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Effect of date of transplanting and row orientation on dry matter partitioning and flower size in chrysanthemum

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ABSTRACT

In order to study the effects of date of transplanting, row spacing and their orientation on the dry matter partitioning and flower size in Chrysanthemum an experiment was conducted during 2019-2020 on *Solan Shringar* cultivar of Chrysanthemum at experimental farm of Department of Environmental Science, Dr. Yashwant Singh Parmar University of Horticulture & Forestry Nauni (30°86'N, 77°16'E and 1275 m amsl). Days required attaining different phenophases decreased with delayed transplanting and for maturity from 185 to 155 days. The effect of row spacing and orientation on number of these days was observed significant in earlier (D_1 and D_2) transplanted crop compared to late (D_3). The phasic rate of dry matter accumulation was highest 148.2g per successive phase (R^2=0.991) under D_1 followed by 109.7g (R^2=0.987) under D_2 and a drastic reduced rate of 54.4 g (R^2=0.991) per successive phase under late transplanting (D_3).A close relationship (R^2>0.98) was observed between dry matter accumulation and successive phenophases. The dry matter partitioning trend among different parts was observed as flower > stem > leaves > roots. The plant density and row orientation significantly affected crop growth rate and dry matter accumulation under different environments. A close linear relationship (R^2> 0.96) was observed between flower dry mass (FDM) leaf area index (LAI) per plant of the chrysanthemum crop.

Keywords: dry matter partitioning, flower yield, LAI, plant density and Chrysanthemum.

1. INTRODUCTION

Chrysanthemum (*Dendranthema grandiflora* Tzvelev) is a valuable commercial flower crops grown for its attractive flowers in all over the world. The chrysanthemum name was given by great botanist Carl Linneas in 1753 which originated from Greek word "Chryos" means "Sun" (Kher, 1988). As a flowering herb Chrysanthemums were first cultivated around 15th century BC as one of the ten most popular traditional flowers in China and most popular cut flowers in the world hence, occupy a very important position in the world flower industry (Anderson, 2007). The Chrysanthemum herb used in the treatment of autoimmune diseases includes inflammation and elevated blood pressure as well as those that target the respiratory apparatus of the human body (Kato *et al.*, 1987).

It occupies a place of pride in India both as a commercial and exhibition and the most important cut & loose flower (Liu *et al.*, 2012) crops which is being cultivated and traded throughout the country. In Hindi commonly known as *Guldaudi* and also known as *"Queen of the East"* & *"Glory of the East"* (Mohapatra *et al.*, 2000; Randhava and Mukhopadhyay, 1986), *Samanti* in the southern states and *Shevanti* in the western states, and *'Bijli'* in Maharashtra. It covers around 20.55 thousand hectares with loose flower production of 188.81 thousand metric tons and cut flower production 15.38 thousand metric tons, Himachal Pradesh ranks 5th in the country with a total production of 11.46 thousand tons (Anonymous 2017).

The prediction of plant behavior under different environmental conditions has long been an aim of plant science. This aim is driven not just by scientific curiosity only but by the practical needs also of crop cultivation, especially for horticultural plants (Singh and Jangra, 2018). In many crops the main interest is production and yields itself whereas in ornamental plants, like chrysanthemum, both the flower yield and other external quality characteristics aspects are important (Kang *et al*., 2012). Dry matter partitioning among plant parts is considered to be a major determinant for crop yield. It is dependent upon the efficiency of translocation of photosynthate in different parts of the crop. Heuvelink (1999) observed that a constant partitioning to the leaves of tomato as a fraction of the total growth of vegetative parts, but this fraction was constant in chrysanthemum during the vegetative phase only (Acock *et al.*, 1979). Partitioning of DM to the leaves declined strongly as fraction of total plant growth and total growth of chrysanthemum during the generative phase (Hughes and Cockshull, 1971; Karlsson and Heins, 1992). In India studies on dry matter partitioning are available for different agricultural crops but unfortunately not for chrysanthemum. Therefore, present study was undertaken with the aim to know the translocation of dry matter in different parts and flower size of chrysanthemum under different environmental conditions in mid hills of Himachal Himalayas.

2. MATERIALS AND METHODS

Location of Study

The experiment was conducted during 2019-2020 at experimental farm of Department of Environmental Science, Dr. Yashwant Singh Parmar University of Horticulture & Forestry Nauni (30^{o}86'N, 77^{o}16'E and 1275 m amsl).The climate of the area is sub-tropical to sub-temperate and semi-humid characterized by cold winters and experiences distinguished major four seasons in the year. The normal maximum temperature was 25.3 ^{o} C, minimum temperature 11.5^{o} C, relative humidity 64 per cent and rainfall 1118mm, respectively. The soil is normal having pH experimental6.8 to 7.2 with brown in color and sandy loam texture. For the crop duration daily maximum (Max-T), minimum temperature (Min-T), morning (RH-m) & evening (RH-e) relative humidity, rainfall, bright sunshine hours (BSH) were recorded at Agromet observatory installed at near the experimental farm (Fig 1).

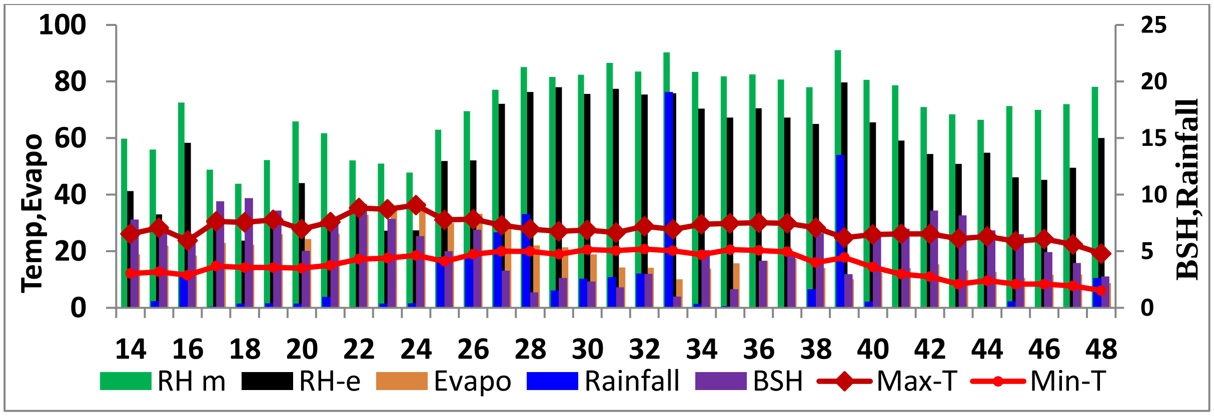

Fig.1: Weather conditions during study period for Chrysanthemum

Experimental Details

The field experiment was conducted during 2019-2020 on *Solan Shringar* cultivar of Chrysanthemum. The one month old seedlings prepared from the cuttings of the chrysanthemum was transplanted at three dates D$_1$ (25th May), D$_2$ (9th June) and D$_3$ (24th June) in well prepared plots at two plant density S$_1$ (20 plants m^{-2}) and S$_2$ (15 plants m^{-2}) with two row orientations of O$_1$ (N-S) and O$_2$ (E-W) with three replications making total numbers of plots 36. The recommended packages of practices for the crop were adopted. After transplanting when the seedlings (cuttings) well established in the field and showed growth characteristics then the apical buds were pinched out to get maximum branching (lateral shoots) to bear increased numbers of flower for getting highest flower yield.

Plant Measurements

The number of days to attain various phenophases namely pinching, bud formation, flowering and maturity were visually observed from randomly selected three plants from each treatments after transplanting. In all treatments destructive measurements were carried out 3 to 10 days until the final harvest. Samples were taken from three or five plants in two rows on each side of a treatment bed. Total leaf area (with the help of line quantum sensor), and fresh and dry (105^{o}C for 14 h in oven with ventilated) mass of root, stem, leaves and flowers were measured.

3. RESULTS & DISCUSSION

Phasic Development

Results of two years pooled data analysis showed that number of days required by Chrysanthemum to attain different phenophases under different treatments after transplanting varied from 18-29 for pinching, 108-137 for bud formation, 125-154 for flowering and 155 to 185 for maturity/harvesting (Table 1).

Table 1: Days taken to attain successive phenophasesunder different treatments

Treatments	Pinching	Bud formation	Flowering	Maturity/ Harvesting
$D_1S_1O_1$	26	133	151	181
$D_1S_1O_2$	28	135	153	184
$D_1S_2O_1$	29	137	154	185
$D_1S_2O_2$	29	137	153	184
$D_2S_1O_1$	27	121	139	167
$D_2S_1O_2$	29	122	139	166
$D_2S_2O_1$	30	125	142	169
$D_2S_2O_2$	32	131	150	179
$D_3S_1O_1$	18	108	125	155
$D_3S_1O_2$	19	108	125	155
$D_3S_2O_1$	20	112	130	161
$D_3S_2O_2$	20	112	130	161

The number of days required for different phenophases decreased with delayed transplanting. The effect of row to row spacing and their orientation on number of days required to attain different growth stages was observed significant in earlier (D_1 and D_2) transplanted compared to late (D_3) transplanted Chrysanthemum crop. On an average the maturity (flower harvesting) was attained by the crop transplanted on 25th May, 9th June and 24 June in 184 days, 171 days and 158 days, respectively with a deviation of 13 days between each date. Jacobsen and Amsen (1992) reported significant deviation in number of days from bud burst to bloom in Chrysanthemum. Sargun *et al*., (2019) also reported deviation in days for attaining various phenophases and maturity with delayed date of sowing of pea cultivars. Similar results were obtained by Singh and Bhatia (2012) in apple.

Dry Matter Partitioning

The accumulation of dry matter among different parts (root, stem and leaves) of chrysanthemum was observed highest in stem up to the bud formation phenophase under all the dates of transplanting (Table 2). At full bloom and maturity the maximum dry matter was translocated to the flower of the crop. The dry matter accumulation in stem and leaves attained their peak at flowering, after that it started declining to harvest of flower or maturity which showed that their growth slowed down after flowering. This trend was observed for all the three dates of transplanting. The root weight showed a continuous increasing trend but its share in the total plant dry matter decreases with maturity. From bloom to maturity the highest percentage of dry matter accumulated in flower under all the dates of transplanting.

Table 2: Effect of transplanting date on DM accumulation at successive growth stages

Phenophases	Dry matter accumulation in different plant parts (g/plant)				
	Root	Stem	Leaves	Flower	Total
	First transplanting (D_1): 25th May				
Pinching	1.5 (23.9)*	2.5 (40.6)	2.2 (35.5)	0.0 (0)	6.2
Bud formation	18.1 (13.3)	48.2 (35.6)	36.6 (27.0)	32.7 (24.1)	135.5
Flowering	19.6 (6.0)	52.0 (16.0)	42.1 (13.0)	210.9 (65.0)	324.6
Maturity	16.8 (3.8)	43.8 (10.0)	39.9 (9.1)	336.8 (77.0)	437.3
	Second transplanting (D_2): 9th June				
Pinching	1.0 (17.0)	2.7 (47.4)	2.0 (35.6)	0.0 (0)	5.7
Bud formation	14.9 (14.4)	41.4 (39.9)	29.3 (28.3)	18.0 (17.4)	103.7
Flowering	16.1 (6.5)	47.7 (19.3)	34.4 (13.9)	149.0 (60.3)	247.2
Maturity	14.0 (4.3)	36.9 (11.4)	32.4 (10.0)	240.4 (74.3)	323.6
	Third transplanting (D_3): 24th June				
Pinching	1.1 (20.1)	2.5 (46.0)	1.8 (33.9)	0.0 (0)	5.4
Bud formation	5.8 (12.8)	17.5 (38.5)	14.7 (32.4)	7.4 (16.3)	45.6
Flowering	7.5 (6.2)	20.9 (17.3)	17.5 (14.5)	74.8 (62.0)	120.6
Maturity	7.9 (4.8)	21.7 (13.4)	18.4 (11.4)	114.0 (70.4)	162.0

* *(Values in parenthesis are percentage of total)*

Total and plant part's dry matter accumulation in the chrysanthemum decreased drastically with delayed transplanting which was observed highest in D_1 (437.3 g) followed by D_2 (323.6 g) and only 162 g under third date. The phasic rate of dry matter accumulation was highest 148.2g per successive phase (R^2=0.991) under early transplanting (D_1) followed by 109.7g (R^2=0.987) under mid transplanting (D_2) and a drastic reduced rate of 54.4 g (R^2=0.991) per successive phase under late transplanting. A close relationship (R^2>0.98) was observed between dry matter accumulation and successive phenophases during the crop growth in each of the treatments (Fig 2).

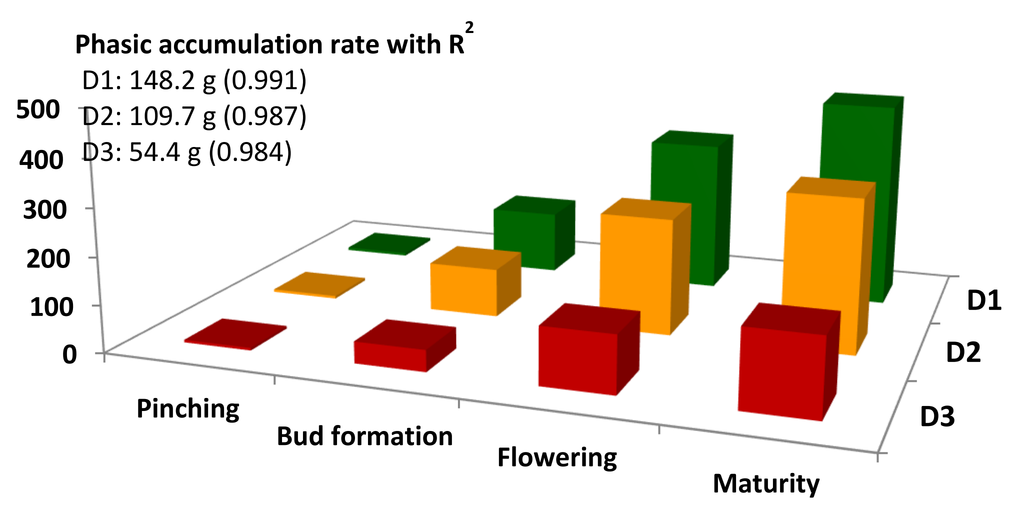

Fig 2: Total phasic DM accumulation under varying date of transplanting

The plant density and row orientation significantly affected crop growth rate and dry matter accumulation under different environments. The highest dry matter accumulation observed under first date of transplanting with plant density of 15 plants m^{-2} and E-W orientation ($D_1S_2O_2$) whereas lowest was recorded under third date of transplanting with plant density of 20 plants m^{-2}

and N-S row orientation ($D_3S_1O_1$) (Table 3). The dry matter partitioning trend among different parts was observed as flower > stem > leaves > roots.

Table 3: Effect of different treatments on DM partitioning (%)

Treatments	Root	Stem	Leaves	Flowers
$D_1S_1O_1$	3.89	10.18	9.00	76.94
$D_1S_1O_2$	3.90	10.02	9.07	77.01
$D_1S_2O_1$	3.89	10.42	9.59	76.10
$D_1S_2O_2$	3.70	9.40	8.78	78.12
$D_2S_1O_1$	4.13	11.37	10.14	74.36
$D_2S_1O_2$	4.39	11.80	10.22	73.59
$D_2S_2O_1$	4.35	11.31	9.77	74.56
$D_2S_2O_2$	4.37	11.14	9.92	74.57
$D_3S_1O_1$	5.07	14.15	12.05	68.73
$D_3S_1O_2$	5.12	14.14	11.89	68.85
$D_3S_2O_1$	4.58	12.25	10.62	72.55
$D_3S_2O_2$	4.70	13.31	11.14	70.84
CD (0.05)	***0.12***	***0.19***	***0.23***	***0.68***

Flower Numbers, Size and Yield

The total dry matter (TDM) production of flower was ranged from 722.5g to 998.6 g/plant under different treatments. For D_1it was between 981.4 to 998.6g/plant for D_2between 955.5-969.3g/plant and for D_3 between 722.5-740.6g/plant. The fresh and dry TDM of flower was continuously decreased with delayed transplanting of the crop. Flower size has the potential to increase when sink/source ratio is reduced i.e. when the number of competing sinks for assimilates is reduced or the source activity is increased which agree with finding of Cockshull (1982) and Lee *et al.,* (2001). In contrast with TDM, flower mass ratio (*FMR – i. e. ratio of total flower dry weight to the total aerial plant dry weight*) was highly influenced by the numbers of flower per plant. Marcelis (1991), Heuvelink and Buiskool (1995) has been observed in vegetable crops that the dry mass translocation towards the fruits is also highly dependent on the numbers of fruit per plant and at a saturation response.

FMR showed a saturation type response to the number of flower per plant with a maximum of 0.21 (Fig 3). This agree with earlier studies results obtained by Cockshull and Hughes (1971) observed a delayed floret initiation under delayed transplanting which would possibly results in a less number of florets and, hence, in a smaller sized flower.

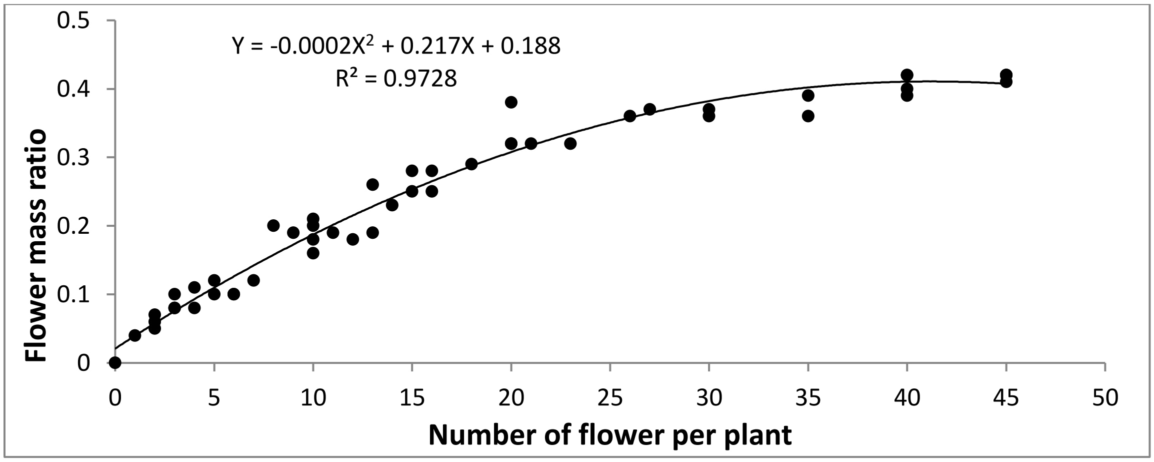

Fig 3: Relation of FMR with number of flowers per plant

As chrysanthemum has a basipetal progression of flower bud initiation and its development (Langton, 1992), the observed effect of the position flower on the size of flower can partly be explained by the hypothesis that flowers those initiate first they maintain their lead throughout their development (Fig 4). This effect was earlier described by Jullien *et al*., (2001) for development of fruit in banana.

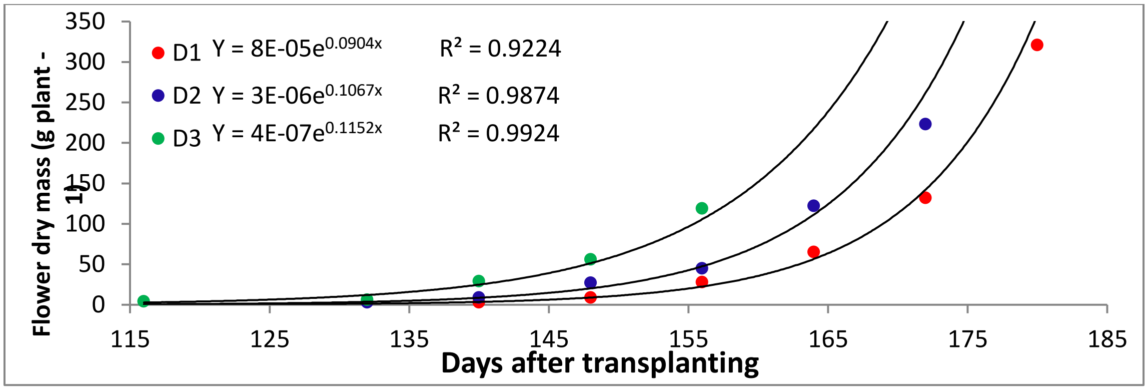

Fig 4: Dynamics of flower dry mass per plant in chrysanthemum

Flower dry mass vs and LAI

A close linear relationship ($R^2 > 0.96$) was observed between flower dry mass (FDM) leaf area index (LAI) per plant during crop growth in each of the three dates of transplanting and for pooled data of three dates (Fig 5). The slope of these lines could be used to estimate the specific leaf area of the crop by using the parameters determined by Acock *et al.,* (1979). Since LAI is high at full bloom (maturity), resulting in interception of almost all light (closed canopy), over estimation of LAI hardly influences light interception and hence, the simulated crop growth rate.Even though there were large differences in crop management and environmental conditions between the present experiment and the commercially grown crops, predicted leaf growth based on measured flower dry mass agreed very well with measured leaf growth (Fig 5). LAI is often hugely over estimated before the closure of the canopy (Lieth and Pasian, 1991; Heuvelink, 1999). In the present study estimation of LAI before the closure of canopy (LAI ~ 4.5) agreed well with the measurements done using a simple approach of dry mass partitioning to flower as a function of relative times (Fig 4). This approach is valuable for photosynthesis driven crop growth models, as their accuracy depends strongly on prediction of light interception.

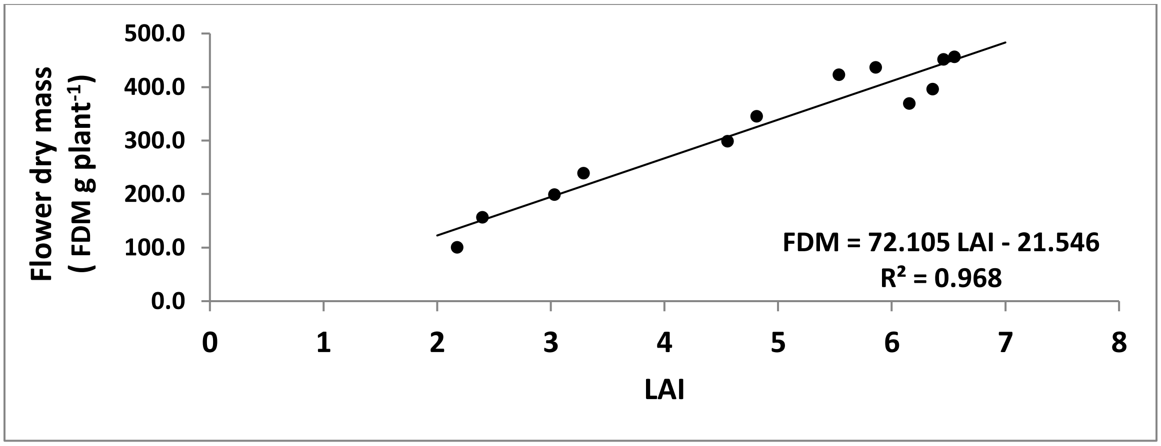

Fig 5: Relation between FDM and LAI (*pooled of three dates*)

4. CONCLUSION

More number of days for attaining different phenophases with higher heat units was observed with the longer duration Chrysanthemum crop. On an average the maturity (flower harvesting) was attained by the crop transplanted on 25th May, 9th June and 24 June in 184 days, 171 days and 158 days, respectively with a deviation of 13 days between each date. The dry matter accumulation continuously decreased with delayed transplanted crop. Significantly higher dry mass accumulation recorded from 140 to 160 days after transplanting due to higher growth efficiency during maximum branching, leaves and flowering which could be reasoned for significantly better biomass and flower yield. A close relationship (R^2>0.98) was observed between dry matter accumulation and successive phenophases during the crop growth. The dry matter partitioning trend among different parts was observed as flower > stem > leaves > roots. The plant density and row orientation significantly affected crop growth rate and dry matter accumulation under different environments. The estimation of LAI before the closure of canopy agreed very well with measurements, using a very simple approach which based on dry mass partitioning to flower as a function of relative times. A close linear relationship ($R^2 > 0.96$) was observed between flower dry mass (FDM) leaf area index (LAI) per plant during crop.

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Conflict of Interest

The author declares that they have no conflict of interest.

Data and materials availability

All data associated with this study are present in the paper.

REFERENCES AND NOTES

1. Acock, B., Charles-Edwards, D.A. and Sawyer, S. (1979). Growth response of a *Chrysanthemum* crop to the environment. III. Effects of radiation and temperature on dry matter partitioning and photosynthesis. *Annals of Botany*, 44: 289–300.
2. Anderson, N.O. (2007). Flower Breeding and Genetics: Issues, Challenges and Opportunities for the 21st Century, *Springer Science & Business Media*, 2006.
3. Anonymous. (2017). Indian Horticulture Database. Available at www.nhb.gov.in assessed 3rdNovember, 2017. NHB.
4. Cockshull, K.E. (1982). Disbudding and its effect on dry matter distribution in Chrysanthemum morifolium. *J Hort. Sci 57*: 205–207.
5. Cockshull, K.E. and Hughes, A.P. (1971). The effects of light intensity at different stages in flower initiation and development of Chrysanthemum morifolium. *Ann Bot 35:* 915–926.
6. Heuvelink, E. (1999). Evaluation of a dynamic simulation model for tomato crop growth and development. *Annals of Botany*, 83: 413–422.
7. Heuvelink, E. and Buiskool, R.P.M. (1995). Influence of sink-source interaction on dry matter production in tomato. Ann Bot 75: 381–389.
8. Hughes, A.P. and Cockshull, K.E. (1971). The effects of light intensity and carbon dioxide concentration on the growth of *Chrysanthemum morifolium* cv. *Bright Golden Anne Annals of Botany*, 35: 899–914.
9. Jacobsen, L., Amsen, M. G. (1992). The effect of temperature and light quality on stem elongation of chrysanthemum, *Acta Horticulturae*, 305: 45–50.
10. Jullien, A., Male´zieux, E., Michaux-Ferrie`re, N., Chillet, M. and Ney, B. (2001). Within-bunch variability in banana fruit weight: importance of developmental lag between fruits. *Ann Bot 87:* 101–108.
11. Kang, M.Z., Heuvelink, E., Susana, M.P., Carvalho and Reffye, D.P. (2012). A virtual plant that responds to the environment like a real one: the case for chrysanthemum, *New Phytologist, 195*: 384–395.10.
12. Karlsson, M.G. and Heins, R.D. (1992). Chrysanthemum dry matter partitioning patterns along irradiance and temperature gradients. *Canadian Journal of Plant Science* 72: 307–316.
13. Kato, T., Noguchi, K., Miyamoto, Y. (1987). Effects of Chrysanthemum indicum Linn. on coronary, vertebral, renal and aortic blood flows of the anesthetized dog, *Archives Internationales De Pharmacodynamie Et De Therapie, 285* (2): 288–300.
14. Kher, M.A. (1988). Chrysanthemum in India. New Delhi.*Associated Publishing Company*, p-4.
15. Langton, F.A. (1992). Interrupted lighting of chrysanthemums: monitoring of average daily light integral as an aid to timing. *Sci. Hortic 49*: 147–157.
16. Lee, B.J., Won, M.K., Lee, D.H. and Shin, D.G. (2001). Effects of sourcesink on flowering and growth in chrysanthemum (*Dendranthema grandiflora* Tzvelev). J Korean Soc. *Hortic Sci 42:* 625–630.

17. Lieth, J.H. and Pasian, C.C. (1991). A simulation model for the growth and development of flowering rose shoots. *Scientia Horticulturae 46*: 109–128.
18. Liu, P.L., Wan, Q., Guo, Y.P., Yang, J. and Rao, G.Y. (2012). Phylogeny of the genus *Chrysanthemum* L.: evidence from single-copy nuclear gene and chloroplast DNA sequences, *PLoS ONE*, 7: e48970.
19. Marcelis, L.F.M. (1991). Effect of sink demand on photosynthesis in cucumber. *J Exp Bot 42:* 1387–1392.
20. Mohapatra, A, Arora, J.S. and Sidhu, G.S. (2000). Evaluation of Chrysanthemum varieties for pot culture, *J. Orna. Hort., New Series*, 3(2): 79-82.
21. Randhava, M. and Mukhopadhyay, A. (1986). Chrysanthemum: Floriculture in India, pp 362-367.
22. Sargun, K., Mohan Singh and Bhardwaj, S.K. (2019). Response of Pea Cultivars to Varying Environments in Mid Hills of Himachal Himalayas, *Int J Recent Sci Res.,* 10(12): 36626-36629.
23. Singh, M and Jangra, S. (2018). Thermal indices and heat use efficiency of apricot cultivars in Himachal Himalayas, *Climate Change*, 4(14): 224-234.
24. Singh, M. and Bhatia, H.S., (2012). Thermal indices in relation to crop phenology and fruit yield of apple, *MAUSAM, 63(3):* 449-454.