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Study of Different Drip Irrigation and NK Fertigation Levels on Performance of Cauliflower

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Authors' contributions

This work was carried out in collaboration among all authors. Author MLP, MU and VR designed the work. Author GS executed the work and performed both statistical and nutrient analysis under the chairmanship of author MLP. Author MLP drafted the manuscript. Author MU and VR monitored regularly the experiment and corrected the draft. All authors read and approved the final manuscript.

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ABSTRACT

A field experiment on cauliflower with different drip irrigation and NK fertigation levels was conducted at Rajendranagar, Hyderabad, Telangana during rabi 2019-2020. The experiment was laid out in a split plot design with nine treatments, comprising of three drip irrigation regimes viz., 0.6 Epan (I_1), 0.8 Epan (I_2) and 1.0 Epan (I_3) as main plots and three drip NK fertigation levels of control (N_0K_0-F_1), 50 % recommended dose of NK (N_{40} K_{50}- F2) and 100 % recommended dose of NK (N_{80} K_{100}- F_3) as sub plots and replicated thrice. Growth and yield attributes were significantly higher at irrigation scheduled at 1.0 Epan. Plant height and yield attributes were comparable between 1.0 Epan and 0.8 Epan. Whereas plant height and dry matter production between 0.8 and 0.6 Epan were comparable. Drip irrigation scheduled at 1.0 Epan recorded significantly higher curd yield (18.7 t ha^{-1}) than 0.8 Epan (17.1 t ha^{-1}) and 0.6 Epan (15.0 t ha^{-1}). NPK uptake were significantly higher in irrigation scheduled at 1.0 Epan than 0.8 and 0.6 Epan. All growth, yield attributes and NPK uptake at harvest increased significantly with increase in NK fertigation level from control to 100% recommended dose of NK. Drip fertigation at 100 % recommended dose of NK recorded significantly higher curd yield (23.8 t ha^{-1}) than 50 % recommended dose of NK (19.7 t ha^{-1}) and N_0K_0 (7.2 t ha^{-1}). Application of 1.0 E Pan irrigation and 100% recommended dose of NK performed better than other treatments.

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Keywords: Cauliflower; drip irrigation; fertigation; NPK uptake; curd yield.

1. INTRODUCTION

Cauliflower (Brassica *oleracea var. botrytis* L.*)* is a valuable cole crop, belonging to the Brassicaceae family. The edible part of cauliflower is known as curd, the curd is used in curries, soups and pickles. Cauliflower is classified as super food as it contains rich source of proteins, carbohydrates, minerals, vitamin A and C, low fat and high fibre and it protects the human health due to presence of antioxidants, poly phenols, phyto chemicals which reduces the risk of aggressive prostrate cancer.

The cauliflower varieties are grouped under three categories viz., early season, main season and late season varieties. In Telangana, early-season varieties are sown during May to August and ready to harvest from September to December. Main season varieties are sown during September to October and are ready for harvest from December to January, while late-season varieties are sown during October to December and harvested from mid-January to April end.

The total area and production of cauliflower in India is about 0.45 Mha and 8.67 Mt, respectively [1]. West Bengal, Bihar and Madhya Pradesh are top three states in cauliflower cultivation. In Telangana, vegetables are cultivated in 0.14 M ha area with total production of 2.7 M t. In Telangana, cauliflower is grown in an area of 1580 ha largely in per urban areas [1].

In vegetable cultivation, especially in cauliflower, illogical water and nutrient management system not only caused unnecessary wastage of water and fertilizer resources, but also led to shallow ground water nitrate pollution and other environmental problems [2]. Water and fertilizer are considered as the important inputs for obtaining higher yield. Economic use of these inputs is crucial as they are limited in nature and becoming costlier day by day. It is the need of the hour to utilize water and fertilizer judiciously by efficient ways to enhance the input use efficiency on sustainable basis.

Cauliflower has wide range of adaptation to diverse climatic conditions. It is grown in all types of soil with good fertility and water regime. In light soils, cauliflower is more sensitive to water stress, therefore adequate moisture supply is most important. In view of rapid expansion of vegetable crops are under micro irrigation. Earlier studies on cauliflower under drip fertigation revealed that different drip and NK fertigation levels had significant influence on growth, yield and nutrient uptake. Study on different drip irrigation regimes (60, 80 and 100% CPE) and drip fertigation levels (80,100 and 120% RDF and furrow irrigation with 100 % RDF) revealed that irrigation scheduled at 80 % CPE with 80% RDF recorded higher curd yield (28.58 t ha^{-1}) [3]. In another study under drip irrigation where irrigation scheduled at 80% PE with 100 % RDF recorded higher curd yield (25.6 t ha^{-1}) [4].

In this context, there is a need to develop the location specific crop water requirement and fertigation levels for getting higher water and fertilizer use efficiency. Keeping in view of the above, the present experiment was conducted with an objective to study the nitrogen and potassium fertigation levels on growth, yield and N, P, K uptake in cauliflower.

2. MATERIALS AND METHODS

2.1 Characteristics of Study Area

The present study carried at Water Technology Centre, Professor Jayashankar Telangana State Agricultural University (PJTSAU), Rajendranagar, Hyderabad, Telangana during *rabi* 2019-2020. The experiment is located at 17°19' 18'' N latitude, 78°24' 18'' E longitude and at an altitude of 527 m above mean sea level (MSL). Cauliflower was grown in open field under drip irrigation system. The soil was sandy loam with moderate infiltration rate, slight alkaline and moderate saline. The soil status was low in organic carbon content, medium in available N, high in available P_2O_5 and K_2O.

2.2 Details of Experiment and Cultural Practices

The experiment was laid out in a split plot design with nine treatments, comprising of three drip irrigation levels *viz.,* drip irrigation scheduled at 0.6 Epan (I_1), 0.8 Epan (I_2), 1.0 Epan (I_3) as main plots and three drip NK fertigation levels of control (N_0K_0-F_1), 50 % recommended dose of NK (N_{40} K_{50}- F_2) and 100 % recommended dose of NK (N_{80} K_{100}- F_3) as sub plots and replicated thrice. Irrigation scheduling was done as per daily evaporation data observed from local observatory. The recommended fertilizer dose of

80:80:100 kg N-P_2O_5-K_2O ha^{-1} were applied in the form of urea, single super phosphate and white muriate of potash. A common basal dose of 80 kg P_2O_5 ha^{-1} through SSP was applied in all the treatments and N and K_2O applied as fertigation once in four days (Table 1). The crop growth period was from 15th November 2019 to 23rd February 2020 (100 days) including of nursery period. 25 days old seedlings were transplanted at 50/40cm × 45 cm in paired row method. Weed, pest and disease management was done as per the recommendations of the university.

2.3 Data Collection on Growth and Yield Parameters and NPK Analysis

The data was recorded on growth parameters like plant height, number of leaves $plant^{-1}$, dry matter production (g $plant^{-1}$), yield attributes viz., curd diameter (cm), curd depth (cm), curd volume (cm^3) and curd yield (t ha^{-1}).

Pounded samples of leaf and curd at harvest were used for nitrogen content (%) estimation by the micro Kjeldhal method [5] using Kelplus Supra LX - analyzer. The di-acid digested plant and curd samples were analyzed for phosphorus content by Vanado-molybdo phosphoric acid [6]. The intensity of yellow colour developed was measured by using UV-VIS spectrophotometer (Make - Systronics, Model -108) at 420 nm. Leaf and curd potassium content in the di-acid was determined by using flame photometer (Make - Elico, Model - CL 361) [5].

The N, P and K uptake at harvest was calculated by using nutrient concentration and dry matter yield or curd yield as follows.

$$\text{Nutrient uptake (kg ha}^{-1}\text{)} = \frac{\text{Nutrient content (\%) x Dry matter (kg ha} - 1\text{)}}{100}$$

2.4 Statistical Analysis

The data on various parameters collected from the experiment were statistically analyzed by analysis of variance (ANOVA) for split plot design [7]. Critical difference was worked out at five per cent probability level when the treatment differences were found significant and the values were furnished. Non significant treatmental differences were denoted by NS.

3. RESULTS AND DISCUSSION

3.1 Growth Parameters

Plant height was significant among irrigation and different fertigation levels at harvest. Interaction was found non significant (Table 2.). Among the irrigation levels, drip irrigation scheduled at 1.0 EPan recorded significantly higher plant height (40.7 cm) than 0.6 E Pan (38.2 cm) and at par with 0.8 E Pan (39.3 cm) at harvest. Plant height at 0.8 Epan and 0.6 Epan were comparable. Among the fertigation levels, plant height at harvest was increased significantly with increase in NK fertigation level from N_0K_0 (32.4 cm) to 100 % recommended dose of NK. This increase in plant height with increase in N is expected given the role N fertilization plays in plant growth when water availability to plant is optimum. Plant height during harvest was significantly higher at 100 % recommended dose of NK (45.0 cm) than 50 % recommended dose of NK (40.8 cm) and control (32.4 cm) respectively. Plant height at 50 % recommended dose of NK was significantly higher than control.

Both drip irrigation and fertigation levels significantly influenced the no of leaves $plant^{-1}$. Interaction was non significant at all stages. (Table 2). Among irrigation levels, no of leaves $plant^{-1}$ at harvest increased significantly with increase in drip irrigation level from 0.6, (15.8 $plant^{-1}$), 0.8 (17.7 $plant^{-1}$) and 1.0 E Pan (21.0 $plant^{-1}$) respectively. This could be attributed due to the optimum moisture availability in the vicinity of the root zone during whole crop period enhances the vegetative growth and ultimately might have improved the no of leaves $plant^{-1}$. These results were found similar with observations of Kapoor and Sandal [8] and Sohail et al. [9].

Table 1. Fertigation schedule for nitrogen and potassium nutrients (g $plot^{-1}$ $split^{-1}$) during different crop growth stages of cauliflower (*rabi*, 2019-2020)

	1-16 DAT		17-40 DAT		41-60DAT	
	N and K		N and K		N and K	
	$N_{80}K_{100}$	$N_{40}K_{50}$	$N_{80}K_{100}$	$N_{40}K_{50}$	$N_{80}K_{100}$	$N_{40}K_{50}$
Urea (g $plot^{-1}split^{-1}$)	100.2	50.1	560.9	280.5	340.5	170.2
MOP (g $plot^{-1}split^{-1}$)	115.2	57.6	384	192	960	480
Number of splits	4		6		5	

Among fertigation levels, drip NK fertigation level from N_0K_0 (16.1 plant^{-1}), 50% recommended dose of NK (18.2 plant^{-1}) to 100% recommended dose of NK (20.3 plant^{-1}) significantly increased the number of leaves plant^{-1} at harvest respectively. This might be due to adequate availability of nutrients coupled with favourable moisture in the vicinity of root zone which regulate plant physiological functions and morphological functions favourably and enhanced the increase in leaf buds and finally increased the number of leaves plant^{-1}. These results corroborate with the findings of Gocher et al. [10].

Dry matter production was significantly influenced by both drip irrigation levels and drip NK fertigation levels. Interaction was found non significant (Table 2). Drip irrigation scheduled at 1.0 Epan recorded significantly higher dry matter production in plant, curd and total dry matter at harvest (99.3, 58.0 and 157.2 g plant^{-1}) than 0.8 Epan (79.0, 49.0 and 128.1 g plant^{-1}) and 0.6 Epan (70.7, 42.2 and 112.9 g plant^{-1}) respectively. Total plant dry matter at harvest was comparable between 0.8 and 0.6 Epan. This might be due to rapid growth by maintenance of adequate moisture supply and better nutrient mobilization which manifested in higher plant height and more number of leaves plant^{-1} ultimately higher dry matter production. Similar results were found by Sohail et al. [9].

Increase in drip NK fertigation level from N_0K_0, 50 % recommended dose of NK to 100 % recommended dose of NK significantly increased the dry matter production plant^{-1} in plant (54.2, 88.1 and 106.7 g plant^{-1}), curd (22.4, 58.3 and 68.5 g plant^{-1}) and total dry matter at harvest (76.6, 146.4 and 174.1 g plant^{-1}) respectively. This could be due to continuous supply of nutrients in small quantities around the root zone through drip irrigation facilitates better nutrient uptake and photosynthesis leads to luxurious crop growth reflected in the dry matter production plant^{-1} of cauliflower plant. The above results are akin with the outcome of Kishor [11], Gadhavi et al. [12] and Sohail et al. [9] who got significantly higher dry matter plant^{-1} at 100% RDF than other doses.

3.2 Yield Attributes and Curd Yield

Drip irrigation at 1.0 Epan observed significantly higher curd diameter, depth and volume (12.4 cm, 5.7 cm and 548.7 cm^3) than 0.6 Epan (10.3 cm, 5.0 cm and 410.6 cm^3) and on par with 0.8 Epan (11.7 cm, 5.5 cm and 492.8 cm^3) (Table 2). Drip irrigation at 0.8 Epan recorded significantly higher curd diameter, depth and volume than 0.6 Epan. Curd diameter, depth and volume were increased significantly with every increment in NK fertigation level from 0 to 100 % recommended dose of NK fertigation. Drip fertigation at 100 % recommended dose of NK recorded significantly higher curd diameter, depth and volume (14.1 cm, 6.7 cm and 875.0 cm^3) than 50 % recommended dose of NK (11.8 cm, 5.7 cm and 403.2 cm^3) and N_0K_0 (8.6 cm, 3.5 cm and 173.9 cm^3).

Curd yield was significantly more in drip irrigation at 1.0 Epan (18.7 t ha^{-1}) than 0.8 Epan (17.1 t ha^{-1}) and 0.6 Epan (15.0 t ha^{-1}) (Table 2). Curd yield at 0.8 Epan was significantly higher than 0.6 Epan. This is attributed due to the optimum moisture in the vicinity of root zone in whole crop period enhanced the vegetative growth in the form of higher plant height, no of leaves plant^{-1} and production of higher dry matter of the crop thereby increase in the photosynthesis and efficient translocation of photosynthates towards the reproductive organ i.e., curd, which increased the curd diameter, depth, volume and curd weight plant^{-1} finally resulted into increased curd yield of cauliflower. Similar findings are reported by Khodke and Patil [13], Popale et al. [14] and Biswal [15].

Curd yield was increased significantly with every increment in NK fertigation dose from 0 to 100 % RD of NK fertigation. Drip fertigation at 100 % recommended dose of NK recorded significantly higher curd yield (23.8 t ha^{-1}) than 50 % recommended dose of NK (19.7 t ha^{-1}) and N_0K_0 (7.2 t ha^{-1}). Curd yield is a cumulative effect of yield attributes like curd diameter, depth, volume and curd weight plant^{-1}. Curd yield increased gradually with increase in 100 % recommended dose of the N and K fertigation level. This might be due to the continuous supply of nutrients in the root zone of the crop through drip fertigation, which created favourable conditions for growth and development by way of increasing metabolic activities in the plant system. These results are in harmony with the findings of Popale et al. [14], Kapoor and Sandal [8], Gadhavi et al. [12] and Kumar and Sahu [16].

3.3 NPK Uptake

Nitrogen uptake was significantly influenced by both drip irrigation levels and different drip NK fertigation. Interaction was found to be non significant (Table 3). Drip irrigation given at 1.0 Epan recorded significantly higher nitrogen uptake in leaf, curd and total uptake (120.4, 80.3 and 200.8 kg ha^{-1}) than 0.8 Epan (90.6, 62.9 and 153.6 kg ha^{-1}) and 0.6 Epan (72.8, 53.4 and 126.2 kg ha^{-1}) respectively. The results were in accordance with the observations of Kumar and Sahu [16], Kapoor and sandal [8], Singh et al. [4] and Shams and Farag [17] who reported higher nitrogen uptake at higher irrigation levels.

Nitrogen uptake increased significantly with an each increment in drip NK fertigation level from N_0K_0 to 100% recommended dose of NK fertigation at all stages. Nitrogen uptake was significantly higher at 100% recommended dose of NK (127.9, 93.5 and 221.4 kg ha^{-1}) than 50% recommended dose of NK (102.7, 76.5 and 179.2 kg ha^{-1}) and control (53.3, 26.7 and 80.0 kg ha^{-1}) in leaf, curd and total uptake respectively. Similar results were obtained by Kapoor and Sandal [8], Singh et al. [4], Jahan et al. [18], Kumar and Sahu [16] and Kishor [11]. It was noticed that among irrigation levels, the percentage of nitrogen partitioned into the curd ranged from 40 to 42.3%. High percentage was partitioned in irrigation scheduled at 0.6 Epan and the maximum in 1.0 Epan. Among fertigation levels, the % partition from total N uptake ranged from 33.37 to 42.68%. The least was noticed in control and maximum was observed in 50% recommended dose of NK. At 100% recommended dose of NK it got reduced to 42.23%.

Phosphorous uptake was significantly influenced by both drip irrigation levels and different drip NK fertigation levels. Interaction was found to be non significant (Table 3). Among irrigation levels, drip irrigation given at 1.0 Epan recorded significantly higher phosphorous uptake in leaf, curd and total at harvest (18.5, 18.0 and 36.5 kg ha^{-1}) than 0.8 Epan (13.4, 13.6 and 27.0 kg ha^{-1}) and 0.6 Epan (9.2, 11.5 and 20.7 kg ha^{-1}) respectively. In curd, phosphorous uptake was found to be comparable between 0.8 Epan and 0.6 Epan. The results corroborate with the findings of Kumar and Sahu [16], Kapoor and sandal [8], Singh et al. [4] and Shams and Farag [17] who reported higher phosphorous uptake at high irrigation levels.

Among fertigation levels, phosphorous uptake increased significantly with an increment in drip NK fertigation level from N_0K_0 to 100 % recommended dose of NK fertigation at all stages. Phosphorous uptake was significantly higher at 100 % recommended dose of NK (20.9, 23.6 and 44.5 kg ha^{-1}) than 50 % recommended dose of NK (15.0, 15.2 and 30.2 kg ha^{-1}) and control (5.2, 4.2 and 9.5 kg ha^{-1}) in leaf curd and total uptake at harvest respectively. Similar results were obtained by Kapoor and Sandal [8], Singh et al. [4], Jahan et al. [18], Kumar and Sahu [16] and Kishor [11] who found higher phosphorous uptake at high fertigation levels.

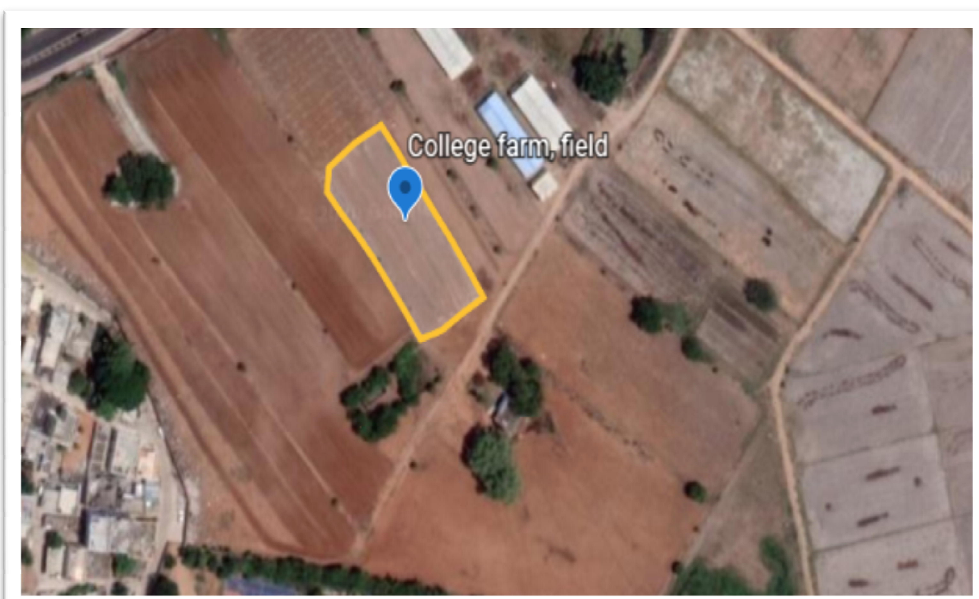

Fig.1. Location of the experimental site (Google Earth)

Table 2. Growth, yield attributes and yield as influenced by different drip irrigation and NK fertigation levels in cauliflower during rabi 2019-20

Treatments	Plant height (cm)	No of leaves plant^{-1}	Dry matter Production (g plant^{-1})			Curd diameter (cm)	Curd depth (cm)	Curd volume (cm^3)	Curd yield (t ha^{-1})
			Plant	curd	Total				
Main plots -Irrigation levels									
I_1: Drip irrigation at 0.6 Epan	38.2	15.8	70.7	42.2	112.9	10.3	5.0	410.6	15.0
I_2: Drip irrigation at 0.8 Epan	39.3	17.7	79.0	49.1	128.1	11.7	5.5	492.8	17.1
I_3: Drip irrigation at 1.0 Epan	40.7	21.0	99.3	58.0	157.2	12.4	5.7	548.7	18.7
SEm ±	0.4	0.4	1.6	1.1	2.8	0.2	0.1	18.1	0.2
C.D (P=0.05)	1.7	1.7	6.7	4.5	11.5	0.8	0.4	72.9	0.8
Sub plots - Fertigation levels									
F_1:Control (N_0 K_0)	32.4	16.1	54.2	22.4	76.6	8.6	3.5	173.9	7.2
F_2:50 % Recommended dose (N_{40} K_{50})	40.8	18.2	88.1	58.3	146.4	11.8	5.7	403.2	19.7
F_3:100 % Recommended dose ($N_{80}K_{100}$)	45.0	20.3	106.7	68.5	174.1	14.1	6.7	875.0	23.8
SEm ±	0.7	0.3	2.2	1.3	3.4	0.3	0.1	12.9	0.6
C.D (P=0.05)	2.3	0.8	7.0	4.2	10.6	1.1	0.4	40.7	2.0
Fertigation at same level of irrigation									
SEm ±	0.7	0.7	2.9	2.0	4.9	0.3	0.2	31.3	0.4
C.D (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Irrigation at same or different fertigation levels									
SEm ±	1.1	0.5	3.5	2.2	5.6	0.5	0.2	25.7	1.0
C.D (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 3. NPK uptake at harvest as influenced by different drip irrigation and NK fertigation levels in cauliflower during rabi 2019-20

Treatments	N uptake (kg ha^{-1})			P uptake (kg ha^{-1})			K uptake (kg ha^{-1})		
	Leaf	Curd	Total	Leaf	Curd	Total	Leaf	Curd	Total
Main plots - Irrigation levels									
I_1: Drip irrigation at 0.6 Epan	72.8	53.4	126.2	9.2	11.5	20.7	118.7	47.6	166.3
I_2: Drip irrigation at 0.8 Epan	90.6	62.9	153.6	13.4	13.6	27.0	140.5	59.4	199.9
I_3: Drip irrigation at 1.0 Epan	120.4	80.3	200.8	18.5	18.0	36.5	190.5	73.4	263.9
SEm ±	2.4	2.3	4.3	0.6	0.6	1.1	2.5	0.7	3.1
C.D (P=0.05)	9.7	9.1	17.5	2.3	2.6	4.6	10.0	2.9	12.3
Sub plots - Fertigation levels									
F_1:Control (N_0 K_0)	53.3	26.7	80.0	5.2	4.2	9.5	84.9	23.0	108.0
F_2:50 % Recommended dose (N_{40} K_{50})	102.7	76.5	179.2	15.0	15.2	30.2	153.8	68.2	222.1
F_3:100 % Recommended dose ($N_{80}K_{100}$)	127.9	93.5	221.4	20.9	23.6	44.5	210.9	89.1	300.1
SEm ±	3.4	2.4	4.7	0.8	0.9	1.6	4.4	1.3	4.8
C.D (P=0.05)	10.6	7.5	14.6	2.6	2.9	4.9	13.9	4.1	14.9
Fertigation at same level of irrigation									
SEm ±	0.08	3.9	7.5	0.9	1.1	1.9	4.3	1.2	5.3
C.D (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Irrigation at same or different fertigation levels									
SEm ±	0.09	4.1	7.9	1.3	1.4	2.5	6.8	1.9	7.4
C.D (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS

Potassium uptake was significantly influenced by both drip irrigation levels and different drip NK fertigation levels at all stages. Interaction was found to be non significant at all stages (Table 3). Drip irrigation at 1.0 Epan recorded significantly higher potassium uptake in leaf, curd and total K uptake at harvest (190.5, 73.4 and 263.9 kg ha^{-1}) than 0.8 Epan (140.5, 59.4 and 199.9 kg ha^{-1}) and 0.6 Epan (118.7, 47.6 and 166.3 kg ha^{-1}) respectively. The results were corroborate with the observations of Kumar and Sahu [16], Kapoor and sandal [8], Singh et al. [4] and Shams and Farag [17] who reported higher potassium uptake at high irrigation levels.

Potassium uptake increased significantly with an each increment in drip NK fertigation level from N_0K_0 to 100 % recommended dose of NK fertigation. Potassium uptake was significantly higher at 100 % recommended dose of NK (210.9, 89.1 and 300.1 kg ha^{-1}) than 50 % recommended dose of NK (153.8, 68.2 and 222.1 kg ha^{-1}) and control (84.9, 23 and 108.0 kg ha^{-1}) in leaf and curd respectively. Similar results were obtained by Kapoor and Sandal [8], Singh et al. [4], Jahan et al. [18], Kumar and Sahu [16] and Kishor [11] who found higher potassium uptake at high fertigation levels.

4. CONCLUSION

Application of 1.0 Epan irrigation and 80 kg N, 100 kg K_2O ha^{-1} by fertigation in 15 number of split doses once in four days interval is recommended for maximization of yield and nutrient uptake in cauliflower cultivated in rabi season in Telangana.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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