Effects of Drip and Micro-Sprinkler Irrigation System on Lady's Finger Production inside a Green House of North-Eastern Hilly Region

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Abstract—*North-Eastern region has several unique features such as fertile land, abundant water resources, evergreen dense forests, high and dependable rainfall, mega biodiversity and agriculture-friendly climate. Yet it has failed to convert its strengths optimally into growth opportunities for the well-being of the people and is contrasted by widespread poverty, low per capita income, high unemployment and low agricultural productivity leading to food-insecurity. Also, cultivation of vegetables year round in the soils is not possible because of extremes variation of rainfall, temperature and humidity. In the present study, the experiment for growing Lady's Finger vegetable crop with drip and sprinkler method of irrigation was carried out inside a green house constructed in the Department of Agricultural Engineering, Assam University, Silchar. Crops were grown in four replications and growth parameters number of branches leaves per plant etc. and yield parameters such as number of fruits, fruit length, fruit weight, yield per plant, yield per unit area and yield in q/ha were observed and monitored for both the irrigation systems. The average plant height of lady's finger with drip irrigation system was found less (120.97 cm) as compared to micro sprinkler irrigation system (131.12 cm). The fruit yield in q/ha was found to be more in case of micro-sprinkler irrigation system (432 q/ha) as compared to drip irrigation system (381 q/ha). Thus, micro-sprinkler irrigation system gives comparatively better vegetative growth and yield of lady's finger than the drip irrigation system inside the green house may be due to the uniform distribution of water on plants and soil. In micro sprinklers method of irrigation the water is sprayed in air and then wets the entire plot but drip irrigation system only provides the water to the root zone of the plants only.*

Keywords*: Hilly region, green house, lady's finger, drip irrigation system, micro-sprinkler irrigation system, growth, yield.*

1. INTRODUCTION

The North-East Region is a land of magnificent beauty, possessing undulating hills, rolling grasslands, cascading waterfalls, snaking rivers, terraced slopes and thrilling flora and fauna. The region has several unique features: fertile land, abundant water resources, evergreen dense forests, high and dependable rainfall, mega biodiversity and agriculture-friendly climate. Yet it has failed to convert its strengths optimally into growth opportunities for the well-being of the people. The region suffers from weaknesses such as subsistence agriculture with poor infrastructure like roads and markets. The high vulnerability to natural calamities like floods, submergence, landslides, soil erosion, etc. has resulted in low and uncertain agricultural productivity. The region, which is heavily dependent on the agriculture sector, needs a green revolution to eradicate poverty and boost its economy.

Lady's finger (*Abelmoschus esculentus* L.) is an important vegetable crop belonging to the family Malvaceae. It is also referred as lady's finger or okra. It is an annual vegetable crop and generally propagated through seeds. It is a cheap and nutritious vegetable. Hundred grams of consumable unripe lady's finger contains 10.4 g dry matter, 3100 calories of energy, 1.8 g protein, 90 mg calcium, 110 mg iron, 0.1 mg carotene, 0.01 mg thiamine, 0.08 mg riboflavin, 0.08 mg niacin nd 18 mg vitamin C. The dry seeds contain 13 to 22% edible oil and 20 to 24% protein.

Greenhouse technologies provide optimum conditions of light, temperature, humidity and carbon dioxide, and protect the plants from the adverse climatic conditions so as to achieve maximum yield and good quality produce. Water has also become scare and it has become difficult to meet its demand in agriculture. Green Houses are built of a G.I. structure wherein crops are grown under a favorable artificially controlled environment and other conditions viz. temperature, humidity, light intensity, photo period, ventilation, soil media, disease control, irrigation, fertigation and other agronomical practices throughout the season irrespective of the natural conditions outside.

Drip irrigation can distribute water uniformly, precisely control water amount, increase plant yields, reduce evapotranspiration (ET) and deep percolation, and decrease dangers of soil degradation and salinity Using this method, irrigation is based on measurement of actual soil water condition; rainfall and evaporation need not be measured; minimized drainage losses through the choice of appropriate target potentials; tensiometer measurements are rapid, cheap and easy to make [1]. So, it is very adaptive for farmers to use.

Sprinkler Irrigation is a method of supplying water for irrigation in a method similar to rainfall. Water is distributed through a mesh of pipes spread out on a field. The water from these pipes into the air and so irrigates the entire soil surface through many spray heads [2]. Sprinklers provide better and efficient coverage for small to large areas and are suitable for use on all types of fields. It is also adaptable to nearly all irrigable soils since sprinklers are available in a wide range of discharge capacity.

2. MATERIALS AND METHODS

2.1. Selection of green house

In conventional Agronomical practices, the crops are being grown / cultivated in the open field under natural conditions where the crops are more susceptible to sudden changes in climate i.e. temperature, humidity, light intensity, photo period and other conditions due to which the quality, yield of a particular crop can get affected and may be decreased. Green houses are climate controlled and have a variety of applications, the majority being, off-season growing of vegetables, floriculture, planting material acclimatization, fruit crop growing for export market and plant breeding and varietals improvement. So in the present study a green house constructed in a hilly terrain of Department of Agricultural Engineering, Assam University Silchar, Assam, India was selected to carry out field experiment.

2.1.1. Green house structure

High-tech green house is a tubular structure covered with 200 micron UV film and shade net, which is designed to withstand wind up to 120km/hr., and trellising loads up to 25 kgm^{-2}, with 4-way fogger irrigation system and cooling system by foggers, cooling pads and exhaust fans.

Fig. 1: High-tech green house

The green house generally reflects back about 43% of the net solar radiation incident upon it allowing the transmittance of the "photo synthetically active solar radiation" in the range of 400-700 Nm wave length. The sunlight admitted to the protected environment is absorbed by the crops, floor, and other objects. It is a high cost structure shown in Fig. 1.

2.2 Selection of crop

Lady's finger is a warm-weather crop. It can grow in the temperature range from 22˚c to 35˚c. Lady's finger is susceptible to frost and cold injury below 12˚c temperature. Temperature and light intensity affect the fruit-set, pigmentation and nutritive value of the fruits. Lady's finger can be grown on a wide range of soils, having good internal drainage. Soils with high organic matter are preferred. Application of lime or dolomite may be done in acid soil to bring the pH in the range of 6.0 - 6.5. Hence, Lady's finger seed of hybrid "H.S. F-1 hybrid seeds" is selected with crop spacing of 60cm x 30cm. The nutritional value of 100g of edible lady's finger is characterized 1.9 g protein, 0.2 g fat, 6.4 g carbohydrate, 0.7 g minerals and 1.2 g fibers. Lady's finger has a good potential as a foreign exchanger crop.

2.3. Characteristics of Drip irrigation system

Drip irrigation involves technology for irrigating plants at the root zone through emitters fitted on a network of pipes (mains, sub-mains and laterals). Drip irrigation system is installed with drippers (4 litres/hour), PVC laterals (12 mm diameter), PVC main line (50 mm diameter) with control valve, flush valve etc. has been selected.

2.4. Characteristics of Micro-sprinkler irrigation system

Micro-sprinkler irrigation is sprinklers providing irrigation to vegetation, or for recreation, as a cooling system, or for the control of airborne dust. The sprinkler system irrigates the field drop by drop and thus it is widely used in sandy areas as it checks the wastage of water through seepage and evaporation [4]. Micro-sprinkler irrigation system is installed with sprinkler (10 litres/hour) of radius 1.5 m, PVC laterals (12 mm diameter), PVC main line (50 mm diameter) with control valve, pump, flush valve etc. has been selected.

2.5. Experimentation inside the green house

2.5.1. Seedbed preparation

Seedbed preparation in the green house often involves secondary tillage via hand tools such as rakes and hoes. This may follow primary tillage by shovels, picks, or mattocks. A seedbed or seedling bed is prepared in which seeds of lady's finger are planted in the green house.

2.5.2. Nutrient requirement

The recommended dose of N: P: K for Lady's finger production is 100:50:50 kg per ha. N percentage in Urea is 46%, K percentage in Potash is 60% and P percentage in

single super phosphate is 14.5% [3]. The required N,P,K was estimated and applied using chemical fertilizers such as Urea (two splits, one at the time of sowing and other at the time of flowering), Potash, Single Super Phosphate of 131, 50, and 207 gram for the experimental area (6m^2), respectively.

2.5.3. Sowing of seeds

The lady's finger seeds (H.S. F-1 hybrid) were sown in lines using hill dropping method as per the layout of irrigation system in the green house. Before hill dropping of seeds in the seedbed, the seeds are kept in distilled water for 1-2 hours.

2.5.4. Irrigation requirement

The daily water requirement of lady's finger crop is 2.4 l/day/4 plants during early growth stage and during the peak growth stage irrigation requirement is 7.6 l/day/4 plants recommended by *National Committee on Plasticulture Applications in Horticulture* [8]. The drip irrigation system should be operated daily for 10 minutes during initial growth stage and for 30 minutes during peak growth of the crop with an emitter capacity of 4 lph. And the micro-sprinkler system should be operated daily for 5 minutes during initial growth stage and 15 minutes during peak growth of the crop with an emitter capacity of 10 lph.

2.6. Monitoring and Analysis of Growth and Yield

Monitoring the growth parameters such as height of plant, number of branches, leaves, fruits and yield inside the green house with drip and micro-sprinkler irrigation was compared on the basis of their yield and productivity. Plant growth parameters monitored in both the irrigation system regularly.

3. RESULTS AND DISCUSSION

3.1. Determination of physico-chemical status inside the green house

3.1.1. Soil physical characteristics

The soil physical characteristics such as moisture content, bulk density, field capacity, saturated moisture content and wilting point of soil of each plot were evaluated to provide the proper and accurate irrigation scheduling. The details of soil physical characteristics observed for the drip and micro-sprinkler system installed in the green house area are presented in Table 2.

In this experiment, the percentage of organic Carbon, Nitrogen (N), Phosphorus (P) and Potassium (K) were statistically determined. Four soil samples were taken from the both irrigation systems inside the green house. The soil analysis was shown in the Table 4.2 and Fig. 2. [6]

3.1.2. Soil chemical characteristics

The soil chemical characteristics such as pH (1:2.5) and electrical conductivity (ds/m) of soil of each plot were evaluated to provide the proper and accurate irrigation scheduling inside the green house. The details of soil chemical characteristics observed for the drip and micro-sprinkler system installed in the green house area.

The soil physico-chemical properties and nutrient content status of the green house revealed that the soil is sandy loam with field capacity 12.72% (wb) and wilting point of 6.63% and has available organic carbon content, Nitrogen (N), Phosphorous (P), Potassium (K), pH and Electrical Conductivity of 0.42%, 155.12 kg ha^{-1}, 21.80 kg ha^{-1}, 231.30 kg ha^{-1}, 5.13 and 0.35 respectively. [5]

Table 1: Variation of Soil physical characteristics inside the green house.

Type of irrigation	Bulk Density (g/cm3)	Moisture Content, %	Saturated Moisture Content, %	Field Capacity, %	Wilting Point, %
Drip	1.58	18.12	23.14	12.13	06.94
Micro-sprinkler	1.52	20.83	25.33	13.15	06.33

Table 2: Variation of organic Carbon, N, P, K status inside the green house.

Soil sample	Parameters with values			
	Organic Carbon (%)	Available Nitrogen (kg/ha)	Available Phosphorus (kg/ha)	Available Potassium (kg/ha)
1	0.38	175.26	20.52	322.96
2	0.45	137.98	23.08	139.64
3	0.50	250.88	25.65	274.18
4	0.34	150.52	17.95	191.25

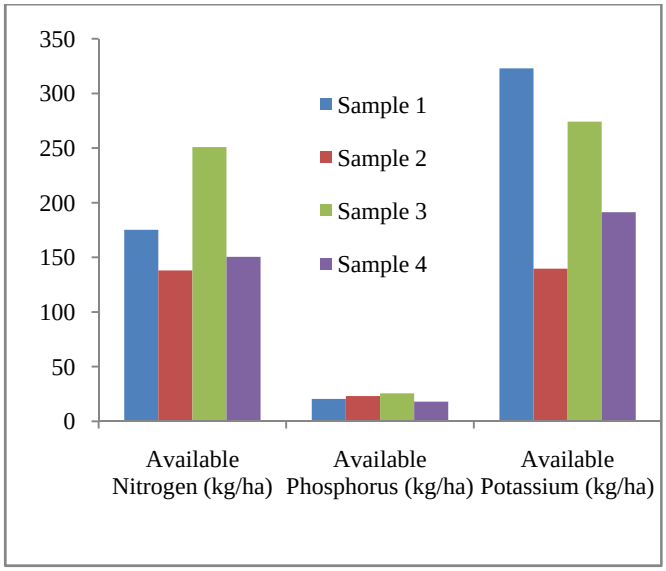

Fig. 2: Variation of N, P, K status inside the green house.

3.2. Variation of growth and yield parameters

Growth parameters such as number of branches and leaves were monitored regularly for both drip and micro-sprinkler irrigation system and presented in Table 3. Also the height of lady's finger plant for both irrigation systems was determined after 10 days interval shown in Fig. 3.

Table 3: Variation of Plant growth parameters inside the green house.

Type of irrigation system	Average no. of branches per plant	Average no. of leaves per plant	1st flowering in days	1st harvesting in days	Last day of harvesting
Drip	24	33	40	64	144
Micro-sprinkler	32	38	35	57	137

Table 4: Variation of plant height in different types of irrigation.

Interval	Height of plant	
	drip irrigation (cm)	micro-sprinkler irrigation (cm)
10 days	8	9
20 days	17	20
30 days	29	36
40 days	41	47
50 days	52	58
60 days	63	69
70 days	72	78
80 days	81	86
90 days	93	97
100 days	101	107
110 days	109	117
120 days	116	124
130 days	120	131

The effects of irrigation were found to be significant on plant height at different stage of plant growth of Lady's finger crop. It was also found that inside the greenhouse micro-sprinkler irrigation system produced the plants with higher plant height at all stages of plant growth as compared to drip irrigation system. The maximum average number of branches per plant, number of leaves per plant, 1st day of flowering and 1st and last day of harvesting also differed significantly with the different irrigation systems. Flowering of lady's finger shown in Fig. 4.

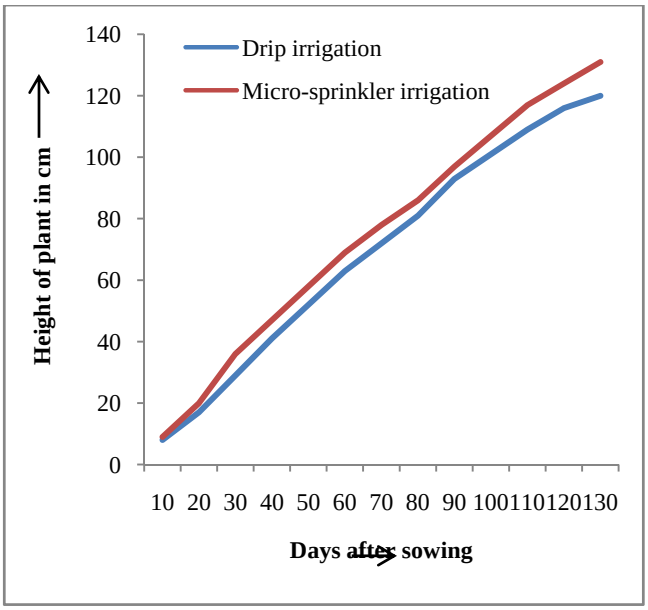

Fig. 3: Plant heights at different growth stage of Lady's finger.

Fig. 4: Flowering of lady's finger

Table 4: Average number of fruits per plant

Type of irrigation system	R 1	R 2	R 3	R 4	Average
Drip	18	17	20	22	20
Micro-sprinkler	21	20	23	24	22

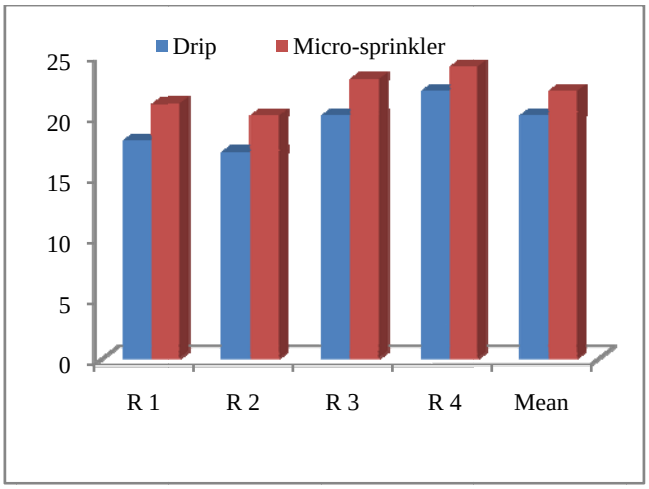

Fig. 5: Average no. of fruits per plant

The number of fruits per plant varied significantly under different types of irrigation systems. The average number of fruits (22) per plant recorded from the green house using micro-sprinkler irrigation system was significantly higher than drip irrigation system (20).From Table 4. And Fig. 5.the result revealed that the number of fruits using micro-sprinkler irrigation was 9.1% more than the drip irrigation system [10]. As the growth in all respects like number of branches, number of flowers and plant height are more in micro-sprinkler irrigation system; therefore the number of fruits per plant has come to be more. Lady's finger vegetables are shown in Fig. 6.

There was also slight variation in fruit length of lady's finger due to different types of irrigation system. Fruit length ranged from 11 to 15 cm with an average of 13.5 cm in sprinkler irrigation system, on the other hand, fruit length of plants grown in drip irrigation system ranged from 9 to 13 cm with an average of 10.5 cm. Slightly longer fruits (13.5 cm) were obtained from the micro-sprinkler irrigation system. The drip irrigation system produced slightly shorter fruits (10.5 cm) [7].

Fig. 6: Fruit of Lady's finger

Table 6. Average fruit yield per plot in kg

Type of irrigation	R 1	R 2	R 3	R 4	Mean	Total (kg)
Drip	0.88	0.97	0.93	1.03	0.95	22.86
Micro-sprinkler	1.15	1.03	1.07	1.09	1.08	25.92

The micro-sprinkler irrigation system produced more yield of fruit (25.92 kg/plot and 432 q/ha) than the drip irrigation system showed the minimum (22.86 kg/plot and 381 q/ha) fruit yield per plot and quintal per hectare. The micro-sprinkler irrigation system produced the higher yield of fruits per plot and per hectare. The percentage increase in yield (q/ha) using micro-sprinkler irrigation was found 11.8% more than the drip irrigation system and is shown in Fig. 7. [9]

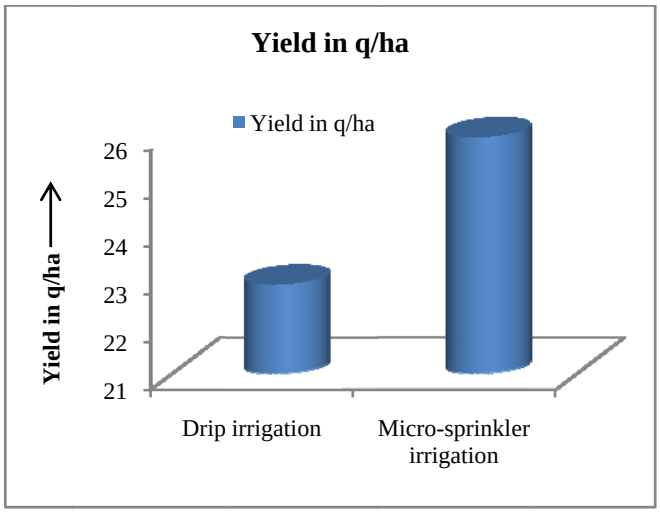

Fig. 7: Average yield in q/ha.

4. CONCLUSIONS

Assam University falls in the Barak Valley which is surrounded by low hills and basically falls under hilly terrains. The valley receives an annual rainfall more than the state's annual rainfall. This often results in changes in soil properties and washes off various soil nutrients present in the soil. It is well known that soil bulk density and strength are important factors affecting both shoot and root growth of plants. The average organic Carbon content was found to be 0.42 % Average total Nitrogen, Phosphorus and Potassium content available in the soil was found to be 155.12 kg ha-1, 21.80 kg ha-1 and 231.30 kg ha-1 respectively. However, the aforementioned findings provide logistic information for a sustainable agricultural planning in the study site. The micro-sprinkler irrigation system produced the maximum yield of fruit (25.92 kg/plot and 432 q/ha) and the drip irrigation system showed the minimum (22.86 kg/plot and 381 q/ha)

fruit yield per plot and quintal per hectare respectively. Thus, we conclude that micro-sprinkler irrigation system gives comparatively better vegetative growth and yield of lady's finger than the drip irrigation system inside the green house may be due to the uniform distribution of water on plants and soil. However, detailed soil water distribution, nutrient movement could be done further.

5. ACKNOWLEDGEMENTS

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