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GROWING CONDITION INFLUENCES VARIATION IN INITIATION TO WILTING OF FLOWERS OF WINTER ANNUALS

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KEYWORDS

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Winter annuals

Flowering period

ABSTRACT

Present study was conducted to study the differences in flowering behavior of twenty different ornamental winter annuals, mostly used for landscaping purpose under different agro-climatic conditions, in the Terai region of West Bengal, India under open field and protected condition. Flowering parameters such as Days required for flower bud initiation (FBI), Days required for flower bud development (FBD), Days required for blooming, Days required for wilting of flower were recorded in each plot and their average was calculated. *Calendula officinalis* showed earliness in FBI (23.25 DAT), FBD (32.88 DAT), blooming (35.50 DAT) and wilting (43.00 DAT) under open condition and the late flowering was found in *Antirrhinum majus* (74.67 DAT), whereas, the delayed wilting was observed in *Helichrysum bracteatum* (94.30 DAT) both under protected condition. *Iberis umbellata* required minimum time period (6.17 days) to reach flower bud development from flower bud initiation stage. The shortest period for wilting of flowers was recorded in *Eschscholtzia californica* (2.00 days) under protected condition, while, *Helichrysum bracteatum* required the maximum time period (21.84 days) from blooming to wilting.

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1 Introduction

An annual plant is a plant that completes its life cycle within a particular growing season of the year. Whereas, annual plant which having short period of lifespan is known as flowering annuals. Plants which are sown during winter months starting from October to first week of November and flowering commences within February are called as winter flowering annuals or winter annuals for the plains. (Randhawa & Mukhopadhyay, 1986) Plants with strong vernalization requirement are often referred as winter annuals. Winter flowering annuals provides excellent relaxation, attracts people when planting in a mass and serve as beautification in any landscape plan (Brown, 2012). Annuals are also used as bedding plants, rockery, window baskets, garden plants and herbaceous borders in garden.

Flowering in plant is an inductive process which includes initiation of floral meristem in which the apical meristem modified towards floral development (McDaniel et al., 1992). Murfet (1977) summarized as the flowering is the end result of physiological processes, biochemical sequences, and gene action, which are influenced by environmental stimuli and the passage of time (Munir 2003; Zheng et al., 2006) as well as genotype; a genotype can take two seasons to flower in an environment whereas it may flower within a single season in different environment. Usually, after completing of juvenile and developmental phases plants go through reproductive phase responding to the environmental factors (temperature, photoperiod). The literatures related to the winter annuals like effects of differential temperature on the growth, morphology and flowering of *Antirrhinum majus*, flower production of calendula, growth and flowering of Californian poppy, *Helichrysum bracteatum*, *Coreopsis*, Cornflower, Sweet Williams (Krogt, 1980; Kanamadi et al., 1999; Kazinczi et al., 1999; Shang et al., 2003; Mili & Sable, 2003; Singh, 2005; Dhatt & Kumar, 2007; Ibrahim et al., 2010), flower initiation and development of Petunia and Viola (Mattson & Erwin, 2003), responds of Calendula, Chrysanthemum, Pansy and Snapdragon to high temperatures, impact of reduce temperature and irradiance flowering and growth of four annual bedding plants (Warner & Erwin, 2006; Boldt & Atland, 2019) and assessment of height, earliness and biomass production in winter annuals (Bhattarai et al., 2019) revealed the variation on plant height, growth habit, shape, size, color of flowers, time and duration of flowering within the genotypes, even though these are the species of same growing season. But reports regarding the comparative study and the performance of diverse winter ornamental annuals under different growing environments are in scarcity. Winter annuals being a source of garden decoration are need precise documentation and characterization to satisfy the gardening practices and landscaping principles. In this study, an attempts have been made to study the comparative flowering behavior of twenty different winter flowering ornamental annuals

both under open field and protected conditions to develop a database on the performance of ornamental annuals in the Terai region of West Bengal for more diversified use of ornamental annuals in landscape, garden display as well as in commercial floriculture.

2 Materials and Methods

Present experiment was carried out at the instructional field of Department of Floriculture, Medicinal and Aromatic plants, Faculty of Horticulture, Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, West Bengal, India. Experiment was designed in Randomized Block Design with 20 different winter flowering annuals, each annual were replicated twice (4 plants per each replication). The detail of the selected flowering species is depicted in Table 1. Seeds of 20 winter flowering annuals were

Table 1 Details of the winter flowering ornamental annuals used

Sl. No.	English common name	Botanical name	Plant family
1	Snapdragon	<i>Antirrhinum majus</i> L.	Scrophulariaceae
2	Pot Marigold / Calendula	<i>Calendula officinalis</i> L.	Compositae
3	Straw Flower / Helichrysum	<i>Helichrysum bracteatum</i> (Vent.) Andrews	Compositae
4	Petunia	<i>Petunia hybrida</i> Vilm.	Solanaceae
5	Livingstone Daisy / Mesembryanthemum	<i>Mesembryanthemum criniflorum</i> L.	Aizoaceae
6	Larkspur	<i>Delphinium ajacis</i> L.	Ranunculaceae
7	Daisy / English Daisy	<i>Bellis perennis</i> L.	Compositae
8	Californian Poppy	<i>Eschscholtzia californica</i> Cham.	Papaveraceae
9	Shirley Poppy	<i>Papaver rhoeas</i> L.	Papaveraceae
10	Lupin	<i>Lupinus hartwegii</i> L.	Leguminosae
11	Sweet Pea	<i>Lathyrus odoratus</i> L.	Leguminosae
12	Brachycome / Swan River Daisy	<i>Brachycome iberidifolia</i> Benth.	Compositae
13	Dimorphotheca / African Daisy / Cape Marigold	<i>Dimorphotheca aurantiaca</i> DC.	Compositae
14	Phlox	<i>Phlox drummondii</i> Hook.	Polemoniaceae
15	Sweet William	<i>Dianthus barbatus</i> L.	Caryophyllaceae
16	Coreopsis / Calliopsis / Tick-seed	<i>Coreopsis tinctoria</i> L.	Compositae
17	Dianthus / Common Pink	<i>Dianthus chinensis</i> L.	Caryophyllaceae
18	Candytuft	<i>Iberis umbellata</i> L.	Cruciferae
19	Cornflower	<i>Centaurea cyanus</i> L.	Compositae
20	Pansy	<i>Viola tricolor</i> L.	Violaceae

sown on October 2012 in the seed bed. Beds were prepared having a dimension of 3m x 1m and height of the beds was maintained up to 15 cm from the ground level. 10 g seeds of each winter flowering annual (10x20=200g) were sown in 5 seed beds, seeds of 4 winter annuals were sown in each bed. The initial nutrient provided was 5 kg FYM along with 10 g each of N₂, P₂O₅ and K₂O / m². Copper oxychloride at 2 gL⁻¹ of water was sprayed as preventive measure in the seed bed twice at 10 and 20 days after the seedling emergence.

Seedlings of 28 days were transplanted in the main field with spacing varies with the genotypes (Table 2). Repeated ploughing was followed to bring land to make fine tilth. The entire experimental land was divided into raised beds measuring 1.0 m x 1.0 m and there were 40 plots in each open field and polyhouse condition. Each bed was separated to the other through a 30 cm wide path in both ways. Winter flowering annuals (20 Nos.) were planted in a same manner in open field as well as in polyhouse condition. For present experiment, the galvanized iron pipe frame polyhouses having 200 gauges UV stabilized polyethylene sheet as cladding material and sides were covered with insect proof white nets with side vents open facility were used (zero energy polyhouse).

The average minimum and maximum temperature of open and protected condition varied from 7.96°C and 11.31°C during January to 30.38°C and 34.74°C during October respectively. The relative humidity of the study area varies from 41.87 to 98.03%. Meteorological data for open field was obtained from Gramin Krishi Mausam Seva, AMFU-Pundibari, Coochbehar, West Bengal, India and polyhouse temperature and relative humidity were measured by digital hygrometer. Consequently, the area is warm and humid except a short spell of winter extending from December to February. The meteorological data of the study period is given in Figure 1.

2.1 Parameters recorded:

Flowering parameters such as days required for flower bud initiation (FBI), days required for flower bud development (FBD), Days required for blooming, Days required for wilting of flower were recorded in each plot and their average was calculated. Data were analyzed using GLM procedure of statistical system (SAS) Software (Version 9.3). Design of the experiment was based on randomized block design with two replications in both the condition and parameters were tested at the 5% level of significance.

3 Results and Discussion

Twenty different winter flowering ornamental annuals when grown under open and protected conditions; the flowering commences earlier in open field and later in polyhouse situation.

Table 2 Spacing of the selected Genotypes

Spacing	Genotypes
25cm x 25cm	Daisy, Phlox, Dianthus, Californian Poppy,
	Petunia, Shirley Poppy, Coreopsis, Sweet
	William, Pansy, Candytuft
30cm x 30 cm	Brachycome, Ice Plant, Antirrhinum, Lupin,
	Cornflower, Larkspur, Helichrysum
50cm x 30 cm	Calendula, Dimorphotheca, Sweet Pea

Figure 1 Monthly mean meteorological data of open field and polyhouse during the period of experiment a) Temperature and b) Relative Humidity.

Table 3 Days required for flower bud initiation (FBI), flower bud development (FBD), blooming and wilting of winter annuals in open field and in polyhouse condition.

Genotypes	Open field				Polyhouse			
	FBI (DAT)	FBD (DAT)	Blooming (DAT)	Wilting (DAT)	FBI (DAT)	FBD (DAT)	Blooming (DAT)	Wilting (DAT)
Daisy	40.00	46.70	48.90	58.40	60.88	68.88	72.63	80.00
Phlox	43.80	53.50	55.80	59.30	54.30	65.10	67.80	71.10
Ice Plant	39.34	51.75	55.75	72.00	62.84	74.50	77.17	87.84
Helichrysum	38.67	55.00	60.33	82.17	53.84	69.10	75.67	94.30
Larkspur	48.75	64.88	67.13	79.75	55.17	71.17	73.67	84.34
Antirrhinum	47.00	57.17	60.50	67.33	74.67	86.17	89.00	93.17
Calendula	23.25	32.88	35.50	43.00	29.34	39.67	42.17	49.34
Sweet William	42.34	54.17	56.50	62.67	40.00	50.00	52.50	60.67
Petunia	47.70	55.50	57.50	61.40	67.00	75.13	77.50	83.25
Lupin	51.03	59.43	61.50	65.98	36.75	44.50	46.00	52.25
Brachycome	45.25	55.75	58.33	62.92	62.25	70.50	73.00	77.25
Cornflower	30.82	50.42	52.97	60.10	49.25	65.88	68.50	75.50
Dimorphotheca	40.60	55.20	58.00	65.80	59.00	67.92	71.21	79.84
Dianthus	45.63	55.88	58.38	64.50	48.88	58.50	61.50	69.50
Californian Poppy	45.67	53.75	55.84	59.00	65.75	75.00	77.00	79.00
Shirley Poppy	44.38	55.38	57.13	59.75	52.17	63.34	65.17	68.00
Pansy	26.23	34.15	36.35	46.13	56.94	65.10	67.47	76.77
Candytuft	31.50	39.34	41.17	48.33	34.34	40.50	42.17	50.00
Coreopsis	34.46	51.09	53.25	60.59	44.45	63.73	65.85	72.80
Sweet Pea	37.17	46.84	49.50	56.17	38.25	47.00	49.50	58.75
Pr>F	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
SEM	1.27	1.71	1.80	1.89	2.51	2.38	2.38	2.59
CD at 5%	3.77	5.07	5.32	5.60	7.44	6.99	7.04	7.68

*DAT – Days After Transplanting

Results of study revealed that Calendula reached the flower bud initiation stage earliest (23.25 DAT) and showed resultant earlier flower bud development (32.88 DAT) and full blooming (35.50 DAT) as well as wilting of flowers (43.00 DAT) under open field condition. Delayed flowering was observed in Antirrhinum (74.67 DAT) while delayed wilting was observed with Helichrysum (94.30 DAT) under polyhouse situation. Least time period required to reach FBD from FBI was observed in candytuft (6.17 days), blooming from FBD in Lupin (1.50 days) and wilting of flowers from blooming was recorded in Californian poppy (2.00 days) under polyhouse, whereas, highest time period required from FBI to FBD was noticed in Cornflower (19.60 days) under

open field, from FBD to blooming in Helichrysum (6.57 days) under polyhouse and from blooming to wilting in Helichrysum (21.84 days) in open field condition (Table3).

Annuals showed marked variation to reach into their reproductive phase classifying them as early flowering, mid-season flowering or late bloomers. However, this is well established since time immemorial but the quantitative measurements of these durations were lacking. Moreover, the changes in duration under varied growing conditions also represent the physiological changes within the species as an influence of the growing environment. In this experiment all the winter ornamental annual species except

Table 4 Grouping of genotypes on the basis of FBI and FBI to FBD

FBI				FBI TO FBD			
Means with the same letter are not significantly different				Means with the same letter are not significantly different			
Open field condition		Polyhouse condition		Open field condition		Polyhouse condition	
't' grouping	Genotypes	't' grouping	Genotypes	't' grouping	Genotypes	't' grouping	Genotypes
A	Lupin	A	Antirrhinum	A	Cornflower	A	Coreopsis
B	A Larkspur	B	Petunia	B A	Coreopsis	B A	Cornflower
B	A C Petunia	C	B Californian Poppy	B A	Helichrysum	B	Larkspur
B	D C Antirrhinum	C	B D Ice Plant	B A	Larkspur	B	Helichrysum
B E D C	Californian Poppy	C E B D	Brachycome	B C	Dimorphotheca	C	Ice Plant
B E D C	Dianthus	F C E B D	Daisy	D C	Sweet William	D C	Antirrhinum
B E D C	Brachycome	F C E G D	Dimorphotheca	D C E	Ice Plant	D C E	Shirley Poppy
E D C	Shirley Poppy	F E G D	Pansy	D E	Shirley Poppy	D C E	Phlox
F E D	Phlox	F H E G	Larkspur	D E	Antirrhinum	D C E	Calendula
F E G	Sweet William	F H G	Phlox	D E	Brachycome	D C E	Sweet William
F	G H Dimorphotheca	F H G	Helichrysum	D E	Dianthus	D C E	Dianthus
G H	Daisy	H G	Shirley Poppy	D F E	Phlox	D F C E	Californian Poppy
G H	Ice Plant	H I	Cornflower	D F E	Sweet Pea	D F C E	Dimorphotheca
G H	Helichrysum	H I	Dianthus	D F E	Calendula	D F C E	Sweet Pea
I H	Sweet Pea	J I	Coreopsis	D F E	Lupin	D F	E Brachycome
J I	Coreopsis	J K	Sweet William	F E	Californian Poppy	F	E Pansy
J	Candytuft	J K	Sweet Pea	F E	Pansy	F	E Petunia
J	Cornflower	L K	Lupin	F E	Candytuft	F	E Lupin
K	Pansy	L K	Candytuft	F E	Petunia	F	E Daisy
K	Calendula	L	Calendula	F	Daisy	F	Candytuft

Sweet William and Lupin takes higher time period to reach the FBI under polyhouse cultivation as compared to the open field condition. As compared to both the cases *Calendula* showed the earliest FBI whereas the delayed effect was found variable as in open field condition, *Lupin* reached the FBI stage last of all (51.03 DAT) and in polyhouse condition *Antirrhinum* reached the FBI stage last of all (74.67 DAT). Findings of present study are in close conformity with Cavins et al. (2000), the author reported that warmer greenhouses in each year extended production time for *Antirrhinum*.

Based on the results through the 't' grouping of LSD means, the genotypes reflected 12 classes of data under polyhouse condition as compared to 10 under open field (Table 4) showed more heterogeneity of growth of winter annuals under protected condition. Grouping of genotypes resulted ten winter annuals out of twenty (*Helichrysum*, *Larkspur*, *Sweet William*, *Lupin*, *Brachycome*, *Cornflower*, *Dimorphotheca*, *Dianthus*, *Candytuft* and *Sweet Pea*) required higher time period to attain FBD from FBI under open field as compared to polyhouse. Although, data pertaining from the table 4 showed that in both the cases genotypes were grouped into 6 (Table 4) but wide variation in the growth of flower bud was also noticed as the same species were not grouped in a similar pattern showing differential response to

agro-climatic and microclimatic condition. However, only 8 winter annuals (*Ice plant*, *Antirrhinum*, *Calendula*, *Lupin*, *Brachycome*, *Californian Poppy*, *Coreopsis* and *Sweet Pea*) took maximum time period to reach the blooming stage under open field condition than polyhouse. Data presented in Table 5, on the basis of growth of flower buds showed 8 classes under protected condition as compared to 7 classes under open field situation reflecting wider heterogeneity of flower bud maturity by the genotypes under polyhouse situation might be due to differential response to microclimate. It was found that the *in-situ* longevity of flowers under open field was found better than polyhouse condition except *Sweet Pea*, *Candytuft*, *Shirley poppy*, *Dimorphotheca*, *Lupin*, *Petunia* and *Sweet William*. Grouping of genotypes showed marked variation within the genotypes and it is also become useful to select the relative placement of annuals in several garden components, herbaceous borders and in outdoor landscaping.

In any landscaping condition synchronized blooming is an essential principle to use its best effect along with color combination of winter annuals (Lindgren et al., 2007; Love et al., 2009). The current experiment gave the precise database of the comparative performance of twenty different winter annuals with respects to the duration between the major stages of flowering in

Table 5 Grouping of genotypes on the basis of FBD to Blooming

FBD to Blooming										
Means with the same letter are not significantly different										
Open field condition					Polyhouse condition					
't' grouping		Genotypes			't' grouping		Genotypes			
A		Helichrysum			A		Helichrysum			
B		Ice Plant			B		Daisy			
C	B	Antirrhinum			C	B	Dimorphotheca			
C	D	Dimorphotheca			C	B	D	Dianthus		
C	D	E	Sweet Pea		C	E	D	Antirrhinum		
C	D	E	Calendula		C	F	E	D	Phlox	
	D	E	Brachycome		C	F	E	D	Ice Plant	
F	D	E	Cornflower		C	F	E	D	Cornflower	
F	D	E	Dianthus		G	C	F	E	D	Calendula
F	G	D	E	Sweet William	G	C	F	E	D	Larkspur
F	G	D	E	Phlox	G	C	F	E	D	Brachycome
F	G	D	E	Larkspur	G	C	F	E	D	Sweet William
F	G	D	E	Daisy	G	C	F	E	D	Sweet Pea
F	G	D	E	Pansy	G	H	F	E	D	Petunia
F	G	D	E	Coreopsis	G	H	F	E	D	Pansy
F	G	D	E	Californian Poppy	G	H	F	E		Californian Poppy
F	G		E	Lupin	G	H	F			Shirley Poppy
F	G		E	Petunia	G	H				Candytuft
F	G			Candytuft	G	H				Coreopsis
	G			Shirley Poppy		H				Lupin

both ways from the day after transplanting as well as from the preceding stage. This experiment was performed to provide the information about winter annuals for the growers to sow the late bloomers well ahead with a quantitative measurement. Various researchers also found that the species-wise variation regarding different durations might be due to the combination of several factors like environmental stimuli, inherent growth pattern, soil condition, genotypic configuration of the species (Munir et al., 2004; Inaba & Ohshiro, 2005; Ibrahim et al., 2010; Ali, 2013). Apart from that, the variation in maturity was observed due to the effect of temperature under different growing conditions during flowering period (Niu et al., 2000; Kang & Iersel, 2001; Niu et al., 2006; Warner, 2010). Fluctuation in flowering behavior under open and protected condition was observed in this experiment due to temperature and light quality was corroborated by the observations of Kumar & Kaur (2000) and Warner & Erwin (2002) also noticed significant variation in FBI and other phases of flower development within the different ornamental annual species.

Conclusion

The results obtained from the present experiment revealed that the variability exists within the genotypes under each growing environment or in the same genotype under different growing conditions. To exert the best effect in any landscaping situation, especially in herbaceous borders - simultaneous blooming is an essential principle with color combination. To achieve this objective, it is essential to categorize the plants accordingly by comparing its flowering habit and colour combination.

Conflict of Interest

No conflict of interest.

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