E-ISSN: 2618-0618
P-ISSN: 2618-060X

www.agronomyjournals.com
2024; SP-7(8): 784-787
Received: 23-06-2024
Accepted: 29-07-2024

Nandikolla Venkata Neelima
Master' student, Department of Agronomy, Professor Jayashankar Telangana State Agricultural University, Rajendranagar, Hyderabad, India.

Md. Latheef Pasha
Professor, Department of Agronomy, Professor Jayashankar Telangana State Agricultural University, Rajendranagar, Hyderabad, India.

P Revathi
Scientist, Department of Agronomy, Water Technology Center, Professor Jayashankar Telangana State Agricultural University, Rajendranagar, Hyderabad, India.

G Kiran Reddy
Scientist, Department of Soil science, AICRP on Integrated Farming Systems, Professor Jayashankar Telangana State Agricultural University, Rajendranagar, Hyderabad, India

Corresponding Author:
Nandikolla Venkata Neelima
Master' student, Department of Agronomy, Professor Jayashankar Telangana State Agricultural University, Rajendranagar, Hyderabad, India.

Response of broccoli yield attributes, yield and water productivity to drip irrigation and N-K fertigation levels during *rabi*

Nandikolla Venkata Neelima, Md Latheef Pasha, P Revathi and G Kiran Reddy

DOI: https://doi.org/10.33545/2618060X.2024.v7.i8Sj.1384

Abstract
A field experiment was performed at Water Technology Centre, College Farm, College of Agriculture, Rajendranagar, Hyderabad, Telangana during *rabi* 2023- 2024. The experiment had been designed in split plot design with nine treatments, consisting of three drip irrigation levels *viz.*, 0.6 Epan (I1), 0.8 Epan (I2) and 1.0 Epan (I3) as main plots and three drip NK fertigation schedules of 75% recommended dose of NK (F1- N120 K75), 100% recommended dose of NK (F2- N160 K100) and 125% recommended dose of NK (F3- N200 K125) as sub plots. The experimental field soil was sandy loam soils with a pH of 7.9 and EC of 0.35 dS m^{-1}. The experimental soil was low in organic carbon (0.22%) and available nitrogen (246.0 kg ha^{-1}), while high in available phosphorous (76.38 kg ha^{-1}) and potassium (427.3 kg ha^{-1}). Seedlings of 21 days old were transplanted at 50/40 x 40cm in paired row method in the field. Yield attributes and curd yield were significantly higher in drip irrigation scheduled at 1.0 Epan (21.9 t ha^{-1}) than 0.8 Epan (19.5 t ha^{-1}) and 0.6 Epan (16.7 t ha^{-1}). Water productivity showed higher in drip irrigation regime scheduled at 0.6 Epan (7.8 kg m^{-3}) than 0.8 Epan (7.2 kg m^{-3}) and 1.0 Epan (6.6 kg m^{-3}).Yield attributes and yield were significantly higher in 125% recommended dose of NK (22.6 t ha^{-1}) than 100% recommended dose of NK (18.4 t ha^{-1}) and 75% recommended dose of NK (17.1 t ha^{-1}). Water productivity was significantly higher with 125% recommended dose of NK than 100% recommended dose of NK and 75% recommended dose of NK at all the stages of crop.

Keywords: Irrigation regimes, fertigation, significant, water productivity, yield

1. Introduction

The consumption of Broccoli (*Brassica oleracea var. italica* L.; 2n=x=18) has been steadily increasing from the last decade and the health promoting properties of broccoli have been greatly concentrated. It is the cole crop belongs to the family Brassicaceae and originated from the Mediterranean region. Broccoli is known as the "Crown of jewel nutrition" and "Super food" as it is a rich source of many minerals, vitamin A and C, carotenoids, fiber, calcium and folic acid besides its antioxidant and anti-carcinogenic properties (Fahey *et al.*, (2001) [1].

World area and production of broccoli (combined for production reports with cauliflowers) are 1.37 mha^{-1} and 25.53MT India ranks second in area (0.36 mha^{-1}) and production (9.57 MT) of broccoli (FAO stat, 2021) [2]. The broccoli crop is shallow-rooted and sensitive to water stress. It can be grown on a wide range of soil types. The edible part of broccoli is inflorescence and is harvested before the flower buds begin to open. (Nagraj *et al.*, 2020) [3]. Water deficits in any growth stage will decrease optimum growth and head quality of broccoli. Broccoli is also a nutrient-demanding crop, among different nutrients, nitrogen, phosphorus and potassium are the primary plant nutrients which play a crucial role in growth and development of broccoli. Optimum yield, growth quality of crop produce can be obtained when needed primary nutrients (N, P_2O5 and K_2O) are supplied sufficiently (Magen *et al*., 2008) [4]. Water is the basic need in agricultural development and its demand is increasing day by day. At the same time, availability of water is decreasing due to climatic changes. Industrialization, increasing population, addition of heavy metals, pesticides, organic pollutants leading to these climatic changes (yang *et al.*,

2023) [5]. Also, the predominant use of outdated and inefficient flood irrigation methods leading to excessive water use. Therefore, it is necessary to economize the use of water for agriculture to bring more area under irrigation, as agriculture alone consumes 80% of total water usage. This challenge in the agriculture sector can be overcome by efficient usage of water for increasing food production. (Abdelraouf *et al.*, 2020) [6].

In this context, drip irrigation is an important irrigation management system, which plays a vital role in increasing water productivity. The drip irrigation system improves crop yield by 25–30% and saves irrigation water up to 50%. (Singh *et al.*, 2022) [7]. Meanwhile, regular and unbalanced use of chemical fertilizers leading to decrease in the base saturation and acidification of soil. Inappropriate method of fertilizer application leads to severe nutrient losses by leaching and fixation (Harisha *et al*., 2017) [8] with low fertilizer use efficiency. Total fertilizer consumption in india was estimated at 29.84 million M T in 2021-22 (Annual Review-FAI, 2022-23) [9]. Hence, judicious use of fertilizers needs to be addressed. Fertigation, benefits the users with high crop productivity, quality, resource use efficiency, flexibility in field operations, effective weed management and successful crop cultivation in fields with undulating topography (Priya *et al.*, 2017) [10]. In this regard, fertigation can be a logical approach.

Fertigation is the application of nutrients through irrigation water. It is a modern agro-technique, which provides an excellent opportunity to maximize yield and minimize environmental pollution by increasing fertilizer use efficiency with less fertilizers applied. Previous studies have reported that remarkable fertilizer savings of 20 - 60% along with 8 - 41% increases in yields of horticultural and vegetable crops as a result of fertigation (Lavanya *et al.*, 2022) [11]. Considering the current Indian scenario, water will soon become insufficient to feed the burgeoning population. Therefore, efficient water and nutrient management are most critical for profitable cultivation of broccoli. Drip fertigation over traditional methods in broccoli cultivation can offer several advantages in terms of water and nutrient management. Hence, drip fertigation plays a significant role in broccoli production.

2. Material and Methods

The experiment was conducted at Water Technology Center, College Farm, College of Agriculture, Professor Jayashankar Telangana State Agricultural University (PJTSAU), Rajendranagar, Hyderabad, Telangana during *rabi* 2023-2024. The experimental study 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. In this research, broccoli was grown in open field conditions under drip irrigation system. The key objective of the study was to determine the irrigation and fertigation schedules, water productivity, nutrient uptake and to compute the cost economics of broccoli. The crop growing period was from 31st October 2023 to 26th January 2024 (85 days from transplanting). The experimental field soil was sandy loams having moderate infiltration rate, slightly alkaline condition and moderately saline in reaction. The fertility position of the experimental field soil was in low organic carbon and available nitrogen, high in available phosphorus and potassium.

The study field was plotted in a split plot design, comprising of three drip irrigation regimes *viz.*, drip irrigation scheduled at 0.6 Epan (I1), 0.8 Epan (I2) and 1.0 Epan (I3) as main plot treatments and three drip NK fertigation schedules of 75% recommended dose of NK (N120 K75-F1), 100 % recommended dose of NK (N160 K100- F2) and 125 % recommended dose of NK (N200 K125- F3) as sub plots which replicated thrice. The water source for the irrigation was from an open well near the field. Irrigation scheduling was imposed based on daily evaporation data taken down from USWB class ‘A’ open pan evaporimeter at Agro Climatological Research Centre, ARI Farm, Rajendranagar, Hyderabad. The daily cumulative evaporation during crop growing period was 296.7mm. The total water used by the crop was 213.7, 272.1 and 331.4 mm in 0.6, 0.8 and 1.0 Epan levels respectively. The recommended dose of fertilizer was 160, 100 and 100 kg N, P2O5 and K2O ha^{-1}, which were given to the field in the form of urea, single super phosphate and sulphate of potash. A dose of 100 kg P2O5 ha-1 through SSP was applied for all the treatments and N and K_2O were applied through fertigation for once in four days. 21 days old seedlings were transplanted at 50/40cm × 40 cm in paired row method in the experimental field. Weed, pest and disease management were conducted according to the university's recommendations.

3. Result and Discussion

3.1. Yield attributes

3.1.1. Curd diameter (cm)

Curd diameter was significantly influenced by different drip irrigation regimes and drip NK fertigation schedules. Interaction was reported to be non-significant (Table 1).

Drip irrigation regime scheduled at 1.0 Epan reported significantly higher curd diameter (13.1 cm) than 0.8 Epan (9.9 cm) and 0.6 Epan (8.1 cm). Curd diameter at 0.8 Epan was on par with 0.6 Epan. Higher curd diameter at 1.0 Epan might be due to presence of optimal moisture at the root zone during the entire growth period of the crop, which increases the vegetative growth thereby enhances the photosynthesis and translocation of photosynthates towards storage organs development. This was responsible for the significant improvement of the curd diameter. These observations were alike with the findings of Naik *et al.* (2021) [12], Deka *et al.* (2023) [13], Rathod and Sheikh, (2023) [14] and Gupta *et al.* (2015) [15].

Curd diameter was significantly improved with each increment in the NK fertigation level from 75% to 125 % recommended dose of NK fertigation schedules. Drip fertigation scheduled at 125 % recommended dose of NK reported significantly higher curd diameter (13.4 cm) than 100 % recommended dose of NK (9.4 cm) and 75% recommended dose of NK (8.4 cm).Curd diameter was on par between 75% and 100% recommended dose of NK. Higher curd diameter at 125% recommended dose of NK could be due to the whole solubleness and presence of nutrients at the regular intervals in needed whole solubleness and presence of nutrients at the regular intervals in needed quantity resulted in higher nutrient uptake by curds leading to the higher curd diameter. These findings were corroborate with the findings of Ansul *et al.* (2023) [16] and Lavanya *et al.* (2022) [11].

3.1.2. Curd depth (cm)

Curd depth was significantly influenced by both different drip irrigation regimes and drip NK fertigation schedules. Interaction was reported to be non-significant (Table 1)

Drip irrigation regime scheduled at 1.0 Epan reported significantly higher curd depth (10.1 cm) than 0.6 Epan (8.4 cm) and showed on par with the treatment 0.8 Epan (9.5 cm). This result might be attributed due to presence of optimal soil moisture with higher uptake of nutrients resulted in increased photosynthetic area and cell metabolism resulted in good partitioning of dry matter and finally brought out the increased curd depth. These findings were identical with the reportings of Rathod and Sheikh, (2023) [14] and Gupta *et al.* (2015) [15].

Curd depth was significantly increased with each increment in NK fertigation schedule from 75% to 125 % recommended dose of NK fertigation schedule. Drip fertigation scheduled at 125 % recommended dose of NK reported significantly higher curd depth (10.4 cm) than 100 % recommended dose of NK (9.5 cm) and 75% recommended dose of NK (8.1 cm). It could be due to entire solubleness and availability of nutrients at the surroundings of root zone in optimal quantities due to drip fertigation resulted in the increment of yield and yield related attributes. These observations were in conformity with the results of Lavanya *et al.* (2022) [11].

3.1.3. Curd weight (g plant-1)

Curd weight was significantly influenced by both different drip irrigation regimes and drip NK fertigation schedules. Interaction was reported to be non-significant (Table 1)

Drip irrigation regime scheduled at 1.0 Epan reported significantly higher curd weight (490.3 g plant^{-1}) than 0.8 Epan (444.0 g plant^{-1}) and 0.6 Epan (389.9 g plant^{-1}). This might be due to higher nutrient availability, especially at the root zone might have increased photosynthates translocation to storage organs, which results in an increased curd weight of broccoli under drip irrigation regimes. The enhanced biochemical reactions in soil and slowdown of evaporation led to higher moisture content in the soil, builds sufficient photosynthates and better nutrient availability for the plants. These findings were in corroborate with the observations of Deka *et al.* (2023) [13], Naik *et al.* (2021) [12], Spehia and Negi (2021) [17] who reported that the higher curd weight at higher irrigation levels.

Curd weight was significantly increased with each increment in the NK fertigation schedule from 75% to 125% recommended dose of NK fertigation. Drip fertigation schedule at 125 % recommended dose of NK reported significantly higher curd weight (492.1 g plant^{-1}) than 100 % recommended dose of NK (434.4 g plant^{-1}) and 75% recommended dose of NK (397.8 g plant^{-1}). Drip fertigation schedules facilitate sufficient supply of nutrients and builds sufficient photosynthates which enables the increase in the curd diameter and curd depth eventually resulted in increase in the curd weight of broccoli. These observations were identical with the findings of Debbarma *et al.* (2019) [18] and Ansul *et al.* (2023) [16] who found the higher curd fresh weight at the higher fertigation schedule than lower doses.

3.2. Yield

3.2.1. Curd yield (t ha^{-1}) of broccoli.

Curd yield was significantly influenced by different drip irrigation regimes and different drip NK fertigation schedules. Interaction was reported to be non-significant (Table 1).

Curd yield was reported significantly higher in drip irrigation scheduled at 1.0 Epan (21.9 t ha^{-1}) than 0.8 Epan (19.5 t ha^{-1}) and 0.6 Epan (16.7 t ha^{-1}). This could be due to the presence of optimal moisture at the root zone throughout the crop growing period which improved the vegetative growth of the crop thereby which increased the photosynthesis and translocation of photosynthates towards the storage organ i.e., broccoli curd, which enhances the curd diameter, depth and curd weight finally resulted in increased curd yield of broccoli. Similar observations were found by Singh *et al.* (2022) [7] and Himanshu *et al.* (2013) [19].

Each increment level in NK fertigation from 75% to 125 % recommended dose of NK fertigation schedules significantly increased the curd yield. Drip fertigation scheduled at 125 % recommended dose of NK reported significantly higher curd yield (22.6 t ha^{-1}) than 100% recommended dose of NK (18.4 t ha^{-1}) and 75% recommended dose of NK (17.1t ha^{-1}). Curd yield at 100% recommended dose of the NK and 75% recommended dose of the NK were comparable. Curd yield is cumulative result of yield attributes like curd diameter, curd depth and curd weight plant^{-1}. Curd yield increased in 125 % recommended dose of the NK fertigation schedule due to regular supply of nutrients at the vicinity of crop root zone through drip fertigation, which enhanced favouring conditions for the growth and development by improving the metabolic regulations in the plant. These findings were alike with the observations of Prakash kanwar *et al.* (2023) [20], Verma *et al.* (2020) [21] and Erdem *et al.* (2010) [22].

3.3. Water productivity (kg m-3)

Different drip irrigation regimes and drip NK fertigation schedules were significantly influenced the water productivity. Interaction effect was reported to be non significant (Table 1)

Water productivity was recorded significantly higher in drip irrigation scheduled at 0.6 Epan (7.8 kg m^{-3}) than 0.8 Epan (7.2 kg m^{-3}) and 1.0 Epan (6.6 kg m^{-3}). Even though the curd yield was higher in drip irrigation scheduled at 1.0 Epan, it was reported significantly lower water productivity (6.6 kg m^{-3}). The water productivity decreased slowly with the increase in the irrigation regime. Similar findings were observed by Himanshu *et al.* (2013) [19] and Siddartha *et al.* (2021) [23] in broccoli and cauliflower crops respectively.

Water productivity increased significantly with each increment in drip NK fertigation level from 75% to 100 % recommended dose of NK. Water productivity was significantly higher at 125 % recommended dose of NK (8.4 kg m^{-3}) than 100 % recommended dose of NK (6.8 kg m^{-3}) and 75% recommended dose of NK (6.3 kg m^{-3}). Water productivity at 100% recommended dose of NK was on par with 75% recommended dose of NK. This might be due to minimal water loss through percolation, runoff, seepage and evaporation as water was applied directly at the rooting zone of the crop. Similar observations were found by Himanshu *et al.* (2013) [19] and Siddartha *et al.* (2021) [23] respectively.

Table 1: Yield attributes, yield and Water productivity of broccoli as influenced by varied drip irrigation and fertigation schedules

Treatments	Curd diameter (cm)	Curd Depth (cm)	Curd weight (g plant-1)	Curd yield (t ha-1)	Water productivity (kg m-3)
Main plots - Irrigation levels					
I_1: Drip irrigation at 0.6 Epan	8.1	8.4	389.9	16.7	7.8
I_2: Drip irrigation at 0.8 Epan	9.9	9.5	444.0	19.5	7.2
I_3: Drip irrigation at 1.0 Epan	13.1	10.1	490.3	21.9	6.6
SEm ±	0.5	0.2	10.4	0.5	0.1
C.D (P=0.05)	2.1	0.8	40.7	1.9	0.4
Sub plots - Fertigation levels					
F1: 75% RDNK (N120 K75)	8.4	8.1	397.8	17.1	6.3
F2: 100% RDNK (N160 K100)	9.4	9.5	434.4	18.4	6.8

F3: 125% RDNK (N200 K125)	13.4	10.4	492.1	22.6	8.4
SEm ±	0.5	0.2	11.6	0.6	0.3
C.D (P=0.05)	1.7	0.7	35.7	1.8	0.9
Fertigation at same level of irrigation					
SEm ±	0.9	0.4	19.4	0.9	0.2
C.D (P=0.05)	NS	NS	NS	NS	NS
Irrigation at same or different fertigation levels					
SEm ±	1.0	0.4	20.0	1.0	0.4
C.D (P=0.05)	NS	NS	NS	NS	NS

*NS = Non significant

4. Conclusion

It is concluded that for broccoli crop grown during rabi season under micro irrigation in sandy loamy soils, implementation of irrigation at 1.0 Epan and 125% RDNK i.e., 200 kg N and 125 kg K2O ha^{-1} resulted in higher yields. Among the irrigation regimes, irrigation scheduled at 0.6 Epan recorded higher water productivity during the *rabi* season which can be used at regions of limited water conditions.

5. References

1. Fahey JW, Zhang Y, Talalay P. Broccoli sprouts: an exceptionally rich source of inducers of enzymes that protect against chemical carcinogens. Proc Natl Acad Sci U S A. 2001;94(19):10367-10372.
2. FAO Statistics. World Food and Agriculture Statistical Year Book, c2022. Available from: https://www.fao.org. Accessed 2021-22.
3. Nagraj GS, Chouksey A, Jaiswal S, Jaiswal AK. Broccoli. In: Nutritional composition and antioxidant properties of fruits and vegetables. Academic Press; c2020. p. 5-17.
4. Magen H. Balanced crop nutrition: fertilizing for crop and food quality. Turk J Agric For. 2008;32(3):183-193.
5. Yang P, Wu L, Cheng M, Fan J, Li S, Wang H, Qian L. Review on drip irrigation: impact on crop yield, quality, and water productivity in China. Water. 2023;15(9):1733.
6. Abdelraouf RE, El-Shawadfy MA, Ghoname AA, Ragab R. Improving crop production and water productivity using a new field drip irrigation design. Plant Arch. 2020;20(1):3553-3564.
7. Singh A, Kumar S, Dhaloiya A, Kumar N, Mor A, Kumar A, Dhanger P, Dagar H. Soil water dynamics and yield response of broccoli (*Brassica oleracea*) under drip irrigation with different irrigation frequency. Indian J Agric Sci. 2022;92(12):1447-1452.
8. Harisha CB, Asangi H, Singh R. Impact of drip irrigation and fertigation on residual soil nutrient status, nutrient uptake and nutrient use efficiency of fenugreek under semi-arid conditions. Int J Pure Appl Biosci. 2017;5(2):661-667.
9. Annual Report 2022-2023. FAI-The Fertiliser Association of India; c2023. Available from: 10 Shaheed Jit Singh Marg, New Delhi-110 067, India.
10. Priya RS, Chinnusamy C, Karthikeyan R, Kuttimani R. Drip fertigation in vegetable crops for enhancing productivity and resource use efficiency: an overview. Int J Curr Microbiol Appl Sci. 2017;6(11):3215-3230.
11. Lavanya AVN, Mamatha A, Nayak MH, Kumari DA, Suresh V. Standardization of fertigation schedules on plant growth and yield of broccoli. The Pharma Innovation J. 2022;11(7):3455-3459.
12. Naik S, Kumar K, Kumar Rondla S, Kishan K. Effect of irrigation and N-fertigation levels on broccoli performance in a Polynet house. Int J Environ Climate Change. 2021;11(12):261-267.
13. Deka B, Bhagawati M, Dutta M. Effect of drip, fertigation and plastic mulching on growth and yield of cabbage. Ann Plant Soil Res. 2023;25(4):688-693.
14. Rathod SD, Sheikh AH. Response of cucumber to different irrigation and fertigation levels in summer under polyhouse condition. J Pharm Innov. 2023;12(7):1167-1174.
15. Gupta AJ, Chattoo MA, Singh L. Drip irrigation and fertigation technology for improved yield, quality, water and fertilizer use efficiency in hybrid tomato. J Agri Search. 2015;2(2):94-99.
16. Anshul MK, Kapil RN, Vijay AJ. Optimization of Nitrogen Dose through Fertigation in Cauliflower under Drip Irrigation. Environ Ecol. 2023;41(3):2160-2167.
17. Spehia RS, Negi R. Drip irrigation and fertigation requirement of broccoli under mid hill conditions. Veg Sci. 2021;48(01):35-40.
18. Debbarma S, Bhatt L, Singh PK, Gautam P, Raghav M, Yadav L, Singh AK. Standardization of fertigation scheduling in broccoli (*Brassica oleracea* var italica). Indian J Agric Sci. 2021;91:1160-1164.
19. Himanshu SK, Singh AK, Kumar S, Kalura P. Response of broccoli to irrigation scheduling and methods under drip, sprinkler and surface irrigation. Int J Eng Adv Technol. 2013;2(4):777-782.
20. Prakash Kanwar DA, Wagh AP, Ghawade SM, Kankal DS, Walke RD. Effect of fertigation levels and schedules on economics of broccoli (*Brassica oleracea* var. italica) cultivation. Int J Res Agronomy. 2020;7(2):85-89.
21. Verma A, Tripathi D, Sharma U, Devi M. Influence of drip fertigation on yield and economics of cauliflower cv. PSBK-1. Int J Conserv Sci. 2020;8(1):1144-1146.
22. Erdem T, Arın L, Erdem Y, Polat S, Deveci M, Okursoy H, Gültaş HT. Yield and quality response of drip irrigated broccoli (*Brassica oleracea* L. var. italica) under different irrigation regimes, nitrogen applications and cultivation periods. Agric Water Manag. 2010;97(5):681-688.
23. Sidhartha G, Pasha ML, Umadevi M, Ramulu V. Nutrient uptake studies under varying drip irrigation regimes and fertigation levels in rabi cauliflower in Telangana State. Int J Plant Soil Sci. 2021;33:12.