

Original Research Article

Effect of different level of Liquid Nitrogen, Phosphorus and Potassium on Growth, Yield and Quality of Broccoli (*Brassica oleraceae var. italica*) in Hydroponics

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 during 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/PI), T2(9.37ml NPK/PI) T3(10.62ml NPK/PI) T4(11.87ml NPK/PI) T5(13.12ml NPK/PI) T6(14.37ml NPK/PI) T7(15.62ml NPK/PI) with a control (T₀), 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, 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 each and 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 the 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

(*Pandey et al., 2009; Sardare and Admane, 2019*) [1] 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 (*Téllez and Merino, 2012; Lazar et al., 2015*)[2]. Fertilizers are important source of plants nutrients which can be used as a solution in hydroponics. In hydroponics a single fertilizer is not enough for growing plants (*Ikeda and Tan, 1998*). Broccoli (*Brassica oleracea var. italica*) is a cruciferous cool (18 to 24°C) season crop which is very popular throughout the world (*Tindall, 1992*)[3]. 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 innate immune system (*Nasr and Ragab, 2000; Wadmare et al., 2019*) [4] As all the nutrient are given manually therefore therefore it has to be given according 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 form online platform. It contains all the major and minor nutrients in right proportion for the development of the plants.

On the other hand, for an 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 period of time and the flow of

the solution available to the plant roots during the crop cycle (*Furlaniet al, 1999*) [5]. 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*) [6] should be maintained through the experiment. The EC was measured by EC meter in the lab and the pH was measures by the digital pH meter in the lab in presence of the lab in-charge.

2. Materials and methods

2.1 Experimental site

This experiment was carried out in the month of 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 subtropical belt in the South east of Uttar Pradesh, which experience extremely hot summer and fairly cold winter. The maximum temperature of the location reaches up to 46°C – 48°C and seldom falls as low as 4°C – 5°C. The relative humidity ranges between 20 to 94 per cent. 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 Randomised 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 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)

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

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

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 higher concentration of N, P & K, which facilitate the overall physiological growth of the plants up to certain level due to rapid cell elongation, cell multiplication, new cell formation in the meristmatic tissue. Because in T7 which has higher concentration of Liq.NPK show lesser plant height as compared to T6. This finding correlates the findings of *Tumbareet al., [10], Sundar et al., (2019).[7]*

Number of leaves

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 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. This finding correlates the findings of *Ahmed et al., Suyantohadi et al., [8], Frasetya et al., [9], Singh et al., [10].*

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 were supplemented into the water as per of plant's requirement. This finding correlates with the finding of the *Ashish Kumar Dubey et.al(2017)*

Chlorophyll content

The maximum chlorophyll content (56.94) in the leaves of the Broccoli plant were 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 higher amount of N, P and K in the treatment which helps in the building of chloroplasts cells in the leaves. As Nitrogen, Phosphorus and Potassium play a pivotal role in chlorophyll synthesis absence of these nutrients may cause depleted amount of chlorophyll contents (27.6)as it was observed in the plants of T0(control). Application of higher dosage of N also increase the chlorophyll content. This finding correlates the findings of *Coronel et al and Hokmalipour et al.,[11]*

Root Length

The root system is the main organ for nutrient absorption in plants, and it can synthesize and transport physiological activators (*Tian et al., 2009; Mohd et al., 2013*) [12].The maximum root length (22.6

cm) was observed in T6 with 14.37ml NPK/PI followed by T7 (21 cm) with 15.62ml NPK/PI and the minimum root length was observed in T0 (control) with 6 cm. It may

be due the high amount of N, P and K which causes the growth of the root inside the Hydroponics.

Table 2. Growth parameters of Lettuce like plant height, plant spread, number of leaves/plant, leaf length, leaf width, water used

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

3.2 Quality and Yield Parameters

T.S.S

Maximum T.S.S content 7.57 °brix was recorded in T3 (10.62ml NPK/PI) followed by T2(9.37ml NPK/PI) with 7.13 °brix and minimum 6.13 °brix was recorded in T5(13.12ml NPK/PI) (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? This finding correlates the findings of *Ahamed et al., [13] and Franquera et al.,*

Ascorbic acid:

Maximum vitamin C content 88.70 mg/100g was recorded in T3 (10.62ml NPK/PI) followed by T2 (9.37ml NPK/PI) with 87.13 mg/100g and minimum 79.35 mg/100g was recorded in T7 (15.62ml NPK/PI) (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 the findings of *Lisiewska and Kmiecik (1996)*

Earliness parameter

The least days to 1st bud formation and 50% bud formation occurs in the plants of treatment T6 (14.37ml NPK/PI) which takes

64.33 days and 70 days respectively followed by plants with the treatment T7 (15.62ml NPK/PI) which takes 65 days and 70.33 days respectively as compared to the control where bud formation does not take at all.(Table4) It is due to reason that it does not contain any kind of nutrient solution. T6 and T7 contain higher amount of NPK concentration which causes overall physiological growth and thus facilitates the Broccoli plants to develop the 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 (*Khan MB et al,2012*); therefore, plays a role in the storage and transfer of energy released during photosynthesis and its deficiency delays plant maturity.

Yield Parameter

Average weight

Maximum average weight (100.50 g) was recorded in **T6 (14.37ml NPK/PI)** followed

by **T7 (15.62ml NPK/PI)** with (96.27 g) whereas minimum weight (80.87 g) was recorded in **T1 (8.12ml NPK/PI)** (Table 5). Which can be due to application of N, P, and K which attributed to enhanced photosynthesis, accumulation of carbohydrates and favorable effect on vegetative growth as well reproductive growth. This finding correlates the findings of *Akanbi et al.,*

Number of Flower buds/structure

The maximum number of flower buds appear in the treatment **T6 (14.37ml NPK/PI)** and **T7 (15.62ml NPK/PI)** **simultaneously** that is 24 out of 24 followed by **T5 (13.12ml /NPK/PI)** which is 19.89 out of 24. (Table5). 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.

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/PI)	6.83	86.83
T2(9.37ml NPK/PI)	7.13	87.13
T3(10.62ml NPK/PI)	7.57	88.70
T4(11.87ml NPK/PI)	6.73	83.65

T5(13.12ml /NPK/PI)	6.13	82.95
T6(14.37ml NPK/PI)	6.43	81.53
T7(15.62ml NPK/PI)	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/PI)	71	75.33
T2(9.37ml NPK/PI)	70.33	74.67
T3(10.62ml NPK/PI)	70	74.33
T4(11.87ml NPK/PI)	66.33	74.67
T5(13.12ml /NPK/PI)	65.33	73.33
T6(14.37ml NPK/PI)	64.33	70.00
T7(15.62ml NPK/PI)	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/PI)	80.87	19.89
T2(9.37ml NPK/PI)	83.37	21.99
T3(10.62ml NPK/PI)	86.17	21.00
T4(11.87ml NPK/PI)	88.83	21.99
T5(13.12ml /NPK/PI)	92.03	23.01
T6(14.37ml NPK/PI)	100.50	24.00
T7(15.62ml NPK/PI)	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

Conclusion

From the present investigation it can be concluded that T6 (14.37ml NPK/PI) 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) where as in Qualitative parameters like TSS (7.57) ,Ascorbic acid(88.70mg/100g), T3(10.62ml NPK/PI) performs the best .where as Earliness Parameter of Broccoli like 1st bud initiation (64.33 days) and 50% bud formation (70 days) T6 14.37ml NPK/PI performs the best in yield parameters like 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.

References

- Coronel G. Chang M, Rodríguez-Delfín A. Nitrate Reductase Activity and Chlorophyll Content in Lettuce Plants Grown Hydroponically and organically. *Acta Horticulturae*. 2009;843(843):137- 144.
- Frasetya B, Harisman K, Ramdaniah NAH. The effect of hydroponics system on the growth of lettuce. *IOP Conference Series: Materials Science and Engineering*. 2020;1098.
- Khan MB, Rafiq R, Hussain M, Farooq M, Jabran K. Ridge sowing improves root system, phosphorus uptake, growth and yield of Maize (*Zea Mays L.*) Hybrids. *J Anim Plant Sci*. 2012;22: 309–317
- Lisiewska, Z. and Kmiecik, W. (1996).** Effects of level of nitrogen fertilizer, processing conditions and period of storage of frozen broccoli and cauliflower on vitamin C retention. *Food Chemistry*, 57(2): 267-270
- Nasr, M.H.A. and Ragab, W.S.M. 2000. Yield, head quality and nutritional composition of a new late flowering broccoli variety grown under Assiut conditions. *Journal of Agricultural Science*. 31(1): 55-77.
- Olabode OS, Sola O, Akanbi WB, Adesina GO, Babajide PA. Evaluation of *Tithonia diversifolia* (Hemsl.) A Gray for soil improvement. *World Journal of Agricultural Sciences*. 2007;3(4): 503-7
- Suyantohadi A, Kyoren T, Hariadi M, Purnomo M H and Morimoto T. Effect of high concentrated dissolved oxygen on the plant growth in a deep hydroponic culture under a low; 2010.
1422. Saeid Hokmalipour and Maryam Hamele Darbandi. Effects of Nitrogen Fertilizer on Chlorophyll Content and Other Leaf Indicate in Three Cultivars of Maize (*Zea mays L.*). *World applied Science Journal*. 2012;16(6).
- Tindall, H.D. 1992. *Vegetables in the tropics*. The Macmillan Press ltd. London and Basingstoke
- Tumbare AD, Bhotte SU. Effect of solid soluble fertilizer applied through fertigation on growth and yield of chilli (*Capsicum annum*). *Indian J. Agric. Sci*. 2002;72(2):109-111.
- Tian, Q. Y., Sun, P., and Zhang, W. H. (2009). Ethylene is involved in nitrate-dependent root growth and branching in *Arabidopsis thaliana*. *New Phytol*. 184, 918–931. doi: 10.1111/j.1469-8137.2009.03004.x
- Téllez, L.I.T. and Merino, F.C.G. 2012. Nutrient solutions for hydroponic systems, in hydroponics: A standard methodology for plant biological researches, Asao, T., Ed.; Pp. 1-20. In Tech: Rijeka, Croatia, pp: 1-20. <https://doi.org/10.5772/37578>

Zienab FR Ahmed, Alghazal KH Alnuaimi, Amira Askri and Nikolaos Tzortzakis. Evaluation of Lettuce (*Lactuca sativa* L.) Production under Hydroponic System: Nutrient Solution Derived from Fish Waste vs. Inorganic Nutrient Solution. *Horticulturae* 2021;7:292.

UNDER PEER REVIEW