Madras Agric. J., 100 (7-9): 680-685, September 2013
https://doi.org/10.29321/MAJ.10.001382

Effect of Spacing and Fertigation on Growth, Yield and Quality of Tropical Cauliflower (*Brassica oleracea* L.var. *botrytis*)

K.S. Ilakyanila, T. Saraswathi* and B.K. Savitha
Department of Vegetable Crops, Horticulture College and Research Institute
Tamil Nadu Agricultural University, Coimbatore - 641 003

Field experiments were conducted to find out the "Effect of spacing and fertigation on yield and quality of cauliflower (*Brassica oleracea* L. var. *botrytis*)" at Horticultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore during July- November. 2011 and December, 2011- April, 2012. Tropical cauliflower hybrid Pawas using. The experiment consisted of three different spacings (60 x 60, 60 x 45 and 60 x 30 cm) and nine fertigation treatments. In fertigation, four levels of straight fertilizers (125, 100, 75 and 50 per cent of 200:125:125 kg NPK ha^{-1}) and four levels of water soluble fertilizers (125, 100, 75 and 50 per cent of 200:125:125kg NPK ha^{-1}) and conventional method were compared. The treatments were replicated thrice in split plot design. The results revealed that the spacing of 60 x 45 cm with the application of 100 per cent RDF through water soluble fertilizer recorded better growth, yield and quality characters in both the seasons. However higher BC ratio was recorded with the application of 75 per cent RDF through straight fertilizers at a spacing of 60 x 60 cm.

Key words: Cauliflower, Spacing, fertigation, growth, yield, quality, BC ratio.

Cauliflower (*Brassica oleracea* L.var. *botrytis*) (Family: Brassicaceae), cultivated for its white tender curds, rich in vitamin C, K and also a very good source of potassium, fibre, phosphorus, B vitamins and boron. Consumption of cauliflower is known to reduce the risk of lung, colon, breast, ovarian and bladder cancers (Rumeza Hanif *et al*., 2006). India ranks second in terms of production with an annual production 67.45 lakh tonnes from 3,69,000 hectares with 18.3 t ha^{-1} productivity. Tamil Nadu stands in the 20^{th} position with respect to area (700 hectares), production(13,300 tonnes) and productivity (19 t ha^{-1}) among the states of India (Anon., 2011) Tropical cauliflowers are able to produce curds of acceptable quality at temperatures above 20° C. Hence, there is a scope for increasing area and production by introducing tropical cauliflower and by standardizing the agronomic practices such as spacing and fertigation.

Optimum plant spacing will help to achieve more returns per unit area and also facilitate efficient absorption of nutrients (Bhangre *et al*., 2011). Fertigation increases the efficiency of applied fertilizers and allows drastic reduction in cost of cultivation. Hence, the study was taken up to assess the effect of spacing and fertigation on growth, yield and quality of tropical cauliflower.

Materials and Methods

Field experiments were conducted at Horticultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore during July-November, 2011 and December, 2011- April, 2012. with tropical cauliflower hybrid Pawas. was used The soil was well drained, sandy loam in texture, with a pH of 8- 8.5 and nitrogen (230 kg ha^{-1}), phosphorus (13.1 kg ha^{-1}) and potassium (865 kg ha^{-1}). The experiment was laid out in split plot design with three replications and nine treatments viz., T_1- Recommended dose (200:125:125kg NPK/ha) through straight fertilizers by soil application and flood irrigation, T_2 -Fertigation with 125% of RDF as straight fertilizers, T_3 - Fertigation with 100% of RDF as straight fertilizers, T_4 - Fertigation with 75% of RDF as straight fertilizers, T_5 - Fertigation with 50% of RDF as straight fertilizers, T_6 - Fertigation with 125% of RDF as water soluble fertilizers, T_7 - Fertigation with 100% of RDF as water soluble fertilizers, T_8 - Fertigation with 75% of RDF as water soluble fertilizers ,T_9 - Fertigation with 50% of RDF as water soluble fertilizers were assigned to main plot and three different spacings viz., S_1 - 60 x 60 cm, S_2 - 60 x 45cm and S_3 - 60 x 30 cm were allotted to sub-plot. Growth characters (plant height and stem diameter), yield characters (curd weight and curd yield) were recorded and quality parameter (ascorbic acid) was analysed. BC ratio was also worked out. Ascorbic acid content of the curd was estimated as per Rosenberg (1975) and expressed as mg g^{-100} of fresh sample.

*Corresponding author

Results and Discussion

Effect of spacing

Higher plant height (Table 1) and stem diameter (Table 2) were observed under 60 x 45 cm spacing (50.24 and 10.46 cm), followed by 60 x 60 cm (48.81 and 10.00 cm) and 60 x 30 cm (48.35 and 9.53 cm) respectively. Closer spacing with more number

of plants per unit area resulted in lower growth, possibly, due to competition for nutrients, moisture and solar energy. Plant height and stem diameter decreased with decreasing levels of spacing due to the competition by more number of plants. These results are in accordance with the findings of Singh *et al*. (2004) and Mujeeb-ur-Rahman *et al.* (2007) in cauliflower.

In the present investigation, 60 x 45 cm plant spacing excelled in almost all the parameters. This result is in conformity with the findings of Mujeeb-ur-Rahman *et al.* (2007). Since there was less competition among the plants for nutrient better growth performance was observed. Similar views were expressed by Sarker *et al.* (2002) in cabbage and Solunke *et al.* (2011) and Bhangre *et al.* (2011) in broccoli.

Table 1. Effect of spacing and fertigation on plant height (cm) of cauliflower

S / T	Season I				Season II				Pooled analysis			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
T_1	45.20	45.20	43.86	44.75	43.50	43.53	42.20	43.08	44.35	44.37	43.03	43.92
T_2	51.00	52.00	51.46	51.49	49.33	50.00	49.46	49.60	50.17	51.00	50.47	50.55
T_3	48.20	49.20	50.86	49.42	46.20	47.20	48.86	47.42	47.20	48.20	49.87	48.42
T_4	50.00	51.80	50.00	50.60	48.76	50.50	48.40	49.22	49.38	51.15	49.20	49.91
T_5	46.33	46.46	46.00	46.26	44.73	44.86	44.60	44.73	45.53	45.67	45.30	45.50
T_6	53.26	54.80	50.40	52.82	50.96	54.90	48.20	51.35	51.62	55.55	49.55	52.24
T_7	53.86	58.20	52.13	54.73	52.56	57.06	50.46	53.36	53.21	57.63	51.30	54.05
T_8	49.00	48.33	48.00	48.44	47.00	46.33	46.00	46.44	48.00	47.33	47.00	47.44
T_9	50.86	52.26	50.46	51.19	48.86	50.26	48.46	49.19	49.87	51.27	49.47	50.20
Mean	49.75	50.92	49.24		47.99	49.40	47.40		48.81	50.24	48.35	
	T	S	T x S	S x T	T	S	T x S	S x T	T	S	T x S	S x T
S.Ed	0.75	0.31	1.08	0.95	0.80	0.32	1.13	0.98	0.77	0.32	1.10	0.96
CD(0.05)	1.59	0.64	2.25	1.94	1.70	0.66	2.35	1.99	1.64	0.65	2.29	1.96

T_1 - Recommended dose (200:125:125kg NPK/ha) through straight fertilizers by soil application and flood irrigation
T_2 - Fertigation with 125% of RDF through straight fertilizers
T_3 - Fertigation with 100% of RDF through straight fetilizers
T_4 - Fertigation with 75% of RDF through straight fertilizers
T_5 - Fertigation with 50% of RDF through straight fertilizers
T_6 - Fertigation with 125% of RDF through water soluble fertilizers
T_7 - Fertigation with 100% of RDF through water soluble fertilizers
T_8 - Fertigation with 75% of RDF through water soluble fertilizers
T_9 - Fertigation with 50% of RDF through water soluble fertilizers

Spacing S_1-60 x 60 cm S_2- 60 x 45 cm S_3-60 x 30 cm: T- Main plot, S-Sub-plot, T x S – Main plot x Sub – plot, S x T – Sub-plot x Main plot Spacing S_1-60 x 60 cm S_2- 60 x 45 cm S_3-60 x 30 cm: T- Main plot, S-Sub-plot, T x S – Main plot x Sub – plot, S x T – Sub-plot x Main plot v

Higher curd weight (1152 g) was recorded at wider spacing (60 x 60 cm) compared to closer spacing of 60 x 30 cm (591.26 g) (Table 3)**.** This might be due to proper utilization of accumulates conserved by the plant. Singh *et al.* (2004) also made same observations in cauliflower. The increased plant spacing increased the head weight in cabbage as reported by Sharma and Lal (1986) and Moniruzzaman (2011). In broccoli, Jett *et al*. (1995), Kelly (2007), Agarkar *et al.* (2010), Bhangre *et al*. (2011) and Hossain *et al*. (2011) recorded similar observations.

Table 2. Effect of spacing and fertigation on stem diameter (cm) of cauliflower

S / T	Season I				Season II				Pooled analysis			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
T_1	8.06	8.20	6.33	7.53	6.06	7.33	5.87	6.42	7.06	7.77	6.10	6.98
T_2	10.33	10.80	9.87	10.33	9.67	10.47	9.65	9.93	10.00	10.64	9.76	10.13
T_3	10.40	10.75	9.39	10.18	9.60	10.07	9.27	9.65	10.00	10.41	9.33	9.91
T_4	10.47	10.60	10.29	10.45	10.23	10.47	10.21	10.30	10.35	10.54	10.25	10.38
T_5	9.60	10.27	9.50	9.79	8.50	9.77	8.40	8.89	9.05	10.02	8.95	9.34
T_6	11.00	11.06	10.57	10.88	10.67	11.20	10.33	10.73	10.84	11.13	10.45	10.81
T_7	11.50	11.88	10.97	11.45	11.49	11.78	10.84	11.37	11.50	11.83	10.91	11.41
T_8	10.93	11.20	10.78	10.97	10.57	11.29	10.43	10.76	10.75	11.25	10.61	10.87
T_9	10.59	10.80	10.39	10.59	10.27	10.39	8.40	9.69	10.43	10.60	9.40	10.14
Mean	10.32	10.62	9.79		9.67	10.31	9.27		10.00	10.46	9.53	
	T	S	T x S	S x T	T	S	T x S	S x T	T	S	T x S	S x T
S.Ed	0.22	0.11	0.35	0.34	0.28	0.18	0.52	0.54	0.19	0.11	0.34	0.34
CD(0.05)	0.46	0.23	0.73	0.70	0.59	0.37	1.07	1.09	0.40	0.23	0.69	0.69

T_1 - Recommended dose (200:125:125kg NPK/ha) through straight fertilizers by soil application and flood irrigation
T_2 - Fertigation with 125% of RDF through straight fertilizers
T_3 - Fertigation with 100% of RDF through straight fertilizers
T_4 - Fertigation with 75% of RDF through straight fertilizers
T_5 - Fertigation with 50% of RDF through straight fertilizers
T_6 - Fertigation with 125% of RDF through water soluble fertilizers
T_7 - Fertigation with 100% of RDF through water soluble fertilizers
T_8 - Fertigation with 75% of RDF through water soluble fertilizers
T_9 - Fertigation with 50% of RDF through water soluble fertilizers

Spacing S_1-60 x 60 cm S_2- 60 x 45 cm S_3-60 x 30 cm: T- Main plot: S-Sub-plot: T x S – Main plot x Sub – plot: S x T – Sub-plot x Main plot

The adoption of proper spacing is an important factor for securing higher yield of desirable curd size. The successful production of cauliflower depends on maintenance of optimum plant density in the field. The highest curd yield per hectare (Table 4) was recorded with the spacing of 60 x 45 cm (29.54, 25.88 and 27.51 t) in the first, second season and pooled analysis respectively. Low yield in the case of close spacing might be due to the lower plant height, leaf length, leaf breadth, number of non - wrapper leaves per plant, stem height and shorter diameter of stem and also the competitive growth of plants. These results get support from the results of Mujeeb-ur-Rahman *et al.* (2007).

Since ascorbic acid is synthesized from sugars supplied through photosynthesis, the amount and intensity of light during the growing season had a definite influence on the amount of ascorbic acid formed. In general, the lower the light intensity during growth, the lower the ascorbic acid content of plant tissues (Lee and Kader, 2000). Hence, lower level of ascorbic acid (60.31mg $_{g-100}$)was recorded at closer spacing of 30 x 30cm (Table 5). At wider spacing (60 x 60cm) the micro climate permitted more light and high temperature and such stress might have accelerated the ascorbate oxidase enzyme which degrades of ascorbic acid (Loewus and Loewus, 1987). Hence, reduced level of ascorbic acid (53.17mg $_{g-100}$) was recorded at wider spacing. Higher ascorbic acid content was recorded under the spacing of 60 x 45cm (65.64mg $_{g-100}$) which offered the conducive microclimate for increased level of ascorbic acid. This result is in line with the findings of Sharma and Chandra (2004).

Table 3. Effect of spacing and fertigation on curd weight (g) of cauliflower

S / T	Season I			Mean	Season II			Mean	Pooled analysis			Mean
	S_1	S_2	S_3		S_1	S_2	S_3		S_1	S_2	S_3	
T_1	1017.02	804.35	518.46	779.94	699.88	733.33	381.36	604.86	867.00	762.31	450.00	693.10
T_2	1254.40	1000.00	645.99	966.80	1061.55	897.69	540.68	833.30	1185.86	929.35	592.67	902.63
T_3	1268.57	1031.02	645.99	981.86	1088.57	917.69	539.32	848.53	1191.43	966.67	594.00	917.37
T_4	1268.57	997.69	653.33	973.20	1078.69	853.33	563.77	831.93	1160.14	923.98	602.22	895.45
T_5	1211.55	957.69	631.11	933.45	906.90	823.33	528.89	753.04	1096.29	893.33	587.33	858.98
T_6	1248.45	982.04	647.35	959.28	1048.69	844.35	533.33	808.79	1155.00	899.35	595.56	883.30
T_7	1382.98	1088.98	714.01	1061.99	1222.74	972.04	610.43	935.07	1311.43	1023.98	662.22	999.21
T_8	1305.83	1013.33	674.01	997.73	1114.29	872.04	583.77	856.70	1207.26	942.31	628.89	926.16
T_9	1282.74	986.67	657.78	975.73	1111.31	850.00	573.33	844.88	1193.57	912.31	608.44	904.78
Mean	1248.90	984.64	643.11		1036.96	862.64	539.43		1152.00	917.07	591.26	
	T	S	T x S	S x T	T	S	T x S	S x T	T	S	T x S	S x T
S.Ed	39.92	5.50	42.13	16.51	20.70	10.98	22.94	32.95	21.48	6.16	26.26	18.50
CD(0.05)	84.62	11.16	88.92	33.48	43.88	22.28	70.01	66.84	45.55	12.50	54.88	37.52

T_1 - Recommended dose (200:125:125kg NPK/ha) through straight fertilizers by soil application and flood irrigation
T_2 - Fertigation with 125% of RDF through straight fertilizers
T_3 - Fertigation with 100% of RDF through straight fertilizers
T_4 - Fertigation with 75% of RDF through straight fertilizers
T_5 - Fertigation with 50% of RDF through straight fertilizers
T_6 - Fertigation with 125% of RDF through water soluble fertilizers
T_7 - Fertigation with 100% of RDF through water soluble fertilizers
T_8 - Fertigation with 75% of RDF through water soluble fertilizers
T_9 - Fertigation with 50% of RDF through water soluble fertilizers

Spacing S_1-60 x 60 cm S_2- 60 x 45 cm S_3-60 x 30 cm: T- Main plot: S-Sub-plot: T x S – Main plot x Sub – plot: S x T – Sub-plot x Main plot

Effect of fertigation

The levels of fertigation had significant influence on growth parameters (Table 1 & 2). Plant height (54.05 cm) and stem diameter (11.41 cm) were significantly

Table 4. Effect of spacing and fertigation on curd yield (t ha^{-1}) in cauliflower

S / T	Season I			Mean	Season II			Mean	Pooled analysis			Mean
	S_1	S_2	S_3		S_1	S_2	S_3		S_1	S_2	S_3	
T_1	23.73	24.13	23.33	23.73	16.33	22.00	17.16	18.50	20.23	22.87	20.25	21.12
T_2	29.27	30.00	29.07	29.44	24.77	26.93	24.33	25.34	27.67	27.88	26.67	27.41
T_3	29.60	30.93	29.07	29.87	25.40	27.53	24.27	25.73	27.80	29.00	26.73	27.84
T_4	29.60	29.93	29.40	29.64	25.17	25.60	25.37	25.38	27.07	27.72	27.10	27.30
T_5	28.27	28.73	28.40	28.47	21.16	24.70	23.80	23.22	25.58	26.80	26.43	26.27
T_6	29.13	29.46	29.13	29.24	24.47	25.33	24.00	24.60	26.95	26.98	26.80	26.91
T_7	32.27	32.67	32.13	32.36	28.53	29.16	27.47	28.39	30.60	30.72	29.80	30.37
T_8	30.47	30.40	30.33	30.40	26.00	26.16	26.27	26.14	28.17	28.27	28.30	28.25
T_9	29.93	29.60	29.60	29.71	25.93	25.50	25.80	25.74	27.85	27.37	27.38	27.53
Mean	29.14	29.54	28.94		24.21	25.88	24.27		26.88	27.51	26.61	
	T	S	T x S	S x T	T	S	T x S	S x T	T	S	T x S	S x T
S.Ed	1.21	0.07	1.22	0.21	0.63	0.32	1.00	0.97	0.65	0.16	0.76	0.48
CD(0.05)	2.57	0.14	2.60	0.42	1.33	0.65	2.08	1.96	1.39	0.32	1.60	0.98

T_1 - Recommended dose (200:125:125kg NPK/ha) through straight fertilizers by soil application and flood irrigation
T_2 - Fertigation with 125% of RDF through straight fertilizers
T_3 - Fertigation with 100% of RDF through straight fertilizers
T_4 - Fertigation with 75% of RDF through straight fertilizers
T_5 - Fertigation with 50% of RDF through straight fertilizers
T_6 - Fertigation with 125% of RDF through water soluble fertilizers
T_7 - Fertigation with 100% of RDF through water soluble fertilizers
T_8 - Fertigation with 75% of RDF through water soluble fertilizers
T_9 - Fertigation with 50% of RDF through water soluble fertilizers

Spacing S_1-60 x 60 cm S_2- 60 x 45 cm S_3-60 x 30 cm: T- Main plot: S-Sub-plot: T x S – Main plot x Sub – plot: S x T – Sub-plot x Main plot

higher with application of 100 per cent RDF through water soluble fertilizers (T_7). The increased growth parameters might be due to better absorption of nitrogen in water soluble fertilizers, which is useful for better carbohydrate and protein synthesis that are essential for building of new cells besides it accelerates synthesis of chlorophyll and amino acids, leading to improvement in vegetative growth. Similar finding was reported by Brahma *et al*. (2010).

Under drip fertigation, water soluble fertilizers were applied at frequent intervals. This might have resulted in higher availability and uptake by the roots which ultimately would have favoured better growth and yield. Compared to straight fertilizers, water soluble fertilizers had significant effect on the above mentioned parameters, possibly due to better availability of nutrients at all stages of plant growth and maintaining favourable water balance in

Table 5. Effect of spacing and fertigation on ascorbic acid (mg g $^{-100}$) in cauliflower

S / T	Season I				Season II				Pooled analysis			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
T	32.26	32.26	16.13	26.88	26.88	32.26	16.13	26.09	29.57	32.26	16.13	25.99
T_2[1]	58.89	64.15	53.76	58.93	53.64	58.89	53.76	55.43	56.27	61.52	53.76	57.19
T_3	59.13	64.15	48.39	57.22	59.13	58.89	48.39	55.47	59.14	61.52	48.39	56.35
T_4	59.13	80.64	64.15	68.09	59.13	80.64	59.13	66.30	59.14	80.64	61.82	67.20
T_5	53.76	64.51	48.39	55.55	53.76	64.51	53.76	57.34	53.76	64.51	51.08	56.45
T_6	59.13	64.51	53.84	59.16	59.13	64.51	53.84	59.16	59.14	64.51	53.84	59.16
T_7	80.64	80.64	80.64	80.64	80.64	80.64	80.64	80.64	80.64	80.64	80.64	80.64
T_8	80.64	64.51	48.39	64.51	64.51	80.64	48.39	64.51	80.64	64.51	48.39	64.51
T_9	64.15	80.64	64.51	69.88	80.64	64.51	64.51	69.88	64.51	80.64	64.51	69.89
Mean	60.90	66.22	53.17		59.72	65.06	53.17		60.31	65.64	53.17	
	T	S	T x S	S x T	T	S	T x S	S x T	T	S	T x S	S x T
S.Ed	2.15	1.18	3.62	3.56	2.69	1.37	4.30	4.11	2.25	1.16	3.63	3.49
CD(0.05)	4.57	2.41	7.47	7.23	5.71	2.78	8.80	8.35	4.77	2.36	7.50	7.09

T_1 - Recommended dose (200:125:125kg NPK/ha) through straight fertilizers by soil application and flood irrigation
T_2 - Fertigation with 125% of RDF through straight fertilizers
T_3 - Fertigation with 100% of RDF through straight fertilizers
T_4 - Fertigation with 75% of RDF through straight fertilizers
T_5 - Fertigation with 50% of RDF through straight fertilizers
T_6 - Fertigation with 125% of RDF through water soluble fertilizers
T_7 - Fertigation with 100% of RDF through water soluble fertilizers
T_8 - Fertigation with 75% of RDF through water soluble fertilizers
T_9 - Fertigation with 50% of RDF through water soluble fertilizers

Spacing S_1-60 x 60 cm S_2- 60 x 45 cm S_3-60 x 30 cm: T- Main plot: S-Sub-plot: T x S – Main plot x Sub – plot: S x T – Sub-plot x Main plot

the root zone of plants. The enhancement of growth parameters might be due to the restricted wetting area and root zone application of nutrients through drip system coupled with constant and continuous availability of optimum soil moisture, which facilitated the plants to absorb more nutrients (Patil, 1999). In the case of soil application of fertilizers with furrow irrigation, fertilizers were applied on a wider area, which had resulted in faster depletion of nutrients from rhizosphere. Further, faster rate of infiltration in furrow irrigation resulted in water deficit, which might have led to many changes in plant anatomy such as decrease in cell size and intercellular spaces and limiting cell division and elongation, reflecting its effect on plant growth (Guinn *et al*., 1981). Kacjan-Marsic and Osvald (2004) found that growth characters of white cabbage were significantly increased when 30 per cent of total N was pre-plant incorporated and remaining N and total amounts of P and K were applied through fertigation.

Table 6. Effect of spacing and fertigation on BC ratio (pooled analysis)

S / T	Pooled analysis		
	S_1	S_2	S_3
T_1	2.59	2.83	2.29
T_2	3.81	3.79	3.24
T_3	3.98	3.99	3.31
T_4	4.08	3.89	3.49
I_5	3.77	3.85	3.41
T_6	2.25	2.23	2.04
I_7	2.83	2.77	2.51
T_8	2.95	2.82	2.64
T_9	3.31	3.11	2.89

T_1 - Recommended dose (200:125:125kg NPK/ha) through straight fertilizers by soil application and flood irrigation
T_2 - Fertigation with 125% of RDF through straight fertilizers
T_3 - Fertigation with 100% of RDF through straight fertilizers
T_4 - Fertigation with 75% of RDF through straight fertilizers
T_5 - Fertigation with 50% of RDF through straight fertilizers
T_6 - Fertigation with 125% of RDF through water soluble fertilizers
T_7 - Fertigation with 100% of RDF through water soluble fertilizers
T_8 - Fertigation with 75% of RDF through water soluble fertilizers
T_9 - Fertigation with 50% of RDF through water soluble fertilizers

Spacing S_1-60 x 60 cm S_2- 60 x 45 cm S_3-60 x 30 cm

The highest curd weight (999.21 g) was recorded with application of 100 per cent RDF (T_7) through water soluble fertilizers (Table 3). This could be attributed to higher availability of nutrients in soil solution, which obviously would have led to increased growth and better photo-assimilation and translocation of assimilates from source to sink leading to increased curd weight. These results are in conformity with Brahma *et al.* (2010), who observed the highest head weight with application of 100 per cent recommended dose of nitrogen through fertigation.

Higher curd yield per hectare (Table 4) was recorded with the application of 100 per cent RDF (T_7) through water soluble fertilizers (32.36, 28.39 and 30.37 t) in the first, second season and pooled analysis respectively. Compared to straight fertilizers, water soluble fertilizers had significant effect on growth and yield parameters, which might be due to better availability of nutrients at all stages of plant growth and maintaining favourable water balance in the root zone of plants. Similarly Singla and Singh (2011) recorded higher curd yield with the application of 100 per cent recommended dose of nitrogen through fertigation. In broccoli, Patel and Rajput (2003) observed increased marketable yield with 100 per cent recommended dose of N and K applied through fertigation.

Application of 100 per cent RDF through water soluble fertilizers recorded the highest level of ascorbic acid content (80.64 mg g_{-100}) in all the spacing levels. The results are in accordance with the findings of Sharma and Sharma (2006), who reported that the application of nitrogen @ 240 kg N ha_{-1} recorded the highest (95.63 mg g_{-100}) ascorbic acid content in cauliflower. In this study, 125 per cent RDF through water soluble fertilizer recorded lower level (59.16 mg g_{-100}) of ascorbic acid. Nitrogen fertilizers, at higher rates seemed to decrease the concentration of ascorbic acid. Plant growth is generally enhanced by the nitrogen fertilization so that the relative dilution effect and also increased concentration of No_3 might simultaneously decrease the ascorbic acid content (Mozafar, 1993) .Similar findings on increasing levels of nutrients and negative relationship between ascorbic acid content was reported by Nilson (1980) and Lisiewska and Kmiecik (1996) in cauliflower.

Economics of spacing and fertigation

Drip fertigation in vegetables requires high capital investment and more so with the water soluble fertilizers. Hence, the economic viability of drip fertigation system was calculated considering the longer life span of the drip system, increased productivity and net extra income over conventional fertilization. Though the investment towards drip system for fertigation was high, considering the longer life of drip system, the benefit accrued was also for longer period.

Though the highest gross income was recorded at 125 per cent RDF through water soluble fertilizers and 60 x 45 cm spacing, the BC ratio was low (Table 6). Straight fertilizers are cheaper than water soluble fertilizers and the highest BC ratio (4.08) was recorded with 75 per cent recommended dose of fertilizer through straight fertilizers at 60 x 60 cm spacing, followed by 100 per cent RDF through straight fertilizers with the spacing of 60 x 45 cm. Though there was yield increase due to water soluble fertilizers, the BC ratio was low and 75 per cent RDF through straight fertilizers was found economically feasible. Savitha (2008) reported that fertigation regime with application of 75 per cent RDF through straight fertilizers recorded the highest BC ratio in onion.

From the results of the present study, it could be concluded that a spacing of 60 x 45 cm with the application of 100 per cent RDF through water soluble fertilizers recorded better growth, yield and quality traits in cauliflower. However, the benefit cost ratio was higher with 75 per cent RDF through straight fertilizers with spacing of 60 x 60 cm. Based on the economic feasibility, straight fertilizers were found to be beneficial compared to water soluble fertilizers.

References

Agarkar, U.R., Damal, K.D., Nikas, N.S. and Piwlatkar, G.K. 2010. Effect of nitrogen levels and spacing on growth and yield of broccoli (*Brassica oleracea* var.*italica* L**.**). *Green farming.***1**: 477-479.

Anonymous. *2011.* http://nhb.gov.in/area-pro/data base-2011.pdf

Bhangre, K.K., Sonwane, P.C. and Warade, S.D. 2011. Effect of varieties and spacing on growth and yield parameters of broccoli (*Braccica oleracea* L.var.*Italica Plenck*). *Asian J.Hort.,* **6**: 74-76.

Brahma, S., Phookan, D.B., Kachari, M., Hazarika, T.K. and Das, K. 2010. Growth, yield and economics of broccoli under different levels of nitrogen fertigation. *Indian J. Hort.,* **67:279-282**.

Guinn, G., Mauney, J.R. and Fry, K.E. 1981. Irrigation scheduling and plant population effects of growth bloom rates on abscission and yield of cotton. *Agron. J.,* **73 :** 529-534.

Hossain, M.F., Ara, N., Uddin, M.R., Dey, S. and Islam, M.R. 2011. Effect of time of sowing and plant spacing on broccoli production. *Trop. Agri. Res. Extn.,* **14:** 90-92.

Jett, L.W., Morse, D.R. and Dell. C.R.O. 1995. Plant density effects on single head broccoli production**.** *Hort.Sci.,* **30:** 50-52.

Kacjan-Marsic, N. and Osvald, J. 2004. The effect of fertigation on yield and quality of four white cabbage (*Brassica oleracea* var. *capitata* L.) cultivars. *Acta agriculturae slovenica.* **83:** 23-29.

Kelly, W.T. 2007. Greater plant population may increase broccoli yield**.** *Ext. Res. Report.* pp.7-8.

Lee, S.K. and Kader, A.A. 2000. Preharvest and postharvest factors influencing vitamin C content of horticultural crops. *Postharvest Biology and Technology***, 20**: 207–220.

Lisiewska, Z. and Kimiecik, W. 1996. Effects of level of nitrogen fertilizer, processing conditions and period of storage for frozen broccoli and cauliflower on vitamin C retention. *Food Chem***., 57:** 267-270.

Loewus, F.A. and Loewus, M.W. 1987. Biosynthesis and metabolism of ascorbic acid in plants. *Crit. Rev. Plant Sci.,* **5**: 101–119.

Mary, S.S. and Balakrishnan, R. 1990. Studies on the effect of irrigation, nitrogen and potassium on growth and yield of chilli. *Indian J. Hort.,* **47:** 413-416.

Moniruzzaman, M. 2011. Effect of plant spacings on the performance of hybrid cabbage (*Brassica oleracea* var.*capitata*) varieties. *Bangladesh J. Agrl. Res.,* **36:**495-506.

Mozafar, A. 1993. Nitrogen fertilizers and the amount of vitamins in plants. *J. Plant Nutr.,* **16:** 2479–2506.

Mujeeb-ur-Rahman, Iqbal, M., Jilani, M.S. and Waseem, K. 2007. Effect of different plant spacing on the production of cauliflower (*Brassica oleracea* var. b*otrytis)* under the agro-climatic conditions of Pakisthan. *Pak.J.Biol. Sci.,* **10:** 4531-4534.

Nilson, T. 1980. The influence of soil type, nitrogen and irrigation on yield, quality and chemical composition of cauliflower. *Swedish J. Agric. Res.,* **10:**65-75.

Patel, N. and Rajput, T.B.S. 2003. Yield response of some vegetable crops to different levels of fertigation. *Ann. Agric. Res.,* **24:** 542-545

Patil, V.C. 1999. Drip irrigation, Department of Agronomy, UAS, Bangalore,140.p.

Rosenberg, S.P. 1975. Chemistry and physiology of the vitamins. Inter Science Pubilishers, New York.p.120

Rumeza Hanif, Iqbal, Z., Iqbal, M., Hanif, S. and Rasheed, M. 2006. Use of Vegetables as Nutritional Food: Role in Human Health., *J. Agric. Bio. Sci.,* **1:**18-22.

Sarker, M.Y., Azad, A.K., Hasan, M.K., Nasreen, A., Naher,

Q. and Baset, M.A. 2002. Effect of plant spacing and sources of nutrients on the growth and yield of cabbage. *Pak. J. Biol. Sci.,* **5:** 636-639.

Savitha, B.K. 2008. Standardization of drip fertigation in onion (*Allium cepa L.)*. M.Sc.Thesis, Department of Vegetable Crops, Tamil Nadu Agricultural University, Coimbatore. P.105

Sharma, A. and Chandra, A. 2004. Effect of plant density and nitrogen levels on physio-chemical parameters of cauliflower. *Haryana J. Hortl. Sci.,* **33:** 148-149.

Sharma, R. and Sharma, S.K. 2006. Response of nitrogen, phosphorus and potassium on some quality traits of cabbage hybrid Bajrang. *Crop Res.,* **31:** 89-92.

Sharma, R.M. and Lal, H. 1986. Effect of different levels of nitrogen on growth and yield of cabbage cultivars. *Prog. Hort.,* **18:** 132-134.

Singh, K., Dhaka, R.S. and Fageria, M.S. 2004. Response of cauliflower (*Brassica oleracea* var.*botrytis* L.) cultivars to row spacing and nitrogen fertilization. *Prog.Hort.,* **36:** 171-173.

Singla, C. and Singh, K.G. 2011. Crop water requirements and fertigation options for early drip irrigated cauliflower (*Brassica oleracea* var. *botrytis* Linn.) grown in a greenhouse. *Prog. Hort.,* **43:** 99-101.

Solunke, B.G., Wagh, A.P., Dod, V.N. and Nagre, P.K. 2011. Effect of dates of planting and spacing on growth and yield of broccoli. *Asian J. Hort.,* **6 :**294-296.

Received: February 1, 2013; Accepted: June 28, 2013