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High-Density Apple Planning Budget

Using this budget, Missouri farmers can estimate the costs and returns for growing apples in a high-density commercial orchard. Careful planning is necessary. A high-density orchard is a significant capital investment and will take several years to produce enough apples to provide potential positive yearly financial returns. Assumptions in this budget can be modified for your situation. The important budget topics discussed in this guide can serve as a checklist in your budget planning.

High-density production

In a high-density apple orchard, tree density tends to be more significant than in a traditional orchard. Typically, trees are planted with in-row spacing of 3 to 5 feet and between-row spacing of 10 to 14 feet. Specific in-row spacing recommendations depend largely on rootstock/scion combinations, site characteristics and the type of training system chosen. Row width should allow for trucks, tractors and any implements used to travel between rows.

This budget assumes the use of 3-foot in-row spacing and 12-foot between-row spacing. Tree density was set at 1,210 trees per acre.

Advantages of a high-density orchard can include improved production (e.g., earlier and increased yield, higher fruit quality, improved fruit packout) and efficiencies (e.g., labor, pesticides). Disadvantages can include higher establishment costs and greater need for management (e.g., training, pruning) than in a traditional orchard.

High-density apple production is a relatively new system and most research to-date has been performed in Michigan, Washington, New York and North Carolina. Missouri-specific recommendations for this system are not available, although the system is being widely deployed amongst new apple orchards in the lower Midwest. Networking with local and regional growers, and staying up to date on current research can help guide management decisions in this system.

Site selection

Location and scale are important for a commercial orchard site. Apple orchards need full sun, well-drained soils and protection from frost and wind. Avoid low areas; rolling land with some elevation can provide frost protection. For wind protection, avoid hill tops or ridges. To help minimize investment costs, avoid land that needs clearing or drainage. Several web-based tools — such as the U.S. Department of Agriculture (USDA) National Resources Conservation Service's (NRCS) Web Soil Survey (websoilsurvey.nrcs.usda.gov/app) and MU Extension's AgSite Assessment Tool (agsite.missouri.edu) — can help assess the soil and hydrologic characteristics of a given site.

Scale is important to allow for efficiencies in equipment (when fixed costs are spread over more acres, cost per acre decreases), purchasing discounts for bulk inputs and access to better markets.

This budget assumes a 10-acre orchard on a suitable site with minimal land adaptation costs.

Rootstock and cultivars

Dwarf rootstocks are required for high-density apple orchards. Many factors — such as climate, soil type, apple variety, planting system and disease/pest resistance — affect rootstock selection. Select scion cultivars that match your end-market needs and grow well in your area. Use a reputable nursery and plan to order well in advance of planting — up to two years beforehand.

Dwarf apple rootstocks with no defined scion cultivars are represented in this budget, at the industry average cost of $11.50 per tree.

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Trellis support system

Many types of trellis support systems and configurations are commonly used in apple orchards. Most importantly, construct a strong support system that can handle windy weather and heavy crop loads for the orchard's lifespan.

Concrete or steel posts can be substituted for pressure-treated wooden posts if cost effective. Posts need to be pounded or vibrated into the soil, depending on the soil characteristics. These activities are often outsourced to contractors with specialized equipment unless you have access to a hydraulic or vibrating post driver that can accommodate tall poles. The North Carolina State Extension publication High Density Apple Orchard Management (content.ces.ncsu.edu/high-density-apple-orchard-management) includes discussion and diagrams of trellis systems.

This budget assumes the use of a 10-foot, five-wire trellis system. High-tensile wires are strung along pressured-treated wood support and end posts. Trees are secured with trellis clips.

Site preparation

Important tasks in the year before planting may include:

- Test soil for pH and fertility. Sample at two depths: 1 to 8 inches and 8 to 16 inches. Fertilize and lime based on the results of the sample. Lime is generally spread over the entire orchard, and other amendments are spread over a 4-foot-wide strip centered on the tree row.
- Dig several soil pits to investigate the soil profile.
- Eliminate perennial and noxious weeds in and around the orchard site. If perennial weeds are present, plow the entire field and seed the row middles with a noninvasive grass such as turf fescue or orchard grass. If a good sod exists, locate the tree rows and kill the vegetation in the tree rows.
- Remove obstructions to air drainage from around the orchard site.
- Subsoil the site parallel and perpendicular to proposed tree rows.
- Consider drainage of wet areas in the site. Tile lines might be needed, or another option would be to plant on raised berms within the tree rows.
- If using woven weed-barrier fabric, install now.
- Install the trellis support system.
- Install the irrigation system.
- Install a deer exclusion fence around the site perimeter.

All of these jobs can be contracted out, if desired. In many cases, growers contract out subsoiling and the installation of tile lines, trellising, weed-barrier fabric and an irrigation system. In some cases, a grower will have the equipment and expertise to do all of these tasks.

To better understand the factors influencing cold air drainage and how to improve it on your site consult Analyzing and Improving Your Farms Air Drainage (canr.msu.edu/news/analyzing_and_improving_your_farms_air_drainage) from Michigan State University Extension. For more information on managing deer and deer-exclusion fencing, consult MU Extension publication MP685, Controlling Deer Damage in Missouri (extension.missouri.edu/publications/mp685).

Planting

An apple orchard should be planted in early spring or late fall. Tree rows are more ideal in a north-south orientation to maximize sunlight exposure. Planting depth is important; for example, the bud union of dwarf trees should be planted between 3 and 6 inches above the soil line. The section of the tree below the graft union is called the shank. As the length of the shank above the soil line is increased, the dwarfing characteristics of the rootstock are more pronounced in the tree. Recommendations for shank length are evolving and depend in part on the rootstock and scion selected. Trees can be planted in a variety of methods, ranging from hand planting to mechanical apple planters. Labor efficiency is gained with mechanical solutions but must outweigh the investment cost and equipment use over time to justify the investment.

This budget assumes hand planting trees and subsequent labor hours for the apple orchard.

Training and pruning

Proactive training of apple trees is critical in a high-density production system. The most common training systems in high-density orchards currently being installed are the slender spindle and tall spindle systems. These systems are designed to favor fruit production over vegetative growth

Research on best practices for pruning and training in these systems is evolving and can be specific to rootstock–cultivar combinations, site conditions and seasonal impacts on growth. The systems depend on minimal pruning of young trees, i.e., not using heading cuts so as to promote tall thin growth and early cropping (one to two years after planting). Limb bending is another practice deployed to induce early cropping. In years 1 to 5, dominant side branches that compete with the central leader are removed. In subsequent years,

pruning is focused on branch caliper management. This practice involves removing side branches that are more than 50% of the diameter of the central leader, and using dutch cuts to renew side fruiting branches. There are slight variations in how trees are pruned in different training systems, but the goal of pruning in all high-density systems is to maintain a columnar tree with a narrow canopy that promotes light penetration within each tree and across the row.

Cornell University's publication Pruning Concepts for High Density Apple Orchards (PDF) (rvpadmin.cce.cornell.edu/pdf/submission/pdf178_pdf3.pdf) highlights key concepts of training and pruning in these systems. The best integrated approach to gaining an understanding of training and pruning systems is to visit local orchards engaged in high-density production, join apple growers organizations, and attend conferences that provide research updates on this production system.

Crop load management

Fruit thinning is done to increase fruit size and reduce the chance of initiating biennial bearing of annual-bearing cultivars, which can be induced by an excessively heavy crop load. Thinning can be accomplished through hand thinning, chemical thinning, and pruning.

In high-density systems, thinning is primarily accomplished through pruning and hand thinning of flower buds. In years 2 to 4, the goal of thinning and pruning is to balance vegetative growth and fruit production. An excessively heavy crop load in these years can reduce vegetative growth and future bearing potential of the tree. Maintaining an appropriate balance of fruiting and vegetative growth in years 2 to 4 will result in a tree that will have limited but stable vegetative growth in future years. This practice allows for development of a tree size and structure that will optimize fruit production through the life of the orchard. Trunk cross-sectional area (TCA) can be used to guide crop load management and thinning based on university recommendations of fruits/cm^2 TCA. Cornell University publication Crop Load Management of New High-Density Apple Orchards (PDF) (fruit.wisc.edu/wp-content/uploads/sites/36/2016/03/Crop-Load-Management-of-New-High-Density-Apple-Orchards.pdf) provides more details on this topic.

Fertility management

A preplanting soil test will determine if lime, potassium, phosphorus, magnesium, calcium or micronutrients are needed. Seldom are micronutrients needed. Nutrients should be brought up to desired levels, and lime should be applied if soil pH is too low, which is common in Missouri.

Nonbearing apple trees typically will need 40 to 80 pounds of actual nitrogen per treated acre annually. Nitrogen applications should be based on soil test recommendations and tree age.

Fertilizer application rates in bearing orchards will be based on tree growth, fruit quality, plant tissue tests and soil fertility. After the first several years of growth, nitrogen fertilization rates should be greatly reduced. Excessive nitrogen applications can reduce fruit quality and result in excessive vegetative growth, causing canopy management problems. Fertigation is the primary method by which small doses of nitrogen are added in the bearing years of high-density orchards. Fertigation allows for timely application of nitrogen and is favored over dry fertilizer applications. In many Missouri soils, mineralization of existing soil organic matter will release nitrogen at amounts sufficient for mature high-density orchards. The goal of nitrogen management in mature orchards is to produce only enough vegetative growth necessary to maximize fruit yield. Tissue testing should be employed to monitor the nutrient status of trees and guide application of primary and secondary macronutrients, such as nitrogen and calcium, and micronutrients, such as boron.

Irrigation

Drip irrigation is recommended in a high-density orchard due to its ability to efficiently control water timing and dosage, which results in better crop yields and fruit quality. Water sources could be municipal water, groundwater wells or surface water impoundment. Wells that lift water from a deep source, or irrigation systems that require significant pressure can increase the cost of pumping water and overall irrigation cost.

This budget assumes investing in a drip irrigation system with fertigation capabilities. Water source is assumed an existing groundwater well, and only minimal connection expenses are expected.

Disease and insect management

Use of integrated pest management (IPM) techniques is crucial in implementation of a disease and insect management program. Monitoring insects through scouting and trapping can allow growers to make informed decisions on insecticide applications and save money by avoiding unnecessary sprays. Care should be taken at flowering to avoid adverse impacts of insecticide applications on pollinators. Understanding the weather

conditions that influence fungal and bacterial disease development can help inform applications of fungicides.

The costs for a spray program will depend on several variables:

- Pest pressure in the orchard — presence or absence of pests in the orchard, level of pest or disease presence in the orchard
- Characteristics of the orchard — resistant vs. susceptible cultivars, tree and row spacing, density of tree canopies
- Environmental conditions — for example, extended environmental conditions favorable to disease or insect development may require additional sprays
- Pest application equipment
- Choice and rate of pesticides

The Midwest Fruit Pest Management Guide (ag.purdue.edu/department/hla/extension/sfg-sprayguide.html) provides detailed information on pesticide options and spray schedules.

The cost of a spray program included in this budget is based on a typical spray program in a typical season in Missouri for nonbearing and bearing apple crops.

Machinery and equipment

The machinery and equipment used in this budget reflect a machinery complement for a 10-acre orchard. Machinery costs were estimated by year for necessary activities and rates based on typical life (years), use (hours) and performance (fuel and labor) factors for each power unit and implement used. Tractor fuel cost was assumed at $3.25 per gallon. Note that differing equipment complements could be used but may have different costs. For example, an operation could perform apple harvest by manual ladders rather than using a tractor-driven work platform, which would decrease machinery cost but might increase labor time and cost.

This budget assumes a 45-horsepower cabbed tractor with loader, airblast sprayer, weed sprayer, finish mower, work platform and harvest trailer are used in production activities.

Harvest activities may involve picking, transporting and storing apples. Some of these handling activities and equipment needs are based on what market channels you are using to sell apples.

This budget assumes apples are harvested on a work platform into harvest totes, moved onto a trailer and hauled into on-farm cold storage.

Marketing

Selling prices for apples vary by market channel. Producers may consider fresh markets such as farmers markets, u-pick, on-farm markets, online marketplaces, retailers, institutions and wholesalers and distributors. High-density apple production systems often serve as the main attraction and anchor for agritourism operations. Smaller scale producers in Missouri generally focus on direct-marketing channels to maximize returns per acre. Each channel has pros and cons. Learn more about costs in market channels in MU Extension publication G6221, Market Channels for Locally Raised Foods (extension.missouri.edu/publications/g6221). Marketing costs — such as packaging, promotion, labor and delivery — also vary by market channel. Learn more about market channels in MU Extension publication G647, Refining Market Channel Selections Based on Cost (extension.missouri.edu/publications/g647). Selling price has been shown to be the primary driver of profitability in high-density systems. Producers should carefully evaluate suitable market channels for their income potential and marketing costs.

This budget assumes a $22.50-per-bushel selling price for fresh market apples. Marketing and packaging costs are estimated at 10% of sales.

Economics

Table 1 presents planning budget estimates for a Missouri high-density apple orchard based on assumptions and prices in March 2025. Use the "Your estimate" columns in Table 1 to plan your apple operation's costs and returns. Detailed assumptions and capital investments are summarized in Tables 2, 3 and 4. Assumptions in this budget can be modified for your situation.

Table 2 provides establishment assumptions for the high-density apple planning budget. Note that labor for site preparation and planting are shown separately in Table 3. Custom hire is assumed for field preparation (i.e., subsoiling, tilling rows, land clearing, liming) and installing trellis system posts (i.e., excavator with tamper).

Table 3 provides selected labor and fertilizer inputs for this budget by year. Labor is estimated at $18.50 per hour for all activities. Most fertilizer is assumed to be applied through a dripline irrigation system.

Table 4 provides investments needed by year. A 10-foot, five-wire treated-wood trellis system and wildlife-control fence is developed in the site preparation year. An existing groundwater well is assumed as the water supply for the irrigation system, with an

Table 1. High-density apple planning budget per acre.

	Site preparation Year 1		Planting Year 2		No production Year 3		First production Year 4	
	Total (dollars)	Your estimate	Total (dollars)	Your estimate	Total (dollars)	Your estimate	Total (dollars)	Your estimate
Apple production yield							*180 bushels*	
Income								
Apples							4,050	
Government payments							0	
Total income							4,050	
Operating costs								
Apple trees			12,705					
Fertilizer and soil amendments	114		311		311		291	
Chemicals	7		584		584		986	
Labor	769		1,478		867		1,827	
Supplies	0		996		28		124	
Custom hire	1,675							
Machinery fuel	10		31		43		127	
Repairs and maintenance	89		108		156		757	
Marketing and packaging							405	
Crop insurance							54	
Utilities								
Other expenses								
Interest on operating capital	107		140		80		183	
Total operating costs	2,769		16,354		2,068		4,753	
Ownership costs								
Depreciation on infrastructure	502		502		502		1,464	
Interest on infrastructure	399		399		399		1,302	
Machinery ownership	32		79		161		673	
Real estate charge	50		50		50		50	
Other overhead, taxes, insurance	107		107		107		347	
Total ownership costs	1,090		1,136		1,218		3,836	
Total costs	3,859		17,490		3,287		8,589	
Income over operating costs	**–2,769**		**–16,354**		**–2,068**		**–703**	
Income over total costs	**–3,859**		**–17,490**		**–3,287**		**–4,539**	

Table 1. High-density apple planning budget per acre. **(continued)**

	Second production Year 5		Third production Year 6		Fourth production Year 7		Full production Year 8	
	Total (dollars)	Your estimate	Total (dollars)	Your estimate	Total (dollars)	Your estimate	Total (dollars)	Your estimate
Apple production yield	*350 bushels*		*600 bushels*		*800 bushels*		*1,000 bushels*	
Income								
Apples	7,875		13,500		18,000		22,500	
Government payments								
Total income	7,875		13,500		18,000		22,500	
Operating costs								
Apple trees								
Fertilizer and soil amendments	291		291		291		291	
Chemicals	986		986		986		986	
Labor	2,280		3,122		3,473		3,778	
Supplies	124		124		124		124	
Custom hire								
Machinery fuel	158		209		236		261	
Repairs and maintenance	880		1,105		1,220		1,341	
Marketing and packaging	788		1,350		1,800		2,250	
Crop insurance	113		194		259		323	
Utilities	105		180		240		300	
Other expenses								
Interest on operating capital	229		302		345		386	
Total operating costs	5,953		7,863		8,975		10,040	
Ownership costs								
Depreciation on infrastructure	1,464		1,464		1,464		1,464	
Interest on infrastructure	1,302		1,302		1,302		1,302	
Machinery ownership	877		1,234		1,433		1,590	
Real estate charge	50		50		50		50	
Other overhead, taxes, insurance	347		347		347		347	
Total ownership costs	4,040		4,396		4,595		4,753	
Total costs	9,993		12,259		13,570		14,793	
Income over operating costs	**1,922**		**5,637**		**9,025**		**12,460**	
Income over total costs	**–2,118**		**1,241**		**4,430**		**7,707**	

Table 2. Custom hire assumptions used in high-density apple planning budget per acre.

Activity	Unit	Dollars per unit	Quantity of units	Total (dollars)
Lime (deliver and spread)	ton	30.00	2	60
Subsoiling	acre	25.00	1	25
Tilling rows	acre	25.00	2	50
Fertilizer spreading	acre	10.00	1	10
Land clearing	hour	197.50	1	198
Excavator with tamper	hour	174.00	8	1,392

Table 3. Input assumptions used in high-density apple planning budget per acre.

Selected inputs	Unit	Dollars per unit	Year 1 units	Year 2 units	Year 3 units	Year 4 units	Year 5 units	Year 6 units	Year 7 units	Year 8 units
Apple trees	each	10.50		1,210						
Tree tubes	each	0.80		1,210						
Labor – Site preparation and planting	hour	18.50	40	50	2	1				
Labor – Machinery operator	hour	18.50	2	5	5	8	8	9	9	9
Labor – Irrigation	hour	18.50		10	10	10	10	10	10	10
Labor – Pruning and training	hour	18.50		15	30	50	50	50	50	50
Labor – Thinning	hour	18.50				15	30	60	65	70
Labor – Harvesting	hour	18.50				15	25	40	54	65
Nitrogen	pound	4.77		60	60	45	45	45	45	45
Potassium	pound	0.38	75							
Calcium	pound	4.92				8	8	8	8	8
Solubor	pound	2.05				6	6	6	6	6

Table 4. Equipment and infrastructure assumptions used in high-density apple planning budget per acre.

Investments	Year installed	Total (dollars)	Lifespan (years)	Annual depreciation (dollars)	Annual interest (dollars)
Treated wooden end posts	Year 1	2,312	25	92.48	86.70
Treated wooden middle posts	Year 1	2,321	25	92.82	87.02
Treated wooden H brace poles	Year 1	663	25	26.52	24.86
Brace pins	Year 1	54	25	2.18	2.04
High tensile wire	Year 1	793	25	31.71	29.73
Tensioners	Year 1	594	25	23.75	22.27
Gripples	Year 1	598	25	23.94	22.44
Staples	Year 1	20	25	0.79	0.74
Trellis clips	Year 1	726	15	48.40	27.23
Irrigation system, dripline, fertigation, well connection	Year 1	1,525	15	101.67	57.19
Wildlife control fence (high tensile)	Year 1	896	25	35.83	33.59
Miscellaneous equipment and tools	Year 1	150	7	21.43	5.63
Harvest totes	Year 4	4,858	25	194.30	182.16
Cold storage	Year 4	19,200	25	768.00	720.00
Total		**34,709**		**1,463.81**	**1,301.58**

investment needed only for supply connection. Irrigation investment includes dripline equipment, supplies, fertigation system and installation expense. In the first year of apple production, harvest totes and cold storage are purchased and installed. Annual interest rate assumed on capital investments is 7.5%.

Farmers can customize this budget using the Missouri High-Density Apple Budget spreadsheet, which can be downloaded from the specialty crops section of the Missouri Crop and Livestock Enterprise Budgets webpage (extension.missouri.edu/programs/agricultural-business-and-policy-extension/missouri-crop-and-livestock-enterprise-budgets).

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