

# A Novel Tool for Managing Transplant Stress that Produces Plants with Greater Yield Potential



**By Al Green, *Research Manager, AgroFresh***

# Executive Summary

AgroFresh, a global leader in food quality preservation and freshness solutions, has developed an innovative 1-MCP-based plant stress management technology for transplanted crops that has been proven to support optimal plant health, grow bigger and more marketable produce, and increase yields on average of 15%. The company operates in more than 45 countries and maintains the largest and most comprehensive database of 1-MCP/ethylene technical information in the world.

## A Look at the Problem

No matter how healthy and vigorous seedlings are in the plant house, they are vulnerable to harmful, often unpredictable stresses during handling, transportation, transplanting, and after transplanting in the field.

Seedling stress is known to directly and indirectly reduce produce quality, size, and yield. A 5% yield reduction in tomatoes can result in a yield loss of \$1,000 an acre or more. Some of the sources of plant stress and the stages in which they occur, are summarized in **Table I.**

	Loading	Shipping	Transplanting	Field	<b>Table I.</b> Sources of plant stress for each stage of seedling establishment
Handling					
Containerization					
Movement					
Desiccation/drought					Probability of stress
High temperature					
Low temperature					
Ultraviolet rays					
Insect feeding					
Wind damage					
Sandblasting					
Soil saturation					
Temperature change					
					High
					Moderate
					Low

One way crops respond to stress is hormonal signaling,<sup>1</sup> which can interfere with the growth processes (i.e., reduce photosynthesis or increase respiration) or change resource allocation (i.e., increase root growth under drought stress and decrease shoot growth). Anytime the crop is not growing optimally, a reduction in yield is possible.

In particular, plant stress stimulates increased biosynthesis of ethylene gas, the effects of which can include, depending on severity and duration:<sup>2,3</sup>

- Net reduction in growth due to reduced photosynthesis and increased respiration
- Epinasty (leaf drooping or downward bending)
- Leaf yellowing, browning, or abscission
- Cessation of stem growth
- Early tissue or plant death
- Increased susceptibility to diseases
- Enhanced attractiveness to feeding insects
- Flower and fruit abortion

All of these issues can damage plants, compromise crop health, and potentially reduce yields. Worse, biosynthesis of ethylene can adversely affect not just the stressed plant, but other plants in close proximity.<sup>4</sup>

A stressed plant emits some of its ethylene gas to the atmosphere where surrounding plants absorb it and respond to it, triggering the negative effects listed above. The “second-hand” effect is amplified in closed surroundings, such as when seedlings are shipped in a small, sealed containers.

## Current Methods of Addressing Plant Stress

All of the current methods of addressing plant stress work to reduce the production of ethylene by producing stronger, tougher seedlings.

Better genetics, fertilization, and agronomic management produce more vigorous plants or plants that are less sensitive to stresses. Other growth regulators and SAR (Systemic Acquired Resistance) products change the plants’ resource partitioning or biochemistry to reduce their responses to stress.

The problem is that none of these prevent ethylene production, and even small amounts of ethylene production can adversely affect seedlings. LandSpring Technology is the only product that prevents ethylene from binding to the plants' receptors, thus making crops insensitive to large or small amounts of this plant stress hormone.

Research has shown that plants are most protected from transplant stress when LandSpring use is combined with other stress mitigation practices.

## LandSpring: Innovative Stress Management

LandSpring, a plant growth regulator (PGR) and stress management technology, is the only product using 1-MCP to mitigate stress impacts on seedlings.

LandSpring is applied to seedlings prior to their exposure to stress. This helps the plants withstand the stress they typically encounter during transport and after field transplantation.

Numerous studies (see [Table II](#)) show that treating seedlings with LandSpring can result in many crop improvements for growers, including:

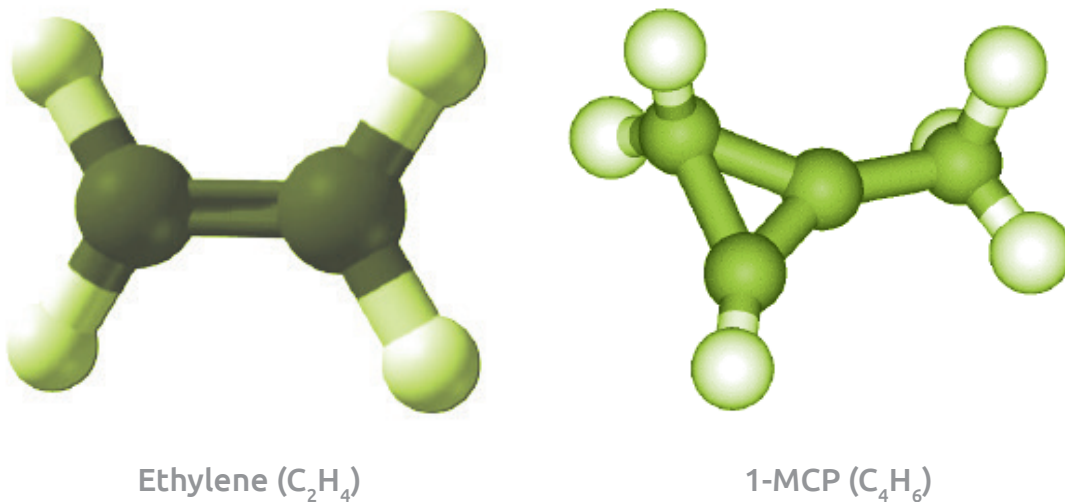
- **Higher seedling survival rates**
  - » Fewer replants
  - » More uniform and consistent crops
- **Better and faster seedling establishment**
  - » Faster root establishment
  - » More vigorous growth
  - » More leaf area
  - » Reduced attraction of feeding insects to the plants
- **Healthier plants**
  - » Reduced disease incidence
  - » Larger plants - greater biomass to support yield
  - » Greater resistance to disease-causing bacteria
  - » Better late-season health
- **Improved yields of 15% on average and as high as 20% to 40%**
  - » Note: in around 70% of transplanted fields, seedlings are stressed enough that LandSpring results in a measurably higher yield
- **Reversal of gibberellin (GA) inhibitors**



## The Key to LandSpring Stress Management: 1-MCP

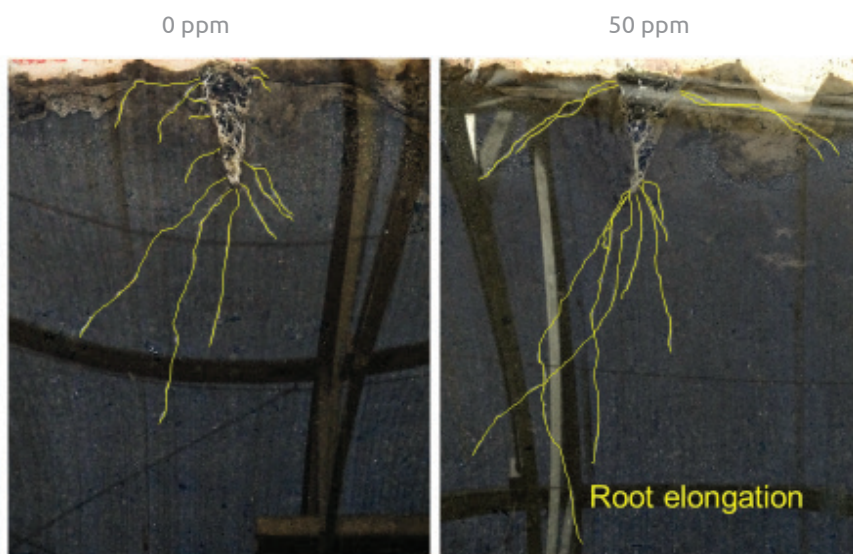
The 1-Methylcyclopropene (1-MCP) molecule is similar in structure to ethylene, a hydrocarbon that is also a natural plant hormone. When LandSpring is applied, the 1-MCP molecules bind to open ethylene receptors in plant cells.<sup>5</sup>

This action, in turn, stops the ethylene from binding on those receptors, thereby preventing ethylene's negative effects. LandSpring has a favorable safety profile with no detectable residue or phototoxic effects.



**Figure 1.**

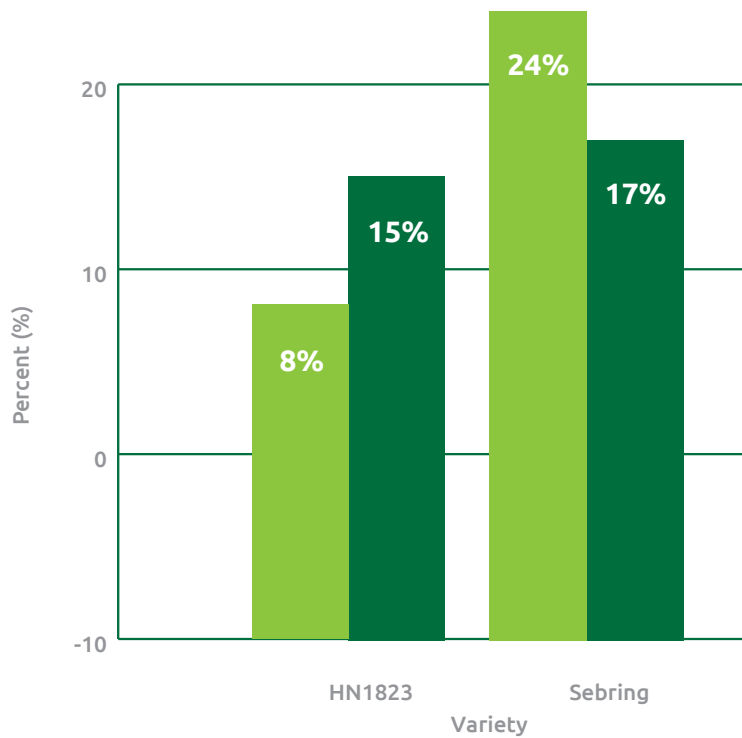
The 1-MCP molecule, close in molecular structure to ethylene, binds with receptors in plants, preventing the hormone from doing so.



**Figure 2.**

FLBM1603-TM – In tomato plants, LandSpring resulted in significantly longer roots, more root branching, and faster root establishment

4 Days After Transplanting



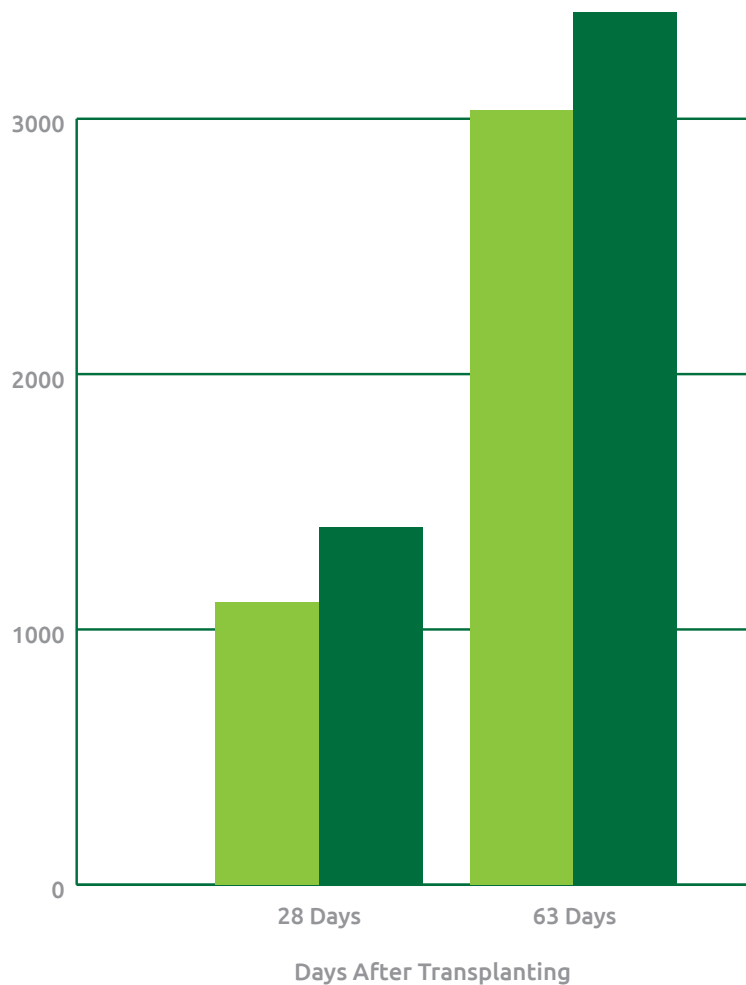
**Figure 3.**

LandSpring makes crops more bacteria-resistant

Increased bacterial tolerance

Yield increase

Source: University of Florida trial <sup>6</sup>



**Figure 4.**

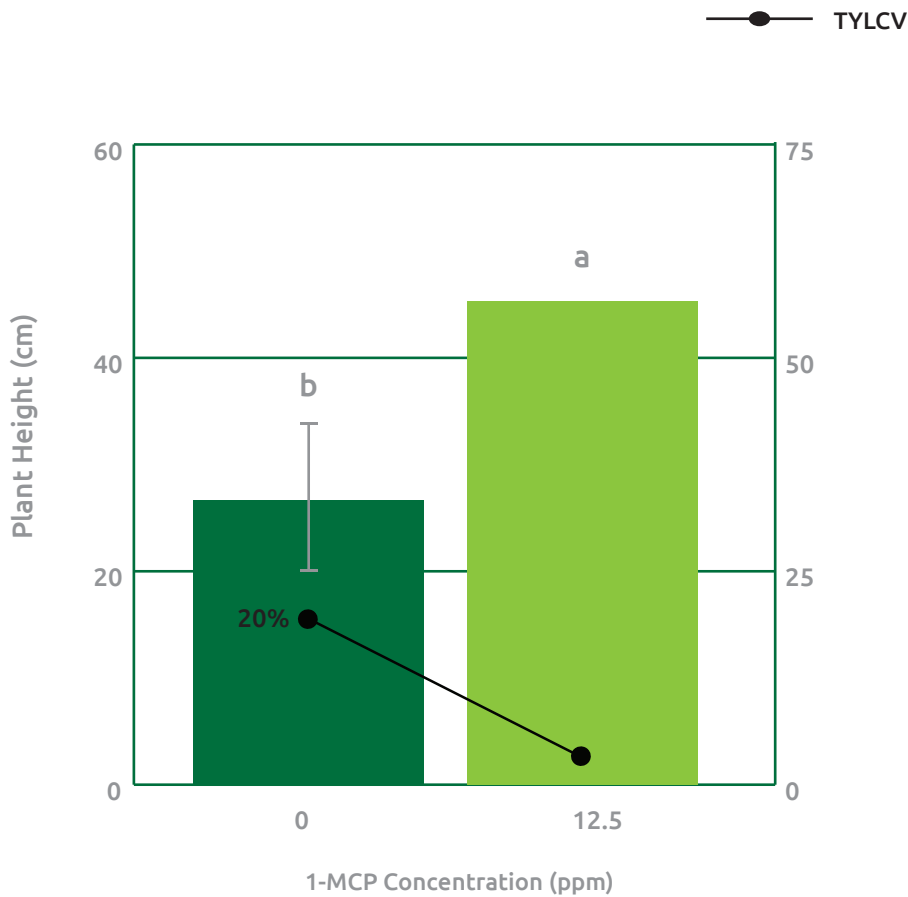
LandSpring benefits extend over time as depicted by this canteloupe leaf area

Untreated

LandSpring treated

Source: University of Florida trial

TYLCV-Infected Plants (34 days after transplanting)



**Figure 5.**

LandSpring significantly reduced Tomato Yellow Leaf Curl Virus infection rate and increased tolerance of infected plants, resulting in considerably larger plants

LandSpring is EPA approved for 14 seedling crops\*:

- Tomatoes
- Bell and non-bell peppers
- Broccoli
- Brussels sprouts
- Cabbage
- Cauliflower
- Cantaloupe
- Cucumber
- Eggplant
- Gherkin
- Muskmelon
- Summer squash
- Watermelon

\*California registrations pending.

## LandSpring is Applied with Your Plant House Spray System

Each bottle of LandSpring is dissolved in enough water to treat 1,350 square feet. The resulting solution works with most plant house application equipment and standard production and crop-protection practices.

Application of LandSpring works best when the sprayer is set to apply a high volume of large droplets (>400 gallon/acre). Large droplets stay on the seedlings much longer than small ones, which results in a greater release of the beneficial 1-MCP over a longer period.

The active ingredient of LandSpring is 1-MCP, a gas. The 1-MCP gas bubbles are trapped within the spray droplet. Larger droplets keep the LandSpring gas in the vicinity of receptor sites longer than fine mist for maximum 1-MCP binding with plant.

## Study Methodology and Select Test Results

Our 10 years of field research with 1-MCP comprises nearly 1,000 total studies. These include over 100 studies with the 14 plants species EPA-approved for LandSpring.

To fully understand stress and LandSpring's mode-of-action, AgroFresh has conducted basic science research with several universities, widespread trials with contract researchers throughout the world, and commercial research with leading plant houses, growers, and produce companies in key crop production regions including Florida, Georgia, and California.

**Table II** summarizes select key LandSpring studies.



**Table II.**

Selected LandSpring  
studies and results

Study	Location	Findings
FLPC1401-TM Fresh Tomatoes	Central Florida	>Larger Plants 7-28 DATr >Yield
FLBM1401-TM Fresh Tomatoes	Central Florida	>Yield
FLPC1403-TM Fresh Tomatoes	Central Florida	>Yield
INCB14005-CA Cabbage	India	>Yield
CNBJ1404-CU Cucumber	China Greenhouse production	>Seedling Survival (anthracnose) >Plant Size >Yield
BDBR14003-CF Cauliflower	Bangladesh	>Vigor 2 - 35 DATr >Yield
TXUV15001-TM Various Tomato types	Growth Chamber heat stress	>Height >Stem Diameter >Leaf Area
AGF15005-TM Fresh Tomatoes	Central Florida	Taller Plants 3-14 days after transplanting (DATr) >Roots 29 DATr >Chlorophyll 26 DATr
FLMC15001-TM Fresh Tomatoes	South Central Florida	<Incidence of Target Spot ( <i>Corynespora cassiicola</i> ) >Yield
BDJR15005-TM Fresh Tomatoes	Bangladesh	>Seedling Survival >Yield
FLBD15001-TM Fresh Tomatoes	Central Florida	>Height 28 DATr >Flowers >Fruits >Yield
CAYU15001 Processing Tomatoes	North Central Valley California	>Vigor 2 - 14 DATr Taller plants 2 - 14 DATr >Roots 14 DATr >Shoots 14 DATr ># Tomatoes >Yield
CAWL1502 Processing Tomatoes	North Central Valley California	># Total Yield >Marketable Yield >Red Tomatoes Larger Tomatoes
CAFP1501-TM Processing Tomatoes	Central Valley California	Less Beet Curly Top Incidence

Study	Location	Findings
BDBR15016-CU Cucumbers	Bangladesh	># Fruit >Larger Fruit >Yield
BDJH15001-EP Eggplants	Bangladesh	Taller & wider plants 14 DATr More Fruit Higher Yield
CAFI1601-TM Processing Tomatoes	Central Valley California: salinity stress	># Total Yield >Marketable Yield
CASA1602-TM Processing Tomatoes	West Coast California	>Vigor 14 DATr >Height 14 DATr >Flowers >Marketable Yield
FLBM1603-TM Fresh Tomatoes	Central Florida - greenhouse rhizotron	>Larger Roots 2-9 DATr >Larger Plants 14 DATr
FLBM1602-TM Fresh Tomatoes	Central Florida, shipping stress	>Canopy Area 14-28 DATr >Yield
CASR1603-TM Fresh Tomatoes	Central Valley California	>Vigor 14 DATr >Flowers >Marketable Yield
AZYM1701-WM Watermelons	SW Arizona	>Larger Plants 14-21 DATr >Growth rate 14-21 DATr
CASM1701-BR Broccoli	West Coast California	>Larger Plants 14+ DATr

## Conclusions

The world will require a 70% increase in crop yields by 2050.<sup>7</sup> Climate change creates unpredictable weather patterns, exposing more crops globally to more stress from rapidly changing extremes of heat and cold.

LandSpring is proven to enable plants to better resist stress during transport, transplant, and during early establishment, producing fruits and vegetables with greater yield potential.

## About AgroFresh

AgroFresh Solutions, Inc. (NASDAQ: AGFS) is a global industry leader in providing innovative data-driven specialty solutions aimed at enabling growers and packers of fresh produce to preserve and enhance the freshness, quality and value of fresh produce and to maximize the percentage of produce supplied to the market relative to the amount of produce grown. Its flagship product is the SmartFresh<sup>SM</sup> Quality System, a freshness protection technology proven to maintain firmness, texture and appearance of fruits during storage and transport. SmartFresh<sup>TM</sup> is currently commercialized in over 40 countries worldwide. Additionally the company has a number of different solutions and application technologies that have either been launched (Harvista<sup>TM</sup>, RipeLock<sup>TM</sup>, LandSpring<sup>TM</sup>) or will be launched in the future that will extend its footprint to other crops and steps of the global produce supply chain. For more information, please visit [www.agrofresh.com](http://www.agrofresh.com).

## The Next Step

For a limited time only, when you buy a bottle of LandSpring at the regular price, you will receive a second bottle free. For more information, visit [landspring.info](http://landspring.info).

## About the Author

Al Green is Agricultural Research Manager for AgroFresh Solutions. He earned an MS in plant breeding and genetics from the University of Minnesota and a BS in agronomy from Iowa State University. Prior to joining AgroFresh, Mr. Green held research and executive positions with Schillinger Seeds, Aventis CropScience, and American Cyanamid.

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