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Short communication

Prechill effect on flowering of mature heads of cabbage cultivars

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Cabbage (*Brassica oleracea* var. *capitata* L.) cultivars are diverse with respect to heading, chilling requirement for flowering and winter hardiness. Wiebe (10) categorised cabbage as having obligate requirement for exposure to low temperatures for flowering, 4° to 7°C temperatures as optimum (that led to fastest flowering response), while effective temperature range as 0 to 12°C. Cabbage must attain certain size and more than 16°C temperature was termed as anti or devernalizing. Sheen (5) reported reversal of low temperature effect on sugar accumulation and cancellation of vernalization by either high temperature (20°, 30°C) or alternating temperature (20°/5°C or 30°/5°C day/night temperatures) in radish. He suggested that in sub-tropics, relatively high day temperature in winters prevents bolting. Data (collected at metrological unit of deptt. of Soil Science and Water Management, UHF, Solan) shows anti and devernalizing day temperature (>16°C mid Feb to mid Nov., 2001-2007). Thus, it was planned to initiate flowering in mid seasons heading cabbage cultivars Pusa Mukta and KGAT-I hybrid that fail to flower at Solan due to insufficient exposure to continuous low temperature for complete vernalization, by artificial exposure to low temperature.

The seedlings of cabbage cultivars were transplanted at 3-4 leaf stage in-first week of September at spacing 45 cm × 45 cm in experimental plots (Deptt. of Vegetable Crops UHF, Solan) measuring 1.8 m × 1.8 m. Crop density was 16 plants per meter square. Recommended fertilization, irrigation and crop protection schedules were applied. Required number of mature, compact cabbage heads 20, in 4 lots of each cultivar, three replicates in subsequent year were uprooted in mid February (Kanwar *et al*., 2). Average leaf number was >14, average head weight with roots was 1.190 kg and average head diameter was 13.72 cm in Pusa Mukta, while average leaf number was >18, average head weight was 1.770 kg and average head diameter was 13.60 cm in case of KGAT-I. Root system was packed in soil, wrapped with jute piece and each head with roots was covered with transparent polythene sheet and kept 5±1°C, in dark, for 3, 5 or 7 weeks. Every head was aerated and roots were moistened atleast once in a week during exposure to low temperature. Before planting in field under recommended fertilization and irrigation schedules, each head was given 1 cm deep cross cut at the top (Pant *et al*., 4) and GA_3 (1000 mg/l) was coapplied. However, as GA_3 treatment after 3 and 5 weeks of pre-chill did not appreciably increase flowers stalk length or extent of flowering, it was discontinued after 7 week pre-chill (Table 1).

The flowering stalks in Pusa Mukta cabbage heads planted in field after three weeks of exposure to 5±1°C temperature, failed to grow after three days whether GA_3 1000 mg/l was applied or not. Flowering stalks bolted by 15th day. The central flowering stalk of KGAT-I hybrid elongated but there were no lateral flowering stalks. In 5 and 7 weeks, pre-chilled cabbage heads central, flowering stalk elongated after three days and 8 and 12 lateral flowering stalks were formed in Pusa Mukta. GA_3 (1000 mg/l) applied with cross cut did not appreciably increase either length or number of lateral flowering stalks. Suzuki and Metzger (7) had reported increase in average number of stems, days taken to first open flower and flowering response to increase with duration of vernalization. Survival of Pusa Mukta cabbage heads was higher after three weeks of artificial chilling (75%) and 5 or 7 weeks of exposure to low temperature did not lower it appreciably. The survival of KGAT-I hybrid cabbage heads was 66% after 3 and 5 weeks of artificial exposure to low temperature and was 50% after 7 weeks of artificial chilling (Table 1). Malhotra (3) had reported transplanting shock to reduce seed yield in head to seed method of cabbage seed production.

After 30 days of field planting of heads all flowers became senescent on terminal as well as on axillary inflorescence each flowering stalk. Pre-chill of 5 and 7 weeks increased number of silique set per flowering stalk in Pusa Mukta compared to 3 weeks of pre-chill (Table 2). However, no silique was set in KGAT-1 even after 45 days of field planting. Thus, artificial exposure to low temperature of rooted cabbage heads initiated 100% flowering. Growth of flowering stalks and number of silique set per flowering stalk was higher with 5 and 7 weeks of exposure in Pusa Mukta. Thomas and Vince Prue (8) concluded vernalization process to be located primarily in meristematic zone of shoot apex. In cabbage, results indicate that vernalization itself leads to development of flower buds. Friend reported cabbage varieties to be neutral to photoperiod subsequent to completion of vernalization. Sui *et al*. (6) reported

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Table 1. Effect of artificial exposure to low temperature (5±1°C) on flower initiation, flower stalk growth and survival of cabbage heads planted in field.

Cultivar	Exposure period (wk)	Flower initiation (% of total heads exposed to low temperature)	Flower stalk length in field planted cabbage heads after						Survival (%) of cabbage heads planted in field
			3 days			15 days			
			Primary stalk (cm ± SE)	Secondary No. (cm ± SE)	Flowers (cm ± SE)	Primary (cm ± SE)	Secondary stalk No. (cm ± SE)	Flowers	
Pusa Mukta	3	100	-	-	-	11.3±2.1	12 (16.3±1.8)	Lower open	76
	3 + GA_3 1000 mg/l	100	-	-	-	11.5±1.1	13 (17.5±1.9)	Lower open	75
	5	100	5.1±0.7	8 (1.3±0.9)	Not open	15.2±1.4	14 (20.8±2.2)	All open	64
	5 + GA_3 1000 mg/l	100	6.3±0.7	9 (2.4±1.1)	Not open	15.4±1.3	16 (21.5±2.6)	All open	66
	7*	100	6.4±0.6	12 (2.5±1.2)	Not open	15.6±1.5	15 (20.8±2.7)	All open	66
KGAT-I	3	100	2.5±1.0			13.8±1.3	16 (30.2±2.9)	Lower open	65
	3 + GA_3 1000 mg/l	100	3.2±1.1			14.0±1.4	15 (30.8±3.1)	Lower open	64
	5	100	6.3±1.1	12 (2.6±1.0)	Not open	15.6±1.3	16 (32.6±2.5)	All open	64
	5 + GA_3 1000 mg/l	100	5.8±1.1	13 (2.4±1.1)	Not open	15.8±0.3	15 (33.1±2.7)	All open	66
	7*	100	6.0±1.2	16 (3.6±1.0)	Not open	16.0±1.1	17 (32.8±2.8)	All open	50

*Application of GA_3 (1000 mg/l) co-applied on field planting was discontinued as the treatment did not appreciably increase flower stalk length or extent of flowering.

decrease in cabbage (plant vernalization responsive species) of FLC (*Flowering Locus* C) transcript after cold treatment, unlike repression of flowering by FLC in *Arabidopsis* (a seed vernalization responsive species). They proposed different mechanisms to be involved in regulation and expression of FLC in cabbage and *Arabidopsis*.

Table 2. Silique growth in field planted pre-chilled heads of Pusa Mukta and KGAT-I hybrid cabbage after 15 and 30 days of flowering.

Cultivar	Chilling period (wk)	15 days after flowering		30 days after flowering	
		Flower	Av. No. of silique per flowering stalk (mean ± SE)	Av. No. of silique per flowering stalk (mean ± SE)	Average silique length (cm ± SE)
Pusa Mukta**	3	Senescent	2.6 ± 0.5	5.1 ± 2.5	4.4 ± 0.5
	5	Senescent	10.4 ± 0.8	14.2 ± 2.7	5.8 ± 0.3
	7	Senescent	14.5 ± 1.5	18.6 ± 2.9	5.4 ± 0.3
KGAT-1	3	Senescent	-	-	-
	5	Senescent	*2.5 ± 2.6	*3.2 ± 2.2	1.3 ± 0.3
	7	Senescent	*3.8 ± 2.2	*4.1 ± 2.9	1.2 ± 0.2

*Ovary abscise after attaining about 1 cm length.

**Average silique length (without beak) after 90 d of flowering was 7±0.5 cm and seed number per pod varied from 11±3.4 (for 5 wk pre-chilled heads) to 16±4.1 for 7 wk pre-chilled heads.

Mature cabbage heads uprooted after approximately five months of growth and wrapped in polythene sheets and exposed to low temperature of 5±1°C in dark for 5 or 7 weeks duration. After pre-chill, each cabbage head was given 1 cm deep cross cut at the top and GA_3 at 1000 mg/l was co-applied, on planting in the field. It was observed that after 3 weeks of artificial chilling, flowering response of cultivars was poor but with 5 or 7 weeks of exposure to low temperature, flowering response was saturated.

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