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# Nutrient Uptake Studies under Varying Drip Irrigation Regimes and Fertigation Levels in *Rabi* Cauliflower in Telangana State

**G. Sidhartha[1], Md. Latheef Pasha[1*], M. Umadevi[1] and V. Ramulu[1]**

*[1]Water Technology Centre, Professor Jayashankar Telangana State Agricultural University, Rajendranagar, Hyderabad-500030 Telangana, India.*

***Authors' contributions***

*This work was carried out in collaboration among all authors. Authors 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. Authors MU and VR monitored regularly the experiment, corrected the draft. All authors read and approved the final manuscript.*

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## ABSTRACT

A field study was conducted with different drip irrigation regimes and NK fertigation levels on cauliflower at Hyderabad, Telangana during *rabi* 2019-2020. The experiment was laid out in a split plot design with three drip irrigation regimes viz., 0.6, 0.8 and 1.0 Epan as main plots and three drip NK fertigation levels of control ($N_0K_0$), 50 % recommended dose of NK ($N_{40}$ $K_{50}$) and 100 % recommended dose of NK ($N_{80}$ $K_{100}$) as sub plots altogether nine treatments and replicated thrice. 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 and S uptake were significantly higher in irrigation scheduled at 1.0 Epan than 0.8 and 0.6 Epan during all stages except at 30 DAT and harvest where S uptake was found to be non significant among different irrigation levels. 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$^{-1}$). Drip NK fertigation levels significantly increased the NPK and S uptake with each increment in NK fertigation level from $N_0K_0$ to 100 % recommended dose of NK at all stages.

**Corresponding author: E-mail: lateefpasha@gmail.com;*

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## 1. INTRODUCTION

Vegetables are essential commodities for food and nutrition security of India. Vegetable cultivation is able to generate both on-farm and off-farm employment round the year, as India is blessed with wide range of agro climatic and geographical conditions suitable for growing various kinds of vegetables throughout the year. 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 full of antioxidants, poly phenols, phyto chemicals which reduces the risk of aggressive prostarte cancer.

The total area and production of cauliflower in India is about 0.45 M ha and 8.67 Mt, respectively [1]. In Telangana, cauliflower is grown mostly in per urban areas adjacent to Hyderabad city. Light textures soils are more prevalent in Telangana. Cauliflower is more sensitive to water stress under light soils. Therefore adequate moisture supply is most important for successful crop growth.

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 drip fertigation where both water and fertilizers are applied at a low rate to the vicinity of plant root zone directly in available forms to match both water and nutritional requirement of crop at different growth stages. It resulted into higher and better quality of crops at lower fertilizer dose. Fertigation reduced 25% of fertilizers unlike in the traditional methods, fertilizers are applied in large quantity, and a lot of fertilizers go waste due to leaching, evaporation and fixation in the soil.

Earlier studies on cauliflower under drip fertigation revealed that different levels of NK fertigation and drip irrigation regimes had significant effect on cauliflower growth and yield. Kumar [2] studied different drip irrigation regimes (60, 80 and 100 % CPE) and drip fertigation levels (80,100 and 120 % RDF and furrow irrigation with 100 % RDF) and found that irrigation scheduled at 80 % CPE with 80 % RDF recorded higher curd yield (28.58 t $ha^{-1}$). In another study by Kishor [3] tested different drip fertigation levels (100 % and 75 % RDF by drip fertigation, drip irrigation with 100 % RDF by soil and drip irrigation with no fertiliser ) in cauliflower and recorded higher leaf and curd NPK content with drip fertigation by 100 % RDF than other treatments.

In view of rapid expansion of vegetable crops are under micro irrigation, there is need to develop water and fertilizer requirement of cauliflower under drip irrigation in Telanagana. Hence the present study was proposed.

## 2. MATERIALS AND METHODS

A field experiment was conducted at Water Technology Centre, College Farm, Rajendranagar, Hyderabad, Telangana during *rabi* 2019-2020. The experimental location is situated at 17°19' 18" N latitude, 78°24' 18" E longitude and at an altitude of 527m above mean sea level in the Southern Telangana Agro-Climatic Zone in Telangana State The experimental soil was sandy loam with a pH of 7.7 and EC of 0.27 dS $m^{-1}$. The soil fertility status was low in organic carbon (0.22 %), medium in available nitrogen (326.4 kg $ha^{-1}$), high in available phosphorus (77.83 kg $P_2O_5$ $ha^{-1}$) and potassium (429.9 kg $K_2O$ $ha^{-1}$).

The experiment was laid out in a split plot design with nine treatments, comprising of three drip irrigation regimes *viz.,* 0.6, 0.8 and 1.0 Epan as main plots and three drip NK fertigation levels of control ($N_0K_0$), 50 % recommended dose of NK ($N_{40}$ $K_{50}$) and 100 % recommended dose of NK ($N_{80}$ $K_{100}$) as sub plots with three replication. Irrigation scheduling was done as per daily evaporation data observed from local observatory. The quantity of irrigation water applied including special operations (water applied at nursery and transplanting) at different drip irrigation levels of 0.6, 0.8 and 1.0 Epan was 160.8, 207.6 and 254.2 mm respectively.

The recommended fertilizer dose of 80:80:100 kg $N\text{-}P_2O_5\text{-}K_2O$ $ha^{-1}$ 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. Variety "Suhasini Plus" was used as test variety for experiment. Nuresery was grown in plug trays under shadenet. 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. Post emergence herbicide Quizalofop Ethyl 5% EC @ 1.25 ml $l^{-1}$ was sprayed to control grassy weeds during 15 days after transplanting. Hand weeding was done twice at 35 and 55 days after planting to maintain weed free environment. Plant protection measures were followed for the control of pests and diseases. Pests like Spodoptera larvae and sucking pests were controlled by spraying spinosad @ 0.3 ml $l^{-1}$ and chloripyriphos 50 EC @ 1.6 ml $l^{-1}$.

The data was recorded on dry matter production (g $plant^{-1}$) at different stages of crop growth and curd yield (t $ha^{-1}$). Powdered samples of plant at 30 DAT, 45 DAT and samples of leaf and curd at harvest were used for nitrogen content (%) estimation by the micro Kjeldhal method [4] using Kelplus Supra LX - analyzer. The di-acid digested plant and curd samples were analyzed for phosphorus content by Vanado-molybdo phosphoric acid [5].

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

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

The initial and final soil NPK status was analyzed by using standard procedures. Alkaline permanganate method using KELPLUS SUPRA LX – analyser was used for available nitrogen [6]. Available P status was analysed by Olsen's method for extraction and Ascorbic acid method for estimation by using UV-VIS spectrophotometer (Make-systronics, Model-108) at 420 nm [7]. Neutral normal ammonium acetate method using (Make-Elico, Model- CL361), Flame photometer [8] was adopted for analysis of available potassium status.

The collected data was statistically analyzed by analysis of variance (ANOVA) for split plot design [9]. Op stat software used for analysis. Whenever the treatment differences were found significant, critical differences were worked out at five per cent probability level in LSD. Treatment differences that were nonsignificant were denoted by NS and the results were critically interpreted with proper justification with relevant literature.

**Table 1. NK Fertigation doses to cauliflower stage wise**

| Crop duration | Nitrogen (g $day^{-1}$) | $K_2O$ (g $day^{-1}$) |
|---|---|---|
| 1-16 DAT | 350 | 375 |
| 17-40 DAT | 2067 | 1250 |
| 41-60 DAT | 1240 | 3200 |

## 3. RESULTS AND DISCUSSION

### 3.1 Dry Matter Production

Dry matter production was significantly influenced by both drip irrigation levels and drip NK fertigation levels in all stages except effect of drip irrigation levels at 30 DAT. Interaction was non significant at all stages. (Table 2 )

Dry matter production was significantly higher in drip irrigation scheduled at 1.0 Epan during 45 DAT, in leaf, curd and total dry matter at harvest (43.6, 99.3, 58.0 and 157.2 g $plant^{-1}$) than 0.8 Epan ( 34.3, 79.0, 49.0 and 128.1 g $plant^{-1}$) and 0.6 Epan ( 30.0, 70.7, 42.2 and 118.8 g $plant^{-1}$) respectively. Total plant dry matter at harvest was on par 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, more number of leaves $plant^{-1}$, higher leaf area and ultimately higher dry matter production. Similar results were found by Sohail et al. [10].

Increase in drip NK fertigation level from control (N0K0), 50% recommended dose of NK to 100 % recommended dose of NK significantly increased the dry matter production $plant^{-1}$ across all stages of 30 DAT (5.9, 11.3 and 15.7 g $plant^{-1}$), 45 DAT (24.1, 38.3 and 45.5 g $plant^{-1}$) 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 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 were akin with the outcome of Kishor [3], Gadhavi et al. [11] and Sohail et al. [10] who got significantly higher dry matter plant$^{-1}$ at 100 % RDF than other doses.

### 3.2 Curd Yield

Curd yield was significantly influenced by both drip irrigation and ifferent drip NK fertigation levels. Interaction was found to be non significant (Table 2 ).

Curd yield was significantly higher in drip irrigation scheduled 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$^{-1}$). Curd yield at 0.8 Epan was significantly higher than 0.6 Epan. This might be due to that, the optimum moisture in the vicinity of root zone throughout the crop growth period enhanced the vegetative growth in the form of higher plant height, number of leaves plant$^{-1}$, leaf area, chlorophyll content and dry matter production 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 [12], Popale et al. [13], Biswal [14].

Every increment level in NK fertigation from 0 to 100 % recommended dose of NK fertigation significantly increased the curd yield. 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 control ($N_0K_0$) (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. [13], Kapoor and Sandal [15], Gadhavi et al. [11] and Kumar and Sahu [16]

### 3.3 Plant Nitrogen Content and Uptake

Plant nitrogen content was significantly influenced by both irrigation and fertigation levels at all stages. Interaction was found to be non significant at all stages (Table 3). Among the irrigation levels it ranged from 0.79 to 0.94%, 1.44 to 1.69%, 2.02 to 2.41% and 2.38 to 2.75% at 30, 40 DAT, in leaf and curd samples respectively. Significantly higher N content was observed in irrigation scheduled at 1.0 Epan and least in 0.6 Epan at all stages. N content between 1.0 Epan and 0.8 Epan at 45 DAT and in leaf were comparable with each other where as in curd, N content at 0.8 and 0.6 Epan were on par.

Among the fertigation levels, it ranged from 0.65 to 1.09%, 1.37 to 1.76%, 1.97 to 2.41% and 2.38 to 2.75% at 30 DAT, 45 DAT, in leaf and curd samples respectively. It increased significantly with increased fertigation levels from control to 100% recommended dose of NK at all stages except at 45 DAT, in leaf and curd samples N content at 100% recommended dose of NK was on par with 50% recommended dose of NK and least in control. These results were in line with the Jahan et al. [17] and Shams and Farag (18).

Nitrogen 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 scheduled at 1.0 Epan recorded significantly higher nitrogen uptake during 30, 45 DAT, in leaf and curd (6.03, 37.1, 120.4 and 80.3 kg ha$^{-1}$) than 0.8 Epan (4.54, 29, 90.6 and 62.9 kg ha$^{-1}$) and 0.6 Epan (4.48, 21.7, 72.8 and 53.4 kg ha$^{-1}$) respectively. Nitrogen uptake was significantly higher in irrigation scheduled at 1.0 Epan than 0.8 Epan and 0.6 Epan at all stages except during 30 DAT where it was comparable between 0.8 Epan and 0.6 Epan. The results were in accordance with the findings of Kumar and Sahu [16], Kapoor and sandal [15], Singh et al. [18] and Shams and Farag [19] who reported higher nitrogen uptake at higher irrigation levels.

Nitrogen uptake increased significantly with an each increment in drip NK fertigation level from control ($N_0K_0$) to 100% recommended dose of NK fertigation at all stages. Nitrogen uptake was significantly higher at 100% recommended dose of NK (8.52, 37.8, 127.9 and 93.5 kg ha$^{-1}$) than 50% recommended dose of NK (4.63, 33.5, 102.7 and 76.5 kg ha$^{-1}$)

and control (1.91, 16.5, 53.3 and 26.7 kg $ha^{-1}$) during 30 DAT, 45 DAT, in leaf and curd respectively. Similar results were obtained by Kapoor and Sandal [15], Singh et al. [18], Jahan et al. [17], Kumar and Sahu [16] and Kishor [3].

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%.

## 3.4 Plant Phosphorous Content and Uptake

The P content in cauliflower plant was significantly influenced by both irrigation and fertigation levels except irrigation levels during 30 DAT and interaction effect during all stages were found to be non significant (Table 4). Among the irrigation levels it ranged from 0.036 to 0.044%, 0.094% to 0.157%, 0.228 to 0.364% and 0.458 to 0.618% at 30 DAT, 45 DAT, in leaf and curd respectively. Irrigation scheduled at 1.0 Epan recorded significantly higher P content than 0.8 Epan and 0.6 Epan and the least was noticed in 0.6 Epan at 45 DAT, in leaf and curd samples. But P content at 0.6 Epan and 0.8 Epan were comparable in curd samples.

Among the fertigation levels, it ranged from 0.020 to 0.059%, 0.081 to 0.166%, 0.186 to 0.397% and 0.358 to 0.694% at 30 DAT, 45 DAT, in leaf and curd respectively (Table). Significantly higher Phosphorous content was noticed at 100% recommended dose of NK followed by 50% recommended dose and the least in control at all stages. These results were in line with the Jahan et al. [17] and Shams and Farag [19].

Phosphorous uptake was significantly influenced by both drip irrigation levels and different drip NK fertigation levels at all stages except at 30 DAT where irrigation levels did not show any significant effect on phosphorous uptake. Interaction was found to be non significant at all stages (Table 4 ).

Among irrigation levels, drip irrigation scheduled at 1.0 Epan recorded significantly higher phosphorous uptake during 45 DAT, in leaf and curd (3.5, 18.5 and 18.0 kg $ha^{-1}$) than 0.8 Epan (2.5,13.4 and 13.6 kg $ha^{-1}$ ) and 0.6 Epan (1.6, 9.2 and 11.5 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 [15], Singh et al. [18] and Shams and Farag [19] 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 control ($N_0K_0$) to 100 % recommended dose of NK fertigation at all stages. Phosphorous uptake was significantly higher at 100 % recommended dose of NK (0.4, 3.7, 20.9 and 23.6 kg $ha^{-1}$) than 50 % recommended dose of NK (0.2, 2.8, 15.0 and 15.2 kg $ha^{-1}$) and control (0.1, 1.0, 5.2 and 4.2 kg $ha^{-1}$) during 30 DAT, 45 DAT, in leaf and curd respectively. Similar results were obtained by Kapoor and Sandal [15], Singh et al. [18], Jahan et al. [17], Kumar and Sahu [16] and Kishor [3] who found higher phosphorous uptake at high fertigation levels.

## 3.5 Plant Potassium Content and Uptake

Plant potassium content was significantly influenced by both irrigation and fertigation levels at all stages except at 45 DAT where irrigation levels and interaction effect at all stages found to be non significant (Table 5).

Among the irrigation levels potassium content ranged from 1.22 to 1.43%, 2.58 to 2.70%, 3.32 to 3.79% and 2.20 to 2.48% at 30 DAT, 45 DAT, leaf and curd samples respectively. Irrigation scheduled at 1.0 Epan recorded significantly higher K content followed by 0.8 Epan and least was noticed at 0.6 Epan at 30 DAT and in leaf samples while in curd samples, irrigation scheduled at 1.0 Epan recorded significantly higher K content than 0.6 Epan and the K content at between 1.0 Epan and 0.8 Epan and 0.8 Epan and 0.6 Epan were comparable.

Among the fertigation levels, it ranged from 0.88 to 1.75%, 2.49 to 3.09%, 3.16 to 3.98% and 2.10 to 2.63% at 30 DAT, 45 DAT, leaf and curd samples respectively. Significantly higher K content was recorded in 100% recommended dose of NK followed by 50% recommended dose and least in control at all stages. These results were in line with the Jahan et al. [17] and Shams and Farag [19].

**Table 2. Dry matter production (g plant$^{-1}$) at different days after transplanting and curd yield of cauliflower as influenced by varied drip irrigation and fertigation levels**

| Treatments | 30 DAT | 45 DAT | Harvest | | | Curd yield (t ha$^{-1}$) |
|---|---|---|---|---|---|---|
| | | | Leaf | Curd | Total | |
| Main plots - Irrigation levels | | | | | | |
| $I_1$: Drip irrigation at 0.6 Epan | 10.7 | 30.0 | 70.7 | 42.2 | 118.8 | 15.0 |
| $I_2$: Drip irrigation at 0.8 Epan | 10.2 | 34.3 | 79.0 | 49.1 | 128.1 | 17.1 |
| $I_3$: Drip irrigation at 1.0 Epan | 12.1 | 43.6 | 99.3 | 58.0 | 157.2 | 18.7 |
| SEm ± | 0.5 | 0.8 | 1.6 | 1.1 | 2.8 | 0.2 |
| C.D (P=0.05) | NS | 3.1 | 6.7 | 4.5 | 11.5 | 0.8 |
| Sub plots - Fertigation levels | | | | | | |
| $F_1$:Control ($N_0$ $K_0$) | 5.9 | 24.1 | 54.2 | 22.4 | 76.6 | 7.2 |
| $F_2$:50 % Recommended dose ($N_{40}$ $K_{50}$) | 11.3 | 38.3 | 88.1 | 58.3 | 146.4 | 19.7 |
| $F_3$:100 % Recommended dose ($N_{80}$ $K_{100}$) | 15.7 | 45.5 | 106.7 | 68.5 | 174.1 | 23.8 |
| SEm ± | 0.3 | 1.1 | 2.2 | 1.3 | 3.4 | 0.6 |
| C.D (P=0.05) | 0.9 | 3.6 | 7.0 | 4.2 | 10.6 | 2.0 |
| Fertigation at same level of irrigation | | | | | | |
| SEm ± | 0.9 | 1.3 | 2.9 | 2.0 | 4.9 | 0.4 |
| C.D (P=0.05) | NS | NS | NS | NS | NS | NS |
| Irrigation at same or different fertigation levels | | | | | | |
| SEm ± | 0.6 | 1.8 | 3.5 | 2.2 | 5.6 | 1.0 |
| C.D (P=0.05) | NS | NS | NS | NS | NS | NS |

**Table 3. Nitrogen content and uptake of cauliflower at different days after transplanting as influenced by varied drip irrigation and fertigation levels**

| Treatments | Nitrogen content (%) | | | | Nitrogen uptake (kg $ha^{-1}$) | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 30 DAT | 45 DAT | Harvest leaf | curd | 30 DAT | 45 DAT | Harvest Leaf | curd | Total |
| Main plots - Irrigation levels | | | | | | | | | |
| $I_1$: Drip irrigation at 0.6 Epan | 0.79 | 1.44 | 2.02 | 2.45 | 4.48 | 21.7 | 72.8 | 53.4 | 126.2 |
| $I_2$: Drip irrigation at 0.8 Epan | 0.84 | 1.67 | 2.29 | 2.53 | 4.54 | 29.0 | 90.6 | 62.9 | 153.6 |
| $I_3$: Drip irrigation at 1.0 Epan | 0.94 | 1.69 | 2.41 | 2.77 | 6.03 | 37.1 | 120.4 | 80.3 | 200.8 |
| SEm ± | 0.01 | 0.04 | 0.05 | 0.05 | 0.16 | 0.69 | 2.4 | 2.3 | 4.3 |
| C.D (P=0.05) | 0.05 | 0.16 | 0.19 | 0.19 | 0.65 | 2.79 | 9.7 | 9.1 | 17.5 |
| Sub plots - Fertigation levels | | | | | | | | | |
| $F_1$:Control ($N_0$ $K_0$) | 0.65 | 1.37 | 1.97 | 2.38 | 1.91 | 16.5 | 53.3 | 26.7 | 80.0 |
| $F_2$:50 % Recommended dose ($N_{40}$ $K_{50}$) | 0.83 | 1.76 | 2.34 | 2.62 | 4.63 | 33.5 | 102.7 | 76.5 | 179.2 |
| $F_3$:100 % Recommended dose ($N_{80}K_{100}$) | 1.09 | 1.67 | 2.41 | 2.75 | 8.52 | 37.8 | 127.9 | 93.5 | 221.4 |
| SEm ± | 0.02 | 0.05 | 0.05 | 0.05 | 0.13 | 1.06 | 3.4 | 2.4 | 4.7 |
| C.D (P=0.05) | 0.05 | 0.17 | 0.16 | 0.16 | 0.41 | 3.32 | 10.6 | 7.5 | 14.6 |
| Fertigation at same level of irrigation | | | | | | | | | |
| SEm ± | 0.02 | 0.07 | 0.08 | 0.08 | 0.28 | 1.2 | 0.08 | 3.9 | 7.5 |
| C.D (P=0.05) | NS | NS | NS | NS | NS | NS | NS | NS | NS |
| Irrigation at same or different fertigation levels | | | | | | | | | |
| SEm ± | 0.03 | 0.09 | 0.09 | 0.09 | 0.25 | 0.09 | 0.09 | 4.1 | 7.9 |
| C.D (P=0.05) | NS | NS | NS | NS | NS | NS | NS | NS | NS |

**Table 4. Phosphorous content and uptake of cauliflower at different days after transplanting as influenced by varied drip irrigation and fertigation levels**

| Treatments | Phosphorous content (%) | | | | Phosphorous uptake (kg $ha^{-1}$) | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 30 DAT | 45 DAT | Harvest leaf | curd | 30 DAT | 45 DAT | Harvest Leaf | curd | Total |
| Main plots - Irrigation levels | | | | | | | | | |
| $I_1$: Drip irrigation at 0.6 Epan | 0.036 | 0.094 | 0.228 | 0.458 | 0.2 | 1.6 | 9.2 | 11.5 | 20.7 |
| $I_2$: Drip irrigation at 0.8 Epan | 0.042 | 0.138 | 0.322 | 0.499 | 0.2 | 2.5 | 13.4 | 13.6 | 27.0 |
| $I_3$: Drip irrigation at 1.0 Epan | 0.044 | 0.157 | 0.364 | 0.618 | 0.3 | 3.5 | 18.5 | 18.0 | 36.5 |
| SEm ± | 0.002 | 0.004 | 0.007 | 0.014 | 0.02 | 0.1 | 0.6 | 0.6 | 1.1 |
| C.D (P=0.05) | NS | 0.015 | 0.027 | 0.054 | NS | 0.5 | 2.3 | 2.6 | 4.6 |
| Sub plots - Fertigation levels | | | | | | | | | |
| $F_1$:Control ($N_0$ $K_0$) | 0.020 | 0.081 | 0.186 | 0.358 | 0.1 | 1.0 | 5.2 | 4.2 | 9.5 |
| $F_2$:50 % Recommended dose ($N_{40}$ $K_{50}$) | 0.042 | 0.142 | 0.332 | 0.522 | 0.2 | 2.8 | 15.0 | 15.2 | 30.2 |
| $F_3$:100 % Recommended dose ($N_{80}K_{100}$) | 0.059 | 0.166 | 0.397 | 0.694 | 0.4 | 3.7 | 20.9 | 23.6 | 44.5 |
| SEm ± | 0.001 | 0.004 | 0.008 | 0.015 | 0.01 | 0.2 | 0.8 | 0.9 | 1.6 |
| C.D (P=0.05) | 0.003 | 0.013 | 0.026 | 0.048 | 0.04 | 0.6 | 2.6 | 2.9 | 4.9 |
| Fertigation at same level of irrigation | | | | | | | | | |
| SEm ± | 0.003 | 0.006 | 0.012 | 0.023 | 0.04 | 0.2 | 0.9 | 1.1 | 1.9 |
| C.D (P=0.05) | NS | NS | NS | NS | NS | NS | NS | NS | NS |
| Irrigation at same or different fertigation levels | | | | | | | | | |
| SEm ± | 0.002 | 0.007 | 0.014 | 0.026 | 0.03 | 0.3 | 1.3 | 1.4 | 2.5 |
| 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 5).

Drip irrigation scheduled at 1.0 Epan recorded significantly higher potassium uptake during 35 DAT, 45 DAT, in leaf and curd (9.25, 63.0, 190.5 and 73.4 kg $ha^{-1}$) than 0.8 Epan (7.22, 45.7, 140.5 and 59.4 kg $ha^{-1}$ ) and 0.6 Epan (7.19, 40.7, 118.7 and 47.6 kg $ha^{-1}$ ) respectively. At 35 DAT, potassium uptake was comparable between 0.8 Epan and 0.6 Epan. The results were corroborate with the findings of Kumar and Sahu [16], Kapoor and sandal [15], Singh et al. [18] and Shams and Farag [19] who reported higher potassium uptake at high irrigation levels.

Potassium uptake increased significantly with an each increment in drip NK fertigation level from control ($N_0K_0$) to 100 % recommended dose of NK fertigation at all stages. Potassium uptake was significantly higher at 100 % recommended dose of NK (13.59, 69.8, 210.9 and 89.1 kg $ha^{-1}$) than 50 % recommended dose of NK (7.47, 49.9, 153.8 and 68.2 kg $ha^{-1}$ ) and control (2.61, 29.6, 84.9 and 23 kg $ha^{-1}$ ) during 30 DAT, 45 DAT, in leaf and curd respectively. Similar results were obtained by Kapoor and Sandal [15], Singh et al. [19], Jahan et al. [17], Kumar and Sahu [16] and Kishor [3] who found higher potassium uptake at high fertigation levels.

### 3.6 Plant Sulphur Content and Uptake

The S content in cauliflower plant was significantly influenced by both irrigation and fertigation levels in curd. The S content was found to be non significant at all other stages among irrigation and fertigation levels and in interaction (Table 6).

Among the irrigation levels sulphur ranged from 0.004 to 0.005%, 0.012 to 0.014%, 0.029 to 0.034% and 0.011 to 0.016% at 30, 45 DAT, in leaf and curd samples respectively. Irrigation scheduled at 0.6 Epan recorded significantly higher S content and lower at 0.8 and 1.0 Epan during 30 DAT and in curd samples.

Among the fertigation levels, Sulphur content ranged from 0.003 to 0.005%, 0.013 to 0.014%, 0.027 to 0.034% and 0.002 to 0.012% at 30, 45 DAT, in leaf and curd samples respectively. Significantly higher S content was recorded in control followed by 50% recommended dose of NK and least was noticed in 100% recommended dose of NK in curd samples.

Sulphur uptake was significantly influenced by drip, NK fertigation levels at all stages. Sulphur uptake under drip irrigation levels and interaction effect at all stages was found to be non significant except at 45 DAT, where drip irrigation levels significantly influenced the sulphur uptake (Table 6 ).

Drip irrigation scheduled at 1.0 Epan recorded significantly higher sulphur uptake during 45 DAT (0.3 kg $ha^{-1}$) than 0.8 Epan (0.21 kg $ha^{-1}$ ) and 0.6 Epan (0.21 kg $ha^{-1}$ ) respectively. Sulphur uptake was found comparable between 0.8 Epan and 0.6 Epan.

Sulphur uptake increased significantly with an increment in drip NK fertigation level from control ($N_0K_0$) to 100% recommended dose of NK fertigation at all stages. Sulphur uptake was significantly higher at 100 % recommended dose of NK (0.04, 0.3, 1.8 and 0.7 kg $ha^{-1}$) than 50 % recommended dose of NK ( 0.02, 0.2, 1.4 and 0.2 kg $ha^{-1}$) and control (0.01, 0.2, 0.7, and 0.1 kg $ha^{-1}$ ) during 30 DAT, 45 DAT, in leaf and curd respectively. Sulphur uptake was comparable between control and 50 % recommended dose of NK at 30 DAT.

### 3.7 Post Harvest Soil Status of N, $P_2o_5$ and $K_2o$

Drip irrigation levels and NK fertigation levels significantly influenced the final soil available NPK status. Interactions were observed to be not significant (Table 7).

Among drip irrigation levels, final soil N, $P_2O_5$ and $K_2O$ status was significantly higher in irrigation scheduled at 0.6 Epan (317.08, 80.27 and 408.72 kg $ha^{-1}$) than 0.8 Epan (309.56, 78.65 and 399.22 kg $ha^{-1}$) and 1.0 Epan (301.00, 76.0 and 386.82 kg $ha^{-1}$) . Irrigation scheduled at 0.8 Epan was observed to be significantly higher with regard to final soil available N, $P_2O_5$ and $K_2O$ status than 1.0 Epan.

Soil available N and $K_2O$ status was increased significantly with each increment of NK fertigation level from control ($N_0K_0$) to 100 % recommended dose of NK. Soil available N and $K_2O$ status was significantly higher at 100 %

**Table 5. Potassium content and uptake of cauliflower at different days after transplanting as influenced by varied drip irrigation and fertigation levels**

| Treatments | Potassium content (%) | | | | Potassium uptake (kg ha$^{-1}$) | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 30 DAT | 45 DAT | Harvest leaf | curd | 30 DAT | 45 DAT | Harvest Leaf | curd | Total |
| Main plots - Irrigation levels | | | | | | | | | |
| $I_1$: Drip irrigation at 0.6 Epan | 1.22 | 2.70 | 3.32 | 2.20 | 7.19 | 40.7 | 118.7 | 47.6 | 166.3 |
| $I_2$: Drip irrigation at 0.8 Epan | 1.31 | 2.66 | 3.53 | 2.37 | 7.22 | 45.7 | 140.5 | 59.4 | 199.9 |
| $I_3$: Drip irrigation at 1.0 Epan | 1.43 | 2.58 | 3.79 | 2.48 | 9.25 | 63.0 | 190.5 | 73.4 | 263.9 |
| SEm ± | 0.01 | 0.04 | 0.02 | 0.05 | 0.39 | 0.6 | 2.5 | 0.7 | 3.1 |
| C.D (P=0.05) | 0.06 | NS | 0.10 | 0.19 | 1.57 | 2.5 | 10.0 | 2.9 | 12.3 |
| Sub plots - Fertigation levels | | | | | | | | | |
| $F_1$:Control ($N_0$ $K_0$) | 0.88 | 2.49 | 3.16 | 2.10 | 2.61 | 29.6 | 84.9 | 23.0 | 108.0 |
| $F_2$:50 % Recommended dose ($N_{40}$ $K_{50}$) | 1.33 | 2.64 | 3.51 | 2.35 | 7.47 | 49.9 | 153.8 | 68.2 | 222.1 |
| $F_3$:100 % Recommended dose ($N_{80}K_{100}$) | 1.75 | 3.09 | 3.98 | 2.63 | 13.59 | 69.8 | 210.9 | 89.1 | 300.1 |
| SEm ± | 0.03 | 0.05 | 0.04 | 0.04 | 0.26 | 1.4 | 4.4 | 1.3 | 4.8 |
| C.D (P=0.05) | 0.08 | 0.14 | 0.12 | 0.13 | 0.81 | 4.2 | 13.9 | 4.1 | 14.9 |
| Fertigation at same level of irrigation | | | | | | | | | |
| SEm ± | 0.02 | 0.06 | 0.04 | 0.08 | 0.67 | 1.1 | 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 ± | 0.04 | 0.07 | 0.06 | 0.07 | 0.54 | 2.0 | 6.8 | 1.9 | 7.4 |
| C.D (P=0.05) | NS | NS | NS | NS | NS | NS | NS | NS | NS |

**Table 6. Sulphur content and uptake of cauliflower at different days after transplanting as influenced by varied drip irrigation and fertigationlevels**

| Treatments | Sulphur content (%) | | | | Sulphur uptake (kg $ha^{-1}$) | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 30 DAT | 45 DAT | Harvest leaf | curd | 30 DAT | 45 DAT | Harvest Leaf | curd | Total |
| Main plots - Irrigation levels | | | | | | | | | |
| $I_1$: Drip irrigation at 0.6 Epan | 0.005 | 0.014 | 0.034 | 0.016 | 0.03 | 0.21 | 1.2 | 0.3 | 1.5 |
| $I_2$: Drip irrigation at 0.8 Epan | 0.004 | 0.012 | 0.030 | 0.011 | 0.02 | 0.21 | 1.2 | 0.3 | 1.5 |
| $I_3$: Drip irrigation at 1.0 Epan | 0.004 | 0.014 | 0.029 | 0.013 | 0.02 | 0.3 | 1.4 | 0.3 | 1.7 |
| SEm ± | 0.0004 | 0.001 | 0.002 | 0.001 | 0.02 | 0.01 | 0.08 | 0.02 | 0.08 |
| C.D (P=0.05) | 0.001 | NS | NS | 0.002 | NS | 0.05 | NS | NS | NS |
| Sub plots - Fertigation levels | | | | | | | | | |
| $F_1$:Control ($N_0$ $K_0$) | 0.003 | 0.013 | 0.027 | 0.012 | 0.01 | 0.2 | 0.7 | 0.1 | 0.8 |
| $F_2$:50 % Recommended dose ($N_{40}$ $K_{50}$) | 0.004 | 0.014 | 0.032 | 0.007 | 0.02 | 0.2 | 1.4 | 0.2 | 1.6 |
| $F_3$:100 % Recommended dose ($N_{80}K_{100}$) | 0.005 | 0.014 | 0.034 | 0.002 | 0.04 | 0.3 | 1.8 | 0.7 | 2.4 |
| SEm ± | 0.001 | 0.001 | 0.002 | 0.0004 | 0.001 | 0.02 | 0.1 | 0.02 | 0.1 |
| C.D (P=0.05) | NS | NS | NS | 0.001 | 0.004 | 0.05 | 0.3 | 0.06 | 0.34 |
| Fertigation at same level of irrigation | | | | | | | | | |
| SEm ± | 0.001 | 0.001 | 0.004 | 0.001 | 0.004 | 0.02 | 0.1 | 0.04 | 0.14 |
| C.D (P=0.05) | NS | NS | NS | NS | NS | NS | NS | 0.1 | NS |
| Irrigation at same or different fertigation levels | | | | | | | | | |
| SEm ± | 0.001 | 0.001 | 0.004 | 0.001 | 0.003 | 0.03 | 0.2 | 0.03 | 0.17 |
| C.D (P=0.05) | NS | NS | NS | NS | NS | NS | NS | 0.1 | NS |

**Table 7. Influence of varied drip irrigation levels and fertigation levels on soilnutrient status after harvest**

| Treatments | Soil status after harvest (kg ha$^{-1}$) | | |
|---|---|---|---|
| | N | $P_2O_5$ | $K_2O$ |
| Main plots - Irrigation levels | | | |
| $I_1$: Drip irrigation at 0.6 Epan | 317.08 | 80.27 | 408.72 |
| $I_2$: Drip irrigation at 0.8 Epan | 309.56 | 78.65 | 399.22 |
| $I_3$: Drip irrigation at 1.0 Epan | 301.00 | 76.00 | 386.82 |
| SEm ± | 1.03 | 0.28 | 1.00 |
| C.D (P=0.05) | 4.16 | 1.15 | 4.06 |
| Sub plots - Fertigation levels | | | |
| $F_1$:Control ($N_0$ $K_0$) | 290.78 | 78.57 | 376.55 |
| $F_2$:50 % Recommended dose ($N_{40}$ $K_{50}$) | 313.90 | 78.22 | 399.60 |
| $F_3$:100 % Recommended dose ($N_{80}K_{100}$) | 322.96 | 78.13 | 418.61 |
| SEm ± | 0.90 | 0.39 | 0.77 |
| C.D (P=0.05) | 3.09 | NS | 2.40 |
| Fertigation at same level of irrigation | | | |
| SEm ± | 1.78 | 0.49 | 1.74 |
| C.D (P=0.05) | 5.9 | 2.25 | NS |
| Irrigation at same or different fertigation levels | | | |
| SEm ± | 1.74 | 0.62 | 1.48 |
| C.D (P=0.05) | 5.9 | 2.07 | NS |
| Initial soil nutrient status (kg ha$^{-1}$) | N | P | K |
| | 326.4 | 77.8 | 429.9 |

recommended dose of NK (322.96 and 418.61 kg ha$^{-1}$) than 50 % recommended dose of NK (313.90 and 399.60 kg ha$^{-1}$) and control (290.78 and 376.55) respectively. Drip NK fertigation levels did not show any significant influence on soil available P status.

It was noticed that, final status of available nitrogen was depleted in all drip irrigation treatments when compared to initial soil available nitrogen status. The depletion level was ranged from 2.9 to 8.4 % and it was higher in irrigation scheduled at 1.0 Epan (8.4 %) followed by 0.8 Epan (5.4 %)and depletion level was lower at 0.6 Epan (2.9 %). Among fertigation treatments, the depletion level of final soil available nitrogen status was ranged from 1.0 to 12.2 %. The depletion level was higher at control treatments (12.2 %) followed by 50 % recommended dose of NK (4.0 %) and was lesser at 100% recommended dose of NK (1.0 %).

The final soil available $P_2O_5$ was added in both drip irrigation and fertigation treatments than initial status. Among irrigation levels, soil available $P_2O_5$ built up was ranged from 1.1 to 3.2 % and it was higher in irrigation scheduled at 0.6 Epan (3.2 %) and accumulation was lower in 0.8 Epan. Whereas in 1.0 Epan, the final soil available $P_2O_5$ was depleted to 2.3 % as compared to initial status. Among fertigation levels, addition of final soil available $P_2O_5$ was ranged from 0.4 to 1.0% and it was higher at control (1.0 %) followed by 50 % recommended dose of NK (0.5 %) and lower at 100% recommended dose of NK (0.4 %).

Both drip irrigation and fertigation levels exhausted the final soil available $K_2O$ as compared to initial value. Among drip irrigation treatments, the depletion level was ranged from 5.1 to 11.1%. The depletion level was higher in irrigation scheduled at 1.0 Epan (11.1 %) followed by 0.8 Epan (7.7 %) and least in 0.6 Epan (5.1 %). Among fertigation treatments, the depletion level of final soil available $K_2O$ was ranged from 2.7 to 14.2 % and depletion level was higher at control (14.2 %) followed by 50 % recommended dose of NK (7.7 %) and it was least at 100% recommended dose of NK (2.7%).

## 4. CONCLUSION

It is concluded that cauliflower crop grown during *rabi* season under micro irrigation in sandy loam soils of Southern Telangana Zone, 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.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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