

Inorganic Fertilizers for Home Garden Vegetables and Fruits in Central Washington

WASHINGTON STATE UNIVERSITY EXTENSION • EM070E



WASHINGTON STATE
UNIVERSITY
EXTENSION

This manual is part of the WSU Extension Home Garden Series.

Inorganic Fertilizers for Home Garden Vegetables and Fruits in Central Washington

Why Inorganic Fertilizers?

Soil naturally supplies a significant quantity of nutrients for growing garden crops. Nonetheless, no gardener can produce abundant and high-quality produce without adding organic amendments or inorganic fertilizers, which supply crops with enough essential nutrients for healthy growth.

Organic amendments, such as animal manures, are made from materials derived from living things. In contrast, inorganic fertilizers are synthesized from nonliving materials through chemical processes. For gardeners, organic amendments provide more benefits than inorganic fertilizers (Burrows and Graper 2005). Unlike inorganic fertilizers, organic amendments improve soil structure, buffer soil pH, increase soil organic matter, and increase the soil's ability to retain both water and nutrients. However, organic amendments do have one significant limitation—they are released slowly and are not immediately available to plants at the amount needed. Before plants can take up nutrients from organic matter, soil microorganisms must break down the matter into inorganic molecules and ions.

In contrast, the nutrients in inorganic fertilizers are already in inorganic form, and therefore, are available for growing crops to use immediately. This is why supplementing your garden crop with inorganic fertilizers is a simple way to meet crop nutrient needs in a timely fashion. Inorganic fertilizers should be applied at the right time, at the right rate, at the right place, and using the right source (Roberts 2006), in order to reduce leaching, leaf burn, and excess accumulation of some nutrients in the root zone and groundwater.

Inorganic Fertilizer Labels

Fertilizer manufacturers are required by law to display the guaranteed analysis of nitrogen, phosphorus, and potassium in a fertilizer bag (Figure 1).

All fertilizer labels have three bold numbers separated by dashes. These three numbers represent the percentage of the primary macronutrients— nitrogen

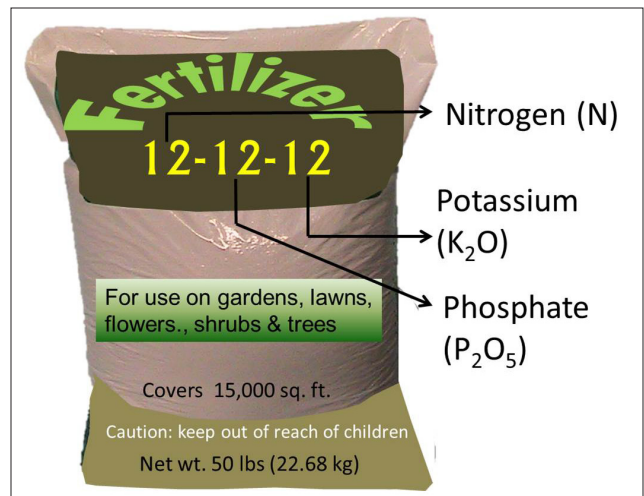


Figure 1. Fertilizer label for 12-12-12 N-P-K fertilizer. Manufacturers include a variety of information on the fertilizer bag to help gardeners to understand the product's content, use, and restrictions.

(N), phosphorus (P), and potassium (K) by weight or percentage, respectively. For example, a 5-10-15 fertilizer contains 5 lb N, 10 lb P_2O_5 , and 15 lb K_2O per 100 lb of fertilizer (1 lb of P_2O_5 equals 0.44 lb P, and 1 lb K_2O equals 0.83 lb K).

Fertilizers come in a single nutrient form or as a blend of two or more nutrient sources (Table 1). For example, 34-0-0 is strictly an N fertilizer, 0-46-0 contains only 46 percent P_2O_5 , and 0-0-60 contains only 60 percent potassium (K_2O). Fertilizer labeled 18-46-0 is a blend of 18 percent N and 46 percent P_2O_5 . The rest of the fertilizer label can include plant nutrients or other elements, such as hydrogen and oxygen. In addition, some fertilizer labels include a fourth number that represents a secondary nutrient, such as sulfur and magnesium.

How Do You Determine Fertilizer Needs?

Soil and tissue tests. Soil and tissue tests help gardeners make informed nutrient-application decisions for vegetables and fruits. The soil's nutrient-supplying capacity is a chemical characteristic of

Table 1. Single and Multiple Nutrient Fertilizers Commonly Used in Irrigated Central Washington Home Gardens (Koenig and Rupp 1999).

Fertilizer Nutrient	Name	Fertilizer Label N-P ₂ O ₅ -K ₂ O% [†]	Availability to Plant	Remark
N	Ammonium sulfate (AS)	21-0-0	Quick	Contains 11% sulfur; can lower soil pH
	Urea	46-0-0	Quick	
	Sulfur-coated urea	37-0-0	Slow	
P	Triple superphosphate (TSP)	0-46-0	Quick	Contains 1–1.5% sulfur and 13% Ca
K	Potassium chloride	0-0-60	Quick	Contains 17% S; can be used for chlorine-sensitive crops
	Potassium sulfate	0-0-50	Quick	
Multi-nutrient fertilizer	Monoammonium phosphate (MAP)	11-52-0	Quick	Contains 0–2% S
	Diammonium phosphate (DAP)	18-46-0	Medium	N and P composition can vary
	Potassium nitrate	13-0-44	Quick	Increases soil pH
	Balanced fertilizer	16-16-16	Quick	
	Vegetable food	12-12-12	Quick	

[†]Nutrient concentrations may vary slightly from source to source.

Table 2. Sample Soil Test Result for a Central Washington Vegetable and Fruit Site.

Soil Property	Soil Test Value	Level Relative to Recommended Rate			
		Low	Medium	High	Excessive
Nitrate-N	10 ppm				
Bicarbonate-P	15 ppm				
Extractable-K	330 ppm				
pH	7.3				
Electrical Conductivity	0.5 mmho/cm				
Organic Matter	1.2%				

Recommendations

Nitrogen: Because your soil is low in N, apply 3–4 lb N/1000 ft² to garden crops with high N demand (such as sweet corn, cole crops, and potatoes) and 1–2 lb N/1000 ft² for garden crops with lower N demand (such as beans, lettuce, and squash). Apply 1 lb of N 1000 ft² before planting or transplanting, and the remainder 3 to 6 weeks later when plants are ready to begin rapid growth.

Phosphorus: Apply 1–2 lb P₂O₅/1000 ft² and before planting to complete the moderate soil available P.

Potassium: This nutrient is adequate; do not add any more to your soil.

Organic matter: Amend soil with compost (1/2 to 1 inch per year) and/or grow cover crops to maintain organic matter. Use compost with low electrical conductivity (low salts). If you apply compost, reduce the phosphorus application to 0 to 1 lb P₂O₅/1000 ft². Apply compost well ahead of planting your garden crops.

the soil, and therefore is most reliably measured or estimated using soil testing, which is interpreted to provide proper amounts of fertilizer for application (Hart and McNeilan 2000). The in-season tissue test is also commonly used for vegetables and fruits. In Central Washington, soil and tissue analysis labs are scattered throughout the region. Please see *Analytical Laboratories and Consultants Serving Agriculture in the Pacific Northwest* (Daniels 2005, <http://puyallup.wsu.edu/analyticallabs/services>) for a list. These labs provide instructions on how to prepare and submit your soil samples. A comprehensive routine soil test may cost between \$12 and \$60 per sample. Con-

ducting a complete soil test every three years should be adequate (Koenig and Rupp 1999). However, in-season visual deficiency symptoms, followed by a tissue test, can assist gardeners in making fertilizer application decisions while the garden crop is growing. Gardener's should strictly follow the lab's instructions for the preparation and submission of samples. Most of the time, these instructions are available online from at the testing laboratories. For guidance on collecting a representative soil sample for submission to the lab, see WSU Extension videos *How to Take Soil Samples* (Cogger 2010) and *Soil Testing* (Collins 2012).

Soil test interpretation. After the soil samples are tested, examine the results to identify any nutrient deficiencies in the garden. Most labs provide fertilizer recommendations along with the soil test results, and this is a good place to start. Please refer to *Soil Test Interpretations and Fertilizer Management for Lawns, Turf, Gardens, and Landscape Plants* (Rosen et al. 2008) and *Using Soil Test Results for Garden Fertilization: A Guide for Fertilizing Home Landscapes and Gardens in Idaho* (Moore et al. 2011), for soil test interpretation guidelines.

A generic soil test result with corresponding recommendations is provided in Table 2. In the table, soil nitrate-N is low and extractable K is high.

Generic Fertilizer Recommendations for Garden Vegetables and Fruits

It is true that the quantity of primary macronutrients (N, P and K) needed varies by crop. However, for a home garden, a small deviation from the recommended amount of fertilizer is unlikely to cause a large decrease in crop yields. Additionally, home gardens are generally small, which makes it difficult to develop individual fertilizer recommendations for each garden crop. Although different crops have different nutrient needs, in general, crops need the primary nutrients in the approximate ratio of 4-1-2 (N-P₂O₅-K₂O).

Table 3. Recommended Fertilizer Rates for Common Vegetables and Fruits Grown in Central Washington Home Gardens (Cogger et al. 2014).

Crop	Level	Recommended Nutrient in Pounds/1000 Sq Ft		
		N	P ₂ O ₅	K ₂ O
Legume (peas, bean)	Low	0.5 to 2	3 to 5	2 to 5
	Medium to High	0 to 1	0.3 to 2	1 to 2
Asparagus, artichoke, beet, carrot, melon, cauliflower, cucurbit, pepper, tomato, lettuce, radish, spinach, broccoli, brussel sprout, cabbage, collard green, eggplant, and mushroom	Low	2 to 4	3 to 4	3 to 7
	Medium	1.5 to 3	1 to 2	2 to 4
	High	1 to 2	0 to 0.5	0 to 1
Sweet corn, potato, onion, and garlic	Low	3 to 5	2 to 3	6 to 11
	Medium to High	2 to 4	0 to 2	1 to 3
New plantings of blackberry, blueberry, raspberry, strawberry, and apple	Low	1 to 2	2 to 3.5	4.5 to 7
	Medium	0.5 to 1.5	1 to 2	2 to 4
	High	0 to 1	0 to 0.5	0.5 to 1
Established plantings of blackberry, blueberry, raspberry, strawberry, and apple	Low	0.5 to 2	1 to 1.7	2 to 4
	Medium	0.3 to 1.6	0 to 0.5	1 to 3
	High	0 to 1.3	0	0 to 1

The recommendations in Table 3 are general, and the nutrient requirement of a crop can be affected by many factors such as soil texture, soil organic matter, and water availability. Furthermore, the recommendations assume that the gardener is supplying some nitrogen through a legume-based rotation (such as a vetch or clover cover crop followed by sweet corn) or in the case of fruits, intercropping (planting crimson clover between strawberry rows). If a gardener has a soil with percent organic matter greater than 3, the soil may supply enough nutrients and additional fertilizer may not be needed. A soil test will confirm this. Refer to *Methods for Successful Cover Crop Management in Your Home Garden* (Benedict et al. 2014) for more information on cover crops to supply nitrogen.

Steps in Determining NPK Fertilizer Rate

Once you have a soil test report along with nutrient recommendation, you can determine your fertilizer rate. You also need to know the fertilizer nutrient composition in terms of weight. Please refer to the *Fertilizer Calculator* by Hitchcock and Kissel (<http://aesl.ces.uga.edu/soil/fertcalc/>). Here are three steps to follow:

- 1. Know the composition.** The amount of nutrient in a fertilizer brand is the product of the weight of the fertilizer and the percentage

of the nutrient in the fertilizer product. For example, if you apply 1 lb of diammonium phosphate (DAP) in a 1000 sq ft area, you are applying $1 \times 0.18 = 0.18$ lb of N and $1 \times 0.46 = 0.46$ lb of P_2O_5 .

- 2. Know the area you plan to fertilize.** Determine your garden area by using a measuring tape. Most of the time, the gardener knows the size of his or her garden. Generally, garden fertilizer rates are based on the amount needed per 1000 sq ft (see *Measuring the Area of a Home Lawn*, Clemson Cooperative Extension Home and Garden Information Center HGIC 1220).
- 3. Determine the rate per area of the fertilizer product.** Once you know how much nutrient is needed in a standard 1000 sq ft area and you know the size of your garden, you can determine the amount of fertilizer material you need to apply by using the following formula (Koenig and Rupp 1999):

$$\text{Fertilizer} = \frac{\text{Nutrient application rate, lbs}}{1000 \text{ sq ft}} \times \frac{1 \text{ lb fertilizer}}{\text{Proportion of nutrient in the fertilizer}} \times \text{Garden area, sq ft}$$

Examples of how to use the formula for different fertilization scenarios is shown in Table 4.

Buying Fertilizer

An important consideration when buying fertilizer from a local store is the cost per pound of the

actual nutrient in the fertilizer. Once you know how much actual nutrient you are getting from a fertilizer, you can make a decision as to which fertilizer to buy based on unit price and your specific garden needs (Koenig and Rupp 1999). The cost per pound depends on the package price, weight, and nutrient concentration. Figure 2 illustrates price calculation for N and P_2O_5 , each from two fertilizer sources.

If we are concerned only about supplying N, then the unit price of actual N in AS is twice that of the N in urea (Example 1 in Figure 2). For a gardener who is seeking to apply N, urea is the preferred option. If both N and sulfur are needed, AS is the best fertilizer choice. In most cases, unit prices account for additional benefits that the buyer experiences above and beyond the major nutrient indicated on the label.

Fertilizer Application Methods

Some nutrients such as N move freely in the soil. Others, such as P and K, do not move in the soil. Using the right method of application, the right time, and the right placement is important for the successful and efficient use of an inorganic fertilizer. A granular or dry fertilizer can be broadcast or banded. Broadcast fertilizer application refers to a uniform distribution of material on the soil surface (like N) or the incorporation of the material at a shallow depth (approximately 2 to 3 inches) of all nutrients.

Uniform broadcasting is the simplest way of applying N and other nutrients that move in the soil. Hardware and garden stores offer different types of drop-type fertilizer spreaders (Figure 3).

Table 4. Fertilizer Calculation for Three Fertilization Scenarios.

Scenario	Nutrient per 1000 sq ft	Proportion of Nutrient in the Fertilizer [†]	Garden Area sq ft	Fertilizer Needed
Single Nutrient: A gardener would like to apply 3 lb N per 1000 sq ft using ammonium sulfate (AS). The garden size is 5000 sq ft.	3 lb N from AA	0.21	5000	71 lb AS
Single Nutrient from Two Sources: The gardener would like to supply 4 lb N per 1000 sq ft using urea (75%) and diammonium phosphate [DAP] (25%) because the garden needs some P. The garden is 600 sq ft.	3 lb N from urea 1 lb N from DAP	N in urea = 0.46 N in DAP = 0.18	600	5.2 lb urea 0.8 lb of DAP
Two Nutrients from Two Sources: A soil test result showed that a gardener should apply 3 lb N and 1 lb P_2O_5 per 1000 sq ft. The gardener has two fertilizers, ammonium nitrate (AN) and monoammonium phosphate (MAP). The garden size is 5000 sq ft.	1 lb P_2O_5 from MAP 2 lb of N from AN	P2O5 in MAP = 0.52 N in MAP = 0.11 N in AN = 0.34	5000	9.6 lb of MAP; MAP provides 1 lb N 29.4 lb of AN

[†]Refer to Table 1 for fertilizer composition information.

Example 1: What is the price of a pound of nitrogen from urea and AS fertilizers?

Urea and AS cost \$15 and \$12.50 per 50 lb bag, respectively. Based on label information in Table 1 (above), 50 lb of urea and AS contain 23 and 10.5 lb of N. Therefore, the cost per pound of N from urea and AS would be \$0.65 (\$15.00/23 lb) and \$1.19 (\$12.50/10.5 lb), respectively.

Example 2. What is the price of a pound of P₂O₅ from MAP and DAP fertilizers?

MAP and DAP cost \$15 and \$16.50 per 50 lb bag. Based on the label information in Table 1 (above), 50 lb of MAP and DAP contains 26 and 23 lb of P₂O₅. The cost per pound of P₂O₅ from MAP and DAP is thus \$0.63 (\$16.50/26 lb) and \$0.71 (\$16.50/23 lb), respectively.

Note: Use of mixed fertilizer such as MAP provides additional nitrogen that could reduce the additional nitrogen only fertilizer. Therefore, gardeners should conduct soil tests and know the most deficient nutrient in order to minimize fertilizer cost.

Figure 2. Different fertilizers have different price-per-pound of nutrient. See Figure 1 for fertilizer label information.

Figure 3. Drop-type fertilizer spreader for applying granular fertilizer in a garden.



Most of these spreaders come with an instruction manual that contains useful information about capacity, use restrictions, and other essential information. The following are simple steps you can follow to calibrate your fertilizer spreader.

1. Mark an area that is 50 ft long and 2 ft wide (100 sq ft). If your spreader is not two feet wide, modify the length accordingly so that

you always get a 100 sq ft area for calibration. The figure “100 sq ft” is an easy number to deal with as you calibrate your spreader.

2. Use a tarp or box-shaped gutter to catch fertilizer as it comes out of the spreader. You can also build a custom fertilizer collection box from any resources locally available to you, such as plastic sheet or tarp (Figure 4).
3. Set the spreader on the manufacturer’s suggested number, based on the desired rate of application.
4. Pour the fertilizer into the spreader, and push it over the 100 sq ft area.
5. Weigh the collected fertilizer material, and multiply by 10. This will give the amount you should apply over a 1,000 sq ft area.
6. Return the fertilizer used for calibration to the spreader hopper, and spread the fertilizer in the target area.

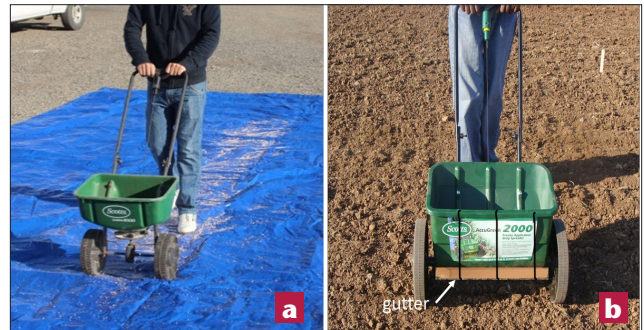


Figure 4. Fertilizer collection using a tarp (a) and box-shaped gutter (b).

Avoid calibrating your spreader in alleys or parking strips to avoid fertilizer washing to unintended areas; your garden area is the most preferred place. Empty the spreader hopper after you finish the application of fertilizer, and thoroughly clean it. Return the excess fertilizer to the bag, and tie it securely. Store remaining fertilizer in a dry and secure location, according to the manufacturer’s instructions.

Another method for fertilizer application is banding (also known as side-dressing). Banding refers to placing nutrients at close proximity to any side of the seed or growing plant (Relf et al. 2009). The N, P and K fertilizers can be applied to garden crops using broadcasting or banding, but it is important to take into consideration row spacing, row configuration, slope, and other field conditions. When row spacing is wide, banding the fertilizer is more efficient than broadcasting. When fertilizer has to be banded in plant rows, it is important to divide the fertilizer amount for the entire garden by the total number of rows to get the amount of fertilizer to apply per row.

As in broadcasting, it is important to incorporate banded fertilizer at 2 to 3 inch depth. The incorporation can be done with shallow tillage using a hoe or small garden tiller.

Yet another fertilizer application method is foliar feeding (apply fertilizer solution on foliage). This is ideal for in-season correction of nutrient deficiencies. See *Nutrient Disorders in Tree Fruits* (Benton et al. 1994) to learn more about foliar feeding of plant nutrients. Foliar feeding is commonly used to apply very low concentrations of P, K, and micronutrients. Follow the manufacturer's label if you decide to foliar-feed your crop. Some fertilizers can form a low pH solution, which can burn leaves. It's very important to read the product label before use.

Good timing is critical for improving a crop's nutrient use. It is advisable to split N between the planting and vigorous vegetative growth stages to ensure that it is not lost, and that the crop can use it when needed. Nitrogen should be split-applied using the following formula: ½ at planting time or following regrowth after winter, and the other ½ applied 3 to 5 weeks after planting or when plants are growing actively. P and K should be applied pre-planting. Based on your soil test results, in some cases it is wise to foliar-feed these nutrients when the crop is at its peak demand and the soil supply of nutrients is limited.

Summary

To maintain high yield, it is essential to supplement garden crops with inorganic fertilizer. When you purchase fertilizer, read the label carefully. Use soil tests and fertilizer guides to determine the appropriate rate. Calculate the amount of fertilizer you need and spread it uniformly via broadcast or band. Time the applications so that the nutrients are available when the plants need them.

References

- Analytical Laboratories and Consultants Serving Agriculture in the Pacific Northwest (accessed May 21, 2014). Washington State Pest Management Resource Service. <http://puyallup.wsu.edu/analyticallabs/>.
- Benedict, C., C. Cogger, and N. Andrews. 2014. Methods for Successful Cover Crop Management in Your Home Garden. *Washington State University Extension Publication* FS119E.
- Benson, N., C.G. Woodbridge, and R.D. Bartram. 1994. Nutrient Disorders in Tree Fruits. Oregon State University Extension. *Pacific Northwest Extension Publication* PNW 121E.
- Burrows, R. and D. Graper. 2005. Vegetable Gardening. *South Dakota Cooperative Extension Service Publication* EC 688. <http://agbiopubs.sdstate.edu/articles/EC668.pdf>.
- Cogger, C. 2010. How to Take a Soil Sample. http://www.puyallup.wsu.edu/soilmgmt/Videos/Video_HowToSoilSample.htm.
- Cogger, C., C. Benedict, N. Andrews, S. Fransen, and A. McGuire. 2014. Cover Crops for Home Gardens East of the Cascades. *Washington State University Extension Publication* FS117E.
- Collins, Doug. 2012. Soil testing: A Guide for Farms with Diverse Vegetable Crops. *Washington State University Extension Publication* EM050E. <http://cru.cahe.wsu.edu/CEPublications/EM050E/EM050E.pdf>.
- Daniels, C.H. 2005. Analytical Laboratories and Consultants Serving Agriculture in the Pacific Northwest. *Washington State University Extension Publication* EB1578E. [out of print]
- Hart, J. and R. McNeilan. 2000. Fertilizing Your Garden. *Oregon State University Extension Service Publication* EC 1503. <http://extension.oregonstate.edu/catalog/html/ec/ec1503/>.
- Home and Garden Information Center. 2013. Measuring the Area of a Home Lawn. Home and Garden Information Center. *Clemson Cooperative Extension Publication* HGIC 1220. <http://www.clemson.edu/extension/hgic/plants/pdf/hgic1220.pdf>.
- Koenig, R. and L. Rupp. 1999. Selecting and Using Inorganic Fertilizers. *Utah State University Extension Publication* HG-509. http://extension.usu.edu/files/publications/publication/HG_509.pdf.
- Moore, A., M. Bauer and S. Bell. 2011. Using Soil Test Results for Garden Fertilization: A Guide for Fertilizing Home Landscapes and Gardens in Idaho. *University of Idaho Extension Publication* CIS 1182.
- Relf, D., A. McDaniel, and S. Donohue. 2009. Fertilizing the Vegetable Garden. *Virginia Cooperative Extension Publication* 426-323. http://www.pubs.ext.vt.edu/426/426-323/426-323_pdf.pdf.

Roberts, T.L. 2006. Improving Nutrient Use Efficiency. In Proceedings of the IFA Agriculture Conference: *Optimizing Resource Use Efficiency for Sustainable Intensification of Agriculture*, 27 February–2 March 2006. Kunming, China. International Fertilizer Industry Association (IFA). Paris, France.

Rosen, C.J., P.M. Bierman, and R.D. Eliason. 2008. Soil Test Interpretations and Fertilizer Management for Lawns, Turf, Gardens, and Landscape Plants. *University of Minnesota Extension Publication* 01731.



By **Kefyalew Desta**, Soil Management Scientist/Specialist, WSU Irrigated Agriculture Research and Extension Center, Prosser, WA; and **Craig Cogger**, Extension Soil Specialist, WSU Puyallup Research and Extension Center.

Use pesticides with care. Apply them only to plants, animals, or sites as listed on the label. When mixing and applying pesticides, follow all label precautions to protect yourself and others around you. It is a violation of the law to disregard label directions. If pesticides are spilled on skin or clothing, remove clothing and wash skin thoroughly. Store pesticides in their original containers and keep them out of the reach of children, pets, and livestock.

Copyright 2014 Washington State University

WSU Extension bulletins contain material written and produced for public distribution. Alternate formats of our educational materials are available upon request for persons with disabilities. Please contact Washington State University Extension for more information.

You may download copies of this and other publications from WSU Extension at <http://pubs.wsu.edu>.

Issued by Washington State University Extension and the U.S. Department of Agriculture in furtherance of the Acts of May 8 and June 30, 1914. Extension programs and policies are consistent with federal and state laws and regulations on nondiscrimination regarding race, sex, religion, age, color, creed, and national or ethnic origin; physical, mental, or sensory disability; marital status or sexual orientation; and status as a Vietnam-era or disabled veteran. Evidence of noncompliance may be reported through your local WSU Extension office. Trade names have been used to simplify information; no endorsement is intended. Published May 2014.

EM070E