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Effect of Date of Sowing on Growth, Yield and Economics of Early Cauliflower-marigold Intercropping System

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ABSTRACT

Background: Production of cauliflowers early in the season is always a challenging task for the farmers of plains due to prevalence of extreme temperature and/or heavy rainfall. Hence, early cauliflowers are predominantly cultivated in hilly tracts of India. Here, in this experiment, an attempt had been made to find out the optimum sowing time of early cauliflowers based on the growth and yield performances under cauliflower-marigold intercropping system in *terai* belt of West Bengal as offseason farming.

Methods: Four early cauliflower F_1 hybrids (BN 50, Monsoon Queen, White Pearl and White Treasure) were sown starting from third week of April to first week of June at weekly interval and transplanted in a low-cost poly house using marigold (Pusa Narangi) as an intercrop with three replications. The entire experiment was laid out in Factorial Randomized Block Design (FRBD) with seven dates of sowing and four early cauliflower varieties. The experiment was conducted during 2022 and 2023 growing season. The results were summarized based on the pooled analysis of both the years.

Result: The pooled analysis have indicated that **t**he cauliflower seeds sown during second week of May resulted maximum plant height, plant spread, number of leaves per plant, curd diameter, stalk length, gross plant weight, net curd weight, curd yield per plot and curd yield per hectare. However, the minimum days required to initiate the curd formation and the same for curd maturity were found in first week of May sown cauliflower plants. The overall performance of cauliflower varieties was found in following order Monsoon Queen > White Pearl >White Treasure > BN 50. The marigold plant transplanted during first week of June resulted best performance regarding growth, flowering and yield of flowers. The benefit: cost ratio of second week of May sown cauliflowers-marigold intercropping varied between 2.72 to 2.90.

Key words: Benefit: Cost ratio, Cauliflower, Intercropping, Marigold, Offseason.

INTRODUCTION

Cauliflower is one of the most popular and nutritious winter vegetable grown in India (Kaur *et al*., 2023). It is rich in minerals like Ca, Mg, P and K and Vitamin C and B3. Hundred gram of cauliflower provides 21 kcal energy in our body (Butnariu and Butu, 2014). Now-a-days, cauliflowers are available almost round the yearin the markets. This is possible due to presence of a wide range of varieties that aresuitable for cultivation in early season as offseason farming. Early cauliflower fetches premium price in the market (Pandey *et al.*, 2021). The curd initiation in early cauliflowers occurs between 20-25°C atmospheric temperature (Giri *et al*., 2023). Therefore, the sowing of early season cauliflowers is required to be started when atmospheric temperature rises at the end of winter (Pandey *et al.*, 2021). However, presence of extreme heat and/or occurrence of heavy rainfall limit the cultivation of early cauliflower in the plains. Since, high temperature is sensitive and heavy rainfall is detrimental for cauliflower production (Poudel *et al*., 2017). Therefore, the optimum growing condition for cultivation of early cauliflower prevails only in lower to mid-hill parts of India (Bijalwan *et al*., 2024). Hence, till date, offseason cultivation of cauliflower during July to November is restricted only in the hilly parts of India (Shruhty, 2018; Bisht, 2022). Despite having several challenges, the farmers of foothill areas (*terai* belt) are very much interested to cultivate the early cauliflowers for gaining higher income. The atmospheric temperature of foot hill areas (*terai* belts) also remains favourable for growth and development of cauliflower to an extended period of time at the end of winter (Chatterjee and Mahanta, 2013). Introduction of off-season cauliflower also helps a farmer to establish a diversified cropping pattern in their landholdings.

However, risk factors are always associated with offseason vegetable production (Krishna *et al*., 2024). Intercropping is one of the best possible solutions to

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minimize the risk of crop failure. Intercropping helps to stabilize the yield and also minimizes the soil erosion (Mitra *et al*., 2021). Additionally, intercropping has better resource useefficiency as compared to monocropping (Mondal *et al*., 2018). Marigold is reported to be one of the ideal intercrop for the cauliflower (Ojha and Singh, 2003). Since, marigold can be cultivated throughout the year and it is one of the most popular loose flower grown in India (Kumar *et al*., 2019). Additionally, cultivation of marigold as an intercrop reduces the risk of pest attack in main crop (Mrnka *et al*., 2023). Further, there is a constant demand of marigold remains in the market throughout the year. Keeping this great possibility of cauliflower production commercially in *terai* belt during early in the season, this experiment was undertaken to find out the optimum time of sowing for the production of early cauliflowers under cauliflower-marigold intercropping system. The economics of the production is also worked out.

MATERIALS AND METHODS

The present investigation was carried out at Research Farm, Regional Research Station (*terai* zone), Uttar Banga Krishi Viswavidyalaya, Pundibari during 2022 and 2023 growing season. Four early cauliflower F_1 hybrids [BN 50 (V_1), Monsoon Queen (V_2), White Pearl (V_3) and White Treasure (V_4)] and marigold (Pusa Narangi) were sown starting from third week of April to first week of June at weekly interval in portrays. Thus, there were total seven weeks of sowing *viz*. S_1 = Third week of April, S_2 = Fourth week of April, S_3 = First week of May, S_4 = Second week of May, S_5 = Third week of May, S_6 = Fourth week of May and S_7= First week of June. The cauliflower seedlings were transplanted at four leaf stage in a low-cost poly house [made of bamboo poles and frames with two-layer rooftop (upper layer 250 µ thickness transparent polythene sheet to avoid the impact of rain droplets and inner layer consists of 50.0% transmittance shade net and the side coverings with only 50.0% transmittance shade net)] at a spacing of 50 cm (P-P) × 1.0 m (R-R) in 2.0 m × 4.0 m = 8.0 m^2 bed. The high row-row distance was maintained for cauliflower to accommodate the intercrop *i.e.,* marigold plants. The marigold plants were also transplanted in the middle of cauliflower rows at spacing of 50 cm (P-P) × 1.0 m (R-R). Thus, in each 8.0 m^2 bed, there were 16 cauliflower plants (in four rows) and 12 marigold plants (in three rows). Before transplanting, the polyhouse soil was well fertilized with 15.0 t ha^{-1} FYM and NPK @ 100:60:80 kg ha^{-1}. All the recommended crop cultivation practices were followed time-to-time for both the crops during the investigation. Pinching operation was performed twice in marigold at 45 and 60 DAT (days after transplanting) to encourage more flowering. The growth and ancillary observations of cauliflower were recorded from five randomly selected plants planted in center two rows consisting of eight plants following standard procedures. The whole experiment was replicated in thrice. The experimental results were described based on the pooled analysis from data recorded in both the years. The observations on cauliflower were analyzed following Factorial Randomized Block Design (Factor 1: 7 sowing weeks: Factor 2: 4 varieties) and the observations on marigold were analyzed following randomized block design (Snedecor and Cochran, 1967). Cost of cauliflower cultivation is also calculated using cost concepts given by the expert committee (GoI 1980). The grossincome was calculated on the basis of curd (cauliflower) and flower (marigold) yield under 1.0 ha land area (The per plot yield was converted in one hectare), considering the selling price of cauliflowers (Rs.40.00 kg^{-1}) and marigold (Rs. 15.00 kg^{-1}) at farm level during harvesting seasons through rigorous survey of farmers field. Thebenefit cost ratio (BCR) was calculated using the following formula:

$$BCR = \frac{\text{Gross income (Rs/ha)}}{\text{Total cost of cultivation (Rs/ha)}}$$

RESULTS AND DISCUSSION

Performance of cauliflower under cauliflower-marigold intercropping system

The pooled results presented in Table 1 depicted that sowing dates significantly influenced the plant growth characteristics of cauliflower varieties. The cauliflower varieties sown during second week of May had resulted maximum height (45.48 cm) of the plant followed by plants sown during first week of May and third week of May. The lowest value for plant height was recorded in first week of June sown plants (30.17 cm). The cauliflower variety Monsoon Queen recorded maximum plant height (38.82 cm) followed by White Pearl, BN 50 and White Treasure. The combined effect of sowing dates and varieties on plant height revealed significant effect. The cauliflower variety Monsoon Queen sown during second week of May recorded the maximum plant height (47.40 cm). The results also revealed the significant effect of sowing dates on plant spread of cauliflower varieties. The maximum plant spread of 35.95 cm had been recorded in the plants sown during second week of May. The plants sown during first week of June registered lowest values of plant spread (22.92 cm). This might be due to the congenial growing condition prevailing during the month of May onwards for growth and development of early cauliflower, which promoted more vegetative growth in second week of May sown plants. The May sown plants were transplanted in polyhouse in the month of June. Similar result was also reported in early cauliflower variety Pusa Himjyoti (Thakur, 2015). Among the four cauliflower varieties, significantly higher value of plant spread (31.04 cm) was recorded in Monsoon Queen. Significant interaction effect of sowing dates and varieties was also observed for plant spread. The maximum plant spread (36.83 cm) was noted in second week of May sown plant in the variety Monsoon Queen.The results also revealed significant effect of sowing dates on number of

Table 1: Effect of sowing dates on plant growth and curd parameters of cauliflower under cauliflower-marigold intercropping system.

Date of sowing	Plant height (cm)	Plant spread (cm)	Leaves Plant[1]	Gross plant weight (kg)	Curd Initiation (DAS)	Curd maturity (DAS)	Curd diameter (cm)	Stalk length (cm)	Net curd weight (g)
S_1	31.01	23.50	7.02	1.10	51.96	65.23	8.85	1.34	335.21
S_2	36.67	29.79	8.65	1.18	48.05	62.84	10.39	2.02	348.26
S_3	43.38	33.60	10.23	1.27	47.09	60.97	11.21	2.14	369.04
S_4	45.48	35.94	10.85	1.34	48.82	63.06	11.83	2.38	396.48
S_5	40.58	32.88	10.35	1.25	49.78	64.98	10.30	2.26	377.42
S_6	35.88	28.23	9.45	1.18	50.23	66.15	9.03	1.82	358.79
S_7	30.17	22.92	8.63	1.08	52.51	66.61	8.30	1.44	333.75
SEm±	0.44	0.42	0.31	0.02	0.31	0.49	0.28	0.09	4.74
Variety									
V_1	37.67	30.11	8.34	1.18	50.06	64.57	9.89	1.85	321.83
V_2	38.82	31.04	11.51	1.26	51.53	68.24	10.64	2.15	395.45
V_3	38.06	29.29	9.32	1.23	47.84	61.60	9.94	2.04	374.61
V_4	35.82	27.77	8.07	1.12	49.67	62.64	9.46	1.62	347.50
SEm±	0.33	0.32	0.24	0.01	0.23	0.37	0.21	0.07	3.59
Date of Sowing × Variety									
S_1V_1	30.67	25.67	7.43	1.05	51.53	66.23	9.25	1.81	314.33
S_2V_1	36.83	32.83	8.40	1.20	48.00	62.07	11.00	1.83	274.67
S_3V_1	42.17	35.75	9.47	1.28	46.60	59.90	11.83	1.97	321.33
S_4V_1	44.17	35.25	9.33	1.33	49.83	63.33	12.09	2.14	382.00
S_5V_1	41.17	32.33	8.83	1.22	50.63	65.67	9.17	2.22	370.17
S_6V_1	36.58	26.17	8.00	1.15	51.47	66.50	8.25	1.47	338.33
S_7V_1	32.17	22.75	6.92	1.03	52.37	68.27	7.67	1.53	252.00
S_1V_2	34.00	27.00	8.40	1.12	53.20	69.23	9.07	1.17	355.83
S_2V_2	39.83	31.50	10.43	1.18	49.00	66.33	10.01	2.61	400.00
S_3V_2	45.53	34.58	11.90	1.37	49.17	62.80	11.91	2.30	409.50
S_4V_2	47.40	36.83	13.50	1.44	51.43	66.93	12.19	2.89	413.33
S_5V_2	39.73	33.00	12.93	1.31	53.18	70.60	12.07	2.64	405.67
S_6V_2	35.50	29.58	12.20	1.25	50.10	70.08	10.00	2.00	397.50
S_7V_2	29.75	24.75	11.23	1.18	54.63	71.70	9.24	1.43	386.33
S_1V_3	31.17	21.83	6.07	1.19	50.27	61.80	9.42	1.19	341.67
S_2V_3	36.00	26.33	8.67	1.23	47.00	60.90	10.25	1.98	386.69
S_3V_3	44.33	31.00	10.90	1.27	45.80	59.67	10.53	2.52	390.50
S_4V_3	46.67	37.00	11.40	1.38	45.90	60.40	11.83	2.60	403.92
S_5V_3	41.58	35.17	10.70	1.30	46.20	60.30	10.18	2.44	380.17
S_6V_3	34.92	30.33	9.23	1.19	49.47	64.13	9.12	2.07	359.33
S_7V_3	31.75	23.33	8.27	1.08	50.27	64.00	8.26	1.45	360.00
S_1V_4	28.22	19.50	6.17	1.03	52.83	63.63	7.65	1.19	329.00
S_2V_4	34.00	28.50	7.10	1.11	48.20	62.07	11.18	1.66	331.67
S_3V_4	41.50	33.08	8.63	1.15	46.77	61.50	10.32	1.78	354.83
S_4V_4	43.67	34.67	9.17	1.21	48.13	61.57	10.55	1.91	386.67
S_5V_4	39.83	31.00	8.93	1.18	49.10	63.33	9.78	1.75	353.67
S_6V_4	36.50	26.83	8.37	1.12	49.87	63.90	8.73	1.75	340.00
S_7V_4	27.00	20.83	8.10	1.02	52.77	62.47	8.03	1.33	336.67
SEm±	0.89	0.84	0.63	0.03	0.62	0.99	0.57	0.18	9.49
$LSD_{(0.05)}$									
S	1.24	1.18	0.88	0.05	0.86	1.38	0.79	0.25	13.27
V	0.94	0.89	0.67	0.03	0.65	1.04	0.60	0.19	10.03
S × V	2.48	2.36	NS	NS	1.73	2.76	NS	0.50	26.54

leaves of the plant (Table 1). The highest number of leaves (11.57) had been recorded for second week of May sown plants. Cauliflower sown during the month of May produced maximum number of leaves was also reported from plains of Bangladesh (Ara *et al.*, 2009). The results are also in the line of the findings of Halim *et al.* (1999). The cauliflower variety Monsoon Queen recorded the highest values for number of leaves (11.51) as compared to the other varieties. Significant interaction effect of sowing dates and variety was recorded for number of leaves, where higher value for number of leaves (13.50) was recorded for second week of May sown plant in variety Monsoon Queen (Table 1). The genotypic differences existed within the early cauliflower varieties and that might be responsible for variation in plant growth characteristics (Sandhu *et al*., 2024).

Main and interaction effect of sowing dates as wellas varieties on curd parameters were studied (Table 1). There was a significant main and interaction effect of sowing dates and varieties recorded on days taken to curd initiation and curd maturity of cauliflower. The plants sown during first week of May registered minimum days required to curd initiation (47.09 DAS) and curd maturity (60.97 DAS). While, the maximum days taken to curd initiation and curd maturity was recorded from first week of June sown plants. The cauliflower variety White Pearl took minimum days to curd initiation (47.84 DAS) as well as curd maturity (61.60 DAS). The results also revealed the significant effect of sowing dates on curd initiation and maturity of cauliflowers. The cauliflower variety White Pearl when sown during first week of May recorded minimum days to curd initiation (45.80 DAS) and curd maturity (59.67 DAS). The results are in accordance with the finding of Chatterjee and Mahanta (2013). The yield attributing parameters like curd diameter, stalk length, gross plant weight and net curd weight of cauliflower were significantly affected by the sowing dates and varieties. The plants sown during second week of May had resulted curd with maximum diameter (11.83 cm), stalk length (2.38 cm), gross plant weight (1.34 kg) and net curd weight (396.48 g). The May sown cauliflower plant might undergone through a favourable atmospheric condition under shade net condition during the entire growth and development process and resulted maximum yield during May sown cauliflowers. While, the raising of atmospheric temperature from end of May might had a negative impact on plant growth and development and that might be responsible for poor yield in June sown cauliflowers. Cauliflower is known as highly thermo-sensitive cole crop (Singh *et al*., 2018). The vegetative and curd development phases significantly influenced by variations in atmospheric temperature (Rahman *et al*., 2013). The ideal time for production of early cauliflower in *terai* belt is reported to be in the month of May (Chatterjee and Mahanta (2013). These results are also in close conformity with the findings of Singh *et al.* (2015) and Buragohain *et al*. (2024) on early cauliflower. All these parameters except stalk length were registered lowest in the plants sown during first week of June. The cauliflower variety Monsoon Queen performed best regarding curd diameter (10.64 cm), stalk length (2.15 cm), gross plant weight (1.26 kg) and net curd weight (395.45 g). Significant interaction effects of sowing dates and variety were also found for stalk length, gross plant weight and net curd weight. While, interaction between sowing dates and variety failed to influence any significant effect on curd diameter (Table 1).

The highest curd yield (6.34 kgplot-1;7.93 tha^{-1}) was recorded from the plants sown during second week of May (Fig 1A) followed by the plants sown inthird week of May (6.04 kg plot^{-1}; 7.55 tha^{-1}). The lowest yield of curds was noted in plants sown during first week of June. Utilization of significant land area by the intercrop marigold might be responsible for a lower unit yield of cauliflower as compared to cauliflower monocropping.The results are in accordance with the findings of Agrawal *et al*. (2011). The variety Monsoon Queen exhibited the highest curd yield (6.33 kg plot^{-1}; 7.91 t ha^{-1}) followed by White Pearl (Fig 2B). The interaction effect of curd yield was also recorded to be significant and found that the variety Monsoon Queen sown during second week of May resulted the highest curd yield (6.61 kg plot^{-1}; 8.27 t ha^{-1}) (Table 2). A high degree of variations on yield characteristics in early cauliflower varieties is also reported earlier (Sandhu *et al*., 2024).

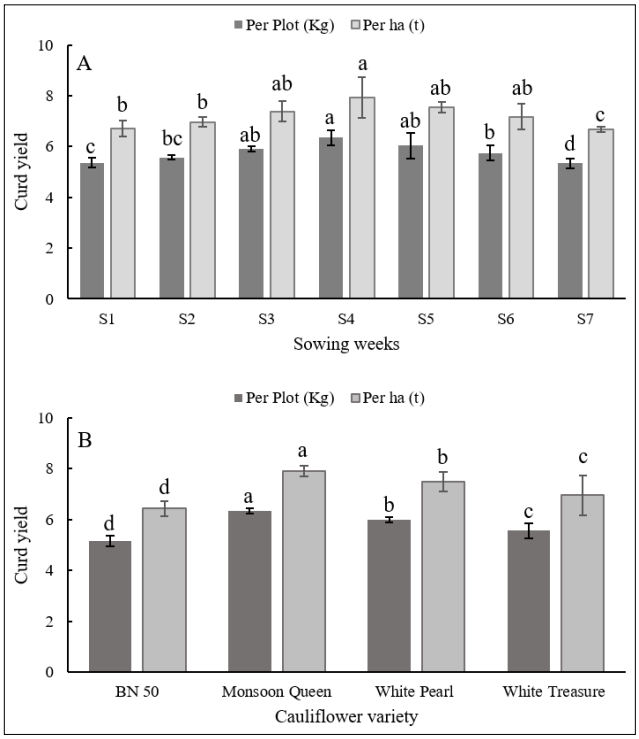

Fig 1: Main effect of sowing dates (A) and variety (B) on yield of cauliflower under cauliflower-marigold intercropping system. The vertical bar indicating the standard error (n=3) followed by the same letter are not significant to each other.

Performance of marigold under cauliflower-marigold intercropping system

The pooled data presented in Table 3 indicated that the sowing dates significantly affected the plant growth and yield of marigold cv. Pusa Narangi. The first week of June sown marigold exhibited maximum height (59.67 cm), spread (46.83 cm) and branch plant^{-1} (25.0). Similar trend was also noted for yield parameters of marigold. The maximum flower diameter (5.08 cm), flower plant^{-1} (35.33), flower yield (404.33 g plant^{-1}; 39.81 q ha^{-1}) were registered in the plants sown during first week of June. All the parameters related to growth and yield of marigold were recorded minimum in second week of April sown plants. The second week of May sown marigold yielded 34.04 q ha^{-1} flowers. Marigold can be cultivated throughout the year (Kumar *et al*., 2019). In this experiment, the marigold bloomed with early-cauliflower intercropping during summer to rainy season. The results are in agreement with the findings of Kumar and Kumar (2017) and Kumar *et al*. (2012) in summer and rainy season marigold cv. Pusa Narangi, respectively.

Table 2: Interaction effect of sowing dates and cauliflower on yield of cauliflower under cauliflower-marigold intercropping system.

Date of sowing × variety	Curd yield plot^{-1} (kg)	Curd yield ha^{-1}(t)
S_1V_1	5.03	6.29
S_2V_1	4.39	5.49
S_3V_1	5.14	6.43
S_4V_1	6.11	7.64
S_5V_1	5.92	7.40
S_6V_1	5.41	6.77
S_7V_1	4.03	5.04
S_1V_2	5.69	7.12
S_2V_2	6.40	8.00
S_3V_2	6.55	8.19
S_4V_2	6.61	8.27
S_5V_2	6.49	8.11
S_6V_2	6.36	7.95
S_7V_2	6.18	7.73
S_1V_3	5.47	6.83
S_2V_3	6.19	7.73
S_3V_3	6.25	7.81
S_4V_3	6.46	8.08
S_5V_3	6.08	7.60
S_6V_3	5.75	7.19
S_7V_3	5.76	7.20
S_1V_4	5.26	6.58
S_2V_4	5.31	6.63
S_3V_4	5.68	7.10
S_4V_4	6.19	7.73
S_5V_4	5.66	7.07
S_6V_4	5.44	6.80
S_7V_4	5.39	6.73
SEm±	0.09	0.24
$LSD_{(0.05)}$	0.27	0.70

Economics of cauliflower-marigold intercropping system

The economics cauliflower-marigold intercropping system was calculated only for the second week of May sown cauliflower (Table 4). Since, this period was found to be the best for sowing of early season cauliflower in this *terai* belt of West Bengal. The production cost of early cauliflower varied between Rs. 92942.00-92359.00/-. Similar production cost of cauliflower required in a medium to marginal farmis also reported by Kumari *et al*. (2021). Rupees 38042.00/- was required for theproduction of marigold. The amount spent for cultivation of marigold is following the similar trend as reported by Majumder *et al.* (2025). The total cost of production (cauliflowerand marigold) varied from Rs. 130984.00 to 130401.00/-. The total gross income of the early cauliflower-marigold intercropping was calculated as Rs. 381860.00 to 356660.00 in different cultivars of cauliflower. The net return of this intercropping system was near about double from production cost. The benefit: cost ratio of the early cauliflower-marigold intercropping system varied between 2.90-2.72. The results are inconformity with the economic analysis of cauliflower-marigold intercropping system as reported by Ojha and Singh (2003) and Mondal *et al*. (2018) in different parts of India.

Table 3: Effect of sowing dates on plant growth, flowering and yield of marigold var. Pusa Narangi.

Date of sowing	Plant height (cm)	Plant spread (cm)	Branch plant^{-1}	Flowers plant^{-1}	Flower diameter (cm)	Flower yield		
						Plant^{-1}(g)	Plot^{-1}(kg)	ha^{-1}(q)
S_1	48.00	35.33	16.33	26.00	4.21	291.67	2.27	28.33
S_2	50.33	36.50	17.33	29.00	4.37	308.67	2.41	30.08
S_3	51.00	40.67	19.17	29.83	4.76	321.00	2.61	32.65
S_4	54.00	43.50	20.67	31.50	4.85	336.17	2.72	34.04
S_5	54.33	43.33	22.50	33.17	4.90	355.67	2.83	35.40
S_6	57.00	43.83	23.50	34.67	5.01	378.83	3.05	38.13
S_7	59.67	46.83	25.00	35.33	5.08	404.33	3.19	39.81
SEm±	1.39	0.90	0.77	0.76	0.07	5.53	0.05	0.66
$LSD_{(0.05)}$	4.03	2.61	2.29	2.21	0.20	15.97	0.15	1.91

Table 4: Production economics of early cauliflower-marigold intercropping system from second week of May sown cauliflower and marigold in 1.0 ha land area.

Cauliflower variety	Cost of cultivation (Rs.)			Yield (Second week of may)		Gross income (Rs)		Total Gross Income (Rs.)	Net Income (Rs.)	Return per rupee
	Cauliflower	Marigold	Total	Cauliflower (t/ha)	Marigold (q/ha)	Cauliflower	Marigold			
BN 50	92942.00	38042.00	130984.00	7.64	34.04	305600.00	51060.00	356660.00	225676.00	2.72
Monsoon Queen	93605.00	38042.00	131647.00	8.27	34.04	330800.00	51060.00	381860.00	250213.00	2.90
White Pearl	92359.00	38042.00	130401.00	8.08	34.04	323200.00	51060.00	374260.00	243859.00	2.87
White Treasure	92478.00	38042.00	130520.00	7.73	34.04	309200.00	51060.00	360260.00	229740.00	2.76

CONCLUSION

Cultivation of vegetable crops out of their normal growing season is always a profitable venture. Since, the demand of that particular vegetable in mark*et al*ways remains high and the produce are sold at higher price. Further, intercropping of main crop with another short duration, high value crop also reduces risk and adds some additional profit. Farming of early season cauliflower with minimum modification (like in low-cost protected structure) in *terai* belt has a very high prospect. This study finds out a better innovative option for the vegetable growers of *terai* belts in West Bengal to cultivate early cauliflower along with marigold in a low-cost protected structure during summer to rainy season for gaining higher income. This experiment also reports the best sowing time of early season cauliflower in *terai* belt of West Bengal is the second week of May.

Conflict of interest

All authors declared that their is no conflict of interest.

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