

# Moly™

by AGRIGUARDIAN



**Molybdenum for All Crops**

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**AGRIGUARDIAN™**

AgriGuardian™ is dedicated to helping growers to be more successful. The company was founded in 2005 by Dr. David Sasseville, who has decades of field and research experience in plant nutrition in over 30 countries. In partnership with Casey Staloch, AgriGuardian™ works with growers across North America and internationally. The AgriGuardian™ team desires to help growers achieve maximum return on their investment, while sustaining agricultural soils. To achieve this, AgriGuardian Moly™ and other AgriGuardian™ products are designed to meet the nutritional needs of all crops. In addition to soil and foliar application, these products also incorporate seed treatments, beneficial microbiology, natural growth promoting compounds and defense mechanisms.

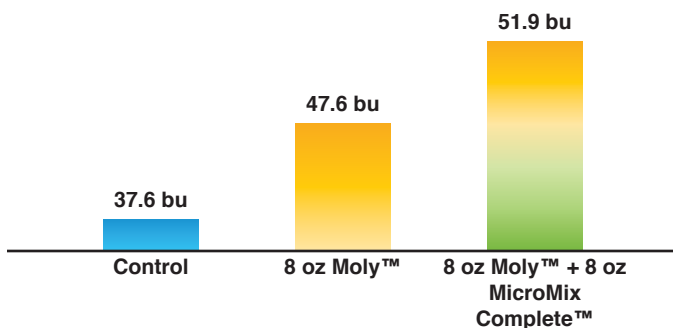
## What is AgriGuardian Moly™?

AgriGuardian Moly™ is a proprietary formulated sugar-based chelated molybdenum complex containing 3% molybdenum. Molybdenum is an essential plant nutrient required by all plants and crops to complete their life cycles. AgriGuardian Moly™ is readily absorbed through plant leaves, shoots, roots and reproductive structures. The product is highly concentrated and only a very small amount is needed. When properly used it promotes greater crop health and higher yields whenever molybdenum is limiting crop performance.

## Why Use AgriGuardian Moly™?

Molybdenum is one of the most common essential crop nutrient deficiencies in agriculture. It is the nutrient deficiency most often ignored and misunderstood. AgriGuardian Moly™ is an effective way to ensure that crops have adequate levels of molybdenum to meet their needs. It is easy to use, and very cost effective. The use of 2-4 oz. per acre applications of AgriGuardian Moly™ will satisfy the needs of most crops. The product is commonly foliar applied with other chemicals or fertilizers, so it is cost effective to use. It can be mixed with glyphosate and most other chemicals without loss of efficacy. The amount of molybdenum provided by AgriGuardian Moly™ is small compared to other applied nutrients, but small differences in molybdenum can make big differences in yield and profits. The overall effect of molybdenum on plant growth and performance is much greater than the small amount needed would suggest.

Soybean Yields using AgriGuardian Moly™



Standard RR soybeans grown on poor soil with no N, P or K applied to crop. Products were tank mixed with glyphosate and foliar applied at V3 and R1. The addition of AgriGuardian MicroMix Complete™ improved the yield in addition to AgriGuardian Moly™. *Data by Dr. Robert Kremer, University of Missouri-Columbia and USDA-ARS.*

## How to use AgriGuardian Moly™

Molybdenum in AgriGuardian Moly™ is a sugar-based chelate complex. This allows rapid absorption of the product by the plant, making molybdenum immediately available for plant use. AgriGuardian Moly™ can be applied many ways to crops:

- **Foliar Spray** used alone or tank mixed with most other fertilizers and pesticides
- **In-furrow** at planting with most other fertilizers and pesticides
- **Irrigation Systems** used alone or mixed with most other fertilizers and pesticides.
- **Starter Solutions or Root Dips** at planting or transplanting, used alone or mixed with most other fertilizers and chemicals.
- **Soil Application or Media Drench** for transplant or seedling production, used alone or mixed with most other fertilizers and chemicals.
- **Nutrient Solutions** for hydroponics and greenhouse house production, used alone or mixed with most other fertilizers and chemicals.



## AgriGuardian™: A Leader in Micronutrient Technology

The scientists, chemists and formulators that developed AgriGuardian Moly™ have over a 100 years experience working with micronutrients to meet the nutritional needs of plants and crops. The product was built from the ground up to ensure that the molybdenum is readily available, quickly absorbed, and immediately usable by the plants and crops. The product was also designed to be compatible in tank mixes with most chemistries including glyphosate. When it comes to meeting the nutritional needs of crops and increasing yields, AgriGuardian Moly™ is one of the most cost effective and efficient molybdenum products on the market today.

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## Molybdenum

### Need for Molybdenum in Crops

Molybdenum is required by all crops to grow properly, produce high yields and quality products. Molybdenum deficiency is one of the most frequent nutrient deficiencies in all crops. In parts of the United States, molybdenum has been found to be deficient in 70% to 90% of soil and tissue samples tested. However, since most labs do not include molybdenum as part of their standard soil tests and tissue analysis, growers and consultants often do not view it as important. Without test results to confirm whether molybdenum is adequate or deficient in the plant or soil, this essential nutrient is either ignored or assumed to be within an acceptable range. Another reason for little concern about molybdenum is that the quantity of molybdenum needed is very low. Molybdenum deficiency is often not considered because molybdenum deficiency commonly looks very much like nitrogen deficiency. Typical deficiency symptoms include yellowing and poorly formed leaves, and stunted plants. Because of the similarities to nitrogen deficiency, molybdenum deficiency is the most common misdiagnosed nutrient deficiency.

### Important Roles for Molybdenum are:

- **Nitrate reduction** - the conversion of nitrate inside the plant for the plant to be able use this nitrogen form for growth. Without molybdenum, nitrate is unusable and accumulates in plant tissues.
- **Sulfate and phosphate utilization** - the conversion of sulfur and phosphorus into forms used by plants.
- **Nitrogen fixation** - the conversion of nitrogen gas in the air into usable nitrogen that plant can use. Nitrogen fixation is normally limited to legume crops, such as soybeans, peanuts, beans, peas, alfalfa and clover.
- **Essential plant growth regulators** - two essential growth regulators, indoleacetic acid (IAA) and abscisic acid (ABA) require molybdenum for these compounds to be made inside plants. These growth regulators control much of the plant's growth and reproduction, as well as the plant's ability to tolerate and defend against environmental stresses. These include drought, temperature extremes, physical damage and pathogen attack as well as helping to protect plants under high salt growing conditions.

### Conditions Limiting Molybdenum Uptake:

- **Acidic or low pH soils** - molybdenum is less available when soil pH is low.
- **Sandy or highly leachable soils** - molybdate (the form of molybdenum most often found in soils) leaches out the soil (like nitrate does).
- **Soils with high rainfall** - leaches out molybdate from soil.
- **Soils high in sulfates and phosphates** - competes with and suppresses uptake of molybdate.
- **Soils low in minerals containing molybdenum** - only certain minerals in the soil contain molybdenum.
- **Molybdenum removed with harvested crops**, but not replenished with fertilizers or soil amendments.

**When AgriGuardian Moly™ is used, soybean growers routinely report increased yields, larger healthier plants, earlier maturity, more pods per plant, bigger beans and higher test weights.**

## Dual Role of Molybdenum in Nitrogen Fixing Crops

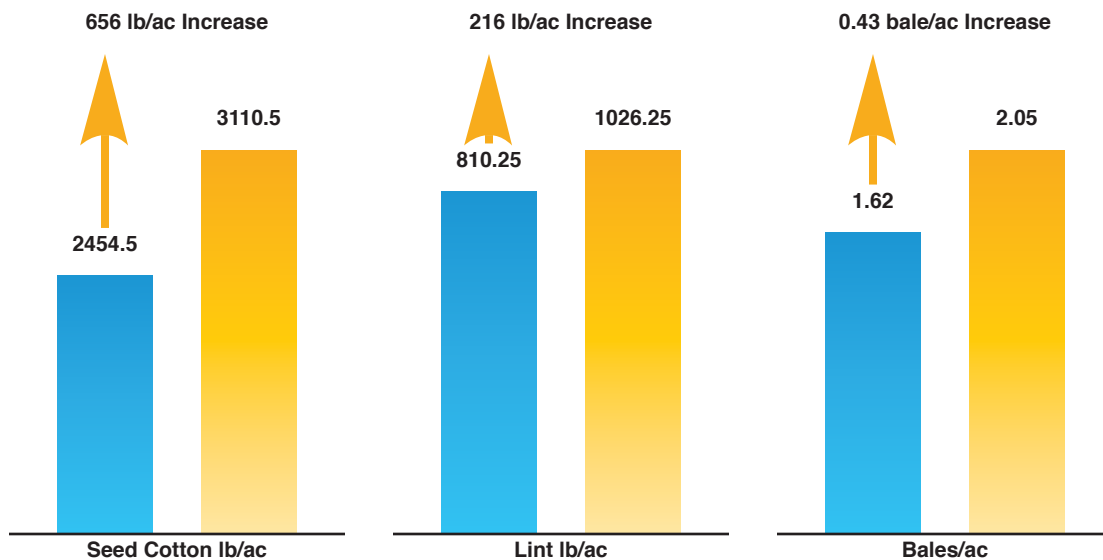
For nitrogen fixing crops, such as soybeans, beans, peas, clover and alfalfa, it is especially important to have molybdenum available to the crop early in the growing season for the formation of nodules and to stimulate nitrogen fixation. Nitrogen fixation will continue so long as the plant is able to provide carbohydrates to the nodules and nitrogen fixing bacteria. However, as crops mature, the demand for carbohydrates to support pod and seed development and vegetative growth increases. This makes less of the plant's carbohydrate supply available for nitrogen fixation. As the carbohydrates supply to the nitrogen fixing bacteria diminishes, the amount of available nitrogen from nitrogen fixation also decreases. The plant then becomes more dependent on the nitrogen supplied from the soil to complete its life cycle. This stage of plant growth also typically occurs during midsummer when soil temperatures are consistently warm. Warm soil temperatures stimulate the conversion of ammonium to nitrate by Nitrosomonas and Nitrobacter microorganisms. Thus available nitrogen from the soil is predominantly in the nitrate form. Nitrate can be readily taken up by all crops. However, molybdenum is required to be able to use nitrate nitrogen for plant growth. Because of the need for molybdenum for both nitrogen fixation AND nitrate reduction, at least two applications of AgriGuardian Moly™ are recommended for nitrogen fixing crops. It is better to provide two or more smaller applications than one large application, especially since excess molybdenum can be leached from the soil by heavy rainfall or irrigation.

### AgriGuardian Moly™ and Cotton Yield in Molybdenum Deficient Soils in California

AgriGuardian Moly™ foliar applied at 2 oz per acre with glyphosate to young plant and again at first square. Preplant soil tests reported Mo  $\leq$ 0.01 ppm. All rates of applied AgriGuardian Moly™ (2, 4 and 8 oz/ac) increased yields over control. The 2 oz/ac rate applied twice showed the greatest return on investment, with all yields increased by greater than 26%.. *Data and photos by University of California researcher.*

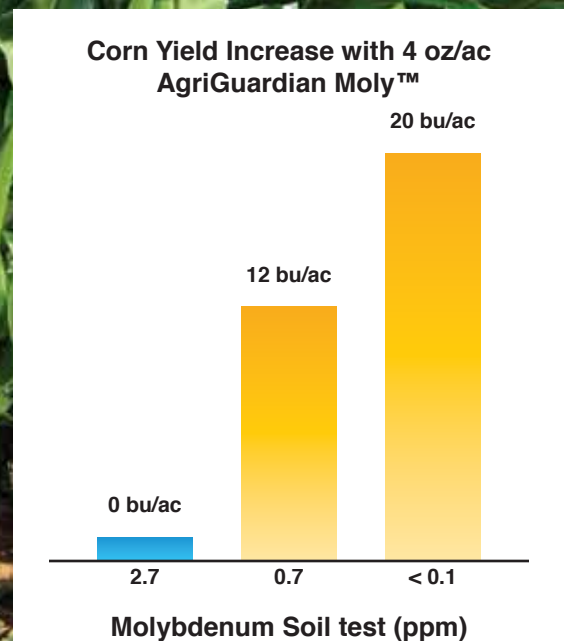


### Without AgriGuardian Moly™ | With AgriGuardian Moly™



## Real-life Consequences of Molybdenum Deficiency

A grower in Colorado desired to grow 300 bu/ac corn, and as he stated, “Everyone knows that it takes a lot nitrogen to grow a good corn crop.” So he put down 5 tons of composted cattle manure, and applied 360 pounds of nitrogen per acre through a central pivot irrigation system. By the time the corn was about waist high (V9), the crop was beginning to show nitrogen deficiency symptoms. At harvest, the crop barely produced 200 bu/ac. After harvest, the grower normally lets his cattle eat any remaining corn stubble. Before releasing his cattle into the cornfield, the stubble was tested for nitrate and was found it to contain over 4,000 ppm of nitrate, enough to kill cattle that would eat it. The grower wanted to know why the corn did not respond to the nitrogen fertilizer, and why the excessively high accumulation of nitrate in the stubble. A simple soil test showed that his land was devoid of molybdenum. Using AgriGuardian Moly™ would correct both of these problems.





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## Benefits

Molybdenum is an essential plant nutrient required by every crop. AgriGuardian Moly™ can provide available molybdenum needed by all crops. Here are some of the ways that AgriGuardian Moly™ can increase yields and crop performance.

### Needed by All Crops

- Increases overall growth and yields of all crops.
- Increases nitrogen, phosphorus and sulfur utilization.
- Increases efficiency of applied nitrogen, phosphorus and sulfur fertilizers.
- Increases efficiency of soil nutrients.
- Prevents/reduces accumulation of nitrate in plant tissues.
- Increases protein content of crops, including wheat and other small grains.

### Application and Uptake

- Provides molybdenum that is rapidly taken up through leaves, stems and roots to quickly correct deficiencies.
- Can be applied as a foliar application, through irrigation systems, in starter solutions, either alone or mixed with most other fertilizers and chemicals.
- Foliar application by-passes soil conditions that reduce uptake of molybdenum (e.g. low pH, high levels of P or S), or when roots have been damaged by diseases, nematodes or mechanical injury.
- Can be applied in-furrow at planting.

### Improves Plant Health and Quality

- Improves resistance to environmental stresses.
- Improves tolerance to high salt soil conditions.
- Improves resistance to diseases.
- Increases resistance and tolerance to insect and disease damage.
- Decreases time for crops to reach harvestable maturity.

### For Specific Crops

- Increases nitrogen fixation in beans, peas, alfalfa, clover and other legumes.
- Increases number of rounds and length of corn ears.
- Increases the size and number of spikes in wheat and other small grains.

**Small differences in molybdenum can make big differences in plant growth, yield, quality of crops (e.g. protein content in wheat) and profits. Test soil and crops to determine if AgriGuardian Moly™ needed.**

## The Science Behind AgriGuardian Moly™

### Role of Molybdenum in Crops

Molybdenum plays many roles in plants that impact the way a plant grows and performs. The most important of these are nitrate reduction, sulfate and phosphate metabolism, nitrogen fixation, and the synthesis of two primary growth regulators - indoleacetic acid (IAA) and abscisic acid (ABA). Because molybdenum is required in many vital plant functions, it is classified as an “essential plant nutrient” for all crops and plants.

### Nitrate Reduction

All crops need Molybdenum to use nitrate nitrogen ( $\text{NO}_3$ ).

- Most nitrogen fertilizer is applied as ammoniacal nitrogen (such as 28% or 32% UAN, urea, anhydrous ammonia, manure), usually preplant or early in the season.
- Ammoniacal nitrogen is the predominant form of nitrogen available to young plants. Crops take up this nitrogen from the soil into the plant to produce proteins and results in growth.

**$\text{NH}_4$  in soil →  $\text{NH}_4$  in plants → Proteins → Growth**

- As spring turns to summer, and the soil warms, microbes in the soil quickly convert ammoniacal nitrogen to nitrate nitrogen by a process called “nitrification.”

**$\text{NH}_4$  in soil →  $\text{NO}_3$  in soil**

- Crops can take up nitrate, but inside the plant it must be converted to ammoniacal nitrogen by a process called “nitrate reduction” before the plant can actually use this nitrogen.

**$\text{NO}_3$  in soil →  $\text{NO}_3$  in plant →  $\text{NH}_4$  in plant → Protein → Growth**

- The enzyme that converts nitrate to ammonium requires molybdenum.
- If crops have adequate molybdenum in the tissues and have more available nitrate than is needed by the plant, the excess nitrate is stored in the plant cells until plant needs the additional nitrogen.
- However, if the crop does not have adequate molybdenum, then the nitrate is stored in the plant cells, and the plant cannot use this nitrate to make protein or promote growth until the plant has adequate molybdenum. An indicator of molybdenum deficiency is an accumulation of excessive  $\text{NO}_3$  in the plant tissues.

Crops need molybdenum to get full use of nitrogen, whether from applied fertilizer or from nitrogen mineralized from the soil.

**AgriGuardian Moly™ is a highly cost effective way to increase the efficiency of nitrogen, phosphorus and sulfur fertilizers, increase nitrogen fixation, and increase growth and defense systems, resulting in increased yields of all crops whenever molybdenum is deficient in a crop.**

## Sulfate and Phosphate Utilization

Full utilization of sulfur and phosphorus requires molybdenum. Molybdenum is intimately involved in sulfate and phosphate utilization. It helps to regulate the chemical forms of sulfur and phosphorus inside the plant that the plant can use. Low molybdenum can appear as sulfate and/or phosphate deficiency because of molybdenum's role in making these nutrients usable by plants.

## Nitrogen Fixation

All crops that fix nitrogen need molybdenum, including soybeans, beans, peas, peanuts, alfalfa, clover and many others. The enzyme that fixes nitrogen contains molybdenum, and without molybdenum, there is no nitrogen fixation.

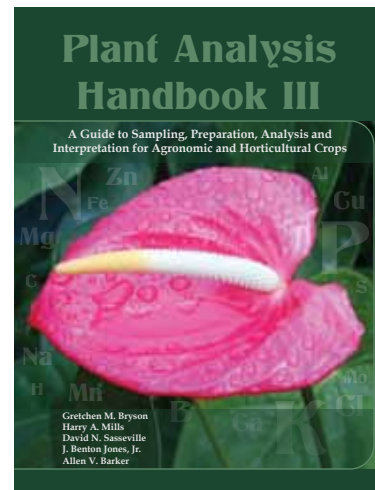
- Low molybdenum in nodules can cause low nitrogen in tissue, poor growth and yields.
- Nitrogen fixing crops need molybdenum early in season when nodules first form for crop to fix the most nitrogen.
- Nodules with good levels of molybdenum are dark pink to bright red inside indicating good nitrogen fixation.
- Tissue test is best way to determine molybdenum levels and deficiencies.



## Essential Plant Growth Regulators

Molybdenum is required for the production of two essential plant growth regulators - indoleacetic acid (IAA) and abscisic acid (ABA). These compounds play an important role in controlling many aspects of plant growth, including cell division and enlargement, tiller growth, flowering, size of grain head and grain filling. They also regulate responses to environmental stresses such as drought, temperature extremes, physical damage and pathogen attack, as well as helping to protect plants in high salt growing conditions. While molybdenum is needed in very small amounts compared to other nutrients, the deficiency of molybdenum can result in an overall reduction in plant growth and yield.

Some common examples of the effects of molybdenum deficiency on crops is overall reduced growth, small leaves, less tolerance to drought and other environmental stresses, and overall reduced yields. In corn, molybdenum is required for the production of IAA (at stage V5-6), which regulates the number of rounds of kernels that form on an ear. Similarly, it influences the number of spikes, weight of spikes, tiller growth and yield of wheat and other grains. Molybdenum through its effect on plant growth regulators plays a greater role on crop performance that would normally be considered based on amount of the nutrient used by each crop.



To learn more about molybdenum and plant nutrition, obtain a copy of their book *Plant Analysis Handbook III* from your AgriGuardian™ distributor.

## The Science Behind AgriGuardian Moly™

### Nitrogen or Molybdenum Deficiency?

Ever had a crop that looked nitrogen deficient, but the tissue tests report shows plenty of nitrogen? The problem may not be nitrogen, but molybdenum deficiency.

Tissue tests measure Total Nitrogen (%N), which is all the nitrogen contained in the plant. Nitrate stored in plant cells is included in the %N even though the plant cannot use the nitrate nitrogen without molybdenum.

#### **%N in tissue = N in protein + NO<sub>3</sub> stored in plant cells**

In a growing crop, adding nitrogen is a costly way to correct a molybdenum deficiency. To get a complete understanding of the nitrogen status in a crop, test for Total N, nitrate and molybdenum. Include molybdenum in all soil and tissue samples to know for sure.

### Soil pH and Molybdenum

Numerous articles have been written by well-meaning authors stating that liming soil will take care of molybdenum deficiencies. The fact that molybdenum is more available in soil at higher pH's is well established. However, the claim that adjusting soil pH alone will take of molybdenum deficiencies makes the assumption that the soil contains adequate molybdenum, but the molybdenum is just not available. However, many soils do not contain enough minerals that contain molybdenum. Additionally, molybdate, the predominant form of molybdenum found in the soil, is readily leachable. Low molybdenum levels in soils are common worldwide. Include molybdenum in all soil and tissue tests to know for sure whether molybdenum is needed.



# Science Based Products

### More than just for Nitrogen Fixation

*“Apart from genetic effects, molybdate [molybdenum] deficiency also affected the expression of many genes involved in transport, stress responses, signal transduction and in the metabolisms of nitrogen, sulfur, and phosphate, but also the levels of amino acids, sugars, organic acids, and purine metabolites were significantly altered, indicating that molybdate [molybdenum] nutrition has global impact on plants.”*  
Source: Bittner, Florian. 2014. Molybdenum metabolism in plants and crosstalk to iron. *Frontiers in Plant Science* 5(28)1-6.

#### **WARNING**

**DO NOT OVERUSE ON FORAGES AND ANIMAL FEEDS**

Continuous feeding of ruminant animals with feed containing 10 ppm of molybdenum can induce a copper deficiency in ruminant animals, which can cause serious illness and even death. Fifty (50) parts per million in feed rations can cause acute poisoning, possibly leading to death of ruminant animals.

### Molybdenum is Not Toxic to Crops (Apply Only What is Needed)

Molybdenum is not toxic to plants, and concentrations up to 1% (10,000 ppm) in plant tissue have been reported without damage to the plant. However, when plants have accumulated large amounts of nitrate from a deficiency of molybdenum and then received high molybdenum applications, the plant rapidly forms the nitrate reductase enzyme. With high levels of this enzyme, the accumulated nitrate quickly converts to ammonium in the plant. This rapid conversion of nitrate to ammonium takes energy from the plant and can cause a depletion of carbohydrates in the plant, thus slowing growth or maturity. It is better to apply small amounts of molybdenum (2-4 oz/ac of AgriGuardian Moly™) 2-3 times per season than trying to apply all the molybdenum that is needed by the crop in one single high rate of application.



# to Help Feed the World

## Application Guidelines for Crops

Always use adequate water (typically 5-10 gallons or more per acre) for foliar application to ensure good cover. For most crops, two applications of 2 oz. per acre AgriGuardian Moly™ are better than one application of 4 oz. per acre. For highest yields, 4 oz. per acre applications may be required. If only one application is made, apply when crop has high levels of foliage, during vegetative or early reproductive stages of development. If mixing with other chemicals or fertilizers, always do jar test to determine compatibility, and also do test application on a small portion of field to ensure no toxic effects occur before applying to all of crop. AgriGuardian Moly™ may be applied to soil in-furrow, typically at 4-8 oz. per acre. Additional foliar applications may be necessary at 2-4 oz. per acre.

**Use soil test and tissue analysis results as basis for application rate of AgriGuardian Moly™.**

### Alfalfa • Hay • Forage Crops

Apply foliar application of 2-4 oz. per acre AgriGuardian Moly™ in spring when early growth is 4-6" tall. Apply an additional 2-4 oz. per acre after each cutting when crop has regrown to 4-6" tall.

### Canola

Apply foliar application of 2-4 oz. per acre AgriGuardian Moly™ during mid-late rosette stage when good foliage is present. Apply an additional 2-4 oz. per acre at flowering.

### Corn

Apply foliar application of 2-4 oz. per acre AgriGuardian Moly™ at V4-V5 stage. Apply an additional 2-4 oz. per acre at V9-V12. A third application of 2-4 oz. per acre may be applied at silking.

### Cotton

Apply foliar application of 2-4 oz. per acre AgriGuardian Moly™ as soon as adequate foliage is present for good absorption. Apply a second foliar application of 2-4 oz. per acre at pinhead square, and a third application of 2-4 oz. per acre may be used at early bloom.

### Fruit and Nut Trees

Apply foliar application of 2-4 oz. per acre AgriGuardian Moly™ as soon as adequate foliage is present for good absorption. Apply 2-4 oz. per acre every 4-6 weeks throughout growing season, especially during reproductive stages of development.

### Grain Sorghum

Apply foliar application of 2-4 oz. per acre AgriGuardian Moly™ as soon as adequate foliage is present for good absorption, typically 5-7 leaf stage. Apply a second application of 2-4 oz. per acre at boot initiation.

### Pasture

Apply foliar application of 1-4 oz. per acre AgriGuardian Moly™ in spring when early growth is 4-6" tall. Apply 1-4 oz. per acre every 6-8 weeks throughout season. Use caution in applying to pasture that is being actively grazed. Do tissue test to confirm need for molybdenum, see WARNING on page 13. Consider using AgriGuardian MicroMix Complete™ that has all essential micronutrients, including molybdenum, but less concentrated.

### Peanuts

Apply foliar application of 2-4 oz. per acre AgriGuardian Moly™ as soon as adequate foliage is present for good absorption. Apply a second foliar application of 2-4 oz. per acre between pegging and beginning pod development.

### Potatoes

Apply foliar application of 2-4 oz. per acre AgriGuardian Moly™ per acre approximately 3-4 weeks after crop emergence when a good canopy has formed. Apply a second foliar application of 2-4 oz. per acre 3-4 weeks later when tubers are forming.

## **Rice**

Apply foliar application of 2-4 oz. per acre AgriGuardian Moly™ as soon as adequate foliage is present for good absorption. Apply a second foliar application of 2-4 oz. per acre after internode elongation or joint movement.

## **Small Fruits • Grapes • Strawberries • Blueberries • Brambles**

Apply foliar application of 2-4 oz. per acre AgriGuardian Moly™ as soon as adequate foliage is present for good absorption. Apply 2-4 oz. per acre every 6-8 weeks throughout growing season.

## **Soybeans • Beans • Peas**

Apply foliar application of 2-4 oz. per acre AgriGuardian Moly™ as soon as adequate foliage is present for good absorption. Apply a second foliar application of 2-4 oz. per acre at the beginning of pod development.

## **Sugar Beets**

Apply foliar application of 2-4 oz. per acre AgriGuardian Moly™ as soon as adequate foliage is present for good absorption. Apply 2-4 oz. per acre approximately 3-4 weeks after initial application.

## **Sunflower**

Apply foliar application of 2-4 oz. per acre AgriGuardian Moly™ as soon as adequate foliage is present for good absorption. Apply a second foliar application of 2-4 oz. per acre at flower initiation.

## **Turf • Ornamentals**

Apply foliar application of 2-4 oz. per acre AgriGuardian Moly™ as soon as adequate foliage is present for good absorption. Apply 2-4 oz. per acre every 3-4 weeks throughout growing season.

## **Vegetables**

Vegetables include a wide variety of crops. With short season vegetable crops one application at 2-4 oz. per acre AgriGuardian Moly™ is applied as soon as crop has adequate foliage for good absorption. For long season crops or perennial crops, apply 2-4 oz. per acre every 4-6 weeks during growing season.

## **Wheat • Small Grains**

Apply foliar application of 2-4 oz. per acre AgriGuardian Moly™ during early tillering when good foliage is present. Apply a second foliar application of 2-4 oz. per acre after first flag leaf stage.



A Product of  
**AGRIGUARDIAN™**

For more information  
about our products and services,  
contact AgriGuardian™ at

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