Engineering a Modern Vineyard Trellis

by
Thomas J. Zabadal

A vineyard trellis is often the single largest cash expense in the establishment of a vineyard. Not only does trellis construction impact on the economics of vineyard establishment but it also can very significantly influence the long term productivity and profitability of a vineyard. A wide range of materials may be used to construct vineyard trellises. Too often little thought is given to the important characteristics of a vineyard trellis. Durability is important. The real cost of a vineyard trellis should be calculated on cost per year of service rather than simply cost per acre. Vineyards that require considerable annual maintenance of trellises and frequent replacement of trellis components are inefficient and unnecessary with today's technology. The performance of the vine itself is influenced by trellis construction. Does a specific trellis promote good canopy management with well exposed leaves and when desired, well exposed fruit? Does the proposed trellis facilitate efficient performance of vineyard tasks? The trend towards increased mechanization of vineyard tasks and the need for precise vine structure to perform these tasks depends on the vineyard trellis. If vineyard rows aren't straight, vineyard wires are sagging and vine trunks are crooked, then the ability to precisely manage this vines is jeopardized. Today it is possible to establish a durable, cost efficient trellis in a cool climate vineyard. The following information will help growers achieve that goal.

I. <u>TRELLIS POSTS</u>

Trellis posts are a major cost component in the establishment of a new vineyard. One's choice of trellis post materials will be influenced by the types of posts available, the post installation equipment available, one's choice of a vine training system, cost and personal preference.

<u>Metal posts</u> - Metal vineyard trellis posts are an attractive option because they are relatively easy to handle and to install and their cost can be competitive with wooden posts. Although there are metal posts specifically fabricated for trellis use in some viticultural regions, those in use in midwest vineyards are generic types which are typically used for fencing. The limitations of metal posts in vineyards include their questionable lateral strength for supporting large vines and crops, and the difficulty of adapting them to more complex trellis designs. Relatively new specialized vineyard metal post products may overcome these limitations. However, their durability under midwest conditions is unknown. Growers have occasionally installed metal posts in a predominantly wooden post vineyard to serve as grounding rods against lightning strikes on vineyard rows. The worth of that strategy is undocumented.

<u>Wooden posts from native tree species</u> - A half century ago, vineyard trellis construction was dominated by the use of posts cut from native tree species. These posts

were occasionally subjected to on-farm preservative treatments at times but often they were used untreated. Most of the native tree species found in a farm woodlot are very poor choices for vineyard trellis posts. Although a few native tree species have durability that make them a viable candidate for vineyard trellising, random selection of trellis posts from native tree species is likely to result in failure of posts in 10 years or less and in many cases 4 to 6 years.

The cost effectiveness of a trellis post is best evaluated on the basis of its total cost per year of service. Total cost is the cash cost of the post plus the labor required to put that post into service. When expressed in these terms, some posts with relatively low purchase price may be very costly per year of service.

One must consider not only which native tree species are suitable for trellis posts but also the quality of the wood in individual posts. Sapwood is the lighter colored outer portion of a tree. Heartwood is the darker colored interior portion of a tree. It may contain substances that make this wood less susceptible to decay. White cedar is a native tree species that is still used for vineyard trellis posts. When these posts have 80% or more of their cross sectional area composed of heartwood, they have a life expectancy of 20 years or more. However, white cedar posts with relatively little heartwood, such as those typical of a so-called second growth wood lot, may fail in as little as 5 years. This is why the reputation of white cedar posts is so variable.

Black locust is the woodlot tree species most frequently utilized for vineyard trellis posts. Split posts from large black locust trees, which contain a very high percentage of heartwood, typically provide more than 20 years of service. They have even been documented to be in service more than 50 years. In contrast, locust posts from a suckering second growth, which have very small proportions of heartwood, may fail in less than 10 years. The sapwood of black locust has a very yellowish coloration and some "veteran" grape growers refer to black locust posts with considerable sapwood as being "yellow locust posts". Black locust posts become very hard when they are fully seasoned. Therefore, some growers install staples on black locust posts before they become fully seasoned. On-farm preservative treatments of native tree species, especially white cedar, were fairly common in years past. Reference materials from the USDA and other sources provided recipes for this type of activity. This is rarely practiced today.

<u>Pressure Treated Wooden Posts</u> - Wooden posts which have been commercially injected under pressure with a preservative are the predominant type of trellis post used in midwest vineyards today. Both red pine or southern yellow pine are used for these posts. Although these posts would fail in 4 to 5 years if they were not preservative treated, with proper treatment these posts typically have a 20 to 30 year life expectancy. Characteristics that will influence this life expectancy include the diameter of the posts, the type of preservative used, the amount of preservative used for unit volume of wood and the vineyard site. Pressure-treated wooden posts are typically sold in categories according to the minimum diameter at the smallest end of the post. The cost of a pressure treated post increases rapidly as its minimum diameter increases (Table 1). Therefore, a fundamental

question in growers' minds is, "What minimum diameter is adequate for a trellis post?" Several factors, as now discussed, influence the answer to that question.

Post Strength and Durability

The strength of a post is proportional to its cross sectional area. For example, the cross sectional areas of 2.5" and 3.0" diameter posts are only 39% and 56% of 4" posts and their measured lateral strengths are only 25% and 42% of a 4" post, respectively (Table 1). The ratio of a post's surface area to its volume decreases as the diameter of a vineyard post increases.

Because the surface area of a post determines its rate of leaching and weathering of the preservative, as a post diameter decreases, the rate of post decay increases. Therefore, both the initial strength of a post and its life expectancy increase dramatically with increasing diameter. The cost of posts is often also directly related to their cross sectional area (Table 1). A 3 1/2" minimum diameter post is often be guaranteed for 30 years of service. Therefore, many growers elect to install this size post for line posts. A 4" diameter post with a lateral breaking force of 970 lbs. (Table 1) will be adequate for line posts when they are new and if they are anchored so tension on load bearing wires is transferred to the anchor. However, as 4" posts decay and/or if anchoring is inadequate, lateral forces in excess of 970 lbs. are likely to cause post failure. Therefore, growers often choose posts with diameters somewhat greater than 4" for end posts. For example, posts with 5" or 6" diameter will have lateral breaking strengths that are twice or more than three times that of a 4" diameter post, respectively (Table 1).

Table 1. The cross sectional area, lateral breaking force and percentages of those values as compared to a 4" diameter post for pressure treated pine posts in six diameter classes.

Post Dia.	Cost		Cross Sectional Area		Lateral Breaking Force[1]	
(in)	(per post)	(% of 4")	(in^2)	(% of 4")	(lb)	(% of 4 ")
2.5	-	-	4.91	39	238	25
3	2.22	59	7.07	56	408	42
3.5	2.87	76	9.62	77	-	-
4	3.75	100	12.57	100	970	100
5	5.22	139	19.64	156	1893	195
6	-	-	28.27	225	3268	337

[1] Average pressure applied 4' above ground to cause the post to fail. Adapted from "How to Build Trellises with USS Max-Ten 200 High-Tensile Fence Wire U.S.S. Catalog T-111575.
[2] Wholesale price of red pine, CCA treated posts as of April, 1996.

The two most common chemical preservatives used today for pressure treating pine posts are pentachlorophenol (PCP) and chromated copper arsenate (CCA). PCP posts are impregnated with a petroleum oil base while CCA treated posts are impregnated with an aqueous solution. The American Wood Preservers Association establishes standards for the minimum amount of these materials that should be impregnated into wood to ensure long term resistance to decay. For both PCP and CCA, this standard for vineyard posts is 0.4 pounds of material per cubic foot of wood. Certificates of treatment and/or service life guarantees may be associated with pressure treated post products. Growers should work with their suppliers to obtain these assurances for this costly part of vineyard establishment. If there is a doubt as to the extent of preservation treatment when purchasing large quantities of pressure treated posts, it is possible to have a post sample analyzed by a private laboratory.

Quantities of Posts Required Per Acre of Vineyard

The quantity of posts required per acre of vineyard will depend upon the row spacing, the distance between posts, and the number of rows required to plant an acre of vineyard. Considerations for row spacing are discussed elsewhere. The distance between posts is dominated by the tendency of wires and vines to sag in the middle of post length as the distance between posts increases. Although the extent of sagging of wire, vines and crop can be influenced by the amount of tension put on trellis wires, the gravitational force that causes sagging cannot be totally eliminated. Increasing tension on the trellis wires beyond a certain point (see section on tensioning of wires) will not greatly diminish this sagging and will only lead to excessive tensions on wires during periods of heavy crop loads and/or wire contraction during cold weather. Therefore, control of sagging of wires and vines is primarily determined by the distance between line posts in a vineyard, which should ideally not exceed 21 feet and never exceed 24 feet. Table 2 presents values for the number of vines per acre, vines per post length, post length and posts per acre for several row and vine spacing combinations. Depending upon one's choice of row spacing, vine spacing and vines per post length, the number of posts required per acre of vineyard ranges from 196 to 356 per acre.

Table 2. Ground area per vine, vines per acre, vines per post length, post length, and posts per acre for several row and vine spacing combinations.

Row x vine spacing (ft)	Ground area per vine (ft^2)	Vines per acre	Vines per post length	Post length (ft)	Posts [1] per acre
10 x 8	80	544	3	24	196
10 x 8	80	544	2	16	287
10 x 7	70	622	3	21	222
10 x 6	60	726	4	24	197
10 x 6	60	726	3	18	257
9 x 8	72	605	3	24	217
9 x 7	63	691	3	21	245
9 x 6	54	807	4	24	217
9 x 6	54	807	3	18	284
9 x 5	45	968	4	20	257
8.5 x 8	68	641	3	24	229
8.5 x 8	68	641	2	16	335
8.5 x 7	59.5	732	3	21	259
8.5 x 6	51	854	4	24	229
8.5 x 6	51	854	3	18	300
8 x 8	64	681	3	24	242
8 x 8	64	681	2	16	356
8 x 7	56	778	3	21	274
8 x 6	48	908	4	24	242
8 x 6	48	908	3	18	318
8 x 5	40	1089	4	20	287

[1] Value assumes 15 continuous rows per acre of vineyard.

Installation of Line Posts

Posts installed within the grape rows are called line posts. Installation of these posts is most easily accomplished when there is good but not excessive soil moisture. Vineyard posts should be installed with their largest diameter down in the soil because this portion of the post will decay more rapidly than the above-ground portion and ultimately cause the failure of the post. In some viticultural areas vineyard posts are sharpened at their bottom end either prior to purchase or on the farm. This is especially useful when the posts are being pounded into heavy soils either with a hydraulic post pounder or with a post maul. In contrast, vineyard posts are rarely sharpened when they are installed in Michigan's light sandy soils. Hydraulic pounding of posts is advantageous because it can be performed relatively rapidly (several times faster than augering), the posts can be set to a precise desired depth and they are firm in the ground from the time they are installed.

Augering of post holes for line posts is also common. It requires less expensive equipment than post pounding. The soil tends to backfill around posts installed in augered holes on light soils relatively quickly to firm up the posts. However, posts installed in augured holes on heavier soils can be relatively loose for long periods. For small back yard plantings, a hand-held post hole digger is a common approach. The combination of a crowbar and post maul is another easy method for installing a small number of posts or replacing occasional posts. To use this technique, begin by punching and then "augering" with a circular motion, a hole with the crow bar. Finish the job with a post maul. A post maul is a specialized sledge hammer with a head-face that may be up to 4 inches in diameter. When using this venerable tool, it is common to stand on the trailer which was used to carry the posts into the vineyard or some other elevated platform.

End Post Anchoring

All material preparation and trellis engineering skills will be for naught if the end posts are not well anchored. End posts function differently than line posts because they are actually subjected to a lateral breaking force. Tension that develops in the load bearing trellis wires is transferred to the end post. An end post that is not anchored or braced will react to the tension by creating a fulcrum at the soil line. A post may develop curvature in response to this tension or it may be pulled through the soil. If end posts are strong enough and set deep enough in the soil to resist these tendencies, they will perform well without additional engineering. For example, large diameter poles or railroad ties have been set into the ground 4 feet or more and used in this manner without any anchoring mechanism. More commonly an end post is chosen for adequate but not excessive breaking strength and used in combination with an end post anchoring or bracing system. The data in Table 1 indicate that an increase in diameter of one inch approximately doubles a post's lateral breaking strength. Four inch diameter posts should be considered a minimum requirement for an end post and a 5" - 6" diameter end post is an excellent choice when used in conjunction with a well engineered anchoring system. End posts are typically installed at an angle to a depth of 3 feet (Figure 1) and then anchored in that position. Installation of the end posts can be accomplished either through augering or post pounding. One method to insure that end posts will line up properly is to first install the end posts on the two outer rows. Then lightly tension a wire between these posts as a guide for the installation and angling of end posts for the interior rows. When installing end posts in a large number of rows, end posts on some inner rows will provide additional guides for installation. Angling end posts 60 ^{o} from horizontal (Figure 1) will transfer of tension from load bearing wires to the anchor at a wider angle than if the post were upright. The more vertical an end post is installed and the closer anchors are placed to the end post, the greater the tendency for the tension of the trellis wires to pull the end post upward and inward.

There are several good approaches for constructing end post anchors. Bracing end posts within the row is advantageous because it avoids possible conflict with equipment in the headlands. However, this approach is generally more complex and more costly to install. Anchoring external to the end post is the most common method of constructing an end post assembly. Desirable characteristics when installing anchors include: (a) Attach the anchoring wire as close as possible on the post to the main crop bearing wire. This minimizes the transfer of tension down the post and reduces the tendency of the point of attachment of the anchor acting as a fulcrum. (b) Angle the anchoring wire to avoid a narrow angle between the post and this wire. If the anchor is installed too close to the post, it may keep the post from raising up but not from being pulled into the row. (c) Install the anchor so that its shaft rests in line with the anchoring wire. Otherwise there will be a tendency to pull or bend the anchor shaft through the soil when tension is applied until it achieves this in-line orientation. (d) Install the anchor deep enough and with an anchor plate of adequate surface area. Use a minimum of 30 inch vertical depth for the anchor plate, which should have a minimum diameter of 6 inches. (e) Use a double stranded # 9 wire or the equivalent for the anchoring wire. This will ensure that this will not be the weakest point in the assembly. Reinforcement rod (3/8" diameter) has also been used very effectively. A loop is bent and welded in the shop at one end of a 7 foot piece of rod. This loop is slid over the post and held with a staple. The other end is bent with a torch through and around the loop in the anchor. (f) Make sure that the anchoring plate is in contact with firm, undisturbed soil. When augering holes in to which anchors will be set, auger a vertically oriented hole. Then make a narrow slit in the soil with a crowbar that angles from that hole up to the point of attachment of the anchor to the post. The shaft of the anchor will reside in the slit in the soil and the plate of the anchor will sit firmly against undisturbed soil on the sidewall of the augered hole (Figure 1).

End post anchoring systems should be in place no later than the start of the third growing season of the vineyard and ideally by the start of the second growing season. Final tensioning of trellis wires is made after construction of anchoring system is completed.

II. WIRE FOR TRELLISES

<u>Wire Characteristics of Importance For Use in Vineyard Trellises</u>

For many decades the purchase of wire for vineyard trellises has focused on two characteristics of wire, gauge and corrosion resistance. Growers intuitively know that the gauge of a wire determines its ability to support a load. Because most wire used for vineyard trellises is made of steel, it is also readily apparent that galvanization of wire is desirable. Because agricultural buyers of wire including grape growers often do not look beyond those two wire characteristics, manufacturers have historically sold odd lots of wire under the designation "agricultural wire".

Improved materials and technology make it possible to install vineyard trellis wires which are no more expensive but improve vine management, reduce trellis maintenance costs and lengthen life expectancy of the vineyard trellis when compared to traditional approaches. The following information will assist growers in the proper choice and installation of trellis wires.

The tensile strength of a wire is a measure of how much pulling (tension) is required on that wire to cause it to break. The tensile strength of a wire is determined by the alloy mixture used to make the wire. Traditional vineyard wire for many decades has been relatively soft, so-called low carbon wire. Today vineyard trellises are increasingly being constructed with stiffer, harder, high-tensile (high carbon) wire. The tensile strength of which is reported as the pounds of pull (tension) that would be required to break a wire if it had a cross sectional area of one square inch. Traditional soft vineyard wire typically has a tensile strength rating of about 65,000 pounds per square inch (psi) whereas high-tensile wire has a tensile strength in the range of 200,000 psi. The strength of a wire to resist breaking is directly proportional to its cross sectional area. Therefore, the breaking point of a particular gauge of wire is determined by its tensile strength multiplied by the cross sectional area of the wire. For example, a soft #9 wire with a tensile strength of 65,000 pounds and a cross sectional area of 0.0172 in^2 would have a breaking point of 65,000 x 0.0172 = 1,118 pounds. Growers often buy large diameter (lower gauge number) wires with large cross sectional areas to obtain large breaking point values for the major load bearing wires of the trellis. However, wire does not simply resist all tension until it reaches its breaking point. Rather, as tension is put on wire, it first begins to stretch. If a small amount of tension is put on a wire it will stretch and when that tension is released, the wire will contract to its original length. However, as the tension is increased on a wire, it will increasingly stretch until at some tension a portion of that stretching becomes irreversible. When that happens the wire has exceeded its yield point. The yield point of a wire occurs at a lower tension that its breaking point. Depending upon the type of the wire, the yield point of a wire will range from 66% to 85% of the tension of its breaking point. The importance of the yield point of trellis wire has only been recognized in recent years. Relatively modest lengthening of trellis wires will cause them to sag considerably between trellis posts. When that happens the vines attached to those wires will also sag. This leads to bowing of vine trunks. Such distorted trunks make equipment access to the vineyard more difficult as well as make the target for mechanical pruning, hilling up and taking out around vines and other tasks more difficult. There is also the matter of trellis maintenance. Wires that have stretched will need retensioning. Vines with cordon training systems may be so embedded into vines that retensioning may not be possible. Lastly, consider the impact of the stretching on the wire itself. When stretching occurs, it reduces the cross sectional area of a portion of the wire slightly. That portion of wire will have a lower yield point and breaking point. Therefore, a repeated occurrence of irreversible wire stretching (leading to eventual breakage) will occur at a lower tension. For all these reasons it is in the grower's best interest if trellis wires are installed with consideration of their yield points and not their breaking point. If a wire never reaches its yield point, none of the above problems will occur. One can avoid reaching the yield point with low-carbon, soft wires by increasing the diameter of wire. However, purchasing a large diameter, soft wire to obtain a higher yielding point wire may not be cost effective. High-tensile wires have yield points which are approximately double that of soft wires for the same diameter (gauge) of wire (Table 3). Therefore, a grower can use a higher gauge (thinner) high-tensile wire and have the same yield point to resist stretching as a smaller gauge (thicker), soft, low-carbon wire. For example, a high tensile 12.5 gauge wire and soft 9 gauge wire have approximately the same yield points of 1063 psi and 1118 psi, respectively (Table 3). In summary, the value of wire types for trellis use should be based on their yield points and the cost per foot (Table 3) rather than their breaking points and/or cost per pound.

Table 3. Characteristics and cost of several kinds of wire typically used in the construction of vineyard trellises.

Wire type	Wire ga.	Dia. (in)	Cross Sec-tional Area (in^2)	Tensile Strength[2] (PSI)	Breaking Point [3] (lb)	Yield Strength[1] (PSI)	Yield Point[4] (lb)	Feet/ lb	Cost/ lb[5]	Cost/ foot [5]
Low carbon	12	.106	.0088	77,000	678	65,000	572	33.7	.60	1.8
Low carbon	11	.121	.0115	77,000	886	65,000	747	26.3	.60	2.3
Low carbon	10	.135	.0143	77,000	1101	65,000	929	20.6	.60	2.9
Low carbon[1]	9	.148	.0172	77,000	1324	65,000	1118	17.1	.60	3.5
High tensile - crimped	11	.121	.0115	210,000[2]	2415	138,000	1587	25.8	.65	2.5
High tensile	10	.135	.0143	200,000[1]	2860	138,000	1973	20.6	.55	2.7
High tensile	11	.121	.0115	200,000[1]	2300	138,000	1587	26.3	.55	2.1
High tensile	12	.106	.0088	200,000[1]	1760	138,000	1214	33.7	.55	1.6
High tensile	12.5	.099	.0077	200,000[2]	1540	138,000	1063	38.2	.60[6]	1.6
High tensile	14.0	.080	.0050	200,000[2]	1000	138,000	690	58.6	.93[6]	1.6
High tensile	16.0	.062	.0030	180,000	540	124,200	373	119.6	1.70[6]	1.4

[1] Values based on yield and tensile strength data from "Mechanical Engineering Design" by J.E. Shigley, 1963.
[2] Minimum tensile strength rating supplied by manufacturer.
[3] Breaking point = tensile strength / cross sectional area in inches.
[4] Yield point = yield strength / cross sectional area in inches.
[5] Local supplier prices in Southwest Michigan as of April, 1996.
[6] Supplier price as of Jan., 1997.

Another quality of wire that is important to the grape grower is its ability to resist corrosion. Most vineyard wires are made of steel. As steel wires rust their tensile strength and yield strength are reduced. The less protection afforded to the surface of these wires against corrosion (rusting) and the smaller the diameter of the wire, the more rapid this process will occur. Small diameter wires without corrosion protection can loose more than half of their tensile strength in less than five years. Zinc galvanizing is the typical approach to protect steel wires. The highest quality of galvanization of steel wires as specified by the American Society of Testing Materials (ASTM Designation A116-57) is a type 3 galvanization which specifies the ounces of zinc required per square foot of wire surface for this process. With this treatment wires may resist the onset of rusting for up to 30 years. When using other types of wire such as aluminum or plastic, growers should obtain assurances of their durability to resist corrosion or ultra-violet light degradation.

Amount of Wire Required

A number of wires required to construct the trellis will range from 1 to 10, depending upon one's choice of a vine training system and the approach taken to implement that training system. Trellis wires generally serve two functions. They either are major crop and vine supporting wires or they are so-called catch wires, which help orient the structure of the vine but do not support much of its weight. Load bearing wires should be chosen with considerable attention given to the value of their yield points. Catch wires have less demanding specifications and can be chosen on the basis of cost per foot of wire and durability.

When deciding how many wires to provide for a vineyard, it may be useful to simply know how many feet of wire there are per pound of wire. That information is provided in Table 4. After a grower decides the type and number of trellis wires to be used in constructing a trellis, information provided in Table 5 will help determine quantity of wire required per acre of vineyard.

Table 4. Feet of wire per 100 lbs for several gauges of wire used in trellis construction.

Gauge	Feet/100 lbs
9	1724
10	2070
11	2617
12	3300
12.5	3846

Table 5. The length of trellis per acre and the pounds of wire for one wire per acre for combinations of five gauges of wire and seven vineyard row spacings.

Vineyard Row spacing (ft)	Trellis length/ acre (ft)	Pounds of wire for one wire/acre				
		9	10	11	12	12.5
6	7260	425	352	276	215	190
7	6223	364	302	237	185	163
8	5445	318	264	207	162	143
8.5	5125	300	249	195	152	134
9	4840	283	235	184	144	127
9.5	4585	268	223	174	136	120
10	4356	255	211	166	129	114

Installation of Wires

Trellis wires are properly tensioned to 275 to 300 pounds of tension. It is quite possible to over tension wires so that excessive strain is put on end posts and/or wires are irreversibly stretched beyond their yield point. A simple, effective technique involving a bucket containing the appropriate weight suspended from the wire can assist individuals in proper tensioning of wires (Figure 2). This technique is used with specific weights being hung on the wire in the middle of a post length as indicated in Table 6.

This technique for tensioning wires will allow the grower to get a feel for the appropriate amount of tension to place on wires. When that learning curve has been accomplished, the grower will have a "feel" for 275-300 pounds of tension on a trellis wire.

Table 6. The total test weight of a chain, bucket and its contents that will indicate 270 or 300 psi tension on wire for three post spacings when used as indicated in Figure 2.

Desired Wire Tension (lb)	Test Weight For 6" Sag for three post spacings (lb)		
	24 '	21 '	18 '
300	25.0	28.6	33.3
270	22.5	25.7	30.0

A grape grower with relatively short trellis rows is at a disadvantage in regard to keeping trellis wires tight because very little movement of end posts will result in considerable sagging wires. Therefore, end post anchoring is essential for constantly tight trellis wires. Even with end post anchoring, it may be difficult to properly tension a short length of wire. Individuals who have short vineyard rows (less than 150 feet) and have difficulty tensioning trellis wires, may consider two other options. The first of these is to use specially designed springs, which may be placed in line with trellis wires to keep them tight year round. A second possibility is to release tension on wires each fall so they won't exceed their yield point when wires contract during the coldest part of the winter, then retension in the spring.

There are several helpful insights that can ensure the proper installation of wires on trellis posts. U-shaped staples are a basic aspect of this vineyard task. Staples should be galvanized or otherwise treated to prevent rusting. A common staple length is 1.5 inches. For a standard trellis wire, staples are applied on the windward side of the posts when paired catch wires are installed, staples will also be applied on the leeward side of the trellis. For level ground, the staple would have a slightly downward orientation as it is nailed to the post. When applying staples to posts in knoll and valley areas they should be applied in a somewhat exaggerated downward or upward angle, respectively. Also apply staples so they are not directly oriented with the grain of the wood in the posts which often means slightly off vertical. One variation for attaching a load bearing wire at the top of a line post is to place it on top of the post rather than on the side. If periodic post pounding to reset line posts due to frost heaving is anticipated, a three-quarter inch deep groove can be made in the top of the line post in line with the vineyard row with a chain saw. Then place the wire in this groove. Depending upon the topography of the vineyard site, it may be desirable to place a staple on top of that groove. In this way, the post can be pounded without causing damage to the wire.

A wide variety of approaches are used to attach wires to end post assemblies. Regardless of the approach used, wires should be managed with gentle bends so no weak points are created in the wire. Be mindful that any time a wire is abruptly bent or stretched, it reduces the yield point and breaking point of that portion of wire becomes the weakest link in the trellis assembly. The simplest method of attaching a wire to an end post is to wrap the wire around the end post once and then make a series of gentle bends on the wire around back on itself. Some prefer not to place the staple on the end post on the windward side but rather on the end or back side of the end post. Others prefer to place a pair of staples on either side of the end post to help maintain the horizontal orientation of closely spaced wires. High-tensile wires may be difficult to attach to end post assemblies. Soft metal crimps are frequently used in these situations. Soft wires or small diameter high-tensile wires may be attached to end post assemblies with L-shaped cranks. In this instance a hole is drilled through the end post at the desired location and the trellis wire fed through this hole. Then a crank made out of 5/8" diameter and 15" length of rod or similar material is used to take out the slack. Typical dimensions for this crank are 9" for the handle and 6" for winding the wire with a 3/16" inch diameter hole drilled in the end of the 6" length for the attachment of the wire. The wire is lightly tensioned with a wire tightener. Then the end of the wire is placed through the hole in the crank. The crank is twisted to wind the wire around it. The crank is then twisted to bring it against the post. Several types of in-line tensioning devices are available. They will work well as long as they do not cause abrupt bending of the wire, which could reduce its breaking point strength.

Moveable catch wires are used with some training systems. They are typically installed on downward slanting nails (or upward slanting in dip areas) on line posts. Special J-shaped staples or V-shaped staples that have been cut on their upper side have also been used. These wires may be either lightly tensioned and permanently attached at the end posts. Some people have used short (± 24) inch lengths of chain that are hooked over nails on the end posts for retensioning these wires after they have been moved.

Tools and Gadgets For Installing Trellis Wires

Basic hand tools that are quite helpful when installing vineyard trellis wires include: fencing pliers for pulling misguided staples and cutting lengths of wire; a standard claw hammer, for extensive nailing of staples; a ratcheting wire tightener, which is preferable to a chain grab wire puller; a wire gripper (Klein Tools, Chicago, IL, model #1613-30F) can be added to the ratchet tightener at one or both ends. This device has a slanting locking mechanism that will hold all wires quite well; a wire reel, which can be purchased or fabricated in several designs, is essential for unwinding rolls of wire; a crimping tool; a post maul; a crowbar and a carpenter's apron for holding staples.

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