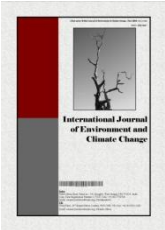

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Factors Affecting Production of Cauliflower: A Review

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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Review Article

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ABSTRACT

This article analyses the research on various cultivars, genetic diversity, heredity, and genetic progress, as well as how variable nitrogen levels and plant spacing affect the yield and growth of cauliflower in various regions of the world. This attempts to enhance productivity and output of cauliflower for fodder and human use. Most significant research papers summarise and report their key findings in separate paragraphs.

Keywords: Genetic variability; heritability and genetic advance; yield; plant spacing; NPK level.

1. INTRODUCTION

Vegetables are the most significant part of the vegetarian diet of the Indian people since it is largely vegetarian. Approximately 191.7 million metric tonnes of vegetables are produced in India at the moment from 10.35 million hectares of land (NHB, 2019-20). Cauliflower is one of the most commercially significant winter vegetables among the many others cultivated in India. According to FAO (2019), India ranks second in the production of potatoes, onions, brinjal, cabbages, and other vegetables and is the world's top producer of cauliflower, along with ginger and okra.

Cauliflower is a member of the cruciferae family (*Brassica oleraceae* var. Botrytis). Dr. Jemson of

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the Botanical Plant in Saharanpur, Uttar Pradesh, brought it to India in 1822 under the common name "Phoolgobhi" (Nath et al., 1994). It is used in curries, soups, and pickles. It is rich in minerals, vitamins A and C, and carbohydrates. It is grown for the 'tender' and 'yellowish white' curd that is generated by the short internode stem structure. It is normally advised to grow cauliflower on soil that is nutrient-rich and has a good capacity to retain moisture [1-4]. Although insect attack is the main factor affecting cauliflower growth and yield, row spacing and the availability of nitrogen also affect these factors [5-9]. The size of the cauliflower head is significantly influenced by plant spacing. Narrower row spacing results in smaller nitrogen heads whereas broader plant spacing results in greater nitrogen heads [10-12]. This review has gathered all the required data regarding row spacing and nitrogen levels that influenced cauliflower production in numerous experiments, keeping in mind the significance of row spacing and nitrogen levels [13-16]. It is a delicate crop, so cold weather might hurt it right before harvest. The plants might not produce the necessary number of heads under dry and hot conditions, which causes the heads to develop too soon and bolt or button. It requires somewhat chilly conditions while it is developing.

2. REVIEW OF SOME KEY RESULTS OF EARLIER REPORTED RESEARCH WORKS

2.1 Varietal Reviews

Based on factors such curd size, yield timing, agroclimatic conditions, commercial viability, etc., there are several types. In the cauliflower variety Snow Ball, the greatest yields of commercially viable curds were reportedly achieved between 20830 and 25640 plants hectare, according to Minami and Victoria (1981). Plana, Revito, Vernan, Linas, and Cerv ma are the finest cultivars for curd yield and floret quality, and they should be planted at 440 mm (3.8 plants m'), according to Whitwell and Senior [17]. White shot and Balaka, according to Mozumdar S.K. et al. (2011), generated early curd, whereas Earlysnowball and Late alhead produced delayed curd. Snow grace, Rupa, and Benarashi fared better on the 15 November planting than Snow queen, White contessa, Whiteshot, Balaka, and Rupa did on the 15 October planting. When planted on October 15th, White Contessagave had the highest curd yield (21.42 t/ha), while Snow Queen produced the highest BCR (7.95). According to Paudel T.R. et al. (2019), cultivar Snow Grace produces the greatest yield when phosphorus is administered (160 kg ha-1), and further study is needed to optimise the P rate for boosting output in Nepal.

2.2 Review Based on Genetic Variability

Genetic diversity is the foundation of any plant enhancement initiative. Superior cultivars can be produced if there is enough genetic diversity [18,19]. In their investigation of genetic diversity and divergence in nine cauliflower cultivars, Sharma and Verma [20] found statistically significant differences in every attribute. The highest values for gross weight per plant, curd output per plant, curd diameter, leaves per plant, and days to curd maturity were found in cluster 2, whereas the greatest genetic difference was attributed to leaves per plant.

According to Ahmed et al. [21] evaluation of 10 cauliflower cultivars in Hathazari, Chittagong, Bangladesh, "Shiroyama-65" had the greatest values for total plant weight (1916.67 g) and width of the largest leaf (22.17 cm), while "Rakhushi Late" had the highest values for plant height (68.00 cm), number of leaves at harvest (25.93), and length of the largest leaf (22.17 cm) (56.03 cm). The maximum curd output (18.38 tonnes ha^{-1}) and curd weight (661.67 g) were both achieved by "Shiroyama-65."

Thakur [22] evaluated 36 cauliflower genotypes for various horticultural and quality traits and discovered wide genotypic differences for all traits except number of leaves per plant, curd diameter, and curd depth. Harvest index and gross weight had high heritability and high genetic advance, whereas plant spread and days to curd maturity had high heritability and low genetic advance.

From CGN-11089 (5.56 cm) to CCS-06-08, a broad range of variability in stalk length was discovered by Kumar et al. [23] after evaluating 15 exotic cauliflower genotypes (9.5 cm). In 25 genetically different cabbage lines, Sharma [24] looked at the variation and interrelationship of phenotypic traits. There were substantial genotypic variations among all of the traits. The genotypic (GCV) and phenotypic (PCV) coefficients of variation for gross weight per plant and net weight of head were both reasonably high (expressed in percentage points).

Twenty-four cauliflower genotypes, including hybrids and released/pre-released variants, were

evaluated by Singh et al. in 2013. Genotype differences were extremely significant for all of the characteristics, according to the analysis of variance. Leaf length (21.04) and leaf weight (17.19) were found to have the highest phenotypic coefficients of variation (PCV), whereas the number of leaves (9.05) and the number of inner leaves (7.01) had the lowest PCVs (9.22).

2.3 Studies on Heritability and Genetic Advance

The proportion of phenotypic and genotypic diversity that is transferred from parent to child is known as heritability. Heritable variation, which accounts for a major portion of genetic diversity, has a higher propensity to be corrected by selection techniques. In order to determine if observed variation for a certain attribute is heritable or attributable to environment, heritability studies are essential. In 2005, Shakuntala and Kalia looked at the variation in quality traits in 11 genotypes of green sprouting broccoli. High genetic progress (78.11%) and heritability (99.20%) for ascorbic acid suggest that additive gene activity contributes to its inheritance. On the other hand, protein content exhibited a modest genetic progress and a moderate heritability (69.60%). (8.98 percent).

Antonova [25] chose novel breeding lines of late head cabbage and researched the heritability and genetic development of several features in open pollinated cultivars. The bulk of the traits under investigation had high broad-sense heritability, ranging from 45 to 92 percent. Vegetation period had the lowest heritability whereas head weight had the greatest.

Days to marketable maturity, number of leaves, net curd weight, and curd compactness all showed high heritability and moderate genetic gain according to Kanwar et al. [26], showing additive gene action and opening the door for effective selective breeding of these characteristics. Six inbred lines were utilised by Qing et al. [27] to research the heredity and ability of combining in cauliflower. Maturity, bracts rate, leaf covering ratio, head height, ball diameter, and head weight were given narrow heritability ratings in that order. Soni et al. [28] investigated the genetic development and heritability of sixteen genotypes of cabbage cultivated in Lucknow. The results showed that plant height (78.20%), equitorial length (72.70%), head polar diameter (71.60%), stalk length (71.20%), and plant spread (69.80%) had low heritabilities, while vitamin C (99.50%), days to maturity (98.90%), core length (88.20%), head weight (87.30%), yield (87.20%), leaf width (83.40%), and leaf length (83.20%) had high heritabilities (66.00 percent).

2.4 Studies Based on Phenotypic Characteristics and Growth Requirements

Among the nitrogen fertilisers examined by Kanisewsky and Rumpel [29], calcium nitrate generated the best yield of cauliflower curds. Out of the five soil types evaluated, the low moor peat and the silty clay loam produced the highest yields of cauliflower. Nitrate nitrogen levels in cauliflower leaves and curds rose linearly as a result of nitrogen fertilisation. Cultivar, soil type, nitrogen rate, and shape all had an impact on the nitrate nitrogen content of leaves and curds.

In three successive plantings (10 October, 24 November 1992, and 12 January 1993) at two in-row spacings (31 and 38 cm) with N and K factorial combinations at 98, 196, and 294 kg ha-1 under subtropical conditions, Csizinszky [30] examined the yield potential of green cauliflower of the variety "Alverda". Using a full-bed polyethylene mulch-seepage (modified furrow) irrigation system, crops were cultivated on fine sand from Eau-Gallie. The January planting produced the highest marketable yields with N at 294 kg ha-1, and 71% of the plants produced curds with a marketable size (0.34 kg) and satisfactory quality. When compared to 31 cm spacing, yields were greater with 38 cm spacing. Increasing N rates boosted yields and curd size at all three planting dates (P 0.01). Rates of potassium had no apparent impact.

Amoli et al. [31] identified the ideal planting date, plant density, and urea fertiliser levels for high production in cauliflower variety Snow crown during the growth season (2003–2004). Three planting dates—September 5, September 20, and October 5—along with three different plant row spacings—50, 60, and 70 cm—and three different urea fertiliser concentrations—0, 200, and 300 kg ha-1—were used in the main plots. The bulk of the qualities under investigation demonstrated meaningful Pearson's correlations with one another at the 1% level of probability. With coefficient correlations of 0.585 and 0.580, respectively, yield and two traits—curd diameter and leaf dry weight—were shown to have substantial positive relationships. Curd diameter

and yield also showed a strong positive association (r= 0.842).

As stated by Pandita et al. [32] increasing plant density reduces the area available for lateral growth, which causes an increase in plant height.

In Bangladesh, it is one of the most widely consumed winter vegetables. According to Din et al. [33] cauliflower does best in a mild, humid atmosphere and cannot tolerate extreme cold or high heat.

Hill [34] examined the impact of nitrogenous (N) fertiliser (0, 50, 100, 200, 300, and 400 kg N ha-1) and plant spacing (4545, 5050, 5555, and 6060 cm) on cauliflower growth and production. A better marketable yield was achieved by plants that were fertilised with 200 and 300 kg N ha-1 and placed 4545 cm apart. Although plant height was unaffected, higher nitrogen levels greatly increased plant breadth.

Rahman M, et al. [35] plant spacing is an important factor for the growth and yield of cauliflower. Amongst various spacing, 45 cm spacing proved better results in all the aspects.

Nitrogen's effects on cauliflower curd production and compactness (at optimal and limiting solutions of 6.8 and 2.6 g plant-1, respectively) were studied by Rather and Schenk in 2008. (*Brassica oleracea* var. botrytis). In contrast to an ideal N supply, bolting started four days ago with a constrained supply of N. The start of bolting was unaffected by the foliar treatment of GA3(10 mg plant) and chlorcholinchloride (100 mg plant). At optimum and inadequate N supplies, benzoylaminopurine (BA, 40-320 g plant) postponed bolting by three and four days, respectively.

Results from Chaterjee and Mahanta [36] indicated that fertiliser source and planting dates had a substantial impact on off-season cauliflower output, with planting on May 14th being the best in terms of plant growth, curd yield, and quality. The optimum nutrient source for off-season cauliflower production, according to 75% of the respondents, is inorganic fertilisers with vermicompost (5 t/ha) and biofertilizer seedling inoculation. The findings showed that planting on May 14th, along with the use of vermicompost (5 t/ha), bio fertiliser seedling inoculation, and 75 percent of the recommended inorganic fertilisers, would produce off-season cauliflower with the desired growth, yield, and quality characteristics when grown in an agricultural shade net.

According to Lavanya et al. [37], early planting (on October 1) with tighter spacing is a good treatment combination for increasing radish seed production. Therefore, the sowing date must be optimised for the development of high-quality cauliflower seeds. According to Singh et al. [38], pre-mature curd formation frequently resulted in a significant negative response from cauliflower to adverse climatic circumstances, such as excessive heat and droughts, which reduced its economic output.

According to Hossain et al. [39], a combination of 1 October planting and 60 cm 50 cm plant spacing gave the maximum seed output due to the increased number of seeds pod-1 (414.81 kg ha-1). After planting on October 10, seed output fell down regardless of plant spacing. Therefore, earlier sowing (1 October) with tighter spacing (60 cm 50 cm) will be economically advantageous for the production of cauliflower seeds in Bangladesh's northwest. Islam et al. [40] discovered that Remi had the considerably greatest curding percentage among the types, with the second planting date (30th November) having the significantly highest curding percentage (75.67%). (83.97 percent). The greatest net curd weight (620.67 g) was generated by the planting on November 15th, with White Excell achieving the highest net curd weight (820.22 g). White Excell, Remi, and Girija produced the greatest curd yields (a combined 26.39 t ha-1), respectively (15.06 t ha-1). The cauliflower varieties Girija, White Excell, Remi, Pushpa, and White Marvel were best cultivated in the Terai district of West Bengal on November 15th, with the exception of Remi.

Joshi T.N. et al. [41] discovered that taller cauliflower plants produce more cauli Joshi T.N. et al. [41] discovered that higher cauliflower plant height during their study may be related to wider plant spacing, which will only be significant up to a certain point; higher leaf counts in 52.545 cm spacing may be related to more resources being available for the leaves' growth and development. The better the exposure for photosynthesis for plants, the more space there is available. Due to competition for nutrients, sunshine, and room for optimal curd growth and development, plants spaced closer together produced poorer results. Higher mortality rates, shorter curd diameters, fewer leaves per plant, lower plant heights, and competitive conditions

might all contribute to poor yield under tight spacing [42-44]. Joshi T.N. et al. [41] discovered that increased cauliflower plant height However, Kaur M. et al. [45] discovered that spacing had no impact on curd count, curd weight, curd output, plant height, number of leaves per plant, spreading diameter, or stalk length. In the Punjabi phagwara area, two cultivars were identified as having promising yields per hectare: RIJK-du (280.10 q/ha) and Denali RZ 26-960 (280.42 q/ha. According to Kumari R. et al. [46], the sowing date, plant spacing, and their interaction impact all had a significant main effect. According to the findings, seeds sown on August 10th and transplanted at a spacing of 60 cm produced the best germination percentage, seedling length, seedling dry weight, vigour Index-I and vigour Index-II. On August 10th, when the seed was planted, the electric conductivity was at its lowest. Increased cauliflower plant height, according to Joshi T.N. et al. [41]'s research Bishop was found to be the best hybrid variety, according to Giri et al. [47], with NS 106, Titan, Artica, and Snow Mystique all being acceptable varieties for enhanced growth and greater curd output in Chitwan circumstances. Similar to this, Freedom was found as a short-lived cultivar that can lessen the impact of increased temperatures in late winter.

3. CONCLUSION

An increase in cauliflower plant height, according to Joshi T.N. et al. [41] the structure of this research investigated the genetic divergence, correlation, correlation coefficient, heritability, genetic advancement, and variability of cauliflower genotypes. It is well-liked by both rural and urban populations because to its superb flavour, but the absence of information about programme modifications makes it challenging for farmers to obtain the most significant advantage. The late-season cauliflower cultivars varied greatly in terms of key indicators of plant growth, including plant height and canopy diameter at different growth stages, curd yield at final harvest, as well as curd initiation and curd maturity. Additionally, it was shown that nitrogen fertiliser enhanced output without postponing harvest time, and improved curd quality.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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