

Research Article

Impact of PlantCatalyst® on Seed Germination and the Hydroponic Culture of Fresh Produce

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Abstract

Background: PlantCatalyst is a patented product claiming to improve plant growth. It is made with a small amount of silica salts and extracts from lignite. Although, there are many published testimonials, no controlled research supporting or negating these claims have been published. **Methodology:** It tested the impact of dilute solutions of this product on the rate and percent seed germination in seed boxes in a growth chamber following stand seed testing protocols. **Results:** Additionally, PlantCatalyst was tested to evaluate its effects on the production of vegetables in a small commercial greenhouse. Average time of seed germination in beans, lettuce and tomatoes was significantly reduced by 7, 12 and 4%, respectively, when treated with PlantCatalyst. In the commercial greenhouse, PlantCatalyst significantly increased production of mixed variety lettuce (13%), tomatoes (24%), bell peppers (46%) and jalapenos (52%). The treatment also reduced the time to ripening in tomatoes by 2 days and jalapenos by 6 days. **Conclusion:** The finding of this study indicate that the application of PlantCatalyst can decrease the time for seeds to germinate and increase the rate of growth of plants. The primary effect seems to result from increased growth rates and shortening the time to reach maturity.

Key words: Tomato, lettuce, pepper, growth rate, yield

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

PlantCatalyst is a plant culture additive containing simple inorganic salts and lignite coal that has been used by many commercial growers since the 1970's to increase growth and improve yields of hydroponic and pot-grown greenhouse plants¹. The solution contains 0.006% calcium, 0.00114% magnesium, 0.04% nitrogen, 0.005% SiO₂ and 99% water.

The original product was patented in 1978 by Willard²⁻⁷ and was claimed to increase seed germination, shorten flowering time, prolong the life of cut flowers, increase flower and fruit production, improve rooting of transplanted clones, improve root growth, decrease water usage, increase soil fertility and nutrient availability, increase the rate of plant growth and foster disease resistance in plants exposed to very small amounts of catalyst-altered water⁸.

The application of PlantCatalyst varies from application to application. In the reservoir of hydroponic systems, the recommended dosages is 60 mL of PlantCatalyst added to the water, regardless of the size or volume of the nutrient solution. PlantCatalyst can be combined with any nutrient formula, but it is recommended that the concentration of nutrients in the solutions may need to be reduced if there is an indication that the plants are getting too many nutrients (e.g., crisping of the leaf margins).

Foliar sprays are also recommended for both soil and hydroponically grown plants. The recommendation for manual operations or smaller crops is 15 mL of PlantCatalyst to 1 L of water and spraying plants once or twice daily. For automated systems or larger crops uses, the dilution rate remains the same with PlantCatalyst being added to any foliar feed program to enhance effectiveness. A mixture of 30 mL of PlantCatalyst to 4 L of water is also recommended for rooting, cuttings and germination of seeds.

Discussions of the impact on plants have appeared online and in print⁹⁻¹². This product is sold throughout the world as an enhancer for gardening^{13,14}. In Rapid City SD, the product has been used by the City Parks Department for the germination and production of bedding plants for over 20 years because "Willard Water exposed seeds produce stronger seedlings and better flowers in the greenhouse and gardens (Personal Communication: Tim Forster, Rapid City Greenhouse Specialist)".

The putative effects of this product have not been evaluated in published controlled studies and there are no published explanations of the mechanisms by which PlantCatalyst is purported to affect plant growth. Therefore, the objectives of the study were to provide data from controlled experiments to evaluate the impacts of

PlantCatalyst on seed germination and food production in the laboratory and a small commercial greenhouse that produces fresh produce for local markets. This study provides the first documentation of some of the impacts of PlantCatalyst on plant growth and development.

MATERIALS AND METHODS

Seed germination studies: Bean (*Phaseolus vulgaris* L., 'Kentucky Wonder'), sweetcorn (*Zea mays* L., 'Golden Cross Bantam'), tomato (*Solanum lycopersicum* L., 'Rutgers') and lettuce (*Lactuca sativa* L., 'Black-seeded Simpson') seeds used in the germination studies in Brookings, SD were purchased from American Meadows Inc. (Williston, VT). PlantCatalyst was provided by CAW Industry Inc., Rapid City, SD. Seed germination was determined in a growth room for each of the 4 species using 100 seeds per treatment (control and PlantCatalyst). The experiment was repeated 5 times. Seeds were germinated in standard clear plastic germination boxes (13×13 cm) on commercial blue blotter paper (Hoffman Manufacturing, Jefferson, OR) as described previously¹⁵. The blotters were wetted with tap water or PlantCatalyst in tap water (8 mL L⁻¹). The seeds were maintained in a growth chamber at 25°C under 80 μmol m⁻² sec⁻¹ PAR and watered with tap water as needed.

The number of days required for seeds to germinate and the total percent germination were monitored for 2 weeks. Seeds were considered germinated when the roots extended from the seed coat by at least 1 mm. Any seeds that had not germinated by the end of 2 weeks were considered non-viable.

Greenhouse production studies: Lettuce ('Encore Lettuce Mix'), tomato ('Orange Blossom' a determinate variety), jalapeno (*Capsicum annuum* L., 'Jalafuego') and bell pepper (*Capsicum annuum* L., 'Flavorburst') seeds used in Granby, Colorado for commercial greenhouse production were purchased from Johnny's Select Seeds (Winslow, ME).

Hydroponic nutrient solutions were made by mixing Silica Blast, Pure Blend Pro Grow and/or Pro Bloom, Cal-Mag, Sweet Raw and Rhizo Blast (Botanicare-American Agritech, Tempe, Arizona) into filtered water in the nutrient recycling reservoirs. A Bluelab Pen (Bluelab Corp. LTD, Tauranga, New Zealand) was used to monitor the nutrient solution pH, which was maintained at ~6.0 using "pH down" from Genhydro (Sebastopol, CA). Electro Conductivity (EC) of the nutrient solutions was monitored using a Bluelab Commercial Truncheon and varied with genotype and age of the plants following the directions provided by Botanicare.

Equivalent EC was maintained in both control and PlantCatalyst treatments in all experiments.

Lettuce seed was planted into 4×4 cm rockwool plugs (~10 seeds per plug), wetted with filtered tap water or diluted PlantCatalyst (5 mL/4 L) in filtered water and germinated under lights (1000 W HID) in the greenhouse in Granby CO. After root emergence, the plugs were inserted into one of four nutrient film hydroponic units. All plants were numbered and the 4 setups were randomly assigned as controls or treatments (2 each). Nutrient solutions, with or without PlantCatalyst (15 mL/114 L) in filtered water were provided to the lettuce seedlings. Nutrient levels were replaced weekly and the nutrient concentrations were increased as the plants grew. Both control and treatment solutions were maintained at the same EC. The first planting occurred on 1 April, 2013 and the second on 13 May, 2013. Plants were grown without supplemental light or heat. Plants were also treated with foliar sprays of either water (control) or PlantCatalyst (8 mL L⁻¹) each day for the first 4 weeks. Fifty plants from each treatment, selected by a random number generator were harvested and weighed before sale.

Tomatoes and peppers were grown using Grodan Ebb and Flow Hydroponic Systems (Roermond, Netherlands). Hydroponic nutrient solutions were made. Each unit accommodated 50 plants and was fed from a 380 L storage/recycling tank containing 340 L of nutrient solution. The monitoring and changing of nutrient solutions and greenhouse conditions were as above. Seeding of tomatoes and peppers were conducted after lettuce experiment above was harvested.

Seeds were germinated in rockwool plugs as above, using 1 seed per plug. After the seedlings had emerged and root length was sufficient, the rockwool plugs were inserted into 10×10 cm rockwool cubes and then placed on 15×10×90 cm growslabs watered by ebb and flow hydroponic units. Foliar sprays were applied. Duplicate sets of 50 plants of each species and treatment were randomly distributed throughout the greenhouse and monitored daily to determine anthesis of the first flower, the appearance of the first visible fruit and the first day a fruit ripened. At harvest produce was picked, weighed and packaged over a 1 or 2 days period, depending on the species, after it had reached salable condition.

Statistical analysis: The lettuce growth experiments in the greenhouse were analyzed by ANOVA using a randomized complete block design. All other data were analyzed by ANOVA by paired evaluation of seed or crop type using SAS JMP 11 PC.

RESULTS AND DISCUSSION

PlantCatalyst has been marketed and used to improve plant production since the late 1970s. There are numerous anecdotal reports of its effects on plant growth and yields^{9-12,14}, but to our knowledge there are no published refereed journal reports documenting these effects or explaining the mechanisms by which this product enhances plant growth. These data provide the first documentation of the impact of PlantCatalyst on plant growth.

Seed germination: The PlantCatalyst treatment had no impact on seed germination rates, but significantly decreased the time required for seed germination for all but corn (Table 1). These data are consistent with the anecdotal reports that are common for this product. In comparison with the others, 'Golden Cross Bantam' seed's lack of response to PlantCatalyst may have been cultivar-specific or may also have resulted from a general inability of the product to alter unique physiological or biochemical characteristics associated with monocot seed germination. However, since corn was the only monocot evaluated in the study, it is unclear whether the product was ineffective for general or specific reasons.

Even at the high concentration of the product used for these experiments, relative to whole plant recommendations, the addition of the PlantCatalyst only increased the EC of the tap water from 530-590 $\mu\text{S cm}^{-1}$ and as shown by the contents found on the label, had a negligible impact on the availability of NPK or other plant nutrients. The N: 0.006%, P: 0%, K: 0%, Ca: 0.006%, MG: 0.00114%, Zn: 0.0000015% and Na₂SiO₃: 0.00596%, before dilution.

Greenhouse lettuce production: Lettuce was grown in Granby, CO in the early spring when temperatures were still quite low and days were relatively short. Each cycle of planting took 6 weeks from seeding to harvest. During the second cycle snowfall reduced the available light and decreased the greenhouse temperature. Therefore, the growth of the lettuce in the second cycle was reduced by about 25% as compared to the first cycle. To account for these differences the data

Table 1: Days from planting until germination in seed boxes

| Seeds | Treatments | Days $\bar{X} \pm \text{SE}$ | p>F |
|---------|---------------|------------------------------|---------|
| Bean | Control | 2.92±0.48 | 0.005 |
| Bean | PlantCatalyst | 2.73±0.07 | |
| Corn | Control | 2.26±0.03 | 0.779 |
| Corn | PlantCatalyst | 2.27±0.03 | |
| Lettuce | Control | 2.73±0.06 | <0.0001 |
| Lettuce | PlantCatalyst | 2.39±0.05 | |
| Tomato | Control | 2.97±0.04 | 0.047 |
| Tomato | PlantCatalyst | 2.86±0.04 | |

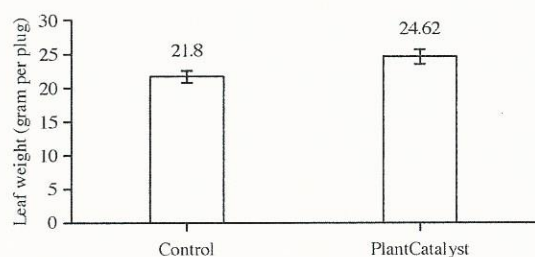


Fig. 1: Greenhouse lettuce production in Granby, CO. Yield for individual rockwool blocks (gram per plug) ($p = 0.0337$)

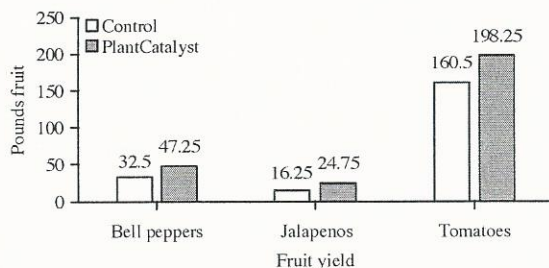


Fig. 2: Total production of fruit grown hydroponically in Granby CO

were analyzed using an ANOVA with a randomized complete block design. The mean production for both cycles is shown in Fig. 1. Both the blocks ($p < 0.0001$) and treatments ($p = 0.0337$) differed significantly.

Observations of the lettuce growth during both cycles showed that plants of both treatments appeared healthy, but that the PlantCatalyst treated plants were just growing more rapidly. The addition of PlantCatalyst did not significantly affect the nutrient concentration of the hydroponic solutions and the small impact on pH was compensated for with pH down.

Greenhouse tomato and pepper production: Days to germination, days to anthesis, days to fruit and days to ripening of the tomatoes and both types of peppers were significantly reduced by treatment with PlantCatalyst. Ripening of the jalapenos was accelerated by almost 6 days (Table 2). The effects of the PlantCatalyst treatment appears to increase growth and development rates when applied to the roots and leaves. Application of the treatments may have some impact on the rate of nutrient uptake and/or tolerance, as preliminary studies suggest that PlantCatalyst reduces leaf edge burn damage induced by increased nutrient concentrations as the EC was raised in the hydroponic solutions.

Fruit yields were increased by PlantCatalyst treatment for all three plant species grown in the greenhouse in Colorado

Table 2: Phenological development of hydroponically grown plants

| Fruit | Developmental stage | Treatments | Days after planting $\bar{X} \pm SE$ | p>F |
|-------------|---------------------|---------------|--------------------------------------|---------|
| Bell pepper | Emergence | Control | 9.36 ± 0.74 | <0.0001 |
| | | PlantCatalyst | 8.18 ± 0.74 | |
| | 1st flower | Control | 55.34 ± 0.15 | <0.0001 |
| | | PlantCatalyst | 54.22 ± 0.15 | |
| | 1st fruit | Control | 62.34 ± 0.16 | 0.005 |
| | | PlantCatalyst | 61.70 ± 0.16 | |
| Jalapeno | Emergence | Control | 9.44 ± 0.09 | <0.0001 |
| | | PlantCatalyst | 8.48 ± 0.09 | |
| | 1st flower | Control | 69.28 ± 0.14 | <0.0001 |
| | | PlantCatalyst | 67.04 ± 0.14 | |
| | 1st fruit | Control | 83.7 ± 0.25 | <0.0001 |
| | | PlantCatalyst | 78.9 ± 0.25 | |
| Tomato | Ripe | Control | 98.54 ± 0.28 | <0.0001 |
| | | PlantCatalyst | 92.92 ± 0.28 | |
| | Emergence | Control | 6.64 ± 0.08 | <0.0001 |
| | | PlantCatalyst | 5.34 ± 0.08 | |
| | 1st flower | Control | 52.48 ± 0.15 | <0.0001 |
| | | PlantCatalyst | 51.32 ± 0.15 | |
| | 1st fruit | Control | 63.02 ± 0.12 | <0.0001 |
| | | PlantCatalyst | 62.08 ± 0.12 | |
| | Ripe | Control | 112.6 ± 0.20 | <0.0001 |
| | | PlantCatalyst | 110.28 ± 0.20 | |

(Fig. 2). Tomatoes showed an increase of 24% in total fruit production, while the peppers showed increases from 45-52% in fresh weight. These results are also consistent with the previous anecdotal reports for the effects of PlantCatalyst.

Results of this study support the original patent claims and anecdotal end-user reports that have accumulated since the introduction of this product. Applications of PlantCatalyst to the growing media and/or through foliar applications improves overall plant condition, stimulates the speed of seed germination and increases the growth and yields in most of the plant species examined.

The mechanisms by which PlantCatalyst increases plant growth rates and yields is unclear. The original patents claim that the effect of PlantCatalyst is to change the structure of water to allow it to more readily mobilize soil nutrients, creating micelles that facilitate ion movement into plants, but there was no direct evidence to support this claim. The small amounts of inorganic salts contained in this product makes it unlikely that increased nutrient availability plays any role in seed germination. Furthermore, the limited mineral content of the solution, especially after dilution is unlikely to be responsible for the increased growth and yields induced by foliar application.

Seed priming with silicates and the effect of silicates on plant growth are also unlikely explanations. The low concentration of Na_2SiO_3 would have little effect on the

osmolality of the germination solutions, compared to those used in normal seed priming experiments^{16,17} and even though low concentrations of silicates have been shown to stimulate crop production, positive effects have only been demonstrated when plants are negatively environmentally impacted, such as when plants are under biotic or abiotic stresses^{16,18}.

There is a possibility that the humic acid or other organic compounds from the lignite might be playing a role in plant growth stimulation^{19,20}. Extracts of lignite have been shown to improve growth and crop yields and to act as chelators that make nutrients more available^{19,21,22}. Humic acids have also been shown to have cytokinin-like properties²³. The seed and plant responses to PlantCatalyst, including increased seed germination and crop yields are consistent with reported effects of cytokinin applications. However, these results do not provide any direct evidence as to how this product stimulates growth and seed germination. Future experiments to measure rates of nutrient uptake and changes in gene expression resulting from root or foliar applications of PlantCatalyst to crops are needed to explain the mechanisms by which PlantCatalyst enhances plant growth rates and yields.

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SIGNIFICANCE STATEMENTS

- PlantCatalyst increases the rate of vegetative plant growth
- PlantCatalyst decreases the number of days to germination, flowering and fruit production
- Use of PlantCatalyst in hydroponic food production has the potential in decrease costs and increase the total output of food crops

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