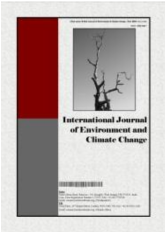

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Standardization of Irrigation and Fertigation Requirement for Snake Gourd under Rain Shelter

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Authors' contributions

This work was carried out in collaboration among all authors. Author AS designed the study, performed the statistical analysis, wrote the protocol, and wrote 239 the first draft of the manuscript. Authors AH, and GP managed the analyses of the 240 study. Author ASD managed the literature searches. Authors AJ and AW helped in 241 correcting the manuscript. All authors read and approved the final manuscript.

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ABSTRACT

Aim: The study entitled "standardization of irrigation and fertigation requirement for snake gourd under rain shelter" was taken up to standardize the irrigation and fertigation requirement of snake gourd (*Trichosanthes cucumerina*) of Manusree variety under rain shelter.
Place and Duration of Study: The experiment was performed in instructional farm of PFDC, KCAET, Tavanur, Kerala, between October 2020 and January 2021.
Methodology: Penman Monteith method was used for the determination of crop water requirement and irrigation scheduling. There were three levels of irrigation i.e., T1 – 60%, T2 – 80% and T3 – 100% of ETc and three levels of fertigation viz: R1 – 100%, R2 – 125% and R3- 150% of recommended dose of fertilizer. Different crop and soil parameters and yield is noted in each bed.
Results: The treatment T3R3 showed comparatively better performance in yield and other growth characteristics as compared to the other treatment. These plants yield longer fruits and bloomed early compared to other fertigation levels. The cultivation is found to be feasible since the benefit cost ratio is greater than one. The result of the study can be used as a guide for the farmers to plan their irrigation and cropping pattern. Also the result can be extrapolated to the future to analyse the

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trends in future crop water demands.
Conclusion: The farming can run feasibly if we follow precision farming. Through this study we got that the optimum water content of snake gourd is 100%of Etc and 150% fertigation.

Keywords: Fertigation; irrigation; rain shelter; snake gourd; yield.

1. INTRODUCTION

Snake gourd scientifically known as *Tricosanthes cucumerina* is a plant which bears fruit that is consumed as vegetable. It is an annual climbing plant which belongs to Cucurbitaceae. Liyanage et al*.* (2016) [1]. Protected cultivation aims to modify the micro climate of the plants by selective control of environment for the protection of the crops from biotic and abiotic stresses for healthy and safe crop production, notably all-round the year including the off-season. Acquah et al. (2018) [2]. Rain shelters are roofed with plastic film and other water proof materials to shelter crops from rain. The houses are effective in reducing crop damage caused by diseases and insect pests, in promoting crop growth, and in achieving stable production of high quality vegetables. Mabhaudhi et al. (2013) [3]. Rain shelters can convert low-priced land with high rainfall, but an otherwise favorable climate and location into very productive properties. The rain shelter effectively prevents ultra violet rays, and adjusts heat and humidity. Ike et al. (2019) [4]. One of the features of precision farming is to have maximum possible use efficiency of applied inputs especially water and fertilizers. The main idea behind irrigation systems is to assist in the growth of agricultural crops and plants by maintaining with the minimum amount of water required, suppressing weed growth in grain fields, preventing soil consolidation etc. Among all irrigation methods, drip irrigation is the most efficient and can be practiced for a large variety of crops. It is an effective type of irrigation as it minimizes evaporation and water runoff. The fertilizers are dissolved at appropriate concentrations in water and applied through irrigation water by micro irrigation systems. Paul et al.(2013) [5]. Fertigation is the practise, where the nutrients and water in required quantity at correct time are placed in the root zone so that maximum absorption of applied nutrients and water is assured to achieve more crops per drop of water. So we use fertilizer more efficiently and get the best return on our inputs.

Now a days farming is becoming a loss due to the high cost of seeds, fertilizers and other farming equipments. And the farmers are not able to meet the expenditure by selling the crops. So we have to apply optimum amount of fertilizers and water to reduce the expenditure. This study helps to find the optimum level of water and fertilizer for higher productivity of snake gourd under rain shelter.

A field experiment was conducted by Narkhede et al*.* (2017) [6] to study the influence of fertigation doses and mulching on yield attributing characters and post-harvest shelf life of pointed gourd cultivation in red lateritic soils of Odisha. In the present study it is seen that application of different graded doses of N, P and K through fertigation in association with mulching increased the yield attributing characters and shelf life of pointed gourd. The results revealed that the, 80% fertigation with mulch was the most effective treatment. Plastic mulch has been used in some treatments to warm the soil, conserve the moisture protection against, control weed population, reduce leaching of nutrients, and provide soil pathogens and thus post-harvest shelf life of fruit.

2. MATERIALS AND METHODS

The experiment was performed in instructional farm of KCAET, Tavanur, Kerala. The study was conducted using snake gourd under naturally ventilated rain shelter of PFDC, KCAET, Tavanur, Kerala.

2.1 Treatment Details

Area of each bed was 6.3m². Beds were prepared inside rain shelter with 9 m length, 0.7 m width and 0.065m height single row planting. Plants were grown at row to row spacing of 0.30 m and plant to plant spacing of 0.90 m. The plants were irrigated daily through drip irrigation system. Irrigation water was pumped using 5hp monoblock pump set and conveyed through the main line of 68 mm diameter PVC pipes after filtering through the disc filter. Discharge rate of single dripper is 2 lph. FYM was applied prior to transplanting. Fruit fly is the most destructive pest of snake gourd. It cause premature fruit drop, yellowing and rotting of fruits, other pest like aphids, Beetle also affect the growth of plant.

Common diseases like downy mildew and powdery mildew also occurs. Crop protection consisted of controlling the incidence of pest and disease. Ekalux insecticide was applied at 50ml/10L of water. Also we used pheromone traps to trap the insects.

Fertilizers were applied through drip irrigation system using venturi assembly. Duration of crop was 120 days, so the fertigation was scheduled as 40 splits with the frequency of once in three days from planting till the end of crop.

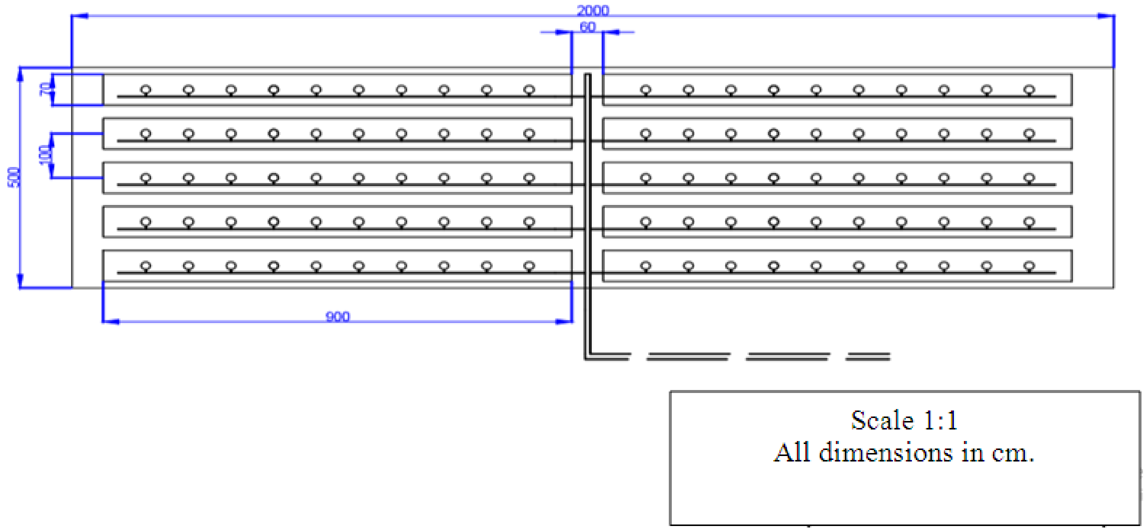

Fig. 1. Layout of experimental field

Table 1. Experimental design

Crop variety	Snake gourd–KAU variety(Manusree)
Area	100m²
Spacing	0.90m ×0.9 m
Replication	3
Growing structure	Rain shelter
Irrigation level	T1=60%
	T2=80%
	T3=100%
Fertigation level	R1=100%
	R2=125%
	R3=150%
Design	Factorial CRD

Table 2. Treatment details

Sl. No.	Treatment	Detail
1	T1R1	Crop with 60% irrigation and 100% fertigation
2	T1R2	Crop with 60% irrigation and 125% Fertigation
3	T1R3	Crop with 60% irrigation and 150% fertigation
4	T2R1	Crop with 80% irrigation and 100% fertigation
5	T2R2	Crop with 80% irrigation and 125% fertigation
6	T2R3	Crop with 80% irrigation and 150% fertigation
7	T3R1	Crop with 100% irrigation and 100% fertigation
8	T3R2	Crop with 100% irrigation and 125% fertigation
9	T3R3	Crop with 100% irrigation and 150% fertigation
10	Control	Crop with 100% irrigation and 0% fertigation

Table 3. Specifications of rain shelter

Sl No.	Particulars	Specifications
1	Rain shelter type	Gable shaped
2	Column height	2m
3	Centre height	3m
4	Inside area	100sq.m
5	Side walls	Covered with 50 mesh net on all four sides at a height of 1m from ground
6	Roof covering	200 micron polythene with 85% light transmission

Table 4.Fertigation schedule of snake gourd

Application stage	Fertilizers	100%(g)	125%(g)	150%(g)
Initial stage(split into 6 doses)	19:19:19	100	125	150
	13:0:45	20	25	30
	urea	170	212.5	255
Development stages(split into 12 doses)	19:19:19	50	62.5	75
	13:0:45	230	287.5	345
	urea	100	125	150
	12:61:0	15	87.5	22.5
Final stage(split into 22 doses)	19:19:!9	50	62.5	75
	13:0:45	230	287.5	345
	urea	100	125	150
	12:61:0	15	68.7	22.5

Crop protection consisted of controlling the incidence of pest and disease. Ekalux insecticide was applied at 50ml/10L of water. Also we used pheromone traps to trap the insects.

Evapo-transpiration is a combination of two processes- evaporation and transpiration. Crop evapo-transpiration from an extensive surface of green grass of uniform height (0.12m), actively growing, completely shading the ground with an albedo of 0.23 and having ample water supply is called reference crop evapo-transpiration and is denoted by ETo. Various methods are in use for the determination of ET_0.

Penman – Monteith Method

$$ET0 = \frac{0.408\Delta\,(Rn - G) + \gamma\, 900\, U2\,(es - ea)\,/\,(T+273)}{\Delta + \gamma\,(1 + 0.34U2)}$$

2.2 Net Irrigation Requirement (NIR)

Irrigation is necessary when rainfall could not meet the evapo-transpiration demands of the crops. Irrigation should apply the right quantity of water at the right time.

NIR = WR – ER – Ge

Where,

WR = Water Requirement (Etc)
ER = Effective Rainfall
Ge = Groundwater contribution from the water table (not considered in the study as this is negligible).

2.3 Duration of Irrigation

The quantity of water for irrigation to be applied was computed for every day. For known discharge rate of emitters (2 lph), the duration of irrigation water was calculated by

T= Vn/ (Ne×Np×q)

Where,

Vn =Net water requirement
Ne = No of emitters per plant
Np = No of plants
q= Emitter discharge L/h

2.4 Irrigation Scheduling

Irrigation scheduling primarily aims at determining how to irrigate, when to irrigate and how much to irrigate. The primary aim of scheduling is to maintain optimum water supply to improve productivity so that the water level in the root zone is maintained between the confines of readily available water (RAW). The schedule

Fig. 2. Crop stand inside rain shelter

Table 5. Water use efficiency

Treatment combinations	Yield (Kg/plant)	Yield (kg /ha)	Gross depth of irrigation water applied in mm	WUE (kg/ha mm)
T1R1	1.23	19523.8	113.1	172.6
T1R2	1.58	25079.3	113.1	221.7
T1R3	2.22	35238.1	113.1	311.6
T2R1	2.38	37777.7	150.8	250.5
T2R2	2.54	40317.4	150.8	267.3
T2R3	2.84	45079.3	150.8	298.9
T3R1	3.32	52698.4	188.5	279.6
T3R2	3.92	62222.2	188.5	330.1
T3R3	5.26	83492.0	188.5	442.9

not only enables the efficient management of water but also develop effective water delivery schedules under restricted supply conditions.

2.5 Determination of Irrigation Water Use Efficiency

Water use efficiency was calculated for each treatment. It is the ratio of yield of crop in kg/ha and total water applied in mm.

WUE= $\frac{Y}{W.A}$

Where,

WUE=Water use efficiency (kg/ha mm) of water used.

Y= Yield of the crops (kg ha^{-1})
W.A = Total water applied (mm

3. RESULTS AND DISCUSSION

Duration of irrigation is the time for which the irrigation water is supplied. It depends on the water to be irrigated, discharge of drippers, no. of drippers and no. of plants in each bed. The duration of irrigation is adjusted by opening and closing of cock valve in the lateral.

3.1 Growth Parameters

Biometric readings are taken for first four week of transplanting. In each week the plants with T3R3 treatment shows highest growth. The number of leaves, stem girth and plant height is maximum in these plants. By observing growth parameters for a week, we can identify that the irrigation and fertigation levels directly affect the plant growth. i.e., fertigation boost the plant growth drastically. The plants with highest levels of irrigation and fertigation showed the maximum growth properties. Considering the whole growing pattern of plants, plants with 100% irrigation and150% fertigation showed the rapid growth, and more healthier than other treatments.

Murthy et al**. (**2020) [7] studied the effect of NPK fertigation with water soluble fertilizers (WSF) and conventional fertilizers and soil application of straight fertilizers on post-harvest soil nutrients status, nutrient uptake and yield of hybrid ridge gourd (*Luffa acutangula* (L.) Roxb.) Arka Vikram. They found that the vine/plant received fertigation with WSF @ 150:90:150 kg NPK ha^{-1} recorded better growth and highest yield (53.73 t ha^{-1}). From this investigation it may be concluded that fertigation with WSF@ 150:90:150 kg NPK ha^{-1} is found to be best for getting better growth, yield and nutrient uptake by hybrid ridge gourd

3.2 Soil Parameters

The treatment T2R3 had a pH of 7.1. The bed with treatment with 60% irrigation 150% fertigation gives a pH of 7.2. And 7.3 are measured at bed with treatment T3R3. Soil temperature decreases as irrigation and fertigation increases. The soil pH, electrical conductivity, organic carbon and available macro and micronutrients status in soil after the harvest were significantly influenced by different treatments and treatment T3 *i.e.* fertigation with water soluble fertilizers @ 150:90:150 kg NPK ha^{-1} found to maintain/ improve the soil fertility status compared to other treatments- (Murthy et al.,2020).

3.3 Yield Parameters

The first harvest was done on 01/12/2020, after seven week of planting. 43.33 kg of snake gourd (*Trichosanthes cucumerina* L.) was obtained from that harvest alone. Last harvest was on 02/02/2021, almost after three and half months of planting the crop. In each harvesting fruits of T3R3 treatment showed maximum yield and longer fruits. Number of female flowers was also higher in these plants. Total yield obtained for the five harvesting is 253.34 kg for $100m^2$. To the end of cultivation size of fruits were also reduced.

Similar result was obtained by Murthy et al*.* (2020) that the fertigation with water soluble fertilizer *i.e*. Urea, 19:19:19 and KNO3 @ 150:90:150 kg NPK/ha is found to be best for field grown hybrid ridge gourd Arka Vikram for realizing better plant growth and fruit yield. The higher level of fertigation, which had made the plants to respond in production higher flowers per plant and percent of fruit set again, has helped in obtaining the highest fruit yield per plant. Higher yield with application of balanced and optimum dose of N, P and K through fertigation might have increased the number of female flowers which leads to increase in the yield. Higher yield may also be due to increased fertilizer and water use efficiency owing to better availability of moisture and nutrients through fertigation.

The increase in the number of early appearance of female flowers per vine made the T3 plant populations to take minimum days for 50% flowering and fruit setting to maturity (Karthick et al*.,* 2017) [8].

The highest fruit yield per hectare is due to more number of fruits per plant, fruit weight as well as increased fruit yield per plant. This increase in yield might have been due to the better performance of yield attributes as these attributes have a positive influence on the yield (Rani et al*.,* 2012) [9].

3.4 Economic analysis

The total expenditure for the cultivation was about 4329rupees. This includes the cost of rain shelter and also the cost farming. Total amount obtained by selling the snake gourd is 6703.25 rupees. And the benefit cost ratio of the cultivation is obtained as 1.55. i.e., expenditure is less compared to the revenue.

Table 6. Duration of irrigation

Sl no.	Stage of growth	Net water requirement (mm)	Duration of irrigation (minutes)
1	Initial stage	4.4 mm	13.2 min.
2	Development stage	15.25 mm	45.75 min.
3	Mid-season stage	28.62 mm	85.87 min.
4	Late season stage	31.1 mm	93.3 min.

Table 7. Yield from various treatments in the field during each harvest

Treatment	1st harvest	2nd harvest	3rd harvest	4th harvest	5th harvest	Total yield	
	(kg)	(kg)	(kg)	(kg)	(kg)	(kg)	Kg/ha
T1R1	1.92	3.3	3.3	3.1	0.7	12.32	1232
T2R1	2.49	4.3	4.1	4.2	0.8	15.89	1589
T3R1	3.47	6.3	5.8	5.6	1.1	22.27	2227
T1R2	3.71	6.7	6.1	6.1	1.2	23.81	2381
T2R2	4.05	7.1	6.6	6.4	1.3	25.45	2545
T3R2	4.42	8.3	7.3	7	1.4	28.42	2842
T1R3	5.49	9.2	8.6	8.3	1.7	33.29	3329
T2R3	6.28	10.9	10.2	9.8	2.1	39.28	3928
T3R3	8.41	14.5	13.8	13.2	2.7	52.61	5261
Control	1	3	2.7	2	0.5	9.2	920

Table 8. Cost benefit analysis

Sl. No.	Item description	Quantity (unit)	Rate	Total	No. of useful seasons	Cost/season
1	**Structure and irrigation components (fixed cost)**					
1.1	Rain shelter			50000	60	833
1.2	Drip lateral (Outer diameter 16 mm CL 11×100 m)	90 (m)	15	1350	40	33.75
1.3	Drip poly grommet take off 16 ×13 mm	10 (no)	6.5	65	40	1.625
1.4	Drip lateral end stop 8 shape 16 mm	10 (no)	3.5	35	40	0.87
1.5	Disc filter armas 50 mm	1 (no)	2650	2650	40	66.5
1.6	Mulching sheet 400 metre 30 micron 1.2m silver/black	1(284 m)	3350	2378.5	8	297.5
1.7	Mini valve	10(no)	40	400	40	10
1.8	Drip j-lock dripper 2lhp	100 (no)	3.6	3600	40	90
1.9	Extra fitting bend, tee and solvent			500	40	12.5
1.10	1.5” PVC pipe	25.5 (6 m)	200	850	40	21.25
1.11	Venturi injector system			500	40	12.5
1.12	Cladding material	400 (m^2)	50	20000	20	1000
2	**Cultivation (variable cost)**					
2.1	Workers wage for bed preparation, planting etc.	2 (men days)	700	1400	1	1400
2.2	Fertilizers	0.5 (kg)	100	100	1	50
2.3	FYM	300 (kg)	1	300	1	300
2.4	Seedling	100(no.)	2	200	1	200
3	**Total expenditure**					**4329**
4	**Benefit from cultivation**					**6703.25**
5	**Benefit cost ratio**					**1.55**

4. CONCLUSION

The study was conducted to standardize irrigation and fertigation requirements for snake gourd under rain shelter and to work out Benefit Cost (B: C) ratio we have taken three set of irrigation and fertigation and combination of it. The crop was cultivated during winter; the rain shelter provided suitable light intensity and optimum weather condition. Compared to normal irrigation, drip irrigation technology along with mulching ensured availability of nutrients and water at the root zone of crops.

The experiment revealed that the irrigation and fertilizer management is an important factor in crop production. Higher water application and inefficient fertilizer application is the current farming scenario. We should standardize the water and fertilizer application according to our area and mode of cultivation. Water use efficiency of the crops has to be increased in order to reduce the water loss from the field. Drip irrigation system is considered as the most effective micro irrigation method, as water is applied directly to the crop root zone. Hence it can be concluded that drip fertigation with 100% of ETc and Fertigation of 150% of RDF is best suited for cultivation of snake gourd under rain shelter.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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