Agricultural Journal 13 (4): 72-79, 2018
ISSN: 1816-9155

Influence of Irrigation and Nitrogen Management on Cauliflower Yield and Quality

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Abstract: Agriculture is the backbone of Pakistan. It is very important to promote the crops meet food requirements of the growing world population. A field experiment was conducted to study the effect of deficit irrigation and nitrogen levels on growth and yield of cauliflower under drip irrigation at research farm, The University of Agriculture Peshawar, Khyber Pakhtunkhwa. The experiment was performed in the growing season of cauliflower, i.e, October 2014-January 2015. The experiment was designed on split plot arrangement (RCBD) having three replications. There were two factors, irrigation and nitrogen. Four irrigation and three nitrogen levels and their interaction were studied. Irrigation was applied as I_1 was 100% of full irrigation (MAD), I_2 was 75% of full irrigation, I_3 was 50% of the full irrigation and I_4 was 25% of full irrigation. Fertilizer nitrogen was applied as N_1 was 20 kg/ha, N_2 was 40 kg/ha and N_3 was 60 kg/ha. Drip irrigation system of emitter spacing of 40 cm and the lateral spacing of 45 cm was being installed at the field of experiment. The length of lateral was 10 m. Area of the experimental field of single replication was 54 m^2 (10×5.4 m). Total numbers of the experimental units were 36 and area of one plot was 4.5 m^2. Soil moisture content was determined by volume basis before sowing and then by Frequency Domain Reflectometer (FDR) at daily basis. Different insecticides were sprayed in the field for elimination of different insects. Agronomic practices were done in the field for bitter crop production. Irrigation levels were applied as I_1-I_4 that were 100, 75, 50 and 25% of full irrigation respectively. Each plot was irrigated by their exact calculated time by the drip irrigation method. Daily rainfall data during research period was recorded. Nitrogen levels were applied as N_1- N_3 that were 20, 40 and 60 kg/ha, respectively. Results showed that different irrigation levels significantly affected number of leaves per plant, leaf length, leaf weight, plant height, days to curd initiation, days to curd maturity, curd diameter, biological yield, curd yield, water use efficiency and harvest index. Maximum number of leaves per plant (23), leaf length (29 cm), leaf weight (457 g), plant height (59 cm), days to curd initiation (93), days to curd maturity (16), curd diameter (27 cm), biological yield (50 ton/ha), curd yield (41 ton/ha), harvest index (8.50%) and water use efficiency (201 kg/ha mm) was recorded. The irrigation levels, nitrogen levels and reduction in irrigation brought significantly affected the number of leaves per plant, leaf length, leaves weight, plant height, curd diameter, biological yield and days to curd initiation, days to curd maturity and curd yield. Higher levels of irrigation and nitrogen recommended may be applied to assess the future highest production.

Key words: Split plot, full irrigation, drip irrigation, frequency domain reflectometer, rainfall data, full irrigation

INTRODUCTION

Cauliflower (*Brassica oleracea* var. Japanica snow white) is a member of family Brassicaceae serious need to decrease the water consumption in irrigation by developing new methods and techniques which can help to effectively use a valuable contribution. Drip irrigation is an effective and modern irrigation method having about 90% irrigation efficiency (Maisiri *et al*., 2005). Drip irrigation increase the total yield up to 30% with a saved volume of water from 50-60% compared with conventional irrigation techniques (Yadav *et al*., 1993). Cultivation of crops in soil having water deficit condition is one of the key issues. About <500 mm rainfall on 60% of the land may be associated with degradation cause of crop production (Deng *et al*., 2005). Vegetables requires high amount of water and are very sensitive to water deficit condition which reduce its metabolism and thus resulting less output. The maximum water is required during the curd developmental stage of cauliflower. The use of drip irrigation improves the potential of water and nitrogen use efficiency as well as by plastic mulching which not only helps to control weeds but give more improvements to water use efficiency (Vazquez *et al*., 2006). Drip irrigation allows greater flexibility in the management of both water and nitrogen (Thompson *et al*., 2000). In fertigation, fertilizer is directly applied by emitters to the root zone and therefore, Fertilizer Use Efficiency (FUE) can be

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improved than the manual methods of using fertilizers (Hebbar *et al.*, 2004). Irrigation scheduling at ET_c 1.2 irrigation rules documented significantly maximum curd yield of 37.58 ton/ha than at irrigation regimes of 0.6, 0.8 and 1.0 ET_c (Yanglem and Tumbare, 2014). The use of nitrogen and drip irrigation applying collectively, small amounts of nitrogen during a crop delivers the nominal capability for accurate nitrogen and irrigation management (Granados *et al.*, 2013). The effects of Nitrogen (N), Phosphorus (P) and potassium (K) on the appearance eligibility ratio and for the content of soft total glucosinolates and glucoraphan on the yield of cauliflower which gives maximum value an experiment on different levels of nitrogen fertilizer, processing conditions and period of storage of frozen broccoli and cauliflower on vitamin C (Lisiewska and Kmiecik, 1996).

MATERIALS AND METHODS

The plots of the experimental field were arranged at the research farm, the University of Agriculture Peshawar, Khyber Pakhtunkhwa. The experiment was conducted in Rabi (Winter) season for the cauliflower crop with growing period from October 2014-January 2015.

Experimental design: Experiment was laid out in Randomized Complete Block Design (RCBD) with split plot arrangement having three replications. An area of 10×5.4 m×3 (162 m^2) having three laterals in three rows containing 72 plants. The crop was planted on October 21, 2014 using a seedling of 30 days old from the primary and nursery beds. The irrigation levels were considered as factor (A) and nitrogen levels were as factor (B). The main focus of the research was factor (A) due to which it was kept in main plots for its effect on cauliflower in term of water use efficiency. Detail of treatments is as follows.

Factor A:Irrigation levels:

- I_1 = 100% of full irrigation (Controlled)
- I_2 = 75% of full irrigation
- I_3 = 50% of full irrigation
- I_4 = 25% of full irrigation

Water through drip irrigation system was applied and the required depth was controlled using duration of application as a fix flow. To apply the measured irrigation water, each plot of the experiment was irrigated separately. In the present case, the Management Allowed Deficit (MAD) maintained as 45%. Soil moisture was continuously taken on daily basis with the help of Frequency Domain Reflectometer (FDR).

Factor B:Nitrogen levels:

- N_1 = 20 kg/ha
- N_2 = 40 kg/ha
- N_3 = 60 kg/ha

The required amount was applied in three split doses. Drip irrigation system with spacing between emitters of 0.4 m and laterals spacing 0.45 m was installed before plantation at the field. The length of each lateral was 10 m. There were 36 number of plots.

When someone grow a crop or vegetable it need a proper care about its pests and weeds attack at any stage of growing season. The following weedicide and pesticides were used during the whole growing season when ever needed (Fig. 1).

Emamectin benzoate is a weedicide which was used two times in the full growing season of cauliflower when weeds were detected more in the field which would affect the crop.

Lufenuron a liquid pesticide and methomyl is a pesticide in the farm of powder which both were mixed and used two time when there was attack of pests on the crop.

	<<------ (R_1) ------>>				<<------ (R_2) ------>>				<<------ (R_3) ------>>			
	I_1N_3	I_2N_1	I_4N_2	I_3N_3	I_4N_1	I_3N_3	I_1N_2	I_2N_3	I_3N_1	I_1N_3	I_2N_2	I_4N_3
10 m	I_1N_2	I_2N_3	I_4N_1	I_3N_2	I_4N_3	I_3N_2	I_1N_1	I_2N_2	I_3N_3	I_1N_2	I_2N_1	I_4N_2
	I_1N_1	I_2N_2	I_4N_3	I_3N_1	I_4N_2	I_3N_1	I_1N_3	I_2N_1	I_3N_2	I_1N_1	I_2N_3	I_4N_1

Fig. 1: RCBD with split plot arrangement of the studied area

Crop sowing and fertilizer application: After the drip irrigation system installation and seed beds preparation the cauliflower seedlings was grown in line along the laterals when the soil of the experimental field reached to field capacity. The recommended rate of NPK is 50-100-50 kg/ha the following formula was used for the calculation of urea fertilizer containing the required amount of nitrogen:

$$\text{Amount of urea (N)} = \frac{\text{plot area m}^2 * \text{Fertilizer dose (kg)}}{10000\ \text{m}^2} \times \frac{1\ \text{kg of urea}}{0.46\ \text{kg of N}} \quad (1)$$

Rainfall: The data about any rainfall event in the study period was taken from the weather station installed at the Agronomy Research Farm. The University of Agriculture Peshawar. Rainfall data was recorded in order to adjust the irrigation scheduling during the study period.

Determination of critical moisture level: The critical moisture content before irrigation was determined by the relation of James as follow:

$$\theta_c = \theta_f\text{-MAD}(\theta_f\text{-}\theta_{pwp}) \quad (2)$$

Where:

θ_c = Critical soil moisture content (%) by volume
θ_f = Soil moisture at field capacity (%) by volume
MAD = Management Allowed Deficit (%)
θ_{pwp} = Soil moisture at permanent wilting point (%) by volume

Determination of irrigation depth: To find the depth to be applied per irrigation, following the relation of Keller and Bleisner as follow:

$$d_x = 10Z(\theta_f\text{-}\theta_i) \quad (3)$$

Where:

d_x = Maximum net depth to be applied per irrigation (mm)
θ_f = Soil moisture at field capacity (%) by volume
θ_i = Soil moisture content at that (ith) day
Z = Effective rooting depth (m)

Cauliflower is a close spaced crop, so to achieve high accuracy, net depth of irrigation to be applied by the relation of Keller and Bleisner as follow:

$$d_n = \frac{d_x p_w}{100} \quad (4)$$

Where:

d_n = Net depth of irrigation after adjusting for percent area wetted (mm)
d_x = Maximum total depth to be applied per irrigation (mm)
P_w = Wetted area (%)

Time calculation for full irrigation: Time of irrigation for the experimental plots under full irrigation which was calculated by the relation, Keller and Bleisner as follow:

$$T = \frac{S_p S_r D_g}{N_p q_a} \quad (5)$$

Where:

T = Time of operation per irrigation (sec)
S_p = Spacing between plants (m^3/h)
S_r = Spacing between rows (m^3/h)
D_g = Gross depth to be applied per irrigation (m^3/h)
N_p = Number of emitters/plant
q_a = Average emitter discharge (m^3/h)

Determination of soil moisture content: Soil moisture content was continuously monitored at a very closed interval to determine when to irrigate the crop under full or optimal irrigation. Calibrated Frequency Domain Reflectometer (FDR) was used to determine the soil moisture in the root zone of experimental plots.

75% of the full Irrigation (I_2): In quantity 75% of full irrigation was equal to the gross depth applied, time of irrigation was calculated by using the formula of gross depth of irrigation in Eq. 3.

50% of the full Irrigation (I_3): In irrigation level of 50% of full irrigation which was equal to net depth applied, time of irrigation was calculated by using respective gross irrigation depth in Eq. 5.

Soil wetted area: In trickle irrigation system, typically water is applied in small amount on frequent basis, maintaining soil water near field capacity but usually not all the soil surface is wetted and much of the root zone is not wetted (at least not by design) by the system. It is to be noted that the system is applying water to each individual plant using one emission point per plant, so wetted area calculated per emitter was area for plant (33%). The wetted soil area Aw was measured 30 cm bellow the soil surface. For the straight single lateral system, the percent wetted area is computed as follow:

$$P_w = \frac{N_p S_e W}{S_p S_r} \times 100 \quad (6)$$

Where:
P_w = Percentage of soil area wetted (%)
N_p = Number of emitters/plant
W = Wetted width at 30 cm depth (m)
S_e = Emitters spacing (m)
S_r = Rows spacing (m)

Weeding and pest controls: Weeds were controlled and removed by mechanical methods. Pests and diseases were controlled and diagnosed under the supervision of professional experts as detected.

Agronomic data: The following agronomic data was collected.

Number of leaves per plant: The data about number of leaves per plant was recorded by counting of leaves of four randomly selected plants in every sub plot and was averaged.

Leaf length: The parameter of leaf length was determined by measuring the length of four plants leaves selected randomly in each sub plot and then was averaged. Leaf length was done by simple measuring tape.

Leaf weight: The leaf weight was done by weighting the leaves of randomly selected four plants of every plot and then was averaged.

Days to curd initiation: Days to curd initiation was recorded from the transplanting date up to the date when pants initiated the curd.

Days to curd maturity: Day to curd maturity was counted the days from the transplanting date to the maturity date of curd. The physiological structure and the color of the curd will show that the curd is mature or not.

Plant height: Plant height was measured when the plant was physiologically matured. It was recorded before harvesting and from each subplot by selection of 10 plants randomly from the base of plant to the tip of shooting leaf.

Curd diameter: Data regarding to curd diameter was measured the diameter of randomly selected four plants in each plot and then averaged. Diameter data was recorded in cm.

Curd yield: For data curd yield, the yield of every plot was taken in kg and then converted into ton/ha.

Biological yield: For biological yield cauliflower was harvested and weighed in gm along with leaves and then converted into ton/ha.

Water use efficiency: Water use efficiency (%) of the crop was calculated by following the equation suggested by Huang *et al.*:

$$\text{WUE} = \frac{\text{Curd yeild}}{\text{ET}} \quad (7)$$

where, 'ET' is the seasonal evapotranspiration. ET was calculated by Cropwat (FAO Penmen-Monteith) method. Harvest Index (%). The data about harvest index was determined by the formula used:

$$\text{Harvest index} = \frac{\text{Economic yeild}}{\text{Biological yeild}} \times 100 \quad (8)$$

Statistical analysis: The analysis of the data was carried out statistically by using the analysis of variance technique by Steel and Torrie, appropriate for randomized complete block design. Among all the treatments significant differences were found by using the Least Significant Difference (LSD).

RESULTS AND DISCUSSION

Number of leaves: A research study was conducted to find the effect of deficit irrigation and nitrogen levels on growth and yield of cauliflower during 2014-15, at research farm the University of Agriculture Peshawar. The data on the given parameters were collected and their results are shown and discussed as follow.

Data about number of leaves plant is shows in Table 1 and 2. Analysis showed that different levels of irrigation had a significant effect on number of leaves per plant while nitrogen levels and interaction of irrigation and nitrogen levels were found non-significant.

Leaf length: The data about leaf length is shown in Table 2. Analysis of variance showed that different

Table 1: Number of leaves plant of cauliflower as affected by irrigation and nitrogen levels

	Nitrogen levels			
Irrigation levels	N_1	N_2	N_3	Mean
I_1	22	23	23	23^a
I_2	22	21	22	22^{ab}
I_3	20	20	21	21^{bc}
I_4	20	20	21	20^c
Mean	21	21	22	

LSD value (at p<0.05) for irrigation, nitrogen and their interaction = 1.58, 1.13 and 2.26, respectively; $^{a-c}$Significant values

Table 2: Leaf length (cm), as affected by irrigation and nitrogen levels

Irrigation levels	Nitrogen levels N_1	N_2	N_3	Mean
I_1	28	29	29	29[a]
I_2	26	25	27	26[b]
I_3	22	24	24	23[c]
I_4	21	23	25	23[c]
Mean	24[c]	25[b]	26[a]	

LSD value, (at $p<0.05$) of irrigation, nitrogen levels and their interaction = 0.79, 0.48 and 0.97, respectively; [a-c]Significant values

Table 3: Leaves weight (g) as affected by irrigation and nitrogen levels

Irrigation levels	Nitrogen levels N_1	N_2	N_3	Mean
I_1	405	472	496	457[a]
I_2	398	406	419	407[b]
I_3	319	315	350	328[c]
I_4	181	212	248	214[d]
Mean	326[c]	351[b]	378[a]	

LSD value (at $p<0.05$) for irrigation, nitrogen levels and their interaction = 17.1, 8.86 and 17.7, respectively; [a-c]Significant values

Table 4: Plant height (cm), affected by different irrigation and nitrogen levels

Irrigation levels	Nitrogen levels N_1	N_2	N_3	Mean
I_1	57	59	60	59[a]
I_2	54	55	58	56[b]
I_3	46	49	51	49[c]
I_4	43	43	45	44[d]
Mean	50[b]	52[b]	53[a]	

LSD value (at $p<0.05$) for irrigation, nitrogen levels and interaction = 2.28, 1.8 and 3.6, respectively; [a-c]Significant values

irrigation water deficit and nitrogen levels had a significant effect on the leaf length of cauliflower.

The minimum leaf length of 21 cm was recorded in interaction I_4N_1 which was 25% of full irrigation and 20 kg N/ha, respectively. The results showed similarity to (Farooq *et al*., 2009) who reported that leaf length was maximum at high irrigation and nitrogen levels.

Leaves weight: Data regarding the leaves weight as affected by irrigation and nitrogen levels is presented in Table 3. Statistical analysis showed that different irrigation water deficit, nitrogen levels and their interaction had significant effect on the leaves weight of cauliflower. This may due to the low availability of water to the plant. These results are supported by Kage *et al.* who described that highest leaves weight can be obtained at higher irrigation and higher nitrogen application

Plant height: Data concerning plant height is presented in Table 4. Analysis of variance showed that plant height was affected significantly by irrigation and nitrogen levels. The maximum plant height in cauliflower at the highest level of irrigation is supported by Yu *et al.* (2006)

Table 5: Days to curd initiation as affected by irrigation and nitrogen levels

Irrigation levels	Nitrogen levels N_1	N_2	N_3	Mean
I_1	92	93	93	93[d]
I_2	100	98	96	98[c]
I_3	107	106	105	106[b]
I_4	113	112	110	112[a]
Mean	103[a]	102[b]	101[c]	

LSD value (at $p<0.05$) for irrigation, nitrogen levels and interaction = 0.76, 0.51 and 1.02, respectively; [a-d]Significant values

Table 6: Days to curd maturity as affected by irrigation and nitrogen levels

Irrigation levels	Nitrogen levels N_1	N_2	N_3	Mean
I_1	17	15	16	16[d]
I_2	19	18	17	18[c]
I_3	21	20	17	19[b]
I_4	25	25	25	25[a]
Mean	20[b]	19[a]	19[a]	

LSD value (at $p<0.05$) of irrigation, nitrogen levels and their interaction = 1.84, 0.63 and 1.27, respectively; [a-d]Significant values

who reported that the production of fresh vegetables usually requires the application of considerable amounts of irrigation water and nitrogen fertilizer.

Days to curd initiation: Data about days to curd initiation is presented in Table 5. Statistical analysis of the data showed that different irrigation and nitrogen levels and the interaction of these two had a significant effect on days to curd initiation. The minimum days to curd initiation 101 was recorded at 60 kg N/ha. Similar results were reported by Tiwari *et al.* (2003) who presented that low amount of water and nitrogen application delay curd initiation.

Days to curd maturity: Data pertaining to curd maturity are presented in Table 6. From analysis of data it was concluded that curd maturity was significantly affected by the application of irrigation and nitrogen. The interactions were also found significant. The results coincide with Tiwari *et al.* (2003) who described that the maturity of curd was delayed by decreasing the nitrogen application.

Curd diameter: The data regarding curd diameter are shows in Table 7. Statistical analysis showed that irrigation and nitrogen levels had a significant effect on curd diameter of cauliflower. The results are similar to that of Westerveld *et al.* (2002, 2003) who reported maximum head diameter in cauliflower can be obtained at high application of water and nitrogen.

Biological yield: Data concerned to biological yield is shown in Table 8. The analysis of variance showed that

Table 7: Curd diameter (cm) as affected by different irrigation and nitrogen levels

Irrigation levels	Nitrogen levels N_1	N_2	N_3	Mean
I_1	27	27	28	27^a
I_2	26	27	28	27^a
I_3	20	22	23	22^b
I_4	16	16	16	16^c
Mean	22^b	23^b	24^a	

LSD value (at p<0.05) of irrigation, nitrogen levels and their interaction = 0.99, 0.69 and 1.38, respectively; a-c Significant values

Table 8: Biological yield (ton/ha) as affected by different irrigation and nitrogen levels

Irrigation levels	Nitrogen levels N_1	N_2	N_3	Mean
I_1	46	50	54	50^a
I_2	47	49	50	49^a
I_3	39	47	47	44^b
I_4	32	34	37	34^c
Mean	41^c	45^b	47^a	

LSD value (at p<0.05) of irrigation, nitrogen levels and interaction = 1.8, 1.1 and 2.2, respectively; a-c Significant values

Table 9: Curd yield (ton/ha) as affected by different irrigation and nitrogen levels

Irrigation levels	Nitrogen levels N_1	N_2	N_3	Mean
I_1	38	42	44	41^a
I_2	39	41	42	41^a
I_3	33	41	40	38^b
I_4	25	26	28	27^c
Mean	34^c	37^b	39^a	

LSD value, (at p<0.05) of irrigation, nitrogen levels and their interaction = 0.96, 0.99 and 1.99, respectively

different water deficit and nitrogen levels highly effected the yield of cauliflower as well as the interaction of irrigation and nitrogen were found less significant. As nitrogen is the most essential element for plant so highest yield were obtained at high level of nitrogen. These findings are supported by Foyer *et al.* (2002) who showed that high appropriate apply of irrigation and nitrogen gives high production.

Curd yield: Data concerned to curd yield is shows in Table 9. The analysis of variance showed that different water deficit and nitrogen levels showed highly significant effect on the yield of cauliflower. The results were also supported in term of nitrogen by Islam *et al.* (2010) who showed that maximum amount of nitrogen gives high production.

Water use efficiency: Water use efficiency was determined by dividing the amount of yield obtained by the crop evapotranspiration of entire growing season of the cauliflower crop. Water use efficiency of the

Table 10: Water use efficiency (kg/ha mm) as affected by irrigation and nitrogen levels

Irrigation levels	Nitrogen levels N_1	N_2	N_3	Mean
I_1	137	140	144	140
I_2	161	166	162	163
I_3	172	167	183	174
I_4	192	201	210	201
Mean	165	169	175	

LSD value (at p<0.05) for irrigation, nitrogen levels and interaction = 28.7, 6.9 and 13.8, respectively

Table 11: Harvest Index (%) as affected by irrigation and nitrogen levels

Irrigation levels	Nitrogen levels N_1	N_2	N_3	Mean
I_1	8.25	8.40	8.20	8.29^a
I_2	8.31	8.35	8.39	8.35^a
I_3	8.36	8.61	8.52	8.50^a
I_4	7.99	7.65	7.65	7.76^b
Mean	8.23^a	8.25^a	8.19^a	

LSD value (at p<0.05) for irrigation = 1.36; a-c Significant values

cauliflower crop is given in Table 10. Statistical analysis indicated that different water deficit levels had a significant effect on the water use efficiency of cauliflower the minimum water use efficiency (140 kg/ha mm) was recorded at the levels where no deficit was given (100% of full irrigation). The results showed similarity to Bozkurt *et al.* (2011) who concluded that the Water Use Efficiency (WUE) in his experiment were decreased by increasing amounts of total irrigation water. The mean maximum water use efficiency of 175 kg /ha mm was recorded at 60 kg N/ha and 169 kg/ha mm at 40 kg N/ha.

Harvest index: The data about harvest index is shows in Table 11. The analysis of variance indicated that different water deficit levels had significantly affected the harvest indices of cauliflower while nitrogen and the interaction between irrigation and nitrogen were found non-significant in most cases. The results were similar with Maurya *et al.* (1992) who showed that at high levels of nitrogen application rates increases the yield of cauliflower hence shows similarity to the present documents.

CONCLUSION

Results showed that different irrigation levels significantly affected number of leaves per plant, leaf length, leaf weight, plant height, days to curd initiation, days to curd maturity, curd diameter, biological yield, curd yield, water use efficiency and harvest index. Different nitrogen levels significantly affected number of leaf length, leaf weight, days to curd initiation, days to curd maturity, plant height, curd diameter, biological yield and water use efficiency and curd yield. In the data, most of the interactions significantly affect the leaf length, leaf weight, plant height, days to curd initiation, days to curd maturity, biological yield, curd yield and water use efficiency. The irrigation levels significantly affected the number of leaves per plant, leaf length, leaves weight, plant height, curd diameter, biological yield and days to curd initiation, days to curd maturity and curd yield.

The different nitrogen levels significantly affected the leaf length, leaves weight, plant height, curd diameter, biological yield and curd yield. The number of leaves per plant, water use efficiency and harvest index were found non-significant.

By the reduction in irrigation from full irrigation to 75%, the curd yield and water use efficiency were not significantly affected. The decrease in the nitrogen from 60-40 kg/ha, the curd yield was significantly affected while water use efficiency did not change.

When irrigation was reduced to 75% and nitrogen to 40 kg/ha (I_2N_2), curd yield was increased by 7% with an increase in water use efficiency by 15%. When irrigation was reduced to 50% and nitrogen level maintained at controlled (60 kg/ha) curd yield was increased by 10% with the increase in water use efficiency by 39%.

RECOMMENDATIONS

Full irrigation (100%) and highest level of nitrogen, i.e., 60 kg/ha for better production of cauliflower is recommended. Higher levels of irrigation and nitrogen recommended may be applied to assess the future highest production. Further study need to be carried out to evaluate the most appropriate irrigation and nitrogen levels for the highest production.

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