EUROPEAN ACADEMIC RESEARCH
Vol. X, Issue 9/ December 2022

Impact Factor: 3.4546 (UIF)
DRJI Value: 5.9 (B+)

ISSN 2286-4822
www.euacademic.org

Development of Low-Cost Hydroponic Solution for Vegetable Production

H. E. M. KHAIRUL MAZED[1]
Scientific Officer, Bangladesh Agricultural Research Institute (BARI)
Regional Agricultural Research Station, Jamalpur-2000, Bangladesh
M. ALAMGIR HOSSAIN
Principal Scientific Officer, Bangladesh Agricultural Research Institute (BARI)
Regional Agricultural Research Station, Jamalpur-2000
M. SAIDUR RAHMAN
Senior Scientific Officer, Bangladesh Agricultural Research Institute (BARI)
Regional Agricultural Research Station, Jamalpur-2000
M. MONJURUL KADIR
Chief Scientific Officer, Bangladesh Agricultural Research Institute (BARI)
Regional Agricultural Research Station, Jamalpur-2000
M. REZAUL KARIM
Scientific Officer, Bangladesh Agricultural Research Institute (BARI)
Horticultural Research Centre (HRC), Gazipur-1701

Abstract:

The experiment was conducted at the Hydroponic net house at Horticulture Research Centre nursery, Regional Agricultural Research Station, Jamalpur during the Sep-May, of 2021-2022 with a view to evaluate the performance of differently formulated nutrient stock solution of BARI. The experiment was done by two crops like BARI Hybrid Tomato-8 and BARI Lettuce-1. Three solutions were: "Coopers solution (A, B)", "Low-cost solution-1 (A, B, C)" and "Low-cost solution-2 (A, B, C)". The production cost of this solutions approximately 450-500 tk, 120-141 tk, and 90-104 tk., respectively. Most of the cases similar production for each crop has been got. By using "Low-cost solution-2 (A, B, C)" farmers would get higher BCR for some crop. In tomato production the highest yield per plant was found 2.22 kg from "Low-cost solution-2 (A, B, C)" treatment while 2.14 kg from Coopers solution treatment. In Lettuce production the highest edible leaf per plant was recorded 318 g from "Low-cost solution-2 (A, B, C)" treatment while 312 g from Coopers solution treatment.

Keywords: Hydroponic Culture, Vegetables, Tomato, Beautiful, Low-cost hydroponic solution.

INTRODUCTION

Day by day our farming land is decreasing and our labor crises increasing. Hydroponics grow plants without soil (Gericke, 1940; Gericke, 1945; Hoagland and Arnon, 1950) using nutrient solution in either an inert non-soil substrate, sometimes called soilless culture, or with no substrate at all – pure hydroponics (Jensen, 1997; Jones, 2005). By hydroponics system one grower can easily grow many crops with less industry and time. In hydroponic crop production system different nutrient solutions were used. But in our country the price of stock solution is high. So, it is the burning issue to reduce the

[1] Corresponding author: hemkhairulmazed@gmail.com

solution price for easy dissemination of this technology to the farmers and entrepreneurs. "Hoagland and Arnon" solution, Coopers solution, Enschishow's solution etc. are most popular used solutions in the world. But these solutions are not readily available in our country. Entrepreneurs can make these stock solutions by mixing different raw powder chemicals in different ratio formulation. The chemicals which are rare to buy the seller demand high price for those raw chemicals. That's why the price of the stock solutions become high and out of reach for general farmers. Some chemicals are also restricted to use in our country also in our Bangladesh due to national security purpose. So, BARI is trying to find some substitute formulation for making the hydroponic stock solution. Some easily accessible and low-price raw chemicals were used to formulate the new stock solution for hydroponic culture. This is called the "Low-cost solution-1 (A B C)". It reduced the price about 300-350 tk. per liter than the previous stock "solution Package A and B". Now one liter "Low-cost solution-1 (A B C)" prices 120-141 tk. per liter. But today scientist again trying to reduce the price more. They formulate "Low-cost solution-2 (A B C)" for reducing more 30 taka per liter of stock solution. Now "Low-cost solution-2 (A B C)" prices 90-104 tk. per liter. How much change in production of vegetables using the newly formulated stock solutions "Low-cost solution-2" it should be examined and determinate. So, this experiment has been taken to measure the accuracy of formulation of new "Low-cost solution-2" for better vegetable production in hydroponic culture.

MATERIALS AND METHODS

The experiment was laid out at CRD design three treatments with six replications. Total 6 wooden box covered with polythene tray were set up for the tomato plant and 3 boxes set up for lettuce plant. There were 30 tomato plants for each treatment and 5 plants were planted for each replication and total 90 tomato plant were planted for the experiment. In lettuce experiment 30 lettuce plant planted for each treatment and 5 plants for each replication. The tomato seeds were sown on 05 January, 2022 and transplanted to the main media on 30 January, 2022. Lettuce seed were sown on 02 November, 2021 and transplanted to the main media on 18 November, 2021. For the formulation of "Coopers solution (A, B)", "Low-cost solution-1 (A, B, C)" and "Low cost solution-2 (A, B, C)" the raw chemicals were collected from the "Shathi Chemical Store", Shuveccha Plaza, Chemical Market, Gulisthan, Dhaka-1000 of Bangladesh. Three different types of formulation were done at Horticulture lab, HRC, RARS, BARI, Jamalpur and Stored in separated 10-liter plastic gallon.

"Coopers solution (A, B)" contained 10 chemical compound like Calcium Nitrate [$Ca(NO_3)_2.4H_2O$], Potassium Nitrate (KNO_3), EDTA-Fe (), Potassium di-Hydrogen phosphate (KH_2PO_4), Ammonium molibdate [$(NH_4)_6Mo_7O_{24}.4H_2O$], Boric Acid (H_3BO_3), Magnesium sulphate ($MgSO_4.7H_2O$), Copper sulphate ($CuSO_4.5H_2O$), Zinc sulphate ($ZnSO_4.7H_2O$), Manganese sulphate ($MnSO_4.4H_2O$). "Low-cost solution-1 (A, B, C)" contained 11 types of chemicals like Calcium oxide (CaO), Potassium Hydroxide (KOH), Nitric Acid (HNO_3), EDTA-Fe ($C_{10}H_{12}FeN_2NaO_8.H_2O$), Potassium di-Hydrogen phosphate (KH_2PO_4), Ammonium molibdate [$(NH_4)_6Mo_7O_{24}.4H_2O$], Boric Acid (H_3BO_3), Magnesium sulphate-Magma ($MgSO_4.7H_2O$), Copper sulphate ($CuSO_4.5H_2O$), Zinc sulphate ($ZnSO_4.7H_2O$), Manganese sulphate ($MnSO_4.4H_2O$). "Low cost solution-2 (A, B, C)" contained 14 types of chemicals like Calcium oxide (CaO), Potassium Hydroxide (KOH), Nitric Acid (HNO_3), Sodium EDTA ($C_{10}H_{12}N_2NaO_8.H_2O$), Ferric Chloride ($FeCl_3$)

Potassium di-Hydrogen phosphate (KH_2PO_4), Ammonium molibdate [$(NH_4)_6Mo_7O_{24}.4H_2O$], Boric Acid (H_3BO_3), Magnesium sulphate-Magma ($MgSO_4.7H_2O$), Copper sulphate ($CuSO_4.5H_2O$), Zinc sulphate ($ZnSO_4.7H_2O$), Manganese sulphate ($MnSO_4.4H_2O$), Ammonium Di-hydrogen phosphate ($NH_4H_2PO_4$).

Electrical conductivity (EC) for different growing stage of different crops were maintained. At early seedling stage, seedling stage, vegetative stage, flowering stage, and fruiting stage the Electrical conductivity (EC) was maintained 1.2, 1.5, 1.8, 2.2 and 2.5 respectively (Mollick, *et al.*, 2016). For the Tomato and lettuce experiment some rectangular boxes were used which were made by 8 inches width wood sheet and thick polythene film and box were covered by corck sheet (6 ft. x 3 ft.) where plants were planted. Each cork sheet contained 15 tomato plants and 32 lettuce plants. The EC was measured by the EC meter named "HANNA Dist-4" made in UK. The pH of the working solution was also maintained from 5.5-6.5 which was also measured by the pH meter named HANNA made in UK. The average temperature of October, Novemner, December, January, February, March and April of our net house were recorded 27, 25, 20, 19, 23, 27 and 32 degrees centigrade, respectively. The average relative humidity of October, November, December, January, February, March, and April of our net house was found 68, 87, 80, 75, 73, 65 and 82 percentage (%), respectively. The temperature and humidity were measured by "INKBIRD IBS-TH1 Plus" Meter, made in Japan which can store the measured value in every 30 min Interval within a day as a data logger. During the experimental time average sunshine hour varied from 10-12 hour per day and average light intensity was recorded for October–December 67000 lux and January-April 54000 lux. The light intensity was measured by "MESTEK LM610 Illumino meter" made in Japan. Data were taken for different parameters and analyzed by 'Statistix-10' computer program.

RESULTS AND DISCUSSION

Tomato

Significant variation was found in few parameters but in most of the parameters did not get any significant variation due to using different BARI formulated nutrient stock solution in this culture tomato and lettuce. (Table 1). The maximum plant height was found from Low-cost solution-2 (116.5 cm) which is statistically identical to copper solution while the minimum was obtained from Low-cost solution-1 (104.7 cm). Number of leaves was also found significant and the maximum number of leaves was recorded from Low cost solution-2 (94.4) on the other hand the minimum was found from Coopers solution (88.0) which is statistically similar to Low cost solution-1 (89.2). Similar trend of data observed in length of leaf parameter. The maximum was found from Low-cost solution-2 (32.8 cm) which is statistically identical to Copper solution (31.9) while the minimum from Low cost solution-1 (32.8 cm). SPAD value indicates the chlorophyll content which helps in the photosynthesis activity. No significant variation was found in SPAD value. The higher SPAD value was recorded in T_3 treatment (61.5) while the minimum was observed in T_2 treatment (58.3). Significant variation was found in stem diameter, the maximum stem diameter was found from T_3 treatment (2.65 cm) which is statistically like T_1 (2.52) treatment while the minimum was recorded from T_2 treatment (2.35 cm). Root length shows the significant variation. The maximum root length was found from T1 treatment (52.9 cm) while the minimum from T_3 treatment (34.1 cm) which is statistically like T_2 (35.5 cm) treatment. In the case of branch number, no significant variation found. The highest value was found from T_1 (12.8) treatment while the minimum was found from T_3 (10.3) treatment. No significant variation found in Plant fresh weight. It is a one of the most important varietal characteristics of plant. Plant fresh weight has a relationship with SPAD value. While the plant fresh weight has become higher the SPAD value indicates the higher value (Hoper, 2015). Similarly, the maximum plant fresh weight was recorded from T_3 (657.4 g) treatment on the other hand the minimum value was found from T_2 (612.6 g) treatment (Table 1).

Table 1. Yield contributing characters of tomato grown in hydroponics culture

Treatment	Plant height (cm)	No. of leaf	length of leaf (cm)	SPAD value	Stem diameter (cm)	Root length (cm)	No. of branch	Plant fresh wt. (g)
T_1 = Coopers solution)	113.3 a	88.0 b	31.9 a	63.4 a	2.52 a	52.9 a	12.8 a	642.3 a
T_2 = Low-cost solution-1	104.7 b	89.2 b	27.3 b	58.3 a	2.35 b	35.5 b	11.6 a	612.6 a
T_3= Low-cost solution-2	116.5 a	94.4 a	32.8 a	61.5 a	2.65 a	34.1 b	10.3 a	657.4 a
LSD $_{(0.05)}$	6.63	2.33	3.42	8.54	0.15	11.23	3.56	118.37
LS	*	**	**	ns	**	**	ns	ns
CV (%)	6.07	5.49	4.00	7.89	6.89	10.29	11.54	5.34

NS = Non-Significant. * indicates significant at 5% level and ** Significant indicates at 1% level of probability.

No significant variation was found in number of fruits plant^{-1}. The maximum number of fruit was found from the T3 (31.0) treatment followed by T2 (28) treatment while the minimum was recorded from the T_1 (34.4) treatment. There was no significant variation found in fruit length parameter. The maximum was observed in T2 (5.8 cm) treatment while the minimum from T3 (5.3 cm) and no significant variation was observed in fruit width and vales were very nearest. No significant variation was found in individual fruit weight and the value ranges from 84.8 to 81.6. No significant variation was found in yield per plant. The yield per plant ranges from 2.22 to 2.14. Significant variation was found in TSS and dry mater content of fruit. The maximum TSS value was observed in T2 (5.4) which is statistically identical to T3 (5.3) treatment on the other hand the minimum was found from the T1 (4.8) treatment. It indicates the "Low-cost solution-1" and "Low cost solution-2" produced fruits were sweeter than "Coopers solution produced fruit". Fruit dry matter follows the reversed trends. The highest dry matter content of fruit recorded from T1 (9.4 %) treatment while the minimum was observed from T3 (8.1 %) treatment (Table 2).

Table 2. Yield contributing characters of summer tomato grown in hydroponics culture

Treatment	Fruit/ plant	Fruit length (cm)	Fruit width (cm)	Single fruit Wt. (g)	Yield/ plant(kg)	TSS value	Fruit dry matter (%)
T_1 = Coopers solution)	24.4	5.4	5.7	82.8	2.14	4.8 b	9.4 a
T_2 = Low-cost solution-1	28.0	5.8	5.8	84.8	2.15	5.4 a	8.3 b
T_3= Low-cost solution-2	31.0	5.3	5.9	81.6	2.22	5.3 a	8.1 b
LSD $_{(0.05)}$	2.78	1.20	1.45	4.56	3.35	0.04	0.07
Lev. of Sig.	NS	NS	NS	NS	NS	**	**
CV (%)	11.95	19.91	22.37	10.45	14.62	6.8	7.3

NS = Non-Significant. * indicates significant at 5% level and ** Significant indicates at 1% level of probability.

Lettuce

Significant variation was found in most of the parameters due to using different lettuce varieties. The highest Plant height was recorded from T_1 (42.0 cm) treatment while the lowest plant height was recorded from T_2 (37.0 cm) treatment. No significant variation was found in days to harvest. The minimum day to harvest was observed in T1 (45.0 days) and T3 treatment which is not desirable, but the maximum was found in T_2 (47.0 days) treatment. Significant variation was found in number of edible leaves per plant and leaf length. The highest number of edible leaves was found from T_1 (19.0) treatment which is statistically identical to T_3 (19.0) treatment while the lowest number of edible leaves was recorded from T_2 (15.0) treatment. The maximum leaf length was observed in T_1 (34.8 cm) treatment which is statistically identical to T_3 (33.8 cm) treatment, but the minimum was found in T_2 (31.2 cm) treatment. There was no significant variation found in leaf breadth and dry matter content parameters. The maximum root length was observed in T_2 (78.1 cm) treatment while the minimum was found in T_1 (68.4 cm) treatment. No significant variation was found in entire single plant weight and edible leaf weight. The highest entire single plant weight recorded from T_3 (365 g) followed by T_1 (351 g) while but the lowest was observed in T_2 (323 g) treatment. The maximum edible leaf weight recorded from T_3 (318 g) treatment followed by T_1 (312 g) treatment while the minimum was observed T_2 (288 g) treatment.

Table 3. Yield and yield contributing character of three lettuce varieties grown on hydroponics culture

Treatment	Plant Height (cm)	Days to harvest	No. of edible leaves	Leaf Length (cm)	Leaf width (cm)	Root length (cm)	Dry matter content (%)	Single plant weight (g)	Edible leaf weight (g)
T_1 = Coopers solution)	39.0 a	45.0	19.0 a	34.8 a	23.2	68.4 c	2.60	351.0	312.0
T_2 = Low cost solution-1	37.0 c	47.0	15.0 b	31.2 b	25.1	78.1 a	2.80	323.0	288.0
T_3= Low cost solution-2	38.0 b	45.0	19.0 a	33.8 a	24.6	72.3 b	2.40	365.0	318.0
$LSD_{(0.05)}$	0.54	2.69	3.36	1.54	4.56	3.89	1.23	51.33	35.67
Level of sig.	*	ns	**	*	ns	*	ns	ns	ns
CV (%)	9.9	5.9	5.6	6.3	8.4	7.6	4.8	9.9	8.3

NS = Non-Significant. * indicates significant at 5% level and ** Significant indicates at 1% level of probability.

CONCLUSION

In this experiment all the all the parameters of tomato and lettuce performed better and showed significant and non-significant variation. If the same crop or plant shows no significant difference in three different formulated solution, then it can be grouped into similar group and used as substitute solution for each other. When farmers or entrepreneurs will get the statistically similar production by using different stock solution then they will select that which is comparatively lower price package. Because that will reduce their production cost give them higher BCR. In this study "Low-cost solution-2" performed better considering all the maters. Further study is needed for more confirmation of the result and find out the suitability for other crops in year-round production.

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