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Effect of Hydroponic Solution pH on the Growth of Greenhouse Rose

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Abstract: High temperature and high light intensity during the summer season tend to induce an unbalance absorption of water and mineral elements of hydroponic cultured roses. In addition, differential uptake of various elements causes pH of the root zone to change constantly. To solve this problem, the experiment was carried out to examine the effect of pH of nutrient solution on the growth of rose plants in rockwool slabs. Nutrient solutions adjusted to pH 4.0, 6.0 and 8.0 were supplied at 5 days or 20 days after pinching. The pinching time and solution pH had little effect on pH of root zone. The pH 8.0 were supplied at 5 days after pinching maintained root zone pH slightly higher and at a more desirable level. Stem length was not significantly affected by either solution pH or pinching stage, except it was slightly smaller in pH 4.0 solution supplied at 20 days after pinching. The yield of cut flowers was the greatest when pH 8.0 solution was supplied from 5 days after pinching. A desirable pH of root zone was maintained by supplying a nutrient solution of pH 8.0 from 10 days to 25 days after pinching. When comparing the study of the higher concentration of pH 8.0 to conventional one must concentration of pH 8.0 to conventional one must considered being unable to supply to it to most of cultivar due to the different absorbing characteristics of water and nutrient according to the difference of cultivar.

Key words: Green house, hydroponic solution, pH, rockwool slab, rose

INTRODUCTION

Root zone pH is the most importantly considered in hydroponic culture. Easily changing of root zone pH will be damaged to the plant growth, so maintaining of pH in root zone is most importantly considered of all the soil factors. The adaptable pH is variable by crops, however they are mostly ranged between 5.5~6.5[1,2]. The pH of rockwool culture was best in 5.5[3] and it ranged between 5.0~6.0 for crop growth. In general, pH will be adjusted by acids or alkary[4-7]. However, it is very difficult for adjusting of pH by acids or alkary only because water and nutrient uptake easily change the pH. Change of root zone pH will be easily affected by root zone temperature[8]. Additionally the increasing of temperature above 20°C improve phosphate uptake and resultantly increase pH of culture solution, however, decreasing of temperature will be decrease phosphate uptake and resultantly reduce the pH.

In deep flow technique (DFT) rose culture, dissolved oxygen (DO) in rhyzosphere between 80-90% will be reduced low or high pH damage such as pH 4 and 8[9]. Pilbean and Kirkby[10] introduced valuable rhyzospere pH was adjusted in NFT (nutrient film technique) system by the refrain of accumulation of H^+ in rhyzosphere.

FAO[11] reported that the higher of carbonic acid or bicarbonic acids in supplying water will be increasing of culture media's pH but in contrast pH was lower in low carbonic or bicarbonic acids contents. And they also indicated that for maintaining of valuable pH, 30~50 ppm of carbonic or bicarbonic acids should be maintained.

Crop growth was mostly depends on water and nutrient in culture media. Of all nutrients, N is the most effective for the growth and they are mostly uptake by the ratio of NH_4^+ and NO_3^- in culture media such as supplying of NO_3^- increase, however, NH_4^+ will be reducing[12,13]. And Jones[14] additionally introduced that more than 90% of NO_3^- of total N will be increase pH and more than 20% of NH_4^+ will be reducing the pH in tomato cultivation.

Schrader *et al.*[15] introduced that N uptake ratio will be increasing by mixed supply of $NH_4^+$and NO_3^- than each single supply and additionally pH of culture media will be stable. However, it was different to cultivation crop.

Ikeda and Osawa[4] introduced that the uptake order between NH_4^+ and NO_3^- is different by crop or cultivar, growth stage, culture media pH and temperature such as

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the pH will be decreasing in straw berry and lettuce because they are firstly uptake of NH_4^+ and after empted or decreasing of NH_4^+ will be maintaining or increasing of the pH in culture media. However, NO_3^- will be firstly uptake in spinach, garden pea uptake of NO_3^- in pH 5 and increasing of pH, however there was no change in pH 7 because of same content of NO_3^- and NH_4^+.

Additional other reports introduced that difference of yield was not observed by N supplying source in adjusted pH[10,12,16] and they additionally introduced that toxicity or decreasing of growth was resulted from the low pH not by NH_4^+.

There was no effect of N uptake and accumulation by source in adjusted pH 6 in tomato and tobacco[16-18].

Plant Photosynthetic activity and stomatal conductance of tomato were greatest in pH 5.5~6.0 of culture media[19] and T/R ratio and dry weight ratio were greater in pH 5.5 of culture media, especially than pH 6 or pH 7. It was different by culture media and the most valuable pH were 5.5~6.0 in vermiculite, 5.5 in perpelite.

Lettuce growth was best in pH 7 but it not grown with no rooting and withered of leaf in pH 3 which reason was no uptake of Mo, however above than pH 8 will be reducing the uptake of Fe, Mn and Cu[20].

Leaf number of Lettuce and water celery growth was best in pH 6 and 7, respectively and fresh weight and dry weight was the heaviest in pH 6[21].

Rose uptake of NH_4^+ preferential and exclude of H^+ which will be reducing culture media pH[12,22]. The uptake speed was same in the ratio 8:2 of NO_3^- and NH_4^+[23] and NH_4^+will be preference uptake in high temperature and chlorosis and defloliration will be appeared in 40% of NH_4^+ and rhyzosphere pH reach in 4.

In rockwool culture, rose grow normally in pH 4.5~7.0 of culture media but it growth will be damaged, especially root growth, in media higher than 8.0 and lower than 4.0 of culture media pH[9].

MATERIALS AND METHODS

Effect of supplying water pH on rose growth in each stage: This study was done in green house (15x40 m) from Aug. 18, 1999 to Sept. 28, 1999 in Busan Horticultural Research Center, National Yeongnam Agricultural Experiment Station, R.D.A, Korea.

Hydrophonically two years old roze was hydrophonically cultured in rockwool for one year before the experiment start. Two years old rose hydrophic cultured.

Rose (*Rosa hybrida,* Rotte rose) was pruned on 1st node of 5th leaf in newly grown shoot on August 18. Two pH treatments were established, supplying culture media pH were adjusted by 4.0, 6.0, or 8.0 from 5 days after pinching for 15 days and from 20 days after pinching for 15 days by the same pH levels. After that duration, pH was adjusted and maintained for 6.0.

Inorganic ion contents of supplying water were analyzed by IC (Ion Chromatograph, 500DX Dionex) and AA (Auto Analyzer, Z-6000 Hitachi) and culture solution was adjusted by the rose culture standard (Table 1), Ehiji-Ken Horticultural Research Center, Japan (NO_3^- 11.0 me L^{-1}, NH_4^+ 2.0 me L^{-1}, $H_2PO_4^-$ 1.2 me L^{-1}, K^+ 4.5 me L^{-1}, Ca^{2+} 6.5 me L^{-1}, Mg^{2+} 2.0 me L^{-1}, SO_4^{-2} 2.0 me L^{-1}, Fe 2.0 ppm, Mn 0.5 ppm, B 0.25 ppm, Zn 0.2 ppm, Cu 0.05 ppm, Mo 0.05 ppm, EC 1.6 $dS.m^{-1}$). Other micronutrients were adjusted by the standard of rose cultivation solution of Eigi-Ken Agricultural research center. Culture solution was supplied 70 mL for 1 week and it was separately supplied 8-10 times per day.

Growth characteristics: For pH measurement, the culture solution was sampled with 60 mL from pinching to flowering in three points for 5 days interval at 2cm on the bottom and it was measured pH meter (340, Mettler Delta). Inorganic nutrients content in plant was analyzed after drying at 85°C for 84 h and finely milled with sample mill then analyzed.

T-N and P were analyzed at 665 and 470 nm in spectrophotometer(Star., Gillford) and Ca, Mg, K were analyzed with atomic absorption spectrophotometer (Z-6000, Hitachi)..

The cut-flower length was ranged from shoot base to top of flower bud and cut-flower weight was included cut-flower leaf, stem and flower. Flower width was measured in the maximum width of flower stalk and flower-node length was contained from the flower bottom to first leaf. Leaf area was included all of leaves in cut-flower branch and they are measured by. Leaf area meter (AMB, Meiwa). Leaf greenness was measured on 1st leaf of 5th node with chrorophyll meter (SPAD-502, Minolta, Japan).

Commercial yield was measured in longer than 30 cm of cut-flower length of shoot after pinching. Statistical data were analyzed in SAS program.

Table 1: Composition of the nutrient solution used in the experiment

Sample	EC ($dS\ m^{-1}$)	pH	NH_4^+	NO_3^-	$H_2PO_4^-$	K^+	Ca^{+2}	Mg^{+2}
			me L^{-1}					
Surface water	0.2	6.9	-	0.3	-	0.1	0.5	0.2
Nutrient solution	1.2	6.3	1.3	7.9	0.77	3.3	4.6	1.3

RESULTS AND DISCUSSION

Effect of supplying water pH with pinching stage on rose growth

Change of rhyzosphere pH: Just after treatment, rhyzospere pH was rapidly decreased in pH 4 treatment until 5-day after treatment in pH 4 and maintained in low pH level (Fig. 1). However, pH was maintained for 6 in pH 6 adjusted plot for 5 days and after that time it was rapidly decreased and maintained constantly for 4 and similar inclination to the pH 4 treatment. The treatment of pH 6 was no effect in dropped pH with 4 by the unbalanced ion content. In treatment pH 8, the pH was slowly increased upto 6 after 8 days treatment then slowly decreased and reached in 4.

In 20 days after pinching, supplying water treatments with pH 4, 6, 8 were maintained pH 6 in all the pH treatment for 10 days after pinching then slowly decreased and reached to 4 and maintained. Just after treatment, pH was maintained at 3 in pH 4 and 6 treatments and this was slowly increased at later growth stage.

In pH 8 treatment, the pH was not changed just after treatment then it was similar inclination with pH 4 and 6 treatments at late growth stage.

In stage treatment experiment of pH, maintaining of high pH at initial growth was better for stabilization of

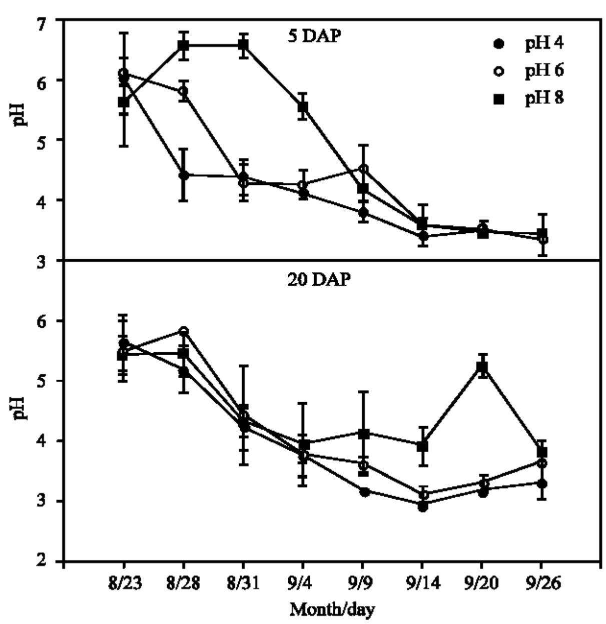

Fig. 1: Changes of pH in root zone of rose grown in rockwool slabs with a nutrient solution adjusted to pH 4, 6 or 8 from 5 or days after cutting. DAP is days after pinching when solution with controlled pH were first supplied

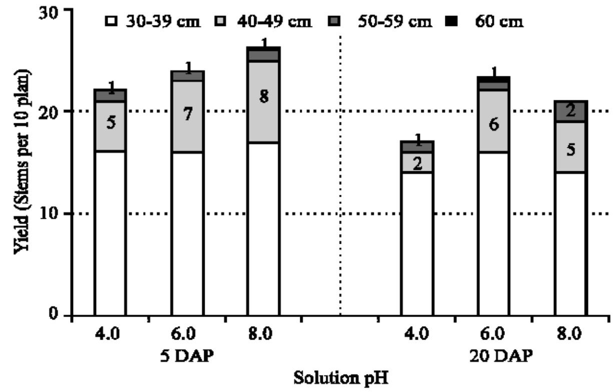

Fig. 2: Yield of rose plants grown in rockwool slabs with a nutrient solution adjusted to pH 4, 6 or 8 from 5 or 20 days after pinching. DAP is days after pinching when solution with controlled pH were first supplied

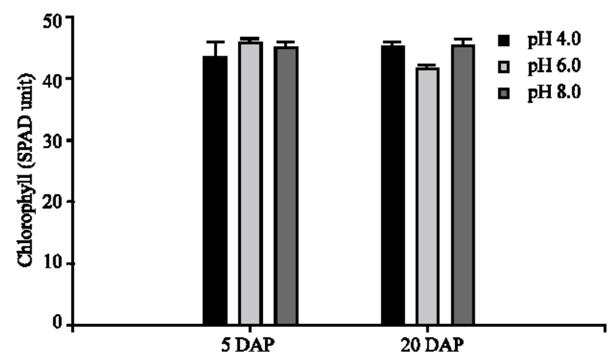

Fig. 3: Leaf chlorophyll concentration in the 1st 5-leaflet from top of plants grown with a nutrient solution adjusted to pH 4, 6 or 8 from 5 or 20 days after cutting. DAP is days after pinching when solution with controlled pH were first supplied

rhyzosphere pH than maintaining of high pH at later growth stage. And this result was similar to the result of Zeislin[9] and he introduced that rhyzosphere pH change of *Indica* rose was decreased from 5.7 to 3.9 at just after treatment and 2 weeks after treatment, respectively.

Cut-flower quality and yield: Cut-flower length was 35 cm in all treatment except pH 4 treatment at 20 days after pinching in pH 4 treatment (Table 2). Among the pinching stage treatment, adjustment of pH at 5 days after was available than other treatments. Cut-flower weight was similar in all treatments except at pH 4 and 6 treatment at 20 days after and similar inclination to cut-flower length in the cut-flower stage treatment. There was no difference between flower width and flower length. Leaf area was higher with decreasing of pH at 5 days after pinching, however it was increased with increasing of pH.

Table 2: Stem length, stem weight, flower diameter, top node length and leaf area of rose plants grown in rockwool with a nutrient solution adjusted to pH 4, 6 or 8 from 5 or 20 days after pinching

DAP[z]	Solution pH	Stem length (cm)	Stem weight (g)	Flower diameter (cm)	Length of top node (cm)	Leaf area (cm^2)
5	4.0	35.7a[y]	11.8ab	10.0ab	8.4bc	311a
	6.0	35.4a	12.0ab	10.1a	8.7abc	264ab
	8.0	35.3a	11.9ab	09.8ab	8.6abc	247b
20	4.0	30.5b	10.3c	09.5b	8.1c	246b
	6.0	34.0a	10.9bc	10.0ab	8.9ab	274ab
	8.0	34.8a	12.5a	09.7ab	9.2a	307a

Table 3: Contents of inorganic elements in cut flower of rose plants grown in rockwool slab with a nutrient solution adjusted to pH 4, 6 or 8 from 5 or 20 days after cutting

DAP[z]	Solution pH	T-N	P	Ca (% of dry weight)	Mg (% of dry weight)	K
5	4.0	1.60a[y]	0.84a	0.47b	0.38ab	2.76ab
	6.0	1.40ab	0.79abc	0.49ab	0.34bc	2.42c
	8.0	1.54ab	0.82ab	0.47b	0.36abc	2.58b
20	4.0	1.30b	0.77bc	0.28c	0.31c	2.48c
	6.0	1.50ab	0.73c	0.54a	0.37ab	2.59bc
	8.0	1.37ab	0.77abc	0.46b	0.41a	2.82a

[z]DAP is days after pinching when solutions with controlled pH were first supplied. [y]Means separation within column by Duncan's Multiple Range Test at p=0.05

This result was similar inclination to the Zieslin's result[9] and it indicated that there was no different of plant growth and leaf growth between pH 4 and 6 for short time.

Similar to the Minotti *et al.*[24] and Rao and Rains[25], rhyzosphere pH was mostly dropped below 4.0 at 5 days after pinching except pH treated 8 and growth pattern was similar after 20 days treatment except pH 4 treatment and it indicated dropped pH at 4 was not affected of NO_3^- uptake.

After 5 days pinching, cut-flower yield was greatest in pH 8 treatment then flowed by pH 6 and 4 (Fig. 2). Cut-flower yield, longer than 30 cm, was greatest in pH 6 of supplying water then pH 8 was followed but it was lowest in pH 4 treatment. Yield was higher at 5 days after with high pH than maintaining at 20 days after high pH.

This result was similar to the Zieslin's[9] result and the paper indicated the growth of rose was not different between pH 4 and 6 of culture media, however rose growth was worse in pH 4 for 22 days long-term experiment.

Nitrogen uptake was reached in maximum level at commercial ripening stage (flowering stage) of rose shoot, it will be dropped the lowest level at shoot growing stage[26]. In this experiment, clear effect of pH treatment was not appeared and the main reasons were estimated that the lower rhyzosphere pH with 4 and especially pH adjustment after 20 days pinching resulted the decreasing of rhyzosphere pH and it reduced the N and other inorganic nutrient uptake.

Chlorophyll concentration (leaf greenness: SPAD-value) and inorganic nutrient in plant: Leaf greenness was lower in pH 4 treatment than pH 6 and 8, however there was no difference between 6 and 8 pH treatments (Fig. 3). It was no difference by the pH treatment of pinching, however, it was lower in 5 days pH treatment than 20 days at pH 4 treatment. This result was a little difference that the report of there was no difference of leaf greenness between pH 4 and 6 in short-term cultivation[9]. This main reason of not significantly different leaf greenness between pH 6 and 8 treatment was considered that the shortage of total growth duration for 35 days and lower rhyzosphere pH 4 at late growth stage that the maximum N absorbing stage was not available[26].

Total N content was greatest (1.60%) in pH 4 treatment at 5 days after pinching and it was lowest (1.30%) after 20 days at pinching (Table 3). Among the pinching stage treatments, T-N was higher in pH adjustment of 5 days after pinching than 20 days after treatment. And this result was a little different to the result of no affected NO_3^- uptake by pH above 4.5 [24]and not decreasing of NO_3^- uptake even at pH 4.[25].

The P content of plant was similar to the T-N. However the Ca content was similar in all treatments at 5 days after pH adjustment, however it was greatest in pH 6 (0.54%) then followed pH 8 (0.46) and pH 4 (0.28) in pH adjustment at 20 days after pinching. Plant Mg content was similar to the treatment.

The K content was greatest (4.0%) in pH 4 treatment then followed pH 8 (2.58) and pH 6 (2.42) if pH adjustment at 5 days after pinching. However, K content was increased with increasing of pH at 20 days after pinching.

Inden[20] indicated that Mg uptake will be decreased with decreasing supplying water, however the uptake of Fe, Mn, Zn, Cu, B and other nutrients will be decreasing with decreasing of pH. However, there was not significant difference among the pH treatment at 5 days after pH adjustment but Ca, K and Mg content were increased with increasing pH and this result was related with the effective nutrients for the growing of flower bud was contributed to the neutralize of culture media.

In summer, rose cultivation on rockwell will be bring about unavailable uptake of water and nutrients, even more rhyzosphere pH will be decreased by the rapid uptake of cation than anion releasing H^+ in the rhyzosphere and finally result in decreased rose growth. So, for solving this problem, three levels of pH treatments, 4.0, 6.0 and 8.0 were evaluated at 5 and 20 days after pinching and concluded the following results.

The pH adjustment effect was recognized at pH 8.0 after 5 days pinching. Cut-flower length was the shortest at pH 4.0 after 20 days pinching and there was no difference in other treatments. Commercial yield was the highest at pH 8.0 after 5 days pinching and pH 6.0 after 20 days pinching.

For available maintaining of rhyzoshpere pH, adjusting the supply of water pH to 8.0 is better than 6.0 at 10 days after pinching for 15 days. Adjustment of pH at each pinching stage is unavailable for summer rose hydroponic culture. However, adjustment of pH at 8.0 in all rose cultivars should be reconsidered because water and nutrient uptake patterns are available in each cultivar. Additionally, rhyzoshpere pH be checked for the supplying water adjustment of pH 8.0, especially at high pH of supplying water.

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