

Studies on Effect of Temperature on Curd Yield under Year Round Production System of Cauliflower (*Brassica oleracea* var. *botrytis* L.) under Mid Hills of Himachal Pradesh

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Abstract

The cauliflower early group variety 'Pusa Himjyoti', mid group variety 'Swati' and late group variety 'PSB K -1' were planted at a gap of one month at different planting dates for two consecutive years during 2009-10 and 2010-11 to study the effect of varying temperatures on net curd yield and other associated characters in each maturity group. The varieties varied in their performance for net curd yield as per the maturity group and temperature regime. Early maturing varieties gave high net curd yield under high temperature planting dates whereas mid late and late maturing varieties gave high net curd yield under the mild/low temperature regimes. Curd diameter in early cauliflower was found to be maximum under increasing temperatures whereas mild temperature range helped in producing maximum curd size in mid group variety. Late group variety also produced maximum curd diameter when temperature increased from freezing to 10-15°C. The plant leaf number plant⁻¹ was found to be highest under higher temperatures in all the maturity group varieties. Cauliflower curds irrespective of maturity group took more time to maturity at lower temperatures as compared to the high temperatures for every maturity group and planting date.

1. Introduction

In India, cauliflower (*Brassica oleracea* var. *botrytis* L.), can be harvested every day of the year by growing different maturity types in different locations. These types can simply be split into early summer (early group), summer autumn (mid late group) and winter types (late/snowball group) though still diversity is there within these types. Plants from different types vary considerably in size and chronological age from sowing to maturity and also have been found to be highly sensitive to weather conditions especially temperature fluctuations. Indian cauliflower has under gone fast diversification (Sheshadri and Chatterjee, 1996) and hence its cultivation has further spread to non-traditional areas whereas the Erfurt's and Alpha strains more commonly known as Snowballs have been confined to the winter cultivation only. The annual temperate types or early summer cauliflowers have been more suited for offseason cultivation in the hills as they give curds during the early summer season when production of quality cauliflowers is limited in plains due to higher temperatures. Development of cultivars like Pusa Himjyoti, and Pusa Early Synthetics (Singh et al., 1994) and existence of a large pool of varieties

in different maturity groups have made it possible to produce cauliflowers more intensively and throughout the year in the mid hills of Himachal Pradesh. However, the cultivation of cauliflower throughout the year has been hampered by undulating geography and varying climatic conditions in different areas of the state and hence failure of the crop in many areas following the year round production system has become common. It is a fact that the spread of time over which a crop of cauliflower matures, and the proportion of the plants that is mature on any occasion, are crop and maturity group characteristics. Therefore, this maturity of the plants needs more attention in year round production system to ensure continuous supply of quality curds. Few studies have however been made to determine the environmental factors which can influence the maturity characteristics of the crop and not many quantitative data are available on this aspect. Therefore, a study was conducted on this background with a simple objective to find out the effect of temperature on curd yield and its associated characters under year round production system and hence to standardize the optimum time of planting for different varieties in this production cycle during 2009-2010 and 2010-11 under mid hills of Himachal Pradesh, India.



2. Materials and Methods

The varieties put under experimentation represented the three maturity groups viz., 'Pusa Himjyoti' (early group/summer), 'PSB K-1' (late group or winter) and a popular private sector hybrids 'Swati' (mid late or early summer), and the data presented are derived from planting these varieties twelve times at one month interval except late season variety which was planted six times only, at the experimental field of Regional Horticultural Research Station, Bajaura, Kullu during 2009-10 and 2010-11. The planting at each location was done in a randomized block design keeping three replications in a plot size of 50 m². Crop was raised as per the standard crop production practices. At the maturity observation were recorded on ten (10) randomly selected plants on days to curd maturity after transplant date, final leaf number plant⁻¹, curd diameter and net curd weight. The statistical analysis of the data recorded was done as per CPCS 1 computer based statistical programme by Cheema and Singh (1993).

3. Results and Discussion

The early group variety 'Pusa Himjyoti' planted in June gave maximum net curd weight of 445.9 g (Table 2) followed July planting which gave net curd weight of 413.4 g. It was observed that there was a significant decrease in net curd weight from June to July planting as there was a decrease of 1.5°C in temperature (Table 1). The data also indicates that curd size presented as curd diameter was maximum (12.9 cm) in the June planted crop and it significantly decreased in the crop planted in July with 12.4 cm curd dia. Hence it is clear from the data that the crops planted under the higher temperature regimes resulted in maximum curd diameter whereas the lower temperature regimes gave significantly lower curd diameter which was also reflected through minimum net curd weight 57.6 g during December planting of this variety. The data reflects that early group variety overall has given low net curd weight during the winter months when the minimum temperature was very low. The lower temperature has also resulted in early maturity (48.6 days, January planting) of the crop. The correlation (Table 3) between net curd weight, curd diameter and temperature is also highly significant for these varieties. Singh et al. 1994 have also reported that early varieties give higher curd yield under high temperature conditions. The August planting of mid late group hybrid 'Swati' produced maximum net curd weight of 556.9 g in 87.8 days after planting. The mid group variety was also observed to produce good marketable curds under mild decrease (July-September) or increase (January-February) in temperature regimes as it is clear from the high net curd weight of 367.0 g in 94.2 days after planting in February. The net curd weight in the mid late group variety decreased with decrease in temperatures after September

planting. This decrease was also observed with the increase in temperature after February planting. However the lower net curd weight in the January planting can be attributed to initial lower temperature regimes faced by the crop and hence 100.2 days taken for maturity of the curds. This also reveal that plant establishment in February planted crop is early because of comparatively higher temperatures as compared to January which enables them to give high yield under this planting date as compared to January. In this group variety also the minimum net curd weight (80.9 g) was observed in the December planting. Like early group, in this group also minimum curd diameter accompanied by low net curd weight indicated towards formation of small curds called buttons with decrease in temperature. Negative correlation between days to maturity and temperature indicates towards low curd production because of buttoning or tendency of curds for direct bolting after fulfillment of chilling requirement. Net curd weight and curd diameter however had positive relationship with temperature. The October planting of late group variety 'Pusa Snowball K -1' gave maximum net curd weight of 906.1 g with maximum curd dia of 15.4 cm, 22.8 leaves plant⁻¹ and after 109.6 days of planting. Highest leaf number plant⁻¹ (26.9) and maximum number of days taken to curd harvest (134.9) was recorded in July planting and thereafter it was observed that with decrease in temperatures the days to maturity as well as leaf number plant⁻¹ decreased significantly with every date of planting. The high leaf number is also related to high temperature in all the maturity groups. Similarly wide range of leaf number produced by winter cauliflower also reflects that planting the crop early will give more vegetative growth due to high temperatures. The data presented in Table 2 also indicates that for early and mid season varieties the curd diameter was

Table 1: Weather data for the period of experimentation

Planting Month	Temperature °C					
	Year 1		Year 2		Mean	
	Maxi-mum	Mini-mum	Maxi-mum	Mini-mum	Maxi-mum	Mini-mum
April	27.1	9.0	29.4	10.1	28.25	9.55
May	30.1	11.9	31.4	13.7	30.75	12.8
June	33.7	15.3	30.2	15.6	31.95	15.45
July	32.2	20.3	28.5	20.4	30.35	20.35
August	31.4	21.2	29.7	21.7	30.55	21.45
September	28.4	16.3	28.3	18.1	28.35	17.2
October	28.5	8.5	27.2	10.2	27.85	9.35
November	21.4	4.1	23.7	4.8	22.55	4.45
December	17.6	1.0	20.3	-0.5	18.95	0.25
January	19.0	1.0	15.2	0.3	17.1	0.65
February	18.7	3.9	17.1	4.0	17.9	3.95
March	25.8	7.9	21.7	6.2	23.75	7.05



minimum when temperature was very low. When there was a decrease in temperatures the curd diameter also decreased. Late season varieties however indicated increase in curd diameter with decreasing temperature regime to a certain level and then with further decrease in temperatures the curd diameter decreased in the November and December plantings. It was found that during December and January planting of early group cauliflowers minimum curd weight corresponds to less number of days for curd harvest which indicates that lower temperatures are not suitable for production of good quality curds in early cauliflowers. This trend of early harvest was also seen in mid late group cauliflower as well. These results are in conformation to those reported earlier by Choudhary and Ramphal (1961). Nowbuth (1997) in the adaptability trials for temperate varieties in Mauritius has reported that under high temperature (up to 25°C) conditions either the curd initiation is inhibited or the days taken to curd initiation and maturity are prolonged whereas the number of leaves produced by a plant is maximum. Wurr et al. (1993) observed that cauliflower has a direct response to temperature especially cool conditions or lower temperature for all the maturity groups. This direct response manifests itself by an increase in curd diameter or increase in curd yield. The cauliflower crop also has been described as having a qualitative cold requirement which means that once it is beyond the juvenile phase it must be exposed to relative cold before it will initiate a curd (Weibe, 1990).

It is also clear from the Table 2 that summer types progress from juvenility to curd maturity in a period of increasing mean temperature while in snowball type late group cauliflower, maturity comes with decreasing temperature regime therefore early (summer) cauliflowers are best suited for production in the period when temperature initially increases but then it starts

declining. The significant regression coefficients of net curd weight with maximum and minimum temperature (Table 4) further indicates that in the maturity groups early and late both maximum and minimum temperature plays a crucial role in harvesting high net curd weight in plants whereas in mid group only maximum temperature affects the production of higher net curd weight in cauliflower and in present studies it is therefore observed that mid group varieties give good plant growth as well as net curd yield plant⁻¹ when the mean temperature is high. Wurr and Fellows (2000) have illustrated that leaf production and induction are distinct processes and the plant will continue to produce leaves until curd initiation is complete which is highly temperature sensitive process and in winter cauliflower's juvenility could end within 19 days of planting even. Haine (1959) and Sadik (1967) during their studies also revealed that varieties vary in their temperature requirement for curd initiation to curd maturity. Salter (1969) has indicated variability in the time of maturity of individual plants in crops and hence length of the maturity period is partially caused by variability in the time of curd initiation of different plants which is further affected by varying temperatures. Singh et al. (1978) have reported mid October to be the best planting time of snow ball group of varieties in Northern India. Chatterjee and Swarup (1983) have studied the maturity period of different cauliflower varieties and have reported lower temperature requirement for curd formation by the late group varieties and higher temperature requirement for curd formation in the early varieties. Aalbersberg (1986) while studying cauliflower planting dates in Netherlands has also recommended mid late varieties for January and February transplanting. The studies are also in conformation to the studies conducted by Pradeepkumar et al. (2002) under Kerala conditions on the

Table 2: Performance of different groups at different planting dates

Planting Month	Net curd weight (g)			Curd diameter (cm)			Leaf number plant ⁻¹			Days to curd maturity		
	Early	Mid	Late	Early	Mid	Late	Early	Mid		Early	Mid	Late
April	145.9	206.8	-	11.4	11.4	-	20.0	25.5	-	69.3	88.6	-
May	348.2	315.7	-	12.2	11.7	-	22.8	24.6	-	78.2	87.5	-
June	445.9	340.9	-	12.9	13.2	-	20.8	22.1	-	74.6	84.8	-
July	413.4	469.7	375.6	12.4	13.5	10.1	19.2	21.5	26.9	73.3	84.4	134.9
August	329.3	556.9	512.7	11.8	14.5	13.5	17.5	20.6	24.0	70.3	87.8	128.3
September	208.2	351.1	797.1	10.4	13.5	14.3	16.4	19.5	23.4	64.6	92.1	124.2
October	138.9	147.7	906.1	9.4	13.1	15.4	15.4	18.5	22.8	61.4	92.8	109.9
November	84.2	85.5	398.4	6.7	9.1	13.5	14.7	16.2	20.2	55.8	77.8	94.7
December	57.6	80.9	269.9	5.6	9.6	10.1	14.4	15.3	16.4	51.6	72.9	84.3
January	64.4	315.0	-	6.2	11.2	-	14.0	19.9	-	48.6	100.2	-
February	73.7	367.0	-	6.5	12.1	-	13.0	24.2	-	53.1	94.2	-
March	106.5	264.2	-	10.7	11.9	-	19.8	24.8	-	65.8	92.5	-
CD ($p=0.05$)	6.09	10.9	10.9	0.37	0.28	0.24	0.42	0.36	0.38	0.46	1.42	2.58

Table 3: Correlation between different characters and temperature for all the groups

Group	Characters	Net curd weight (g)	Curd diameter (cm)	Leaf No. plant ⁻¹	Days to curd maturity	Maximum temp	Minimum temp	Mean temp
Early								
	Net curd weight (g)	1.000	0.8498*	0.7121	0.8637*	0.8536*	0.8561*	0.8799*
	Curd diameter (cm)		1.000	0.8804	0.9709*	0.9360*	0.8570*	0.9165*
	Leaf no. plant ⁻¹			1.000	0.9221*	0.7719*	0.5635	0.6711*
	Days to curd maturity				1.000	0.9344*	0.8152*	0.8911*
Mid								
	Net curd weight (g)	1.000	0.7987*	0.4279	0.3856	0.4078	0.7210*	0.6040*
	Curd diameter (cm)		1.000	0.3362	0.4361	0.6377*	0.8233*	0.7659*
	Leaf no. plant ⁻¹			1.000	0.4938	0.2897	0.2461	0.2723
	Days to curd maturity				1.000	-0.1042	0.0111	-0.0391
Late								
	Net curd weight (g)	1.000	0.8512*	0.3414	0.3175	0.4777	0.2666	0.3438
	Curd diameter (cm)		1.000	0.1567	0.1139	0.3175	0.1183	0.1896
	Leaf no. plant ⁻¹			1.000	0.9599*	0.9543*	0.9113*	0.9372*
	Days to curd maturity				1.000	0.9654*	0.9855*	0.9902*

*Significant at $p=0.05$

Table 4: Analysis of variance for linear regression between net curd weight with temperature

SoV	D.F.	Mean sum of squares								
		Early group			Mid group			Late group		
		Maximum temp	Minimum temp	Mean temp	Maximum temp	Minimum temp	Mean temp	Maximum temp	Minimum temp	Mean temp
Regression	1	166238.8	167219.7	176620.1	38315.5	119796.5	84273.1	743329.2	625321.2	881412.5
Residual Variation	10	6187.6	6089.5	5149.5	19206.5	11.058.5	14610.8	46304.9	58105.7	32496.6
'F' calculated		26.9*	27.5*	34.3*	2.00	10.8*	5.8*	16.1*	10.8*	27.1*
Regr. coefficient 'b'		22.7	16.9	20.5	10.9	14.3	14.2	18.8	27.4	25.7

*Significant at $p=0.05$

early and late season varieties. Observations suggest that in warm weather extension growth of the individual curd peduncle occur more rapidly, with a consequent tendency for the curd to become ready for cutting earlier and at a size smaller than it would have reached in cooler conditions. Warm weather may also cause temporary wilting of the leaves; the curd gets exposed and may need to be harvested prematurely before it becomes discolored. The net result of both these effects is that in hot weather a proportion of the crop is cut before the curds have reached their full size and thus curd size and the duration of the harvest period are reduced.

4. Conclusion

Early group needs high temperature for proper curd formation and plant development. However, different maturity groups had different relationships with temperature and linear regression for net curd weight, can quantify the production for unit change in temperature. Best production cycle for year round

production of cauliflower in the mid hills was therefore found to be June-July (early group); October (late group); followed by February planting of mid late group varieties which can give higher net curd yield besides ensuring best quality curd supply to the markets.

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