This is the fifth article in a six-part series highlighting various horticultural uses of pine trees, pine bark, and associated products as well as data from substrate science research trials.

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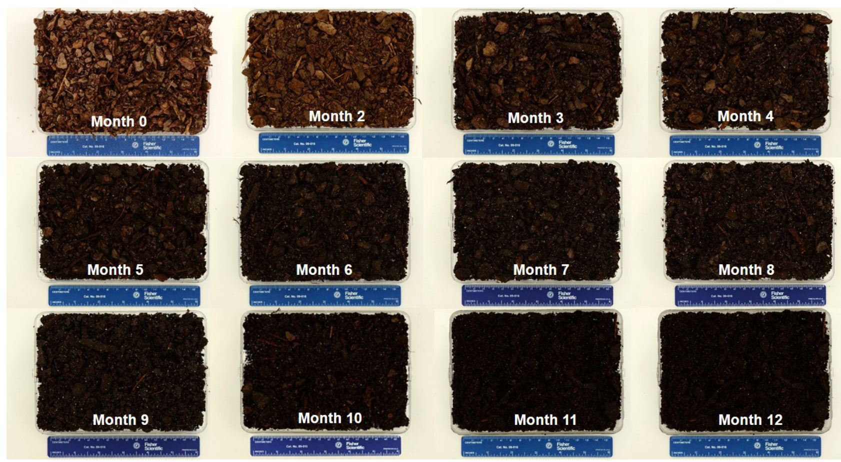
Substrate maturation

Learn how the age of pine bark substrates influences nitrogen use, pH ranges and PGR efficacy.

STORY AND PHOTOS BY **DR. BRIAN E. JACKSON**

Age affects us all. Some may think younger is better while others think age holds the key to wisdom and security. The same arguments could be made for pine bark substrate age and its effect on crop production management strategies. Over the decades, a lot has been speculated but very little has been proven regarding the physical, chemical, hydrological and biological effect that aging has on pine bark substrate materials. There are so many variables that factor into the investigation of age on organic materials and how other inputs, additives and biological entities interact and respond to these changing properties. As seen in the cover photo, age certainly has a visual influence on pine bark, but what changes are present that we cannot see? This article will highlight some of what has been studied in the past and present regarding changes in pine bark substrates.

Pine bark may be used as a fresh, aged, or composted product. As my colleague Dr. James Altland (USDA scientist) has stated in some of his works, "there is no general agreement as to what constitutes fresh, aged, or composted when it comes to bark." I agree with his assessment. What most believe to be acceptable (or at least workable) definitions would be that fresh bark has only been removed from freshly harvest logs for a short amount of time (days to few weeks) and has been processed to reduce its particle size suitable to be used in/as a substrate. Aged bark is bark that has been processed and often screened before being stacked/piled in windrows in open



Pine bark substrates ranging in age from fresh to 12 months.

Pine bark arrives from sawmills to bark suppliers who process the material (A) before screening and windrowing (B) followed by turning and other management strategies (C) that accelerate the aging or composting process (D).

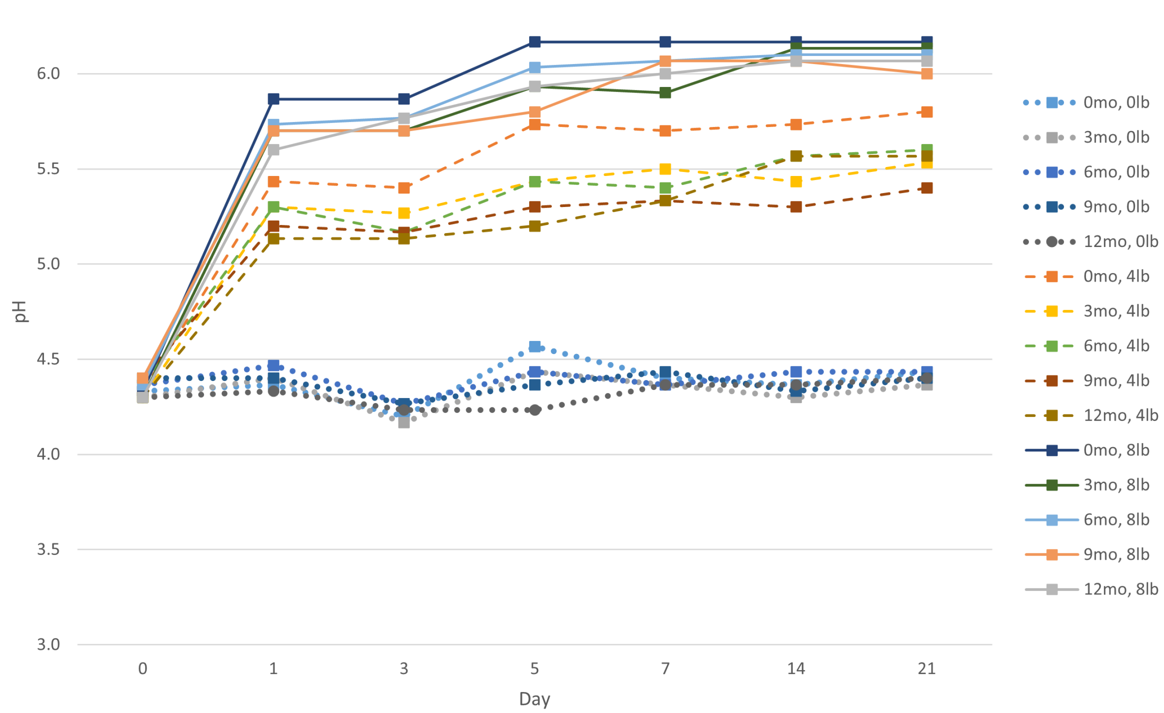
spaces and allowed to sit for a period of weeks to many months **(Fig. 1).** Aging bark does not include the addition of a nitrogen source to accelerate or enhance the degradation process. Aging piles may or may not be frequently turned (aerated) or managed in other ways. Composting bark includes the addition of a nitrogen source and the controlled turning and management of piles/windrows to speed the degradation process as much as possible in efforts to stabilize the bark material. The majority of pine bark supplies in the Southeastern U.S. are aged and not composted, but some proper composting operations do exist. For the purpose of this article, as well as most published works on the topic, bark will be referred to as fresh and aged (not composted).

Fresh and aged bark materials that can be found at numerous bark suppliers and can range in color, particle size and shape, as well as smell and chemical composition as seen in **Figure 2.** While both aged and fresh pine bark can be used successfully, little research has been done to investigate the differences between fresh and aged materials, as well as pine bark of specific ages. Additionally, the actual age of pine bark used for research in the literature is usually not reported, making it hard to extrapolate anything more than general trends for bark that is considered "aged." To gain a greater understanding of the effects of aging and pile management on pine bark substrates, a 12-month study was conducted at a pine bark supplier in Eagle Springs, North Carolina, which included replicated windrows of specifically processed, screened, and monitored bark inventories **(Fig. 3).** This long-term project was initiated with the objectives of tracking and quantifying the chemical, physical, hydrological and biological changes that occur over time in bark materials. At each month, these bark piles were methodically sampled and analyzed. Some of the monthly tests included sand content (contamination from the wind and from the act of turning the bark piles every month; **Fig. 4A**), pH (**Fig. 4B**), and seedling germination trials as a method to detect bark phytotoxicity (**Fig. 4C-D**). In this article we will highlight only some findings from the pH and PGR trials

Fresh bark has a characteristic orange-tan color (A) and can be processed in various particle sizes and shapes while aged bark (B) has a darker color and typically has a smaller particle sizes due to aging.

Pine bark aging study shown in experimental windrows at T.H. Blue Inc., a pine bark supplier in Eagle Springs, North Carolina.

Testing of aged pine bark materials included (A) assessment of sand contamination, (B) pH, and (C-D) seedling germination screening for phytotoxicity.



pH response of pine bark substrate at ages 0, 3, 6, 9, or 12 months to rates of limestone additions.

conducted on some of the bark ages.

Nitrogen

A thorough search through the published scientific literature only provides a few papers that summarize experiments investigating nitrogen use/tie-up of fresh or aged pine bark during crop production. Studies dating back to 1979 through 2008 that evaluated numerous woody plant species under various growing conditions reported that nitrogen was not the limiting factor in any plant growth differences that were observed when plants were grown in fresh or aged pine bark. These reports, a total of seven, associate the growth differences found in their studies to irrigation management, bark particle size, plant available water, or some degree of early onset phytotoxic effect from fresh bark on young plant growth. The nitrogen fertilization trials conducted were not very through in covering a wide range of bark ages but instead most only compared fresh bark to barks aged for many months or even years. However, when no convincing scientific evidence can be found in the literature to suggest a significant immobilization of nitrogen by fresh bark to the extent of it negatively affecting plant growth, it is worth noting. Until some definitive evidence is provided, there seems to be little concern of nutrient management issues for growers who may choose (or have to) use fresh bark.

pH

Pine bark is highly acidic, with a pH range generally between 3.8 to 4.5. Several sources disagree whether the pH goes up or down with aging and/or decomposition, which may be due to the fact that pH may decrease if bark piles are improperly managed and have gone under anaerobic conditions during the aging process. Other researchers have found no changes in pine bark pH based on age, while some have indicated that there may be an increase in pH when the bark has a higher percentage of fine particles. To better understand the effect that age has on pH and pH response in pine bark a study was conducted where samples of pine bark aged for 0, 3, 6, 9, or 12 months were amended with various lime rates to investigate effects of pine bark age on lime efficacy. Pulverized 100 mesh dolomitic limestone was incorporated at rates of 0, 4 and 8 lbs/yd3. On 1, 3, 5, 7, 14 and 21 days after limestone amendment pH was measured using the 1:1 extraction method. We found that pH increased rapidly one day after lime addition, with slight increases during days 3 through 5, and a general stabilization for the remainder of the sample days (**Fig. 5**). Lime had the greatest pH response in fresh bark (0 month) at both the 4- and 8-pound rates compared to older barks. As bark age increased there tended to be a lower pH response to lime additions, possibly due to chemical changes in the bark over time that increased its ability to buffer pH change. If growers choose to grow in fresher bark, management of pH should be monitored closely both in pre-plant lime additions and during crop production.

PGRs

The application of plant growth regulators (PGRs) to control excessive growth, and increase marketability, of containerized crops is common practice in the horticulture industry. The primary benefit of PGRs is to allow the production of compact, uniform crops, that can be more tightly spaced in the growing area. One of the most common application methods of PGRs are substrate drenches. One of the concerns with drench applications is adsorption of active ingredient by organic substrate components. Previous works over the decades have shown that pine bark in substrates can reduce the efficacy (growth control) of PGRs. With pine bark being a common substrate component and age of pine bark possibly differing among suppliers, more scientific data was needed to describe differences between ages and management practices that can maximize effectiveness of the substrate at these different ages. Although studies have investigated different variables that may influence PGR efficacy in pine bark substrates including percent incorporation, bark particle size, and fresh versus composted pine bark, no information was available on the effects of pine bark age on PGR efficacy.

A project in 2017 amended pine bark aged for varying lengths of time with Canadian sphagnum peat at ratios of 60:20 and 40:40% (v:v) peat: pine bark, with the remaining 20% being perlite. Substrate blends were fluffed and wetted by hand to a moisture content of 60% prior to pH adjustment and potting. A control substrate blend of 80:20 (v:v) peat: perlite was also included. Marigold and sunflower plugs were transplanted into 12.7cm azalea containers and plants were fertilized twice a day at each watering with 150 ppm nitrogen from a water-soluble fertilizer. Twenty days after planting, 3 fl oz of solution containing either 0, 1, 2, or 4 mg of active ingredient (a.i.) per container paclobutrazol (Piccolo 10XC; Fine Americas Inc., Walnut Creek, California) was applied to each container as a substrate drench. The experiment was a completely randomized design with six replications of six substrates x four PGR concentration combinations. Although not always significant across all PGR rates, there was a general trend of reduced growth control with increasing age of pine bark as seen in the 40% bark inclusion rate at the highest rate of PGR application (**Fig. 6**). Not shown are the plants grown with 0 PGR application which showed minimal growth differences which supports what we see in Figure 6 to be a result of the PGR and not a major growth retarding influence of fresh bark on the growth of these two species. This data indicate aged bark may cause a greater reduction in drench applied PGR efficacy (reduced growth control) compared to fresh bark but it is unclear if it is the bark chemistry, particle size, or other variable affecting the PGR growth control response.

Bark age does seem to have some effect on various plant growth parameters and cultural management strategies, but the effects do not appear to be greatly inhibiting or difficult to address. Based on the literature over the past four decades, pine bark age does not greatly influence nitrogen or other nutrient regimes but it may offer challenges to irrigation (plant available water) or other chemical applications like pH or PGRs in certain crop production systems. Bottom line, as long as pine bark is not toxic, which most all accounts show that it is not unless growing seedlings or herbaceous plants in very fresh bark with small particle sizes, crops can be grown in any age of pine bark with no serious detriment as long as adjustments are made where needed. When growers factor in the cost differences of fresh versus aged bark (including volume delivered per truck and overall transportation costs) compared to the costs associated with managing crops in fresh pine bark there may be some changes that make sense/cents. As always, it is suggested to have conversations with bark suppliers or other knowledgeable substrate experts to explore options before deciding to convert entire operations to bark you are not used to. NM

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The influence of 4.0 mg of active ingredient Piccolo on (A) sunflowers and (B) marigolds grown in peat-lite (left) and peat substrates containing 40% pine bark aged (from left to right beginning with second pot) 0, 3, 6, 9, or 12 months.