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INFLUENCE OF HARDENING OFF PERIOD AND TEMPERATURE ON CAULIFLOWER YIELD

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Abstract

Cauliflower (*Brassica oleracea* L. var. *Botrytis*, family - Brassicaceae), an important winter vegetable of India, is quite cold resistant and require a cold temperature regime for flowering. The tightly packed, creamy white flower buds (shortened single inflorescence) attached on a fleshy stalk known as head or curd is the edible and consequently marketable part. Curd formation is very sensitive process influenced by many factors. In this investigation a detail study was done using both greenhouse and field transplants to assess the influence of hardening off period on yield and a general study was made of temperature effect on curd formation for four consecutive cultivation seasons in two particular areas of West Bengal plain. Observations suggested that nine to twelve days hardening off period is beneficial for best quality curd and continuous extreme cold or high temperature or fluctuating temperature leads to different curd disorders. Results obtained were critically discussed. However, extensive field trials are needed to ensure maximally profitable cultivation of cauliflower.

Key words: Cauliflower, curd, transplants, hardening off, temperature.

Introduction

Cauliflower (*Brassica oleracea* L. var. *Botrytis*, family - Brassicaceae) is one of the most important winter vegetables of India, comprising of 4.694 M mt yield per year. It belongs to a large group of plants known as Cole crops. It is quite cold resistant and thus are well adapted to cool season and like other Cole crops require a cold temperature regime for flowering. The tightly packed, creamy white flower buds (shortened single inflorescence) attached on a fleshy stalk known as head or curd is the edible and consequently marketable part. Usual practice of cauliflower cultivation is by transplantation method. Slight hardening off (a process of acclimatization) is required before planting. Although some reports are there about temperature influence, but detailed reports about hardening off are really lacking. In this investigation a detail study was done to assess the influence of hardening off period and temperature on yield.

Materials and Methods

Pelleting seeds were germinated both in greenhouse using plastic trays and in direct field in a specially produced (soil level slightly raised in comparison to normal field and having slopes so that water cannot logged) plot, starting from the same date. Temperature in greenhouse is maintained almost in 26°C for the first 7 days and then in 16°C till setting the transplants outside. In a separate study it was determined that 4-5 weeks old transplants give the best quality curd. So, 8 (each having 50) sets of 4 weeks old greenhouse transplants that experienced 0, 3, 6, 9, 12, 15, 18 and 21 days hardening off (setting the trays with seedlings from greenhouse to outside in the shade and gradual and controlled exposure to sunlight as well as experiencing transplants to external temperature) respectively were grown (keeping the space - 20 inch between plants and 30 inch between rows and 0.8 inch depth) in separate plots in a field of Krishnagar (latitude- 23º40' N, longitude - 88º50' E, altitude - 15M, average annual rain fall - 1385.3 mm, mainly deep loamy soils to partly deep clayey loamy soil; Nadia district, West Bengal) and in Beldanga (latitude - 23º93' N, longitude - 88º25' E, altitude - 20M, average annual rain fall - 1400 mm, mainly alluvial light textured soil; Murshidabad district, West Bengal). In Beldanga sowing was done at next day of Krishnagar. Eight sets of field transplants of the same age (4 weeks plus 0, 3, 6, 9, 12, 15, 18 and 21 days

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respectively) like greenhouse transplants were also grown in the same field maintaining the same spacing, depth and same sowing date pattern like that of greenhouse transplants. Design of the plot was made in a way so that transplants of same age from both greenhouse and direct field can be grown in two different side by side plots. After 30 and 60 days from the first transplant sowing date first and second measurements of average curd diameter of the respective 2 plots (transplants of 4 weeks and 0 days of both greenhouse and field) were taken respectively and likewise keeping a gap of 3 days each for rest of the respective plots curd measurements were done.

In a separate field of same area 3 sets (each having 100) of greenhouse transplants were grown for a general study of temperature effect on curd formation.

Water supply and fertilizer application were done as per usual practice. All the observations were made for two consecutive years (2017 and 2018, covering two seasons in each year) with same methods and plot design.

Results and Discussion

From the observations it was clear that for greenhouse transplants (Fig. 2a), both 9 and 12 days hardening off period resulted in best curd (Fig. 2b) yield. Zero to 3 days and 6 days hardening off period leads to small and average quality curd respectively, but both 18 and 21 days hardened greenhouse transplants and field transplants of same age leads (Table 1) to buttoned (miniature curd of 2.5 to 6 cm in diameter) curd (Fig. 2c), sometimes curd with hollow stem (Fig. 2d) and curds that were more prone to different pathogenic infections.

No significant difference in curd quality and yield was observed in between the different sets of field transplants below 4 weeks plus 18 days set, all produced more or less marketable curd; but in general it was observed (Fig. 1) that greenhouse transplants of 4 weeks old plus 9 and 12 days hardening off gave better quality curd in comparison to field transplants of same age (Table 1), which was quite surprising. Theoretically it is expected that field transplants should perform better than greenhouse transplants, as field transplants is growing and acclimatizing simultaneously in the same environment where they will be sown later, but greenhouse transplants have to acclimatize in a slight different and variable environment than the environment they were experiencing before sowing in the field. But the result showed somewhat exceptional findings. Probable explanation of this observation is that unlike field transplants, all transplants grown in greenhouse had neither to face the day to day variation of environment, nor the variation of different times of a single day. As they got uniform and controlled exposure throughout the growing period in greenhouse, they become physiologically more potent after uniform hardening off period for a standard duration.

Best quality and quantity curd can be obtained from cauliflower grown at a continuous, steady rate through its entire life from seedling to harvest. Too much heat or cold or fluctuating temperature, high humidity, clouds are against the formation of best quality curd. Field transplants have to experience these factors from germination to maturity which make them less potent than the greenhouse transplants, but this does not mean that greenhouse transplants after sowing in field never faced these factors; they face, but in such a stage when they are mature enough to withstand these factors slightly more potentially than field transplants.

Temperature has huge influence on cauliflower production, but it is generally accepted that cauliflower yield better in cool (optimum germinating temperature – 26.5°C, seedling growing temperature – 15.5°C, field growing temperature – 21-22°C) weather. Kalisz *et al.*, (2014) were of opinion that low temperature treatment of transplant leads to higher marketable yields. They reported that a low temperature of 6°C maintained for

Table 1: Average curd diameter produced from hardened transplants of 8 different periods.

Hardening off period							**Average curd diameter in cm.**								
0 days		**3 days**		**6 days**		**9 days**		**12 days**		**15 days**		**18 days**		**21 days**	
FT*	GT*	FT	GT	FT	GT	FT	GT	FT	GT	FT	GT	FT	GT	FT	GT
1st year 1st season															
10.0	7.2	10.7	8.8	11.8	12.3	17.4	18.4	16.7	18.6	12.9	13.2	5.3	5.8	4.9	4.8
1st year 2nd season															
11.3	7.5	11.1	8.9	12.0	11.9	16.5	18.6	17.2	18.0	13.4	12.2	5.0	4.8	4.1	4.6
2nd year 1st season															
11.6	7.0	10.9	9.4	12.2	11.8	17.3	18.3	17.9	18.5	14.2	13.0	5.7	4.3	4.5	3.9
2nd year 2nd season															
11.4	6.9	11.3	8.2	12.4	11.5	17.3	18.9	17.6	18.3	14.1	13.3	5.8	4.2	4.0	3.7

* FT - Field Transplants, GT – Greenhouse Transplants.

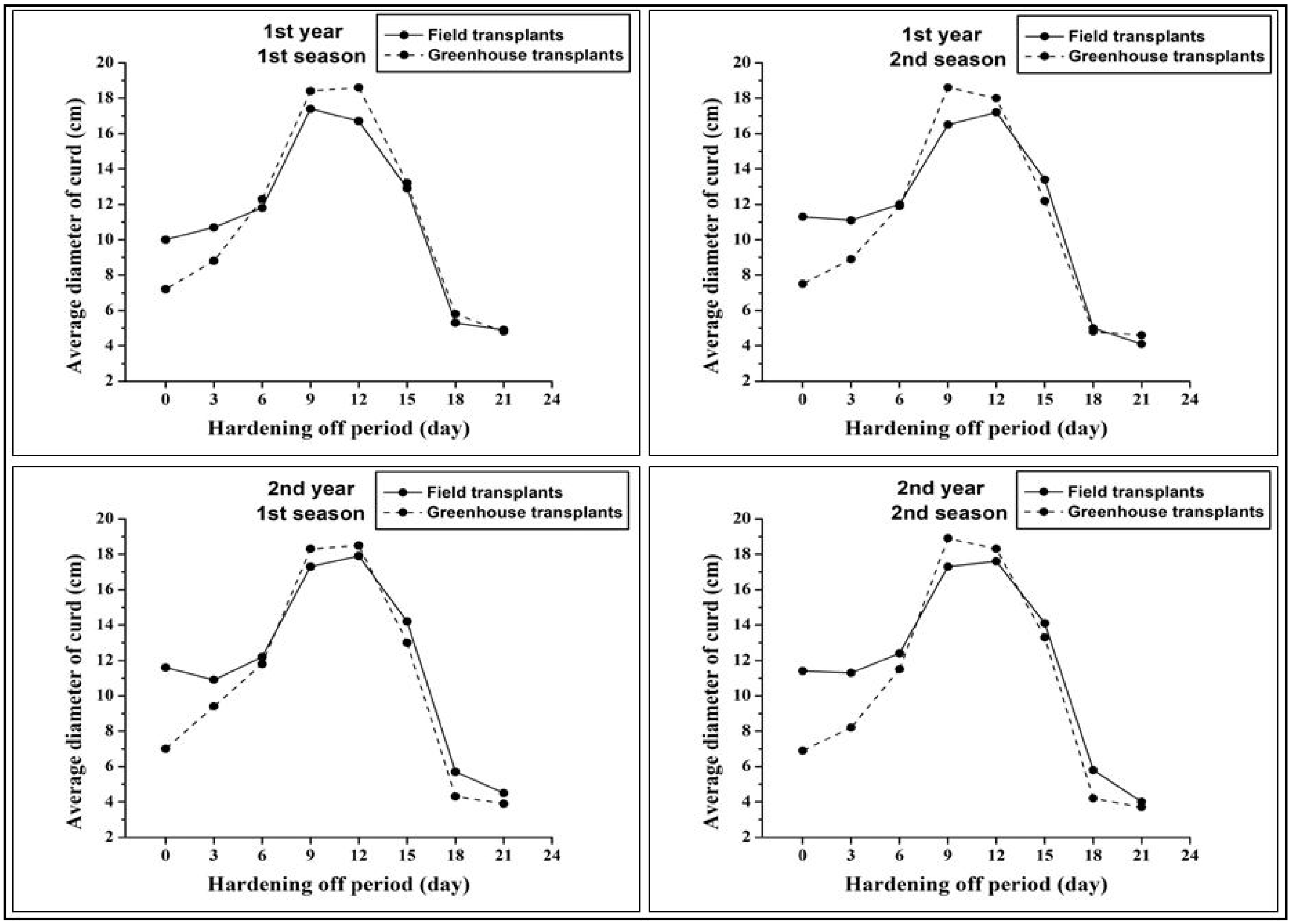

Fig. 1. showing average curd diameter in respect of hardening off period.

both 1st and 2nd week resulted in a significant increase in yield of 6.8 and 7.8% respectively compared to control. They concluded that controlled, low-temperature treatment of cauliflower transplants could play an important role in enhancing tolerance to field conditions and could offer an opportunity to improve yield of cauliflower grown in the field. Nowbuth (1997) suggested that there are genetic differences in the developmental responses of cauliflower varieties to temperature. Nowbuth and Pearson (1998) reported curd initiating temperature of two cauliflower variety as 13.5°C and also mentioned that both cooler and warmer temperature than 13.5°C delay curd initiation. Rahman *et al.*, (2013) reported greater rates of curd growth (curd length, diameter, fresh and dry weights) were achieved at warmer night temperatures than day temperatures, whilst greater leaf and stem growth (leaf area, stem length, fresh and dry weights) were achieved when day temperatures were warmer than night temperatures, even with the same mean temperatures; greater Relative Curd Growth Rate (RCGR) was recorded in plants grown at warmer (24°C) night than day (12°C) temperature compared to the plants grown at cooler (12°C) night than day (24°C) temperature.

Leafy curd (Fig. 2e) develops by high temperatures (>27°C) during curd formation (Norman 1992) as well as drastic fluctuations in day and night temperatures. Fujime and Okuda (1994) were of opinion that leafy heads occur when the curd exposed to the temperature higher than that induce fuzzy heads. They also reported that the extent of chilling requirement for flower bud initiation should be greater than that for curd formation. Riciness (uneven and fuzzy curd of a velvety appearance in which flowering structures emerge through the head, Fig. 2f) is caused by low temperatures just after planting and warm temperatures during curd development which was also suggested by Norman (1992) and Fritz *et al.*, (2009). Grevsen *et al.*, (2003) were of opinion that riciness is caused by low temperature, especially after a preceding period of high temperature. During periods of extremely warm weather (days above 30°C and nights of 26°C) cauliflower remain vegetative; the plants form no heads (Fritz *et al.*, 2009; Verma 2009) at all *i.e.*, blind heads (Fig. 2g). No head formation also results from temperature slightly above 0°C at seedling stage but premature head initiation may triggered by cool temperature (10 - 15°C), which is in contrast to Wurr et al. (1982), who observed delay in curd initiation by cold treatments. But continued

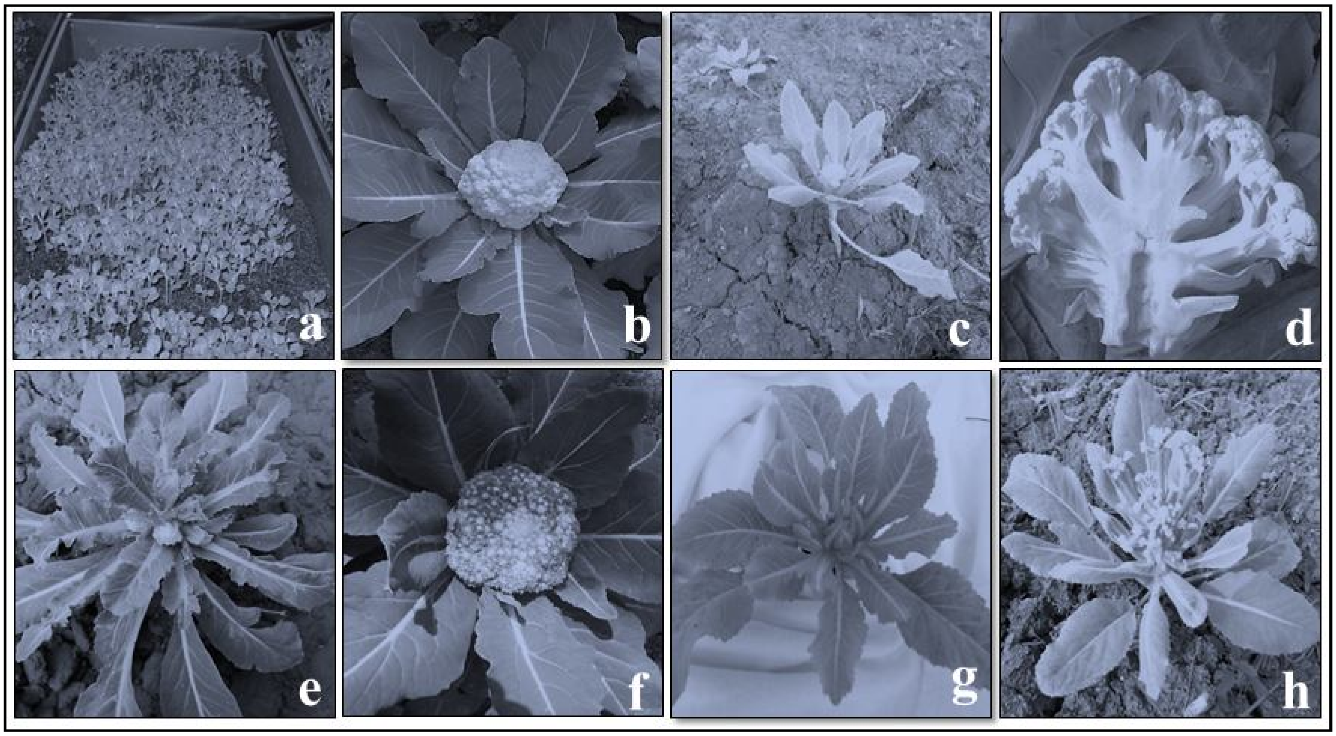

Fig. 2. showing (a) transplant production in greenhouse, (b) best quality curd, (c) single buttoned curd, (d) hollow stem, (e) leafy curd, (f) riciness, (g) blind head and (h) bolting of cauliflower.

cold weather (4-10°C) for 10 days or more may leads to buttoned head (Masarirambi *et al.*, 2011). In general, low temperature promotes flat heads while high temperature promotes conical shaped heads. High temperatures during cauliflower production delay maturity and increase vegetative growth; cool temperature hasten maturity and may induce bolting (Fig. 2h), *i.e.*, premature seed stalk formation.

In young cauliflower plants, there is a fine balance between vegetative and reproductive growth. Curd formation is a very sensitive process. Any temperature stress leads to irregularity in curd formation. Special care, controlled environment are required from seed germination to maturity. Further research, extensive field trials, proper discussions with experienced, skilled local farmers are needed to ensure maximally profitable cultivation of cauliflower.

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