Tropical Agricultural Research Vol. 20: 400 - 404 (2008)
Short communication

Development of a Low Cost and Productive Nutrient Formulation for Simplified Hydroponics Using Commercial Grade Chemicals

M.D.J.S. Saparamadu, W.A.P. Weerakkody[1], H.D. Gunawardhana[2] and R.D. Wijesekera[2]

Department of Chemistry
The Open University of Sri Lanka
Nawala, Nugegoda, Sri Lanka

ABSTRACT. *In order to expand the productivity of agriculture in urban areas, low cost, simple technologies such as simplified hydroponics should be popularized. The major limitations in popularizing simplified hydroponics in Sri Lanka are the high cost of available nutrient packs and their drawbacks. The most popular and available nutrient pack "Albert's Solution" is fairly expensive; the content is not completely soluble and does not carry adequate preparation instructions. This study was carried out to develop a low cost, completely soluble new nutrient formulation with a buffer system (to maintain the pH in the nutrient solution at 5.8 – 6.5) and to evaluate its suitability for simplified hydroponic system with low cost growing media such as rice hull and river sand.*

INTRODUCTION

Simplified hydroponics is practiced under natural climatic conditions, utilizes space efficiently and conserve's nutrients and water by a simple mechanism (Bradely, 2000). Two major limitations in popularizing simplified hydroponics in Sri Lanka are the high cost of nutrients and lack of proper guidelines on nutrient management. The most popular and available nutrient pack for hydroponics in Sri Lanka is "Albert's Solution". Main drawbacks of "Albert's Solution" are high cost, inadequate instructions of preparation of working solutions, insufficient levels of some elements and presence of un dissolved matters in the working solutions. A buffer system in a nutrient formulation will be effective in obtaining the desired pH and also to withstand the pH changes in the growing beds (Morgan, 2000). Rice hull is a waste material that is not adequately exploited for use as a growing medium and rice hull mixed with other materials such as sand in a ratio of 3:2 is successful for use in simplified hydroponics (Bradley and Marulanda, 2000). The availability of ions to the plants in the growing bed will be as same as the nutrient supplied if the medium does not absorb or leach any nutrients, *i.e.* "inert". Apart from the measurements of growth parameters, the decrease in EC in the solution of plant beds within a few hours after application of the nutrient solution (Harris, 1988) and the amounts of the nutrient ions absorbed by plants gives a direct indication on the nutrient uptake by plants. Hence the objective of this study is to develop a low cost, completely soluble new nutrient formulation with a buffer system and

---

[1] Department of Crop Sciences, Faculty of Agriculture, University of Peradeniya, Peradeniya.

[2] Department of Chemistry, University of Colombo, Colombo.

to evaluate its suitability for simplified hydroponics system with low cost growing media such as rice hull and river sand.

MATERIALS AND METHODS

Characteristics of the nutrient formulations that are used in countries with similar climatic conditions (Bradley and Marulanda, 2000), Sri Lankan growing conditions (Ranasinghe and Weerakkody, 2006), the ratio K: N and N: P required for optimum growth (Douglas, 1985) and yield and possible toxicities caused by the macro and micro elements (Smith, 2000) were considered in designing the composition of the new nutrient formulation. The commercial grade compounds were selected considering the purity, solubility, availability and the cost. The selected commercial grade chemicals were analyzed (Clesceri *et al.*, 1988). A buffer system (KOH / KH_2PO_4) of pH of 6.5 was made by adding KOH to H_3PO_4. The tap water in the Nugegoda area was analysed for quality. The "inertness" of the medium was examined by studying cation exchange capacity (CEC), anion exchange capacity (AEC) and leaching patterns. The field experiment was conducted at Nugegoda, in the Western Province (Agro-ecological zone of Low Country Wet Zone) of Sri Lanka, during September, 2006 - February, 2007. Bush bean variety Dave *(Phaseolus vulgaris).* was cultivated in the simplified hydroponics with a mixture of rice hull and river sand in the ratio of 3:2. This experiment was carried out with two treatments, Albert's solution with beans (Al) – control and new formulation with beans (NF), with four replicates. The design of the experiment was completely randomized block design (RCBD).

The solid mixture of the compounds supplying the macro elements were packed in two separate packs, one with calcium nitrate and the other with potassium nitrate and magnesium sulfate. A concentrated solution additional micro nutrient source was prepared. The required amount of ferrous sulfate was packed with the macro element sources, potassium nitrate and magnesium sulfate.

RESULTS AND DISCUSSION

The new nutrient formulation was composed of (in ppm) N = 167, P = 80, K = 281, Ca = 234, Mg = 57, S = 251, Cu = 0.01, Fe = 3.9, Zn = 0.13, Mn = 1.2 and Mo = 0.13 (For K: N ratio, a value as close to the average for all the growth stages, K : N, 1.7 : 1). The compounds, KNO_3, H_3PO_4, KOH, $ZnSO_4.7H_2O$, $MnSO_4.4H_2O$, $FeSO_4.7H_2O$, $CuSO_4.5H_2O$, $MgSO_4.7H_2O$, H_3BO_3, K_2SO_4 were selected as sources of the macro and micro nutrients. The analysis of these commercial grade chemicals indicated that they are suitable to be used as nutrient source for plants (because their compositions did not deviate much from that of the pure salt, very low percentage of un-dissolved solids & no heavy metals). The advantage of using a KOH / KH_2PO_4 buffer system is that, it supplies part of the requirement of K to the plants in addition to the buffering action. Since KH_2PO_4 (commercial grade) was not available, KH_2PO_4 was made using commercial grade KOH and H_3PO_4. The buffer capacity was increased by increasing the total amount of phosphorus up to 80 ppm (the maximum tolerable limit for most terrestrial plants). The levels of the mineral elements in tap water in the Nugegoda area were well below the allowable limits and the water was suitable for use in hydroponics.

Working solution of new nutrient formulation

It was necessary to ensure that the expected amounts of ions are available to the plants when applied. Therefore, possible precautions were taken when preparing the working solution. Calcium nitrate was packed separately to avoid precipitation (as calcium sulfate) due to moisture absorption when present in a mixed pack with other nutrients making it difficult to dissolve. Weighing of micro nutrients that are required in very small quantities accurately is difficult. Furthermore, if the micro nutrients are in a liquid form it would be more homogeneous in the final mix with other nutrients compared to that of a solid mix. Therefore, concentrated solutions were prepared using large quantities amenable for accurate measuring. Ferrous sulfate, which is required in high amounts compared to other micro nutrients and having low solubility, was packed with macro elements potassium nitrate and magnesium sulfate to increase dissolving. The use of concentrated stock solutions was avoided to prevent possible precipitation.

The amounts of chemicals required to make 50 dm^3 of working solution of the new formulation (with tap water) was as follows: Pack A: 61.55 g of $Ca(NO_3)_2.4H_2O$; Pack B: 1.85 g of KNO_3, 27.35 g of $MgSO_4.2H_2O$, 3.5 g of $CaSO_4.2H_2O$, 1.54 g of $FeSO_4.7H_2O$, 50 cm^3 of concentrated micro nutrient solution, 250 cm^3 of concentrated buffer solution.

The CEC and AEC of washed river sand was 7.38 and 14.17 Cmmol *per* 100 g, respectively. The amount of ions other than the soluble silica leached from the rice hull : sand mixture was very low. The low CEC, AEC and low leaching levels of nutrients indicated that the sand and rice hull could be considered to be inert with respect to adsorption and desorption of nutrients.

Field experiment

The temperatures of both day and night and the relative humidity were not in the optimal range for beans. Higher change of EC (Figure 1) (Change of EC = EC of the applied nutrient – EC of the plant bed after 12 hours) in the fruiting stage, in the new formulation indicated that the absorption of nutrients by bean plants from those beds was higher than that of the Albert's Solution.

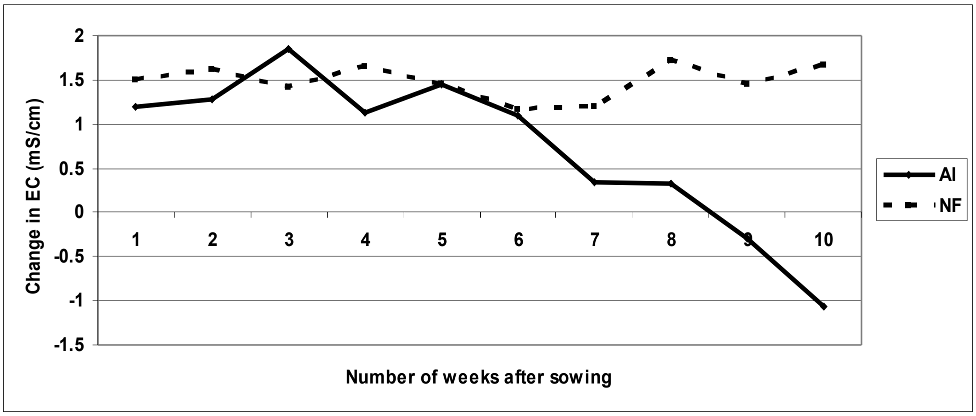

Figure 1. Average change in EC in bean beds with time

Table 1. Average yield and related observations of beans of Trial 1

Treatment	Total number of fruits	Average yield (g) / plant	Amount used (kg)	Cost (Rs.)
Al	23	205.6	1.281	281.82
NF	32	258.4	0.873	118.93

The average yield/plant of the bean plants of the treatment NF is about 33% higher than that of the treatment Al (Table 1). The cost of 1 kg of NF and Al were Rs.136.25 and Rs. 220.00 respectively. The cost of the chemicals for the formulation NF is about 38% less than that of Al. NF gave a 33 % yield increase by using only 68 % of the fertilize dosage, companied to Al.

Nutrient absorption patterns of beans

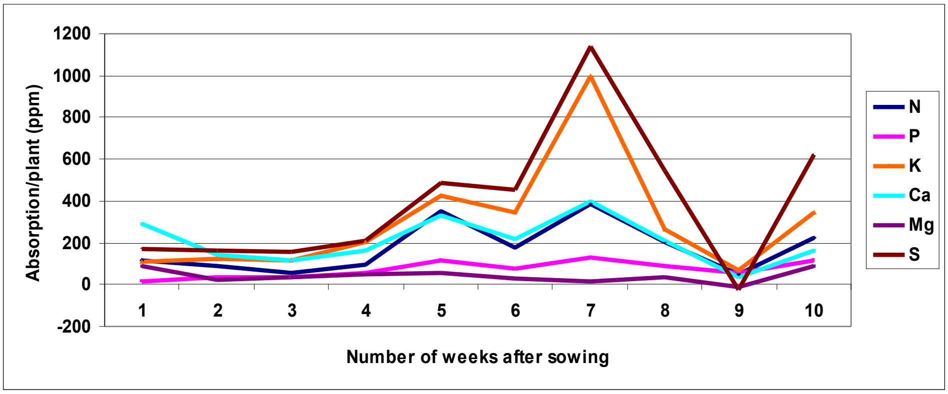

Figure 3. Absorption patterns of macro elements by bean plants of treatment NF

Nutrient amounts absorbed = {concentration x volume of the applied nutrient} – {concentration of the remaining nutrients x volume of the bed after saturation}
The amount of absorption of all the macro elements were more in the new nutrient formulation (Figure 3) compared to the control - Al (Figure 4).

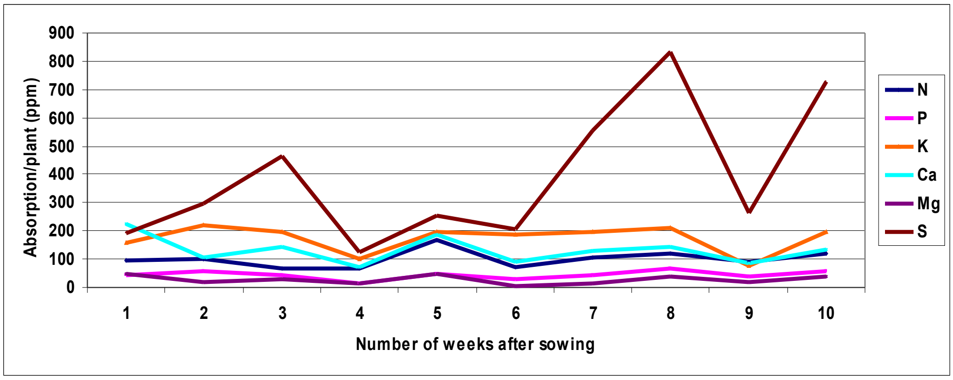

Figure 4. Absorption patterns of macro elements by bean plants of treatment Al

CONCLUSIONS

The new nutrient formulation (NF) is cost effective and productive in simplified hydroponics system compared to Albert's solution. Further evaluations should be carried out under different climatic conditions and during different periods of the year in order to find out the optimum natural conditions under which the new nutrient formulation is more productive. The new formulation should also used on other fruiting and leafy vegetables to examine its performances.

ACKNOLEDGEMENTS

CARP grant (No. 12/624/473) is greatly acknowledged. We are thankful to the University of Colombo for providing the facilities to carryout the research work.

REFERENCES

Bradely, P. (2000). Introducing popular hydroponics gardens in Senegal. The growing edge 11(3): 62-71.

Bradley, P. and Marulanda, C. (2000). Home Hydroponic Gardens, Institute for Simplified Hydroponics, Oregon.

Clesceri, S., Greenberg, A.E. and Eaton, A.D. (1998). American Public Health Association, American water works association, Water Environment federation, United Book Press, Inc., Baltimore, Maryland.

Douglas, J.S. (1985). Advanced Guide to Hydroponics, Pelham books Ltd., London.

Harris, D. (1988). Hydroponics- The Complete Guide to Gardening Without Soil, New Holland Publishers Ltd., London.

Morgan, L. (2000). The Best of Growing Edge: Electrical conductivity (A. Knutson, Ed.). New Moon .Publishing Inc., Corvallis, Oregon.

Ranasinghe, R.A.S. and Weerakkody, W.A.P. (2006). Effects of fertilizer dosage and nutrient balance on growth, yield and nutrient uptake of greenhouse tomato grown in grow-bag culture. Trop. Agri. Res. 18: 394 -398.

Smith, R. (2000). The Best of Growing Edge: Plant nutrients, (A. Knutson, Ed.). New Moon Publishing Inc., Corvallis, Oregon.