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Rajatha KD
Department of Seed Science and Technology, UAS, GKVK, Bangalore, Karnataka, India

Rajatha KD
College of Agriculture, UAS, GKVK, Bangalore, Karnataka, India

Rajatha KD
Seed Technology Research Unit, National Seed Project UAS, GKVK, Bangalore, Karnataka, India

Rajatha KD
Department of Crop Physiology UAS, GKVK, Bangalore, Karnataka, India

Corresponding Author:
Rajatha KD
Department of Seed Science and Technology, UAS, GKVK, Bangalore, Karnataka, India

Evaluation of different nutrient solution in aeroponics for performance of tomato (*Solanum lycopersicum* L.)

Rajatha KD, Rajendra Prasad S, Nethra N and Uadya Kumar M

Abstract
Tomato is an important vegetable crop which will be on demand throughout the year but meeting the demand under the diverse and un-predictable climatic factors, recurrent disease and pest is a challenging task in traditional method of production. Aeroponics is one of the advanced techniques to cultivate plants without soil with minimal water and nutrient consumption where nutrient solution will be sprayed to the root zone with regular time interval. This is the technology which could bring the vertical growth in agriculture. It is an eco-friendly approach widely used for commercial cultivation of vegetables to obtain the supreme quality and yield. Among factors affecting hydroponic and aeroponics production systems, the nutrient solution is considered to be one of the most important determining factors of crop yield and quality. Therefore, standardization of nutrient solution owes an import task for potential quality seed harvest in soil-less agriculture. Different nutrient solutions viz., Chikkaballapur, CPRI, Hoagland's, Ethiopia, USDA and Komosa were studied to understand the effect of the different nutrient combination on tomato hybrid seed production by recording plant growth parameters at every 5 days interval from the date of transplanting to 25 days after transplanting. Based on the result it was found that Hoagland's solution (88.07 cm) performed better at 25 DAT followed by Komosa (82.10 cm) and lower was recorded in Chikkaballapur (67.60 cm).

Keywords: Aeroponics, Hoagland's solution, nutrient solution, *Solanum lycopersicum* L.

Introduction
Providing quality nutritive food to more than 1.6 billion people by the Year 2025 would be a major challenge for the country. Increasing population, decreasing land and water holding, urbanization, industrialization, global warming are some of the major impediments for the country. Various biotic and abiotic stress factors are threatening the open field agricultural production systems throughout the world in varying degrees. The soil fertility status has attained almost the saturation level in most parts of the country as the productivity is not rising pro rata with the amount of inputs (Chen, 2007) [3]. More than 60 million ha area has been considered as unfit for agriculture (Balasubramanian, 2015) [2]. Thus soil-less agriculture have huge scope in near future. This system can also be used for hybrid seed costs which ranging from Rs. 30, 000- 2, 00, 000-/kg. Seeds are the pivotal hub of agriculture. Technology has refashioned much of farming's day-to-day operations, but without an unwavering supply of high-quality seeds productivity and quality would appreciably be decreased.
Tomato (*Solanum lycopersicum* L.) belongs to the Solanaceae family it occupies the largest area among the vegetables in the world after potato. The total global area under tomato is 46.16 lakh ha and the global production is to the tune of 1279.93 lakh tonnes and India contribute 7.3% share of world production and it occupies 789 thousand ha (Anon. 2018) [1]. But the productivity of India (17 t ha-1) is least when compared to other countries *viz.*, USA (66 t ha-1), Brazil (56 t ha-1) and China (24 t ha-1). Thus advanced technology *viz.*, Aeroponics and Hydroponics could be the promising technologies to enhance the productivity by minimizing effect of environmental influence. But among the factors affecting hydroponic and aeroponics production systems, the nutrient solution is considered to be one of the most important determining factors of crop yield and quality. Therefore, standardization of nutrient solution owes an import task for potential quality seed harvest in soil-less agriculture (Trejo-Tellez and Gómez-Merino, 2012) [17]. Thus, an attempt was made for initial standardization of nutrients for tomato.

Materials and Method
The present investigation was carried out during 2017-19, at National Seed Project, University of Agricultural Sciences in collaboration with BASF Nunhems Pvt Ltd. Aeroponics enclosures

of 450 mm X 650 mm X 450 mm PVC boxes, integrated with motors along with the two misters and one timer per box to control the spray rate and an aluminium L angle frame (22 mm X 40 mm) fabricated above the box for staking purpose (Fig 1). The experiment in aeroponics contains six chambers with the individual timer and motor. Six plants were accommodated per chamber, nutrient solution was sprayed to root zone at an interval of 30:180 sec and 30:360 on and off cycle in morning and night respectively.

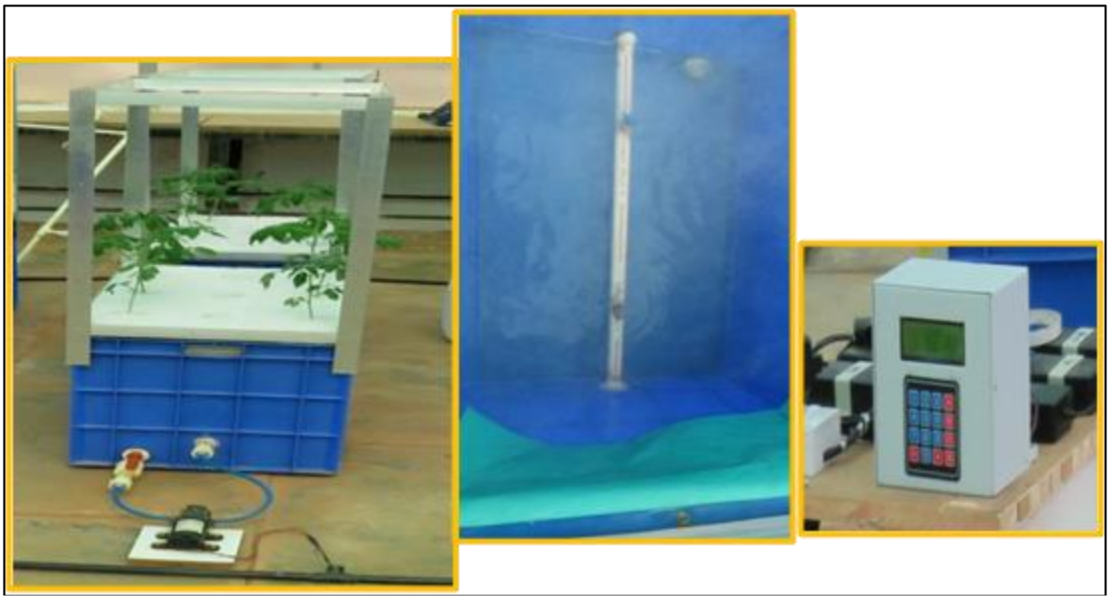

Fig 1: Aeroponics structure designed for tomato

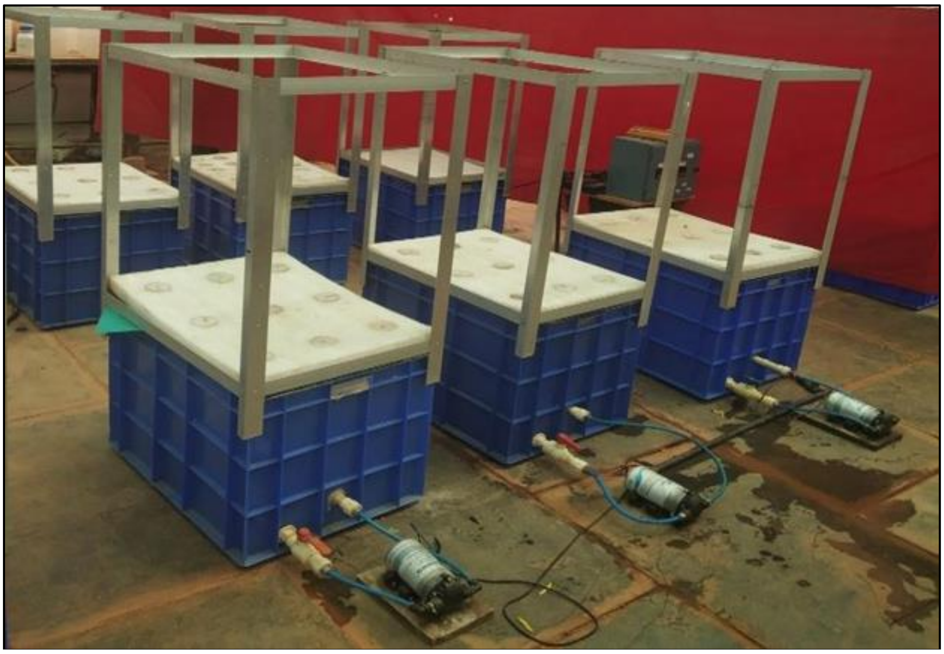

Fig 2: Experimental layout for nutrient standardization in aeroponics for tomato

Seeds were sown on coco-pith in portrays and necessary seedling protections were taken and watered regularly for twenty-eight days and then transferred to the aeroponics chamber with different nutrients solution. Six different nutrient solutions were selected *viz.*, (1) Hogland's solution (Hoagland and Arnon., 1950) [5] (2) CPRI solution (3) Chikkaballapur solution (4) Ethopia solution (Tessema *et al.*, 2017) [16] (5) USDA solution (Otazu, 2010) [8] (6) Komosa solution (Komosa *et al.*, 2014) [6] (Table 1) by recording plant growth parameters *viz.*, number of leaves plant-1, shoot length (cm), root length (cm), total seedling length (cm), plant spread (cm) and plant growth rate [Plant height at second interval (cm)-plant height at first interval (cm))/Time interval] at every 5 days interval from the date of transplanting up to 25 days after transplanting. Based on the performance of seedlings in different nutrient solution nutrients was chosen. The experimental data was statistically analysed by adopting Completely Randomized Design (CRD) as per Sundararaj *et al* (1972) [13] adopting "Fisher Analysis of Variance Technique" with the Critical difference (CD) values were computed at 5% level wherever F test was significant.

Table 1: Standardization of nutrient solution for aeroponics in tomato

Nutrients	Chikkaballapur (PPM)	CPRI (PPM)	Hoagland (PPM)	Ethopia (PPM)	USDA (PPM)	Komosa (PPM)
N	122	342.5	210	85	197	226
P	32	53.9	31	30.9	72.8	70
K	126	759.6	234	232.6	205	351
Ca	11	63.9	200	40	47.6	170
Mg	44	33.8	34	20	48.1	84
S	60	45.6	64	36	63.2	132
Na	-	0	-	0	1.2	27.2
Cl	-	29.6	-	0.6	-	42.2
Fe	-	0.5	2.5		0.4	1.7
Mn	0.2	0.3	0.5	0.2	1.2	0.5
Zn	-	0.5	0.1	0.5	0.5	1.5
B	-	0.2	0.5	0.9	0.1	0.4
Cu	0.4	0.2	0	0.1	0.2	0.1

Result and Discussion

Significant differences were observed at (P=0.01) for different nutrient solutions studied. But at the day of transplanting, seedlings were twenty- eight days old and random seedlings were picked and transplanted, all the seedlings transplanted recorded on par results for the number of leaves, shoot length, root length and total seedling length. Number of leaves per plant varied significantly from 10 days after transplanting and it was higher in Hoagland solution (10, 14, 17 and 18) followed by Komosa solution (9, 13, 15 and 17) and the lower was found in Chikkaballapur (8, 10, 13, 16) at 10, 15, 20 and 25 DAT respectively. Shoot, root and total seedling length showed a significant difference from five days after transplanting. Shoot and root length was found significantly higher in Hoagland's solution (Shoot length: 16, 21.1, 23.4, 36, 43 cm; Root length: 13.05, 19, 23.4, 38.25, 44.8 cm) and lower was found in Chikkaballapur (Shoot length: 15.2, 17.9, 18.7, 25.7, 35.5 cm; Root length 11.75, 17, 17.7, 25.3, 36.7 cm) during 5, 10, 15, 20 and 25 DAT respectively. Similar trend was also observed for total seedling length and plant growth rate. Plant spread recorded at 5 and 10 DAT was on par among different nutrient solution but varied significantly after 15 DAT. Overall plants spread was significantly higher in Komosa (26.6, 30.8 and 35 cm) and was lower in Chikkaballapur (23.1, 28.3 and 32.5 cm) solution at 15, 20 and 25 DAT respectively. Among the six nutrient solutions studied for tomato hybrid seed production, tomato seedlings responded better in Hoagland's solution followed by Komosa in aeroponics system.

Table 2: Seedling growth parameters (up to 10 DAT) affected by different nutrient solution under aeroponic system in tomato

Nutrient solutions	Number of leaves/ plant	Shoot length (cm)	Root length (cm)	Total seedling length (cm)	Plant growth rate	Plant spread (cm)
ADT						
Chikkaballapur	4.00	12.88	8.70	21.58	-	9.37
CPRI	3.67	12.80	8.95	21.75	-	9.37
Hoagland	3.67	12.80	8.50	21.30	-	9.63
Ethiopia	3.33	13.03	9.50	22.53	-	9.00
USDA	3.67	13.10	9.77	22.87	-	9.20
Komosa	3.67	12.93	9.77	23.03	-	9.50
S.Em.±	0.30	0.18	0.39	0.67	-	0.32
CD @ 1%	NS	NS	NS	NS	-	NS
CV(%)	14.37	2.38	7.41	5.23	-	5.86
5 DAT						
Chikkaballapur	6.33	15.20	11.75	26.95	1.07	14.87
CPRI	7.00	15.35	12.45	27.80	1.21	15.03
Hoagland	6.67	16.00	13.05	29.05	1.55	14.40
Ethiopia	6.00	14.95	12.00	26.95	0.88	13.83
USDA	6.33	15.90	13.10	29.00	1.23	14.47
Komosa	7.00	16.15	12.75	28.90	1.17	15.07
S.Em.±	0.24	0.16	0.15	0.28	0.10	0.43
CD @ 1%	NS	0.67	0.64	1.21	0.42	NS
CV (%)	6.23	1.73	2.04	1.72	14.30	5.10
10 DAT						
Chikkaballapur	8.33	17.90	16.50	34.40	1.49	21.60
CPRI	9.00	18.65	16.90	35.55	1.55	18.97
Hoagland	9.67	21.05	18.60	39.65	2.12	19.50
Ethiopia	9.33	18.90	18.15	37.05	2.02	19.60
USDA	9.67	18.75	16.20	34.95	1.19	19.43
Komosa	9.00	19.35	18.50	37.85	1.79	20.17
S.Em.±	0.27	0.42	0.37	0.68	0.13	1.12
CD @ 1%	1.18	1.80	1.60	2.95	0.57	NS
CV (%)	5.14	3.79	3.67	3.24	13.54	9.76

ADT: At date of transplanting, DAT: Days after transplanting

Table 3: Seedling growth parameters (between 15, 20 and 25 DAT) affected with different nutrient solutions under aeroponic system in tomato

Nutrient solutions	Number of leaves per plant	Shoot length (cm)	Root length (cm)	Total seedling length (cm)	Plant growth rate	Plant spread
15 DAT						
Chikkaballapur	10.33	18.70	17.70	35.45	0.21	23.13
CPRI	12.00	19.62	20.13	39.75	0.84	26.37
Hoagland	13.67	23.38	23.35	46.73	1.42	26.67
Ethiopia	12.33	20.60	18.60	39.20	0.43	24.90
USDA	12.00	20.70	18.45	39.15	0.84	26.20
Komosa	13.33	21.13	20.05	41.18	0.67	26.63
S.Em.±	0.43	0.54	0.49	0.73	0.06	0.93
CD @ 1%	1.86	2.35	2.12	3.16	0.25	NS
CV (%)	6.07	4.55	4.31	3.15	13.67	6.27
20 DAT						
Chikkaballapur	13.33	25.67	25.30	50.97	3.10	28.30
CPRI	14.33	29.70	32.00	61.70	4.39	30.10
Hoagland	16.67	35.95	38.25	74.20	5.49	30.03
Ethiopia	14.67	29.00	31.30	60.30	4.22	30.33
USDA	13.67	26.20	29.50	55.70	3.11	30.00
Komosa	14.67	33.45	35.75	69.20	5.60	30.77
S.Em.±	0.33	0.50	0.58	1.05	0.30	1.01
CD @ 1%	1.44	2.16	2.52	4.54	1.30	NS
CV (%)	3.97	2.89	3.15	2.93	12.03	5.82
25 DAT						
Chikkaballapur	15.67	35.50	36.70	67.60	3.33	32.50
CPRI	16.33	37.63	41.13	78.77	3.41	34.30
Hoagland	18.33	42.97	44.77	88.07	2.77	34.23
Ethiopia	16.33	37.33	39.83	77.33	3.41	34.53
USDA	16.00	34.60	41.10	75.63	4.19	33.20
Komosa	16.67	37.93	43.83	82.10	2.58	34.97
S.Em.±	0.45	1.04	0.71	1.30	0.35	0.91
CD @ 1%	1.95	4.51	3.07	5.60	1.52	NS
CV (%)	4.72	4.80	2.98	2.87	18.57	4.64

DAT: Days after transplanting

A nutrient solution for hydroponic systems is an aqueous solution containing mainly inorganics ions from soluble salts of essential elements for higher plants. Eventually, some organic compounds such as iron chelates may be present (Steiner, 1968) [12]. An essential element has a clear physiological role and its absence prevents the complete plant life cycle (Taiz & Zeiger, 1998) [14]. The Hoagland solution contained balanced micro and macro nutrient composition. However, there will be an interaction between macro and micro nutrients. The higher or lower concentration of one nutrient would affect the availability of other. Mousavi *et al.* (2012) [7] stated that phosphorus interferes with zinc uptake. Hence, Steiner created the concept of ionic mutual ratio, it is based on the ratio of anions and cations. Such a relationship is not just about the total amount of each ion in the solution, but in the quantitative relationship that keep the ions together (Steiner, 1961; 1966; 1968) [10, 11, 12]. This might alter the ionic balance making it impossible to supply one ion without introducing a counter ion (Hewitt, 1966) [4]. When a nutrient solution is applied continuously, plants can uptake ions even at lower concentrations continuously. On the other hand, concentrated nutrient solutions lead to excessive nutrient uptake and exhibit toxic effects (Tellez and Merino 2012) [15]. This was also experimented by Komosa *et al.* (2014) [6] in tomato and inferred that higher nutrient solution recorded the lower yield. Thus, in Hoagland's solution there must be a balance between micro and macro nutrients in required proportion, along with maintenance of ionic balance leading to better performance by tomato seedlings.

Chikkaballapur and Ethiopia nutrient solution recorded the lower micro and macro nutrients composition leading to deficiency of nutrients. The Chikkaballapur nutrient solution lacks zinc (Zn), iron (Fe), and boron (B) in its composition. Zn, Fe, and B are essential micronutrients. Zn is essential for protein production in plants besides; it is a main composition of ribosome, an active element in biochemical processes and has chemical and biological interaction with other elements. Zinc deficiency might lead to iron (Fe) deficiency associated with Fe transfer from root to shoot under zinc deficiency conditions. Also, excessive zinc in plant increases harmful effects of boron (B) (Pandey *et al.*, 2006 and Mousavi *et al.*, 2012) [9, 7].

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Reference

1. Anonymous. Annual report. Horticultural statistics at a glance. 2018.
2. Balasubramanian A. The wastelands in India, 2015, 10.13140/RG.2.2.35824.87045.
3. Chen J. Rapid urbanization in China: a real challenge to soil protection and food security. Catena. 2007; 69:1-15.
4. Hewitt EJ. Sand and Water Culture Methods Used in the Study of Plant Nutrition. Technical Communication No. 22. Commonwealth Bureau of Horticulture and Plantation Crops, East Malling, Maidstone, Kent, England, 1996.

5. Hoagland DR, Arnon DI. The water-culture method for growing plants without soil. University of California, Berkeley. 1950; 347:1-32.
6. Komosa A, Kleiber T, Markiewicz B. The effect of nutrient solutions on yield and macronutrient status of greenhouse tomato (*Lycopersicon esculentum* Mill.) grown in aeroponic and rockwool culture with or without recirculation of nutrient solution. Acta Sci. Pol. Hortorum Cultus. 2014; 13(2):163-177.
7. Mousavi SR, Galavi M, Rezaei M. The interaction of zinc with other elements in plants: a review. Intl. J. Agri. Crop Sci. 2012; 4(24):1881-1884.
8. Otazu V. Manual on quality seed potato production using aeroponics. International Potato Center, 2010.
9. Pandey N, Pathak GC, Sharma CP. Zinc is critically required for pollen function and fertilisation in lentil. J. Trace Elem. Med. Biol. 2006; 20:89-96.
10. Steiner AA. A universal method for preparing nutrient solutions of a certain desired composition. Plant and soil. 1961; 15(2):134-154.
11. Steiner AA. The influence of chemical composition of a nutrient solution on the production of tomato plants. Plant and Soil. 1966; 24(3):454-466.
12. Steiner AA. Soilless Culture, Proceedings of the IPI 1968 6th Colloquium of the International Potash Institute, 1968, 324-341p.
13. Sundararaj N, Nagaraju S, Venkataraman MN, Jaganath MK. Design and analysis of field experiment. Univ. Agric. Sci. Bengaluru, 1972, 165p.
14. Taiz L, Zeiger E. Plant Physiology. Sinauer Associates, Inc. Publishers. Sunderland, 1998, ISBN: 0878938311, Massachusetts, U.S.A.
15. Tellez T, Merino FCG. Nutrient solutions for hydroponic systems. Toshikia. China, 2012.
16. Tessema L, Chindi A, Gebremedhin WG, Solomon A, Shunka E, Seid E. Determination of nutrient solutions for potato (*Solanum tuberosum* L.) seed production under aeroponics production system. Open Agric. 2017; 2(1):155-159.
17. Trejo-Tellez LI, Gomez-Merino FC. Nutrient solutions for hydroponic systems. In: Hydroponics-a standard methodology for plant biological researches, 2012, 1-22.