e-GRO Alert

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# Mastering the Mix with Strategic Crop Groupings

*Strategically grouping greenhouse crops based on their environmental or cultural requirements ensures successful growth despite conflicting needs.*

With spring on the way, many greenhouse sections and greenhouses are filling up with a wide array of crop types including annual bedding plants, herbaceous perennials, vegetable and herbs transplants, and tropical plants, most with conflicting environmental and cultural requirements (Fig. 1). Almost all greenhouse and retail garden center businesses produce flats or containers with a single-species and hanging baskets and decorative patio planters with mixes of multi-species. The diverse selection of plant material, containers, and combination planters growing side-by-side for a few weeks like annuals bedding plants or longer-term crops like hanging baskets can lead to growing difficulties that affect overall plant quality and aesthetic appeal. Growers can prevent these growing difficulties by grouping crops to accommodate their environmental and cultural requirements which can lead to success this production season.

Figure 1. A production greenhouse containing a wide array of crop types including annual bedding plants, most with conflicting environmental and cultural requirements. Photo by: W. Garrett Owen.



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## Air Temperature

In the hierarchy of grouping greenhouse crops, growers can first start by assessing environmental responses such as air temperature. Greenhouse crops can be grouped into three temperature-response categories: cold-tolerant, cold-temperate, and cold-sensitive. These categories are based on base temperatures or the temperature in which a plant stops growing and developing. General base temperature and average daily temperature guidelines for each category are listed in Table 1.

Ideally, growers should strive to separate crops by their base temperature and grow in greenhouses under different temperature set points. This strategy is advantageous for crop scheduling, lowering heating costs, and maintaining crop quality; however, it may not be feasible for all greenhouse and retail garden center businesses due to space constraints and environmental control systems.

**Table 1.** The classification of bedding plants into cold-tolerant, cold-temperate, and cold-sensitive categories according to their respective base temperatures.

| Cold-tolerant | Cold-temperate | Cold-sensitive |
|---|---|---|
| **Base Temperature Range** | | |
| **40˚F or lower (<4.4˚C)** | **40 to 45˚F (4.4 to 7.2˚C)** | **45˚F or higher (>7.2˚C)** |
| **Average Daily Temperature Range** | | |
| **60 to 65˚F (16 to 18˚C)** | **65 to 70˚F (18 to 21˚C)** | **70 to 75˚F (21 to 24˚C)** |
| Alyssum | Calibrachoa | Ageratum |
| Argyranthemum | Chrysanthemum | Angelonia |
| Bacopa | Cosmos | Caladium |
| Dianthus | Dahlia | Celosia |
| Diascia | Gazania | Gerbera |
| Dusty miller | Geranium, Ivy | Lantana |
| Marigold, French | Geranium, Seed | New Guinea impatiens |
| Nemesia | Geranium, Zonal | Pentas |
| Osteospermum | Impatiens, seed | Poinsettia |
| Pansy | Lobelia, annual | Portulaca |
| Scaevola | Petunia* | Sweet potato vine |
| Snapdragon | Verbena | Vinca, annual |
| Viola | Wax beonia | Zinnia |

* Not all cultivars.

Adapted from M. Blanchard and E. Runkle. 2021. Chapter 6. Temperature, p. 64–79. In: J. Nau, B. Calkins, and A. Westbrook (eds.) Ball redbook: Crop culture and production 19th ed., vol. 2. Ball Publishing, West Chicago, IL.

## Photosynthetic Daily Light Integral

Greenhouse crops can be grouped by their photosynthetic daily light integral (DLI) requirements or the integrated measurement of light intensity and photoperiod that plants receive over the course of a day (24-hour period). General photosynthetic DLI guidelines are listed in Table 2.

These guidelines can be useful to manipulate the light environment to maintain plant growth and quality. Under low photosynthetic DLIs, growers can deploy supplemental lighting or retract shade curtains, remove external shade, or remove shading compounds. Under high photosynthetic DLIs, growers can stop supplemental lighting and close shade curtains or apply external shade or shading compounds. In certain situations, greenhouse environmental control systems offer growers the capability to set light thresholds, so lighting and shading is manipulated when outdoor conditions are above or below greenhouse setpoints.

Like temperature, grouping crops by their photosynthetic DLI requirements is advantageous for managing supplemental lighting or shade, and maintaining crop quality; however, it may not be feasible for all greenhouse and retail garden center businesses. Grouping plants by photosynthetic DLI can be challenging if greenhouse do not have horticultural lamps or shade curtains, environmental control systems with the capability of controlling lighting and shading, or equipment to measure and monitor photosynthetic DLI.

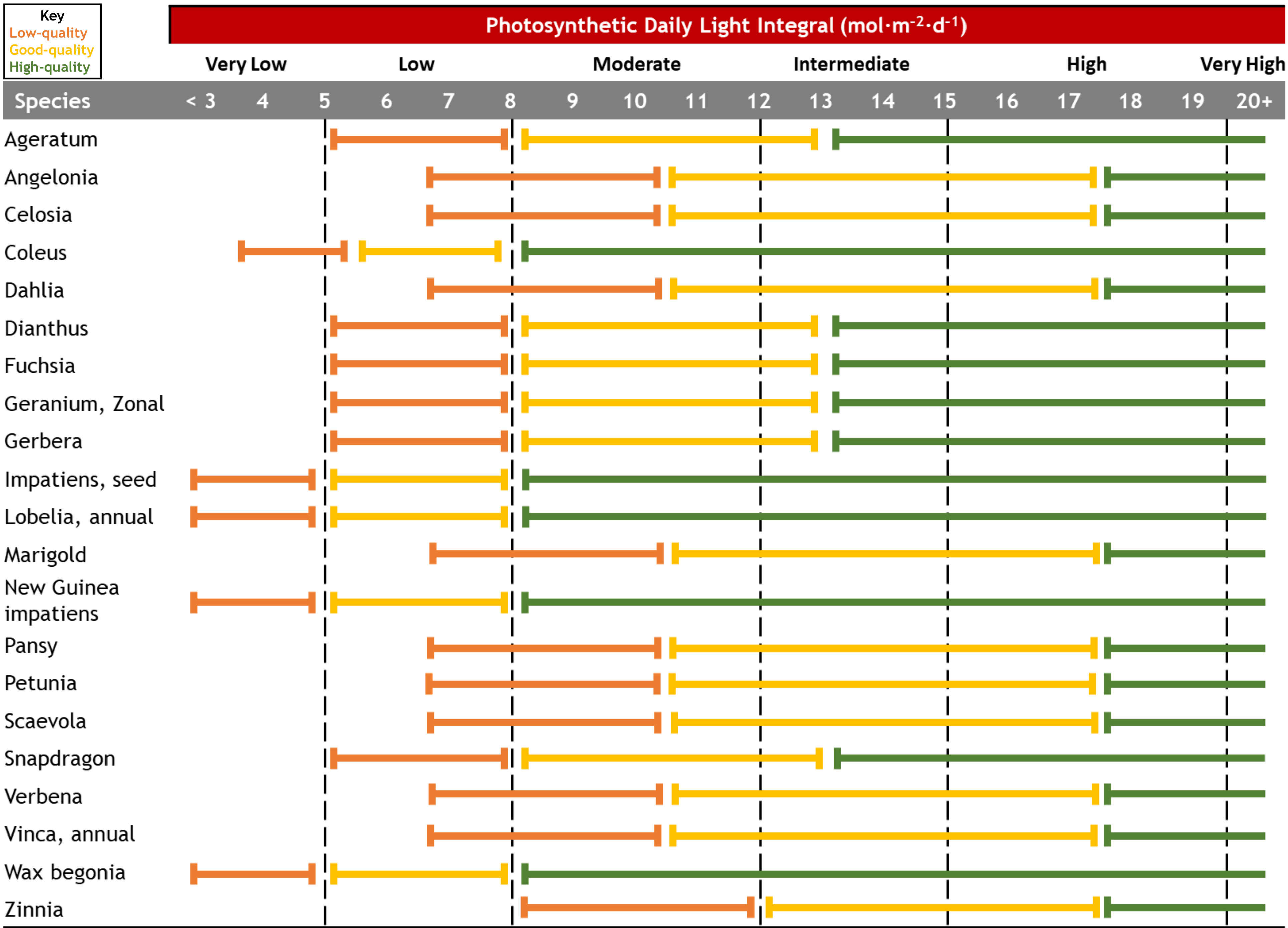
## Substrate pH Preference

If you are limited by grouping greenhouse crops by environmental requirements, then consider grouping crops by different nutrient management preferences such as substrate pH. Greenhouse crops can be grouped into three pH preference categories: iron-inefficient, iron-efficient, and general. These categories are based on how “efficient” plants are at taking up micronutrients. Substrate pH preference guidelines for each category are listed in Table 3.

Iron-inefficient crops are susceptible to developing iron deficiency or chlorosis (yellowing) and interveinal chlorosis of the shoot-tips and recently matured leaves at high substrate pH. If iron deficiency is suspected or substrate pH is unknown, then you should evaluate substrate pH by performing an in-house PourThru, Saturated Media Extraction, or 1:2 Dilution procedure. Results from these procedures will provide insight into nutrient availability based on substrate pH and identify appropriate corrective procedures.

For iron-inefficient crops, maintaining a lower substrate pH ranging from 5.5 to 5.8 increases micronutrient solubility, allowing the nutrients to be readily available for uptake and preventing iron deficiency. Greenhouse operations in locations using well water with high alkalinity (carbonates and bicarbonates) levels likely experience challenges growing iron-inefficient plants because alkalinity, if left unchecked, will cause substrate pH rise and limit micronutrient availability over the cropping cycle, and cause high-pH induced iron deficiency to develop. Therefore, acid injection must be deployed to neutralize alkalinity to prevent substrate pH drift above the recommended substrate pH and maintain micronutrient solubility. Growers can also use acidic fertilizers that

**Table 2.** The classification of bedding plants into very low, low, moderate, intermediate, high, and very high categories according to their responses to photosynthetic daily light integral.




Adapted from R. Lopez and C. Currey. 2021. Chapter 7. Light, p. 80-89. In: J. Nau, B. Calkins, and A. Westbrook (eds.) Ball redbook: Crop culture and production 19th ed., vol. 2. Ball Publishing, West Chicago, IL.

**Table 3.** The classification of bedding plants into iron-inefficient, general, iron-efficient categories according to their substrate pH preference.

| Iron-Inefficient (*Petunia Group*) | General (*Poinsettia Group*) | Iron-efficient (*Geranium Group*) |
|---|---|---|

**Substrate pH**

5.5 5.6 5.7 5.8 5.9 6.0 6.1 6.2 6.3 6.4 6.5

### *General*

*Desired substrate pH*

**5.8 - 6.2**

Chrysanthemum; Impatiens, seed; and Osteospermum

### *Iron-Inefficient*

*Desired substrate pH*

**5.5 - 5.8**

*Normal growth*

*Iron deficiency*

*Crops to group together & monitor:*

| | | |
|---|---|---|
| Bacopa | Diascia | Scaevola |
| Basil | Geranium, Ivy | Snapdragon |
| Brachyscome | Nemesia | Strawflower |
| Calibrachoa | Pansy | Verbena |
| Dianthus | Petunia | Vinca |

### *Iron-Efficient*

*Desired substrate pH*

**6.2 - 6.5**

*Iron/ Manganese toxicity*

*Normal growth*

*Crops to group together & monitor:*

Geranium, Zonal; Geranium; Seed
New Guinea impatiens; Marigold

contain ~55% ammoniacal-nitrogen to lower substrate pH. This strategy provides a limited level of control and is not always effective especially under cool, wet conditions which may cause ammonium toxicity. Other substrate pH management strategies growers can consider including acid water drenches, providing a micronutrient fertilizer package, or drenching with iron-chelate. For specific corrective procedures to lower substrate pH, refer to e-GRO Nutritional Monitoring: Corrective Procedure for Modifying Substrate pH.

Iron-efficient crops are susceptible to developing iron and manganese toxicity on the lower, older leaves. Symptoms of iron and manganese toxicity vary by species. Typical symptoms observed include lower leaf bronzing or black spotting and stunted plant growth. If iron and manganese toxicity is suspected or substrate pH is unknown, then you should evaluate substrate pH by performing an in-house PourThru, Saturated Media Extraction, or 1:2 Dilution procedure. Results from these procedures will provide insight into nutrient availability based on substrate pH and identify appropriate corrective procedures.

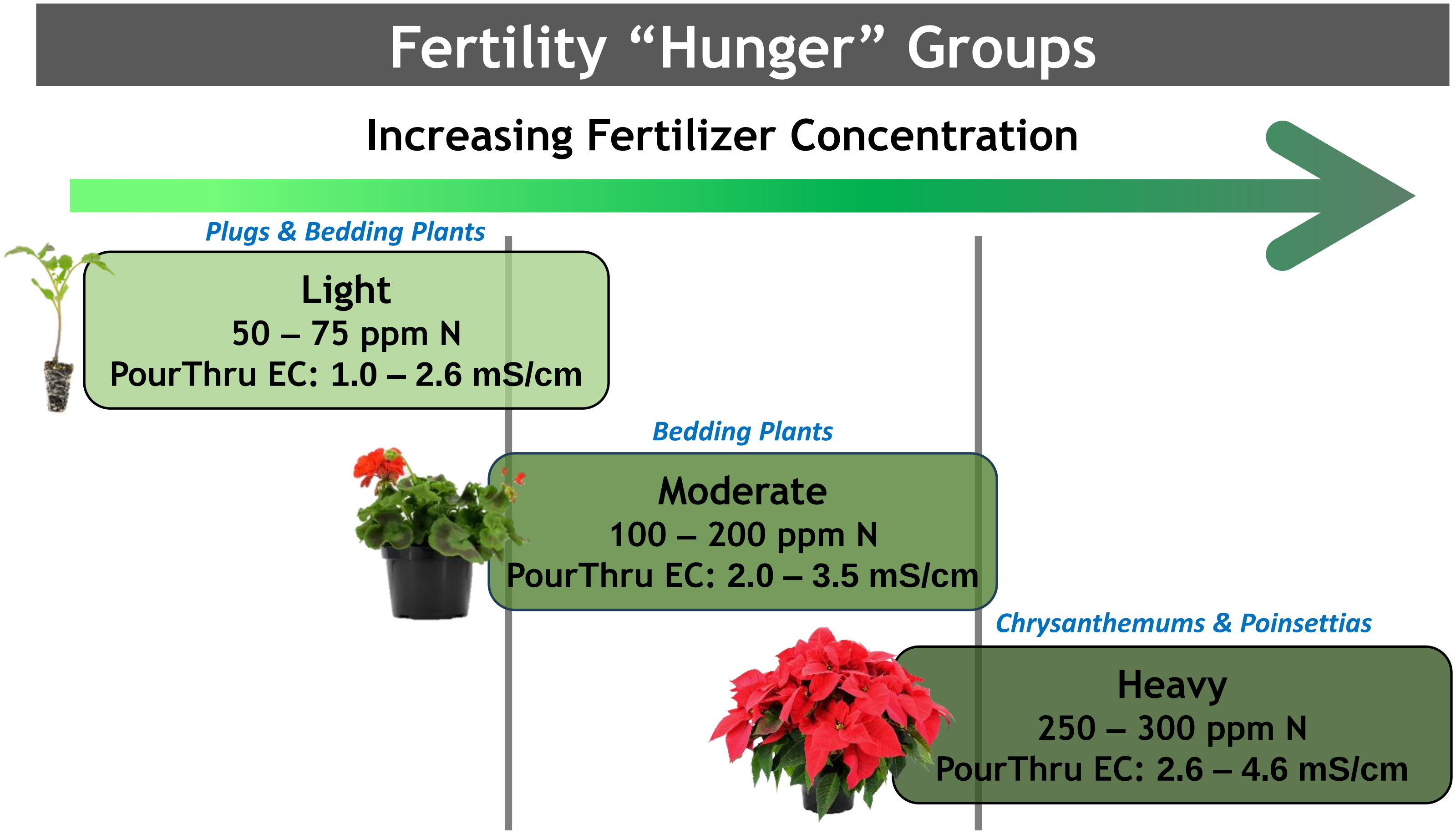
For iron-efficient crops, maintaining a higher substrate pH ranging from 6.2 to 6.5 decreases micronutrient solubility which limits the uptake of nutrients and prevents the excessive accumulation of iron and manganese in the lower, older leaves. To mitigate pH drop, growers can switch to a basic fertilizer that contains ~85% or more nitrate-nitrogen or drench with flowable lime, hydrated lime, or potassium bicarbonate. For specific corrective procedures to increase substrate pH, refer to e-GRO Nutritional Monitoring: Corrective Procedure for Modifying Substrate pH. Additionally, if substrate pH suddenly drops and you utilize acid injection, then it is suggested to inspect the acid injector to determine proper function and injector settings. These guidelines can be useful for monitoring and maintaining substrate pH and preventing nutritional disorders from developing within iron-inefficient and iron-efficient crops.

## Fertilizer Nitrogen Rate

Greenhouse crops can be grouped by nitrogen rate (concentration in ppm or $mg \cdot L^{-1}$) requirements or "hunger or feeders". Growers most often refer to crops within nitrogen concentration groups as light, moderate, and heavy feeders. While these groups are widely acceptable, it is best to manage substrate electrical conductivity (EC) or soluble salts levels to ensure the crops' needs are being met. Nitrogen concentration groups and corresponding substrate EC guidelines for each category are listed in Table 4.

Grouping greenhouse crops by nitrogen concentration requirements can be advantageous; however, growers should implement an in-house substrate EC monitoring program to ensure fertility requirements are met. Providing crops with insufficient or excessive fertility and consequently low or high EC levels, respectively, can compromise plant quality and aesthetic value. Low substrate EC can cause lower leaf and whole plant chlorosis or reddening and stunted plant growth. High substrate EC can cause vigorous or stunted plant growth, marginal leaf chlorosis, and root necrosis (death). If low or high substrate EC is suspected or unknown, then you should evaluate substrate EC by performing an in-house PourThru, Saturated Media Extraction, or 1:2 Dilution procedure. Results from these procedures will provide insight into soluble salt levels in the root-zone and the appropriate corrective procedures. For specific corrective procedures to increase or decrease substrate EC, refer to e-GRO Nutritional Monitoring: Corrective Procedure for Modifying Substrate EC.

**Table 4.** The classification of greenhouse crops into light, moderate, and heavy feeders and according to their nitrogen rate responses and corresponding substrate electrical conductivity (EC) or soluble salts levels.




Grouping crops by nitrogen concentration can also be challenging because fertility requirements are often dynamic, meaning they should generally change throughout the crop growth cycle to meet increasing nutrient demands by maturing plants. However, many growers are successfully not utilizing high nitrogen concentrations. As such, many growers have adapted to "growing lean," meaning they are using lower nitrogen concentrations resulting in lower fertilizer input costs, mitigating fertilizer waste pollution, and controlling crop growth to produce high-quality plants. Other growers are altering their irrigation frequency and duration to manage soluble salt leaching while others prefer to invest in multiple fertilizer injectors and utilize various fertilizer stock solutions.

## Conclusion

By considering crop-specific environmental and cultural needs, growers can strategically group plants to optimize growing conditions, enhance plant quality, and improve overall productivity. The categorization of crops according to their temperature-response categories, photosynthetic DLI requirements, substrate pH preferences, and nitrogen concentration needs provides a roadmap for effective management. By aligning environmental conditions and cultural practices with the specific requirements of each crop group, growers can minimize stressors, reduce resource wastage, and maximize efficiency for a successful spring production season.

## e-GRO Alert

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