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NPK Uptake Studies under Varied Drip Irrigation Regimes and NK Fertigation Levels in Cucumber in Naturally Ventilated Poly House

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The present study was conducted in naturally ventilated poly house at Horticulture garden, College of Agriculture, Rajendranagar, Hyderabad, Telangana during *rabi* 2020- 2021 to standardize the optimum N and K fertigation levels and their effect on growth, yield and uptake of nutrients and to derive the nutrients uptake curves for cucumber under poly house during *rabi* (yasangi).The experiment was laid out in a split plot design with 12 treatments consist of three irrigation regimes *viz.*,drip irrigation scheduled at 0.8 Epan (I_1), 1.0 Epan (I_2) and 1.2 Epan (I_3) as main plots and four NK fertigation levels of 75% recommended dose of NK (F_1- $N_{112.5}$ K_{75}), 100% recommended dose of NK (F_2- N_{150} K_{100}), 125% recommended dose of NK (F_3- $N_{187.5}$ K_{125}) and 150% recommended

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dose of NK (F_4- N_{225} K_{150}) as sub plots and replicated thrice. NPK uptake were significantly higher in irrigation scheduled at 1.2 Epan followed by 1.0 and 0.8 Epan during all stages. Among drip fertigation levels NPK uptake increased with each increment in drip fertigation level from 75% recommended dose of NK to 150% recommended dose of NK at all stages.

Keywords: Fertigation; NPK uptake; Epan; drip irrigation; cucumber.

1. INTRODUCTION

Vegetables cultivation has lot of scope for income improvement of small and marginal farmers in India. It has vast potential to earn foreign exchange by export. Farmers are seeking innovative methods for increasing yield and quality of the vegetables. Vegetable production under protected structures is the best way to obtain higher yield and quality produce, especially cucurbits. Salad cucumber is a commercial crop. In naturally ventilated poly houses, salad cucumber can be grown round the year. Higher yield potential is obtained in poly houses than open field conditions with best management.

It is grown both under open conditions and poly house. Cucumber can be grown throughout the year in poly house condition and quality of fruit is high because of less incidence of pests and diseases and the photosynthetic activity is increased and transpiration losses reduced by which high water and nutrient efficiency is achieved.

The current problem with large scale cultivation of cucumber is that unreasonable water and fertilizer management system (high fertilizer application and inefficient irrigation) not only caused unnecessary waste of water and fertilizer resources, but also led to shallow groundwater nitrate pollution and other environmental problems [1]. Sustainability of any system requires optimal utilization of resources such as water, fertilizer and soil. Fertilizer management is the most important agro-technique, which controls development, yield and quality of a crop. Every attempt is therefore necessary in achieving this objective of higher water and fertilizer use efficiency. Under these circumstances, fertigation, which is known to be hi-tech and efficient way of applying fertilizers through irrigation system as a carrier and distributor of crop nutrients, holds bright promise [2]. Maximization of crop yield, quality and minimization of leaching loss of nutrients below the rooting zone could be achieved by managing fertilizer concentrations in measured quantities of irrigation water using drip irrigation [3].

The package of practices for both irrigation and nutrient management were framed for cucumber varieties which are grown under open field conditions. Recently salad cucumber cultivation under poly houses is gaining popularity in Telangana, where farmers are relying on hybrids which require proper input management especially nutrient and irrigation management for achieving higher yields.

2. MATERIALS AND METHODS

The experiment entitled “Drip irrigation regimes and NK fertigation levels for cucumber (*Cucumis sativus* L.) under naturally ventilated poly house” was conducted at Horticulture garden, College of Agriculture, Professor Jayashankar Telangana State Agricultural University (PJTSAU), Rajendranagar, Hyderabad, Telangana during *rabi* 2020-2021. It is situated at 17°19' 12.93” N latitude, 78°24' 58.13” E longitude and at an altitude of 545 m above MSL in the Southern Telangana Agro-Climatic Zone in Telangana State. It is categorized under semi- arid tropics as per the Troll's [4] classification. The experiment soil belongs to sandy clay loam in texture with rapid infiltration rate, slightly alkaline in reaction and non saline. The soil fertility status of field was low in organic carbon, medium in available nitrogen and available phosphorous and high in available potassium.

The experiment was laid out in split plot design comprising of 12 treatments with three replications. The treatments consist of three irrigation regimes as main plots viz., Drip irrigation scheduled at 0.8 Epan , Drip irrigation scheduled at 1.0 Epan and Drip irrigation scheduled at 1.2 E Pan and four N and K fertigation levels as sub plots viz.,75% RDNK (112.5:100:75 kg N P2O5 K2O ha-1), 100% RDNK (150:100:100 kg N P2O5 K2O ha^{-1}), 125% RDNK (187.5:100:125 kg N P2O5 K2O ha-1) and 150% RDNK (225:100:150 kg N P_2O5 K_2O ha^{-1}).

NPK fertilizers were applied in the form of urea, single super phosphate and white MOP. Recommended dose of fertilizers 150:100:100 N, P_2O_5 and K_2O kg ha^{-1} was used. A common dose of P_2O_5 @ 100 kg ha^{-1} was applied commonly to all the treatments as basal dose before sowing. Nitrogen and potassium were applied through fertigation with the help of venturi system at different growth stages as per treatments (75% Recommended dose of NK ($N_{112.5}$ K_{75}), 100% recommended dose of NK (N_{150} K_{100}) and 125% recommended dose of NK ($N_{187.5}$ K_{125}) and 150% recommended dose of NK (N_{225} K_{150}). The total 19 number of fertigations were given once in four days interval starting from 15 DAS (Days after Sowing) to 90 DAS.

The data was recorded on dry matter production (g $plant^{-1}$), and fruit yield per vine (kg). Pounded samples of leaf and fruit at harvest were used for nitrogen content (%) estimation by the micro Kjeldhal method or Kjeldahl digestion using KELPLUS SUPRA LX – analyser [5]. The Di-acid digested plant and fruit 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 fruit 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 fruit yield as follows.

Nutrient uptake (kg ha^{-1}) = (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. Available P status was analyzed by Olsen's method for extraction and Ascorbic acid method for estimation by using UV-VIS spectrophotometer (Make- systronics, Model-108) at 420 nm. Neutral normal ammonium acetate method using (Make-Elico, Model-CL361), Flame photometer was adopted for analysis of available potassium status.

The collected data was statistically analyzed by analysis of variance (ANOVA) for split plot design. OP STAT software was used for analysis [7]. Whenever the treatment differences were found significant, critical differences were worked out at five per cent probability level in LSD. Treatment differences that were non significant were denoted by NS and the results were critically interpreted with proper justification with relevant literature.

3. RESULTS AND DISCUSSION

3.1 Dry Matter Production

Dry matter production was significantly higher in drip irrigation scheduled at 1.2 Epan (10.6, 177.6 and 184.0 g $plant^{-1}$) than 1.0 Epan (7.2, 125.5 and 138.8 g $plant^{-1}$) and 0.8 Epan (5.1, 90.2 and 103.5 g $plant^{-1}$) at 30 DAS, 60 DAS and at harvest respectively (Table 1).

Dry matter production increased significantly with increase in fertigation level from 75% recommended dose of NK to 150% recommended dose of NK. Significantly higher dry matter production was obtained at 150% recommended dose of NK (9.3, 158.1 and 166.8 g $plant^{-1}$) than 125% (8.2, 140.6 and 149.9 g $plant^{-1}$), 100% recommended dose of NK (7.3, 126.1 and 138.3 g $plant^{-1}$) and 75% recommended dose of NK (5.6, 99.7 and 113.3 g $plant^{-1}$). Dry matter production was comparable at 100% and 125% recommended dose of NK.

3.2 Fruit Yield

Fruit yield was significantly higher in drip irrigation scheduled at 1.2 Epan (83.90 t ha^{-1}) than 1.0 Epan (68.80 t ha^{-1}) and 0.8 Epan (59.50 t ha^{-1}). Fruit yield was comparable between 0.8 Epan and 1.0 Epan. Higher fruit yield at increased drip irrigation level might be due to 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 parts which increased the fruit length, diameter, weight and finally resulted into increased fruit yield of cucumber. Similar findings were reported by Ashour et al. [8], Ningaraju and Joseph [9], Alomran et al. [10] and Sahin et al. [11].

Among the fertigation levels, fruit yield was significantly higher at 150% recommended dose of NK (76.70 t ha^{-1}) than 75% recommended dose of NK (60.30 t ha^{-1}) and on par with 125% (74.20 t ha^{-1}) and 100% recommended dose of NK (71.80 t ha^{-1}). Fruit yield is a cumulative

effect of yield attributes like fruit length, diameter, number of fruits and individual fruit weight. Fruit yield increased gradually with increase in 150% 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 fertigation, which created favorable conditions for growth and development by way of increasing metabolic activities in the plant system. These results are in harmony with the findings of Ningaraju and Joseph [9], Naik et al. [12] and Nisha and Sreelathakumary [13].

3.3 Plant NPK Content

3.3.1 Plant nitrogen content

Plant nitrogen content was significantly influenced by drip irrigation regimes at all stages except 45 DAS 60 DAS and in fruit at 75 DAS where nitrogen content did not influence significantly. Fertigation levels significantly influenced plant nitrogen content at all stages. Interaction was found to be non-significant at all stages (Table 2).

Among drip irrigation regimes nitrogen content in cucumber plant was significantly higher in irrigation scheduled at 1.2 Epan (2.73, 2.78, 1.55, 1.67 and 1.26%) followed by 1.0 Epan (2.54, 2.66, 1.07 1.18 and 0.93%) and least in 0.8 Epan (2.35, 2.40, 0.90, 0.95 and 0.95%) at 15 DAS, 30 DAS, 75 DAS, in plant and fruit at harvest respectively. N content was comparable between 0.8 and 1.0 Epan at 75 DAS and in fruit samples. N content in plant sample at harvest was on par between 1.2 Epan and 1.0 Epan. Similar findings were reported by Hasheem et al. [14].

Among the fertigation levels, significantly higher nitrogen content was noticed in cucumber plant at 150% recommended dose of NK (2.91, 3.03, 2.22, 1.34, 1.33 and 1.43%) followed by 125% (2.67, 2.80, 2.10, 1.26, 1.29 and 1.37%) and 100% (2.46, 2.50, 1.99, 1.21, 1.28 and 1.32%) recommended dose of NK and the least nitrogen content was found in 75% recommended dose of NK (2.12, 2.12, 1.40, 0.96, 0.81 and 0.93%) at 15 DAS, 30 DAS, 45 DAS, 60 DAS, 75 DAS and harvest respectively . N content was comparable among 150, 125 and 100% recommended dose of NK at 60 DAS, 75 DAS and in plant at harvest. While at 45 DAS N content was at par between 150 and 125% recommended dose of NK.

Among the fertigation levels, significantly higher nitrogen content was noticed in cucumber fruit at 150% recommended dose of NK (0.92, 1.12 and 1.26%) followed by 125% (0.82, 1.01 and 1.12%) and 100% (0.78, 0.82 and 0.98%) recommended dose of NK and the least nitrogen content was found in 75% recommended dose of NK (0.50. 0.61 and 0.82%) at 60 DAS, 75 DAS and harvest respectively. Fruit sample at 75 DAS and harvest was comparable between 150% and 125% recommended dose of NK and also on par between 100% and 125% recommended dose of NK during 75 DAS while at harvest at par between 75% and 100% recommended dose of NK.

3.3.2 Plant phosphorus content

Plant phosphorus content was significantly influenced by drip irrigation regimes whereas drip fertigation levels and interaction were found non-significant at all stages (Table 3).

Among drip irrigation regimes phosphorus content in cucumber plant was significantly higher in irrigation scheduled at 1.2 Epan (0.95, 1.17, 0.93, 1.36, 1.12 and 1.00%) followed by 1.0 Epan (0.77, 0.98, 0.75, 1.13, 0.92 and 0.82%) and least in 0.8 Epan (0.58, 0.74, 0.56, 0.86, 0.70 and 0.61%) at 15 DAS, 30 DAS, 45 DAS, 60 DAS, 75 DAS and at harvest respectively. Similar findings were reported by Hasheem et al. [14].

Among drip irrigation regimes phosphorus content in cucumber fruit was significantly higher in irrigation scheduled at 1.2 Epan (0.78, 1.19 and 0.89%) followed by 1.0 Epan (0.63, 0.98 and 0.72%) and least in 0.8 Epan (0.46, 0.74 and 0.54%) at 60 DAS, 75 DAS and at harvest respectively.

3.3.3 Plant potassium content

Potassium content was significantly influenced by drip irrigation regimes at all stages except at 15 DAS where potassium content did not influence significantly. Fertigation levels influenced potassium content significantly at all stages. Interaction was found to be non significant at all stages (Table 4).

Among drip irrigation regimes potassium content in cucumber plant was significantly higher in irrigation scheduled at 1.2 Epan (2.199, 2.362, 2.791, 3.220 and 3.091%) followed by 1.0 Epan (1.994, 2.195, 2.594, 2.993 and 2.874%) and least in 0.8 Epan (1.913, 2.104, 2.487, 2.870 and 2.755%) at 30 DAS, 45 DAS, 60 DAS, 75 DAS and at harvest respectively. Potassium content

was on par between 1.0 Epan and 0.8 Epan. Among drip irrigation regimes potassium content in cucumber fruit was significantly higher in irrigation scheduled at 1.2 Epan (2.009, 33.124 and 2,349%) followed by 1.0 Epan (1.868, 2.903 and 2.184%) and least in 0.8 Epan (1.791, 2.784 and 2.094%) at 60 DAS, 75 DAS and at harvest respectively. Potassium content was comparable between 0.8 and 1.0 Epan in fruit at 60DAS and harvest. Similar findings were reported by Hasheem et al. [14].

Among the drip fertigation levels, significantly higher phosphorus content was noticed at 150% recommended dose of NK (0.078, 2.166, 2.351, 2.779, 3.206 and 3.078%) than 100% (0.076, 2.003, 2.200, 2.599, 2.999 and 2.879 %), 75% recommended dose of NK (0.074, 1.951, 2.073, 2.450, 2.827 and 2.714%) and it was comparable with 125% recommended dose of NK (0.078, 2.022, 2.258, 2.668, 3.079 and 2.955%) at 15 DAS, 30 DAS, 45 DAS, 60 DAS, 75 DAS and harvest respectively.

In fruit at 60 DAS, 75 DAS and harvest significantly higher phosphorus content was recorded at 150% recommended dose of NK (2.001, 3.110 and 2.339%) than 100% (1.872, 2.909 and 2.188%) and 75% recommended dose of NK (1.764, 2.742 and 2.063%) and comparable with 125% recommended dose of NK (1.921, 2.986 and 2.246%).

3.4 NPK Uptake

3.4.1 Nitrogen uptake

Nitrogen uptake was significantly influenced by both drip irrigation regimes and NK fertigation levels at all stages. Interaction was found non-significant at all stages (Table 5).

Among drip irrigation regimes significantly higher plant nitrogen uptake was recorded at drip irrigation scheduled at 1.2 Epan (1.9, 14.1, 32.6, 50.8, 13.8, 64.6, 86.3,119.9, 106.4, 65.9 and 172.4 kg ha^{-1}) than 1.0 Epan (1.2, 7.9, 19.0, 29.8, 33.0, 61.1, 42.7,46.6 and 89.3 kg ha^{-1}) and 0.8 Epan (1.0, 5.2, 11.6, 14.7, 20.7, 41.9, 25.4, 38.7 and 64.1 kg ha^{-1}) at 15, 30, 45, in plant at 60 DAS, 75 DAS and at harvest, in fruit 60 DAS and at harvest and total uptake at 60 DAS, 75 DAS and harvest respectively. Plant nitrogen uptake at 1.2 Epan was on par with 1.0 Epan during 60 DAS, while N uptake was comparable between 1.0 Epan and 0.8 Epan at 15 DAS, in plant and total uptake at 60 DAS, 75 DAS, and at harvest. Similar findings were reported by Srinivas et al. [15].

Among fertigation levels nitrogen uptake increased significantly with an each increment in drip NK fertigation level from 75% to 150% recommended dose of NK fertigation at all stages. Nitrogen uptake was significantly higher at 150% recommended dose of NK (1.8, 13.2, 29.6, 44.0, 15..3, 59.3, 63.0, 36.9, 80.3, 64.3 and 144.6 kg ha^{-1}) than 125% recommended dose of NK (1.5, 10.4, 24.2, 35.2, 13.1, 48.2, 52.8, 31.4, 84.2, 67.3, 54.0 and 121.3 kg ha^{-1}), 100% (1.2, 8.1, 21.3, 31.3, 12.0, 43.3, 46.2, 25.0, 71.2, 55.1, 46.8 and 101.8 kg ha^{-1}) and 75% recommended dose of NK (0.9, 4.6, 9.4, 16.7, 7.0, 23.7, 24.8, 17.3, 42.1, 30.0, 36.7 and 66.7 kg ha^{-1}) during all stages except at 45 DAS, in plant samples and total uptake at 60 DAS and 75 DAS and in plant samples at harvest where it was on par between 100% and 125% recommended dose of NK while N uptake was comparable between 150% and 125% recommended dose of NK in fruit at 60 DAS, in plant at 75 DAS and at final harvest. Similar findings were reported by Abdrabbo et al. [16] and Maragal et al. [17].

3.4.2 Phosphorus uptake

Both drip irrigation regimes and fertigation levels significantly influenced the phosphorus uptake at all stages. Interaction was found non-significant at all stages (Table 6).

Among drip irrigation levels, phosphorous uptake was significantly higher in drip irrigation scheduled at 1.2 Epan (0.6, 5.8, 14.1, 50.3, 13.2, 63.6, 57.0, 40.0, 97.1, 60.3, 46.8 and 107.1 kg ha^{-1}) than 1.0 Epan (0.4, 2.8, 6.8, 25.1, 10.3, 35.3, 27.5, 31.5, 59.0, 28.8, 36.3 and 65.1 kg ha^{-1}) and 0.8 Epan (0.3, 1.6, 3.9, 14.4, 6.1, 20.5, 15.9, 19.4, 35.3, 16.6, 21.9 and 38.5 kg ha^{-1}) at 15, 30, 45, in plant, fruit and total uptake at 60 DAS, 75 DAS and at harvest respectively. Similar findings were reported by Srinivas et al. [15].

Among fertigation levels, phosphorous uptake was significantly higher at 150% recommended dose of NK (0.5, 4.8, 11.6, 41.7, 11.6, 53.3, 47.0, 35.3, 30.3, 65.8, 49.7, 41.0 and 90.7 kg ha^{-1}) than 125% (0.4, 3.6, 8.7, 31.7, 9.8, 41.5, 35.5, 30.3, 65.8, 37.4,35.0 and 72.5 kg ha^{-1}) and 100% (0.4, 3.1, 7.6, 27.6, 9.5, 37.0, 30.5, 29.1, 59.6, 31.8, 33.6 and 65.4 kg ha^{-1}) and 75% recommended dose of NK (0.3, 2.1, 5.1, 18.8, 8.6, 27.3, 20.9, 26.5, 47.4, 22.1, 30.4 and

52.4 kg ha^{-1}) at 15, 30, 45, in plant, fruit and total uptake at 60, 75 DAS and at harvest respectively except fruit uptake at 75 DAS where 150% recommended dose of NK was on par with 125% recommended dose of NK. Phosphorous uptake was comparable between 125% and 100% recommended dose of NK during all stages. Similar findings were reported by Abdrabbo et al. [16] and Maragal et al. [17].

3.4.3 Potassium uptake

Both drip irrigation regimes and NK fertigation levels significantly influenced the potassium uptake at all stages. Interaction was found to be non-significant at all stages (Table 7).

Among drip irrigation regimes, potassium uptake was significantly higher in drip irrigation scheduled at 1.2 Epan (0.053, 10.8, 36.8, 104.6, 34.3, 138.9, 167.0, 106.5, 273.4,189.6, 125.5 and 315.0 kg ha^{-1}) than 1.0 Epan (0.035, 5.9, 20.5, 59.1, 30.5, 89.6, 91.4, 94.6, 186.0, 103.4, 111.5 and 214.9 kg ha^{-1}) and 0.8 Epan (0.033, 4.1, 14.1, 40.2, 23.4, 63.7, 63.4, 72.6, 136.0, 71.8, 85.6 and 157.4 kg ha^{-1}) at all the growth stages respectively. Potassium uptake was comparable in plant between 1.0 Epan and 0.8 Epan at 15 DAS, in plant at 75 DAS and final harvest. Similar findings were reported by Srinivas et al. (1989).

Potassium uptake was significantly higher at 150% recommended dose of NK (0.048, 9.3, 31.6, 90.5, 33.4, 123.9, 143.2, 103.4, 246.6, 162.7, 121.8 and 284.5 kg ha^{-1}) followed by 125% recommended dose of NK (0.043, 7.5, 26.0, 74.5, 30.4, 104.9, 117.4, 94.4, 211. 8, 133.5, 111.3 and 244.7 kg ha^{-1}), 100% (0.038, 6.6, 23.1, 65.7, 28.7, 94.4 103.3, 89.1, 192.4, 116.3, 105.0 and 221.4 kg ha^{-1}) and 75% recommended dose of NK (0.033, 4.3, 14.4, 41.3, 25.2, 66.5, 65.2, 78.1, 143.2, 73.9, 91.9 and 165.9 kg ha^{-1}) at all the growth stages respectively. Potassium uptake in plant was on par between 150% and 125% recommended dose of NK and also between 125% and 100% RDNK at all stages. Similar findings were reported by Abdrabbo et al. [16] and Maragal et al. [17].

Table 1. Dry matter production (g plant^{-1}) of cucumber at different days after sowing as influenced by varied drip irrigation and fertigation levels under naturally ventilated poly house

Treatments	10 DAS	30 DAS	60 DAS	Harvest
Main plots - Irrigation levels				
I_1: Drip irrigation at 0.8 Epan	1.0	5.1	90.2	103.5
I_2: Drip irrigation at 1.0 Epan	1.1	7.2	125.5	138.8
I_3: Drip irrigation at 1.2 Epan	1.3	10.6	177.6	184.0
SEm ±	0.07	0.2	3.7	4.0
C.D (P=0.05)	NS	0.8	14.6	15.8
Sub plots - Fertigation levels				
F_1: 75% Recommended dose ($N_{112.5}$ K_{75})	1.1	5.6	99.7	113.3
F_2:100% Recommended dose (N_{150} K_{100})	1.1	7.3	126.1	138.3
F_3:125% Recommended dose ($N_{187.5}$ K_{125})	1.2	8.2	140.6	149.9
F_4:150% Recommended dose (N_{225} K_{150})	1.2	9.3	158.1	166.8
SEm ±	0.08	0.3	4.6	3.9
C.D (P=0.05)	NS	0.9	13.5	11.5
Fertigation at same level of irrigation				
SEm ±	0.14	0.5	8.0	6.7
C.D (P=0.05)	NS	NS	NS	NS
Irrigation at same or different fertigation levels				
SEm ±	0.15	0.5	7.9	7.1
C.D (P=0.05)	NS	NS	NS	NS

Table 2. Nitrogen content (%) of cucumber at different days after sowing as influenced by varied drip irrigation and fertigation levels under naturally ventilated poly house

Treatments	15 DAS	30 DAS	45 DAS	60 DAS		75 DAS		Harvest	
				Plant	Fruit	Plant	Fruit	Plant	Fruit
Main plots - Irrigation levels									
I_1: Drip irrigation at 0.8 Epan	2.35	2.40	1.72	0.86	0.70	0.90	0.81	0.95	0.95
I_2: Drip irrigation at 1.0 Epan	2.54	2.66	2.02	1.34	0.76	1.07	0.88	1.18	0.93
I_3: Drip irrigation at 1.2 Epan	2.73	2.78	2.05	1.38	0.81	1.55	0.99	1.67	1.26
SEm ±	0.03	0.03	0.23	0.14	0.04	0.12	0.08	0.13	0.01
C.D (P=0.05)	0.13	0.10	NS	NS	NS	0.48	NS	0.50	0.04
Sub plots - Fertigation levels									
F_1: 75% Recommended dose ($N_{112.5}$ K_{75})	2.12	2.12	1.40	0.96	0.50	0.81	0.61	0.93	0.82
F_2:100% Recommended dose (N_{150} K_{100})	2.46	2.50	1.99	1.21	0.78	1.28	0.82	1.32	0.98
F_3:125% Recommended dose ($N_{187.5}$ K_{125})	2.67	2.80	2.10	1.26	0.82	1.29	1.01	1.37	1.12
F_4:150% Recommended dose (N_{225} K_{150})	2.91	3.03	2.22	1.34	0.92	1.33	1.12	1.43	1.26
SEm ±	0.05	0.06	0.08	0.05	0.03	0.05	0.05	0.07	0.06
C.D (P=0.05)	0.15	0.18	0.23	0.15	0.08	0.16	0.14	0.20	0.17
Fertigation at same level of irrigation									
SEm ±	0.09	0.10	0.13	0.09	0.05	0.10	0.08	0.12	0.10
C.D (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Irrigation at same or different fertigation levels									
SEm ±	0.08	0.09	0.26	0.16	0.06	0.15	0.11	0.16	0.08
C.D (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 3. Phosphorus content (%) of cucumber at different days after sowing as influenced by varied drip irrigation and fertigation levels under naturally ventilated poly house

Treatments	15 DAS	30 DAS	45 DAS	60 DAS		75 DAS		Harvest	
				Plant	Fruit	Plant	Fruit	Plant	Fruit
Main plots - Irrigation levels									
I_1: Drip irrigation at 0.8 Epan	0.58	0.74	0.56	0.86	0.46	0.70	0.74	0.61	0.54
I_2: Drip irrigation at 1.0 Epan	0.77	0.98	0.75	1.13	0.63	0.92	0.98	0.82	0.72
I_3: Drip irrigation at 1.2 Epan	0.95	1.17	0.93	1.36	0.78	1.12	1.19	1.00	0.89
SEm ±	0.02	0.02	0.02	0.02	0.03	0.03	0.02	0.02	0.02
C.D (P=0.05)	0.06	0.08	0.06	0.08	0.13	0.10	0.07	0.06	0.08
Sub plots - Fertigation levels									
F_1: 75% Recommended dose ($N_{112.5}$ K_{75})	0.71	0.88	0.69	1.04	0.57	0.85	0.90	0.75	0.66
F_2:100% Recommended dose (N_{150} K_{100})	0.75	0.94	0.73	1.09	0.61	0.89	0.94	0.79	0.70
F_3:125% Recommended dose ($N_{187.5}$ K_{125})	0.76	0.96	0.74	1.11	0.62	0.91	0.96	0.81	0.71
F_4:150% Recommended dose (N_{225} K_{150})	0.85	1.07	0.83	1.23	0.69	1.01	1.07	0.90	0.80
SEm ±	0.04	0.04	0.04	0.05	0.04	0.04	0.05	0.04	0.03
C.D (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Fertigation at same level of irrigation									
SEm ±	0.06	0.07	0.06	0.09	0.06	0.07	0.08	0.07	0.06
C.D (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Irrigation at same or different fertigation levels									
SEm ±	0.06	0.06	0.06	0.08	0.07	0.07	0.07	0.06	0.06
C.D (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 4. Potassium content (%) of cucumber at different days after sowing as influenced by varied drip irrigation and fertigation levels under naturally ventilated poly house

Treatments	15 DAS	30 DAS	45 DAS	60 DAS		75 DAS		Harvest	
				Plant	Fruit	Plant	Fruit	Plant	Fruit
Main plots - Irrigation levels									
I_1: Drip irrigation at 0.8 Epan	0.075	1.913	2.104	2.487	1.791	2.870	2.784	2.755	2.094
I_2: Drip irrigation at 1.0 Epan	0.077	1.994	2.195	2.594	1.868	2.993	2.903	2.874	2.184
I_3: Drip irrigation at 1.2 Epan	0.077	2.199	2.362	2.791	2.009	3.220	3.124	3.091	2.349
SEm ±	0.001	0.055	0.035	0.041	0.030	0.048	0.046	0.046	0.035
C.D (P=0.05)	NS	0.217	0.137	0.162	0.116	0.187	0.181	0.179	0.136
Sub plots - Fertigation levels									
F_1: 75% Recommended dose ($N_{112.5}$ K_{75})	0.074	1.951	2.073	2.450	1.764	2.827	2.742	2.714	2.063
F_2:100% Recommended dose (N_{150} K_{100})	0.076	2.003	2.200	2.599	1.872	2.999	2.909	2.879	2.188
F_3:125% Recommended dose ($N_{187.5}$ K_{125})	0.078	2.022	2.258	2.668	1.921	3.079	2.986	2.955	2.246
F_4:150% Recommended dose (N_{225} K_{150})	0.078	2.166	2.351	2.779	2.001	3.206	3.110	3.078	2.339
SEm ±	0.001	0.030	0.041	0.048	0.034	0.055	0.054	0.053	0.040
C.D (P=0.05)	0.002	0.090	0.120	0.142	0.102	0.164	0.159	0.158	0.120
Fertigation at same level of irrigation									
SEm ±	0.001	0.053	0.070	0.083	0.060	0.096	0.093	0.092	0.070
C.D (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Irrigation at same or different fertigation levels									
SEm ±	0.001	0.072	0.070	0.083	0.060	0.096	0.093	0.092	0.070
C.D (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 5. Nitrogen uptake (kg ha^{-1}) of cucumber at different days after sowing as influenced by varied drip irrigation and fertigation levels under naturally ventilated poly house

Treatments	15 DAS (kg ha^{-1})	30 DAS (kg ha^{-1})	45 DAS (kg ha^{-1})	60 DAS (kg ha^{-1})			75 DAS (kg ha^{-1})			Harvest (kg ha^{-1})		
				Plant	Fruit	Total	Plant	Fruit	Total	Plant	Fruit	Total
Main plots - Irrigation levels												
I_1: Drip irrigation at 0.8 Epan	1.0	5.2	11.6	14.7	9.3	24.0	20.7	21.2	41.9	25.4	38.7	64.1
I_2: Drip irrigation at 1.0 Epan	1.2	7.9	19.0	29.8	12.4	42.2	33.0	28.1	61.1	42.7	46.6	89.3
I_3: Drip irrigation at 1.2 Epan	1.9	14.1	32.6	50.8	13.8	64.6	86.3	33.6	119.9	106.4	65.9	172.4
SEm ±	0.1	0.6	2.7	6.3	0.3	5.1	4.9	2.5	6.3	10.0	0.6	14.5
C.D (P=0.05)	0.3	2.4	10.5	24.6	1.3	20.2	19.4	NS	24.7	39.3	2.3	56.9
Sub plots - Fertigation levels												
F_1: 75% Recommended dose ($N_{112.5}$ K_{75})	0.9	4.6	9.4	16.7	7.0	23.7	24.8	17.3	42.1	30.0	36.7	66.7
F_2:100% Recommended dose (N_{150} K_{100})	1.2	8.1	21.3	31.3	12.0	43.3	46.2	25.0	71.2	55.1	46.8	101.8
F_3:125% Recommended dose ($N_{187.5}$ K_{125})	1.5	10.4	24.2	35.2	13.1	48.2	52.8	31.4	84.2	67.3	54.0	121.3
F_4:150% Recommended dose (N_{225} K_{150})	1.8	13.2	29.6	44.0	15.3	59.3	63.0	36.9	99.8	80.3	64.3	144.6
SEm ±	0.1	0.7	1.7	2.8	0.5	3.9	4.2	1.4	4.5	5.3	2.4	6.2
C.D (P=0.05)	0.3	2.1	5.0	8.2	1.6	11.7	12.4	4.1	13.4	15.7	7.2	18.3
Fertigation at same level of irrigation												
SEm ±	0.2	1.2	2.9	4.8	0.9	6.8	7.2	2.4	7.8	9.2	4.2	10.7
C.D (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Irrigation at same or different fertigation levels												
SEm ±	0.2	1.2	3.7	7.5	0.9	7.8	8.0	3.3	9.2	12.8	3.7	17.2
C.D (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 6. Phosphorus uptake (kg ha^{-1}) of cucumber at different days after sowing as influenced by varied drip irrigation and fertigation levels under naturally ventilated poly house

Treatments	15 DAS (kg ha^{-1})	30 DAS (kg ha^{-1})	45 DAS (kg ha^{-1})	60 DAS (kg ha^{-1})			75 DAS (kg ha^{-1})			Harvest (kg ha^{-1})		
				Plant	Fruit	Total	Plant	Fruit	Total	Plant	Fruit	Total
Main plots - Irrigation levels												
I_1: Drip irrigation at 0.8 Epan	0.3	1.6	3.9	14.4	6.1	20.5	15.9	19.4	35.3	16.6	21.9	38.5
I_2: Drip irrigation at 1.0 Epan	0.4	2.8	6.8	25.1	10.3	35.3	27.5	31.5	59.0	28.8	36.3	65.1
I_3: Drip irrigation at 1.2 Epan	0.6	5.8	14.1	50.3	13.2	63.6	57.0	40.0	97.1	60.3	46.8	107.1
SEm ±	0.02	0.2	0.3	1.6	0.2	1.7	2.7	0.6	3.3	3.3	1.1	3.3
C.D (P=0.05)	0.1	0.7	1.3	6.1	0.7	6.6	10.6	2.5	12.9	13.0	4.4	13.0
Sub plots - Fertigation levels												
F_1: 75% Recommended dose ($N_{112.5}$ K_{75})	0.3	2.1	5.1	18.8	8.6	27.3	20.9	26.5	47.4	22.1	30.4	52.4
F_2:100% Recommended dose (N_{150} K_{100})	0.4	3.1	7.6	27.6	9.5	37.0	30.5	29.1	59.6	31.8	33.6	65.4
F_3:125% Recommended dose ($N_{187.5}$ K_{125})	0.4	3.6	8.7	31.7	9.8	41.5	35.5	30.3	65.8	37.4	35.0	72.5
F_4:150% Recommended dose (N_{225} K_{150})	0.5	4.8	11.6	41.7	11.6	53.3	47.0	35.3	82.3	49.7	41.0	90.7
SEm ±	0.02	0.2	0.5	1.8	0.5	2.0	2.3	1.8	3.0	2.5	1.8	2.8
C.D (P=0.05)	0.1	0.6	1.5	5.5	1.5	5.8	6.9	5.2	9.0	7.5	5.3	8.4
Fertigation at same level of irrigation												
SEm ±	0.04	0.4	0.9	3.2	0.9	3.4	4.0	3.0	5.2	4.4	3.1	4.9
C.D (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Irrigation at same or different fertigation levels												
SEm ±	0.04	0.4	0.8	3.2	0.8	3.4	4.4	2.7	5.6	5.0	2.9	5.4
C.D (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 7. Potassium uptake (kg ha^{-1}) of cucumber at different days after sowing as influenced by varied drip irrigation andfertigation levels under naturally ventilated poly house

Treatments	15 DAS (kg ha^{-1})	30 DAS (kg ha^{-1})	45 DAS (kg ha^{-1})	60 DAS (kg ha^{-1})			75 DAS (kg ha^{-1})			Harvest (kg ha^{-1})		
				Plant	Fruit	Total	Plant	Fruit	Total	Plant	Fruit	Total
Main plots - Irrigation levels												
I_1: Drip irrigation at 0.8 Epan	0.033	4.1	14.1	40.2	23.4	63.7	63.4	72.6	136.0	71.8	85.6	157.4
I_2: Drip irrigation at 1.0 Epan	0.035	5.9	20.5	59.1	30.5	89.6	91.4	94.6	186.0	103.4	111.5	214.9
I_3: Drip irrigation at 1.2 Epan	0.053	10.8	36.8	104.6	34.3	138.9	167.0	106.5	273.4	189.6	125.5	315.0
SEm ±	0.003	0.4	1.5	3.5	0.6	4.0	8.9	2.4	10.4	10.7	3.6	12.4
C.D (P=0.05)	0.011	1.7	5.8	13.8	2.4	15.6	34.7	9.2	41.0	41.8	14.1	48.5
Sub plots - Fertigation levels												
F_1: 75% Recommended dose ($N_{112.5}$ K_{75})	0.033	4.3	14.4	41.3	25.2	66.5	65.2	78.1	143.2	73.9	91.9	165.9
F_2:100% Recommended dose (N_{150} K_{100})	0.038	6.6	23.1	65.7	28.7	94.4	103.3	89.1	192.4	116.3	105.0	221.4
F_3:125% Recommended dose ($N_{187.5}$ K_{125})	0.043	7.5	26.0	74.5	30.4	104.9	117.4	94.4	211.8	133.5	111.3	244.7
F_4:150% Recommended dose (N_{225} K_{150})	0.048	9.3	31.6	90.5	33.4	123.9	143.2	103.4	246.6	162.7	121.8	284.5
SEm ±	0.003	0.5	2.0	5.7	0.8	6.0	9.3	1.9	10.4	10.4	2.4	11.7
C.D (P=0.05)	0.008	1.6	6.0	16.8	1.7	17.7	27.5	5.6	30.8	30.9	7.1	34.7
Fertigation at same level of irrigation												
SEm ±	0.004	0.9	3.5	9.8	1.0	10.3	16.0	3.3	17.9	18.0	4.1	20.2
C.D (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Irrigation at same or different fertigation levels												
SEm ±	0.005	0.9	3.4	9.2	1.1	0.1	16.5	3.7	18.7	18.9	5.1	21.4
C.D (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

The uptake of N, P_2O_5 and K_2O increased with the application of fertilizer from lower (75% RDNK) to higher (150% RDNK) doses. Increased uptake of nutrients might be due to higher dose of nitrogen and potassium through fertigation, which could have activated the physiological activity which in turn created better supply of nutrients to root hairs. The increase in nutrient uptake may also be due to the better availability of nutrients in the root zone due to fertigation. Combined use of organic and inorganic nutrient sources may be increased the availability of nutrients by mineralization process.

3.5 Post Harvest Soil Status of N, P_2O_5 and K_2O

Both drip irrigation levels and NK fertigation levels significantly influenced the final soil available N and K status but did not influenced P status. Interaction was found non-significant for N, P_2O_5 and K_2O (Table 8).

Among drip irrigation levels, final soil N and K_2O status was significantly higher in irrigation scheduled at 0.8 Epan (332.4 and 496.6 kg ha^{-1}) followed by 1.0 Epan (307.3 and 475.1 kg ha^{-1}) and 1.2 Epan (264.5 and 457.1 kg ha^{-1}) respectively. N status was comparable between 0.8 and 1.2 Epan.

Soil available N status was significantly higher at 150% recommended dose of NK (335.9 kg ha^{-1}) than 125% (306.6 kg ha^{-1}),100% recommended dose of NK (288.5 kg ha^{-1}) than 75% recommended dose of NK (274.6 kg ha^{-1}). Soil available N status comparable between 125% and 100% recommended dose of NK and also between 100% and 75% recommended dose of NK. K availability status in soil was significantly higher in 150% recommended dose of NK (503.1 kg ha^{-1}) than 100% (453.0 kg ha^{-1}) and 75% recommended dose of NK (455.5 kg ha^{-1}). K_2O status was comparable between 150% and 125% recommended dose of NK and also between 100% and 75% recommended dose of NK. The Results are in similar in accordance with the findings of Ananda Murthy et al. [18].

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 3.1 to 23.5% and it was higher in irrigation scheduled at 1.2 Epan (23.5%) followed by 1.0 Epan (10.5%) and depletion level was lower at 0.8 Epan (3.1%). Among fertigation treatments, the depletion level of final soil available nitrogen status was ranged from 6.2 to 18.9%. The depletion level was lower at 150% recommended dose of NK (6.2%) followed by 125%

Table 8. Post - harvest soil nutrient status of cucumber as influenced by varied drip irrigation and fertigation levels under naturally ventilated poly house

Treatments	Soil status after harvest (kg ha^{-1})		
	N	**P_2O_5**	**K_2O**
Main plots - Irrigation levels			
I_1: Drip irrigation at 0.8 Epan	332.4	54.4	496.6
I_2: Drip irrigation at 1.0 Epan	307.3	54.4	475.1
I_3: Drip irrigation at 1.2 Epan	264.5	49.8	457.1
SEm ±	10.8	1.6	2.5
C.D (P=0.05)	42.5	NS	9.9
Sub plots - Fertigation levels			
F_1: 75% Recommended dose ($N_{112.5}$ K_{75})	274.6	48.2	455.5
F_2:100% Recommended dose (N_{150} K_{100})	288.5	49.0	453.0
F_3:125% Recommended dose ($N_{187.5}$ K_{125})	306.6	53.8	493.4
F_4:150% Recommended dose (N_{225} K_{150})	335.9	60.3	503.1
SEm ±	9.7	4.2	11.6
C.D (P=0.05)	28.9	NS	34.6
Fertigation at same level of irrigation			
SEm ±	16.9	7.3	20.2
C.D (P=0.05)	NS	NS	NS
Irrigation at same or different fertigation levels			
SEm ±	18.2	6.6	17.6
C.D (P=0.05)	NS	NS	NS
Initial soil nutrient status (kg ha^{-1})	**N**	**P_2O_5**	**K_2O**
	338.7	**48.5**	**473.5**

recommended dose of NK (9.5%), and100% recommended dose of NK (14.8%). N depletion level was higher at 75% recommended dose of NK (18.9%).

Among drip irrigation treatments, the potassium was accumulated in 0.8 Epan (4.9%) and 1.0 Epan (0.42) treatments while it was depleted in 1.2 Epan (3.6%) than initial potassium status.

Among fertigation treatments, available potassium was depleted in 75% (3.9) and 100% recommended dose of NK (4.5), whereas potassium was built up at 125% (4.2%) and 150% recommended dose of NK (6.2%).

4. CONCLUSION

Cucumber crop grown under naturally ventilated poly house during rabi season under drip irrigation in sandy clay loam soils of Southern Telangana Zone, application of 1.2 Epan irrigation and 150 kg N, 100 kg K_2O ha^{-1} by fertigation in 19 number of split doses at 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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