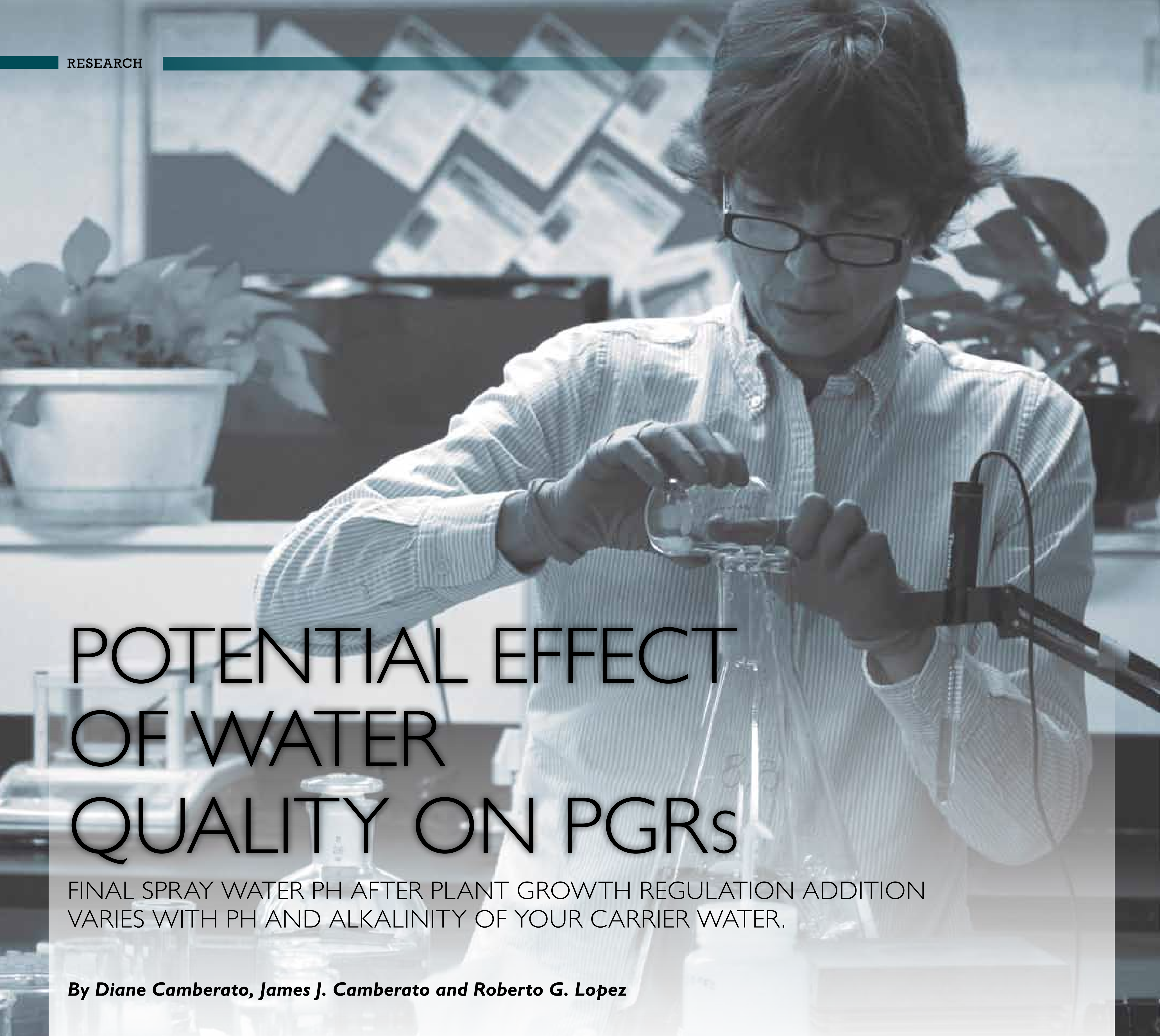

POTENTIAL EFFECT OF WATER QUALITY ON PGRs

FINAL SPRAY WATER PH AFTER PLANT GROWTH REGULATION ADDITION VARIES WITH PH AND ALKALINITY OF YOUR CARRIER WATER.

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Preparation of water samples to determine how PGRs influence the final spray solution pH.

Plant growth regulators (PGRs) have become a common and necessary tool in greenhouse production to produce plants of appropriate size, quality and in flower for specific market dates. The critical effects of water quality (ie. pH and alkalinity) on plant production has been widely discussed in terms of plant nutrition, and growers have become aware of the need to monitor their water quality, be it from a deep or surface well, or from a municipal source.

An additional consideration is the effect water quality has on other chemical applications common in production. Effectiveness of some herbicides and insecticides are reduced when mixed with water containing high amounts of calcium and bicarbonate (components of alkalinity). It would be important to know what type of change, if any, occurs when the various PGRs used in the industry are mixed with water varying in pH and alkalinity. The range in pH and alkalinity differs significantly from growing region to growing region, and even locally depending on the water source, and can vary on a frequent basis if a municipal source is used. Plant growth regulator labels often offer little information in this regard; only the gibberellic acid (GA) products recommend that it be combined with neutral or slightly acid pH water for best results. We consulted with industry professionals and existing publications to compile Table 1 for your reference, which includes the pH of the PGRs used in this study and the final recommended spray solution pH (carrier water + PGR) for application.

The Study

We conducted a large laboratory study at Purdue University to measure change in pH of initial water samples (carrier water) after additions of one of the 11 commonly used PGRs in ornamental plant production. The 11 PGRs trialed included: ancymidol (Abide), benzyladenine (BA; Configure), chlormequat chloride (Cycocel), daminozide (B-Nine), dikegulac-sodium (Augeo), ethephon (Florel), flurprimidol (Topflor), gibberellic acid (GA; Florgib), gibberellic acid/benzyladenine (GA/BA; Fresco), paclobutrazol (Piccolo) and uniconazole (Concise) (Table 1).

The initial water samples represented water quality across the range of pH growers experience across the United States: 5.3, 6.2, 7.2 and 8.2. Reverse osmosis water was used as the carrier water, so that there would be minimal bicarbonate present. An additional study was conducted using initial water samples containing varying levels of bicarbonate (the predominant source of alkalinity in our local tap water and similar to that of most Midwest growers) that again represented the range most growers would experience; 40-, 80-, 142- and 293-ppm bicarbonate expressed in units of calcium carbonate ($CaCO_3$). The PGRs were added at the manufacturers' three recommended rates for bedding plants produced in the northern U.S. for each product; low, medium and high.

Growers should know about the quality of not only their irrigation water, but the water they use to apply agricultural chemicals.

For simplification purposes, just know that we measured the pH (initial) of the "carrier water," added a particular PGR at a particular rate and then re-measured the pH (final). On another set of samples, we established the initial bicarbonate level of the water, measured the pH (initial), added a particular PGR at a particular rate and then re-measured the pH (final). The change in pH is an indicator of any reaction of the PGR with acidic hydrogen ions (H+) in the water, or in the case of alkalinity, with bicarbonate. The general recommendation for growers has been to use a water source with a pH less than 7.0, and less than 100 ppm $CaCO_3$, for maximum effectiveness of PGR application. This recommendation may not be accurate for all PGRs, and many growers do not have a water source that provides water of this quality.

Results in Water Variable in pH

Interesting trends were noted on the interaction of the 11 PGRs with the initial water samples of varying pH, and then varying alkalinity

Table 1: Chemical and product names, product pH, and recommended final solution (PGR + initial carrier water) pH of the plant growth regulators used in the study as indicated on manufacturer label or material safety data sheet unless noted.

Chemical	Product name/ distributor[1]	Product pH[2]	Rec. final solution pH[3]
Ancymidol	Abide/a	8.5	5.5 – 6.5[a] Not critical
Benzyladenine (BA)	Configure/a	4 – 5 (1%)	5.0 – 6.5[b]
Chlormequat chloride	Cycocel/b	4.8 – 5.2	3.0 – 7.0[a]
Daminozide	B-Nine WSG/b	3.9 (1%)	4.0 – 8.0[c]
Dikegulac-sodium	Augeo/b	9.5	6.0 – 9.0[c]
Ethephon	Florel/c	---	<5.0 (4.0)[a]
Fluprimidol	Topflor/d	8.0 (1%)	5.5 – 8.5[d] Not critical
gibberellic acid (GA)	Florgib/a	3 – 4 (50% v/v sol.)	5.5 – 6.5[a]
GA+BA	Fresco/a	4.2 (1%)	5.5 – 6.5[a]
Paclobutrazol	Piccolo/a	7.7	4.0 – 9.0[a]
Uniconazole	Concise/a	6.26	5.5 – 7.0[b]

[1] a=Fine Americas, Inc. Walnut Creek, CA; b=OHP, Inc. Mainland, PA; c=Southern Agricultural Insecticides, Inc. Palmetto, FL; d=SePRO Carmel, IN
[2] pH of product unless noted.
[3] a=Yates et al. (2011), b= Fine Americas, Inc., c= OHP, Inc. Mainland, PA, d= SePRO Carmel, IN

(determined by bicarbonate concentration). Some PGRs were moderately to strongly acidic in reaction, and lowered the pH of the initial water sample; benzyladenine, chlormequat chloride, daminozide, ethephon, and uniconazole. Gibberellic acid (GA) and GA/BA were very mildly acidic. Ancymidol and dikegulac-sodium were basic in reaction and increased the pH of the water sample when added. There were also two PGRs that were chemically neutral, meaning additions of these did not affect pH to a significant degree (flurprimidol and paclobutrazol). The higher the PGR rate, the greater the associated increase or decrease in pH, except for chlormequat chloride, where it depended on the initial water pH and the rate.

Results in Water of Variable Alkalinity

General trends were also noted when these PGRs were added to water samples of varying bicarbonate concentrations. Additions of daminozide, ethephon and uniconazole, resulted in a decrease in final spray solution pH. An increase in the final spray solution pH occurred when ancymidol, dikegulac-sodium, flurprimidol, GA, GA/BA, or paclobutrazol were added to the initial carrier water. Gibberellic acid (GA), GA/BA, and paclobutrazol were mildly basic. Benzyladenine (BA) and chlormequat chloride were chemically neutral in reaction. Rate response was similar to that using reverse osmosis water of varying pH. The more PGR added (higher rate) to water of varying alkalinity, the greater the change in pH, except for daminozide and ethephon. With these two PGRs, the change in pH varied with bicarbonate concentration as well as rate.

What Does This Mean?

Growers are well aware of the fact that ethephon decreases water pH. What they might not realize is that it decreases pH to a much lesser degree if their carrier water has a concentration of bicarbonate greater than 140-ppm $CaCO_3$. As the ethephon spray solution pH should remain under 5.0 for maximum spray effectiveness, adding ethephon at the low rate to water with 140-ppm $CaCO_3$, or at the low and medium rate to water containing 290-ppm $CaCO_3$, could reduce the effectiveness of your PGR application.

With weakly acidic PGRs like benzyladenine, GA, and GA/BA, your final spray solution pH could be above the recommended pH of 6.5 if your carrier water has a high pH (over 7.0) or has a bicarbonate concentration greater than 150-ppm $CaCO_3$. Also, with pH carrier water below 6.5 or low in bicarbonate (80-ppm $CaCO_3$), adding acidic uniconazole can reduce pH below the recommended range of 5.5 to 7.0.

What Every Grower Should Know

It is important that growers that use PGRs use them effectively for economic and environmental reasons. Growers should consult with their PGR representatives to determine the recommended final solution pH range for products not listed in Table 1. In some cases, as with flurprimidol, it is not critical, with others, such as the example of ethephon and uniconazole used above, it may be.

Growers should know about the quality of not only their irrigation water, but the water they use to apply agricultural chemicals. Have a representative water sample tested at a commercial laboratory so that you are aware of the components of pH and alkalinity. If you have a water treatment system, the sample would be taken from the treated water that you are using to make your spray solutions. Be aware that you should test your water more than one time, as these parameters can change due to environmental factors (ie. droughts, excessive rains, etc.). In order to verify that your PGR applications are as effective as possible, it would be ideal to measure the pH of your spray solution with a simple hand-held pH meter.

More information about the study can be found in our article “Determining the Effect of Carrier Water pH and Bicarbonate Concentration on Final pH of Plant Growth Regulator Solutions,” which was published in the September 2014 issue of HortScience. g

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