



## Studies on year round production of cauliflower (*Brassica oleracea* var *botrytis*) under mid hills of Himachal Pradesh

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The cole crops in general and cauliflower (*Brassica oleracea* var *botrytis* L.), in particular have been found to be highly sensitive to weather conditions especially temperature fluctuations. Indian cauliflower has undergone fast diversification (Sheshadri and Chatterjee 1996) and its cultivation has further spread to non-traditional areas with development of tropical cauliflower varieties at IARI, New Delhi. Therefore in the mid hills of states like Himachal Pradesh the major groups of cauliflower, grown are Indian and annual temperate type (the Erfurt's and Alpha strains) more commonly known as Snowballs. The difference between the two is in their adaptability to different temperature conditions, tropical types form curds at temperatures around 20°C or above, while the temperate annual require temperature range between 10°C and 16°C for curd formation. Further, the tropical's are resistant to high rainfall conditions, especially during the vegetative phase. 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 the state. Therefore, maturity of the varieties needs more attention in year round production 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 in this background with a simple objective to determine the relationship between the time of planting and curd maturity at different altitudes.

The varieties Pusa Himjyoti (early), PSB K 1 (late) and popular private sector hybrids Swati (mid), NS 106 (mid late) were taken as representatives in different maturity groups of cauliflower. Experiments were conducted at different altitudes at three locations namely Jhiri (1190m a msl)-L<sub>1</sub>, Pali (1350m a msl)-L<sub>2</sub> and Sharan (1650m a msl)-

L<sub>3</sub> for two consecutive years during 2009-10 and 2010-11. The selected locations are situated within a radius of 10 km from Regional Horticultural Research Station, Bajaura - Kullu. The planting at each location was done in a randomized block design keeping 3 replications in a plot size of 50m<sup>2</sup> as per the following planting pattern details:

Planting pattern 1: June\* (Early)–September\* (Mid)–January\* (Mid Late)

Planting pattern 2: July\* (Early)–October\* (Late)–February\* (Mid Late)

\*Name of the month refers to the time of planting for the group

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 per plant, curd diameter and marketable curd yield converted into quintals/hectares. Benefit: cost ratio for each planting time and experiment was worked out as per the market prices for the crop at the time of harvest. The statistical analysis of the data recorded was done as per CPCS 1 computer based statistical programme by Cheema and Singh (1999).

Early group variety Pusa Himjyoti planted in June gave curd harvest in minimum time of 71.6 days after planting at L<sub>1</sub> with a maximum curd yield of 190.8 q/ha among locations (Table 2). At a higher elevation (L<sub>2</sub>) the variety took 85.3 days after planting to give reduced marketable curd yield, i.e. 152.4 q/ha. It was observed that there was a decrease in curd diameter and number of leaves per plant with increase in elevation. The difference in the magnitude for all the parameters between L<sub>1</sub> and L<sub>3</sub> was found to be highly significant. Singh *et al.* (1994) have also reported that early varieties tolerate high temperature and hence give better yields. June planting of early group varieties was followed by September planting of mid group hybrid Swati and it was found that curd matured in 87.2-91.0 days after planting at L<sub>1</sub> and L<sub>2</sub> respectively. This variety gave maximum curd yield of 238.6 q/ha at L<sub>2</sub> however, at L<sub>3</sub> curds were harvested in 121.6 days after

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Table 1 Weather data for the period of experimentation

Year	Month	Temperature (°C)					
		Location 1		Location 2		Location 3	
		Maximum	Minimum	Maximum	Minimum	Maximum	Minimum
2009	June	33.7	15.3	33.1	13.8	28.1	17.6
	July	32.2	20.3	32.4	18.6	28.8	20.0
	August	31.4	21.2	31.1	19.3	27.9	20.9
	September	28.4	16.3	28.1	13.7	25.7	18.6
	October	28.5	8.5	26.9	7.6	23.4	11.7
	November	21.4	4.1	20.7	3.3	17.3	7.5
2010	December	17.6	1.0	17.1	1.2	13.3	5.1
	January	19.0	1.0	18.0	0.9	14.0	5.0
	February	18.7	3.9	18.5	2.2	13.2	5.3
	March	25.8	7.9	24.8	6.3	21.0	10.5
	April	29.4	10.1	28.5	8.9	23.2	13.7
	May	31.4	13.7	29.3	11.6	25.3	15.4
	June	30.2	15.6	29.2	13.0	25.8	16.0
	July	28.5	20.4	28.6	17.6	24.8	19.6
	August	29.7	21.7	29.3	18.8	25.7	21.4
	September	28.3	18.1	28.2	15.1	24.7	18.0
	October	27.2	10.2	25.7	7.5	22.9	12.7
	November	23.7	4.8	21.8	3.2	19.7	9.8
2011	December	20.3	-0.5	17.5	-0.7	14.7	4.5
	January	15.2	0.3	15.2	-1.3	9.9	2.5
	February	17.1	4.0	15.6	0.9	10.8	4.6
	March	21.7	6.2	22.8	4.0	18.2	9.1
	April	24.0	9.1	24.5	6.8	20.3	10.6
	May	31.4	13.6	28.7	11.8	25.8	15.3
	June	32.5	18.1	30.9	15.7	28.6	18.2

planting with significant reduction in curd yield (96.7 q/ha). Reduction in curd diameter and number of leaves per plant was also observed at L<sub>2</sub>. January planting of mid late group cultivar NS 106 resulted in marketable curd yield of 206.2 q/ha in 105.1 days after planting at L<sub>2</sub>. At L<sub>3</sub>, a significantly reduced marketable curd yield of 109.5 q/ha was obtained in 128.6 days after planting. Low yields under this planting date at all the locations can be attributed to the poor growth and development of the plants at the initial stage when the temperatures are very low (Table 1). It can also be said about the L<sub>2</sub> and L<sub>3</sub> that initiation and maturity of curds under September planting date coincides with the onset of winters in the hills (Table 1) and hence there was increase in the maturity time of the curds as well as decrease in yield.

In the second planting pattern the first planting date was deferred to July at every location and the early group variety Pusa Himjyoti planted at L<sub>1</sub>, matured in 76.8 days whereas at L<sub>2</sub>, this variety gave marketable curds 84.0 days after planting. The early group variety gave marketable curd yield of 189.2 q/ha and 181.1 q/ha at L<sub>1</sub> and L<sub>2</sub> respectively. As the elevation further increased to L<sub>3</sub> the curd maturity period after planting further increased to 98.2 days with significant reduction in curd yield to 102.8 q/ha.

July planting gives the early varieties a fair chance for growth and development under the high temperature conditions and hence the curd yield is high under this planting date as well. The October planting was done with late group variety Pusa Snowball K-1 and this variety gave marketable curd yield after 122.7 and 128.9 days at L<sub>1</sub> and L<sub>2</sub> respectively with maximum curd yield (239.6 q/ha) at L<sub>2</sub>. Pusa Snowball K-1 being a late maturing variety gave highest curd yield under the lower temperature conditions which has also been reported earlier by Choudahry and Ramphal (1961). As the elevation further increased to 1650m at L<sub>3</sub> the curd maturity period further increased significantly to 143.3 days with a corresponding reduction in curd yield (127.1 q/ha) it can attributed to the lower temperatures at higher elevations. The February planted mid late group variety NS 106 at an elevation of 1190 m (L<sub>1</sub>), matured in 105.9 days after planting, whereas at an elevation at L<sub>2</sub> this variety gave marketable curds in 103.4 days after planting. As the elevation further increased to 1650 m (L<sub>3</sub>) the curd maturity period further increased to 109.5 days. The marketable curd yields of 210.0 q/ha, 222.9 q/ha and 187.2 q/ha was recorded at the three locations respectively. Similarly the curd diameter was also found to vary as per the increase or decrease in curd yield. Number of leaves per

Table 2 Effect of planting dates and locations on different horticultural traits in cauliflower

Time of planting	Group (variety)	Days to curd maturity			Marketable curd yield (q/ha)			Curd diameter (cm)			Number of leaves/plant										
		L <sub>1</sub>	L <sub>2</sub>	L <sub>3</sub>	Mean	CD	L <sub>1</sub>	L <sub>2</sub>	L <sub>3</sub>	Mean	CD	L <sub>1</sub>	L <sub>2</sub>	L <sub>3</sub>	Mean	CD					
		(P=0.05)			(P=0.05)			(P=0.05)			(P=0.05)										
Experiment 1																					
June	Early (Pusa Himjyoti)	71.6	75.2	85.3	77.4	2.51	190.8	183.5	152.4	175.6	2.34	12.1	11.7	9.6	11.1	0.071	17.9	17.3	14.4	16.5	0.56
September	Mid (Swati)	87.3	91.0	121.6	100.0	3.04	234.7	238.7	96.7	190.0	3.44	12.4	11.8	8.3	10.8	0.064	18.5	17.1	13.3	16.3	0.71
January	Mid Late (NS 106)	106.2	105.1	128.7	113.3	1.90	205.3	206.2	108.0	197.2	3.49	11.6	11.7	8.7	10.7	0.023	20.0	19.8	16.1	18.6	0.89
Experiment 2																					
July	Early (Pusa Himjyoti)	76.8	84.0	98.2	82.7	2.65	189.2	181.1	102.8	157.7	5.05	11.9	11.4	8.5	10.6	0.14	17.4	17.2	13.3	15.9	0.42
October	Late (PSB K 1)	122.7	128.9	143.3	131.6	1.79	227.5	239.6	127.1	198.1	3.21	13.9	14.2	10.7	12.9	0.058	21.6	21.3	16.8	19.9	0.78
February	Mid Late (NS 106)	105.9	103.4	109.5	106.2	2.12	210.0	222.9	187.2	206.7	3.95	12.1	12.6	10.5	11.7	0.081	20.3	19.9	15.2	18.4	0.82
	CD(P=0.05)	2.79	2.32	3.98			5.06	2.74	3.65			0.31	0.69	0.27			0.87	0.62	0.57		

Table 3 Benefit: cost ratio obtained for different experiments

Location	Elevation (meters)	Group /Variety used	Month of planting	Month of harvest	Curd yield (q/ha)	Total returns /ha (₹)	Net returns /ha (₹)	B:C ratio	Total returns (₹)
Experiment 1									
Jhiri L <sub>1</sub>	1000	Early (Pusa Himjyoti)	June	September	190.8	248 040	145 930	1.43	356 160
		Mid (Swati)	September	December	234.6	117 300	11 590	0.11	
		Mid Late (NS 106)	January	May	205.3	307 950	198 640	1.82	
Pali L <sub>2</sub>	1350	Early (Pusa Himjyoti)	June	September	183.5	238 550	136 440	1.34	350 020
		Mid (Swati)	September	December	238.6	119 300	13 590	0.13	
		Mid Late (NS 106)	January	May	206.2	309 300	199 990	1.83	
Sharan L <sub>3</sub>	1650	Early (Pusa Himjyoti)	June	September	152.4	198 120	96 010	0.94	94 940
		Mid (Swati)	September	December	96.7	48 350	-57 360	-0.54	
		Mid Late (NS 106)	January	May	108	162 000	56 290	0.53	
Experiment 2									
Jhiri L <sub>1</sub>	1000	Early (Pusa Himjyoti)	July	October	189.2	236 500	134 390	1.32	416 670
		Late (PSBK-1)	October	January	227.5	182 000	72 690	0.66	
		Mid Late (NS 106)	February	May	210.2	315 300	209 590	1.98	
Pali L <sub>2</sub>	1350	Early (Pusa Himjyoti)	July	October	181.1	226 375	124 265	1.22	435 275
		Late (PSBK-1)	October	January	239.6	191 680	82 370	0.75	
		Mid Late (NS 106)	February	May	222.9	334 350	228 640	2.16	
Sharan L <sub>3</sub>	1650	Early (Pusa Himjyoti)	July	October	102.8	128500	26 390	0.26	193 850
		Late (PSBK-1)	October	January	127.1	101 680	-7 630	-0.07	
		Mid Late (NS 106)	February	May	187.2	280 800	175 090	1.66	

The cost of cultivation for early, mid and late group varieties is ₹ 102 110/ha, 105 710/ha and ₹ 109 310/ha respectively. The sale prices for the curds grown during different cropping periods in ₹/q are: June-September (1300), September- December (500), January- May (1500), July- October (1250), October- January (800), February- May (1500)

plant also varied with the climate as is indicated by the data presented in Table 3. Both the extremes of temperature forced a decrease in leaf number per plant. Nowbuth (1997) has also reported that warmer temperature favour higher leaf production and it decreases with onset of low temperature conditions.

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. The Fig. 1 and 2 clearly indicates the difference among the varieties planted at different planting dates and altitudes. 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 also reported mid October to be the best planting time of snow ball group of varieties in Northern India. Chatterjee and Swarup (1983) have also 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) from 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 early and late season varieties. The present studies 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 yields under this planting date as compared to January.

January planted crop at L<sub>1</sub> harvested in May was found to give maximum b: c ratio of 1.82: 1 followed by June planting which resulted in a benefit of ₹ 1.43 at an investment of ₹ 1.00. At L<sub>2</sub> also January planted crop gave maximum returns with b: c ratio of 1.83: 1. At L<sub>3</sub> June planting was found to be economical as compared to other planting dates and September planting resulting in negative b: c ratio. Overall benefit gained was highest at L<sub>1</sub> for year round production of cauliflower. This planting pattern was not found to give better returns at the higher altitudes owing to low yield and hence poor returns to the farmers. In the second planting pattern

February planting at L<sub>1</sub> was found to give maximum b: c ratio of 1.98:1 and June planting followed it with b: c ratio of 1.32: 1. At L<sub>2</sub> February planting resulted in significantly higher b: c ratio of 2.16: 1 whereas June planting gave returns of ₹ 1.22 for investment of ₹ 1.00. At L<sub>3</sub> also February planting of mid late group varieties was found to give significantly higher b: c ratio of 1.66: 1. Over all benefit for producing cauliflowers throughout the year was highest at the L<sub>2</sub>.

Therefore from the above results it can be concluded that by planting early group varieties/hybrids in June-July followed by planting of late group varieties in October and after this crop is over in February planting with mid or mid late group varieties will result in maximum benefits in the mid hills of Himachal Pradesh, while ensuring continuous supply of good quality curds throughout the year as well.

SUMMARY

Studies were conducted to standardize the optimum time of planting for different varieties of cauliflower under year round quality curd production system during 2009-10 and 2010-11 under mid hills of Himachal Pradesh. The varieties Pusa Himjyoti (early), PSB K -1 (late) and popular hybrids Swati (mid), NS 106 (mid late) were planted at different altitudes (1090 m a msl, 1350 m a msl and 1650m

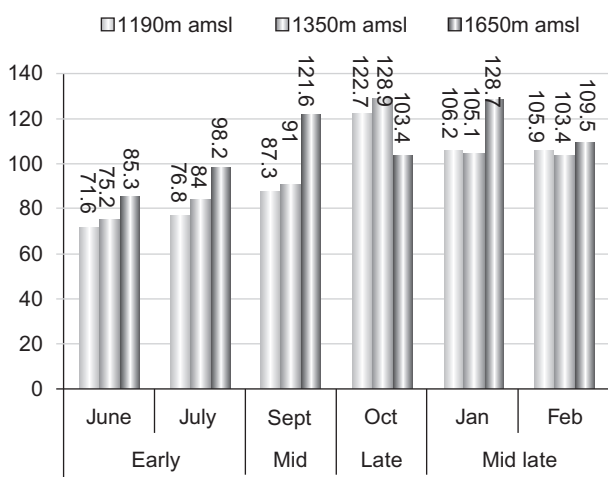


Fig 1 Days to curd maturity

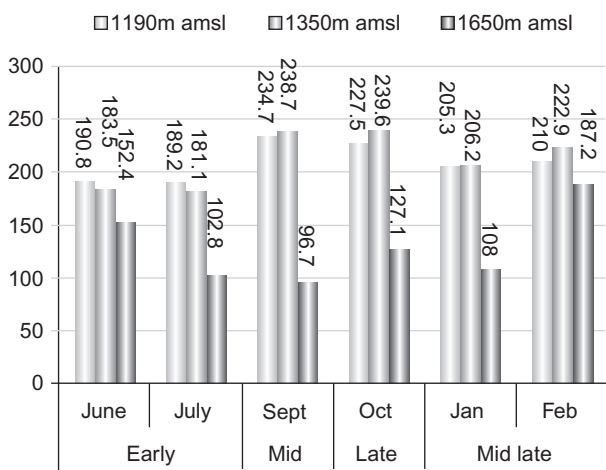


Fig 2 Marketable curd yield

a msl). All the varieties or hybrids planted took more time to curd maturity at higher elevations for irrespective of planting time and maturity group as compared to the lower elevations. Early varieties gave high curd yield under higher temperature conditions, whereas the mid and late varieties gave high curd yield under mild climatic conditions and higher elevations. The June planting date for early group and February planting of mid late group varieties recorded the best benefit: cost ratio under the mid hill conditions. The best planting dates for year round production of cauliflower in the mid hills were therefore found to be June-July (early group); October (late group); followed by February planting of mid or mid late group varieties which can fetch higher returns to the growers besides ensuring best quality curd supply throughout the year to the market.

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