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Effect of different level of nutrients on yield and economics of Spinach Beet (*Beta vulgaris* var. *bengalensis*) under hydroponic system

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Abstract
The research was carried out during January to February, 2021 under shade net condition, Department of Horticulture, SHUATS, Prayagraj, Uttar Pradesh. The experiment was conducted in Randomized Block Design (RBD), with eight treatments and replicated thrice in hydroponic system with Spinach beet variety All-green. It was found that the T_7 (Epsom salts and micros (17.5 ml/10 L) ($MnSO_4$, $ZnSO_4$, $CuSO_4$, B, Common Salt) + Iron Chelate (17.5 m1/10 L) + Mono Ammonium phosphate (17.5 ml/10 L) N:P:K 11:48:00 + Calcium Nitrate (27.5 ml/10 L) N:P:K 15:00:00 + Potassium Nitrate (27.5 ml/10 L) N:P:K 13:00:44 was found superior over other treatments in terms of yield and economics of spinach beet under hydroponic system. Maximum gross return (Rs. 973.32/structure) and net return (Rs. 292.38/structure) with highest benefit cost ratio (1:1.67) was also obtained in T_7.

Keywords: Spinach beet, hydroponics, yield and economics

Introduction
Hydroponic culture, has gained popularity in recent years as a way to simplify the cleaning of edible leaf vegetables and provide them for consumption with minimal processing Nicola *et al.* (2007) [7]. Static solution culture is the oldest and most simple soilless culture technique among hydroponic culture systems. Plants are placed on Styro-foam platforms that float freely over the nutrient solution in today's modified version of the process, which is known as "floating water culture (Morgan, 1999; Gill, 2008) [13, 5]. In 1980, Arizona University invented and produced floating water culture, which was commercially used in vegetable culture in Florida a few years later. The approach is often employed in the creation of seedlings and standard or tiny vegetables (Carrasco *et al*., 2011) [1]. Easy system construction, low labor costs due to automation systems, rapid plant growth, homogeneous products, high quality yields, clean products, greater number of plants per unit area, easy harvest, optimized fertilizer and water use, minimal evaporative losses, environment-friendly production, and easy adaptation to small production areas are all advantages of hydroponic systems Oztekin *et al*., (2018) [8]. Dr. Alen Cooper created NFT in the mid 1960s in England to address the limitations of the ebb and flow method. Water or fertilizer solution circulates throughout the system and enters the growing tray via a water pump that does not have a timer Domingues *et al*., (2012) [3]. Many leafy greens may be easily produced in a hydroponics system, and spinach Beet production is the most extensively employed commercially. Several hydroponic experiments utilizing spinach as a model crop were recently undertaken Sharma *et al*., (2018) [10]. In a hydroponic system, the spinach beet (*Beta vulgaris* var. *bengalensis*) is one of the most commonly grown plants. It is a perennial leafy crop that is grown in both traditional agricultural and hydroponic systems all over the world. Spinach is incredibly nutritious and offers numerous health benefits due to its high quantities of vitamins, minerals, protein, and omega-3 fatty acids. Spinach is a popular food to cultivate in hydroponic systems because of its rapid growth and high nutritional value Petrea *et al*., (2013) [9].

Methodology
The present investigation was carried out during January-February 2021 at shade net, Department of Horticulture, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh, India. The experiment was laid out in randomized block design (RBD) with eight treatments and replicated thrice.

Total treatments include *viz*., T_1 to T_7 Nutrients (Epsom salts and micros (MnSO4, ZnSO4, CuSO4, B, Common Salt) + Iron Chelate + Mono Ammonium phosphate + Calcium Nitrate + Potassium Nitrate) used as different concentration and T_8 (Control tap water).

Table 1: Treatment details of the experiment

Treatments	Epsom salts and micros (ml/10 L) (MnSO4, ZnSO4, CuSO$_4$, B, Common Salt)	Iron Chelate (ml/10 L)	Mono Ammonium Phosphate (ml/10 L)	Calcium Nitrate (ml/10 L)	Potassium Nitrate (ml/10 L)
T_1	2.5	2.5	2.5	12.5	12.5
T_2	5	5	5	15	15
T_3	7.5	7.5	7.5	17.5	17.5
T_4	10	10	10	20	20
T_5	12.5	12.5	12.5	22.5	22.5
T_6	15	15	15	25	25
T_7	17.5	17.5	17.5	27.5	27.5
T_8	0	0	0	0	0

Results and Discussion

The result of the present investigation, regarding the effect of different levels of nutrient on yield and economics of Spinach Beet (*Beta vulgaris* var. *bengalensis*) in hydroponic system under shade net have been discussed and interpreted in the light of previous research work done in India and abroad. The result of the experiment are summarized Table 3.

Among the yield and economics, there was significant difference in treatments at 45 days after transplanting. Significantly higher yield attributing characters like number of leaves per plant, leaf length (cm), leaf width (cm), root length (cm), amount of water used (L.) was obtained in the treatment T_7 (Epsom salts and micros (17.5 ml/10 L) + Iron Chelate (17.5 m1/10 L) + Mono Ammonium phosphate (17.5 ml/10 L) + Calcium Nitrate (27.5 ml/10 L) + Potassium Nitrate (27.5 ml/10 L) *viz*., 25.33, 36.33 cm, 8.95 cm, 6.25 cm, 27.58 cm, 10.43 L, respectively. However, in the treatment T_4, T_5 and T_6 was observed to be statistically at par with T_7. It may attributed to the adequate supply of nutrient, higher uptake and recovery of applied nutrient with application of different nutrient particularly Calcium Nitrate and Potassium Nitrate might have enhanced cell division and formation of more tissues resulting in luxuriant vegetative growth and thereby increasing plant height similar finding was reported by Genuncio *et al*., (2012) [4]. The increase in plant spread and number of leaves per plant in best treatment is due to different treatment combination of Mono Ammonium phosphate. With nitrogen fertilizer or recommended dose of nutrient the similar finding has been reported by Daniel *et al*., (2017) [2]. Significantly higher, plant weight (37.21 g), Yield per structure (4.06 kg), TSS (5.47°Brix) and Chlorophyll content (32.98) were observed in the treatment T_7 (Epsom salts and micros (17.5 ml/10 L) + Iron Chelate (17.5 m1/10 L) + Mono Ammonium phosphate (17.5 ml/10 L) + Calcium Nitrate (27.5 ml/10 L) + Potassium Nitrate (27.5 ml/10 L). However, in the treatment T_4, T_5 and T_6 was observed to be statically at par with T_7. Similar finding were reported by Maneejantra *et al*., (2016) [6]; Wang *et al*., (2017) [11]; Oztekin *et al*., (2018) [8]. The maximum gross return was recorded in treatment T7 (Epsom salts and micros (17.5 ml/10 L) + Iron Chelate (17.5 m1/10 L) + Mono Ammonium phosphate (17.5 ml/10 L) + Calcium Nitrate (27.5 ml/10 L) + Potassium Nitrate (27.5 ml/10 L) with Rs. 973.32/structure and maximum net return was recorded in treatment T_6 with Rs. 315.46/structure. Maximum cost benefit ratio was recorded in treatment T_7 with 1:1.67. As the economics is the need of the farmers while taking decision regarding the adoption of the techniques and scientific knowledge Hence, T_7 (Epsom salts and micros (17.5 ml/10 L) + Iron Chelate (17.5 m1/10 L) + Mono Ammonium phosphate (17.5 ml/10 L) + Calcium Nitrate (27.5 ml/10 L) + Potassium Nitrate (27.5 ml/10 L) recorded highest cost benefit ratio is due to low cost of nutrient and high productivity which increase the market value of the crop.

Table 2: Cost of production

Symbol	Treatment Details	Cost (Rs./m^2)	Fixed cost (Rs. /m^2)	Total cost (Rs./m^2)
T_1	Epsom salts and micros (2.5 ml/10 L) +Iron Chelate (2.5 m1/10 L) +Mono Ammonium phosphate (2.5 ml/10 L) + Calcium Nitrate (12.5 ml/10 L) + Potassium Nitrate (12.5 ml/10 L)	180	220.94	400.94
T_2	Epsom salts and micros (5 ml/10 L) + Iron Chelate (5 m1/10 L) +Mono Ammonium phosphate (5 ml/10 L) + Calcium Nitrate (15 ml/10 L) + Potassium Nitrate (15 ml/10 L)	210	220.94	430.94
T_3	Epsom salts and micros (7.5 ml/10 L) + Iron Chelate (7.5 m1/10 L) + Mono Ammonium Phosphate (7.5 ml/10 L) + Calcium Nitrate (17.5ml/10L) + Potassium Nitrate (17.5 ml/10 L)	240	220.94	460.94
T_4	Epsom salts and micros (10 ml/10 L) + Iron Chelate (10 m1/10 L) + Mono Ammonium phosphate (10 ml/10 L) + Calcium Nitrate (20 ml/10 L) + Potassium Nitrate (20 ml/10 L)	270	220.94	490.94
T_5	Epsom salts and micros (12.5 ml/10 L) + Iron Chelate (12.5 m1/10 L) + Mono Ammonium Phosphate (12.5 ml/10 L) + Calcium Nitrate (22.5 ml/10 L) + Potassium Nitrate (22.5 ml/10 L)	300	220.94	520.94
T_6	Epsom salts and micros (15 ml/10 L) + Iron Chelate (15 m1/10 L) + Mono Ammonium phosphate (15 ml/10 L) + Calcium Nitrate (25 ml/10 L) + Potassium Nitrate (25 ml/10 L)	330	220.94	550.94
T_7	Epsom salts and micros (17.5 ml/10 L) + Iron Chelate (17.5 m1/10 L) +Mono Ammonium phosphate (17.5 ml/10 L) + Calcium Nitrate (27.5 ml/10 L) + Potassium Nitrate (27.5 ml/10 L)	360	220.94	580.94
Control	Tap water	00	220.94	220.94

Table 3: Yield and economics of different treatments

Treatment	Average plant weight (kg)	Yield (kg)	Gross Return (Rs/structure)	Net Return (Rs/structure)	Cost: Benefit ratio
T_1	27.18	15.16	455.00	54.06	1.13
T_2	30.55	19.12	573.60	142.66	1.33
T_3	32.88	24.96	748.80	287.86	1.62
T_4	35.44	26.64	799.20	308.26	1.63
T_5	35.55	27.52	825.60	304.66	1.58
T_6	36.52	28.88	866.40	315.46	1.57
T_7	37.21	32.44	973.32	292.38	1.67
Control	23.29	7.40	222.00	1.06	1.01
S.Em±	1.11	0.24	-	0.37	0.29
C.D(P=0.05)	2.38	0.51	-	0.93	0.62

Conclusion

It was concluded from the experiment that treatment T_7 Epsom salts and micros (17.5 ml/10 L) + Iron Chelate (17.5 m1/10 L) + Mono Ammonium phosphate (17.5 ml/10 L) + Calcium Nitrate (27.5 ml/10 L) + Potassium Nitrate (27.5 ml/10 L) was found superior over other treatments in term of yield and economics of Spinach Beet (*Beta vulgaris* var. *bengalensis*) in hydroponic system under shade net condition.

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