Original Article

Indian Journal of Waste Management
Volume 6 Number 2, July-December 2022

Uniformity Evaluation of Water Application to Cauliflower

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How to cite this article:
Ravindra D Bansod/Uniformity Evaluation of Water Application to Cauliflower/Indian Journal of Waste Management. 2022;6(2):45–49.

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Received on: 25.10.2022

Accepted on: 11.10.2022

Abstract

Cauliflower is a reach source of vitamin B and protein and is a main horticultural crop. Its production can be increased by application of irrigation water with required quantity at right time by right method. Irrigation scheduling, considering crop water requirement, plays a vital role in crop production. The microsprinkler irrigation was used for water application to cauliflower and the treatments were based on different microsprinkler spacings i.e. 8m × 8m (T_1), 7m × 7m (T_2), 6m × 6m (T_3), 5m × 5m (T_4), 4m × 4m (T_5) and 3m × 3m (T_6). The water depth applied in T_1, T_2, T_3, T_4, T_5 and T_6 was 17.1, 18.2, 19.9, 22.1, 26.6 and 32.9 cm, respectively. The cauliflower yield obtained in T_1, T_2, T_3, T_4, T_5 and T_6 was 22.82, 23.80, 28.13, 31.70, 29.00 and 26.40 tonne/ha, respectively. The maximum water use efficiency, 1.43 tonne/ha-cm, was recorded in T_4. Based on Uniformity Coefficient (UCC), depth of water application ($\bar{x}$) and actual yield (Y), the production of cauliflower can be predicted as $Y = -200.531 + 4.083\,\bar{x} + 0.0081\,\bar{x}^2\,\{1 + 1.570\,(1 - UCC/100)^2\}$.

Keywords: The order of importance of each parameter was calculated.

Introduction

The contribution of horticultural crops in the Indian GDP was 6 per cent and about 30 per cent in Agricultural GDP in 2018-19. Vegetables contribute about 60 per cent in total horticultural production. Among the vegetable crops, cauliflower (*Brassica oleracea var.*) is one of the important crops in India *(Renu Kumari, et al., 2021)*.

A study on water application to cauliflower was conducted by *Manju Kumari and Meera Devi (2020)*. based on the IW/CPE ratio and observed higher water use efficiency and benefit cost ratio for 1.0, IW/CPE ratio. The gross income could be increased by adopting drip with mulching technology. The benefit cost ratio was found highest in cauliflower for drip irrigation as compared to conventional method of irrigations. *(Mintu Job, et al, 2018)*. The highest curd yield (79.67 tonne/ha) was found with subsurface pressure compensating drip with waste water application *(Deepak singh et.al. 2020)*. The irrigation efficiency was found to be in the range of 54 to 80 per cent with a sprinkler irrigation system for onion (*M.S. Al-Jamal, et al. 2001)*. Uniformity of water application plays a vital role in crop production. *Christiansen, J.E., (1941)* has done lot of work for estimation of water application uniformity and gave the method for calculation of water application uniformity, known as Christiansen's Uniformity Coefficient (UCC). The relationship between crop production and consumptive use (ET) is important to engineers, economists and water resource planners. This importance is accentuated due to competition among users, declining groundwater reserves, various legal institutions and degradation in water quality. In addition to ET, or ET deficit, sprinkler water application uniformity also affects the crop water production function *(Li, 1998)*. When available water for irrigation is limited, the economically optimal design coefficient of uniformity (UCC) becomes a function of the crop response to water. Information on water application uniformity is essential for designing the pressurized irrigation systems in order to specify the spacing between laterals and the emitting points and consequently to know the overall cost of the irrigation system.

Several scientists *(Howell 1990, Doorenbos and Kassam, 1979, Hanks and Rasmussea, 1982,Wang et al., 1997, Patil et al., 2003, Maity and Chatterjee, 2007, etc.)* worked on the crop response, in terms of yield, to water supply. However they did not include the effects of irrigation uniformity. Ignoring irrigation uniformity leads to underestimates of the optimum irrigation amount *(Letey et al. 1984)*. Howell (1967) originally published the theory that the quantity of crop produced is a function of statistical moments of water applied, and the order of the moments needed to describe the uniformity is exactly same as that of the production function.

To obtain a valid crop response-applied irrigation water model, the relation between depth of water application irrigation uniformity and crop yield, must be developed to determine the optimum irrigation amount based on the economic considerations *(Mantovani, 1995)*. The information on effect of uniformity on crop yield is useful for the irrigation engineer to decide the optimum micropsprinkler spacing in order to get the optimum yield. In view of this, the present study was undertaken to develop a production function for cauliflower based on depth of water and uniformity of water application.

The coefficient of uniformity of irrigation water application given by Christiansen *(Christiansen, 1941)* is most commonly used measure of uniformity and accepted by American Society of Civil Engineers. The Christiansen Uniformity Coefficient (UCC) is:

Where $\overline{x}$ is mean depth of water application.

MATERIALS AND METHODS

The field experiment was to study the effects of uniformity in water application and depth of water application on the growth parameters of the cauliflower. The experiment was designed in Randomized Block Design with six treatments and four replications. The treatments were based on the microsprinkler spacing; 8m × 8m (T_1), 7m × 7m (T_2), 6m × 6m (T_3), 5m × 5m (T_4), 4m × 4m (T_5) and 3m × 3m (T_6). The UCC for each treatment was actually measured in the field using Christiansen's method as described earlier. Catch cans were placed at 50 cm grids and several measurements were done to obtain average UCC for each microsprinkler spacing mentioned in the treatment details. The details of the treatments and experiment are shown in Table 1 and Table 2.

Table 1: Details of treatments

1	**T_1**	**8 m × 8 m microsprinkler spacing**
2	T_2	7m × 7m
3	T_3	6m × 6m
4	T_4	5m × 5m
5	T_5	4m × 4m
6	T_6	3m × 3m

Table 2 Experimental details of cauliflower

Particulars	Treatments					
	T_1	T_2	T_3	T_4	T_5	T_6
Spacing of cauliflower, m	0.6×0.6	0.6×0.6	0.6×0.6	0.6×0.6	0.6×0.6	0.6×0.6
Size of plot, m	3×3	3×3	3×3	3×3	3×3	3×3
No. of rows per plot	5	5	5	5	5	5
No. of plants per row	5	5	5	5	5	5
No. of plants per plot	25	25	25	25	25	25
Microsprinkler spacing, m	8×8	7×7	6×6	5×5	4×4	3×3

RESULTS AND DISCUSSION

The biometric growth and yield parameters such as height of cauliflower, number of leaves, days to curd initiation, curd weight, curd diameter, curd volume and yield of cauliflower were recorded and presented in Table 3 and Table 4.treatment

Table 3. Comparative effects of microsprinkler spacing on biometric growth parameters of cauliflower

Treatment	Biometric growth parameters of cauliflower		
	Mean plant height, cm	Mean number of leaves	Duration for curd initiation, days
T1	38.8	11.5	80
T2	41	12.2	79
T3	47.7	14.5	77
T4	53.1	16.2	73
T5	49.8	15	76
T6	44.8	13.7	78
SEm	1.66*	0.26*	0.95*
CD at 5%	4.96	0.82	2.93
CV	6.8	3.53	2.13

As shown in Table 3, the biometric growth parameters such as mean plant height and number of leaves were 53.1 cm and 16.5, respectively (i.e. maximum) in treatment T_4 (5m × 5m microsprinkler spacing) and 38.8 cm and 11.5, respectively (i.e. minimum) in treatment T_1 (8m × 8m microsprinkler spacing). The duration for curd initiation was lowest, 73 days, in T_4 and maximum, 80 days, in T_1. The better growth of cauliflower in microsprinkler spacing of 5m × 5m (T_4) might be due to status of soil moisture near to field capacity and accordingly the better water usage by plants in treatment.

Table 4. Comparative effects of microsprinkler spacing on yield parameters of cauliflower

Sr. No.	Yield components	Treatments					
		T_1	T_2	T_3	T_4	T_5	T_6
1	Curd diameter (cm)	13.1	15	16.2	17.2	16.3	16
2	Curd weight, g	876	914	1079	1217	1112	1022
3	Curd volume, cm3	630.3	648.3	753.8	825.3	770.6	695
4	Specific gravity of curd, g/cm3	1.39	1.41	1.44	1.47	1.44	1.43
5	Curd yield, tonne/ha	22.82	23.8	28.13	31.7	29	26.4

As presented in Table 4, the highest average diameter (17.2 cm), weight (1217 g) and volume (825 ml) of curd were recorded in microsprinkler irrigation with 5m × 5m spacing (T_4). The values of these yield components were in decreasing trend with the increasing spacing of microsprinkler, might be due to reduced water application uniformity and deviation of application depth from average evapotranspiration of plants. The minimum values of diameter (13.1 cm), weight (876 g) and volume (630 ml) of curd were recorded in microsprinkler irrigation with 8m × 8m spacing (T1).

The yield of cauliflower recorded in T_1, T_2, T_3, T_4, T_5 and T_6 was 22.82, 23.80, 28.13, 31.70, 29.0 and 26.4 tonne/ha, respectively.

The highest yield recorded in microsprinkler irrigation with 5m × 5m spacing might be due to better water usage by the plants as water was applied frequently and near to field capacity and also due to uniform distribution of water.

Table 5. Water saving and water use efficiency for cauliflower

Treatment	Total depth of water applied, cm	Yield, tonne/ha	Water use efficiency, tonne/ha-cm	UCC, %
T_1	17.1	22.82	1.33	68
T_2	18.2	23.8	1.31	78
T_3	19.9	28.13	1.41	87
T_4	22.1	31.7	1.43	90
T_5	26.6	29	1.1	92
T_6	32.9	26.4	0.8	94

Total depth of water applied (including effective rainfall of 44 mm) in T_1, T_2, T_3, T_4, T_5 and T_6 was 171, 182, 199, 221, 266 and 329 mm, respectively. The higher depth of water applied was recorded in microsprinkler irrigation treatments with closer microsprinkler spacing and the lower in treatments with wider microsprinkler spacing as the time of operation of the microsprinkler system was same in each irrigation (Table 5). The lower depth of water received in wider microsprinkler spacing and higher in closer microsprinkler spacing was because of equal time of water application in all treatments and less number of micrsprinklers in wider spacing (such as 6m × 6m, 7m × 7m, 8m × 8m) and more number of microsprinklers in closer microsprinkler spacing (such as 3m × 3m, 4m × 4m, 5m × 5m).

The water use efficiency obtained in respective is presented in Table 5. The maximum water use efficiency, 1.43 tonne/ha-cm, was achieved in microsprinkler irrigation with microsprinkler spacing 5m × 5m (treatment T_4) and the minimum, 0.80 tonne/ha-cm, in T_6. Manjunatha (1998) and Pawar and Bhoi (2001) also reported the higher yields of vegetables in microsprinkler irrigation.

Estimation of yield of cauliflower

The values of actual yield, UCC and depth of water applied (Table 5) were utilized for determination of the coefficients of the production function. The coefficients (a, b and c) of production function were determined as -200.531, 4.083 and 0.0081, respectively.

The production equation for cauliflower based on water depth and UCC is therefore obtained as

Y = -200.531 + 4.083 + 0.0081 2 {1 + 1.570 (1-UCC/100)2}

This equation is useful to predict the yield of cauliflower from the values of UCC and depth of water application. It is of the quadratic form and based on the concepts of Bernuth (1983). Hexem and Heady (1978) also have applied the quadratic forms of production functions for prediction of crop yield.

CONCLUSIONS

The microsprinkler spacing and uniformity has inverse relationship, however uniformity is directly proportional to operating pressure. The treatment T4 (microsprinkler spacing 5 m x 5 m) produced highest yield than other treatments. It is also concluded that the water application and overlapping combination might have been better for T4 as it found to be superior over all other treatments.The highest water use efficiency was obtained in microsprinkler irrigation (5 m x 5 m, microsprinkler spacing) and minimum in 3 x 3 m microsprinkler spacing.

The quadratic type of production equation, Y = -200.531 + 4.083 + 0.0081 2 {1 + 1.570 (1- UCC/100)2}, can be applied to estimate the yield of cauliflower (Y) from known water depth ( ) and uniformity coefficient (UCC).

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