DOI: 10.54083/ResBio/7.1.2025/16-23

Res. Bio., 2025, 7(1):16-23

Research Biotica

e-ISSN: 2582-6743

January-March, 2025

Article ID: RB220

Research Article

Optimization of Planting Time for Two Cauliflower (*Brassica oleracea* var. *botrytis* L.) Cultivars (Carotena and Valentena) under the Agro-climatic Conditions of Tripura

Debasmita Sil[1], Tridip Bhattacharjee[1*], Sayan Saha[1], Sonia Parvin[1], Debashish Sen[1], Abhinaba Das[1] and Soumitra Sankar Das[2]

[1]*College of Agriculture Tripura, Lembucherra, West Tripura, Tripura (799 210), India*
[2]*Faculty of Management and Commerce, ICFAI University Tripura, Kamalghat, Mohanpur, Tripura (799 210), India*

Corresponding Author

Tridip Bhattacharjee

: tridip4u2@gmail.com

Conflict of interests: The author has declared that no conflict of interest exists.

How to cite this article?

Sil, D., Bhattacharjee, T., Saha, S., *et al*., 2025. Optimization of Planting Time for Two Cauliflower (*Brassica oleracea* var. *botrytis* L.) Cultivars (Carotena and Valentena) under the Agro-climatic Conditions of Tripura. *Research Biotica* 7(1), 16-23. DOI: 10.54083/ResBio/7.1.2025/16-23.

Abstract

The optimization of planting time is an important agronomic practice for maximizing cauliflower productivity under varying climatic conditions. A field experiment was conducted at the Experimental Farm of the College of Agriculture, Tripura, Lembucherra, during the rabi season of 2022-2023 to determine the optimum planting time for two cauliflower cultivars, Carotena and Valentena, under the agro-climatic conditions of Tripura. The experiment was laid out in a Randomized Block Design with four planting dates, namely 14th October, 14th November, 14th December and 14th January, each replicated five times. Growth, yield and yield-attributing parameters were recorded and subjected to analysis of variance. Planting time significantly influenced the growth and yield performance of both cultivars. Among the four planting dates, transplanting on 14 November resulted in superior vegetative growth and curd development. In Carotena, the maximum plant height (49.40 cm) and highest net curd weight (0.57 kg plant^{-1}) were recorded under November planting, whereas the lowest curd weight (0.33 kg plant^{-1}) was obtained from January planting. Similarly, Valentena recorded the highest plant height (65.60 cm) and maximum net curd weight (1.00 kg plant^{-1}) when transplanted on 14 November, while January planting produced the lowest curd weight (0.25 kg plant^{-1}). The superior performance of November planting may be attributed to favourable temperature conditions during vegetative growth and curd initiation, whereas delayed planting exposed the crop to less favourable environmental conditions. The findings indicate that mid-November is the optimum planting period for successful cultivation of both Carotena and Valentena under Tripura conditions.

Keywords: Carotena, Cauliflower, Growth, Planting time, Tripura, Valentena, Yield

Introduction

Cauliflower (*Brassica oleracea* var. *botrytis*) is an economically important cole crop valued for its high nutritional content, including vitamins, minerals and antioxidants, and is widely cultivated across diverse agro-climatic regions (Refai *et al.*, 2019; Singh *et al.*, 2024). The edible portion, commonly known as the curd, consists of a compact, pre-floral apical meristem that is rich in protein, vitamin C, dietary fibre and essential minerals. Belonging to the family Brassicaceae ($2n = 2x = 18$), cauliflower is believed to have originated from the wild cabbage (*Brassica oleracea* var. *sylvestris*) and has evolved into numerous cultivar groups adapted to diverse agro-climatic conditions (Bose and Som, 1986; Nimkar and Korla, 2014). Owing to its premium quality and consumer acceptance, cauliflower has often been referred to as the "*Aristocrat of Cole Crops*". Botanically, the edible curd of cauliflower represents a compact, pre-floral fleshy apical meristem formed by the proliferation of shortened floral shoots. Under normal growth conditions, the developing curd remains enclosed by the inner leaves before exposure,

Article History

RECEIVED on 28th August 2024 RECEIVED in revised form 03rd March 2025 ACCEPTED in final form 17th March 2025

a characteristic that contributes to curd quality and market acceptability (Bose and Som, 1986; Nimkar and Korla, 2014).

In addition to improving crop productivity, modern horticultural research increasingly emphasizes enhancement of the nutritional quality of vegetables to address micronutrient deficiencies. Biofortification, achieved through plant breeding, agronomic interventions or modern biotechnological approaches, has emerged as a sustainable strategy for increasing the concentration of essential vitamins and minerals in food crops, thereby contributing to improved human nutrition and long-term food security (Bouis *et al.*, 2011; Saltzman *et al.*, 2015). Although the present investigation primarily focuses on optimizing planting time for maximizing growth and yield, improving agronomic performance remains an important prerequisite for realizing the nutritional potential of cauliflower under diverse agro-climatic conditions.

Cauliflower is highly sensitive to environmental conditions, particularly temperature, which regulates the transition from vegetative growth to curd initiation and subsequent curd development. Unlike many other vegetable crops, successful curd formation depends on exposing plants to an optimum temperature range at the appropriate physiological stage. Young plants generally exhibit vigorous vegetative growth at relatively higher temperatures, whereas curd initiation and development require comparatively cooler conditions. Deviations from the optimum temperature during these critical growth stages may result in delayed curd initiation, poor curd compactness, reduced curd size and substantial yield losses (Bose and Som, 1986; Chabok and Amoli, 2013; Rahman *et al.*, 2013). Cultivar-specific temperature requirements further influence the adaptability of cauliflower across different planting seasons. The optimum temperature requirement varies with the developmental stage and cultivar. Young plants generally grow best at approximately 23 °C, while temperatures of 17-20 °C favour subsequent vegetative growth. Curd initiation and compact curd formation occur most successfully at around 15-20 °C, although tropical cultivars may tolerate comparatively higher temperatures than temperate types (Bose and Som, 1986). Therefore, synchronization of crop growth with the prevailing thermal regime through appropriate transplanting time is essential for obtaining optimum yield and curd quality.

Based on the optimum temperature required for curd initiation and the period of maturity, cauliflower cultivars are generally classified into early, mid-early, mid-late and late groups. Early cultivars initiate curds under relatively warmer conditions (20-27 °C), whereas late cultivars require cooler temperatures (12-16 °C) for proper curd development (Thamburaj and Singh, 1998). Consequently, selection of an appropriate cultivar in combination with suitable planting time is essential for maximizing productivity under different agro-climatic conditions.

Planting time is therefore one of the most important agronomic factors determining the growth, development and productivity of cauliflower. Appropriate planting ensures that vegetative growth and curd formation coincide with favourable environmental conditions, whereas early or delayed planting may expose the crop to temperature stress during critical developmental stages. Earlier studies have demonstrated that planting date significantly influences plant growth, curd characteristics and marketable yield of cauliflower (Ara *et al.*, 2009; Rahman *et al.*, 2016; Bankar *et al.*, 2018; Sharma *et al.*, 2018). More recently, Alam *et al.* (2024) and Kumar *et al.* (2024) also reported that transplanting during the optimum climatic window substantially improved vegetative growth, curd weight and overall productivity compared with early or late planting. Similar responses have also been reported in other field crops, where timely sowing synchronized crop growth with favourable thermal conditions and enhanced productivity (Annie *et al.*, 2020; Momtaz and Khan, 2024). Collectively, these findings emphasize that optimization of planting time is essential for maximizing crop performance under specific agro-climatic conditions.

India is the second largest producer of cauliflower after China, producing approximately 162.90 million metric tonnes from 9.40 million hectares, accounting for 14.04% of global vegetable production and 15.88% of the total vegetable cultivation area worldwide (Kumar and Rohila, 2018). The crop is cultivated across a wide range of agro-climatic regions almost throughout the year with the availability of suitable cultivar groups. The crop occupies an important position among winter vegetables owing to its high market demand and profitability. Although, improved cultivars have expanded cauliflower cultivation into both traditional and non-traditional regions, their performance remains highly dependent on prevailing environmental conditions, particularly temperature and planting time.

Tripura possesses favourable agro-climatic conditions for winter vegetable cultivation; however, seasonal fluctuations in temperature and humidity often influence cauliflower growth and yield (Refai *et al.*, 2019). Under the humid subtropical climate of the state, even small variations in transplanting time may alter the temperature regime experienced during vegetative growth and curd development, thereby affecting crop performance. Despite the commercial importance of cauliflower in the region, information on the optimum planting time for recently introduced cultivars such as Carotena and Valentena under Tripura conditions remains limited. Consequently, location-specific recommendations are required to maximize productivity and provide reliable guidance to farmers.

The present investigation was therefore undertaken to evaluate the influence of different planting times on the growth and yield performance of two cauliflower cultivars, Carotena and Valentena, under the agro-climatic conditions of Tripura. The findings are expected to identify the most suitable transplanting period for achieving optimum vegetative growth, superior curd development and higher yield under the prevailing climatic conditions of the region.

Objectives of the Study:

The present investigation was undertaken with the following objectives:

1. To evaluate the effect of different planting times on the growth and yield of cauliflower (*Brassica oleracea* var. *botrytis* L.) cv. Carotena under the agro-climatic conditions of Tripura.

2. To determine the optimum planting time for cauliflower cv. Valentena for achieving superior growth, curd development and yield under Tripura conditions.

Materials and Methods

Experimental Site

The field experiment entitled "Optimization of Planting Time for Cauliflower (*Brassica oleracea* var. *botrytis* L.) Cultivars Carotena and Valentena under Tripura Agro-climatic Conditions" was conducted during the *rabi* season (October 2022 to March 2023) at the Experimental Farm of the Department of Horticulture, College of Agriculture, Tripura, Lembucherra, West Tripura, India. The experimental site is situated at 22°47´ N latitude and 89°34´ E longitude with an altitude of approximately 8 m above mean sea level.

The experiment was conducted under open-field conditions following the recommended package of practices for cauliflower cultivation in the region. The experimental field consisted of sandy loam soil having a pH of 6.5, organic carbon content of 0.59%, available nitrogen of 265.58 kg ha^{-1}, available phosphorus (P_2O_5) of 10.50 kg ha^{-1} and available potassium (K_2O) of 142.64 kg ha^{-1}. The initial physical and chemical properties of the experimental soil are presented in table 1. Okra was grown as the preceding crop before initiation of the experiment.

The region experiences a humid subtropical climate characterized by heavy rainfall during the *kharif* season (April-September) followed by comparatively cool and dry winter months that are favourable for cauliflower cultivation. The monthly meteorological conditions recorded during the experimental period are presented in table 2.

Table 1: Physical and chemical properties of the experimental soil before transplanting

Parameter	Value	Method/Remarks
Soil texture	Sandy loam	Mechanical analysis
Soil pH	6.50	1:2.5 soil : water suspension
Organic carbon (%)	0.59	Walkley and Black method
Available nitrogen (kg ha^{-1})	265.58	Alkaline KMnO4 method
Available phosphorus (kg ha^{-1})	10.50	Olsen's method
Available potassium (kg ha^{-1})	142.64	Flame photometer
Previous crop	Okra	Field history

Table 2: Monthly meteorological conditions recorded during the experimental period (October 2022-March 2023)

Month	Mean maximum temperature (°C)	Mean minimum temperature (°C)	Relative humidity (%)		Rainfall (mm)
			Max.	Min.	
October 2022	32.20	20.00	95	75	251.70
November 2022	30.90	15.10	95	59	0.00
December 2022	27.50	11.10	98	58	7.70
January 2023	25.10	09.10	97	62	0.00
February 2023	29.50	12.70	94	48	0.00
March 2023	32.20	15.60	93	51	73.50

[Source: Meteorological Observatory, College of Agriculture, Tripura / IMD Agartala]

Planting Materials and Nursery Management

Seeds of two cauliflower cultivars, Carotena and Valentena, were procured from the local market of Agartala, Tripura and were marketed by Syngenta. The seed lot possessed approximately 70% germination and 90% physical purity. To obtain seedlings for the respective transplanting schedules, seeds were sown in the nursery on 15 September, 15 October, 15 November and 15 December 2022 for the October, November, December and January transplanting treatments, respectively.

Seedlings were raised in well-prepared nursery beds measuring 3.0 m × 1.0 m using a growing medium comprising soil, farmyard manure (FYM) and vermicompost. Seeds were treated with *Trichoderma viride* prior to sowing to minimize seed- and soil-borne diseases. Immediately after sowing, the nursery beds were covered with paddy straw to conserve moisture and promote uniform seed germination. The straw mulch was removed after seed emergence. Chlorpyrifos was applied at 1 ml L^{-1} to control ants and termites in the nursery. Vermicompost and FYM were incorporated as nutrient sources and irrigation was provided at intervals of 4-5 days depending on soil moisture conditions. Healthy seedlings of approximately 25 days of age were selected for transplanting into the main field.

Figure 1: Experimental plot at College of Agriculture, Tripura

Land Preparation and Crop Management

The experimental field was prepared by two ploughings followed by harrowing and levelling to obtain a fine tilth. Farmyard manure was incorporated at the rate of 10 t ha^{-1} during final land preparation. The experimental area consisted of twenty unit plots, each measuring 4.0 m × 2.0 m. A spacing of 50 cm was maintained between adjacent plots and 75 cm between replications to facilitate intercultural operations.

Seedlings were transplanted at a spacing of 60 cm between rows and 45 cm between plants, accommodating 28 plants per plot. Irrigation was applied at weekly intervals throughout the crop growth period. Weed control was achieved through manual weeding at approximately 15-day intervals and earthing-up was carried out four times during crop growth. No mulching material was used. Neem oil at 3 ml L^{-1} was applied around the base of plants immediately after transplanting and repeated after 15 days as an organic plant protection measure.

Fertilizer Application

The recommended fertilizer dose for cauliflower comprising 120-150 kg N, 60-80 kg P_2O_5 and 60-80 kg K_2O per hectare was followed. Farmyard manure (10 t ha^{-1}), the full dose of phosphorus and potassium and half of the nitrogen were applied as basal before transplanting. The remaining nitrogen was top-dressed in two equal splits at 25-30 and 45-50 days after transplanting, followed by earthing-up and irrigation. Where required, boron was supplied as borax to minimize physiological disorders such as hollow stem.

Experimental Design and Treatments

The experiment was laid out in a Randomized Block Design (RBD) with four planting-time treatments and five replications for each cultivar. Four transplanting dates, each separated by approximately one month, were evaluated:

1. T_1: October 14th, 2022 (Early planting)
2. T_2: November 14th, 2022 (Mid-season planting)
3. T_3: December 14th, 2022 (Late planting)
4. T_4: January 14th, 2023 (Very late planting)

The net experimental area for each cultivar was approximately 160 m^2, whereas the total experimental area occupied about 218.5 m^2.

Observations Recorded

Five representative plants were randomly selected from each plot for recording observations. Growth parameters including plant height, number of leaves, leaf length, leaf breadth and plant spread were recorded at appropriate growth stages. Yield and yield-attributing characters including curd diameter, curd length, gross curd weight, net curd weight, marketable yield and total yield were recorded manually following standard horticultural procedures. Observations on days to curd initiation, days to first harvest and final harvest were also recorded.

Statistical Analysis

The recorded data were subjected to analysis of variance (ANOVA) appropriate for a Randomized Block Design as described by Fisher and Yates (1963). Statistical analyses were performed using SPSS software (Version 25) and treatment means were compared at the 5% level of significance using the Critical Difference (CD) test.

Results and Discussion

Effect of Planting Time on Growth and Yield of Cauliflower Cultivars

Data on growth, yield and yield-attributing parameters were recorded and represented in tables 3 and 4, subjected to analysis of variance (ANOVA). Planting time exerted a significant influence on the growth, yield and yield-attributing characters of both cauliflower cultivars evaluated under the agro-climatic conditions of Tripura. The observed variations among planting dates were closely associated with the prevailing meteorological conditions during the crop growth period (Table 2). The observed variations among planting dates indicate that environmental conditions prevailing during different stages of crop growth considerably affected vegetative development, curd initiation and final yield. Among the four planting dates, transplanting on 14 November (T_2) consistently produced superior growth and yield in both Carotena and Valentena, whereas delayed transplanting on 14 January (T_4) resulted in the poorest crop performance.

Growth Performance of Carotena

The growth parameters of Carotena were significantly influenced by planting time (Table 3). The tallest plants (49.40 cm) were recorded under T_2 (14 November), followed by T_1 (44.40 cm); whereas the shortest plants (34.20 cm) were observed under T_4. Similar trends were evident for total plant weight, leaf weight, leaf length, leaf breadth and plant spread, all of which attained their maximum values under November planting. The greater vegetative growth recorded during T_2 indicates that the prevailing environmental conditions were highly favourable for canopy development and biomass accumulation.

Table 3: Performance of Carotena in term of growth & yield parameter

Treatment Details	Plant Height (cm)	Total Weight (kg)	Leaf Number	Net Curd Weight (kg)	Leaf Weight (g)	Leaf Length (cm)	Leaf Breadth (cm)	Plant Length (cm)	Plant Breadth (cm)	Curd Diameter (cm)	Curd Length
T_1 (14/10/2022)	44.40	0.85	18	0.46	45.00	46.00	34.00	38.40	17.40	10.40	11.20
T_2 (14/11/2022)	49.40	1.12	15.20	0.57	53.40	50.80	41.40	44.00	17.73	14.20	14.20
T_3 (14/12/2022)	42.30	0.74	13.60	0.38	42.50	44.20	33.87	40.54	17.57	9.20	11.40
T_4 (14/01/2023)	34.20	0.49	9.60	0.33	34.80	42.20	22.80	24.20	10.00	8.40	7.60
SEM	1.24	0.06	0.64	0.03	0.83	1.28	1.37	2.19	0.69	0.49	0.42
CD at 5% level	3.83	0.19	1.96	0.08	2.56	3.94	4.21	6.74	2.12	1.50	1.30
CV	6.52	17.34	10.11	13.89	4.24	6.25	9.26	13.29	9.80	10.35	8.51

The enhanced vegetative growth under November planting may be attributed to exposure of the crop to optimum temperature conditions during the active growth phase (Table 2). Under favourable environmental conditions, photosynthetic efficiency, nutrient uptake and assimilate production are enhanced, leading to vigorous vegetative growth and greater biomass accumulation before curd initiation. Similar observations regarding the beneficial influence of optimum planting time on vegetative growth have been reported by Ara *et al.* (2009), Rahman *et al.* (2013) and Alam *et al.* (2024). Furthermore, Annie *et al.* (2020) demonstrated that timely sowing enabled crops to utilize prevailing thermal resources more efficiently, thereby promoting better growth and yield. Although their study was conducted on green gram, the findings reinforce the broader concept that synchronization of crop phenology with favourable environmental conditions is critical for achieving optimum crop performance.

In contrast, January transplanting produced significantly lower values for most growth attributes. Delayed planting exposed the crop to comparatively less favourable environmental conditions during vegetative development, thereby restricting leaf expansion, biomass accumulation and overall plant vigour. Consequently, plants failed to attain adequate vegetative growth before the onset of curd formation.

Yield Performance of Carotena

Yield and yield-attributing characters also differed significantly among planting dates. The highest net curd weight (0.57 kg plant^{-1}), total plant weight (1.12 kg plant^{-1}), curd diameter (14.20 cm) and curd length (14.20 cm) were recorded in T_2; whereas T_4 produced the lowest net curd weight (0.33 kg plant^{-1}), curd diameter (8.40 cm) and curd length (7.60 cm). The superior curd development under November planting indicates that favourable temperature conditions during curd initiation and enlargement promoted efficient partitioning of photosynthates towards sink development.

The superior curd development under November planting indicates that favourable temperature conditions during curd initiation and enlargement promoted efficient partitioning of photosynthates towards sink development. The findings corroborate those of Dutta (1999), who reported significant improvement in curd weight with optimum planting time. Similar observations have also been reported by Rahman *et al.* (2016), Sharma *et al.* (2018), Alam *et al.* (2024) and Kumar *et al.* (2024), who observed that transplanting during the optimum climatic window significantly enhanced curd development, marketable yield and overall crop productivity.

Growth Performance of Valentena

The response of Valentena to planting time followed a pattern similar to that of Carotena, although the magnitude of response was comparatively greater. Maximum plant height (65.60 cm), total plant weight (1.80 kg plant^{-1}), leaf number (20.0), plant length (58.20 cm) and plant breadth (55.80 cm) were obtained under T_2, whereas T_4 consistently recorded the lowest values for all growth parameters.

The vigorous vegetative growth observed under November planting may be attributed to favourable thermal conditions that promoted continuous leaf production, efficient photosynthesis and better nutrient utilization throughout the crop growth period. Conversely, delayed transplanting reduced the effective growing period available before curd development, thereby restricting vegetative growth and ultimately reducing yield potential.

Yield Performance of Valentena

Planting time significantly affected all major yield attributes of Valentena (Table 4). The highest net curd weight (1.00 kg

Table 4: Performance of Valentina in term of growth & yield parameter

Treatment Details	Plant Height (cm)	Total Weight (kg)	Leaf Number	Net Curd Weight (kg)	Leaf Weight (g)	Leaf Length (cm)	Leaf Breadth (cm)	Plant Length (cm)	Plant Breadth (cm)	Curd Diameter (cm)	Curd Length
T_1 (14/10/2022)	49.40	0.92	15.20	0.41	38.28	39.40	34.60	51.20	43.00	12.00	12.00
T_2 (14/11/2022)	65.60	1.80	20.00	1.00	45.51	38.20	18.13	58.20	55.80	15.00	15.40
T_3 (14/12/2022)	48.40	0.99	11.40	0.53	36.40	40.34	18.14	41.00	41.60	10.60	12.40
T_4 (14/01/2023)	41.00	0.45	5.20	0.25	25.15	26.00	9.80	27.60	28.60	8.40	8.40
SEM	2.04	0.05	0.49	0.03	2.13	2.53	0.82	0.67	1.86	0.56	0.36
CD at 5% level	6.29	0.14	1.52	0.10	6.56	7.80	2.52	2.08	5.73	1.73	1.12
CV	8.94	10.04	8.52	12.90	13.11	15.74	9.07	3.39	9.84	10.91	6.73

plant^{-1}), curd diameter (15.00 cm) and curd length (15.40 cm) were recorded under T_2, while January transplanting produced the smallest curds with a net curd weight of only 0.25 kg plant^{-1}. The substantially greater curd weight recorded in Valentena compared with Carotena suggests better varietal adaptability and greater yield potential under the prevailing climatic conditions of Tripura.

The improved yield observed under November transplanting can be attributed to synchronization of vegetative growth and curd development with the optimum temperature range (approximately 15-20 °C), which is considered ideal for curd initiation and compact head formation in cauliflower. In contrast, January transplanting exposed the crop to less favourable environmental conditions during the critical stages of curd development, resulting in smaller and lighter curds. These observations are in agreement with the findings of Dutta (1999), Rahman *et al.* (2016), Sharma *et al.* (2018), Alam *et al.* (2024) and Kumar *et al.* (2024), who likewise reported that cauliflower transplanted during the optimum planting period produced significantly higher curd weight and yield than crops established under early or delayed planting schedules.

Comparative Performance of the Two Cultivars

Although both cultivars responded similarly to different planting dates, Valentena consistently produced greater vegetative growth and higher curd weight than Carotena across all treatments. The higher plant vigour, larger canopy and superior curd development observed in Valentena indicate a comparatively better adaptation to the prevailing agro-climatic conditions of Tripura. Nevertheless, both cultivars exhibited maximum productivity when transplanted during mid-November, confirming that planting time remained the dominant factor governing crop performance irrespective of varietal differences.

Overall, the present investigation demonstrated that transplanting time was the principal factor governing vegetative growth, curd development and yield performance of both cauliflower cultivars under the agro-climatic conditions of Tripura. Transplanting during mid-November synchronized the critical growth stages with the prevailing thermal conditions, thereby promoting vigorous vegetative growth, efficient assimilate partitioning and superior curd development. In contrast, October transplanting exposed the crop to relatively higher temperatures during the early vegetative phase; whereas January transplanting shortened the effective growing period and subjected the crop to comparatively less favourable conditions during curd initiation and enlargement, resulting in reduced productivity. These findings are consistent with those of Annie *et al.* (2020), who emphasized the importance of synchronizing crop phenology with prevailing thermal resources for maximizing growth and yield, and with Alam *et al.* (2024), who reported that transplanting within the optimum climatic window significantly enhanced curd development and overall productivity. Collectively, the present results reaffirm that precise adjustment of transplanting time to the local thermal regime is fundamental for realizing the yield potential of cauliflower under the humid subtropical conditions of Tripura.

Conclusion

The present investigation demonstrated that planting time is a critical agronomic factor influencing the growth, curd development and yield of cauliflower under the agro-climatic conditions of Tripura. Significant differences were observed among the four transplanting dates, indicating that crop performance was strongly influenced by the prevailing thermal environment during the vegetative and curd development stages. Among the evaluated planting dates, transplanting on 14 November (T_2) consistently produced superior growth and yield in both cultivars. Carotena recorded the maximum plant height (49.40 cm) and net curd weight (0.57 kg plant^{-1}), while Valentena achieved the highest plant height (65.60 cm) and net curd weight (1.00 kg plant^{-1}) under this planting schedule.

The superior performance of the November transplanting may be attributed to the synchronization of vegetative growth and curd initiation with favourable environmental conditions prevailing during the winter season. Moderate temperatures during the active growth phase promoted efficient photosynthesis, better nutrient utilization and enhanced assimilate partitioning towards curd development, resulting in higher productivity. In contrast, delayed transplanting in January exposed the crop to comparatively less favourable conditions during the critical stages of growth and curd formation, leading to reduced vegetative development and lower yield. The present findings are in close agreement with those reported by Alam *et al.* (2024), emphasizing that selection of an appropriate planting window is fundamental for improving cauliflower growth, curd yield and economic productivity.

Among the two cultivars, Valentena exhibited comparatively greater vegetative growth and higher curd yield than Carotena, indicating better adaptation to the prevailing agro-climatic conditions of Tripura. Nevertheless, both cultivars responded similarly to planting time, with mid-November proving to be the optimum transplanting window. Therefore, transplanting Carotena and Valentena during the second fortnight of November is recommended for achieving optimum growth and maximum yield under the agro-climatic conditions of Tripura. Adoption of this planting schedule is expected to improve crop productivity and enhance economic returns for cauliflower growers in the region.

The present investigation was conducted at a single location during one cropping season, and quality attributes and economic analyses were not included. Therefore, further multi-location and multi-season studies involving additional cultivars, weather-based crop modelling, quality assessment and economic evaluation are recommended to develop more robust and location-specific planting recommendations for cauliflower cultivation in Tripura and the North-Eastern region of India.

Ethical Statement

The authors declare that no generative artificial intelligence tools were used in drafting or preparing this manuscript. The manuscript was written, interpreted and revised solely by the authors, who take full responsibility for its content.

References

Annie, M., Goswami, B., Dutta, P., Singh, G., Paschapur, N.S., Rajkhowa, S., 2020. Effect of sowing dates on heat requirements of different cultivars of green gram (*Vigna radiata* L.). *Journal of Agricultural Physics* 20(1), 120-124.

Ara, N., Kaisar, M.O., Khalequzzaman, K.M., Kohinoor, H., Ahamed, K.U., 2009. Effect of different dates of planting and lines on the growth, yield and yield contributing characteristics of cauliflower. *Journal of Soil and Nature* 3(1), 16-19.

Alam, N., Chatterjee, R., Kumar, R., Biswal, S., 2024. Growth, yield and economics of rainy season cauliflower as influenced by the transplanting dates and varieties. Vegetable Science 51(1), 136-141. DOI: https://doi.org/10.61180/vegsci.2024.v51.i1.18.

Bankar, D.S., Pawar, S.B., Kadam, Y.E., 2018. Thermal utilization and heat use efficiency of green gram varieties under different sowing dates. *International Journal of Current Microbiology and Applied Sciences* 7(10), 2270-2276. DOI: https://doi.org/10.20546/ijcmas.2018.710.262.

Bose, T.K., Som, M.G., 1986. *Vegetable Crops in India*. Nayaprakash, Bidhan Sarani, Calcutta. p. 775.

Bouis, H.E., Hotz, C., McClafferty, B., Meenakshi, J.V., Pfeiffer, W.H., 2011. Biofortification: A new tool to reduce micronutrient malnutrition. *Food and Nutrition Bulletin* 32(1 suppl1), S31-S40. DOI: https://doi.org/10.1177/15648265110321S105.

Chabok, K., Amoli, N., 2013. Suitable varieties of cauliflower as second cropping after harvesting of rice in Mazandaran Province. *Research Achievements for Field and Horticulture Crops* 2(3), 221-228. DOI: https://doi.org/10.22092/rafhc.2013.100146.

Dutta. J.P., 1999. Effect of dates of planting on the performance of different groups of cauliflower under the condition of North Bank Plains Zone of Assam. *.Journal of the Agricultural Science Society of North East India* 12(1), 38-42.

Fisher, R.A., Yates, F., 1963. *Statistical Tables for Biological, Agricultural and Medical Research*, 6th Edition. Oliver & Boyd, Edinburgh and London. p. 146.

Kumar, A., Rohila, A.K., 2018. Profitability and marketing behavior of cauliflower crop in Sonipat district of Haryana. *Indian Journal of Agricultural Sciences* 88(9), 1419-1428.

Kumar, A., Fatmi, U., Deepanshu., 2024. Effect of different planting dates on growth, yield and quality of cauliflower (*Brassica oleracea* var. *botrytis* L.) hybrids. *International Journal of Research in Agronomy* 7(9), 351-355. DOI: https://doi.org/10.33545/2618060X.2024.v7.i9e.1532.

Momtaz, M., Khan, M.S., 2024. Analysis of Chlorpyrifos pesticide residue in locally grown cauliflower, cabbage and eggplant using Gas Chromatography-Mass Spectrometry (GC-MS) Technique: A Bangladesh perspective. *Foods* 13(11), 1780. DOI: https://doi.org/10.3390/foods13111780.

Nimkar, S.A., Korla, B.N., 2014. Studies on comparison of biparental and F4 progenies in late cauliflower (*Brassica oleracea* var *botrytis* L). *International Journal of Farm Sciences* 4(1), 27-34.

Rahman, H.U., Hadley, P., Pearson, S., Khan, M.J., 2013. Response of cauliflower (*Brassica oleracea* var *botrytis*) growth and development after curd initiation to different day and night temperatures. *Pakistan Journal of Botany* 45(2), 411-420.

Rahman, M.A., Imran, M., Ikrum, M., Rahman, M.H., Rabbani, M.G., 2016. Effects of planting date and growth hormone on growth and yield of cauliflower. *Journal of Environmental Science and Natural Resources* 9(2), 143-150. DOI: https://doi.org/10.3329/jesnr.v9i2.32185.

Refai, E.F.S., Abbas, H.S., Mohamed, M.F., 2019. Assessment of variability and response to selection for earliness and curd size in cauliflower cv. soultani under Assiut environmental conditions. *Egyptian Journal of Horticulture* 46(1), 107-116.

Saltzman, A., Andersson, M.S., Asare-Marfo, D., Lividini, K., De Moura, F.F., Moursi, M., Oparinde, A., Taleon, V., 2015. *Biofortification Techniques to Improve Food Security*. Reference Module in Food Sciences. Elsevier. pp. 1-9.

Sharma, S., Singh, Y., Sharma, S., Vishalakshi., Sekhon, B.S., 2018. Studies on mean performance for yield and its contributing traits in cauliflower (*Brassica oleracea* L. var. *botrytis* L.) under mid hill conditions of North-Western Himalayas. *International Journal of Current Microbiology and Applied Sciences* 7(2), 3288-3296. DOI: https://doi.org/10.20546/ijcmas.2018.702.395.

Singh, R., Bisen, K., Pal, V., Singh, A.K., Singh, B.P., 2024. Effects of bio-inoculation on the growth of cabbage as well as the disease progression of Alternaria leaf spot. *International Journal of Environment and Climate Change* 14(2), 867-871. DOI: https://doi.org/10.9734/ijecc/2024/v14i24000.

Thamburaj, S., Sing, N., 1998. Cauliflower: In: *Vegetables, Tubercrops and Spices*. Indian Council of Agricultural Research, New Delhi. pp. 77-97.