Container Grown Plant Production

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Section Editor

Phosphorus and Nitrogen Loss from a Container Substrate Without Fertilizer

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Index Words Pine bark, leaching, best management practices

Significance to Industry An experiment was conducted for approximately seven months to determine the loss of nutrients from substrate components when plants received micro-irrigation. Data from the experiment revealed that 2.5 lb (1.1 kg) of total phosphorus and 5 lb (2.3 kg) of total nitrogen would be lost from one acre of 6000 trade 7-gallon containers during a similar production time with similar conditions. The impact of these nutrients on natural waters should be considered when developing Best Management Practices (BMPs).

Nature of Work Loss of nutrients from nursery production areas has been documented in past research (2,5,7). In addition, research has been conducted to mitigate nutrients once discharged from the production fields (6). However, more attention needs to be given to minimizing the opportunity for nutrients to exit the container. Therefore, understanding the sources of nutrients that leave containers should be a priority when developing fertilization strategies or BMPs. For instance, previous research by Yeager and Wright (8) indicated that indigenous phosphorus leached from pine bark. Most container plants are grown in pine bark-based substrates. Loss of phosphorus and nitrogen from substrates composed of pine bark might result in disruption of the biological systems of natural waters, and in Florida there is particular concern regarding nitrogen in natural spring waters (1).

The objective of the following experiment was to investigate the loss of total phosphorus (TP) and total nitrogen (TN) from a pine bark-based substrate in a production scenario similar to that used in the nursery. The percentage of TP and TN losses from the substrate without fertilizer relative to the loss when the substrate was amended with a commonly used fertilizer was investigated.

Multiple branched liners of *Ilex cornuta* `Burfordii Nana´were planted March 7, 2019 in a substrate composed by volume of 70% pine bark, 20% Florida peat, and 10% leaf compost in trade 7-gallon containers [14-inch (36 cm) top diameter]. The substrate was amended with 7 lb (4.2 kg/m^{-3}) of dolomitic limestone, 1.5 lb (0.9 kg/m^{-3}) of Micromax® micronutrients (ICL Specialty Fertilizers, Dublin, Ohio), and 1 lb (0.6 kg/m^{-3}) of Talstar® (FMC Corporation, Philadelphia Penn.) per cubic yard (0.76 m^{3}). The substrate for each of 24 plants was amended with 0.35 lb (157g) of Nutricote® Total 18-6-8 (270-day release for 80% of nitrogen at 77 °F, Florikan, Sarasota, Florida). The substrate of eight additional plants did not receive Nutricote®. All plants were spaced in a triangular arrangement [36 inches (0.9 m) within row, 30 inches (0.8 m) between the rows] on polypropylene ground cover with micro-irrigation previously described by Million and Yeager (3).

The eight plants without fertilizer received micro-irrigation from a single irrigation pipe in which irrigation application was controlled by solenoid valve. The 24 plants in the Nutricote®-amended substrate were divided among three irrigation pipes (eight plants per pipe) each of which was independently controlled by a solenoid valve. Three of the eight plants were selected from each irrigation pipe for determination of the percentage of leaching or leaching fraction (LF= leachate or drainage ÷ water applied x 100) testing as described by Million and Yeager (4). The irrigation application amount was adjusted every 2-3 weeks to maintain a 20-30% LF. The average amount of irrigation applied to the plants fertilized with Nutricote® was applied to plants grown in substrate without Nutricote®.

Three plants from each of the three irrigation pipes with Nutricote® amended substrate were used to collect composites of the container leachate. The composites were collected by elevating each container slightly on a 13-inch diameter pizza pan with drainage hole. Leachate flowed through the hole into drainage pipe that led to tub. Leachate volumes of the composites were determined weekly and each volume represented the leachate or drainage for the previous seven days. Samples were taken from leachates and nitrate nitrogen, Kjeldahl nitrogen, and TP analyses were conducted according to standard procedures of the Environmental Water Quality Laboratory at University of Florida, IFAS. Nitrate nitrogen and Kjeldahl nitrogen were summed for TN. Nutrient concentrations were multiplied by leachate volume (weight) to determine quantities of nutrients lost for each of the 27 weekly samplings.

Three plants without Nutricote®-amended substrate were also elevated on pizza pans; however, a lasagna pan was placed under each pizza pan and leachate was combined for composite. Leachate volumes for composites were determined by weighing leachate for weeks 2, 3, 7, 11, 15, 19, 23, and 27 (Sept. 9, 2019). Each week represented the leachate or drainage for the previous seven days. Nutrient analyses and quantities of nutrients lost were determined as previously described. The quantities of TP and TN lost were summed for the eight weeks of samples and the percentages of TP and TN lost from substrate without Nutricote® relative to substrate amended with Nutricote® were determined.

Plants grown with Nutricote®-amended substrate were measured initially and on week 26. Height was determined from substrate surface to top of foliage. Two perpendicular widths were recorded with one parallel to the irrigation pipe. These plants grew approximately 12 inches (30 cm) in height and width. Plants in substrate without Nutricote® did not grow, became chlorotic, and were not measured.

Results and Discussion For the eight leachate collections that occurred approximately every four weeks from the containers without Nutricote®, there were 41 mg of TP and

109 mg of TN lost in the leachate compared to the substrate with Nutricote® that lost 303 and 3475 mg of TP and TN, respectively, (Table 1) for the same sampling dates. Based on these eight sample dates alone, the amount of TP and TN lost from the substrate without Nutricote® was 13 and 3%, respectively, of the loss for the substrate amended with Nutricote®. Thus, the 13 and 3% that represented eight samplings throughout the experiment were used to estimate the possible amount of loss due to just the components of the substrate amended with Nutricote®. The cumulative amounts of TP and TN lost in all the leachates from the substrate amended with Nutricote® were multiplied by 13 or 3%, respectively, and it was estimated that 2.5 lb of TP and 5 lb of TN would be lost from the substrate components used in this experiment if 6,000 trade 7-gallon containers were used per acre. Yeager and Wright (8) determined that indigenous phosphorus leached rapidly from pine bark, yet there was no implication for how long the phosphorus might leach or the quantity that might leach in outdoor production. The findings reported here indicate that research is needed to further quantify the amount of long-term nutrient loss for common substrate components and to determine their potential impact on natural waters. In addition, the impact of these nutrients on natural waters should be considered when developing BMPs.

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Table 1. Cumulative phosphorus and nitrogen loss from trade 7-gallon containers with a 70% pine bark, 20% Florida peat, and 10% leaf compost without a fertilizer amendment or amended with Nutricote® Total18-6-8 Type 270 (157 g/container). Samples of container leachate were collected two and three weeks after planting (March 7, 2019) *Ilex cornuta*`Burfordi Nana´ and then every four weeks until Sept.9, 2019. Data represent the cumulative loss from containers for one week prior to sample collection.

	Loss per container	
Treatment[z]	Total phosphorus	Total nitrogen[x]
	(mg)	(mg)
WOF	41 ± 1.6[y]	109 ± 3.0[y]
WF	303 ± 18	3475 ± 214
	(percent)	(percent)
WOF÷WF	13	3

[z]WOF=Without Fertilizer (n=1, composite of three containers), WF=With Fertilizer (n=3, composite of three containers from each of three irrigation pipes)
[y]±Standard error
[x]Total nitrogen is sum of nitrate nitrogen and Kjeldahl nitrogen.

Adjusting pH in Peat and Pine Bark Substrates Blended with Pine Tree Substrate

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Index Words Soil substrate, substrate amendments, dolomite, lime addition, *Sphagnum* peat moss, pine bark, wood substrate, pine tree substrate, nursery production, pH analysis

Significance to the Industry Blends of 0,20,40, and 100% pine tree substrate were mixed with both eastern Canadian *Sphagnum* peat moss and pine bark. Four rates of pulverized dolomitic limestone were administered and evaluated to each blend ratio during intervals spanning over 42 days. Characterization of common nursery substrate blends is lacking in sufficient detail in respect to pH variability, and lime additions. A desired pH level can be achieved by manipulating one or more of the three inputs studied (time after lime amendment, substrate material, and rate of lime application) and the choice of which variance(s) will depend on availability and cost for said variance. More information regarding observations and adjustments of pH levels in soil substrates needs to be available to commercial nurseries.

Nature of Work *Sphagnum* peat moss and pine bark are prevalently used in conjunction with wood products for nursery blends. The most common ratios for these blends are generally 80:20 peat:pine tree substrate or 60:40 peat:pine tree substrate. The same can be said with combinations of pine bark and wood. Pine bark has been an extensively common media for use as a growing substrate and is now more often mixed with sand to alter its undesirable physical properties (2). Availability of plant-required nutrients corresponds to the level of pH of the substrate, and is a core reason why this type of study should be carried and made available. The objective of this study was to provide nurseries precise lime addition recommendations for commonly used mixtures to ensure plants with more specific pH needs can be provided optimal nutrients and soil acidity. Soil acidity of these substrates are very high due to the large amount of organic matter in the media, and limestone is added to the substrate to reduce its acidity and increase the pH (3).The information behind the concerns of utilizing pine tree substrate include its additions of limestone and the way in which its pH is affected to obtain ideal levels for plant growth (4).

Four bags of three liters of each blend were prepared with their moisture adjusted to 60%. Lime rates were weighed out in 0lbs/yd, 4lbs/yd, 8lbs/yd, and 12lbs/yd by accounting for each bag being only 3 liters. For Pine bark blends a 100 mesh dolomitic limestone (pulverized) was applied, and for *Sphagnum* peat moss blends a 200 mesh dolomitic limestone (pulverized) was applied. A larger particle size of lime was thought to dissolve slower in the substrate and increase the pH at a more gradual rate than a smaller particle size of lime. This lead to the decision of applying the larger particle size (smaller mesh number) to the pine bark which has larger particle sizes than *Sphagnum* peat moss. However, it has been shown that the buffering capacity of smaller particle sized lime is on close to equal terms of effectiveness in preventing acidification of media, and increase the pH. The differences between pH of *Sphagnum* peat moss blends when amended with different particle sizes of lime has been shown to be minimal (3). Each of the two mesh sizes were applied to a separate 3-liter bag of 100% pine tree substrate as well. The effect of the gradual increase in pH for 100 mesh lime can be clearly seen in the stair-step-like increase of the pH in the 100% pine tree substrate blend it was applied to (Figure 3).

Analysis of the pH was conducted via hand pH meter. Testing of the pH was performed on 100mL samples of each blend that were mixed with 200mL of Deionized-water. The Deionized water pH was measured to be 7.0 before each analysis of the pH on every sample date. Each mixture was stirred twice, and pH measurements were taken after 30 minutes of the initial stirring. In-between each rep the pH meter was rinsed off in Deionized-water before continued measurements were taken. Every blend was contained in a 3 liter plastic bag with the air compressed out of the bag and stored in an air-conditioned room without any exposure to sunlight.

Observations of the pH were taken 1,3,5,7,10,14,21 and 42 days after the applications of lime were amended to the substrate. It was originally hypothesized that the pH of every substrate would level-off by day 21 of the study, regardless of the lime rate applied. Increases were still observed, and the possibility of further increases after 42 days following the application is possible but no measurements past that sample date were taken. Data for Figure 4 were analyzed using SAS (version 15.0; SAS Institute, Cary, NC) graph builder ellipse model set at a coverage of 90%, and also Microsoft Excel (version 15.37) for Figures 1-3.

Results and Discussion The use of dolomitic limestone application in soil was a known practice among practitioners of agriculture even in the first century *BCE,* but experimentation of practicality, effects, and differences among sizes within scientific literature is largely inefficient (1).

It was noted by Atland and Jeong, increasing a substrate pH beyond 6.5 was generally non-achievable because the weak bases' solubility within a substrate inhibit continual pH reactions (1). The data gathered here has shown that every substrate tested reached a pH higher than 6.5 when amended with 12lbs/yd^3. Jarret concluded that it was more than likely rate of lime application that was the most vital factor in affecting substrate pH, while the particle size and actual lime material were almost negligible in comparison. The common belief of combining both the quick acting large mesh number and the gradual slow-release small mesh number limestone has actually been seen to be a waste of lime as the differences in particle size have little to no differential effect on the pH (5). A lack of extensive academic trials regarding pH variance in substrates could be one of the reasons giving rise to conflicting results. A consistent and repeated system of trials is necessary to yield conclusive results.

In Sphagnum peat moss blends, the higher the ratio of pine tree substrate in the blend compared to peat, the higher the pH of the blend. This result also is present in the pine bark blends, but to a lesser degree. It should be noted this increase in pH is also accompanied by a slower rate of change in pH over time as a result of lime additions for the higher pine tree substrate ratios. Pine bark and the blends of pine bark amended with pine tree substrate had an initial large increase over the first five days after lime application, and then remained somewhat steady over the last five sample dates. Peat and its blends, however, had a relatively steady increase over the entire study. In the 100% pine tree substrate measurements, the bag amended with 100 mesh lime resulted in a larger range of pH values that increased at a quicker rate than the 200 mesh lime application.

Statistical analysis of this information regarding the attempt to find optimal values within pH ranges is not a producible value. This study was carried through with the sole purpose of characterizing pH values associated with lime amendments among substrate blends. Different plants have different requirements in terms of an optimal pH range, and showing how every single lime amendment affects the pH of the substrate is the only information a prospective nursery worker would need to know. Choosing the range of pH that is most effective for the individual plant a nursery worker is attempting to grow or keep in optimal condition begins with choosing what substrate media the plant is growing in, and then applying the proper lime rate amendment to achieve said pH range that is required. In order to create the desired pH range for a plant, a nursery has the ability to choose the variables that are most cost effective for them to alter, and studies of this nature give them the information necessary to make such decisions (Figure 4). Further studies and characterization for pH variance due to lime amendments of more nursery blends used within the industry, are necessary to create a comprehensive and accessible guide for nursery workers to have the knowledge to apply precisely the amount of lime needed for their substrate to achieve exactly what is necessary for each individual plant within their nursery.

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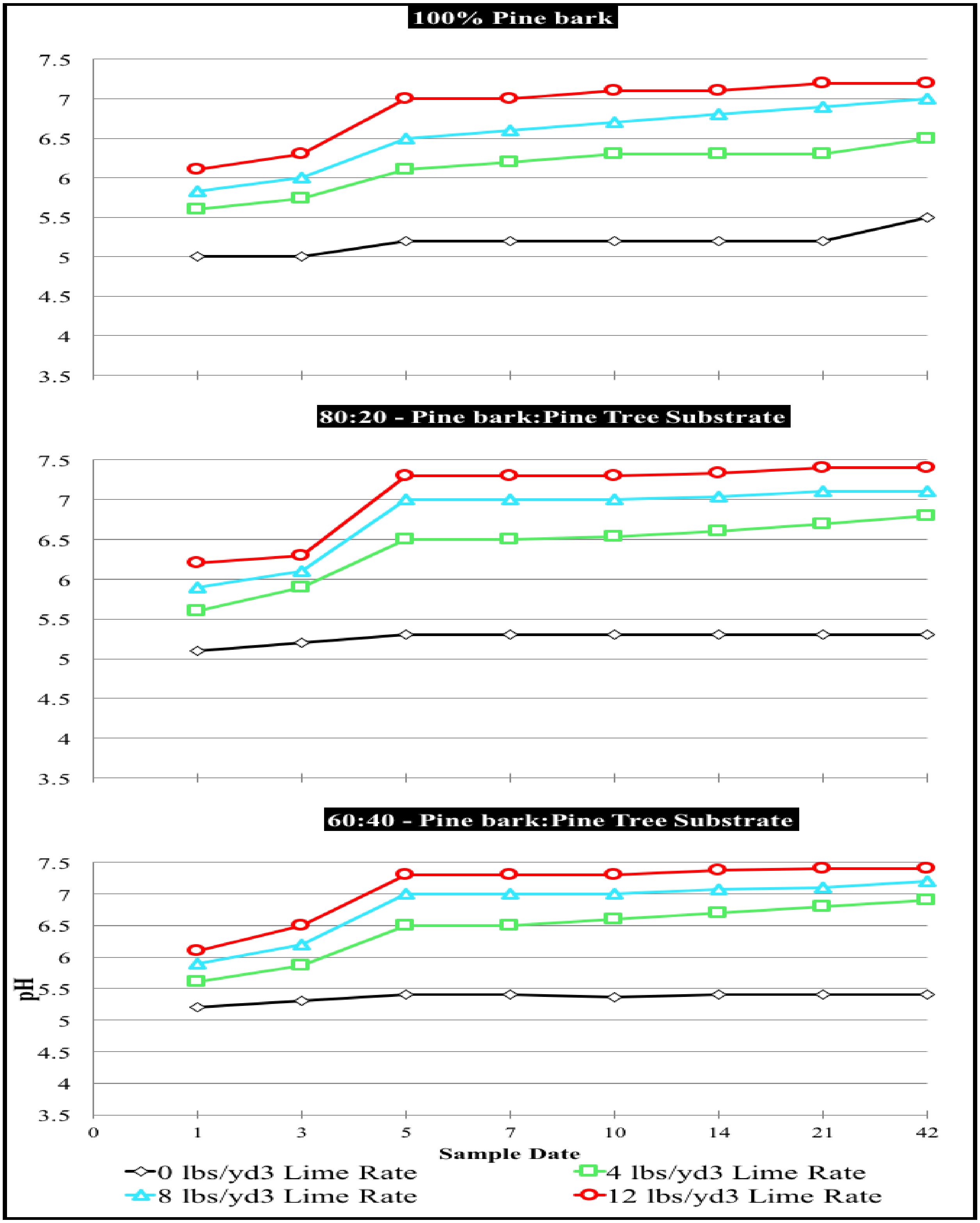

Figure 1. Effect of Lime Rate on pH in Pine Bark and blends of Pine bark amended with Pine Tree Substrate over Time

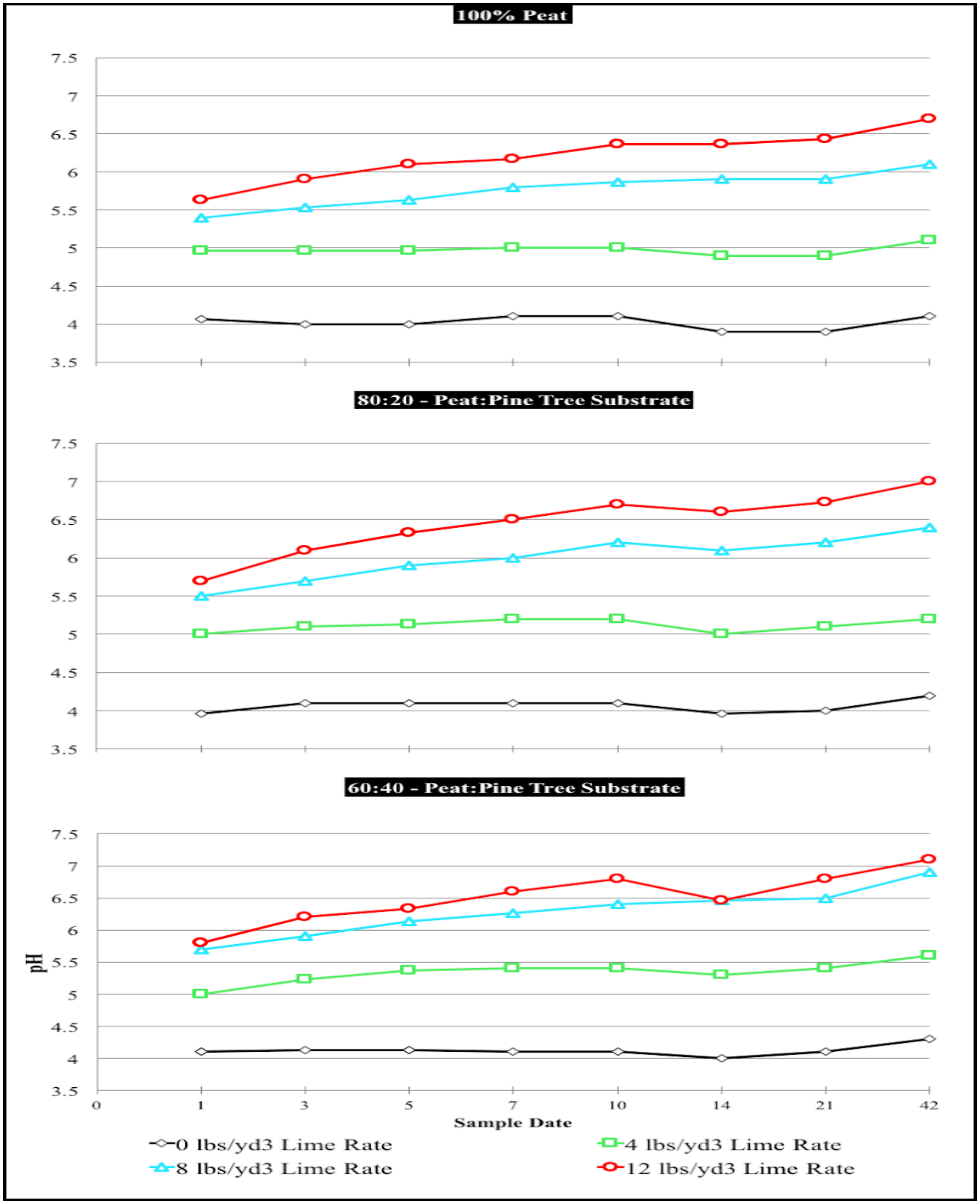

Figure 2. Effect of Lime Rate on pH in *Sphagnum* Peat moss and blends of *Sphagnum* Peat moss amended with Pine Tree Substrate over Time

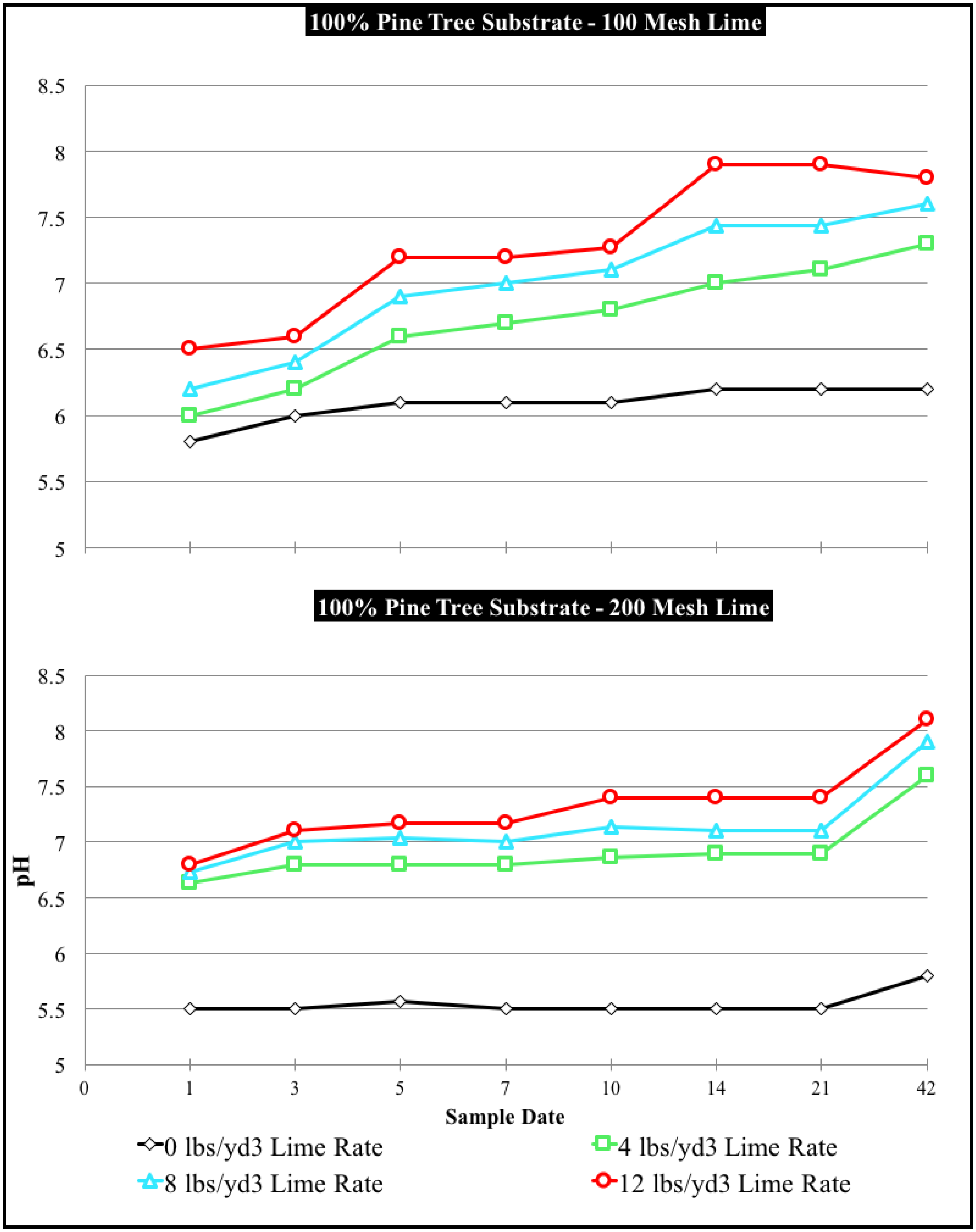

Figure 3. Effect of Lime Rates of 100 mesh and 200 mesh Dolomitic limestone on pH of 100% Pine Tree Substrate over Time

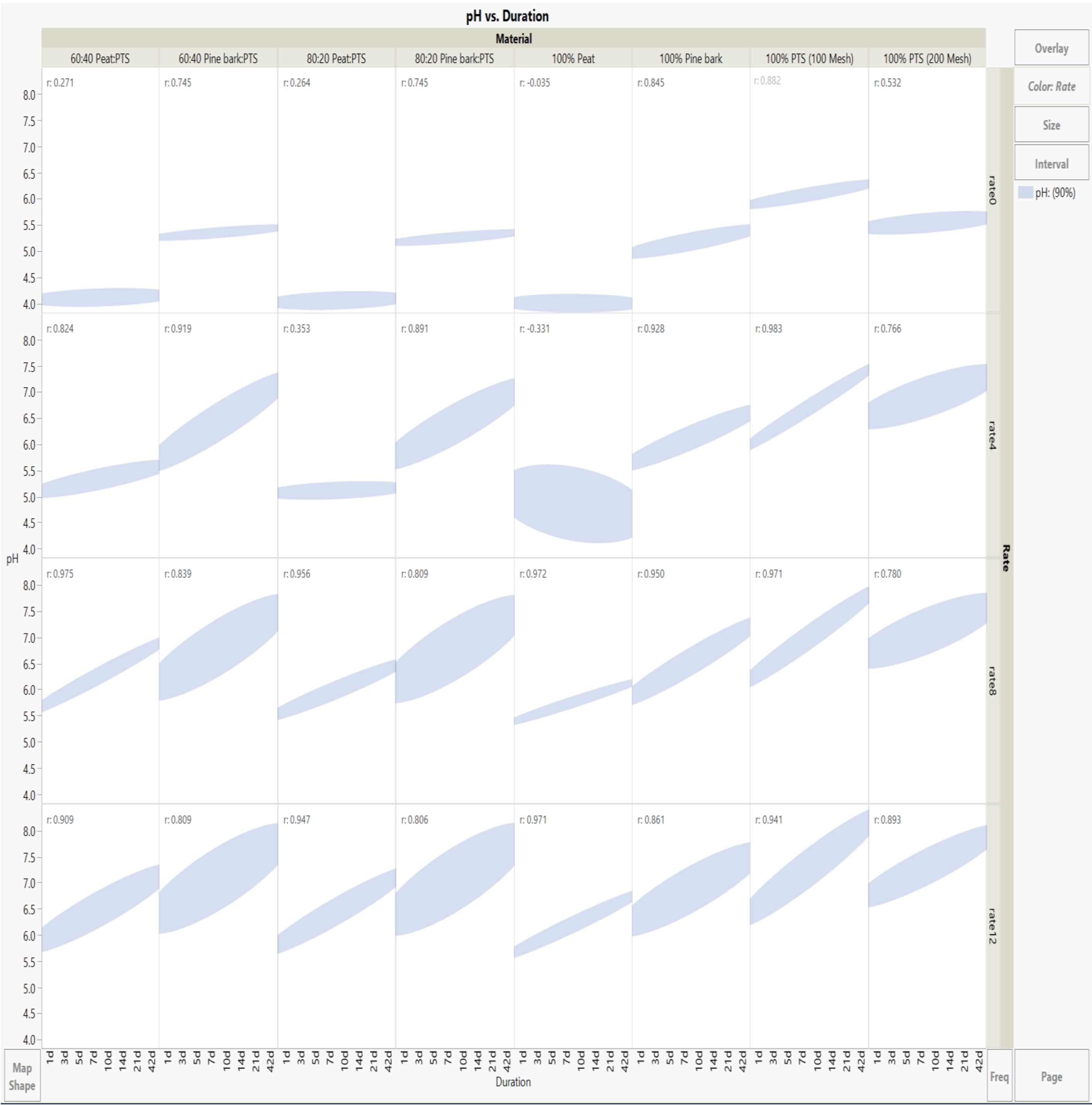

Figure 4. Summary of resultant mean pH of individual substrate blends by rate of lime application amended over time of observation.