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ECONOMIC VIABILITY AND EFFECT OF RATE AND SPLIT APPLICATION OF ALBERT'S FERTILIZER ON GROWTH AND YIELD PERFORMANCES OF SALAD CUCUMBER GROWN IN AN AUTOMATED PROTECTED HOUSE IN THE LOW COUNTRY WET ZONE OF SRI LANKA

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ABSTRACT

An experiment was accomplished in an automated protected house in low country wet zone of Sri Lanka to study the economic viability and growth and yield of Salad cucumber as affected by rate and split application of Albert's fertilizer. Four replicates were used in a 2 x 3 Factorial Completely Randomized Design. The two factors were rate of fertilizer (1.0 g/plant/day, 1.5 g/plant/day and 2.0 g/plant/day) and number of split applications of fertilizer (1 time/day, 2 times/day and 3 times/day). Growth and yield parameters were recorded at weekly intervals and at harvesting respectively. Additionally, economic viability was evaluated using the benefit-cost ratio. According to results, there is no interaction effect between rate and split application of fertilizer for growth and yield parameters of salad cucumber. In addition, there is no significant effect of the split application of fertilizer for both growth and yield parameters of salad cucumber. However, vine length, number of leaves per vine, length of the 21st internode, days taken for first flowering, fresh weight of fruits and number of fruits were significantly affected by rate of fertilizer. The treatments of 1.5g and 2.0 g/plant/day gave significantly higher values on vine length, number of leaves per vine, length of the 21st internode, fresh weight of fruits and number of fruits. Also, Albert's fertilizer application at 2.0 g/plant/day gave a significantly lower value for the days taken for first flowering. Considering the economic point of view and higher yield 1.5 g/plant/day applied as single dose can be recommended as the most suitable treatment. The benefit-cost ratio per unit area of land is 3.13 excluding labour cost and 1.52 including labour cost. Therefore, salad cucumber cultivation under protected house conditions in low country wet zone of Sri Lanka is profitable for farmers and they can obtain more remunerative incomes by using their own labour.

Keywords: Albert's fertilizer, Automated, Benefit-cost ratio, Protected house, Salad cucumber

INTRODUCTION

Salad cucumber (*Cucumis sativus* L.) is one of the vital vegetable crops cultivated broadly throughout the world under protected environmental conditions to gain higher profits in off-season cultivation (Singh, 2018). Though it has low nutritional and calorie values it is a basic source of multivitamins and essential elements. Salad cucumber provides a considerable amount of vitamin A and C. As well, it contains little amounts of Calcium and Potassium. It is a food choice of those facing problems of obesity since it has an enormous amount of water and a little bit of calories. In addition, according to the report of The National Cancer Institute, Pakistan, cucumber is one of the vegetables which protects against certain types of cancers. Different societies in the world use salad cucumber in accordance with their own taste and requirements. Fresh cucumbers can be cut into thin slices and used as salad or in pickled form or can be used as a vegetable garnish (Rahman *et al*., 2016).

As mentioned by Rahman *et al*. (2016), Cucurbit crops give the best results in terms of both quality and quantity when cultivated in protected lands. They further stated stunting of plants occur due to the insufficient provision of nutrients which leads in prolonging the duration of fruit setting. In addition, root growth can also be depressed due to nutrient deficit conditions resulting less vigorous plants which the ultimate result would be low quality and quantity of yields. Although excessive fertilization can enhance crop yields, it can impede root growth due to high nutrient concentration in the root zone. As well, excessive use of water and fertilizer cause to loose unused nutrients through leaching reducing water and nutrient use efficiency (Wu *et al*., 2020) and these practices cause potential environmental problems such as eutrophication along with high costs to be incurred for agricultural inputs. Therefore, optimum fertilization is vital for higher crop productivity (Liang *et al*., 2014).

Fertilizer application via the drip irrigation system is a technique used to direct water and nutrient supplies according to plant requirement. Drip fertilization can be used in vegetable cultivation to nourish root zones of plants with stable water and nutrient contents.

Small amounts of water soluble fertilizers could be frequently applied to the root zone of plants through drip irrigation system. In Sri Lanka, Albert's fertilizer is the most used fertilizer for drip fertilization (Ranasinghe and Weerakkody, 2006). It is the most famous inorganic nutrient package used to promote plant growth and development and is broadly used in hydroponics. This fertilizer package has a broad scope of balanced nutrient ratios and it is a foundation product for a successful fertilization procedure (Ekanayake *et al*., 2020).

Salad cucumber is mostly grown in protected conditions for achieving higher productivity. Commercial production of salad cucumbers under protected house conditions has increased to withstand adverse weather conditions and pest problems (Jilani *et al*., 2009). In protected agriculture, technological intervention is vital to increase the amount and quality of foods (Weerakkody and Mawalagedera, 2020). Thus, automated protected houses are beneficial to farmers to monitor and automatically control the micro climatic conditions inside the protected house. There automation system plays a significant role in maintaining the micro climatic factors at their optimum levels in accordance to the crop requirement.

However, there is no specific recommendation of fertilization schedule for salad cucumber (Lata *et al*., 2018). Usually farmers practice 2.0 g Albert's fertilizer/ plant/ day. Limited research work has been done regarding salad cucumber fertilizer scheduling. Therefore, there is an opportunity to enhance the productivity of cucumber by optimizing fertilization patterns. In addition, split application of fertilizer is vital in nutrient management as it can decrease nutrient loss through leaching, hence profitable, fruitful and environmentally benevolent (Gharge *et al.*, 2020). In split application of fertilizer the whole required fertilizer amount is not applied at once. It is applied to plants at several times giving substantial time to utilize the nutrients thus, splitting of fertilizers increases fertilizer use efficiency. However, limited research work has been done in many parts of the world to investigate the effect of split fertilizer application for optimizing fertilizer use efficiency. Additionally, the knowledge on optimum fertilization patterns on the growth and yield of salad cucumbers grown in protected houses in low country, Sri Lanka are still lacking.

In addition, salad cucumbers can aid in economic empowerment when cultivated effectively, since they provide farmers with strong remunerative revenues from greater output levels when compared to other local crops (Onuwa *et al*., 2021). Salad cucumber crop is a short duration crop which usually has a life cycle of 120 days. Three crop cycles of salad cucumber can be cultivated per year. The demand for salad cucumbers grown under protected cultivation is rising steadily, because there is an increase in the interest of farmers for cultivating salad cucumber during off season under protected house condition as salad cucumber grown under protected house condition has quantitative and qualitative advantages over the traditional cucumber cultivation (Malik, 2017). Concerning above factors, the objective of the study was to evaluate the effect of rate and split application of Albert's fertilizer for growth and yield parameters of salad cucumber (*Cucumis sativus* L. var EFDAL F1) grown under controlled environmental conditions and to assess the economic viability of protected salad cucumber cultivation in low country wet zone of Sri Lanka.

MATERIALS AND METHODS

This study was accomplished in an automated protected house at Faculty of Agriculture, University of Ruhuna (low country wet zone) from October 2021 to January 2022. Eighty-one uniform salad cucumber (Var: EFDAL F1) seedlings were planted in open top coir grow bags as one vine per bag after seven days of nursery period. The optimum number of salad cucumber plants for a 92.90 m^2 (1000 ft^2) protected house is 200 plants in order to facilitate greater ventilation. Therefore, salad cucumber plants were placed on the floor of the protected house with the spacing of 2.0 x 2.5 ft^2 which the total area of the protected house used for the cultivation was 37.6257 m^2 (405 ft^2). Two-factor factorial (2 x 3) Completely Randomized Design was used to carry out the experiment. In addition, there were four replicates and two plants per replicate was used. The two factors were rate of fertilizer (1.0 g/plant/day, 1.5 g/plant/day and 2.0 g/plant/day) and number of split applications of fertilizer (1 time/day, 2 times/day and 3 times/day). Therefore, there were nine treatment combinations altogether (Table 1).

Table 1. Treatment combinations

T_1	1.0 g/plant/day Albert's fertilizer applied 1 time/plant/day
T_2	1.0 g/plant/day Albert's fertilizer applied 2 times/plant/day
T_3	1.0 g/plant/day Albert's fertilizer applied 3 times/plant/day
T_4	1.5 g/plant/day Albert's fertilizer applied 1 time/plant/day
T_5	1.5 g/plant/day Albert's fertilizer applied 2 times/plant/day
T_6	1.5 g/plant/day Albert's fertilizer applied 3 times/plant/day
T_7	2.0 g/plant/day Albert's fertilizer applied 1 time/plant/day
T_8	2.0 g/plant/day Albert's fertilizer applied 2 times/plant/day
T_9	2.0 g/plant/day Albert's fertilizer applied 3 times/plant/day

Albert fertilizer was applied daily while other fertilizers and foliar sprays were applied according to the requirement. Different amounts of Albert's fertilizer solutions were prepared as assigned in different treatments and they were applied to plants at three different times. In 1 time/day treatment, 200 ml of the relevant Albert's solution was applied to plants at 7.00 a.m. In 2 times/day treatment 100 ml of the relevant Albert's solution was applied to plants, each time at 7.00 a.m. and 10.00 a.m. In 3 times/day treatment, 66.7 ml of the relevant Albert's solution was applied to plants, each time at 7.00 a.m., 10.00 a.m. and 1.00 p.m. After the application of fertilizer, irrigation was done using the drip irrigation system. 300 ml of water applied at each time of 8.00 am and 11.00 a.m. while 200 ml of water applied at 2.00 p.m. Thus, 800 ml of water applied per plant per day. Among the 81 salad cucumber plants, 27 plants were fertilized with 1.0g/plant/day Albert's fertilizer and another 27 plants were fertilized with 1.5g/plant/day Albert's fertilizer while the other 27 plants were fertilized with 2.0g/plant/day Albert's fertilizer. Therefore, the total Albert's fertilizer requirement for the 120 days crop cycle was 121.5 g.

Fungicides were used once a week as a preventive measure of fungal attacks. Management of pests and diseases were done according to the recommendations of the Department of Agriculture, Sri Lanka. Pruning of tendrils, aborted and misshapen fruits and old and diseased leaves of salad cucumber vines were done according to the requirement. Training of salad cucumber vines was done weekly.

Growth parameters were recorded as vine length, no. of leaves per vine and length of 7^{th}, 14^{th} and 21^{st} internodes once a week. Vine length and length of the 7^{th}, 14^{th} and 21^{st} internodes were measured using the measuring tape while number of leaves per vine was counted. Fruits were harvested when their center diameter became 30 mm according to the international grades of export market (Seminis grow forward, 2018) and it was measured using the vernier caliper. Number of days taken for the first flowering, fresh weight of fruits, length of fruits and number of fruits were measured as yield parameters at harvesting. Number of days taken for the first flowering and number of fruits were counted while fresh weight of fruits was measured using the weighing balance. Length of fruits was measured using the measuring tape. Relative humidity and temperature in the microclimate was maintained at their optimum levels using exhaust fans and misters of the automation system. Day temperature in the microclimate was maintained between 28 - 30 °C while night temperature in the microclimate was maintained between 25 - 27 °C. Collected data were statistically analyzed using SAS 9.1.3 version and means were compared using the Least Significant Difference Test (LSD) at 5% probability level.

The benefit-cost ratio per square meter of land was calculated to evaluate the economic viability of salad cucumber cultivation. In order to analyze the benefit-cost ratio, the variable costs and revenues were calculated first on square meter basis. The costs of agricultural inputs, labour cost and utility cost were considered as the variable cost excluding the depreciation cost of fixed assets (Eg: protected house, irrigation system, water pump, etc.). The revenue was determined by returns obtained from the harvest. Then the revenue was divided by the total variable cost. In the current study, the cost and return were compiled using a tabular presentation manner. The cost for water was calculated according to the prices given in terms of Section 84 of the National Water Supply and Drainage Board Law No. 02 of 1974. The cost for electricity was calculated according to the electricity tariff and charges presented by the Public Utilities Commission of Sri Lanka. There the horsepower value of the water pump of the drip irrigation system was converted into kilowatt-hour to calculate the electricity cost. The cost for labour was calculated according to the wages of the research farm of Faculty of Agriculture, University of Ruhuna. The average wholesale price of 1 kg of salad cucumber during the study period (October, November, December 2021 and January 2022) was recorded from the Narahenpita Economic Center (Naveen H. G., personal communication, 22.01.2022). It was Rs. 260.00 (Standard deviation value= 36.51). Simple statistical methods like average, ratio, and percentage were used to evaluate the data in order to fulfill the objectives of the present study.

RESULTS AND DISCUSSION

According to the results, rate and split of Albert's fertilizer were not affected interactively for any growth or yield parameter. As well, growth and yield parameters were not significantly affected by split of fertilizer. However, vine length, no. of leaves per vine, length of the 21^{st} internode, no. of days taken for the first flowering, fresh weight of fruits and no. of fruits per vine were significantly affected by rate of Albert's fertilizer.

Fertilizer is one of the most important agricultural inputs in salad cucumber production, and it is crucial to enhance the amount of yield and quality of fruits. Fertilizer requirement of salad cucumber is absolutely high since it has high yielding potential per unit area and time. N, P and K are considered as major macro nutrients, which are required in comparatively large amounts and are frequently deficient in crops due to lack of fertilization (Fleafel *et al*., 2014).

Vine length

Vine length is significantly affected from rate of fertilizer. 2 g/plant/day and 1.5 g/plant/day treatments recorded significantly higher values for vine length

than 1 g/plant/day treatment (Figure 1). Higher vine length obtained from higher amounts of fertilizer might be due to the adequate accessibility of necessary nutrients, especially N in the growing media that remarkably increased vine length. Stunting of plants occurred because of the inadequacy of nutrients (Rahman *et al.*, 2016).

Results of the current experiment are in line with past findings. Naeem *et al.* (2002), mentioned that various quantities of N, P and K fertilizer were important for plant height of chilli. Abdel-Mawgoud *et al*. (2005), stated that enhancing the level of N, P and K fertilizer resulted a positive response in vegetative growth of snap bean. In addition, Ahmed *et al*. (2007), recorded a maximum vine length of salad cucumber plants when nitrogen application was increased.

Vine length of Cucurbits is generally an utmost growth characteristic and their growth can be influenced by environmental factors and nutrients application (Wahocho *et al.*, 2016). Wahocho *et al.* (2016), reported higher vine length for increased nitrogen levels which was mainly attributed with the availability of adequate amount of N in growing media after the fertilizer application. These results agree with the results of Cohen *et al.* (2000), who revealed that higher level of N reported an increased vine length of cucumber.

Nitrogen is regarded as a critical mineral nutrient for healthy growth of plants (Wahocho *et al.*, 2016). As cited by Wahocho *et al.* (2016), Jaksungnaro and Akalisema (2001) have recorded that nitrogen application significantly influenced the vegetative growth of cucumbers. Furthermore, Guler and Ibrikci (2000) stated that higher fertilization levels recorded a considerable increment in vine growth of cucumbers.

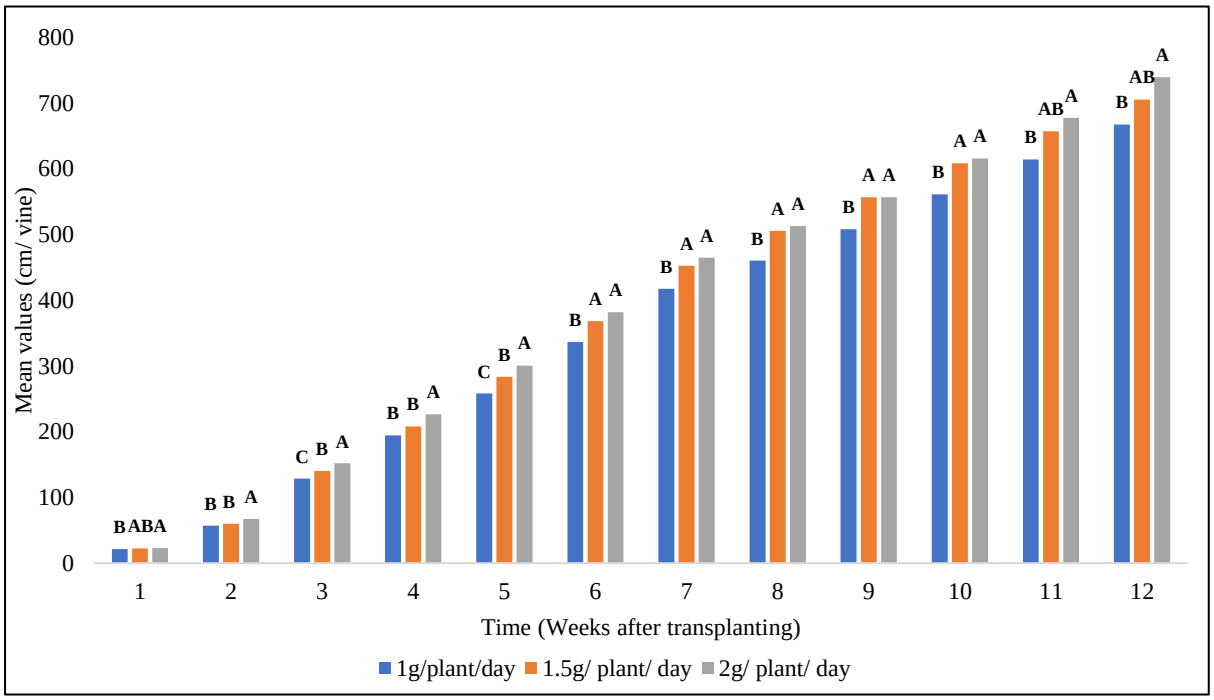

Figure 1. Mean vine length at different weeks after transplanting

Number of leaves per vine

Number of leaves per vine is significantly affected by rate of fertilizer. 2 g/ plant/ day and 1.5 g/ plant/ day treatments gave significantly higher values on no. of leaves per vine than 1 g/ plant/ day treatment (Figure 2). Number of leaves per vine generally means the number of nodes per vine. Nodes of the salad cucumber vine are crucial areas which grow out leaves and fruits. Thus, higher number of leaves indicates the increased amount of photosynthetic tissue (source) along with storage organ (sink) which ultimately increases the yield. Chinatu *et al.* (2017), mentioned that cucumber plants which perform well in vegetative traits are likely to record high reproductive characters which could results higher fruit yield. Wahocho *et al.* (2016), have also reported higher number of leaves per vine in plants receiving higher N levels. Sufficient amount of N application leads to rapid leaf area development causing to increase the overall assimilation rate which then contributes to total yield.

Length of internodes

Nodes of salad cucumber vines are the places which grow out leaves and fruits. If the length of internodes is low, higher number of leaves and fruits can be

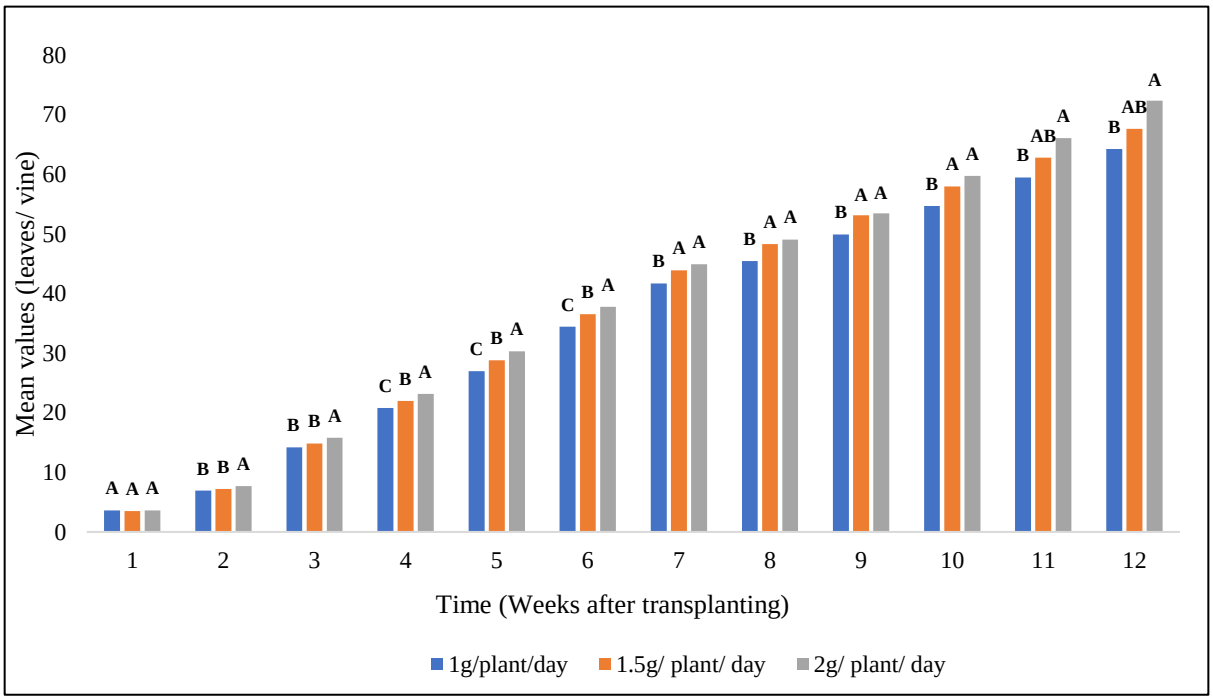

Figure 2. Mean no. of leaves per vine at different weeks after transplanting

obtained per unit length of vine. Although length of the 21st internode was significantly influenced by the rate of Albert's fertilizer in the current experiment, length of the 7th and 14th internodes were not significantly affected by the treatments. The 2.0 g/ plant/ day treatment recorded significantly increased values on the length of 21st internode than 1.0 g/ plant/ day treatment (Figure 3).

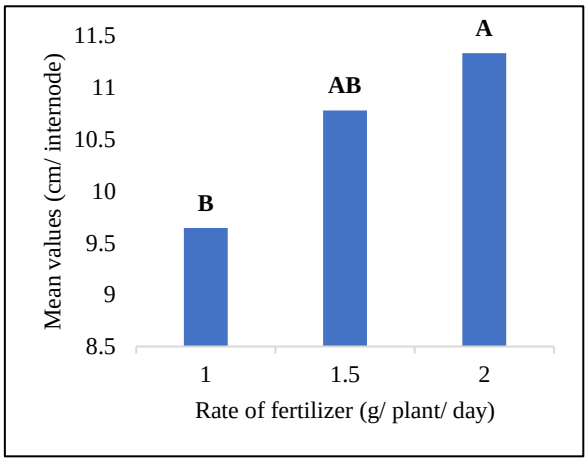

Figure 3. Mean length of 21st internode at different rates of Albert's fertilizer

The reason for this result might be due to the delaying of adaptation of plants for the treatments. When developing the 7th and 14th internodes plants were very young since they have not adapted for treatments. However, when developing the 21st internode, plants had a substantial time to adapt for the treatments. As stated by Sarlikioti *et al.* (2011), longer internodes benefit light distribution in adult tomato plants and thus produce higher biomass. Although lower internodal length is beneficial in salad cucumber in terms of yield and convenience of training, significantly higher fresh weight of fruits was observed from plants with higher internodal length. That might be attributed with overall vine length. Plants with higher vine length gave more fruits than plants with lower vine length.

Number of days taken for the first flowering

Number of days taken for the first flowering was significantly affected by rate of Albert's fertilizer. The application of Albert's fertilizer at 2.0 g/ plant/ day gave a significantly lower number of days taken for the first flowering than 1.0 and 1.5 g/ plant/ day treatments (Figure 4).

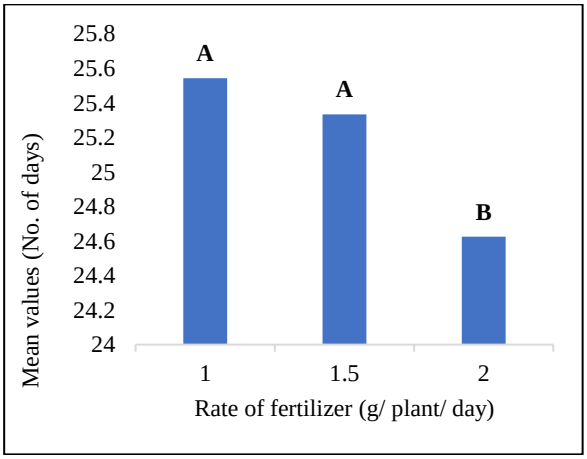

Figure 4. Mean no. of days taken for the first flowering at different rates of Albert's fertilizer

Wahocho *et al.* (2016), stated that larger quantities of N fertilizer application recorded maximum days for first flower initiation. They further stated this might be due to the increased vegetative growth of vines under higher levels of N application results plants to take more days to initiate flowers. They recorded more days to first flower initiation when N was applied at 150.0 kg ha^{-1} and 100.0 kg ha^{-1}, sequentially. The days taken to first flowering was declined when 50.0 kg ha^{-1} N application. However, contrary to these results number of days taken for the first flowering was significantly lower with the highest fertilizer rate of the present study. Sometimes it might be attributed with fertilizer type. Since Albert's fertilizer is a balanced nutrition package, application of sufficient amount of fertilizer may helped to reach plants to their reproductive growth stage quickly.

Length of fruits

Length of salad cucumber fruits was not significantly affected by fertilizer rates as well as by number of splits of fertilization (Table 2 and Table 3).

Table 2. Mean length of fruits at different rates of Albert's fertilizer

Rate of fertilizer (g/ plant/ day)	Average mean values (cm /fruit)
1	14.5141^{A}
1.5	14.5346^{A}
2	14.4872^{A}

Table 3. Mean length of fruits at different splits of Albert's fertilizer

Split of fertilizer (times/ day)	Average mean values (cm /fruit)
1	14.3858^{A}
2	14.4533^{A}
3	14.6968^{A}

Fresh weight of fruits

Fresh weight of salad cucumber fruits was significantly influenced by rate of Albert's fertilizer. The 2 g/plant/ day treatment recorded a significantly higher value for fresh weight of fruits over 1 g/plant/ day treatment. However, 2 g/plant/ day treatment has no significant difference with 1.5 g/ plant/ day treatment (Figure 5). Yield is influenced by different vegetative parameters such as vine length and number of leaves per vine. The treatments of 2 g/plant/day and 1.5 g/plant/day which recorded significantly higher values for above vegetative parameters have resulted significantly higher fresh weight of fruits.

Higher amounts of fertilizer enhanced the supply of nutrients for increasing vegetative growth which ultimately affected to increase yields. Janapriya *et al.* (2010), has reported significantly higher yield of salad cucumber under increased fertilization levels. In addition, Ahmed *et al.* (2007) have mentioned that increasing the level of NPK fertilizer resulted higher yields of salad cucumber. Results of the current experiment are in accordance with the results of Jilani *et al.* (2009) also, who recorded that salad cucumber fruit weight was gradually increased when increasing the N, P and K fertilizer amounts. Wahocho *et al.* (2016), also recorded significantly higher yields for the highest N level which revealed that adequate provision of N improved the vegetative growth hence more fruits per vine was produced. Furthermore, as cited by Wahocho *et al.* (2016), Jaksungnaro and Akalisema (2001), Veesar (2004) and Jilani *et al.* (2009) reported that higher fertilization levels showed better performances in salad cucumber yield.

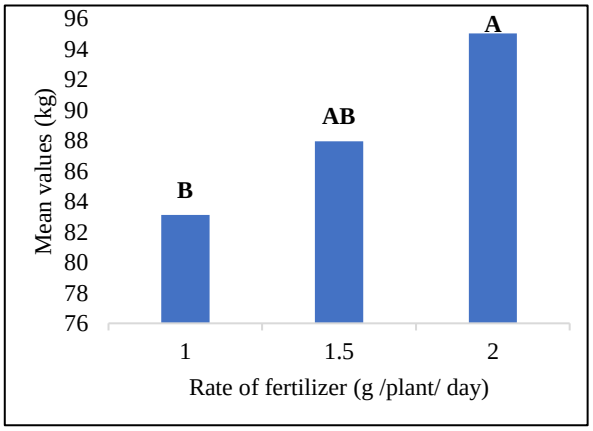

Figure 5. Mean fresh weight of fruits at different rates of Albert's fertilizer

Number of fruits per vine

Number of fruits was significantly affected by rate of Albert's fertilizer. The treatment of 2 g/plant/ dayds recorded a significantly higher value on number of fruits over 1 g/plant/ day treatment. However, 2 g/plant/ day treatment has no significant difference with 1.5 g/ plant/ day treatment (Figure 6).

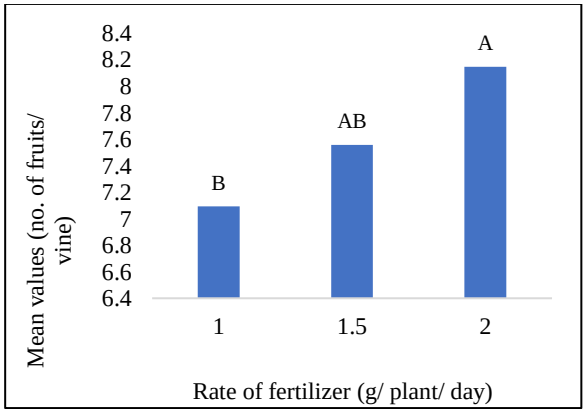

Figure 6. Mean no. of fruits/ vine at different rates of Albert's fertilizer

Wahocho *et al.* (2016), obtained the highest number of fruits in vines which received higher nitrogen amounts of 150.0 kg ha^{-1} and 100.0 kg ha^{-1} respectively. The reduced number of fruits was recorded when N was applied 50.0 kg ha^{-1} while the lowest number of fruits was recorded in control where N fertilization was not practiced. They emphasized that balanced provision of N increased the growth of plants in due course higher number of fruits were produced. Coudhari and More (2001) and Jilani *et al*. (2009) also observed significant increment in number of fruits under increased N levels. Therefore, results of the present experiment agree with the past findings that increased fertilization levels improved the number of salad cucumber fruits.

Benefit - Cost Ratio

The total variable cost of salad cucumber cultivation per square meter in the protected house was LKR 1128.43 excluding labour cost, while it was LKR 2324.42 including labour cost (Table 4). The highest amount of variable cost was spent for labour which was 51.45% of the total variable cost, followed by 16.67% for the fertilizer cost (i.e. cost for Albert's solution). The total return per square meter from the harvest was LKR 3540.61 (Table 5). According to the calculation, benefit-cost ratio for growing salad cucumbers per unit area of land is 3.13 excluding labour cost and 1.52 including labour cost.

Table 4. Cost structure of salad cucumber cultivation

Cost Item		Quantity	Unit Price (LKR)	Value (LKR)
Seedlings		81	90.00	7290.00
Grow bags		81 grow bags x LKR 125.00 = LKR 10125.00 LKR 10125.00 x 1/4* = LKR 2531.25	125.00	2531.25
Plant training thread roll		1	1000.00	1000.00
Fertilizer	Albert's solution	121.5 g x 120 days = 14.58 kg	1000.00	14580.00
	Crop Master	200 ml	225.00	225.00
	Nitrabor	1 kg	150.00	150.00
	30:10:10	500 g	570.00	570.00
	10:52:10	500 g	570.00	570.00
	$MgSO_4$	1 kg	200.00	200.00
Fungicides	Captan	500 g	990.00	990.00
	Mancozeb	100 g	500.00	500.00
	Daconil	400 ml	2035.00	2035.00
	Cabriotop	500 g	2500.00	2500.00
	Amistar	200 ml	2400.00	2400.00
Foliar sprays	K44	250 g	245.00	245.00
	Green care	1 l	640.00	640.00
	Calmax	400 ml	600.00	600.00
Water	100 l/ day x 30 days = 3000 l + service charge (LKR 1000.00 per month)** = LKR 300.00 + LKR 1000.00 = LKR 1300.00 For 4 months = LKR 1300.00 x 4 = LKR 5200.00		100.00 (for 1000 l)**	5200.00
Electricity	0.3728 kWh/ day x 30 days + fixed charge (LKR 30.00 per month) = 11.184 kWh + fixed charge (LKR 30.00 per month)*** = LKR 27.96 + LKR 30.00 = LKR 57.96 For 4 months = LKR 57.96 x 4 = LKR 231.84		2.50 (from 0-30 kWh)***	231.84
Labour	LKR 125.00 x 3 hrs/ day x 120 days		125.00 (for 1 labour hour)	45000.00
Total variable cost (Excluding labour cost)				42458.09
Total variable cost per square meter (Excluding labour cost)				1128.43
Total variable cost (Including labour cost)				87458.09
Total variable cost per square meter (Including labour cost)				2324.42

**One grow bag can be used for four crop cycles (Unpublished data). Therefore, 1/4 cost of grow bags was considered.*
***The Gazette of the Democratic Socialist Republic of Sri Lanka (2016)*
****Public Utilities Commission of Sri Lanka (n.d.)*

Table 5. Return structure of salad cucumber cultivation

Benefit Item	Quantity (kg)	Average Unit Price (LKR)	Value (LKR)
Harvest	512.3	260.00	133198.00
Total return			133198.00
Total return per square meter			3540.61

Benefit - Cost Ratio (Excluding labour cost)
= Benefits / Costs
= 3540.61 / 1128.43
= 3.13
Benefit - Cost Ratio (Including labour cost)
= Benefits / Costs
= 3540.61 / 2324.42
= 1.52

According to the above calculation, salad cucumber production is relatively profitable. Malik (2017) reported 1.43 benefit - cost ratio for salad cucumber cultivated under greenhouse conditions in India. Similar result was obtained from Anusha and Shreya (2022) who observed a benefit - cost ratio of 1.4 from small-scale farmers who grow cucumbers in Kondaigudem village in Telangana State of India. Therefore, these results prove that salad cucumber production under protected house conditions can help to empower household economic status due to greater remunerative incomes that can be obtained by farmers from enhanced output levels.

CONCLUSIONS

The 2 g/plant/day Albert's fertilizer applied treatment recorded a significantly higher fresh weight of fruits and number of fruits over 1 g/plant/day treatment. However, 2 g/plant/day treatment has no significant difference with 1.5 g/plant/day treatment. Therefore, considering the cost of Albert's fertilizer and labour cost for split application of fertilizer, 1.5 g/plant applied 1 time/day is the most suitable treatment to obtain higher yields from salad cucumber grown in automated protected houses in low country wet zone of Sri Lanka. Benefit-cost ratio per unit area of land from salad cucumber cultivation is 3.13 excluding labour cost and 1.52 including labour cost. Therefore, salad cucumber cultivation under protected house conditions in low country wet zone of Sri Lanka is profitable for farmers. In addition, farmers can obtain more remunerative incomes by employing their own or using family labour for the cultivation.

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REFERENCES

Abdel-Mawgoud, A. M. R., El-Desuki, M., Salman, S. R., & Abou-Hussein, S. D. (2005). Performance of some snap bean varieties as affected by different levels of mineral fertilizers. *J. Agron*, *4*(3), 242-247.

Ahmed, N., Baloch, M.H., Haleem, A., Ejaz, M. and Ahmed, N., 2007. Effect of different levels of nitrogen on the growth and production of cucumber. *Life Sci. Int. J*, *1*, pp.99-102.

Anusha, K. and Shreya, B., 2022. Cost-Benefit Analysis of Tomato, Cabbage and Cucumber Production Among Small-Scale Farmers in Kondaigudem Village of Telangana State. *International Journal of Engineering Science and Computing*, 12(2), pp.29246-29250.

Chinatu, L. N., Onwuchekwa-Henry, C. B., & Okoronkwo, C. M. (2017). Assessment of yield and yield components of cucumber (*Cucumis sativus* L.) in Southeastern Nigeria. *Int. J. Agric. Earth Sci*, *3*(1), 35-44.

Choudhari, S. M., & More, T. A. (2001, September). Fertigation, fertilizer and spacing requirement of tropical gynoecious cucumber hybrids. In *II International Symposium on Cucurbits 588* (pp. 233-240).

Cohen, J. E., Ogle, L. R., & Coates-Beckford, P. L. (2000). Effects of plastic mulches on the levels of N, P, and K in soil and leaves of cucumber (*Cucumis sativus* L.). *Tropical agriculture*, *77*(4), 207-212.

Department of Agriculture, *Horticultural Crops Research And Development Institute, Crops*. Sri Lanka. Available at: https://doa.gov.lk/hordi-crops/ (Accessed: 30.09.2021).

Ekanayake, E. M. U. I., Eranga, G. A. S., & Fernando, K. M. C. (2020). Effect of organic and inorganic liquid fertilizers on growth and yield of *Centella asiatica* (L.) and *Capsicum annuum* (L.) VAR. annuum.

Feleafel, M. N., Mirdad, Z. M., & Hassan, A. S. (2014). Effecte of NPK fertigation rate and starter fertilizer on the growth and yield of cucumber grown in greenhouse. *Journal of Agricultural Science*, *6*(9), 81.

Gharge, P.V., Karpe, A.H. and Patil, P.R., 2020. Effect of split nitrogen application on growth parameters of maize. *International Journal of Chemical Studies*, *8*(3), pp.1030-1033.

Güler, S., & Ibrikci, H. A. Y. R. İ. Y. E. (2000, September). Yield and elemental composition of cucumber as affected by drip and furrow irrigation. In *Workshop Towards and Ecologically Sound Fertilisation in Field Vegetable Production 571* (pp. 51-57).

Jaksungnaro and Akalisema. 2001. Effect of sowing time and nitrogen level on growth, yield and quality of cucumber cv. AAUC2. Haryana Journal of Horticultural Sciences, 30(1/2) : 108-110

Janapriya, S., Palanisamy, D., & Ranghaswami, M. V. (2010). Soilless media and fertigation for naturally ventilated polyhouse production of cucumber (*Cucumis sativus* L.) CV Green Long. *International Journal of Agriculture, Enviornment and Biotechnology*, *3*(2), 199-205.

Jilani, M. S., Bakar, A., Waseem, K. A. S. H. I. F., & Kiran, M. (2009). Effect of different levels of NPK on the growth and yield of cucumber (*Cucumis sativus*) under the plastic tunnel. *J. Agric. Soc. Sci*, *5*(3), 99-101.

Kumarasinghe H.K.M.S., personal communication, 17.08.2021.

Lata, K., Choudhary, M. R., Sharma, R., & Ghormade, A. S. (2018). Effect of Growing Media and Fertigation Schedules on Growth and Yield of Cucumber (*Cucumis sativus* L.) under polyhouse condition. *Journal homepage: http://www. ijcmas. com*, *7*(12), 2018.

Liang, X., Gao, Y., Zhang, X., Tian, Y., Zhang, Z., & Gao, L. (2014). Effect of optimal daily fertigation on migration of water and salt in soil, root growth and fruit yield of cucumber (*Cucumis sativus* L.) in solar-greenhouse. *PloS one*, *9*(1), e86975.

Malik, K. (2017). Economic viability of cucumber cultivation in greenhouses. *International Journal for Innovative Research in Multidisciplinary Field*, 3(6), pp.366-368.

Naeem, N., Muhammad, I., Khan, J., Nabi, G., Muhammad, N., & Badshah, N. (2002). Influence of various levels of nitrogen and phosphorus on growth and yield of chilli (*Capsicum annum* L.). *Asian journal of plant sciences*.

Naveen H. G., personal communication, 22.01.2022.

Onuwa, G. C., Emmanuel, B. A., Ubana Eshimutu, U., Victor Fatoke, V., & Birma, J. (2021). Costbenefit analysis of cucumber production under irrigation management. *International Journal of Advanced*, *7*(7).

Public Utilities Commission of Sri Lanka, n.d. *Electricity Tariff and Charges.* Sri Lanka. Available at: https://www.pucsl.gov.lk/electricity/tariff/electricity-tariff-and-charges/

Rahman, K., Jailani, S., Khan, J. 2016. Improving the cucumber (*Cucumis sativus* L.) Off-season production using split doses of nitrogen in plastic tunnel. Sci. Int. (Lahore), 28(5), pp.4523-4526.

Ranasinghe, R. A. S., & Weerakkody, W. A. P. (2006). Effects of fertilizer dosage and nutrient balance on the growth and nutrient uptake of greenhouse tomatoes.

Sarlikioti, V., De Visser, P. H. B., & Marcelis, L. F. M. (2011). Exploring the spatial distribution of light interception and photosynthesis of canopies by means of a functional–structural plant model. *Annals of Botany*, *107*(5), 875-883.

Seminis grow forward, 2018. *Grading slicing cucumbers, agronomic spotlight.* Available at: http://seminisus.s3.amazonaws.com/app/uploads/2018/08/Grading-Slicing-Cucumbers-Seminis.pdf (Accessed: 30.09.2021).

Singh, M. C., Kachwaya, D. S., & Kalsi, K. (2018). Soilless cucumber cultivation under protective structures in relation to irrigation coupled fertigation management, economic viability and potential benefits-a review. *Int. J. Curr. Microbiol. App. Sci*, *7*(3), 2451-2468.

The Gazette of the Democratic Socialist Republic of Sri Lanka, 2016. Available at: http://documents.gov.lk/files/egz/2016/11/1991-37_E.pdf

Veesar, H. A. (2004). Effect of different NPK levels on the growth and fruit yield of cucumber *Cucumis sativus* L.

Wahocho, N. A., Kakar, M. I., Miano, T. F., Memon, N. U. N., Baloch, Q. B., Talpur, K. H., & Rajput, L. (2016). Growth and yield of cucumber (*Cucumis sativus* L.) cultivars in response to different nitrogen levels. *Sci Int*, *28*, 2691-2695.

Weerakkody, W. A. P., & Mawalagedera, S. M. M. R. (2020). Recent developments in vegetable production technologies in Sri Lanka. *Agricultural Research for Sustainable Food Systems in Sri Lanka: Volume 1: A Historical Perspective*, 189-214.

Wu, X., Bai, M., Li, Y., Du, T., Zhang, S., Shi, Y., & Liu, Y. (2020). The Effect of Fertigation on Cabbage (*Brassica oleracea* L. var. capitata) Grown in a Greenhouse. *Water*, *12*(4), 1076.