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Growth, yield and economics of broccoli under different levels of nitrogen fertigation

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ABSTRACT

Fertigation (application of fertilizer solution with drip irrigation) has the potential to ensure that the right combination of water and nutrients is available at the root zone, satisfying the plants requirement of these two critical inputs. Fertigation experiments were carried out on broccoli (*Brassica oleracea* L. var. *italica*) cv. Pusa Broccoli KTS1 during *rabi* season of 2003-04 and 2004-05 at the Horticulture Experimental Farm, Department of Horticulture, Assam Agricultural University, Jorhat to study the effect of different levels of nitrogen fertigation on growth, yield and economics of the crop. The results revealed that there was significant improvement in growth, yield and fertilizer use efficiency of broccoli under drip irrigation and fertigation. Drip fulfillment at 100 percent evaporation replenishment with cent percent supplementation of recommended dose of nitrogen (200 kg/ha) through fertigation was found to be significantly superior in terms of growth, yield and economics of broccoli in comparison to the conventional fertilization with recommended dose of nitrogen. Fertigation saved fertilizers to the tune of 40 percent as compared to conventional fertilization to maintain the same yield levels in broccoli. Study on fertigation efficiency and economics of cultivation revealed that fertigation with cent percent recommended doses of N was the most efficient treatment with fertigation efficiency of 55.44% and 57.31% respectively and cost benefit ratio of 1:4.41. Therefore, it can be concluded that fertigation with the present recommended dose of N (200kg/ha) at 4 days interval corresponding to 21 drips can be practiced for profitable cultivation of broccoli (1:4.41) under the agro-climatic condition of Jorhat (Assam).

Key words: Broccoli, fertigation, growth, yield, economics.

INTRODUCTION

Application of right combination of water and nutrients is the key factor for high yield and quality of produce. Fertigation controls precisely the time and rate of both water and fertilizer application to meet the requirements of a crop at each physiological growth stage (Papodopoulos, 7). This improves water and N use efficiency, minimize leaching and volatilization losses as well as ground water contamination (Papodopoulos, 8). Fertigation is the most efficient and less expensive method of fertilizer application along with irrigation water compared to the traditional methods.

Broccoli (*Brassica oleracea* L. var. *italica*) is a fancy and new vegetable in India, which has enormous nutritional and medicinal values due to its high contents of vitamins (A, B_1, B_2, B_6 and E), minerals (Ca, Mg, Zn and Fe) and antioxidant substances, which prevent the formation of cancer causing agents (Beecher, 1). In the recent years commercial cultivation of broccoli is gaining importance in Assam due to its higher nutritive value, palatability, short duration, high productivity and good market potential. Besides, the soil and climatic conditions of Assam are also ideal for growing this crop. But the productivity of the crop is very low, which is particularly due to lack of available information for optimum nutrient requirement through fertigation.

Pusa Broccoli KTS1 is a high yielding variety, which required balanced application of nutrients for the production of high yield with good quality heads. Doerge *et al*. (4) reported that broccoli takes up little nitrogen in its first 40 days of growth and 90% or more of its nitrogen accumulation may occur during the final 30 to 50 days preceding harvest. In order to meet the nitrogen requirement at different growth stages, fertigation is the only solution to maintain an optimum level of nitrogen in the soil, as per the crop demand without any loss.

However, no research has been conducted to

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manage the fertilization and irrigation under fertigation system of such newly emerging crop like broccoli under the agro climatic condition of Assam. Therefore, the present study was undertaken to study the effects of nitrogen fertigation levels using commercially available granular fertilizers on growth, yield and economics of broccoli.

MATERIALS AND METHODS

The field experiment was conducted at the Horticulture Experimental Farm, Department of Horticulture, Assam Agricultural University, Jorhat during winter (*rabi*) season of 2003-04 and 2004-05. The soil of the experimental plot is sandy loam in texture, medium in available nitrogen (282.5 kg/ha) and phosphorus (56 kg/ha) and low in potassium (96.6 kg/ha). Thirty days old Pusa Broccoli KTS1 seedlings were planted in crop geometry of 45cm row- to- row and plant-to-plant spacing in a plot size of 4.84m^2. The following five treatments of fertilizer applications i.e., T_1=100 % recommended dose of N (200kg/ha) through fertigation, T_2= 80% recommended dose of N (160kg/ha) through fertigation, T_3= 60% recommended dose of N (120kg/ha) through fertigation, T_4=40% recommended dose of N (80kg/ha) through fertigation, T_5=100% recommended dose of N (200kg/ha) through conventional fertilization were considered in the present study. The recommended dose of P_2O_5 (120kg/ha) and K_2O (80 kg/ha) for all the treatments were applied manually one week before planting.

Thus a total of five treatments were laid out in randomized block design with 4 replications. For the drip system 12mm diameter LLDPE (Linear low density polyethylene) pipes were used as laterals and on-line emitters of 4LPH (pressure compensating type) were fixed in the laterals at 45 cm x 45 cm spacing. One dripper (4 LPH) was used for four numbers of plants and laterals were oriented along the middle of two rows. Initially life saving irrigation was applied soon after transplanting and thereafter nitrogen was applied through drip five days after transplanting. For applying nitrogen through fertigation the scheduling was done based on four-growth stages viz., early growth, mid season, button formation and head development stage. The desired amounts of fertilizers were dissolved in 10 l of water and the fertilizers solutions containing nitrogen in the form of urea were applied along with the irrigation water in all the fertigation treatments by maintaining different fertilizer injection durations. A venturi having an injection rate of 28.5 LPH was selected for fertigation for the present study. The amount of water applied through drip and drip operation time was computed based on the lateral and emitter spacing, wetted area, crop coefficient and Pan Evaporation (USDA Class-A) of Jorhat during the crop growing season. Total 21 drips were applied at an interval of 4 days, which corresponds to 100% of evaporation replenishment (46.96 mm water for the entire crop season). While applying fertilizers through fertigation, the rate was adjusted so that the concentration of nitrogen does not exceed 250 ppm.

All the agronomic and plant protection measures were adopted as per package of practice when necessary. Observations on different growth and yield attributes were recorded from five randomly sampled plants from each replication. Economics was worked out on the basis of prevailing market prices of inputs and outputs.

RESULTS AND DISCUSSION

Different levels of nitrogen fertigation significantly and consistently increased growth and yield attributes of broccoli (Table 1& 2). Pooled data revealed that cent percent fertigation of recommended dose of nitrogen (200 kg/ha) produced the highest plant height, leaves per plant, plant spread and head diameter over conventional method of application but statistically at par with 80

Table 1. Effect of N fertigation levels on growth parameter of broccoli (*Brassica oleracea* L. var. *italica*).

Treatment	Plant height(cm)			Leaf number			Plant spread (cm)		
	2003-04	2004-05	Pooled	2003-04	2004-05	Pooled	2003-04	2004-05	Pooled
T_1 = 100 % RD of N	65.86	65.00	65.43	14.31	14.20	14.26	75.35	75.40	75.38
T_2 = 80% RD of N	66.50	66.75	66.63	14.42	14.40	14.41	75.30	75.25	75.28
T_3 = 60 % RD of N	60.24	60.46	60.35	14.31	14.00	14.16	70.13	70.00	70.07
T_4 = 40 % RD of N	58.29	58.43	58.36	13.86	13.50	13.68	60.57	60.50	60.54
T_5 = 100% RD of N through conventional application	49.48	48.40	48.94	13.06	13.00	13.03	54.18	54.10	54.14
$CD_{0.05}$	1.99	1.79	1.74	NS	0.65	NS	1.76	1.55	1.52

Table 2. Effect of N fertigation levels on yield attributing parameter and yield of broccoli (*Brassica oleracea* L. var. *italica*).

Treatment	Head diameter (cm)			Central head weight (g)			Marketable yield(t/ha)			Nitrogen fertigation efficiency (%)	
	2003-04	2004-05	Pooled	2003-04	2004-05	Pooled	2003-04	2004-05	Pooled	2003-04	2004-05
T_1 = 100 % RD of N	21.31	21.38	21.35	392.42	392.45	392.45	20.27	20.45	20.36	55.44	57.31
T_2 = 80% RD of N	21.11	21.21	21.16	391.24	391.50	391.37	20.22	20.27	20.25	55.06	55.92
T_3 = 60 % RD of N	17.72	18.00	17.86	276.62	278.70	276.66	14.29	14.32	14.31	9.59	10.15
T_4 = 40 % RD of N	12.79	12.50	12.65	274.12	274.30	274.21	14.16	14.12	14.14	8.59	8.62
T_5 = 100% RD of N through conventional application	12.17	12.20	12.19	252.52	252.60	252.56	13.04	13.00	13.02	-	-
$CD_{0.05}$	1.13	1.12	1.03	2.35	1.59	1.84	1.34	1.38	1.25		

percent fertigation level of recommended dose of N. Linear increase in plant height in broccoli with increase in the level of nitrogen was also reported by Singh and Singh (10). On a general scale, growth characters registered cumulative increase with increase in nitrogen fertigation levels. It may be due to the fact that increased supply of nitrogen accelerates synthesis of chlorophyll and amino acids, which play an important role in the growth and metabolism in plants (Devlin, 3). Positive influence of cent percent fertigation of recommended dose of N & K (75:60 kg/ha) on growth and yield parameters of tomato was also reported by Brahma *et al.* (2).

Central head weight per plant and marketable yield of broccoli increased significantly with every increment in the level of nitrogen fertigation (Table 2). Highest central head weight was recorded by fertigation with cent percent level of recommended dose of nitrogen (200kg/ha), whereas the lowest central head weight was produced by fertigation with 40 percent recommended dose of N (80kg/ha). Better utilization of nitrogen by the plants improved the photosynthetic efficiency, causing more production of carbohydrates and its conversion to amino acids and proteins might have allowed the plants to grow faster with increased plant vigour and spread

Pooled analysis indicated that treatments T_1 (100 percent RD of N through fertigation) and T_2 (80 percent RD of N through fertigation) were significantly different with control at 0.05 level. Treatment T_3 (60 percent RD of N through fertigation) and T_4 (40 percent RD of N through fertigation) was, however found to be at par with treatment T_5 (100 percent RD of N through conventional fertilization). There was no significant difference in marketable yield of broccoli between treatments T_5 and Treatment T_3. This indicated that fertigation with 60 percent recommended dose of N saved fertilizer to the tune of 40 percent as compared to traditional method of soil application to maintain the same yield levels. Nitrogen fertilizer application through drip irrigation (fertigation) reduces fertilizer usage and minimizes ground water pollution by reducing fertilizer leaching due to excessive irrigation. Similar findings in tomato were also reported by Gupta *et al.* (6). This could be attributed to the fact that the fertilizer application through fertigation is restricted to the wetted volume of soil where the active roots were concentrated and hence available at each physiological growth stage to meet the requirements of the crop. The maximum difference of marketable yield was obtained between treatments T_1 and T_5. Cent percent fertigation of recommended dose of nitrogen recorded the highest marketable head yield and fertigation efficiency compared to the conventional soil application of nitrogen. However, there was no significant difference in marketable head yield between cent percent and 80 percent fertigation level. Supportive findings in capsicum

Table 3. Cost economics of broccoli as influenced by N fertigation levels.

Treatments	Total seasonal) cost of cultivation (Rs./ha	Total yield (t/ha)	Gross seasonal income from produce (Rs./ha)	Net seasonal income (Rs./ha)	Cost: benefit ratio (C:B ratio)
T_1 = 100 % RD of N	37,634.00	20.36	2,03,600.00	1,65,966.00	1:4.41
T_2 = 80% RD of N	37,514.00	20.25	2,02,500.00	1,64,986.00	1:4.40
T_3 = 60 % RD of N	37,194.00	14.31	1,43,100.00	1,05,906.00	1:2.85
T_4 = 40 % RD of N	36,974.00	14.14	1,41,400.00	1,04,426.00	1:2.82
T_5 = 100% RD of N through conventional application	37,634.00	13.02	1,30,200.00	92,566.00	1:2.48

fertigated with 80 percent recommended NPK were also reported by Gupta *et al.* (5).

The increase in marketable yield of broccoli with increasing level of nitrogen fertigation could be attributed to improved vegetative growth, better availability of nutrients at vital growth period and greater synthesis of carbohydrates and their translocation to the storage organs. Increased marketable yield with 100 percent recommended dose of N & K, applied through fertigation was also reported by Brahma *et al*. (2) in tomato and Patel and Rajput (9) in broccoli.

The economic analysis of different treatments under Assam condition is presented in Table 3. It is seen from the table that a net seasonal income of Rs.1,65,966.00 could be generated as against Rs. 92,566.00 realized under traditional method of fertilizer application. The cost benefit ratio of 1:4.41 was recorded by cent percent fertigation of recommended dose of nitrogen, which is closely followed by 80 percent fertigation level (1:4.40). The lowest cost benefit ratio of 1:2.48 was recorded by conventional soil application of recommended dose of nitrogen. From the above study, it can be concluded that drip irrigation at 100 percent ET along with 100 percent recommended N through fertigation (200 kg N/ ha) may be recommended instead of traditional method of nitrogen fertilizer application on the basis of greater yield benefits, fertilizer saving, highest total net income and cost benefit ratio in broccoli under Assam (Jorhat) condition.

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