



International Journal of Research in Agronomy

E-ISSN: 2618-0618
P-ISSN: 2618-060X
© Agronomy
NAAS Rating: 5.20
www.agronomyjournals.com
2025; 8(3): 517-520
Received: 15-12-2024
Accepted: 23-01-2025

Boishali Handique
Department of Crop Physiology,
Assam Agricultural University,
Jorhat, Assam, India

Hemendra Choudhury
Department of Crop Physiology,
Biswanath College of Agriculture,
Biswanath, Assam, India

Sangita Das
Department of Crop Physiology,
Assam Agricultural University,
Jorhat, Assam, India

Corresponding Author:
Boishali Handique
Department of Crop Physiology,
Assam Agricultural University,
Jorhat, Assam, India

Response of broccoli (*Brassica oleracea* var. *italica*) to different fertigation treatments in respect of its yield and quality

Boishali Handique, Hemendra Choudhury and Sangita Das

DOI: <https://www.doi.org/10.33545/2618060X.2025.v8.i3g.2691>

Abstract

A field experiment was conducted during the winter season of 2019-20 to investigate the response of broccoli to different fertigation treatments. The experiment consisted of four irrigation levels (I₁: 1.20 ET_c, I₂: 1.00 ET_c, I₃: 0.8 ET_c, and I₄: 0.6 ET_c) and four fertilizer levels (F₁: 100% recommended dose of NPK (RD), F₂: 75% RD of NPK, F₃: 50% RD of NPK, and F₄: no fertilizer). The results showed that the treatment combination of I₁F₁ produced the highest head diameter (14.84 cm), head yield (225.41 g/plant), total yield (18.69 t/ha), harvest index (52.11%), protein content of head (30.03 mg/g), and starch content (55.73 µg/g). Conversely, the treatment combination of I₄F₄ resulted in the lowest values for these parameters, with head diameter (9.34 cm), head yield (71.41 g/plant), total yield (6.29 t/ha), harvest index (34.35%), protein content of head (19.49 mg/g), and starch content (31.19 µg/g). These findings suggest that optimized fertigation management can significantly improve broccoli yield and quality.

Keywords: Fertigation, broccoli, physio-chemical, photosynthesis, transpiration

Introduction

Broccoli (*Brassica oleracea* L. var. *italica*) is a nutritious Cole Crop, cool-season, belongs to the *Brassica* family and is renowned for its high nutritional value, rich in vitamins, minerals, and antioxidants (Li *et al.*, 2019) [6]. Originating in the Mediterranean region, China leads in broccoli production. The crop's name is derived from the Latin word 'brachium,' meaning arm or branch (Boswell, 1949) [2]. Broccoli's morphology is characterized by a large, green, flower head or buds, with a branching out of thick, edible stalks. The crop requires a day temperature of 20-25 °C during vegetative growth and 15-20 °C during the heading stage (Verma and Sharma, 1998) [17]. Broccoli is sensitive to temperature extremes, with above 24 °C leading to early flowering and maturity (Thompson and Kelly, 1983) [15]. Broccoli thrives in fertile, well-drained soils with a slightly acidic to alkaline pH. The recommended fertilizer application is 100-125:50-60:60-80 kg N:P:K/ha, along with 20-25 tons of farmyard manure (FYM) (Nath *et al.*, 2008) [10]. Irrigation is crucial for broccoli cultivation, with frequent watering at 10-15 day intervals, depending on weather conditions (Paschold *et al.*, 2000) [12]. Drip irrigation with water-soluble fertilizers is recommended for high-value broccoli production (Wojciechowska *et al.*, 2020) [18]. Broccoli is rich in vitamins A and C, thiamine, niacin, and riboflavin, as well as minerals like calcium and iron. It is also a rich source of sulphoraphane, a compound associated with reducing cancer risk (Nandini, 2020) [9]. Broccoli's market demand is increasing globally due to its nutritional value and multifarious uses (Rangkadilok *et al.*, 2004) [13].

Materials and Methods

The field experiment was done on the Water Technology Park in the Instructional-cum-Research (ICR) Farm, Assam agricultural university, Jorhat, Assam during *rabi* season of 2019-20. The farm was situated at 24°47'N latitude, 94°12'E longitude and at an altitude of 86.6 m above the mean sea level. The experimental field was designed in factorial randomized block design (FRBD) with three replications and each replication there are 16 numbers of plots. The individual size of the plot was (4x3)m. Each treatment in each replication was accommodated

randomly. The gross and net area of the experimental field were 948 m² and 576 m², respectively. The treatment combinations comprised of drip irrigation and fertilizer levels are as mentioned below along with their notations. The variety Green Magic (F₁ hybrid) a high yielding variety of broccoli with excellent uniformity and high yield was selected for the study.

Treatment details

Drip irrigation level (I)	Fertilizer level (F)
I ₁ : 120% Etc	F ₁ : 100% RDF
I ₂ : 100% Etc	F ₂ : 80% RDF
I ₃ : 80% Etc	F ₃ : 60% RDF
I ₄ : 60% Etc	F ₄ : No fertilizer

*RDF- Recommended dose of fertilizer

Observations

Head diameter

The five broccoli heads per plot were selected randomly and diameter (maximum width) was measured using a measuring tap. The average of five heads was calculated as diameter and was expressed in cm.

Head yield

The five broccoli plants were randomly selected from each plot, the head portion was harvested along with 5cm stock intact with the head. The head yield was measured in an electronic balance and the average of five head weight was recorded. The head weight was expressed in g/plant.

Total yield

Total yield of broccoli was calculated out by multiplying average head weight per plant with the number of plant per hectare and was expressed in t/ha.

Harvest index

Harvest index of broccoli was calculated with the following formula and was expressed in per cent.

$$\text{Harvest index (\%)} = \frac{\text{Economic yield}}{\text{Biological yield}} \times 100$$

Protein content

The leaf protein content was estimated at 45 DAT following procedure given by Lowry *et al.*, (1951)^[8]. measuring the OD value at 660 nm in LAS -4200 Spectrophotometer. The amount of protein present in broccoli leaf was calculated and was expressed in mg g⁻¹.

Starch content

The starch content was estimated by Hedge and Hofreiter (1962)^[5] procedure. The sample (0.5g) was homogenized in 80% ethanol for removing the sugars. After that the samples were then centrifuged at 3000 rpm for 30 minutes to discard the supernatant. The remaining residue was again centrifuged till the washings do not give color after adding the anthrone reagent. To the residue again 5.0 ml of water and 6.5 ml of 52% perchloric acid was added. After 20 min of centrifugation it was extracted and centrifuged. 0.2 ml of the supernatant was pipetted out and made up the volume to 1ml with water. Then, 4ml of anthrone reagent was added and heated for 8min in water bath. After cooling, the intensity of green to dark green color i.e. OD value at 630 nm was measured in spectrophotometer. For finding the

starch content in the sample the following formula was used and multiply it with a factor of 0.9.

$$\text{Amount of Starch} = \frac{\text{Concentration from graph}}{0.2\text{ml}} \times \frac{100}{0.5\text{g}} \times 0.9 \left(\mu \frac{\text{g}}{\text{g}}\right)$$

Economics

Total cost of cultivation

The total cost of cultivation was calculated in rupees per hectare for each treatment combination. It included all gross investment such as cost of land preparation, labour wages, materials input cost (Seeds, manures & fertilizers, chemical etc.), transportation cost and miscellaneous cost.

Gross and net return

Gross and net return were calculated in rupees per hectare treatment combination wise. Gross return was calculated with the multiplication of the economic yield to the prevailing market price. Net return was subtracted by the total cost of cultivation from gross return on per ha basis.

$$\text{Net return} = \text{Gross return} - \text{Cost of cultivation}$$

Benefit-cost ratio (B:C)

The benefit cost ratio was computed by dividing gross return received per hectare by total cost of cultivation involved per hectare.

Statistical analysis

The data generated in the present investigation were statistically analyzed following the method described by Panse and Sukhatme (1967)^[11]. Critical differences (CD) (at 5% probability level) was calculated.

Results and Discussion

Yield parameters

The highest head diameter of 14.84 cm was recorded in I₁F₁ and the lowest was recorded in I₄F₄ (9.34 cm). This might be due to the reason that the fertilizers applied might create a conducive growth environment with optimum nutrient level near the root zone that helped the plants to absorb sufficient nutrients from the soil. This helped the plant to produce more dry matter to maintain efficient dry matter partitioning towards the head of broccoli that ultimately led to increased size of broccoli head. Our observations are in close conformity with the findings of earlier researchers. Demchak *et al.* (1990)^[3], Brahma *et al.* (2002)^[1], Yang *et al.*, (2006)^[19] and Fereres *et al.*, (2009)^[4]. Again, the highest head yield, total yield and harvest index were found in I₁F₁ (225.41 g/plant, 18.69 kg/plant and 52.11%) and the lowest were exhibited in I₄F₄ (71.41 g/plant, 6.29 kg/plant and 34.35%). This might be due to the logic that, the optimum level of water the plant gained throughout the growing period in drip irrigated plots empowered the plant to achieve vigorous vegetative growth with higher chlorophyll content, CSI, RLWC, LAR and LAD. The plants with superiority in those morpho-physiological traits could carry out more photosynthesis and maintain better source and sink relationship with efficient dry matter partitioning. These, ultimately help to produce more yield with drip fertigation in broccoli. The performance of I₂ and I₃ were also better than I₄ for the said causes. Similar results are also reported by Tumuhairwe and Gumbs (1983)^[16].

Table 1: Yield parameters of broccoli influenced by different fertigation treatments

Treatments	Head diameter (cm)	Head yield (g/plant)	Total yield (kg/plant)	Harvest index (HI %)
I ₁ F ₁	14.84	225.41	18.69	52.11
I ₁ F ₂	13.33	220.00	17.17	49.75
I ₁ F ₃	12.74	210.47	16.90	48.87
I ₁ F ₄	12.73	181.67	16.73	47.62
I ₂ F ₁	12.47	175.45	15.63	47.01
I ₂ F ₂	12.26	168.50	14.53	46.75
I ₂ F ₃	11.88	159.00	13.61	45.29
I ₂ F ₄	11.16	147.00	12.47	45.14
I ₃ F ₁	10.33	133.33	12.15	44.03
I ₃ F ₂	9.57	123.67	11.90	43.75
I ₃ F ₃	9.55	120.33	10.79	42.69
I ₃ F ₄	9.51	116.75	9.63	41.32
I ₄ F ₁	9.45	111.33	8.27	40.14
I ₄ F ₂	9.40	97.67	7.90	38.50
I ₄ F ₃	9.33	89.33	6.87	33.01
I ₄ F ₄	9.34	71.41	6.29	34.35

Quality parameters

The Protein Content (30.03 mg/g) and Starch Content (55.73 µg/g) were highest at I₁F₁. However, significantly, lowest fruit quality were observed in I₄F₄ i.e. 19.49 mg/g and 31.19 µg/g respectively. This might be due the reason that the plants under higher drip irrigated plots received appropriate amount of water so, it could be assumed that they never experienced any kind of moisture deficit situation. Thus, the plants under higher drip were able to absorb adequate amount of water and nutrients from the soil. With the absorption and utilization of more

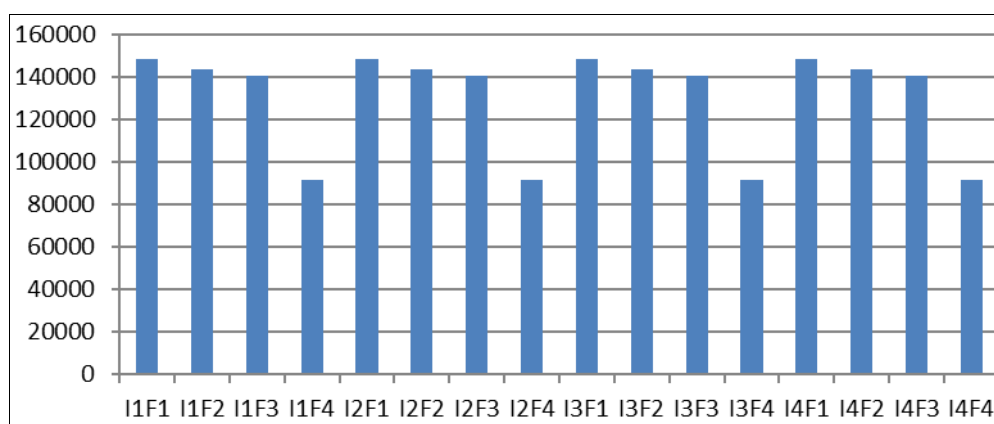
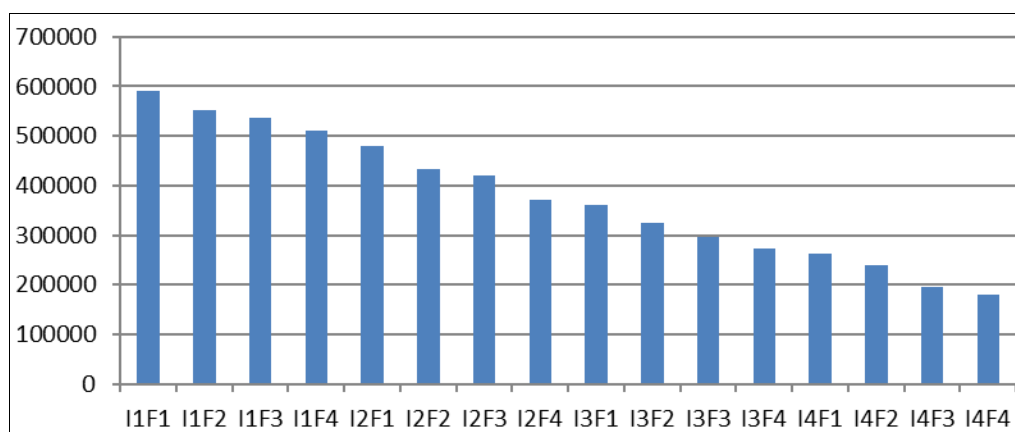
nutrients probably, the metabolic activity of the plant such as protein, starch, sugars synthesis etc. were increased. Similar results have been reported by Letey *et al.*, (1983)^[7] and Sharif (2008)^[14] in broccoli that drip irrigation increased the production of carbohydrates and proteins for more vigorous growth ultimately enhanced the fruit quality.

Table 2: Quality parameters of broccoli influenced by different fertigation treatments

Treatments	Protein content (mg/g)	Starch content (µg/g)
I ₁ F ₁	30.03	55.73
I ₁ F ₂	29.33	54.75
I ₁ F ₃	26.33	50.86
I ₁ F ₄	26.12	48.03
I ₂ F ₁	25.67	46.41
I ₂ F ₂	25.15	44.53
I ₂ F ₃	24.40	42.50
I ₂ F ₄	24.33	42.23
I ₃ F ₁	23.97	38.92
I ₃ F ₂	23.67	36.98
I ₃ F ₃	23.15	35.45
I ₃ F ₄	23.03	33.92
I ₄ F ₁	22.47	32.89
I ₄ F ₂	21.37	31.88
I ₄ F ₃	19.67	31.55
I ₄ F ₄	19.49	31.19

Economics

The benefit: cost ratio of broccoli was highest in treatment combination I₁F₁ (3.99:1). While, the lowest was observed in I₄F₄ (1.96:1).

**Fig 1:** Total cost of cultivation (Rs./Ha.)**Fig 2:** Gross Return (Rs./Ha.)

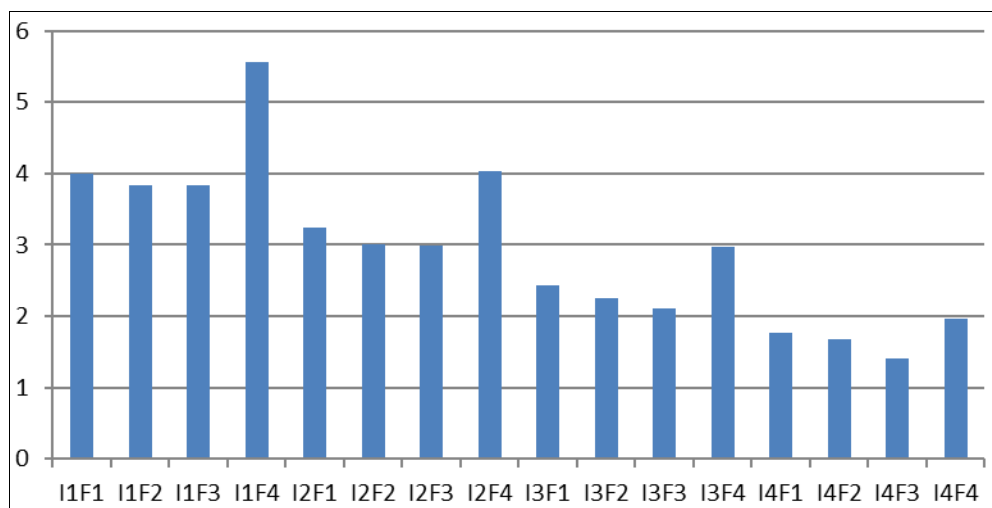


Fig 3: Benefit-cost Ratio(B:C)

Conclusion

The drip irrigation and fertilizer application significantly increase the growth, yield and quality of broccoli crop. The drip irrigation with higher level of water like 120% Etc and NPK @ 301.78, 366.77 and 206.97 t/ha application produces the best performance in terms of growth, yield and quality of broccoli. Thus, this treatment combination may be recommended for the broccoli growers of Assam as well as North-East part of India. The same treatment combination also maintains the highest Benefit: Cost ratio 3.99:1. Thus, the outcome of the present investigation is expected to help the vegetable growers to uplift their socio-economic condition and thereby may attract the educated youth of the state to consider the cultivation of high value vegetable crops like broccoli on commercial basis.

References

1. Brahma S, Phookan DB, Barua P, Bora DK. The effects of NPK fertilizers on the nutrient uptake, yield, and quality of broccoli (*Brassica oleracea* var. *italica*) cv. KTS-1. *Veg Sci.* 2002;29(2):154-156.
2. Boswell VR. Our vegetable travelers. *Natl Geogr Mag.* 1949;96:134-217.
3. Demchak KT, Smith CB. Yield response and nutrient uptake of broccoli as affected by lime type and fertilizer. *J Amer Soc Hort Sci.* 1990;115:737-740.
4. Fereres E, Pasquale D, Theodore C. AquaCrop - The FAO crop model to simulate yield response to water: II. Main algorithms and software description. 2009.
5. Hedge JE, Hofreiter BT. In: *Carbohydrates Chemistry*, 17. Academic Press; 1962. New York.
6. Li D, Jiang N, Zhang M, Duan X. A comparative study of drying methods on physical characteristics, nutritional properties, and antioxidant capacity of broccoli. *Drying Tech.* 2019;38:1378-1388.
7. Letey J, Jarrell WM, Valoras N, Beverly R. Fertilizer application and irrigation management of broccoli production and fertilizer use efficiency. *Agron J.* 1983;75:502-507.
8. Lowry OH, Brought NTR, Farr LA, Randall RJ. Protein measurement with Folin phenol reagent. *J Biol Chem.* 1951;193:265-275.
9. Nandini DB. Sulforaphane in broccoli: The green chemoprevention, role in cancer prevention and therapy. 2020;24(2):405-409.
10. Nath A, Bagchi B, Misra LK, Deka BC. Changes in post-harvest phytochemical qualities of broccoli florets during ambient and refrigerated storage. *Food Chem.* 2008;127(4):1510-1514.
<https://doi.org/10.1016/j.foodchem.2011.02.007>.
11. Panse VG, Sukhatme PV. *Statistical Methods for Agricultural Workers*. ICAR Pub. New Delhi; 1985. p. 347.
12. Paschold PJ, Zengerle KH, Kleber J. Influence of irrigation on the yield and the nitrogen balance of broccoli (*Brassica oleracea* L. var. *italica*). *Acta Hort.* 2000;537:831-837.
13. Rangkadilok N, Nicolas M, Bennett R, Eagling D. The effect of sulfur fertilizer on glucoraphanin levels in broccoli (*Brassica oleracea* L.) at different growth stages. *J Agric Food Chem.* 2004;52:2632-2639.
14. Sharif AA. Effects of spacing and potassium on growth and yield of broccoli (*Brassica oleracea* var. *italica* L.). M.Sc. Thesis, Sher-E-Bhanga Agricultural University, Dhaka; 2008.
15. Thompson HC, Kelly WC. *Vegetable Crops*. 5th ed. Tata McGraw Hill Pub. Co. Ltd., New Delhi, India; 1983. p. 611.
16. Tumuhairwe JK, Gumbs A. Effect of mulches and irrigation on the production of cabbage in the dry season. *Trop Agric.* 1983;60(2):122-127.
17. Verma TS, Sharma SC. Pusa Broccoli KTS1: New broccoli. *Ind Hort.* 1998;43(3):16-29.
18. Wojciechowska W, Adamczewska K, Krygier M. Effect of living mulches on selected soil structure indicators in eggplant cultivation. *Veg Crops Res Bull.* 2020;77:49-59.
19. Yang J, Zhu Z, Gerendas J. Interactive effects of phosphorus supply and light intensity on glucosinolates in pakchoi (*Brassica campestris* L. ssp. *chinensis* var. *communis*). *Plant Soil.* 2006;323:323-333.