



## Effect of nitrogen doses and inter crops on growth and yield of broccoli (*Brassica oleracea* L. var. *italica*)

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### ABSTRACT

A field trial was conducted in 2016-2017 at Vegetable Seed Production Farm, Punjab Agricultural University, Ludhiana in randomized complete block design with three doses of nitrogen (125, 150 and 175 kg/ha) and four summer season vegetables (capsicum, chilli, cucumber and tomato) as intercrops replicated thrice. The maximum plant height (57.11 cm), number of leaves per plant (15.85), leaf size (394.87 cm<sup>2</sup>), leaf area index (3.39), plant spread (64 cm), head weight (176.72 g), number of axillary sprouts per plant (9.01), weight of axillary sprouts per plant (130.50 g) and total yield (145.47 q/ha) obtained with nitrogen @ 175 kg/ha were statistically at par with nitrogen @ 150 kg/ha. The statistical differences were found to be non-significant in intercropping systems but the sole crop of broccoli showed maximum values for growth and yield parameters. The highest benefit cost ratio (BCR: 3.74) and land equivalent ratio (LER: 1.67) were observed in broccoli + tomato followed by broccoli + chilli.

**Key words:** BCR, Broccoli, Capsicum, Chilli, Cucumber, LER, Nitrogen doses, Tomato.

### INTRODUCTION

India ranks second in the vegetable production in the world after China (Gupta, 2012). The vegetable requirement of India is evaluated as 225 million tonnes by 2020 (Anonymous, 2011), hence it necessitates the need to enhance the vegetable productivity. Presently, the increase in agricultural productivity through intensive practices has created some problems such as decline in soil fertility, environmental pollution and emergence of chemical resistant weeds and pests (Poggio, 2005). On the other hand, expanding population and industrialization have further elevated the shortage of arable land. Hence, effective land utilization to enhance the productivity is need of the hour. Diversification through intensive cropping for instance, increasing number of crops, has been proposed as the probable solution to all the above mentioned problems. In developing countries like India, intercropping plays a pivotal role in achieving the enhanced productivity with maintenance of soil health without additional resources (Choudhuri and Jana, 2012; Yadav *et al.*, 2016).

Harsh climatic conditions in northern regions of India offers limited period to grow vegetables like capsicum, chilli, cucumber and tomato in open field conditions throughout the year. Moreover, small farmers cannot afford the costly techniques like polyhouse, green house etc. to grow these vegetables in off season. So, to raise them earlier and fetch high returns, intercropping in frost tolerant vegetables with more spreading type growth such as broccoli, is found to be an appropriate solution. It has high nutritional value

and due to presence of some cancer fighting substances like sulforaphane, it has gained momentum in its production and demand by health conscious customers.

However, the objective of maximum production of broccoli cannot be achieved in absence of essential plant nutrients (Ali *et al.*, 2008). The high yield of broccoli in intercropping system demands care of nutrient management especially nitrogen as it is highly responsive to varying nitrogen levels. Nitrogen improves food quality, enhances the yield (Ullah *et al.*, 2010) and increases the photosynthetic activity, leaf area, leaf area duration and net assimilation rate (Ahmad *et al.*, 2009). Although the role of nitrogen is reported frequently but nitrogen requirement of broccoli in intercropping system under Punjab conditions is not documented yet.

Therefore, due to lack of research particularly under field conditions, to show the effects of nitrogen, the present study was undertaken to find the suitable nitrogen dose responsible for higher yields of main crop along with intercrop(s) in plains of Punjab.

### MATERIALS AND METHODS

The experiment was conducted at Vegetable Seed Production Farm and biochemical analysis was done at Biochemistry Laboratory, Department of Vegetable Science, Punjab Agricultural University, Ludhiana during 2016-2017. Ludhiana is situated between 30°54'N latitude and 75°48'E longitude at 247 m above mean sea level having semi-arid region and sub-tropical climate. Hot and dry summer from

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**Table 1:** Sowing and transplanting time of crops.

Crop	Sowing Time	Transplanting time
Broccoli	15 <sup>th</sup> September, 2016	15 <sup>th</sup> October, 2016
Capsicum	22 <sup>nd</sup> September, 2016	25 <sup>th</sup> October, 2016
Chilli	22 <sup>nd</sup> September, 2016	22 <sup>nd</sup> October, 2016
Cucumber	20 <sup>th</sup> September, 2016	25 <sup>th</sup> October, 2016
Tomato	20 <sup>th</sup> September, 2016	25 <sup>th</sup> October, 2016

April to June, humid rainy season from July to September and cold winter from December to February prevail here. The monthly maximum and minimum temperature, relative humidity, rainfall and total evaporation during the crop growing period were recorded from the School of Climate Change and Agricultural Meteorology, Punjab Agricultural University, Ludhiana. The soil at experimental site had pH-8.2, available N-125.22 kg/ha, P-21.6 kg/ha and K-146 kg/ha. The experiment was executed in factorial randomized block design (FRBD). It was replicated thrice with three doses of nitrogen, viz., 125 kg/ha (N<sub>1</sub>), 150 kg/ha (N<sub>2</sub>) and 175 kg/ha (N<sub>3</sub>) in broccoli as a main crop along with four intercrops, viz., (I<sub>1</sub>) chilli-CH-1, (I<sub>2</sub>) capsicum-Bharat, (I<sub>3</sub>) cucumber-Punjab Naveen and (I<sub>4</sub>) tomato-Punjab Upma. Broccoli was transplanted in mid-October whereas, the transplanting of intercrops was done in last week of October (Table 1) on ridges in 3×3 m<sup>2</sup> plot. The seedlings of chilli and capsicum were transplanted in between plants of broccoli in every row whereas, cucumber and tomato seedlings were transplanted in alternate rows in between the broccoli plants. The intercrops were protected only under the spreading growth of broccoli. Nitrogen was given in the form of urea in three split doses i.e. at the time of transplanting, 30 and 60 days after transplanting. The other intercultural operations were performed according to Package of Practices for cultivation of vegetables, Punjab Agricultural University, Ludhiana (Anonymous, 2017).

Data was recorded from randomly selected five plants during the initial growth stage. The observations were plant height, number of leaves per plant, leaf size, leaf area

index, plant spread, number of days to the first harvest, head diameter, weight of main head, number of axillary sprouts per plant, weight of sprouts per plant, total yield, benefit cost ratio (BCR) and land equivalent ratio (LER).

## RESULTS AND DISCUSSION

### The effect of nitrogen doses and intercropping systems on growth parameters of broccoli

**Plant height:** The data exhibited in Table 2 showed that application of nitrogen doses had significant effect on plant height of broccoli. The highest plant height (57.11 cm) at harvest obtained in N<sub>3</sub> was statistically at par with N<sub>2</sub> (54.25 cm), whereas, N<sub>1</sub> recorded the minimum plant height (49.36 cm). So, these consequences showed that plant height increased with increasing dose of nitrogen. Similar positive trend was also observed in studies of (Neethu *et al.*, 2015; Qureshi *et al.*, 2014; Giri *et al.*, 2013; El-Helaly, 2012; Moniruzzaman *et al.*, 2007) with their genetic material in their set of conditions. The increase in plant height might be due to enhanced photosynthesis. Nitrogen being an important component of chlorophyll imparts green colour to the plants and thus, improves the photosynthesis which resulted into more production of photosynthates and ultimately increased the plant height (Rao *et al.*, 2014).

Intercropping systems had non-significant effect on plant height of broccoli. Similar result was also recorded with regard to plant height of sole broccoli as compared to the intercropping systems in study of (Yadav *et al.*, 2017) under their environmental conditions. The interaction effect was also found to be non-significant.

**Number of leaves per plant:** Significantly maximum number of leaves (15.85) was found in treatment N<sub>3</sub> which was statistically at par with treatment N<sub>2</sub> (15.04). However, minimum number of leaves (13.17) was found in N<sub>1</sub>. In general, the number of leaves per plant increased with increase in nitrogen dose. The present findings are in consonance with the studies of (Dhakal *et al.*, 2016; Neethu *et al.*, 2015; Qureshi *et al.*, 2014; Moniruzzaman *et al.*, 2007)

**Table 2:** Effect of nitrogen doses and intercropping systems on growth parameters of broccoli (*Brassica oleracea* L.var. *italica*).

Treatment	Plant height at harvest (cm)	No. of leaves per plant	Leaf size (cm <sup>2</sup> )	Leaf area index	Plant spread (cm)
<b>Nitrogen (kg/ha) (N)</b>					
N <sub>1</sub> (125 kg/ha)	49.36	13.17	373.43	2.65	54.53
N <sub>2</sub> (150 kg/ha)	54.25	15.04	392.42	3.09	61.71
N <sub>3</sub> (175 kg/ha)	57.11	15.85	394.87	3.39	64.00
CD (P=0.05)	4.17	0.91	15.51	0.20	3.71
<b>Intercropping System (I)</b>					
I <sub>1</sub> Broccoli (Sole)	54.28	15.43	390.63	3.08	60.84
I <sub>2</sub> Broccoli + Capsicum	53.28	14.58	388.43	3.04	59.57
I <sub>3</sub> Broccoli + Chilli	53.95	14.20	388.27	3.01	59.99
I <sub>4</sub> Broccoli + Cucumber	53.40	14.52	388.31	3.04	59.97
I <sub>5</sub> Broccoli + Tomato	52.95	14.70	378.88	3.05	60.03
CD (P=0.05)	NS	NS	NS	NS	NS
Interaction Effect (N x I)	NS	NS	NS	NS	NS

who also reported such increase in leaf number per plant with their genetic material in their climatic conditions. This increase in number of leaves could be due to beneficial effect of nitrogen which promotes the meristemic activity and hence, increase the number of tissues and organs (leaves) as reported by (Ghoneim, 2005).

The effect of intercropping system was non-significant on number of leaves per plant of broccoli. This result is supported by the studies of (Yadav *et al.*, 2017; Demir and Polat, 2011; Guvenc and Yildirim, 2006).

The interaction effect of nitrogen doses and intercropping systems was also non-significant effect on number of leaves per plant.

**Leaf area (cm<sup>2</sup>):** Results given in Table 2 indicated that nitrogen doses had statistical differences with regard to broccoli leaf area. The highest value was achieved in treatment N<sub>3</sub> (394.87 m<sup>2</sup>) and which was at par with N<sub>2</sub> (392.42 cm<sup>2</sup>). The minimum leaf size was recorded in N<sub>1</sub> (373.43 cm<sup>2</sup>). The present investigation is in congruence with the studies of (Dhakal *et al.*, 2016; Neethu *et al.*, 2015; El-Helaly, 2012). Nitrogen enhances the cytokinin production in the roots of the plants and hence, more cytokinin carried

to the leaves, resulted in more cell division. Therefore, an obvious increase in leaf area was obtained and leaf expansion took place. So, leaf area increases with higher dose of nitrogen.

Non-significant differences were observed on leaf area of broccoli due to interaction.

**Leaf area index (LAI):** The results presented in Table 2 indicated that LAI was increased significantly with higher dose of nitrogen. These results are in agreement with the study of (Boroujerdnia and Ansari, 2007). The enhanced leaf area index might be due to more leaf area. So, the higher rate of nitrogen linearly increased the LAI accounting to more photosynthates production and finally higher yield.

The intercropping systems and interaction effect was found non-significant differences for leaf area index. Significantly maximum LAI (3.39) was found in treatment N<sub>3</sub> followed by N<sub>2</sub> (3.09) and minimum in N<sub>1</sub> (2.65).

**Plant spread (cm):** Maximum value of plant spread was recorded in N<sub>3</sub> (64 cm) which was statistically at par with N<sub>2</sub> (61.71 cm) and minimum value was found in N<sub>1</sub> (54.53 cm). The present results are in accordance with the study of

**Table 3:** Effect of nitrogen doses and intercropping systems on yield parameters of broccoli (*Brassica oleracea* L.var. *italica*).

Treatment	Head weight (g)	No. of axillary sprouts per plant	Weight of axillary sprouts per plant (g)	Total yield (q/ha)
<b>Nitrogen (kg/ha) (N)</b>				
N <sub>1</sub> (125 kg/ha)	149.05	6.97	117.50	134.19
N <sub>2</sub> (150 kg/ha)	174.34	7.90	129.29	143.11
N <sub>3</sub> (175 kg/ha)	176.72	9.01	130.50	145.47
CD (P=0.05)	10.56	0.49	8.20	8.69
<b>Intercropping System (I)</b>				
I <sub>1</sub> Broccoli (Sole)	167.32	8.38	127.20	144.86
I <sub>2</sub> Broccoli + Capsicum	166.39	7.58	124.69	140.57
I <sub>3</sub> Broccoli + Chillii	167.00	7.99	125.36	139.78
I <sub>4</sub> Broccoli + Cucumber	166.87	8.03	126.70	140.29
I <sub>5</sub> Broccoli + Tomato	165.94	7.82	124.87	139.12
CD (P=0.05)	NS	NS	NS	NS
Interaction Effect (N x I)	NS	NS	NS	NS

**Table 4:** Effect of different doses of nitrogen and intercropping systems on economics and land equivalent ratio of broccoli (*Brassica oleracea* L.var. *italica*).

Treatment	Gross return (Rs/ha)	Cost of cultivation (Rs/ha)	Net return (Rs/ha)	Benefit cost ratio	Land equivalent ratio		
<b>Nitrogen (kg/ha)</b>							
N1 (125 kg/ha)	1,34,190	36,905.93	97,284.07	2.63	-	-	-
N2 (150 kg/ha)	1,43,110	37,237.81	1,05,872.19	2.84	-	-	-
N3 (175 kg/ha)	1,45,470	37,569.68	1,07,900.32	2.87	-	-	-
<b>Intercropping System</b>							
					<b>LER (Broccoli)</b>	<b>LER (Intercrops)</b>	<b>Total LER</b>
Broccoli (Sole)	1,44,860	37,237.80	1,07,622.2	2.8	-	-	-
Broccoli + Capsicum	2,13,629	48,133.8	1,65,495.2	3.43	0.97	0.60	1.57
Broccoli + Chillii	2,15,926	47,987.7	1,67,938.3	3.49	0.96	0.69	1.65
Broccoli + Cucumber	1,40,290	37,987.81	1,02,302.2	2.69	0.96	-	0.96
Broccoli + Tomato	2,19,403	46,278.05	1,73,124.95	3.74	0.96	0.71	1.67

(Qureshi *et al.*, 2014; Moniruzzaman *et al.*, 2007). Plant spread is directly related to leaf size. More leaf area will ultimately results into more plant spread.

The combined effect of both treatments and effect of intercropping system was found to be non-significant.

#### **The effect of nitrogen doses and intercropping systems on yield parameters of broccoli**

**Head weight (g):** Results presented in Table 3 indicated that nitrogen rate had significant effect on head weight of the broccoli. The maximum head weight was found in N<sub>3</sub> (176.72 g) and was statistically at par with N<sub>2</sub> (174.34 g). The lowest value of head weight was obtained in N<sub>1</sub> (149.05 g). The present finding is in consonance with the investigations of El-Helaly, (2012); Hussain *et al.*, (2012); Xu *et al.*, (2010); Yoldas *et al.*, (2008); Moniruzzaman *et al.*, (2007). The enhanced head weight might be due to more photo synthetic activity with higher nitrogen rate resulting into accumulation of photosynthates and hence, more head weight. The intercropping systems and interaction was found to be non-significant effect on head weight.

**Number of axillary sprouts per plant:** The evaluated data in Table 3 showed that number of sprouts followed increasing trend with increment in nitrogen rate. The maximum number of sprouts were found in N<sub>3</sub> (9.01) followed by N<sub>2</sub> (7.90) and minimum sprouts were recorded in N<sub>1</sub> (6.97). The present result is supported by findings of (Giri *et al.*, 2013; Yoldas *et al.*, 2008). This beneficial effect of nitrogen could be due to the enhanced meristemic activity of plants and hence production of new tissues and organs (sprouts). The intercropping system and the interaction (N x I) had non-significant effect on number of axillary sprouts of broccoli.

**Weight of axillary sprouts per plant (g):** Results presented in Table 3 exhibited that, maximum weight of sprouts per plant was obtained in N<sub>3</sub> (130.50 g) which was statistically at par with N<sub>2</sub> (129.29 g) and minimum weight of axillary sprouts was recorded in N<sub>1</sub> (117.50 g). Higher nitrogen doses increases number of sprouts per plant hence maximum weight of sprouts. These results are in agreement with the study of Singh *et al.*, (2015). No significant variation was observed in intercropping systems and interaction effect for weight of axillary sprouts.

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**Total yield (q/ha):** Significant differences were observed in nitrogen doses with respect to total yield of broccoli. The highest total yield was recorded in N<sub>3</sub> (145.47 q/ha) followed by N<sub>2</sub> (143.11 q/ha), and lowest yield was obtained in N<sub>1</sub> (134.19 q/ha). Similar results were also reported by Bashyal *et al.*, (2013); El-Helaly, ((2012); Schellenberg *et al.*, (2009); Yoldas *et al.*, (2008); Moniruzzaman *et al.*, (2007) at their place in broccoli. The intercropping systems showed non-significant variation for total yield of broccoli.

#### **The effect of nitrogen doses and intercropping systems on economics and land equivalent ratio of broccoli**

**Economics:** The perusal of data given in Table 4 showed that among nitrogen doses, the highest net return (Rs.1, 07,900.32/ha) and benefit cost ratio (2.87) was observed in N<sub>3</sub> followed by N<sub>2</sub> (Rs. 1,05,872.19/ha and 2.84, respectively).

Among the intercropping systems, broccoli + tomato was found the most remunerative treatment as it recorded the highest net return (Rs. 1, 73,124.95/ha) and benefit cost ratio (3.74) followed by broccoli + chilli (Net return: Rs. 1,67,938.3/ha and benefit cost ratio: 3.49). Cucumber being temperature sensitive was found least remunerative as intercrop in broccoli with lowest net return (Rs. 1,02,302.2/ha) and benefit cost ratio (2.69).

**Land equivalent ratio (LER):** LER is an important factor to determine the efficiency of intercropping system. If the value of LER is greater than one in intercropping system then it indicates the efficient use of land. The results in Table 4 indicated that broccoli + tomato intercropping system was found the most remunerative as it was recorded the highest LER (1.67) followed by broccoli + chilli. The lowest LER (0.96) was observed in broccoli + cucumber due to mortality of cucumber seedlings in month of December. The results confirmed that tomato and chilli can be successfully grown as intercrops in broccoli.

#### **CONCLUSION**

According to the results, growth and yield parameters both increased with higher rate of nitrogen. However, broccoli + tomato showed the highest net return, benefit cost ratio and land equivalent ratio. is highly responsive to the varying levels of nitrogen so further experimentation is required to refine the nitrogen dose for broccoli cultivation along with summer vegetable crops as intercrops.

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