Efficacy of Advanced Nutrients pH Perfect® Technology in Correcting and Stabilizing pH in Hydroponics

Product Efficacy Test Report

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Introduction

Hydroponic growers strive to maintain the pH of the nutrient solution (NS) that bathes the substrate and the plant roots within a desired pH range. This involves regular and often intensive pH monitoring. Large commercial greenhouses monitor and maintain the pH using modern, often computerized systems, which automatically add buffering agents to the NS as needed. Smaller producers and individual gardeners usually cannot afford such expensive equipment.

According to *Science in Hydroponics*,[1] an online blog on growing plants hydroponically, growers often ask how to stabilize the pH of the NS using buffering agents that keep pH levels within an acceptable range over long periods. The question is important since changes in pH can cause serious problems, such as impaired nutrient availability. Moreover, adding large quantities of acids or bases to the NS in order to correct pH deviations can be detrimental to plant growth.

For the benefit of hydroponic growers, Advanced Nutrients Ltd. (AN) has developed a line of hydroponic fertilizers which, when used according to the label directions, help to stabilize the pH of the NS in addition to providing nutrients. The propriety buffering technology invented by AN is called pH Perfect. Products formulated with pH Perfect have the term "pH Perfect® Technology" printed on their labels.

According to AN, when a base fertilizer containing pH Perfect (pH Perfect base) is applied hydroponically using low-mineralized water, the pH of the NS is brought within 5.5–6.3 (optimal range) and remains within this range for at least one week.

AN considers pH 5.5–6.3 to be optimal for nutrient availability for plants grown hydroponically. Secondary scientific literature confirms similar optimal ranges for plants grown in soil and in various soilless, or hydroponic, substrates and systems (Irwin, 2002; Resh, 2004; Simidtchiev et al., 1983; Voogt, 1995; Whipker, 1998; etc.).

AN's pH Perfect bases include the following products:

- A three-part base fertilizer consisting of pH Perfect® Grow, pH Perfect® Micro, and pH Perfect® Bloom (pH Perfect GMB);
- A two-part base fertilizer consisting of pH Perfect® Sensi Grow Part A and pH Perfect® Sensi Grow Part B (pH Perfect Sensi Grow);
- A two-part base fertilizer consisting of pH Perfect® Sensi Bloom Part A and pH Perfect® Sensi Bloom Part B (pH Perfect Sensi Bloom);
- A two-part base fertilizer consisting of pH Perfect® Connoisseur Part A and pH Perfect® Connoisseur Part B (pH Perfect Connoisseur).

Any pH Perfect base can also be mixed in the NS with a line of AN additives known collectively as the Bigger Yields Flowering System® (the System). The additives of the System are not designed to stabilize the pH of the NS on their own, but provide additional pH buffering when used in tandem with a pH Perfect base. The additives are sold individually and in bundles. The bundles are grouped into four "grower" levels and accompanied by a feeding schedule (Appendix, Table 11) supplied at the point of sale. They include the following products:

- B-52, Big Bud, Overdrive, and VooDoo Juice (Hobbyist Level®);
- Bud Candy, Final Phase, and Piranha (Expert Grower Level®);

[1] http://scienceinhydroponics.com/

- Nirvana, Sensizym, and Tarantula (Professional Grower Level®);
- Bud Ignitor, Bud Factor X, and Rhino Skin (Grand Master Grower Level®).

This report documents three experiments conducted to determine the extent to which pH Perfect bases, whether used on their own or in tandem with the System, stabilize the pH of nutrient solutions (NSes) in a variety of hydroponic conditions.

Experiment A

Experiment A evaluated the effectiveness of a pH Perfect base in bringing the pH of NSes into the optimal range.

NSes were made using two types of water. The waters and their initial pH readings were recorded as follows:

Table 1. Initial pH of the two types of water.

Type	pH
Reverse osmosis water (RO water)	7.07
Tap water from Sofia, Bulgaria (tap water)	7.16

To determine the impact of a pH Perfect base on the pH of the waters, two NSes were prepared by mixing each water with pH Perfect Sensi Bloom at the label rate (4 mL of each of the two parts of the base fertilizer to 1 L of water). Four replications were conducted (Appendix, Tables 12 and 16). The mean pH of each NS was calculated and recorded as follows:

Table 2. Mean pH of the NSes.

NS	pH
NS 1: RO water & pH Perfect Sensi Bloom	5.91
NS 2: Tap water & pH Perfect Sensi Bloom	6.09

The influence on pH of three commonly used hydroponic substrates was established by adding deionized water of pH 6.65 to baked clay pellets (clay pellets), mineral rockwool (rockwool), and Sunshine Mix #4 (sunshine mix).[2] Twenty grams of each substrate was put in 0.5-L Erlenmeyer flasks. One hundred mL of deionized water was added to the flasks containing the clay pellets and the sunshine mix. Because rockwool absorbs more water than the other substrates, 200 mL of deionized water was added to the flask containing the rockwool. The flasks were sealed with a plastic cap and placed in a shaker for 30 minutes. The liquid was poured off the substrates through a Whatman Blue Ribbon paper filter. The substrates and their initial pH readings were recorded as follows:

Table 3. Influence of substrates on pH of water.

Substrate (ratio of deionized water to substrate)	pH
Clay pellets (1:5)	6.93
Rockwool (1:10)	7.16
Sunshine mix (1:5)	6.12

[2] http://www.sungro.com/products_displayProduct.php?product_id=139&brand_id=3

To evaluate the influence on pH of the interaction of the NSes with the substrates, the same process was followed as described above, except that the NSes containing pH Perfect Sensi Bloom (Table 2) were used in place of deionized water. Four replications of each treatment were conducted and the pH readings recorded (Appendix, Tables 13–15 and 17–19). The mean pH of each treatment was calculated and recorded as follows:

Table 4. Mean pH of NSes after interaction with substrates.

NS	Mean pH of NS after interaction with substrates		
	Clay pellets	Rockwool	Sunshine mix
NS 1	5.95	5.96	5.92
NS 2	6.23	6.24	5.95

The results show that the pH Perfect base brought the pH of the NSes within the optimal range (Table 2) and that the pH of the NSes remained within the optimal range after the NSes were applied to all substrates (Table 4).

Experiment B

Experiment B evaluated the effectiveness of a pH Perfect base, used in tandem with the System, in bringing the pH of NSes into the optimal range and maintaining it there for one week in a non-circulating hydroponic system. No plants were present.

A base NS was prepared by mixing RO water of pH 6.50 with pH Perfect GMB at the label rate (4 mL of each of the three parts of the base fertilizer to 1 L of water) in a 60-L reservoir. The base NS was used to create separate NSes by cumulatively adding each level of the System at the label rate (2 mL of each additive per 1L of water) according to the feeding schedule (Appendix, Table 11). This process resulted in the following treatments:

Table 5. Test scheme of a single replication of Experiment B.

NS
pH Perfect GMB + pH Perfect Hobbyist Level
pH Perfect GMB + pH Perfect Hobbyist & Expert Levels
pH Perfect GMB + pH Perfect Hobbyist, Expert, & Professional Levels
pH Perfect GMB + pH Perfect Hobbyist, Expert, Professional, & Grand Master Levels

The treatments were sampled and the pH readings recorded daily (Appendix, Tables 20–23). The Day 1 and Day 7 pH readings were recorded as follows:

Table 6. pH of NSes including the Hobbyist Level and the Expert Level.

Week	NS incl. the Hobbyist Level		NS incl. the Expert Level	
	pH start	pH end	pH start	pH end
1	5.70	5.90	5.70	5.90
2	5.70	5.90	5.70	5.90
3	5.70	5.90	5.70	5.80
4	5.70	5.90	5.70	5.80
5	5.60	5.80	5.60	5.80
6	5.60	5.80	5.60	5.80

Table 7. pH of NSes including the Professional Level and the Grand Master Level.

Week	NS incl. the Professional Level		NS incl. the Grand Master Level	
	pH start	pH end	pH start	pH end
1	5.70	6.00	5.70	6.00
2	5.70	6.00	5.70	5.80
3	5.70	5.90	5.70	5.90
4	5.70	5.90	5.70	5.90
5	5.60	6.20	5.60	5.90
6	5.60	6.20	5.60	5.90

The results (Tables 6 and 7) show that the NSes were brought within the optimal range and maintained there throughout each week in all treatments.

Experiment C

Experiment C evaluated the effectiveness of a pH Perfect base, whether used on its own or in tandem with the System, in bringing the pH of NSes into the optimal range and maintaining it there for one week in a closed-loop hydroponic system with plants present.

After rooting for 12 days, the plants were transferred to five 10-cm^3 pots containing sunshine mix. They were grown for 25 days in a phytochamber at 26°C with relative humidity of 60–65% and illuminated with 600 W/m^2 lamps for 18 hours during each 24-hour interval. The roots were fed NS by drip irrigation from a 60-L reservoir.

On the 25th day, the plants were transplanted into 12-L pots containing clay pellets. They were fed a NS prepared with RO water and AN's three-part base fertilizer Grow, Micro, and Bloom (GMB) for three weeks. The GMB used during this three-week period did not contain pH Perfect.

At the start of Week 4, a base NS was prepared by mixing RO water with pH Perfect GMB at the label rate (4 mL of each of the three parts of the base fertilizer to 1 L of water) in a 60-L reservoir. Additional separate NSes were created by cumulatively adding each level of the System to the base NS at the label rate (2 mL of each additive per 1L of water) according to the feeding schedule (Appendix, Table 11). This process resulted in the following treatments:

Table 8. Test scheme of a single replication of Experiment C.

Treatment	NS
1	pH Perfect GMB
2	pH Perfect GMB + Hobbyist Level
3	pH Perfect GMB + Hobbyist & Expert Levels
4	pH Perfect GMB + Hobbyist, Expert, & Professional Levels
5	pH Perfect GMB + Hobbyist, Expert, Professional, & Grand Master Levels

Two replications were conducted . The pH of each treatment was measured daily for one week (Table 9). The ion balance of each treatment was measured on Day 1 and Day 7 (Table 10).

Table 9. pH of the treatments over one week.

Treatment	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
1	5.96	5.98	5.92	5.97	6.02	6.05	6.06
2	6.12	6.12	6.15	6.05	6.09	6.12	6.12
3	5.86	5.88	5.85	5.98	5.98	6.02	6.02
4	6.05	5.98	5.92	5.87	5.91	5.85	5.76
5	5.93	6.30	6.15	6.12	5.88	5.76	5.78

Table 10. Cationic and anionic balance of the treatments after one week.

Treatment	Σ cations meq/l	Σ anions meq/l	Σ anions − Σ cations	Σ anions + Σ cations	% Σ anions − Σ cations
1	15.32	15.67	0.36	30.99	1.16
2	14.31	15.99	1.67	30.30	5.53
3	17.23	21.05	3.82	38.28	9.97
4	20.58	23.88	3.29	44.46	7.40
5	16.18	18.01	1.83	34.19	5.35

The results show that the pH of all treatments remained within the optimal range throughout each week. In Treatment 5, which included the Grand Master Level, the pH increased on Day 2 before decreasing through Day 6 (Table 9). It is interesting to note that the ion balance in Treatment 5 was the most stable among Treatments 2 to 5—the NSes that included additives (Table 10 and Appendix, Tables 24 and 25), suggesting that the decrease in pH could be attributed to the active absorption of nutrients by the plants. The high level of hydrocarbonates supports this.

The ion balance analysis (Table 10 and Appendix, Tables 24 and 25) shows that the balance between cations and anions was stable across all treatments. Only Treatment 3, which included the Expert Level, approached the deviation limit value of 10%, yet remained below it.

The additives in the most advanced levels of the System, the Professional Level and the Grand Master Level, contain components that balance mineral nutrition and stabilize the balance of ions. Thus, the constituent additives—Nirvana, Sensizym, Tarantula, Bud Factor X, Bud Ignitor, and Rhino Skin—served as additional buffers in Treatment 4 and Treatment 5, respectively. They helped to balance ions, explaining why nutrient absorption in these treatments was enhanced.

References

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Appendix

Table 11. Feeding schedule for the flowering phase—pH Perfect base + the System.

Level of the System	Nutrient	Week						
		1	2	3	4	5	6	7
		mL/L						
	Base fertilizer	4	4	4	4	4	4	
Hobbyist	VooDoo Juice	2	2					
	Big Bud Liquid		2	2	2			
	B-52			2	2	2	2	
	Overdrive					2	2	
Expert	Piranha	2	2					
	Bud Candy	2	2	2	2	2	2	
	Final Phase							2
Professional	Tarantula	2	2					
	Nirvana			2	2	2	2	
	Sensizym	2	2	2	2	2	2	
Grand Master	Bud Ignitor	2	2					
	Rhino Skin	2	2	2	2	2	2	
	Bud Factor X	2	2	2	2	2	2	

Table 12. pH of NS prepared with RO water.

Replication	pH
1	5.90
2	5.92
3	5.91
4	5.90

Table 13. pH of NS prepared with RO water in clay pellets.

Replication	pH
1	5.95
2	5.95
3	5.95
4	5.95

Table 14. pH of NS prepared with RO water in rockwool.

Replication	pH
1	5.95
2	5.96
3	5.96
4	5.95

Table 15. pH of NS prepared with RO water in sunshine mix.

Replication	pH
1	5.91
2	5.92
3	5.92
4	5.92

Table 16. pH of NS prepared with tap water.

Replication	pH
1	6.07
2	6.10
3	6.09
4	6.08

Table 17. pH of NS prepared with tap water in clay pellets.

Replication	pH
1	6.22
2	6.22
3	6.23
4	6.24

Table 18. pH of NS prepared with tap water in rockwool.

Replication	pH
1	6.24
2	6.23
3	6.23
4	6.24

Table 19. pH of NS prepared with tap water in sunshine mix.

Replication	pH
1	5.92
2	5.95
3	5.94
4	5.97

Table 20. pH of NSes including the Hobbyist Level.

Week	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
1	5.70	5.70	5.80	5.80	5.80	5.90	5.90
2	5.70	5.80	5.80	5.80	5.90	5.90	5.90
3	5.70	5.70	5.80	5.80	5.80	5.90	5.90
4	5.70	5.70	5.80	5.80	5.80	5.90	5.90
5	5.60	5.60	5.70	5.70	5.80	5.80	5.80
6	5.60	5.60	5.70	5.70	5.80	5.80	5.80

Table 21. pH of NSes including the Expert Level.

Week	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
1	5.70	5.70	5.80	5.70	5.70	5.80	5.90
2	5.70	5.70	5.80	5.70	5.60	5.70	5.90
3	5.70	5.70	5.70	5.60	5.50	5.70	5.80
4	5.70	5.70	5.70	5.60	5.50	5.70	5.80
5	5.60	5.60	5.70	5.60	5.50	5.70	5.80
6	5.60	5.60	5.70	5.60	5.50	5.70	5.80

Table 22. pH of NSes including the Professional Level.

Week	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
1	5.70	5.70	5.70	5.60	5.70	5.90	6.00
2	5.70	5.70	5.70	5.60	5.70	5.90	6.00
3	5.70	5.70	5.70	5.50	5.60	5.70	5.90
4	5.70	5.70	5.70	5.50	5.60	5.70	5.90
5	5.60	5.60	5.50	5.50	5.60	5.90	6.20
6	5.60	5.60	5.50	5.50	5.60	5.90	6.20

Table 23. pH of NSes including the Grand Master Level.

Week	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
1	5.70	5.70	5.80	5.60	5.70	5.80	6.00
2	5.70	5.70	5.80	5.60	5.60	5.70	5.80
3	5.70	5.70	5.70	5.60	5.60	5.80	5.90
4	5.70	5.70	5.70	5.60	5.60	5.80	5.90
5	5.60	5.60	5.70	5.50	5.60	5.80	5.90
6	5.60	5.60	5.70	5.50	5.60	5.80	5.90

Table 24. Ion balance in analyzed NSes, ppm.

Level	Al^{3+}	Ca^{2+}	Cu^{2+}	Fe^{3+}	K^{+}	Mg^{2+}	Mn^{2+}	Na^{+}	Zn^{2+}	NH_4^{+}	PO_4^{3-}	SO_4^{2-}	HCO_3^{-}	Cl^{-}	NO_3-	BO_3^{3-}	Total N
Limit ppm	0.1	1	0.01	0.1	1	1	0.01	1.0	0.01	0.1	1	1	10	5	1	0.10000	
1	<0.1	139	0.05	2.6	408	32	0.77	6.6	0.31	39.2	498	249	75	13	684	0.54399	346.5
2	<0.1	140	0.06	2.5	374	33	0.75	8.3	0.31	34.9	465	270	100	15	675	0.54399	314.3
3	<0.1	238	0.07	2.9	420	49	0.85	9.4	0.32	37.4	342	359	65	14	1024	0.54399	333.2
4	<0.1	265	0.10	3.0	527	58	0.91	10.0	0.34	38.6	501	463	62	9	1143	0.54399	305.9
5	<0.1	137	0.21	3.0	427	34	0.80	12.3	0.51	41.2	522	276	126	21	749	1.08798	393.0

Table 25. Ion balance in analyzed NSes, meq/L.

Level	Al^{3+}	Ca^{2+}	Cu^{2+}	Fe^{3+}	K^{+}	Mg^{2+}	Mn^{2+}	Na^{+}	Zn^{2+}	NH_4^{+}	PO_4^{3-}	SO_4^{2-}	HCO_3^{-}	Cl^{-}	NO_3-	BO_3^{3-}
1	<0.001	1.733	0.000381	0.015532	10.435	0.658	0.00701	0.287	0.00237	2.178	1.748	1.295525	1.230	0.366	11.032	0.00308
2	<0.001	1.746	0.000458	0.014934	9.565	0.679	0.00683	0.361	0.00237	1.939	1.632	1.404787	1.639	0.423	10.887	0.00308
3	<0.001	2.968	0.000534	0.017324	10.742	1.008	0.00774	0.409	0.00245	2.078	1.200	1.867846	1.066	0.394	16.516	0.00308
4	<0.001	3.304	0.000763	0.017921	13.478	1.193	0.00829	0.435	0.00260	2.144	1.758	2.408949	1.016	0.254	18.435	0.00308
5	<0.001	1.708	0.001602	0.017921	10.921	0.700	0.00729	0.535	0.00390	2.289	1.832	1.436004	2.066	0.592	12.081	0.00617