



PYROLIGNEOUS ACID

Powerful benefits for the plant-soil system —
and the planet.



June
2025
(update)

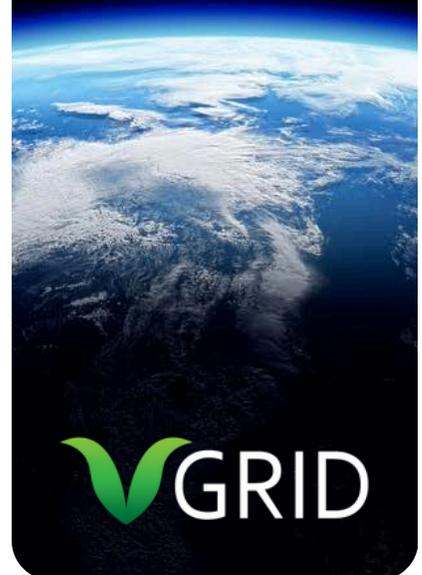


Table of Contents

1

What is Pyroligneous Acid (PA)?

- Introduction and Overview
- Manufacturing Process
- Components of PA
- Feedstock and Production Variations

2

Benefits to Plants and Soil

- Nutrient Efficiency
- Stress Resilience
- Seed Germination
- Root Development
- Soil Microorganisms
- Photosynthesis

3

Trial Validation and Application

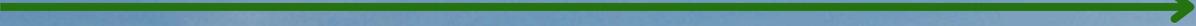
- Third Party Trials - Persist® PAF
 - Nursery Trials: *Broccoli, Celery, Ornamentals*
 - Crop Trials: *Soybean, Celery, Pepper, Strawberry*
- Application Rates, Timing, and Dilution
- Benefits for Composting

4

Looking Ahead

- Regulatory Environment
- Biostimulant Market Outlook

Introduction: Impact of PA Use in Farming



The world's population has grown by a billion people in just 12 years. To meet increased food demand, global agriculture production needs to increase by 60-70 percent by 2050. New solutions are required to improve crop yields while balancing limited resources, climate change impacts, and the demand for sustainable farming practices.

PA is a proven solution with numerous benefits to plants and soil, validated by extensive research and crop trials. PA is cost-effective and can be produced in substantial quantities from agricultural and forestry waste. Furthermore, PA is typically made within a process that generates renewable biomass energy and biochar, providing durable CO₂ removal and helping reverse climate change.



Introduction: Why care about PA?

I care about my livelihood.

PA boosts grower profits by increasing yields, cutting fertilizer costs, and protecting soil health for future generations.



Yield Increases

+14-159%



Range of yield increase in VGrid crop trials.

Nutrient Efficiency

+4-47%



Increases in nutrient uptake in VGrid trials.

ROI Gain per Acre

+\$4,500



ROI increase per acre in crop trial (pepper).

And I care about my planet.

PA has an essential role in reversing climate change, protecting vulnerable ecosystems, repairing damaged soils, and reducing waste.



Sustainable Energy Production

14 kWh



VGrid electricity produced per gallon of PA.

Reduction in Fertilizer (N) Runoff

-22%



Potential decrease in nitrogen fertilizer use.

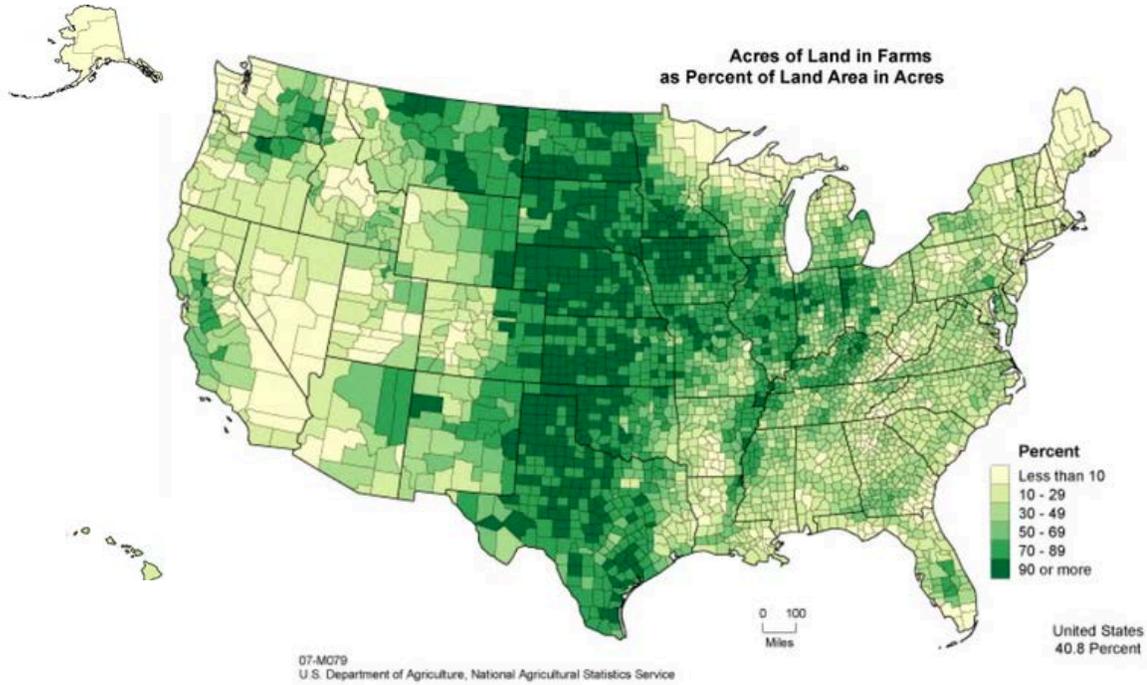
Avoided Agricultural Waste

28 lbs



VGrid biomass processed per gallon of PA.

Introduction: Impact of PA Use in Farming



~900 million: Acres of U.S. farmland.

~5.0 gallons: Average PA applied per acre (annually).

~4.5 billion: Total potential gallons of PA (annually).

Corresponding impact of 4.5 billion gallons of PA production

Based on VGrid Energy Systems production data

64 million

U.S. tons of biomass processed annually (landfill avoided).

64,250

Gigawatts of sustainable biomass electricity produced annually.

12 million

Metric tons of high quality biochar produced annually.

Introduction: Impact of PA Use in Farming

PA is made in a process that also produces renewable electricity and biochar. Biochar, a porous, charcoal-like material, locks in carbon from the source biomass for generations, stopping it from being released back into the atmosphere as it decomposes. This process net removes CO₂ from the atmosphere, while the biomass-created energy displaces fossil fuel sources. Additionally, when biochar and PA are added to soil, they deliver further environmental benefits, like conserving water and reducing synthetic fertilizer use while increasing yields.

Corresponding annual impact of 4.5 billion gallons of PA production

Potentials based on VGrid Energy Systems production data.



Scan to view data, calculations, sources, and assumptions supporting the claims above.

What is Pyroligneous Acid?



Pyroligneous acid (PA) is a unique class of plant-based biostimulants ...

... created in the high-temperature, thermal decomposition of plant material (lignocellulosic biomass). PA is a complex mix of beneficial bioactive substances and is sometimes informally called pyrolysis liquid, wood vinegar, bio-distillate, or liquid smoke.

Dark brown with a smoky aroma, PA is packed with organic acids, phenols, and lightweight biomolecules like Karrikins, which form in nature after wildfires. Plants have evolved to respond positively to the components of PA in different ways, including accelerated germination, better nutrient uptake, improved stress response, stronger root growth, and enhanced chlorophyll production.

Manufacturing Process

PA is produced through pyrolysis (no combustion) or gasification (limited combustion) processes that convert biomass through thermal decomposition into vapors, gases, and biochar. The vapors are cooled and condensed into liquid fraction that is then further processed to become pyroligneous acid.

Example of a mobile biomass downdraft gasification system that processes agricultural and forestry waste into sustainable electricity, biochar, and PA. (VGrid Energy Systems)



What is Pyroligneous Acid?



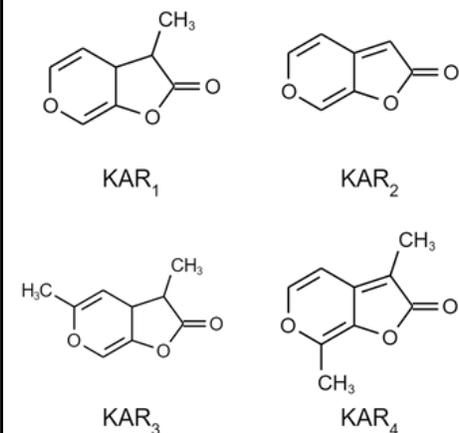
PA is roughly 15% organic matter by weight, with the rest being water. Its organic components include a mix of organic acids, polyphenols, and lightweight biomolecules. Acetic acid is the most abundant organic acid, along with propionic, butyric, pyruvic, malic, lactic, succinic, and other organic acids.

PA also contains Karrikins, lightweight biomolecules belonging to a family of compounds derived from plant smoke. They were first discovered in the early 2000s and have since been found to play a significant role in triggering seed germination and supporting early plant growth after wildfires.

While their exact functions are still being explored, Karrikins are recognized as key signaling molecules in plant regeneration after wildfires. This aligns with the long history of using fire in agriculture as a tool for renewal and growth.

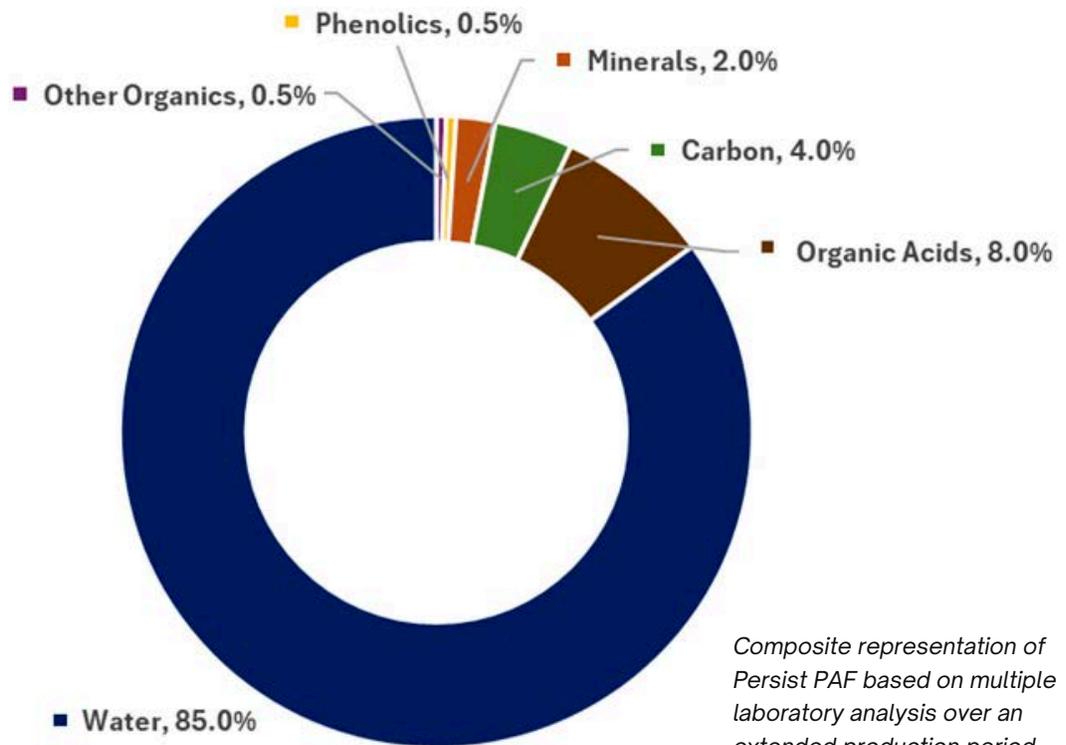
Karrikin molecules share a structural similarity with strigolactones, a group of specialized plant growth hormones. They are part of a sophisticated signaling network in plants, working alongside hormones like auxins, cytokinins, and gibberellins to regulate growth and adapt to environmental challenges.

Chemical Structures of Karrikins (KAR₁, KAR₂, KAR₃, and KAR₄)



What is Pyroligneous Acid?

Sample Composition Summary (laboratory analysis)



Organic Acids

Organic acids feed soil microbes and break down nutrients for improved bioavailability. Many plant stress responses involve the exudation of organic acids (OA) at the root-soil interface.



Phenolic Compounds

Polyphenols regulate crucial physiological functions in plants to provide resistance against biotic and abiotic stresses while boosting cell division, elongation, and differentiation.



Karrikin Molecules

Karrikins, molecules derived from plant smoke, enhance germination and growth. Plants evolved over millions of years to respond quickly to these “smoke compounds.”

PA: Feedstock Variations

Various plant materials can be used as feedstock to create PA, including woody waste, nut shells, bamboo, rice hulls, straw, corn stover, and other types of agricultural residues. The choice of feedstock affects the composition of the organic acids and compounds in PA.

Feedstocks rich in lignin, such as nut shells and hardwoods, produce more polyphenols and organic acids, specifically acetic acid, enhancing PA's efficacy.

Feedstocks with high resin content, including softwoods and soybean waste, create PA with more tars and oils that require additional processing to remove.

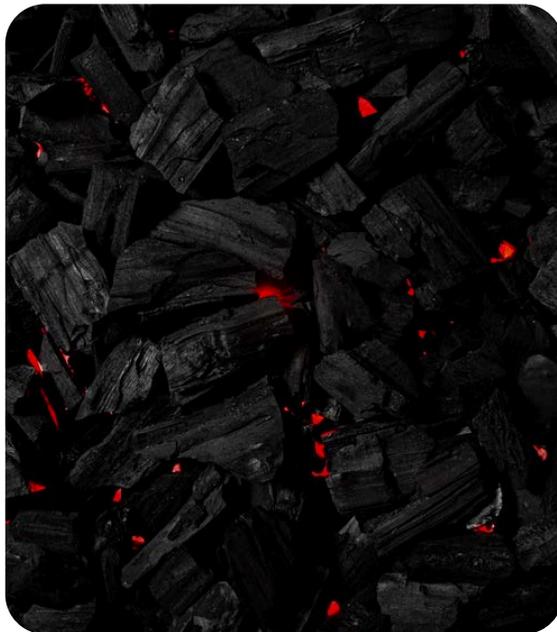


The elemental composition of biomass influences PA characteristics. High carbon-to-oxygen ratios, as seen in hardwoods and nut shells, produce PA rich in beneficial phenols and organic acids.

Feedstocks with high moisture create a more dilute PA, while drier feedstocks generate a more concentrated PA with a lower percentage of water and larger amounts of organics.

PA: Production Variations

In addition to differences based on feedstock, PA also varies by manufacturing process, specifically the heating rate, presence of oxygen, and operating temperature.



Pyrolysis is a process that breaks down organic materials using heat in an environment with little or no oxygen. Various equipment and methods can be used, generally classified as either 'slow pyrolysis' or 'fast pyrolysis.' Slow pyrolysis involves lower heating rates, longer residence times (minutes to hours), and operating temperatures of 350–500°C. In contrast, fast pyrolysis features much shorter residence times (just a few seconds), higher heating rates, and temperatures around 500–600°C.

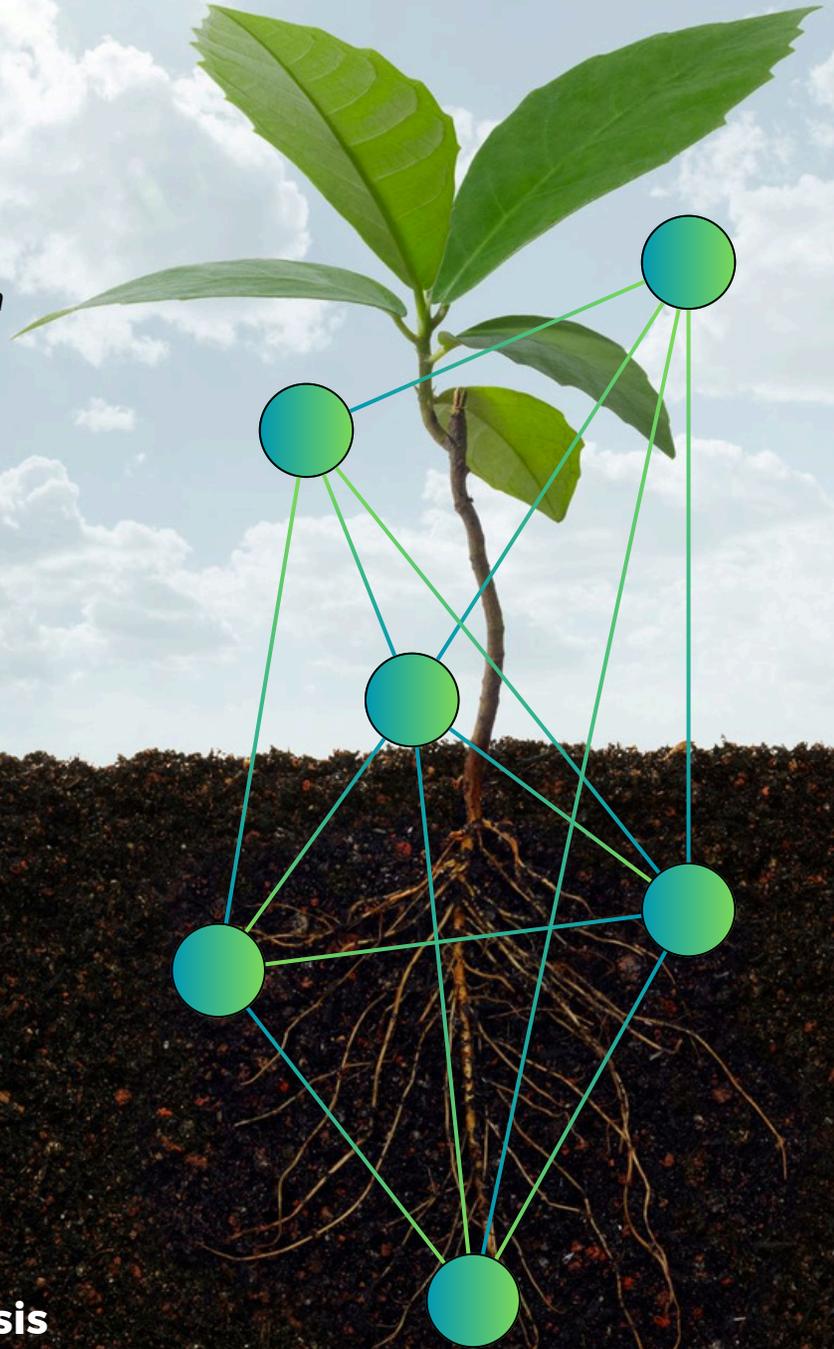
Slow pyrolysis typically produces a greater quantity of PA. The longer residence times also allow for a more significant breakdown of lignin, which results in more phenolic compounds and organic acids. Fast pyrolysis is typically not employed for PA production due to lower yields, higher tar content, reduced phenolic content, and higher concentrations of VOCs.

In a gasification process, such as used by VGrid Energy Systems to create Persist® PAF, a controlled amount of air is introduced to generate limited combustion of biomass. As a result, the operating temperatures are much higher, typically over 1,200 deg C. Because of the higher temperature, gasification is more “thermally destructive” to biomass, resulting in PA richer in organic acids and other low-weight biomolecules.

Benefits of PA: Introduction

PA offers a wide range of interconnected benefits for plants and soil. While the following sections will explore six key advantages in detail, it's important to view these impacts as part of a dynamic, holistic system that boosts plant and soil productivity together.

- **Nutrient Efficiency**
- **Stress Resilience**
- **Seed Germination**
- **Root Development**
- **Soil Microbiology**
- **Plant Photosynthesis**



Benefit: Increased Nutrient Availability

According to research, organic acids in PA form complexes with components of soil minerals, releasing previously unavailable nutrients for plant growth and development.

The organic acids in PA help convert NPK, and micronutrients into acetates, preventing them from precipitating and making them more accessible to plants. PA also dissolves nutrient-containing compounds in the soil, boosting their availability. Additionally, it helps minimize nutrient loss by reducing volatilization and enhancing soil organic matter (SOM), which improves nutrient retention.



From the research ...

+18%



¹ Increase in nitrogen in soil rhizosphere, when PA was co-applied with biochar.

+61%



¹ Increase in basil plant nitrogen uptake, when PA was co-applied with biochar.

1) Becagli, M., Santin, M., & Cardelli, R. (2022). Co-application of wood distillate and biochar improves soil quality and plant growth in basil (*Ocimum basilicum*). *Journal of Plant Nutrition and Soil Science*, 185, 120–131. <https://doi.org/10.1002/jpln.202100239>.

2) Yuan, Y., Kong, Q., Zheng, Y., Zheng, H., Liu, Y., Cheng, Y., Zhang, X., Li, Z., You, X., & Li, Y. (2022). Co-application of biochar and pyroligneous acid improved peanut production and nutritional quality in a coastal soil. *Environmental Technology & Innovation*, 28, 102886. <https://doi.org/10.1016/j.eti.2022.102886>.

3) R. Adeleke, C. Nwangburuka, B. Oboirien, Origins, roles and fate of organic acids in soils: A review, *South African Journal of Botany*, Volume 108, 2017, Pages 393-406, ISSN 0254-6299, <https://doi.org/10.1016/j.sajb.2016.09.002>.

4) Joo Kyung Lee, Hyun Jun Park, Seung Ju Cha, Seon Ju Kwon, Jin Hee Park, Effect of pyroligneous acid on soil urease, amidase, and nitrogen use efficiency by Chinese cabbage (*Brassica campestris* var. *Pekinensis*), *Environmental Pollution*, Volume 291, 2021, 118132, ISSN 0269-7491, <https://doi.org/10.1016/j.envpol.2021.118132>.

Benefit: Stress Resistance



PA has shown potential for stress reduction by enhancing plants' natural resilience to environmental stressors, primarily through its antioxidant properties and ability to regulate plant metabolism.

Plants often respond to stress by releasing organic acids (OAs) at the root-soil interface—the same OAs found in pyroligneous acid. Studies show that these OAs, along with phenols in PA play a key role in regulating vital plant functions, helping plants resist biotic and abiotic stresses like drought, heat, pathogens, salinity, insect pressure, UV radiation, and heavy metal exposure.

From the research ...

7X



¹ *Delayed mortality in begonia with low dose acetic acid.*

+20%



⁴ *Acetic acid increased average willow leaf thickness under drought conditions.*

- 1) Allen, M. M., & Allen, D. J. (2021). Acetic acid is a low cost antitranspirant that increases begonia survival under drought stress. *Scientia Horticulturae*, 287, 110257. <https://doi.org/10.1016/j.scienta.2021.110257>.
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- 3) Poonam Panchal, Anthony J Miller, Jitender Giri, Organic acids: Versatile Stress-Response Roles in Plants, *Journal of Experimental Botany*, Vol. 72, Issue 11, 18 May 2021, Pages 4038–4052, <https://doi.org/10.1093/jxb/erab019>.
- 4) Kong, X., et al. (2022). Acetic acid-induced changes in rhizosphere microbes and metabolic composition enhance willows' drought resistance. *Science of The Total Environment*. [://doi.org/10.1016/j.scitotenv.2022.157132](https://doi.org/10.1016/j.scitotenv.2022.157132).
- 5) Kudo, T., To, T.K. & Kim, JM. Simple and universal function of acetic acid to overcome the drought crisis. *Stress Biology* 3, 15 (2023). <https://doi.org/10.1007/s44154-023-00094-1>.

Benefit: Seed Germination

PA contains Karrikins — specialized biomolecules derived from plant material smoke that serve as plant growth regulators. Plants have evolved over hundreds of millions of years to respond quickly to these “smoke compounds.”

Karrikins activate key plant growth enzymes, leading to improved germination rates, flowering, root development, and overall seedling growth. These compounds are incredibly potent—research shows they can trigger seed germination at concentrations as low as one picogram (one trillionth of a gram).



From the research ...

+14%



¹ Increase in seedling vigor of PA-primed seeds (w/ aluminum chloride treatment).

+7%



Increase in soybean plants per acre in VGrid trial with two PA applications.

1) Ofoe, R., Gunupuru, L. R., Wang-Pruski, G., Fofana, B., Thomas, R. H., & Abbey, L. (2022). Seed priming with pyroligneous acid mitigates aluminum stress, and promotes tomato seed germination and seedling growth. *Plant Stress*, 4, 100083. <https://doi.org/10.1016/j.stress.2022.100083>

2) Nelson DC, Flematti GR, Ghisalberti EL, Dixon KW, Smith SM. Regulation of seed germination and seedling growth by chemical signals from burning vegetation. *Annu Rev Plant Biol.* 2012;63:107-30. doi: 10.1146/annurev-arplant-042811-105545. Epub 2012 Feb 9. PMID: 22404467.

3) H.M. Ghebrehiwot, M.G. Kulkarni, G. Szalai, V. Soós, E. Balázs, J. Van Staden, Karrikinolide residues in grassland soils following fire: Implications on germination activity, *South African Journal of Botany*, Volume 88, 2013, Pages 419-424, ISSN 0254-6299, <https://doi.org/10.1016/j.sajb.2013.09.008>.

Benefit: Root Development



PA increases root length, surface area, and overall mass. This strengthens nutrient uptake and promotes root initiation and elongation.

While the exact mechanism remains unclear, research suggests that PA may affect plant hormones such as auxins, key regulators of root development, by promoting their production and increasing their activity.

In two nursery trials conducted in 2023 with broccoli and celery, Persist PAF significantly enhanced root mass, promoted new root growth, and increased average plant weight (see page 20 for details).

From the research ...

+51%



¹ Increase in plant height (*Komatsuna*) with 800-fold PA dilution.

+36%



² Increase in dry biomass weight in basil plants; PA co-applied with biochar.

1) Jindo K, Goron TL, Kurebito S, Matsumoto K, Masunaga T, Mori K, Miyakawa K, Nagao S, Tokunari T. Sustainable Plant Growth Promotion and Chemical Composition of Pyroligneous Acid When Applied with Biochar as a Soil Amendment. *Molecules*. 2022 May 25;27(11):3397. doi: 10.3390/molecules27113397.

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3) Sivaram AK, Panneerselvan L, Mukunthan K, Megharaj M. Effect of Pyroligneous Acid on the Microbial Community Composition and Plant Growth-Promoting Bacteria (PGPB) in Soils. *Soil Systems*. 2022; 6(1):10. <https://doi.org/10.3390/soilsystems6010010>.

4) Macias-Benitez, S., Garcia-Martinez, A. M., Caballero Jimenez, P., Gonzalez, J. M., Tejada Moral, M., & Parrado Rubio, J. (2020). Rhizospheric organic acids as biostimulants: monitoring feedbacks on soil microorganisms and biochemical properties. *Frontiers in plant science*, 11, 633.

Benefit: Soil Microbiology

The organic acids in PA are easily consumed by microbes, boosting soil biological activity and overall function.

Research has shown that low concentrations (0.1-1%) of PA significantly improve soil biology by enhancing the beneficial plant growth-promoting bacteria (PGPB), including *Acetobacter*, *Azospirillum*, *Bacillus*, *Beijerinckia*, *Bradyrhizobium*, *Corynebacterium*, *Herbaspirillum*, *Mesorhizobium*, *Micromonospora*, *Pseudomonas*, and *Rhizobium*

PA boosts microbial growth in soil, helping to improve nutrient cycling, organic matter decomposition, and soil fertility overall.



From the research ...

+58%



¹ Increase in dissolved organic carbon in rhizosphere; PA co-applied with biochar.

+11-32%



² Range of increase in soil microbial abundance with 0.01% PA application.

Select Sources

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- 2) Sivaram AK, Panneerselvan L, Mukunthan K, Megharaj M. Effect of Pyroligneous Acid on the Microbial Community Composition and Plant Growth-Promoting Bacteria (PGPB) in Soils. *Soil Systems*. 2022; 6(1):10. <https://doi.org/10.3390/soilsystems6010010>.
- 3) Macias-Benitez, S., Garcia-Martinez, A. M., Caballero Jimenez, P., Gonzalez, J. M., Tejada Moral, M., & Parrado Rubio, J. (2020). Rhizospheric organic acids as biostimulants: monitoring feedbacks on soil microorganisms and biochemical properties. *Frontiers in plant science*, 11, 633.

University Trial: Soil Microbiology

Conclusion: PAF enhances plant-beneficial microbes, most significantly the Nitrospirae and Firmicutes phyla.

The study, conducted in the Netherlands, compared pistachio shell biochar—produced by VGrid's Bioserver® units—with standard coir slabs, untreated biochar, acetic acid-treated biochar, and biochar pre-treated with PAF. Researchers evaluated microbial activity in both the growing medium and tomato rhizosphere over a 23-week cultivation period using advanced qPCR and DNA metabarcoding methods. The key findings are summarized below:

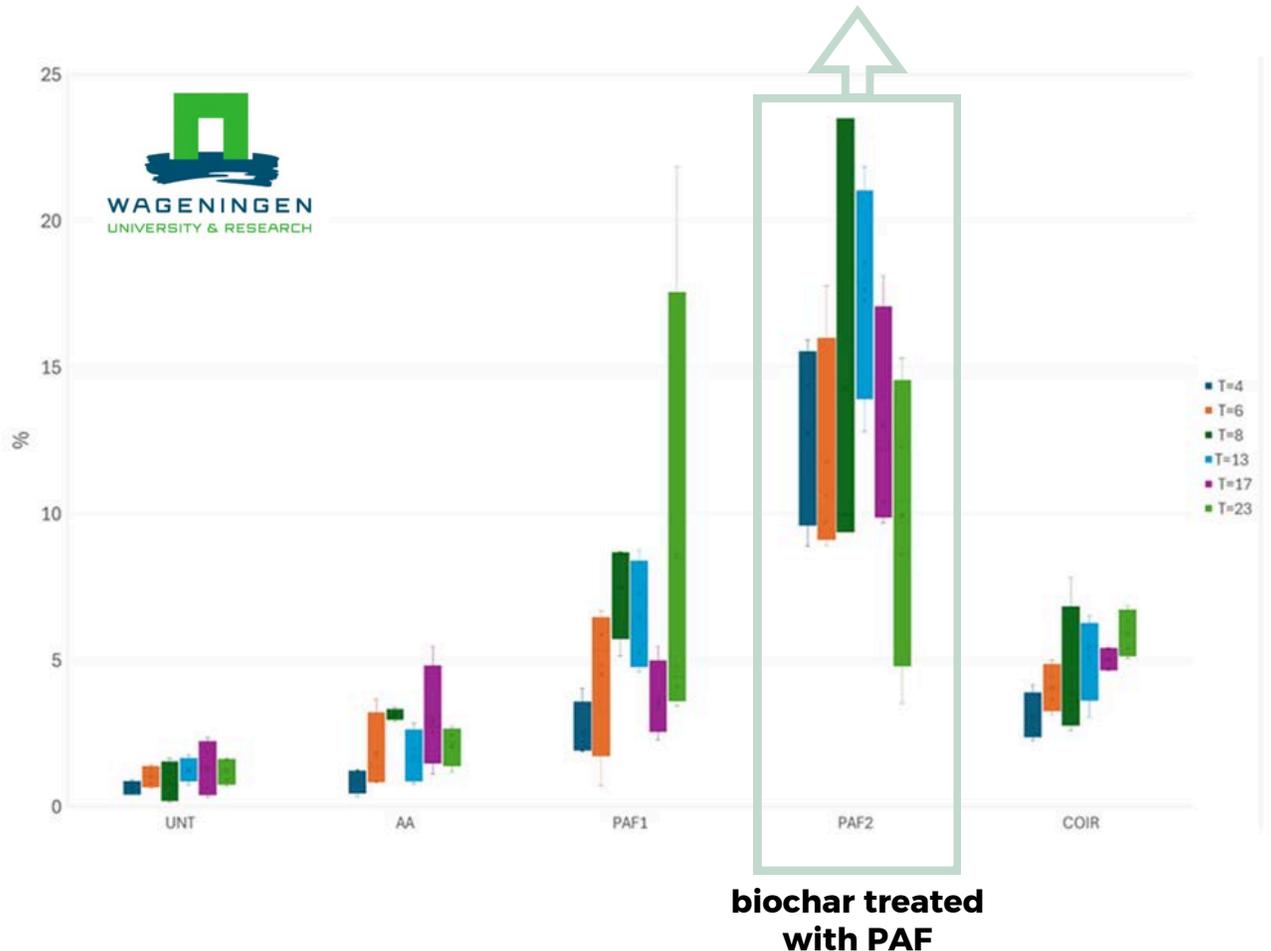
- PAF enhanced microbiome diversity in both biochar and tomato rhizosphere throughout the cultivation period.
- Nitrospirae and Firmicutes, which are known to promote nutrient cycling and plant resilience, were substantially more abundant in the PAF-treated biochar.

From the research ...

+10x increase



Increased abundance of beneficial bacteria in biochar grow media treated with Persist PAF.



Benefit: Photosynthesis

In a recent study², soybean plants treated with PA demonstrated increased photosynthesis rates and accelerated metabolic turnover, contributing to a 13.8% improvement in leaf carbon capture. In multiple trials across a wide variety of crops, PA treatments have consistently enhanced plant growth and yield. Research indicates these benefits are linked to elevated chlorophyll levels, improved CO₂ assimilation, and greater carotenoid production in plant leaves.



From the research ...

+48-54%



³ Chlorophyll content compared of PA treated lettuce compared to control.

+14%



² Increased leaf carbon capture with Coriphol™ pyroligneous acid (1-2 gal/acre).

1) Ofoe, R., Mousavi, S. M. N., Thomas, R. H., & Abbey, L. (2024). Foliar application of pyroligneous acid acts synergistically with fertilizer to improve the productivity and phytochemical properties of greenhouse-grown tomato. *Scientific reports*, 14(1), 1934. <https://doi.org/10.1038/s41598-024-52026-2>

2) Noel R, Schueller MJ, Ferrieri RA. Radiocarbon Flux Measurements Provide Insight into Why a Pyroligneous Acid Product Stimulates Plant Growth. *Int J Mol Sci*. 2024 Apr 10;25(8):4207. doi: 10.3390/ijms25084207. PMID: 38673791; PMCID: PMC11050665.

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PA Validation in Third Party Trials

WHITE PAPER: PYROLIGNEOUS ACID

VGRID ENERGY SYSTEMS

The following pages highlight select crop and nursery trials sponsored by VGrid to evaluate Persist® PAF pyroligneous acid. These trials provide practical, on-farm evidence of PA's ability to improve yields, reduce inputs, and increase growers' ROI.

Trial: Nursery plant establishment

In two 2023 nursery trials, PA-treated plants showed stronger root establishment and overall growth rates.

It's estimated that an average of 10-20% of nursery plugs do not survive transplanting in crop systems. These losses significantly affect a grower's bottom line. A leading cause is *transplant shock*, which occurs when a plant experiences stress due to the disruption of its root system during transplanting. Stronger root systems developed in the nursery can mitigate this risk.

In these trials, transplant-ready plugs were grown in two-liter pots; eight replicant plants per treatment. Two foliar applications of Persist® PAF were applied with a backpack sprayer.

Plant Species: Broccoli (*Brassica oleracea*)
Trial Date: Q2 2023
Trial Location: Ventura County, California
Researcher: Holden Research & Consulting

Plant Weight (PA treated vs. untreated)

+60%



Root Weight (PA treated vs. untreated)

+63%



Plant Species: Celery (*Apium graveolens*)
Trial Date: Q1 2023
Trial Location: Ventura County, California
Researcher: Holden Research & Consulting

Plant Weight (PA treated vs. untreated)

+31%



Root Weight (PA treated vs. untreated)

+27%



Trial: Nursery plant establishment

In 2024, a large California nursery evaluated PA to improve germination and root growth.

+4.5 pp



Percentage point increase in germination rate for Coleus planted with Vermiculite cover (87.15% control vs. 91.67% Persist PAF. Measured two weeks after sowing).

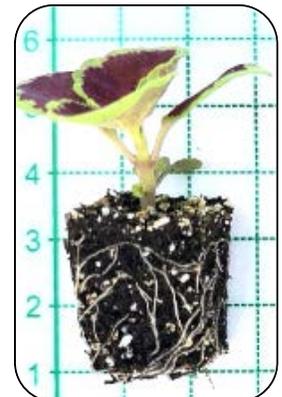
Persist® PAF was foliar applied at 2-4 fl oz per 1,000 sq ft, diluted 1:400 (0.25%). The first application (at planting) was half the rate, with three successive applications at the full rate.

The nursery reported a positive ROI from higher germination rates, along with improved root growth, plant mass, and the overall quality of the liners.

Control (no PA treatment)



Treated with Persist® PAF



Control (no PA treatment)

Visually greater root growth and overall mass with Persist PAF.

Crop Production Trial: Soybean



+7%



Increase in plant population per acre.

+4%



Increase in plant height.

In this SynTech Research trial, two modified PAF treatments produced an impressive 7% more soybean plants per acre and 4% larger plants on average.

- Two liquid applications were made - one at planting and the second co-applied with an herbicide at R2-R3 plant stage.
- This modified treatment was 60% pyroligneous acid and 40% biochar extract, which was then diluted 1% (1:100).
- 80% PA and 20% biochar extract was also evaluated, producing 3% more plants and 8% larger plants.



Crop Production Trial: Celery

Persist PAF increased celery yield by **159%** in fusarium-infected soil.

Plant Species: Celery (proprietary variety)
Trial Period: Q2 2024
Trial Location: Ventura County, California
Researcher: Holden Research & Consulting



This celery production trial was conducted in known, heavily diseased soil (fusarium). The overall yields seen across all treatments would not be considered economically sustainable in a typical growing environment.



Zero Quality Rating (no visible disease)

Four applications of PAF were made by soil drench, with two to three weeks between applications. The 1% PAF application (diluted 1:100 v/v) performed the best.

0-1 quality rating (marketable celery)

+93%



Percentage of plants with a 0-1 quality score. 1% PAF treatment compared to the control.

Weight above 550 gram (ready to cut)

+83%



Percentage of plants over 550 grams. 1% PAF treatment compared to the control.

Extrapolated Yield Increase

+159%



1% PAF treatment compared to the control.

Crop Production Trial: Bell Pepper

Persist® PAF liquid was applied in a 1% dilution at a total rate of 3.5 gallons per acre, spread over four foliar spray applications, with two to three weeks between applications. Persist biochar was added to pre-plant fertilizer at a rate of 480 pounds per acre.

The Persist® treatment produced 15% more peppers and a 13% overall increase in harvested weight per acre. Peppers were categorized according to industry sizing standards: medium, large, extra-large, and jumbo.

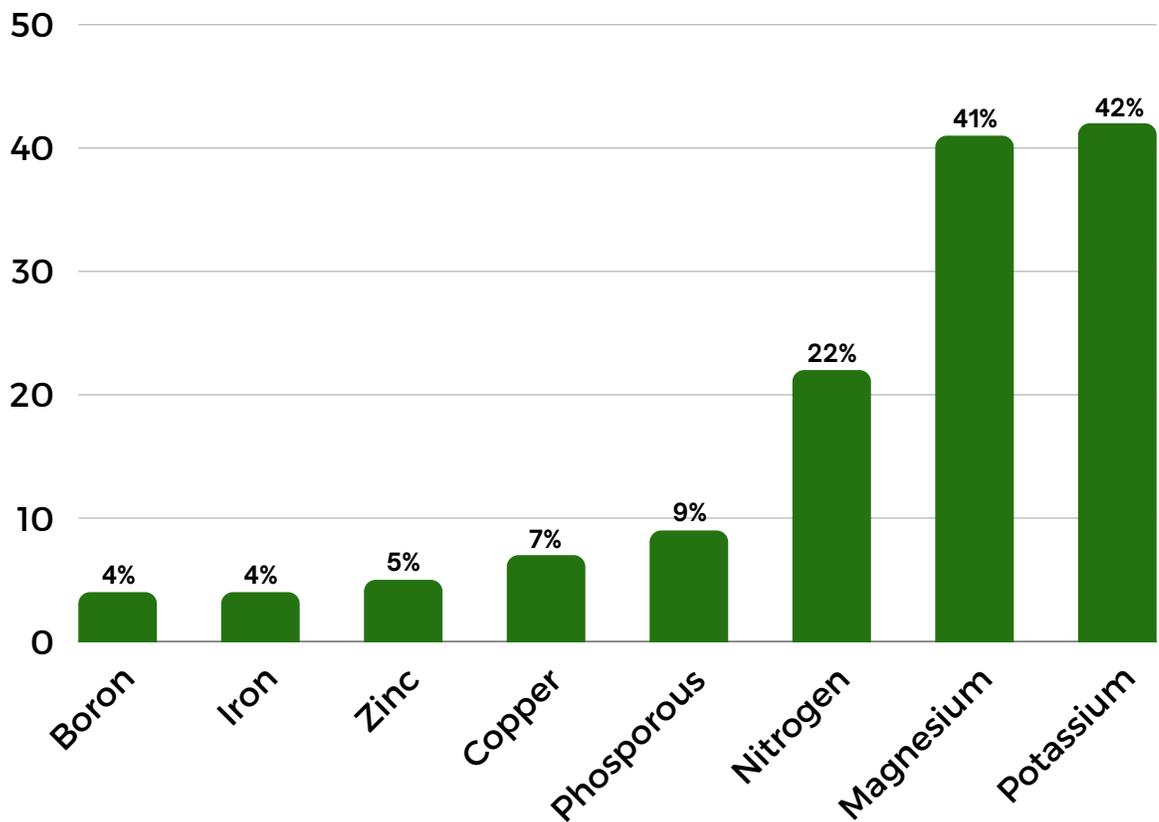
Persist® showed particularly strong results in large and extra-large peppers, with a combined increase of 24% by count. The result is a calculated net ROI gain to the grower of over \$4,800 per acre, using USDA-published pricing on the harvest date.



| | |
|------------------|--------------------------|
| → Yield (count) | +15% |
| → Yield (weight) | +13% |
| → ROI Increase | +\$4,800 per acre |

Bell Pepper Trial: Nutrient Uptake

Bell Pepper Production Trial In-Season Tissue Sampling (A&L Western Labs) Holden Research (Camarillo, California, U.S.A.)



Overuse of nitrogen fertilizer causes various environmental problems, including groundwater contamination, eutrophication from algal blooms, air pollution from ammonia and nitrous oxide emissions, biodiversity loss, and soil health degradation. For these reasons, many states are now considering limits on the amount of Nitrogen applied in agriculture.

-22%



Reduction in Nitrogen (N) Fertilizer

PA breaks down nutrients to make them more bioavailable. This allows growers to maintain or even increase yields while reducing their reliance on synthetic fertilizers.

Crop Production Trial: Strawberry



Plant Species: Strawberry (Portola variety)
Trial Period: Q3 2022
Trial Location: Ventura County, California
Researcher: Holden Research & Consulting

Compared to the control plot, the yield of marketable strawberries produced per acre improved by 14% when adding Persist® biochar and PAF. Total trays of strawberries increased by 49% with the Persist® treatments.

Prior to planting, Persist® biochar was placed in the slot at a rate of 480 lbs/acre. Persist® PAF liquid was applied at 1% dilution with a backpack sprayer at a total rate of 3.5 gal/acre (four applications total).

Pictured below is a comparison of PAF only treatment in a grower trial conducted in 2023 (images are not from the Holden Research trial)

Yield increase - Total trays

+49%



Extrapolated yield increase.

Yield increase - Marketable trays

+14%



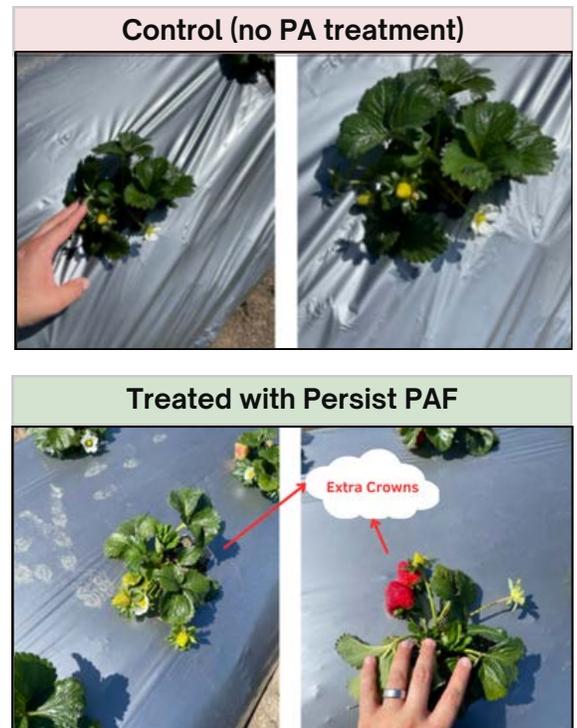
Extrapolated yield increase.

Net ROI to Grower

+\$2,000



Per acre ROI gain to grower after all costs.



Turfgrass: Customer Evaluation

When a professional soccer club took over a neglected practice facility, a turfgrass consultant was brought in to restore the field. Persist® PAF was included in the treatment plan, delivering exceptional results. The appearance and quality of the playing surface improved dramatically, surpassing expectations in both the speed and effectiveness of the recovery.

Before Persist PAF treatment program.



After Persist PAF treatment program.



Application Rates and Methods

PA is versatile and works effectively with foliar, soil-applied, or irrigation water applications. It should be diluted before use and is best applied during the growing season, with a minimum of two weeks between applications. PA is generally compatible with most fertilizers, biologicals, herbicides, insecticides, and fungicides; however, a jar test is recommended to confirm compatibility. Always consult the manufacturer's MSDS sheet for detailed usage instructions and safety precautions.



Select Application Rates for Persist® PAF Liquid

Row Crops (corn, soybean, wheat, strawberry, pepper, tomato, carrot, potato, beet, etc.)

- **Per Application Rate:** 1.0-1.5 gal/acre of PAF, drip irrigation or foliar spray
- **Minimum Dilution:** 1:100 (1.00%), for spray applications
- **Application Timing:** Apply once at planting using half of the above rate and 2-3 additional applications at the full rate. Allow 2-4 weeks between applications.

Permanent Crops (orchards, vineyards, berry crops, nut trees, citrus, etc.)

- **Per Application Rate:** 1.0-1.5 gal/acre of PAF, drip irrigation, or foliar spray
- **Minimum Dilution:** 1:200 (0.50%), for spray applications
- **Application Timing:** Apply 3-5 times during the growing season (first application at bud swell). Allow 3-5 weeks between applications. Avoid applying directly to flowers.

Turfgrass (warm and cool season grasses)

- **Per Application Rate:** 1.5-2.0 gal/acre of PAF
- **Minimum Dilution:** 1:200 (0.50%)
- **Application Timing:** Apply 4-6 times during the growing season, starting with the first application when the grass begins growing in spring. 3-5 weeks between applications.

PA Benefits for Composting



Microbial Activity

1

Organic acids in PA are beneficial carbon and energy sources for soil microbes, promoting their growth and activity to help accelerate the decomposition process, improve humus content, and increase nutrient cycling.

pH Balancing

2

High pH levels in compost can upset the microbial balance, deplete nutrients, and cause ammonia volatilization, resulting in unpleasant odors. PA is a natural, organic solution for lowering pH in compost.

Retain Nutrients

3

PA reduces nitrogen loss by improving microbial balance, minimizing ammonia volatilization, and binding nitrogen to carbon-rich compounds, improving compost quality with higher nutrient levels and less odor.

Rate per Cubic Yard

1.0-1.5 fl oz

Minimum Dilution Ratio

1:200 (0.5%)

Application Interval

≥ 3 weeks

Looking Ahead: PA Biostimulants

The market for biostimulants is experiencing significant growth, driven by several key factors:

1. Rising Demand for Sustainable Agriculture

- Farmers increasingly seek solutions to improve crop yields while reducing chemical inputs. Biostimulants are seen as a sustainable alternative to traditional fertilizers and pesticides.

2. Renewed Focus on Soil Health

- Biostimulants like PA improve soil health and structure, which aligns with global efforts to combat soil degradation.

3. Increasing Adoption of Organic Farming

- Organic farming is growing rapidly, and biostimulants are well-suited for organic certifications due to their natural and eco-friendly origins. (*Persist PAF is OMRI Listed for organic production*).

4. Growing Regulatory Support

- Governments worldwide are promoting the use of biostimulants through incentives and policies aimed at reducing the environmental impact of agriculture.



The global biostimulant market is expected to grow at a compound annual growth rate (CAGR) of around 12–13% over the next few years. Regions like Europe, North America, and Asia-Pacific are key growth drivers, with Europe currently leading due to its stringent environmental regulations.

→ Global Market Size (USD)

\$4.36 Billion

→ CAGR

12-13%

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