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RESPONSE OF DIFFERENT LEVELS OF NITROGEN AND SPACING ON YIELD AND QUALITY OF CAULIFLOWER GROWN UNDER CENTRAL REGION OF PUNJAB

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ABSTRACT

The field experiment was conducted during rabi season of 2018-2019 to find out the response of different levels of nitrogen and spacing on yield and quality of cauliflower. The experiment was carried out under Factorial Randomized Block Design (FRBD) with three replications and twelve treatments with four different levels of nitrogen levels (N0: 0%; N1: 50%; N2: 75% and N3: 100 % ha^{-1}) and three different spacing (S1: 45×30 cm; S2: 45×45 cm and S3: 60×45 cm). The result revealed that the maximum fresh weight of curd (833.33 g), dry weight of curd (0.89 g), shelf life (8.07 days), total soluble solids (5.05°Brix), vitamin A (16.35 mg), vitamin C (68.40 mg) and chlorophyll content in leaves of cauliflower (1.68 mg) were obtained from $N_{100}S_{45\times30}$. While, maximum curd yield $plot^{-1}$ (30.03 kg) and ha^{-1} (326.90 q) were obtained from $N_{100}S_{45\times30}$. However, maximum net return (₹ 299443.45) and B: C ratio (3.22) were obtained with 100 % N ha^{-1} + 45×30 cm. On the basis of results of present investigation, it concluded that treatment T_{12} (100 % N ha^{-1} + 60×45 cm) were found effective in improving the yield and quality of cauliflower.

INTRODUCTION

Cauliflower (*Brassica oleracea var. botrytis* L.) belongs to family cruciferae having chromosome no. 2n = 14 and generally termed as cole crop. It is widely cultivated all over world for its special nutritive values, high productivity and wider adaptability under different ecological conditions. It is good source of vitamin A and C and also contains minerals like potassium, sodium, calcium, iron, phosphorus and magnesium (Singh *et al.*, 2018). Consumption of cauliflower helps in detoxification of body fats, boosting healthy heart, improved digestion and helpful in treating scurvy as a blood purifier as suggested by (Ashraf *et al.*, 2017). Like other vegetable crops cauliflower also a heavy feeder of mineral elements, it removes large amount of macronutrients from the soil (Shree *et al.*, 2014). Being a heavy feeder, it demands constant supply of large amount of nutrients and water for its luxuriant growth (Bashyal, 2011). Nitrogen is essentially required macronutrient for plant growth and fruit development and its recommendation for cauliflower may differ with the soil type and its availability in the soil (Sahito *et al.*, 2018). Proper use of nitrogen improves the nutritional value of cauliflower. It is involved in various physiological and enzymatic activities. It is also associated with vigorous vegetative growth and helps in the formation of large size of curd. According to Yeshiwas (2017) the nitrogen is a major fertilizer which is constituent of protein ,protoplasm of chlorophyll and enzymes. It is required in much large quantities than other nutrients. Lack of nitrogen causes stunted growth or leaves discoloration in cauliflower. Its deficiency causes interveinal yellowing, rolling of leaves, chlorosis necrosis and also reduces the yield of cauliflower. Kodithuwakku and Kirthisinghe (2009) reported that the farmers use urea as a nitrogen fertilizer to enhance flowering, curd set and increase curd size in cauliflower. It is also stated that the excessive application of nitrogen on the other hand is not only uneconomical but also induces physiological disorder and pollutes the environment. Spacing is another factor that was reported to be having a significant influence on Brassica production. Spacing is defined as the distance between the plants in the row and between the rows of planted crops. Farzana *et al*. (2016) observed that the maximum results of yield contributing characters are obtained at higher spacing. Optimum spacing ensures judicious use of natural resources and makes the intercultural operation easier as suggested by (Hasan *et al.*, 2017). The spacing of crop varied according to climatic condition, soil fertility and cultivar adaption to particular region (Bairwa *et al.*, 2017). Considering the above facts, the present experiment was planned and undertaken with the objective to study the response of different levels of nitrogen and spacing on yield and quality of cauliflower grown under central region of Punjab.

MATERIALS AND METHODS

The present experiment was carried in the Experimental Farm, Department of Agriculture, Mata Gujri College, Fatehgarh Sahib, Punjab from October 2018 to February 2019. The experiment was laid out in Factorial Randomized Block Design (FRBD) with three replications. The experiment consisted of two factors such as Factor A: Nitrogen levels, N_0: 0 % ha^{-1}, N_1: 50 % ha^{-1}, N_2: 75 % ha^{-1} and N_3: 100 % ha^{-1} and Factor B: Spacing, S_1: 45×30 cm, S_2: 45×45 cm and S_3: 60×45 cm.

There were 12 treatment combinations such as N_0S_1, N_0S_2, N_0S_3, N_1S_1, N_1S_2, N_1S_3, N_2S_1, N_2S_2, N_2S_3, N_3S_1, N_3S_2 and N_3S_3. The seeds of cauliflower cultivar 'Golden-75' were sown on well prepared raised nursery beds on October 3rd, 2018. The experimental Farm was ploughed followed by clod breaking, hoeing and levelling. Vigorous seedlings were transplanted into field on October 27th, 2018. The field was divided into three blocks and each block was divided into 12 plots. There were 36 unit plots and the size of the each unit plot was 3×2.4 m. All appropriate cultural practices including weeding, watering, hoeing and insect-pest control were timely performed. Urea was used as source of nitrogen fertilizer. The observations recorded for yield and quality attributing characters *viz*. fresh weight of curd (g), dry weight of curd (g), yield plot^{-1} (kg), yield ha^{-1} (q), shelf life (days), total soluble solids (ºBrix), vitamin A (mg 100^{-1}), vitamin C (mg 100^{-1}) and chlorophyll content in leaves (mg 100^{-1}). For estimation of vitamin C, 2, 6- dichlorophenol-indophenol method (A.O.A.C., 1975) was adopted. Six plants in each treatment combination and in each replication were randomly selected and tagged properly for recording various observations. The data obtained for different parameters were statistically analysed to find out the significance difference of nitrogen fertilization and spacing on growth and yield contributing characters of cauliflower. The experimental data for various observations were analyzed by fisher's method of analysis of variance (ANOVA) as per outlined by Gomez and Gomez (1984). The data were analyzed and are presented at the 5% level of significance.

RESULTS AND DISCUSSION

Yield parameters

The results of the present study clearly indicate that the individual and combine effect of different levels of nitrogen and spacing significantly affected the various yield parameters of cauliflower such as fresh weight of curd (g), dry weight of curd (g), yield plot^{-1} (kg) and ha^{-1} (q).

The mean performance of different levels of nitrogen showed that maximum fresh weight of curd (827.02 g) was obtained with N_3 (100% N ha^{-1}) because nitrogen fertilizers ensure favourable condition for the growth of plant with optimum vegetative growth and ultimately increase the fresh weight of curd. However, minimum fresh weight of curd (681.60 g) was recorded in the N_0 (control). In spacing, maximum fresh weight of curd (788.11 g) was obtained with S_3 (60×45cm). However, minimum fresh weight of curd (731.94 g) was recorded in the S_1 (45×30cm) because spacing significantly affected fruit size, with the closest spaced plants having the smallest fruits, while the widest spaced plants had the largest fruits. Similar result was also observed by Meena *et al*. (2017), Gogoi *et al*. (2016) in broccoli, Boroujerdnia and Ansari (2007) in lettuce and Joshi *et al*. (2018) in cauliflower. Statistically significant variation was recorded due to interaction effect of different levels of nitrogen and spacing in terms of fresh weight of curd of cauliflower. The highest fresh weight of curd (833.33 g) was found from N_3S_3. While, minimum fresh weight of curd (580.17 g) was found from N_0S_1.

Table 1: Effect of different levels of nitrogen and spacing on yield characteristics of cauliflower.

Treatment	Fresh weight of curd (g)	Dry weight of curd (g)	Curd yield plot^{-1} (kg)	Curd yield ha^{-1} (q)
Factor A				
N_0 (0 % N ha^{-1})	681.6	0.68	18.64	241.83
N_1 (50 % N ha^{-1})	760.4	0.78	23.6	266.67
N_2 (75 % N ha^{-1})	796.69	0.83	28.65	318.12
N_3 (100 % N ha^{-1})	827.02	0.88	29.72	325.54
SEm (±)	14.65	0.02	0.7	3.73
$CD_{0.05}$	30.4	0.04	1.47	7.73
Factor B				
S_1 (45×30 cm)	731.94	0.75	26.14	295.69
S_2 (45×45 cm)	779.23	0.81	25.32	287.14
S_3 (60×45 cm)	788.11	0.83	24	281.29
SEm (±)	16.92	0.02	0.81	4.3
$CD_{0.05}$	35.1	0.05	1.69	8.93
Interaction (N×S)				
N_0S_1 (0 % N ha^{-1} + 45×30 cm)	580.17	0.6	18.65	263.87
N_0S_2 (0 % N ha^{-1} + 45×45 cm)	727.73	0.71	18.63	235.67
N_0S_3 (0 % N ha^{-1} + 60×45 cm)	736.9	0.72	18.62	225.97
N_1S_1 (50 % N ha^{-1} + 45×30 cm)	750	0.73	26.43	269.47
N_1S_2 (50 % N ha^{-1} + 45×45 cm)	765.03	0.8	24.64	266.17
N_1S_3 (50 % N ha^{-1} + 60×45 cm)	766.17	0.82	19.74	264.37
N_2S_1 (75 % N ha^{-1} + 45×30 cm)	776.2	0.82	29.44	322.53
N_2S_2 (75 % N ha^{-1} + 45×45 cm)	797.83	0.83	28.35	321.17
N_2S_3 (75 % N ha^{-1} + 60×45 cm)	816.03	0.85	28.16	310.65
N_3S_1 (100 % N ha^{-1} + 45×30 cm)	821.4	0.86	30.03	326.9
N_3S_2 (100 % N ha^{-1} + 45×45 cm)	826.33	0.88	29.67	325.57
N_3S_3 (100 % N ha^{-1} + 60×45 cm)	833.33	0.89	29.48	324.17
SEm (±)	29.31	0.04	1.41	7.45
$CD_{0.05}$	60.8	NS	2.94	15.46

Table 2 : Effect of different levels of nitrogen and spacing on quality characteristics of a cauliflower

Treatment	Shelf life (days)	TSS (oBrix)	Vitamin A (mg 100g^{-1})	Vitamin C (mg 100g^{-1})	Total chlorophyll content (mg 100g^{-1})
Factor A					
N_0 (0 % N ha^{-1})	6.16	3.87	12.18	59.08	1.12
N_1 (50 % N ha^{-1})	7.3	4.44	13.49	63.88	1.37
N_2 (75 % N ha^{-1})	7.63	4.72	15.74	66.73	1.61
N_3 (100 % N ha^{-1})	8.03	5	16.24	68.08	1.67
SEm (±)	0.21	0.17	0.25	0.79	0.02
CD	0.45	0.35	0.53	1.64	0.05
Factor B					
S_1 (45×30 cm)	6.99	4.21	13.84	62.93	1.37
S_2 (45×45 cm)	7.2	4.62	14.55	64.68	1.45
S_3 (60×45 cm)	7.66	4.69	14.84	65.71	1.51
SEm (±)	0.25	0.2	0.29	0.91	0.03
$CD_{0.05}$	0.52	0.41	0.61	1.9	0.06
Interaction (N×S)					
N_0S_1 (0 % N ha^{-1} + 45×30 cm)	5.33	3	10.63	54.9	0.98
N_0S_2 (0 % N ha^{-1} + 45×45 cm)	5.87	4.27	12.61	59.3	1.1
N_0S_3 (0 % N ha^{-1} + 60×45 cm)	7.27	4.32	13.29	63.03	1.29
N_1S_1 (50 % N ha^{-1} + 45×30 cm)	7.28	4.33	13.33	63.32	1.31
N_1S_2 (50 % N ha^{-1} + 45×45 cm)	7.3	4.47	13.49	64.13	1.39
N_1S_3 (50 % N ha^{-1} + 60×45 cm)	7.33	4.53	13.65	64.19	1.42
N_2S_1 (75 % N ha^{-1} + 45×30 cm)	7.33	4.56	15.25	65.74	1.55
N_2S_2 (75 % N ha^{-1} + 45×45 cm)	7.6	4.73	15.88	67.22	1.63
N_2S_3 (75 % N ha^{-1} + 60×45 cm)	7.97	4.87	16.08	67.23	1.64
N_3S_1 (100 % N ha^{-1} + 45×30 cm)	8	4.93	16.14	67.77	1.65
N_3S_2 (100 % N ha^{-1} + 45×45 cm)	8.03	5.02	16.22	68.08	1.67
N_3S_3 (100 % N ha^{-1} + 60×45 cm)	8.07	5.05	16.35	68.4	1.68
SEm (±)	NS	NS	0.51	1.58	0.05
$CD_{0.05}$	NS	NS	1.06	3.29	0.11

Table 3 : Effect of different levels of nitrogen and spacing on economic parameters of cauliflower.

Treatment	Cost of cultivation (₹ha^{-1})	Gross return (₹ha^{-1})	Net return (₹ha^{-1})	B:C ratio
T_1 = 0 % N ha^{-1} + 45×30 cm	90511.3	316644	226132.7	2.49
T_2 = 0 % N ha^{-1} + 45×45 cm	90511.3	282804	192292.7	2.12
T_3 = 0 % N ha^{-1} + 60×45 cm	90511.3	271164	180652.7	1.99
T_4 = 50 % N ha^{-1} + 45×30 cm	92023.92	323364	231340.1	2.51
T_5 = 50 % N ha^{-1} + 45×45 cm	92023.92	319404	227380.1	2.47
T_6 = 50 % N ha^{-1} + 60×45 cm	92023.92	317244	225220.1	2.44
T_7 = 75 % N ha^{-1} + 45×30 cm	92430.23	387036	294605.8	3.18
T_8 = 75 % N ha^{-1} + 45×45 cm	92430.23	385404	292973.8	3.16
T_9 = 75 % N ha^{-1} + 60×45 cm	92430.23	372780	280349.8	3.03
T_{10} = 100 % N ha^{-1} + 45×30 cm	92836.55	392280	299443.5	3.22
T_{11} = 100 % N ha^{-1} + 45×45 cm	92836.55	390684	297847.5	3.2
T_{12} = 100 % N ha^{-1} + 60×45 cm	92836.55	389004	296167.5	3.19

The data recorded on dry weight of curd have been presented in Table 1. It was observed that different levels of nitrogen and spacing showed significant variation on dry weight of curd. The data revealed that maximum dry weight of curd (0.88 g) was obtained with N_3 (100% N ha^{-1}) because nitrogen is combined with plant constituents of compounds during photosynthesis such as glucose, ascorbic acid, amino acid and protein which increases the dry weight of curd. While, minimum dry weight of curd (0.68 g) was recorded in the N_0 (control). In spacing, maximum dry weight of curd (0.83 g) was obtained with S_3 (60×45cm). Due to increase in spacing dry weight of curd shows increasing trend because of less competition for nutrients among the plants during growth stages. Whereas, minimum dry weight of curd (0.75 g) was recorded in the S_1 (45×30cm). Similar findings were found by Fatimah *et al*. (2019) in cabbage, Hasan *et al*. (2017) and Moniruzzaman (2006) in lettuce. The interaction effect of different levels of nitrogen and spacing in terms of dry weight of curd was found to be non-significant.

The data pertaining to curd yield plot^{-1} have been presented in Table 1. The mean performance of different levels of nitrogen showed that maximum curd yield plot^{-1} (29.72 kg) was obtained with N_3 (100% N ha^{-1}). Due to application of nitrogen at higher rate, the crop traits improved substantially and these traits linearly influenced the yield plot^{-1} in positive direction. However, minimum curd yield plot^{-1} (18.64 kg) was recorded in the N_0 (control). In spacing, maximum yield plot^{-1} (26.14 kg) was obtained from the closest spacing because the increase in number of plants per unit area While, minimum curd yield $plot^{-1}$ (24.00 kg) was recorded in the S_3 (60×45cm). Similar results have been recorded by Kumar *et al*. (2019) in cauliflower, El-Shabrawy *et al*. (2005) in cabbage and Biswas *et al*. (2015) in tomato. Statistically significant variation was recorded due to interaction effect of different levels of nitrogen and spacing in terms of curd yield $plot^{-1}$ of cauliflower. The highest curd yield $plot^{-1}$ (30.03 kg) was found from N_3S_1. Whereas, minimum curd yield $plot^{-1}$ (18.65 kg) was found from N_0S_3.

The data recorded on curd yield ha^{-1} have been presented in Table 1. It is evident from the data that the curd yield ha^{-1} was significantly affected by different treatments. The mean performance of different levels of nitrogen showed that maximum curd yield ha^{-1} (325.54 q) was obtained with N_3 (100% N ha^{-1}) because in increase in nitrogen helps plant for higher vegetative growth. While, minimum curd yield ha^{-1} (241.83 q) was recorded in the N_0 (control). In spacing, maximum curd yield ha^{-1} (295.69 q) was obtained with S_1 (45×30cm) because in case of wider spacing, individual plants will yield more but yield ha^{-1} may be reduced due to low plant population. Therefore, closer spacing must be worked out at which average yield ha^{-1} was found maximum. Whereas, minimum curd yield ha^{-1} (281.29 q) was recorded in the S_3 (60×45cm). Similar finding was observed by Manasa *et al*. (2017) in red cabbage, Baloch *et al*. (2014) in radish and Hiwale *et al*. (2010) in cabbage. Statistically significant variation was recorded due to interaction effect of different levels of nitrogen and spacing in terms of curd yield ha^{-1} of cauliflower. The highest curd yield ha^{-1} (326.90 q) was found from N_3S_1. However, minimum curd yield ha^{-1} (225.97 q) was found from N_0S_3.

Quality parameters

The data recorded on shelf life have been presented in Table 2. It was observed that different levels of nitrogen showed significant variation on shelf life. The data revealed that curds from plots treated with 100% N ha^{-1} at high relative humidity conditions had the longest shelf life (8.03 days) (Kodithuwakku and Kirthisinghe, 2009). Minimum shelf life (6.16 days) was recorded in the N_0 (control). In case of spacing, maximum shelf life (7.66 days) was obtained from 60×45 cm. This is mainly because of bigger size fruits having thicker pericarp. The rind thickness of fruit was positively correlated with fruit size and shelf life of fruits (Thakur *et al*., 2018). These findings are similar with Hiwale *et al*. (2010) in cabbage.

The mean performance of different levels of nitrogen showed that maximum TSS (5.00 °Brix) was obtained with N_3 (100% N ha^{-1}). This is due to that application of inorganic nitrogen fertilizers increased glucose and fructose content (Hiwale *et al*., 2010). Total soluble contents are an indicator of mineral nutrition concentration in fruits and these values increased with nitrogen fertilization (Krezel and Kolota ,2008). Minimum TSS (3.87 °Brix) was recorded in the N_0 (control). In spacing, maximum TSS (4.69 °Brix) was obtained with S_3 (60×45 cm). Wider spacing increased the availability of solar radiation, which increased the respiration rate of fruits, resulting in degradation of starch and production of glucose and fructose contributing to high sugar content (Krimi *et al*., 2011). However, minimum TSS (4.21 °Brix) was recorded in the S_1 (45×30 cm). These findings are similar with Kumar and Rawat (2002) in cabbage and El-Desuki *et al*. (2005) in radish.

Significant variation in amount of vitamin A was found due to influence of nitrogen level and different plant spacing. Maximum vitamin A (16.24 and 14.84 mg) was observed from N_3 (100% N ha^{-1}) and S_3 (60×45 cm) respectively. A promotional effect of nitrogen on carotene content might be due attributed to the fact that it is the main constituent of all amino acids, protein and lipids that while acting as a structural compound of the chloroplast might in turns helped to produce more vitamin A (Yadav *et al*., 2016). The maximum vitamin A content was recorded from the widest spacing because larger spacing increases the availability of nutrients which enhances the vitamin A content in curd (Roni *et al*., 2014). Similar findings were reported by Singh *et al*. (2017) in carrot.

During the present study, maximum vitamin C (68.08 and 65.71 mg) was observed from N_3 (100 % N ha^{-1}) and S_3 (60×45 cm) respectively. Nitrogen initiates meristematic activity, thereby increasing the assimilation surface leading to a greater production and accumulation of photosynthetic product. These biosynthetic functions of nitrogen positively affect the vitamin C content of cauliflower (Vishwakarma *et al*., 2017). In case of planting spacing, wider spacing significantly increased vitamin C content in curd as compared to closer spacing. This might be due to the wider spacing increases dry matter content resulting in higher content of ascorbic acid (El-Shabrawy *et al*., 2005). The results were corroborating with those of Shree *et al*. (2014), Hiwale *et al*. (2010) in cabbage and Singh *et al*. (2018) in broccoli.

The data revealed that the maximum chlorophyll content in leaves (1.67 and 1.51 mg) was recorded in N_3 (100 % N ha^{-1}) and S_3 (60×45 cm) spacing respectively. Nitrogen plays a vital role in the physiological process of plant; nitrogen makes the plant dark green, increases the chlorophyll content in leaves. Nitrogen encourages the formation of good quality foliage which play a vital role in accumulation of food starch via photosynthesis process because nitrogen is an important constituent of chlorophyll (Tsiakaras *et al*., 2014). In case of spacing, wider spacing provides sufficient space for plant growth and there was less competition between plant to plant for available nutrient and light (Kumar and Rawat, 2002). Similar results were reported by Sowinska and Uklanska (2009) in endive.

Economics

Higher money value and less cost of cultivation are desirable characters for getting higher returns. Hence, economics of the treatments was worked out under different levels of nitrogen and spacing. Examination of the data revealed that maximum net return (₹ 299443) and highest gross return (₹ 392280) were obtained in T10 (100 % N ha^{-1} + 45×30 cm). Whereas, minimum gross return (₹ 271164) and net return (₹ 180652) were obtained in T_3 (0 % N ha^{-1} + 60×45 cm). On the same lines, maximum benefit: cost ratio (3.22) was calculated in T_{10} (100 % N ha-1 + 45×30 cm) and minimum (1.99) was recorded in T_3 (0 % N ha^{-1} + 60×45 cm). Economics was calculated by Parmar *et al*. (2015) and Gessesew *et al*. (2015).

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