch is disengaged. This is a nice feature to have when operating a front end loader.

Narrow front versus wide front—Common abbreviations in classifieds and elsewhere, NF and WF, refer to tractors with wheels placed close together and right underneath the engine in a tricycle formation (NF) versus having the wheels spaced apart to straddle crops or a raised bed (WF). Not only are narrow front tractors less safe on a hillside, on a vegetable farm, a wide front is essential. About the only thing going for a NF tractor is that it might be cheaper and it will have a tighter turning radius. With kits and parts, many NF tractors can be converted to WF but before you buy check on part availability.

Off-set Engine—A engine that is mounted to left side of a tractor so that the operator has a clear view of the ground below the tractor for accurate, close cultivation.

Fast Hitch, Quick Hitch— Two-point hitch alternatives found on some older tractors. They are inferior to the 3-point hitch and find implements for them may be difficult and will certainly limit options. All newer tractors have 3-point hitches that are standardized.

Grey market tractor—A used, reconditioned, imported tractor.

Flail Mower— A mower with many free-swinging, L-shaped knives attached to a horizontal shaft. A flail mower chops cover crops in small pieces allowing for quicker decomposition and incorporation. Many flail mowers have shoots to blow chopped forage into a wagon. If this is not desired, the shoot can be closed or the back opened up to allow the chopped material to fall to the ground. Example manufacturers: Befco, Vrisimo, Land Pride, John Deere.

Sickle Bar Mower—A cutting implement that functions like a large hedge trimmer with a set of reciprocating knives on a bar. The cutting bar extends out to one side of the tractor and cuts just above ground level. These are not all that useful on a vegetable farm as they were made for cutting hay in preparation for raking, drying, and baling.

Brush mower (Brush hog/Rotary mower) —These mowers have one or more blades that spin perpendicular to the ground like a normal lawn mower. They are heavy duty to handle dense stands, brush, and saplings. They are most useful for pathways and perimeters rather than field work.

Finishing Mower—A rotary mower designed to cut a lawn. Can be used to cut some cover crops but not intended for rugged use.

Tool Bar— As the name implies, this is a metal bar for mounting tools to a tractor. A tool bar might be at the front, middle (belly), or rear of the tractor. A multitude of different cultivating tools can be mounted to a tool bar. Some tool bars are single units while other implements may have multiple tool bars to position a large number of tools.



Draw bar—A flat horizontal metal bar at the rear of a tractor used for pulling wagons or implements that are not mounted using a three point hitch.



Horsepower— This is a measure of power and indicates a machine's ability to move a load. When comparing HP ratings and determining if a tractor has enough HP for your purposes, it is important to ensure you are comparing apples to apples. Listed or published horsepower ratings may refer to engine (or *indicated*) HP, PTO HP, or drawbar HP. The indicated horsepower of an engine is higher than the horsepower at the PTO shaft and this is greater than what is available at the toolbar for pulling an implement due to losses of power due to friction in the engine, transmission inefficiencies, rolling resistance and tire slippage. Drawbar horsepower (or *effective* horsepower) is the important figure to consider. The advertised horsepower of modern tractors is usually PTO horsepower while the horsepower of older tractors was generally measured at the drawbar.

Rope trip implements—Rope trip implements are from an earlier era and allow the tractor driver to raise and lower an implement such as a moldboard plow or field digger without getting off the tractor. This technology predates the use of hydraulics. While hydraulics are more advanced and likely preferable, many rope trip implements are perfectly acceptable and usable on a market farm.

Hydrostatic transmission—This eliminates the nuisance of changing gears and is especially useful when reversing direction often. A hydrostatic transmission is much safer than a clutch-activated power train and is very helpful for loader work. However, it consumes 15-20% of engine horsepower.

Power steering—As in a car, power steering makes steering much easier, especially when the tractor is stopped or moving very slowly. Power steering is essential for front loader work.

Resources⁵

Tractorhouse

www.tractorhouse.com

Nationwide new and used tractor and implement website. Post "wanted to buy" ads or search or browse classifieds. Useful to gauge prices for various makes and models and locate machinery locally and regionally.

Yesterdays Tractors

www.ytmag.com

Web site on older tractors with lots of pictures, discussion forums, info on repairs/restoration, etc.

TractorByNet

www.tractorbynet.com

Reviews, photos, classifieds, and dealers (especially for compact tractors)

Tractor Blue Book

www.pricedigests.com/other/tractorbluebook.htm

One source for used tractor values. \$24.95

Market Farm Implement

www.marketfarm.com/index.cfm

New and used implements for vegetable farming.

Roeters Farm Equipment

www.roetersfarmequipment.com

Specialize in new and used vegetable and farm equipment sales. They salvage antique tractors and equipment and hard-to-find equipment parts.

Buckeye Tractor

www.buctraco.com

Manufacturer of specialized agricultural equipment

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⁵ No endorsement of listed businesses or products is intended, nor is criticism implied of those not mentioned

TABLE 1: Horsepower Requirements for Tillage Tools and Other Implements¹		
Implement Type	Horsepower Required	Notes
Rotovator	$\frac{3}{4}$ hp per inch of tillage width ²	See Primary Tillage Tools text and notes below
Spading Machine	40 hp to 70 hp	Depends on make and model. Higher hp rated machines till deeper.
Chisel Plow	10 hp per shank ³	3, 4, 5, or 7 shank plows are common on market farms
Subsoiler	25 hp per shank ³	1, 2 and 3 shank models are common
Moldboard Plow	10-20 hp per plow share ⁴	Three-bottom plows require significant horsepower (70 plus) and very good traction.
Tandem Disk	5 hp per foot	Heavy duty disks require 8 to 10 hp per foot
Field Cultivator / Spring Tooth Harrow	4 to 5 hp per foot	
Flail Mower	5 to 10 hp per foot	Upper end of range is best esp. if cutting thick, dense cover crops.
Potato Digger	18 to 20 hp per row	
Bed-shaper (for raised beds)	5 to 10 hp per inch of bed height	The Lesche bed shaper can be handled by low hp tractors, requiring only 25 hp for a 4' bed.
Plastic Mulch Layer	7-10 hp per foot of bed	
Raised Bed Plastic Mulch Layer	15 to 20 hp per foot of bed	Depends on model of layer and height of raised bed.
Grain drill	2 hp per foot	
Sprayer	Less than 1 hp per foot	

1: Horse power needs below are for standard 2-wheel drive tractors. Horsepower requirements will be reduced by as much as $\frac{1}{2}$ if you have 4-wheel drive. Actual horsepower needs will vary based on soil type and traction. Tire tread, tractor weight, soil conditions and other factors will impact traction.

2: Actual horsepower needs will depend on the make and model of the tiller, soil type, and tilling conditions. For example, if another primary tillage tool is used prior to rototilling (chisel plowing for example) this will reduce the horsepower requirement. It is very important to buy a tiller that can be powered by your tractor but it is also true that too much power can be a problem. Tillers have maximum horsepower ratings. The $\frac{3}{4}$ HP per inch of tilling width is a rough guideline and can help ensure that you buy a tractor with enough power to handle various tillage tasks.

3: Subsoilers and Chisel plows also require good tire traction.

4: The Lesche bed shaper can be handled by low hp tractors, requiring only 25 hp for a 4' bed.