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Effect of Drip Irrigation Levels on Yield of Salad Cucumber under Naturally Ventilated Polyhouse

V.M. Abdul Hakkim[1], A.R. Jisha Chand[2]
[1]Principal Investigator, [2]Research Associate Precision Farming Development Centre (PFDC), Kerala Agricultural University, KCAET, Tavanur (P.O.), Malappuram (Dist), Kerala – 679 573, India.

Abstract: - An experiment was conducted to study the yield response of salad cucumber under different drip irrigation levels to determine the most suitable irrigation requirement for salad cucumber grown under naturally ventilated polyhouse. Drip irrigation applied at the rate of 2 litre plant^{-1} day^{-1} to the control plants was reduced by 5, 20, 35 and 50% by applying corresponding irrigation rates of 1.9, 1.6, 1.3 and 1 litre plant^{-1} day^{-1} under different treatments. Lowering irrigation level to 65% sustained the production and increased water use efficiency without decreasing the yield of cucumber. However, irrigation level of less than 65% reduced the yield without increasing water use efficiency. The maximum fruit number (49), fruit weight (7.194 kg plant^{-1}) and fruit yield (88.8 t ha^{-1}) were obtained from drip irrigation level of 65% (1.3 litre plant^{-1} day^{-1}) and the lowest fruit number (35), fruit weight (5.043 kg plant^{-1}) and fruit yield (62.26 t ha^{-1}) from drip irrigation level of 50% (1 litre plant^{-1} day^{-1}), with the lowest water application rate . Irrigation treatments had significant effects ($P < 0.05$) on yield. However, interaction within groups was found to be non significant. There were significant positive correlations ($P < 0.01$) between fruit number, fruit weight and fruit yield. The total quantity of water applied through 65% drip irrigation level was 144.4 mm and which showed 35 per cent water saving over control with highest water use efficiency (6148.31 kg ha^{-1}cm^{-1}) and Benefit Cost (BC) ratio (3.41).

Keywords: *- Cucumis sativus, Drip irrigation, Economics, Naturally ventilated polyhouse, Water use efficiency*

I. INTRODUCTION

Efficient use of available irrigation water is essential for increasing agricultural production for the alarming Indian population. Water availability for irrigation is going to be a major constraint for agriculture in the near future. Hence, judicious use of the available water resources through more efficient methods of water application like drip irrigation under conditions of protected cultivation becomes necessary to enhance the yield and water use efficiency (Dunage et al., 2009). Protected cultivation of vegetables provides the best way to increase the productivity and quality of vegetables, especially cucurbits. Naturally ventilated greenhouses are highly suitable for year round cultivation of parthenocarpic cucumber varities. High frequency water management by drip irrigation provides daily requirement of water to a portion of the root zone of each plant and maintains a high soil matric potential in the rhizosphere to reduce plant water stress (Nakayama and Bucks, 1986).

The cucumber (*Cucumis sativus* L.) is an important and big group of vegetables belonging to the family cucurbitaceae. Cucumber has tremendous economic and dietic importance. The immature fruits are eaten raw as salad. Cucumber is a coarse prostrate, annual vining plant with stiff hairs or spines on leaves and stems. Unbranched lateral tendrils developed at the leaf axils. As the lateral branches are developed, flower clusters appear at leaf axils (Maqsood et al., 2004).

Many studies were reported on cucumber cultivation under protected conditions. Wang et al. (1999) studied the relationship between irrigation amount, yield and quality of cucumber under greenhouse. Xiaobo et al. (2002) studied the water requirement of cucumber for different cropping in solar greenhouse. Reducing water supply at seedling stage, controlling water supply at flowering stage and increasing water supply at fruiting stage of cucumber can increase yield and water use efficiency (Shao et al., 2010). Keeping in view the above facts, the present study was undertaken to determine the most suitable irrigation requirement for salad cucumber grown under naturally ventilated polyhouse.

II. MATERIAL AND METHODS

The experiment was conducted inside the Naturally Ventilated Polyhouse (NVPH) of 292m^2 area located at Precision Farming Development Centre, KCAET, Tavanur during May- August 2013. The study area is located between 10^0 52' 30'' North Latitude and 75^0 58' 34'' East Longitude and oriented in the east west direction. The soil of the experimental site was well drained laterite soil. The experimental setup consisted of screen filter, main, sub mains, laterals, drippers and other accessories required for drip irrigation. A 5 HP submersible pump was used to lift water from the bore well and supply to the drip irrigated plot. The main and sub main pipelines used for drip irrigation were made of PVC pipes of 63 mm and 50 mm diameter respectively.

Linear Low Density Poly Ethylene (LLDPE) pipes of 16mm diameter were used for laterals in the drip irrigation treatments. Drippers of 4 litres per hour (lph) capacity were fitted on the laterals at a spacing of 90 cm.

The experiment was laid out under completely randomized design with salad cucumber hybrid Hilton F1 as the test crop. Spacing adopted for single row planting was 90 cm x 90 cm on raised beds with a spacing of 50 cm between beds. The treatments comprised of five drip irrigation levels at 50, 65, 80, 95 and 100% with four replications. Each plant was fertigated once in three days through a drip emitter with nutrient concentration levels of N:P:K- 175:125:300 kg ha^{-1} from planting to the end of the crop.

Plants were pruned to a single stem by removing lateral shoots. Fruits set on nodes of the main stem and lateral shoot. Harvesting was started 55 days after sowing. As practiced by commercial growers, curved or deformed fruits were removed from the plant during pruning operations and marketable immature fruits were harvested in 2–3 days and then weighed. The number of fruits were also counted.

Statistical analysis of the data was performed using a completely randomized design with four replications. The analysis of variance was also accounted for factors. The level of the significant difference (LSD at $P < 0.05$) was used in the ANOVA to test the effect of irrigation treatments on different response variables (Steel and Torrie, 1980).

Field water use efficiency of each treatment was computed using the following equation:

WUE= Y/WR

Where, Y = Weight of marketable produce of the crop, kg ha^{-1}; WR = Depth of water used, cm.

The expenditure incurred from field preparation to harvest was worked out and expressed as $Rs.ha^{-1}$. The salad cucumber yield was computed per hectare and the total income was worked out based on the prevailed minimum market rate of Rs. 30/- per kg. The net return was calculated by subtracting the cost of cultivation from gross return. The cost of naturally ventilated polyhouse and drip system for one hectare was worked out based on current market rates. The life of the NVPH was assumed to be 10 years and drip system for 6 years. Prevailing market price of NVPH and drip components obtained from a standard firm was used. Interest on capital investment was taken as 8 per cent per annum.

The benefit cost ratio (BCR) was worked out by using the formula suggested by Palaniappan (1985):

BCR = Gross Return ($Rs.ha^{-1}$) / Total cost of cultivation ($Rs.ha^{-1}$)

III. RESULTS AND DISCUSSION

Crop yield is always an important effective and economic index consideration in the crop development. The number of fruits per plant is an important determinant of yield in salad cucumber. The highest fruit number (49) was found in 65% drip irrigation level and the lowest (35) in the lowest level of drip irrigation at 50% (Table 1). Irrigation treatments had significant effects ($P < 0.05$) on fruit number. However, interaction within groups was found to be non-significant (Table 2). The highest mean fruit weight (7.194 kg $plant^{-1}$) was obtained from drip irrigation level of 65% and the lowest (5.043 kg $plant^{-1}$) at 50% drip irrigation level (Table 1). Irrigation treatments had significant effects ($P < 0.05$) on fruit weight. However, interaction within groups was found to be non-significant (Table 3). The highest yield (88.8 t ha^{-1}) was obtained with 65% drip irrigation level and the lowest (62.26 t ha^{-1}) from the treatment with a drip irrigation level of 50% (Table 1). Irrigation treatments had significant effects ($P < 0.05$) on fruit yield. However, interaction within groups was found to be non-significant (Table 4).

When a multiple comparison was made using Post Hoc test, yield from 50% drip irrigation level, which watered the least was comparatively low and showed significant difference. There was no significant difference among other four treatments (Table 1). The graph represents the effect of drip irrigation levels on yield of salad cucumber (Fig. 1).

Table 1. Effect of drip irrigation levels on yield of salad cucumber

Treatment	Fruit number ($plant^{-1}$)	Fruit weight (kg $plant^{-1}$)	Fruit yield (t ha^{-1})
T1: 50% drip irrigation level	35^b	5.043^b	62.26^b
T2: 65% drip irrigation level	49^a	7.194^a	88.8^a
T3: 80% drip irrigation level	44^a	7.133^a	88.06^a
T4: 95% drip irrigation level	45^a	6.705^a	82.77^a
T5: 100% drip irrigation level	44^a	6.625^a	81.79^a

*Mean value of observations from 20 plants in 4 replications.

*Figures given in parenthesis are SE; means of fruit weight, fruit number and fruit yield in each column with superscripts of same letters do not differ significantly.

*The mean difference is significant at the 0.05 level.

Table 2. ANOVA of data on fruit number of salad cucumber in various irrigation treatments

Source	Sum of Squares	df	Mean Square	F	Sig.	Remarks
Block	140.550	3	46.850	2.524	0.107	NS
Treatment	401.700	4	100.425	5.411	0.010	*
Error	222.700	12	18.558			
Total	764.950	19				

* - significant at 5 % level, NS- not significant

Table 3. ANOVA of data on fruit weight of salad cucumber in various irrigation treatments

Source	Sum of Squares	df	Mean Square	F	Sig.	Remarks
Block	3.276	3	1.092	1.539	0.255	NS
Treatment	12.218	4	3.054	4.305	0.022	*
Error	8.515	12	0.710			
Total	24.008	19				

* - significant at 5 % level, NS- not significant

Table 4. ANOVA of data on fruit yield of salad cucumber in various irrigation treatments

Source	Sum of Squares	df	Mean Square	F	Sig.	Remarks
Block	499.363	3	166.454	1.539	0.255	NS
Treatment	1861.977	4	465.494	4.304	0.022	*
Error	1297.810	12	108.151			
Total	3659.15	19				

* - significant at 5 % level, NS- not significant . .

Among the drip irrigation levels, the highest field water use efficiency (6148.31kg ha^{-1} cm^{-1}) was found at 65% irrigation level, indicating comparatively more efficient use of irrigation water (Table 5) with a possibility of water saving of 35% water by adopting T2 (1.3 litre plant^{-1} day^{-1}) over control T5 (2 litre plant^{-1} day^{-1}). The graph represents the effect of drip irrigation levels on water use efficiency of salad cucumber (Fig. 2).

Table 5. Field water use efficiency of salad cucumber as influenced by drip irrigation levels

Treatment	Yield (kg ha^{-1})	Water used (cm)	Water saving (%)	Water use efficiency (kg ha^{-1} cm^{-1})
T1: 50% drip irrigation level	62256	11.11	50	5603.35
T2: 65% drip irrigation level	88804	14.44	35	6148.31
T3: 80% drip irrigation level	88060	17.78	20	4953.65
T4: 95% drip irrigation level	82770	21.11	5	3920.90
T5: 100% drip irrigation level	81786	22.22	0	3680.57

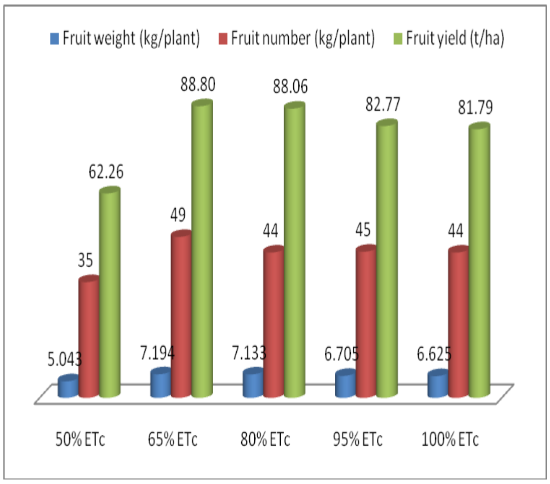

Fig. 1. Effect of drip irrigation levels on yield

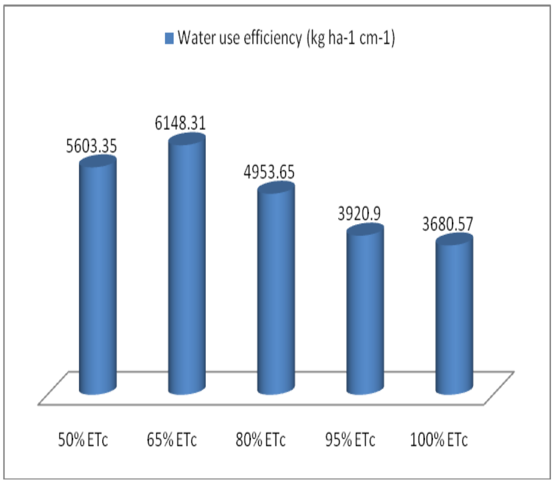

Fig. 2. Effect of drip irrigation levels on WUE

The maximum net return of Rs. 18,83,327 per ha could be obtained by using drip irrigation level of 65% with a Benefit Cost (BC) ratio of 3.41 (Table 6).

Table 6. Economics of salad cucumber as influenced by drip irrigation levels

Treatment	Crop yield (t ha^{-1})	Gross return (RS.$ha^{-1)}$	Total cost* (Rs.ha^{-1})	Net return (Rs.ha^{-1})	Benefit Cost ratio
T1: 50% drip irrigation level	62.256	1867680	780793	1086887	2.39
T2: 65% drip irrigation level	88.804	2664120	780793	1883327	3.41
T3: 80% drip irrigation level	88.060	2641800	780793	1861007	3.38
T4: 95% drip irrigation level	82.770	2483100	780793	1702307	3.18
T5: 100% drip irrigation level	81.786	2453580	780793	1672787	3.14

*Includes the costs of drip irrigation system, NVPH construction and cost of cultivation

IV. CONCLUSION

Indian agriculture today faces the challenge of meeting demand for safe and quality food. Care has to be taken in protecting the natural resources and the environment in the race for food security. Water is a major input in agriculture. The 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 into soil at the crop root zone.

The results of the study showed that drip irrigation levels have significant ($P < 0.05$) effects on crop yield. There were significant positive correlations ($P < 0.01$) between fruit number, fruit weight and fruit yield. Increase in fruit number was the most important factor representing yield increase. Fruit yield was almost uniform except in T1: 50% drip irrigation level (1 litre $plant^{-1}$ day^{-1}), which watered the least. The yield obtained from T2 was statistically similar to T5 (control). Thus T2: 65% drip irrigation level (1.3 litre $plant^{-1}$ day^{-1}) was the most effective treatment with 35% water saving with highest water use efficiency (6148.31 kg $ha^{-1}cm^{-1}$), yield (88.8 t ha^{-1}) and Benefit Cost ratio (3.41) compared to the control T5: 100% drip irrigation level (2 litre $plant^{-1}$ day^{-1}). Hence it can be concluded that drip irrigation level of 65% (1.3 litre $plant^{-1}$ day^{-1}) is the best irrigation level recommendation for salad cucumber grown under naturally ventilated polyhouse in order to get higher economical cucumber yield.

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