International Journal of Environment and Climate Change

Volume 13, Issue 9, Page 1921-1927, 2023; Article no.IJECC.103673
ISSN: 2581-8627
(Past name: British Journal of Environment & Climate Change, Past ISSN: 2231–4784)

Effect of Different levels of Liquid Nitrogen, Phosphorus and Potassium on Growth, Yield and Quality of Broccoli (*Brassica oleraceae var. italica*) in Hydroponic

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Authors' contributions

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

Article Information

DOI: 10.9734/IJECC/2023/v13i92424

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/103673

Original Research Article

Received: 20/05/2023
Accepted: 22/07/2023
Published: 25/07/2023

ABSTRACT

Hydroponics is a Plant growing procedure in water. The experiment was carried out to find out the effect of different levels of NPK on growth, yield and quality of broccoli (*Brassica oleracea L. var. Italica*). The variety was "Green Magic" which is F1 hybrid. They were bought from the local market of "Alopibag" Prayagraj. The present experiment was carried out from October, 2021 to January, 2022 in Shade Net Research Field, Department of Horticulture, SHUATS, Prayagraj. The experiment was conducted in Randomized Block Design (RBD), with eight treatments T1(8.12ml NPK/Pl), T2(9.37ml NPK/Pl), T3(10.62ml NPK/Pl), T4(11.87ml NPK/Pl), T5(13.12ml NPK/Pl),

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T6(14.37ml NPK/Pl), T7(15.62ml NPK/Pl**)**, with a control (T_0), replicated thrice in nutrient field technique (NFT) hydroponics system. The best result was shown by the treatment T6.The initiation of curd formation, growth of plant and chlorophyll content all parameter were superior in T6. The plants in T0 do not show any significant improvement as there were no nutrients given to them. The systems ran 4 hours daily during their vegetative growth and the timing was increased to 6 hours during their reproductive phase of development. Curd formation occurs in almost all plants in every treatment.

Keywords: Broccoli; NFT; F1 hybrid; chlorophyll content; RBD and NPK.

1. INTRODUCTION

"Broccoli *(Brassica oleracea L. var. Italica*) is one of the most commonly grown hydroponic vegetables. Hydroponics is a method of growing plants without soil. Plants may be grown in a nutrient solution only (liquid culture). In both systems, all of the plants' nutritional needs are supplied through irrigation water. Hydroponics is a highly exacting and demanding system that requires a greater amount of production knowledge, experience, technical skill and financial investment than many other greenhouse systems. A grower must be committed to meeting the daily demands of production to be successful. Hydroponics is the process of growing plants in water or nutrient solutions" [1-3] "in a liquid nutrient solution with or without the use of artificial media. Water is supplemented with plants macro and micronutrients in hydroponics such as nitrogen, calcium, potassium, sodium, magnesium and iron" [4-6]. "Fertilizers are an important source of plants nutrients that can be used as a solution in hydroponics. In hydroponics, a single fertilizer is not enough for growing plants [7]. Broccoli (*Brassica oleracea* var. italica) is a cruciferous cool (18 to 24°C) season crop which is very popular throughout the world" [8-10]. "It is consumed both fresh and cooked but also as processed and is rich in vitamin A, vitamin C, riboflavin, iron, calcium and other nutrients necessary for strengthening the innate immune system" [10-12] As all the nutrient are given manually therefore it has to be given according to the need of the plants, type of the plant, what is the phase of the development of the plant. The liquid nutrients were used was purchased from an online platform. It contains all the major and minor nutrients in the right proportion for the development of the plants [13,14,4].

"On the other hand, for effective nutritional management and, consequently, an increase in hydroponic broccoli yield, it is indispensable the appropriate control of the nutrient solution. Among the factors to be controlled are electrical conductivity (CE), pH, temperature and oxygen concentration, as well as the time and the flow of the solution available to the plant roots during the crop cycle" [15]. The EC range from 2.8 to 3.5 and the pH range from 6.0 to 6.8 (Hardeep Singh and Dunn Bruce, 2016) [16] should be maintained through the experiment. The EC was measured by EC meter in the lab and the pH was measured by the digital pH meter in the lab in presence of the lab incharge.

2. MATERIALS AND METHODS

2.1 Experimental Site

This experiment was carried out in October to January at the Horticultural research field, Naini Agricultural Institute, Sam Higginbottom University of Agriculture Technology and Sciences, Prayagraj (25.4358° N latitude 81.8463° E longitude) India .The area of Prayagraj district comes under the subtropical belt in the Southeast of Uttar Pradesh, which experiences extremely hot summer and fairly cold winter. The maximum temperature of the location reaches up to 46^oC – 48^oC and seldom falls as low as 4^oC – 5^oC. The relative humidity ranges between 20 to 94 percent. The average rainfalls in this area are around 1013.4 mm annually.

2.2 Experimental Details

At the Shade Net Research Field of the Department of Horticulture, Naini Agricultural Institute, an experiment was conducted to study the effect of different levels of Liquid NPK on the growth, yield, and quality of Broccoli. The experiment was designed using a Randomized Block Design approach to eliminate any potential bias and to increase the accuracy of the results obtained. The experiment was carried out using the Green Magic (F1 Hybrid) variety of Broccoli, and the seed sowing time was on the 18th of September 2021. The transplanting of the

Table 1. Treatment details (ml/10litres)

Treatment	Initial	15 DAT	30 DAT	45DAT	60 DAT	75 DAT	Liq.NPK /plant
T_1(NPK)	20	25	30	35	40	45	8.12ml NPK/Pl
T_2(NPK)	25	30	35	40	45	50	9.37ml NPK/Pl
T_3(NPK)	30	35	40	45	50	55	10.62ml NPK/Pl
T_4(NPK)	35	40	45	50	55	60	11.87ml NPK/Pl
T_5(NPK)	40	45	50	55	60	65	13.12ml NPK/Pl
T_6(NPK)	45	50	55	60	65	70	14.37ml NPK/Pl
T_7(NPK)	50	55	60	65	70	75	15.62ml NPK/Pl
T_0(NPK)	00	00	00	00	00	00	Tap water

seedlings was done on the 14th of October 2021, and they were placed in hydroponics system number two in the Department of Horticulture at SHUATS A total of 200 seedlings were prepared for the experiment, which were sown in pots of size 8*5. The media used in the pots was a combination of sandy soil, coco peat, and Vermicompost in a ratio of 1:1:1. The experiment was conducted under a shade net to provide appropriate conditions for the growth of the Broccoli plants.

Following are the concentration details used in the hydroponics system (Table 1).

2.3 Instruments Used

EC meter – to evaluate the electrical conductivity of the solution.

pH meter – to check the $H^{+\ ion}$ concentration in the solution.

SPAD meter – to check the chlorophyll content of the broccoli leaves.

Lux meter – to record the light intensity inside the shade net.

Vernier caliper- to measure the girth of the plant.

Scale - to measure the length of the plant.

3. RESULTS AND DISCUSSION

3.1 Growth Parameters

Plant Height: Maximum plant height was observed as 23.57 cm followed by 22.02 cm in treatment T6 (14.37ml NPK/Pl) and T7 (15.62ml NPK/Pl) respectively (Table 2). The reason behind this trend could be thehigher concentration of N, P & K, which facilitate the overall physiological growth of the plants up to certainlevel due to rapid cell elongation, cell multiplication, new cell formation in the meristematic tissue. Because in T7 which has a higher concentration of Liq.NPK shows lesser plant height as compared to T6. The results match the result of Abou El- nour et al. [3], Gholami et al. (2014) and Elhindi et al. [17].

Number of leaves: A Maximum number of leaves/plant 12.00 was recorded in T6 (14.37ml NPK/Pl) followed by T7 (15.62ml NPK/Pl) 11.13 leaves/plant and a minimum 4.17leaves/plant was recorded in T0 (NPK 00ml/plant) (Table 2). Poorly balanced nutrient solution composition led to improper growth and hence less number of leaves also components of water, nutrients and dissolved oxygen must be available proportionally. Similar results were found by Trotta et al. (2016) and Gholami et al. [18]. This finding correlates with the findings of Ahmed et al., Suyantohadi et al. [19], Frasetya et al. [20], and Singh et al. [21].

Girth: The maximum stem girth diameter (20.03 mm) was recorded in the T6 with 14.37ml NPK/Pl followed by T7 (18.93 mm) with 15.62ml NPK/Pl. While the minimum(3.20 mm) was recorded in T0 (control) as it contains no amount of N,P and K. This was probably due to better vegetative growth of plants with availability of sufficient nitrogen, phosphorus, potassium and other essential nutrients which weresupplemented into the water as per of plant's requirement. These finding correlates with the finding of Wang et al. [22] and Duan et al. [9].

Chlorophyll content: The maximum chlorophyll content (56.94) in the leaves of the Broccoli plant was obtained in the T6 with 14.37ml NPK/Pl followed by T7 (55.93) with 15.62ml NPK/Pl. It may be due the reason of the higher amount of N, P and K in the treatment which helps in the building of chloroplast cells in the leaves. As Nitrogen, Phosphorus and Potassium play a pivotal role in chlorophyll synthesis absence of these nutrients may cause a depleted amount of

chlorophyll contents (27.6) as was observed in the plants of T0(control).The Application of higher dosage of N also increases the chlorophyll content. This finding correlates with the findings of Coronel et al. [6] and Hokmalipourand Darbandi, 2012 [23].

Root length: The root system is the main organ for nutrient absorption in plants, and it can synthesize and transport physiological activators [24], (Mohd et al. 2013) [25]. The maximum root length (22.6 cm) was observed in T6 with 14.37ml NPK/Pl followed by T7 (21 cm) with 15.62ml NPK/Pl and the minimum root length was observed in T0 (control) with 6 cm. It may be due to the high amount of N, P and K which causes the growth of the root inside the Hydroponics.

3.2 Quality and Yield Parameters

T.S.S: Maximum T.S.S content 7.57^0brix was recorded in T3(10.62ml NPK/Pl) followed by T2(9.37ml NPK/Pl) with 7.13^0brix and minimum 6.13^0brix was recorded in T5(13.12ml NPK/Pl) (Table 3). Which can be due to increasing the rate of NPK application resulting in the percentage of T.S.S content and significantly reduced with increasing salt concentration.

Ascorbic acid: Maximum vitamin C content 88.70 mg/100g was recorded in T3 (10.62ml NPK/Pl) followed by T2 (9.37ml NPK/Pl) with87.13 mg/100g and minimum 79.35 mg/100g was recorded in T7 (15.62ml NPK/Pl) (Table 3). Which can be due to the climatic conditions during crop growth and development which have a greater overall effect on Ascorbic Acid? It is shown that excessive use of nitrogen decreases the Ascorbic acid content. This finding correlates with the findings of Lisiewska and Kmiecik [26].

Earliness parameter: The last days to 1^{st} bud formation and 50% bud formation occur in the plants of treatment T6 (14.37ml NPK/Pl) which takes 64.33 days and 70 days respectively followed by plants with the treatment T7 (15.62ml NPK/Pl) which takes 65 days and 70.33 days respectively as compared to the control where bud formation does not take at all (Table 4), it is due to the reason that it does not contains any kind of nutrient solution. T6 and T7 contain a higher amount of NPK concentration which causes overall physiological growth and thus facilitate the Broccoli plants to develop flower buds. The P increases cell division and stimulates root growth and flowering. The high amount of P in the hydroponics system stimulates metabolism and rapid cell division [27]; therefore, plays a role in the storage and transfer of energy released during photosynthesis and its deficiency delays plant maturity.

3.3 Yield Parameter

Average weight: Maximum average weight (100.50 g) was recorded in T6 (14.37ml NPK/Pl) followed by T7 (15.62ml NPK/Pl) with (96.27 g) whereas minimum weight (80.87 g) was recorded in T1 (8.12ml NPK/Pl) (Table 5). This can be due to application of N, P, and K which are attributed to enhanced photosynthesis, accumulation of carbohydrates and favorable effect on vegetative growth as well reproductive growth. This finding correlates with the findings of Ferreira et al. 2010, Cordoso et al. 2013, Ochoa et al. 2014.

Table 2. Growth parameters of Broccoli like- plant height, number of leaves/plant, Girth and Root length

Treatments	Plant height(cm)	Number of leaves	Girth(mm)	Root length
T1(8.12ml NPK/Pl)	17.33	7	7.40	13.27
T2(9.37ml NPK/Pl)	18.8	7.23	9.70	14.83
T3(10.62ml NPK/Pl)	19.8	7.47	13.13	15.73
T4(11.87ml NPK/Pl)	20.63	8.00	14.8	17.67
T5(13.12ml /NPK/Pl)	21.17	8.37	15.53	19.37
T6(14.37ml NPK/Pl)	23.57	12.00	20.03	22.6
T7(15.62ml NPK/Pl)	22.03	11.13	18.93	21
T0(Tap water)	10.67	4.17	3.20	6

Table 3. Qualitative Parameter of Broccoli depicting TSS and Ascorbic Acid (mg/100g)

Treatments	TSS (^{0}Brix)	Ascorbic Acid (mg/100g)
T1(8.12ml NPK/Pl)	6.83	86.83
T2(9.37ml NPK/Pl)	7.13	87.13
T3(10.62ml NPK/Pl)	7.57	88.70
T4(11.87ml NPK/Pl)	6.73	83.65
T5(13.12ml /NPK/Pl)	6.13	82.95
T6(14.37ml NPK/Pl)	6.43	81.53
T7(15.62ml NPK/Pl)	5.83	79.35
T0(Tap water)	00	00
F-test	S	S
SE.d (+,-)	0.26	0.79
C.D $_{(P\ 0.05)}$	0.57	1.27

Table 4. Earliness Parameter of Broccoli depicting days to 1st bud initiation and 50% bud formation

Treatments	Days to 1st bud appearance	Days to 50% bud formation
T1(8.12ml NPK/Pl)	71	75.33
T2(9.37ml NPK/Pl)	70.33	74.67
T3(10.62ml NPK/Pl)	70	74.33
T4(11.87ml NPK/Pl)	66.33	74.67
T5(13.12ml /NPK/Pl)	65.33	73.33
T6(14.37ml NPK/Pl)	64.33	70.00
T7(15.62ml NPK/Pl)	65	70.33
T0(Tap water)	00	0.00
F-test	S	S
SE.d (+,-)	0.82	0.633
C.D $_{(P\ 0.05)}$	1.78	1.37

Table 5. Yield Parameter of the Broccoli depicting the Average weight and Number of flower buds/ structure

Treatments	AVG. Wt/Treatment(g)	Number of Flower Buds/str
T1(8.12ml NPK/Pl)	80.87	19.89
T2(9.37ml NPK/Pl)	83.37	21.99
T3(10.62ml NPK/Pl)	86.17	21.00
T4(11.87ml NPK/Pl)	88.83	21.99
T5(13.12ml /NPK/Pl)	92.03	23.01
T6(14.37ml NPK/Pl)	100.50	24.00
T7(15.62ml NPK/Pl)	96.27	24.00
T0(Tap water)	0.00	0.00
F-test	S	S
SE.d (+,-)	3.01	0.37
C.D $_{(P\ 0.05)}$	6.5	0.80

Number of Flower buds/structure: The maximum number of flower buds appearing in the treatment T6 (14.37ml NPK/Pl) and T7 (15.62ml NPK/Pl) simultaneously that is 24 out of 24 followed by T5 (13.12ml /NPK/Pl) which is 19.89 out of 24 (Table 5). The reason behind the 100% flower bud formation in T6 and T7 may be the right concentration of NPK in the hydroponics solution which attributes the proper bud formation in the Broccoli plants.

4. CONCLUSION

From the present investigation it can be concluded that T6 (14.37ml NPK/Pl) performs best in terms of all Growth parameters like Plant height (23.57 cm), number of leaves/plant (12), chlorophyll content (56.93), Root length (22.6 cm) whereas in Qualitative parameters like TSS (7.57), Ascorbic acid (88.70mg/100g), T3 (10.62ml NPK/Pl) performs the best. Whereas

Earliness Parameter of Broccoli like 1st bud initiation (64.33 days) and 50% bud formation (70 days) T6 14.37ml NPK/Pl) performs the best in yield parameters like the Number of Broccoli/treatment, average weight of broccoli bud. Considering BC ratio T6 show the highest cost- benefit ratio of 1.36 among all other treatments.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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