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Germination, vegetative and flowering behavior of Balsam (*Impatiens balsamina* L.) in response to natural photoperiods

Muhammad Aslam Baloch[1], Tanveer Fatima Miano*[1], Niaz Ahmed Wahocho[1], Naheed Akhtar Talpur[2], Abdul Qadir Gola[1]

[1]Department of Horticulture, Sindh Agriculture University Tandojam, Pakistan
[2]Department of Soil Science, Sindh Agriculture University Tandojam, Pakistan
Corresponding Author: **Dr. Tanveer Fatima Miano***, Associate Professor
Corresponding Author Email: drtanveerfmiano@yahoo.in

Abstract**—** *A lack of application of photoperiod and light intensity to manipulate the growth of current spring annuals has, in part, been due to the lack of information identifying the photoperiodic and light intensities requirements of various species. Present pot experiment was carried out at Horticulture Garden, Department of Horticulture, Sindh Agriculture University Tandojam, during spring 2017, which was laid out in a three replicated Complete Randomized Design (CRD). Two varieties of balsam (V1= Tom Thumb, V2 = Double Camcellia) were studied under NP_1= Control (Normal day length), NP_2=3 hrs (8:00 am- 11:00 am), NP_3= 6 hrs (8:00 am – 2:00 pm), NP_4= 9 hrs (8:00 am-5:00 pm), NP_5= Natural shade. Results from the research data revealed significant ($P<0.05$) photoperiodic effect on the growth and flower quality of balsam. The study revealed that maximum seed germination (44.81 %), germination index (0.62 gi) plant height (13.96 cm), leaves plant^{-1} (37.60), days to 1st flower (52.62)' flowers plant^{-1} (3.40), days to flower persistence (8.74), weight of single flower (0.59 g), chlorophyll content (34.1 SPAD) was recorded from variety Tom Thumb, whereas the variety Double camellia had minimum seed germination (38.51 %), germination index (0.55 gi) plant height (11.42 cm), leaves plant^{-1} (26.10), days to 1st flower (51.72)' flowers plant^{-1}(2.80), days to flower persistence (6.98), weight of single flower (0.52 g), chlorophyll content (31.29 SPAD) The results for natural photoperiods on vegetative and flowering behavior of Balsam are significant effect on different growth parameters. The results indicated that maximum seed germination (74.99 %), germination index (1.18 gi) plant height (17.28 cm), leaves plant^{-1} (58.33), days to 1st flower (64.75)' flowers plant^{-1} (5.41), days to flower persistence (13.16), weight of single flower (1.26 g), chlorophyll content (46.79 SPAD) was recorded from NP_4= 9 hrs (8:00 am-5:00 pm) as compared to seed germination (63.88%), germination index (0.66 gi) plant height (14.92 cm), leaves plant^{-1} (48.16), days to 1st flower (45.96)' flowers plant^{-1} (5.00), days to flower persistence (11.16), weight of single flower (0.62 g), chlorophyll content (36.46 SPAD) was recorded from NP_1= Control (Normal day length).*

Keywords*— *flowering behaviour, natural photoperiods, Complete Randomized Design.

I. INTRODUCTION

Balsam, (*Impatiens balsamina* L.) is an ornamental plant in the Balsaminaceae family (Gardeners, 2017). It is a quick growing summer annual flower, with gardenia-like blooms (Tooke and Battey, 2000). Continuous blooms grow on top of a bushy plant with leaves. The balsam is originated in Asia, North America and South Africa and there are numerous annual and perennial varieties (Christopher, 2013). The blooms appear in about 60-70 days and colours include shades of white, pink, rose, violet, and red (Park *et al*., 2003; Wang *et al*., 2009). Different parts of the plant are used as traditional remedies for disease and skin afflictions. Juice from the leaves is used to treat warts and snakebite, and the flower is applied to burns (Wang *et al*., 2009). This species has been used as indigenous traditional medicine in Asia for rheumatism, fractures, and other ailments (Park *et al*., 2003). Changes in temperature and day-length trigger physiological and seasonal developmental processes of ornamental plants that enable ornamental plants withstand severe climatic conditions (Adams *et al*. 2005). Climate change is expected to increase the air temperature in the summer, while the natural decreasing photoperiod remains unaffected (Kim *et*

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al., 2009). As shown previously, an increase in air temperature inhibits CO_2 assimilation, with a concomitant increased capacity for zeaxanthin-independent dissipation of energy exceeding the photochemical capacity of plants (Busch *et al*.,2008). Flowering behaviour in plant cycle shows the adaptability of plants to seasonal changes (Kim *et al*., 2009) and increase in duration of photoperiod reduced time to first visible bud. Temperature and day length are related in the sense that as the natural day length becomes longer or shorter, the temperature warms or cools, respectively (Ha, 2014). A lack of application of photoperiod and light intensity to manipulate the growth of current spring annuals has, in part, been due to the lack of information identifying the photoperiodic and light intensities requirements of various species. The proposed study is mainly aimed at examining the effect photoperiod on germination of vegetative and flowering traits Balsam (*Impatiens balsamina* L) under light intensity.

II. MATERIALS AND METHODS

Present study was conducted during summer, 2017 at Horticulture Garden, Department of Horticulture, Sindh Agriculture University, Tandojam. Seed of two balsam verities (V_1= Tom Thumb, V_2 = Double Camellia) were sown in 20-cm diameter earthen pots in late February 2017 using a silt FYM-based medium in a 1:1 ratio based on volume. Potted seed of both balsam varieties were germinated with five natural photoperiod treatments resulted from the installation of black shade cloth. For control treatment pots were simply kept under normal day length in sun light, while pots of both varieties were kept under shade for normal day length, while for other photoperiod pots were covered with black cloth and uncovered as per photoperiod hours. Such a design has been used to exclude any direct illumination and to obviate any microclimate alterations due to the presence of the shade cloth. A two factor (**Factor -A**: Varieties (V) = 02 (V_1 = Tom Thumb, V_2 = Double Camellia); **Factor-B**: Natural Photoperiods (NP) = 04 (NP_1= Control (Normal day length= 12 hrs= 6 am to 6 pm), NP_2=3 hrs (8:00 am-11:00 am), NP_3= 6 hrs (8:00 am – 2:00 pm), NP_4= 9 hrs (8:00 am-5:00 pm), NP_5= Natural shade) Completely Randomized Design (CRD); was set out with three replications where each replication was had four pots. Frame structure was made by placing wooden pegs of about 4 ft in height from ground length on both side of the plant row than a black thick cloth was covered leaving 3 inches from the ground surface for aeration, where plants were observed for seed Germination (%), germination index (GI), plant height (cm), leaves plant^{-1}, days to 1st flower, flowers plant^{-1}, days to flower persistence, weight of single flower (g), chlorophyll content (SPAD).

Procedure of recording observations

Seed Germination (%): Germination percentage was calculated as per following formula. Total number of seeds was sown and at seventh day germinated seedlings were calculated from each treatment than were divided with total number of seeds sown which were multiplied by 100 as per follows:

GP = Seeds germinated / Total No. of seed x 100

Germination index (GI): Germination /emergence index (GI/E) was calculated by following formula used by Association of Official Seed Analsis (AOSA, 1990)

$$\text{GI or EI} = \frac{\text{No of germinated or emerged seeds}}{\text{Days of first count}} + \ldots\ldots + \frac{\text{No of germinated or emerged seeds}}{\text{Days of final count}}$$

Plant height (cm): Four plants of each variety's were selected at random from pots and their hight was meausred from ground surface to the top with foot scale and the average tallness was worked out in cm at the time of the flowering.

Leaves plant^{-1}: Average number of leaves per plant was calculated on visually from six randomly plant of each variety under each treatment

Days to 1st flower: Days to flower emergence from each variety of the randomly selected plants were noted as they 1st appeared after germination and average was worked out.

Flowers plant^{-1}: Flowers from each variety of the randomly selected plants were counted visually at maturity as they appeared and then average was worked out.

Days to flower persistence: This observation was recorded from the day of flower emergence till the flower withered or dropped on plant than days were counted and average was worked out.

Weight of single flower (g): Flowers of each variety were collected and tagged at random and weighed as an individual on weighing balance machine to record the weight in g.

Chlorophyll content (SPAD): Chlorophyll content each plant from each treatment was noted on chlorophyll meter. Leaves from top, mid and bottom where tagged and then placed while attached on the plant digital meter (SPAD METER) then reading were noted and there after average was done.

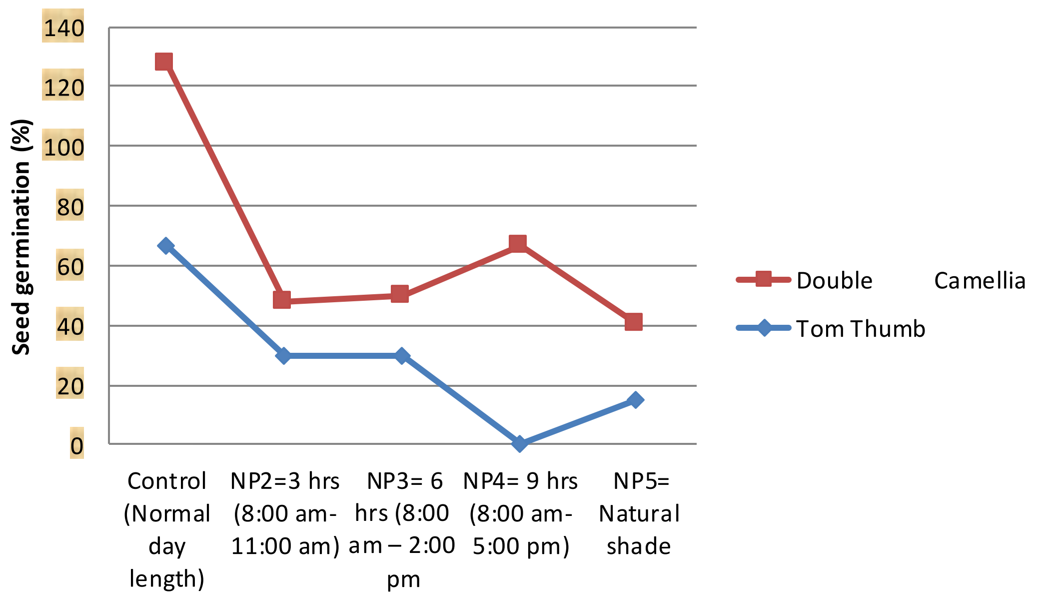
Average temperature and RH recorded during entire experiment:
February= 18-22 °C, March = 25-27°C, April= 25-32 °C
RH= 75-85%

Statistical analysis:
The data was statistically analyzed using Statistix-8.1 computer software (Statistix, 2006). The Deccan's Multiple Range Test was applied to compare treatments superiority in case results are significant at $P \leq 0.05$ probability level.

III. RESULTS AND DISCUSSION

Seed Germination (%)
Results pertaining to germination (%) as affected by different natural photoperiods on vegetative and flowering behavior of Balsam are presented in the Fig-1. Both the varieties responded well when exposed to natural photoperiod from 8:00 am to 5:00 pm. Tom Thumb had maximum seed germination (83.33%) followed by Double camellia (66.66). However when both varieties were exposed to low photoperiod from 8:00 am to 11:00 am produced less seed germination (29.62 and 18.51 % respectively). Results also revealed that the maximum seed germination (74.99) was observed from NP_4= 9 hrs (8:00 am-5:00 pm) followed by control (12 hrs= 6 am to 6 pm) where plant were grown in full day sunlight (63.88). Further data showed that NP_2=3 hrs (8:00 am- 11:00 am), NP_3= 6 hrs (8:00 am – 2:00 pm and NP_5= Natural shade had maximum seed germination of balsam (24.06, 24.99 and 20.36 %, respectively).

Fig. 1: Seed germination (%) of balsam in response to natural photoperiods



Germination index
The results for varieties seed germination index (Fig. 2) revealed that the variety Tom Thumb produced maximum (0.62 GI) germination index as compared to Double Camcellia (0.55 GI). Both the varieties responded well when exposed to natural photoperiod from 8:00 am to 5:00 pm. Tom Thumb had maximum germination index (1.30 GI) followed by Double camellia (1.07 GI). However when both varieties were exposed to low photoperiod from 8:00 am to 11:00 am produced less germination index (0.28 GI and 0.22 GI respectively). Results also revealed that the maximum germination index (1.18) was observed from NP_4= 9 hrs (8:00 am-5:00 pm) followed by control (12 hrs= 6 am to 6 pm) where plant were grown in full day sunlight (0.66 GI). Further data showed that NP_2=3 hrs (8:00 am- 11:00 am), NP_3= 6 hrs (8:00 am – 2:00 pm and NP_5= Natural shade had minimum germination index of balsam (0.25, 0.46 and 0.39 GI).

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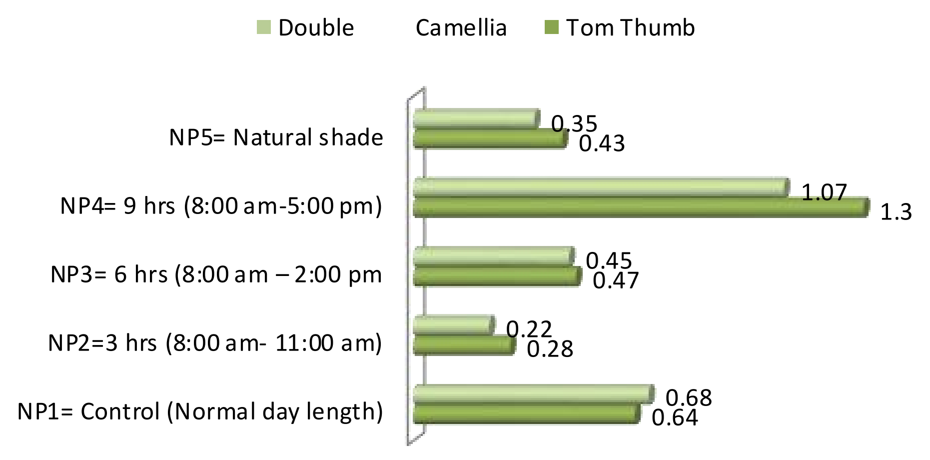
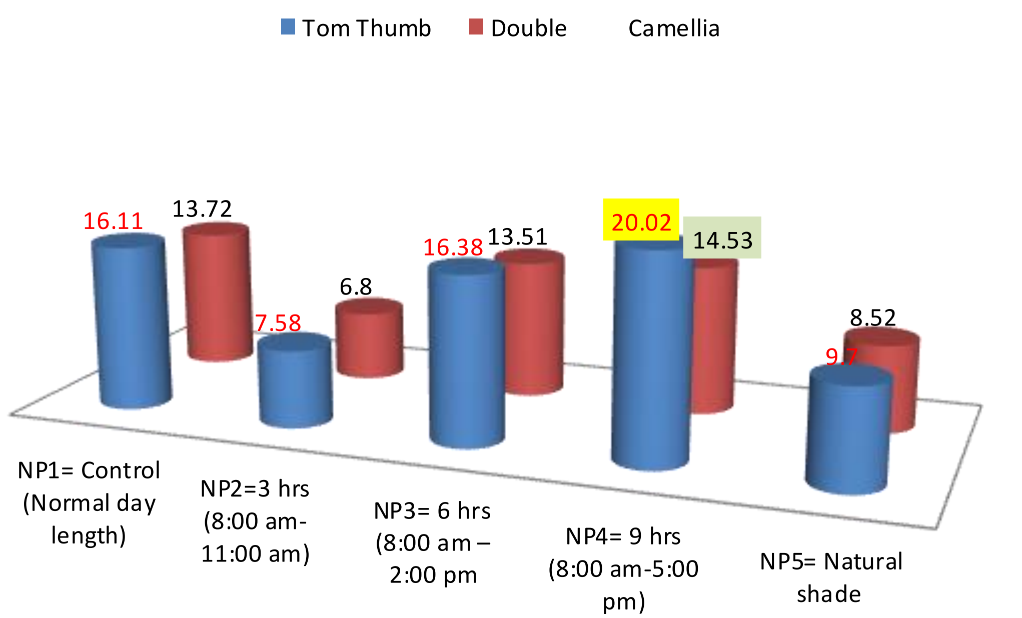
Fig. 2: Germination index (GI) of balsam in response to natural photoperiods



Plant height (cm)

The data regarding for plant height as affected by different natural photoperiods on vegetative and flowering behavior of Balsam are presented in the Fig-3 It can be seen from the results that plant height varied significantly (P<0.05) for the treatments and varieties. The results for varieties revealed that the variety "Tom Thumb" produced maximum plant height as compared to "Double Camcellia". Both the varieties responded well when exposed to natural photoperiod from 8:00 am to 5:00 pm. "Tom Thumb" had maximum plant height (20.02 cm) followed by "Double camellia" (14.53 cm) followed by normal day length of 12 hours. However when both varieties were exposed to low photoperiod from 8:00 am to 11:00 am produced less plant height (7.58 and 6.80 cm, respectively) as well as under natural shades their response was also negative.

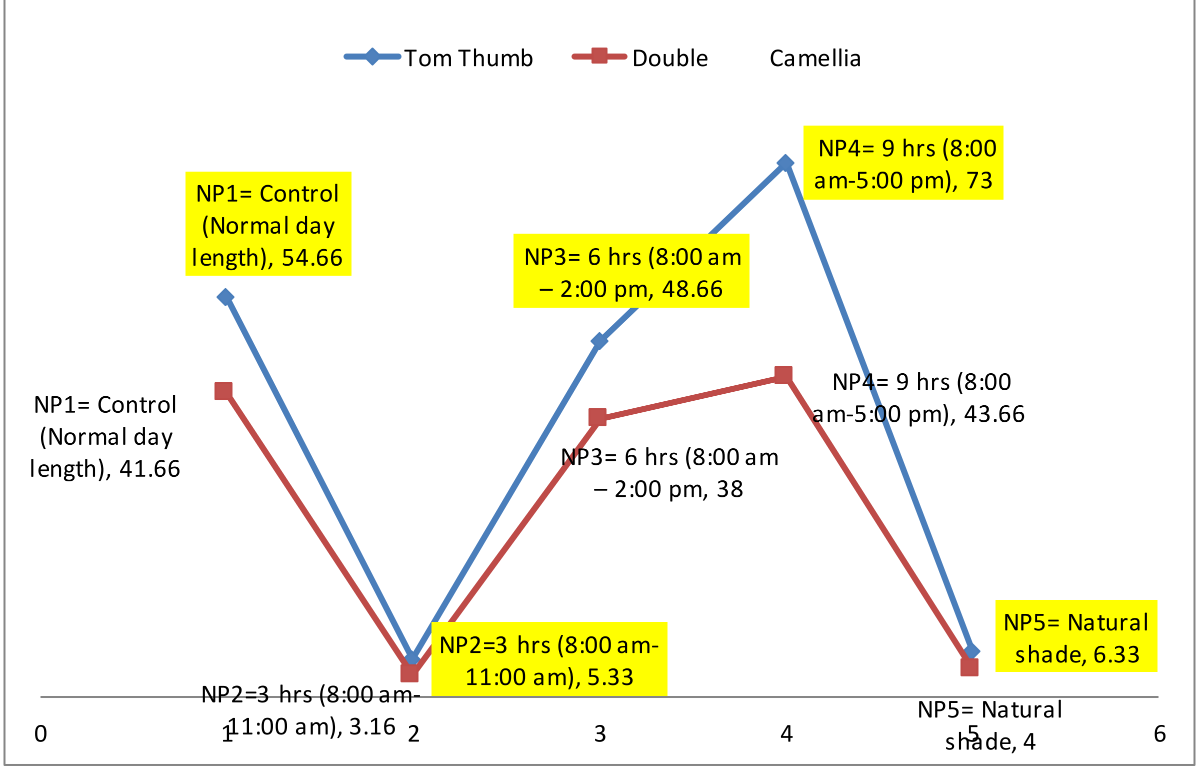
Fig. 3: Plant height (cm) of balsam in response to natural photoperiods



Leaves plant^{-1}

The data regarding leaves plant^{-1} as affected by different natural photoperiods on vegetative and flowering behavior of Balsam are presented in the Fig-4 It can be seen from the results that leaves plant^{-1} varied significantly (P<0.05) between the treatments and varieties. Both the varieties responded well when exposed to natural photoperiod from 8:00 am to 5:00 pm. "Tom Thumb" had maximum leaves plant^{-1} (73.00) followed by "Double camellia" (43.66) followed by normal day length (12 hours) where "Tom Thumb" produced 54.66 leaves where as "Double camellia" produced 41.66 leaves on single plant . However when both varieties were exposed to low photoperiod from 8:00 am to 11:00 am produced less leaves plant^{-1} (5.33 and 3.16, respectively) followed by plants grown under natural shades 6.33 and 4.0 ("Tom Thumb" and "Double camellia", respectively) .

Fig. 4: Leaves plant^{-1} of balsam in response to natural photoperiods

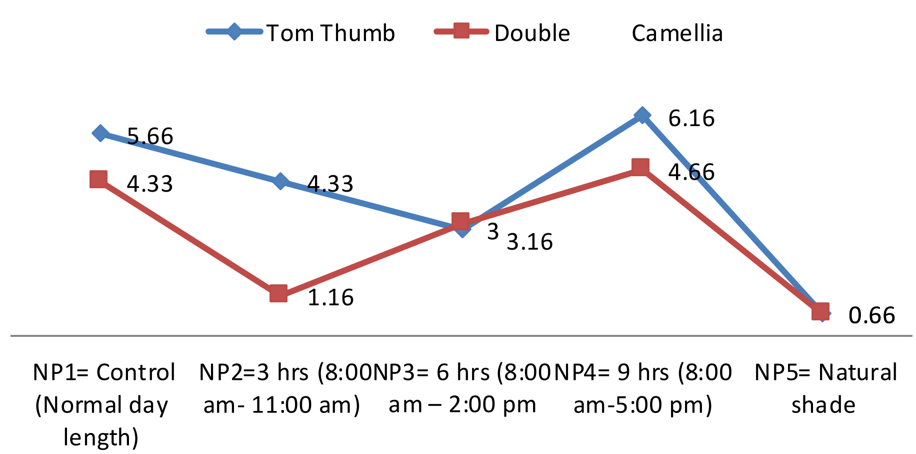


Flowers plant^{-1}

The data regarding for flowers plant^{-1} as affected by different natural photoperiods on vegetative and flowering behavior of Balsam are presented in the Fig-5 It can be seen from the results that flowers plant^{-1}varied significantly (P<0.05) between the treatments and varietal interaction.

The results revealed that both the varieties responded well when exposed to natural photoperiod from 8:00 am to 5:00 pm. Balsam variety "Tom Thumb" had maximum flowers plant^{-1} (6.16) followed by "Double camellia" (4.66) followed by natural photoperiod of 12 hours where "Tom Thumb" developed 5.66 flowers on single plant and "Double camellia" produced 4.33 flowers on single plant. However when both varieties were exposed to low photoperiod from 8:00 am to 11:00 am produced less flower plant^{-1} (4.33 and 1.16, respectively) followed by plants grown under shade (0.66 and 0.66, respectively).

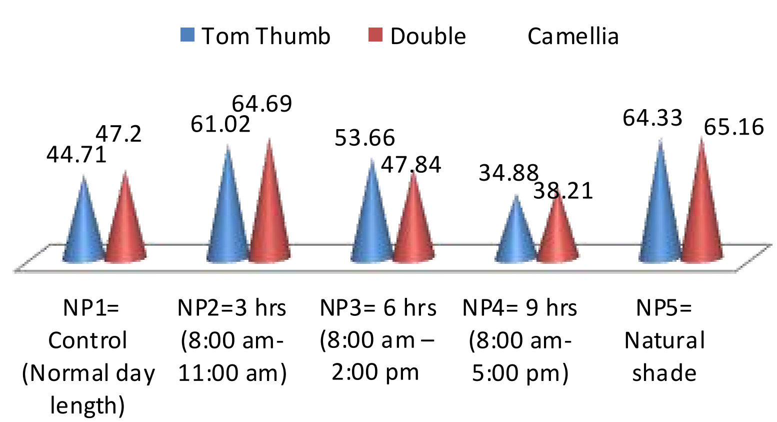
Fig. 5: Flowers plant^{-1} of balsam in response to natural photoperiods



Days to 1st flower plant^{-1}

The data (Fig. 6) regarding for days to first flower plant^{-1} as affected by different natural photoperiods on vegetative and flowering behavior of Balsam presented varied significant ($P<0.05$) difference between the treatments and varieties. Results revealed that both the varieties responded well in terms of days to 1st flower appearance when exposed to 09 hours of natural photoperiod from (8:00 am- 5:00 pm). Here the variety "Tom thumb" had produced first flower plant^{-1} within minimum number of days (34.88) followed by "Double Camelia" (38.21) followed by natural photoperiod of 12 hours where variety "Tom thumb" had developed first flower after 44.71 days followed by "Double Camelia" that had first flower after 47.2 days of sowing. However when both varieties were grown under Natural shade took maximum days to first flower appearance plant^{-1} for both the varieties (64.33 and 65.16, respectively) followed by 6 hours of photoperiod exposure (8:00 am- 11:00 am).

Fig. 6: Days to 1st flower of balsam in response to natural photoperiods



Days to flower persistence

The data regarding for days to flower persistence as affected by different natural photoperiods are presented in the Fig.7. It can be seen from the results that days to flower persistence varied significantly ($P<0.05$) for varieties under treatments. The results for varieties revealed that the variety Tom Thumb produced maximum (13.33) days to flower persistence as compared to Double Camcellia (13.00) well when exposed to natural photoperiod of 09 hours from 8:00 am to 5:00 pm, followed by control where plants were

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grown in full day sunlight of 12 hours where "Tom Thumb" had maximum days to flower persistence (12.00) followed by Double camellia (9.33). However when both varieties were exposed to low photoperiod from 8:00 am to 11:00 am aloted less days to flower persistence (3.34 and 2.01, respectively) followed by natural shade (4.66 and 3.04, respectively) for both the varieties of Balsam.

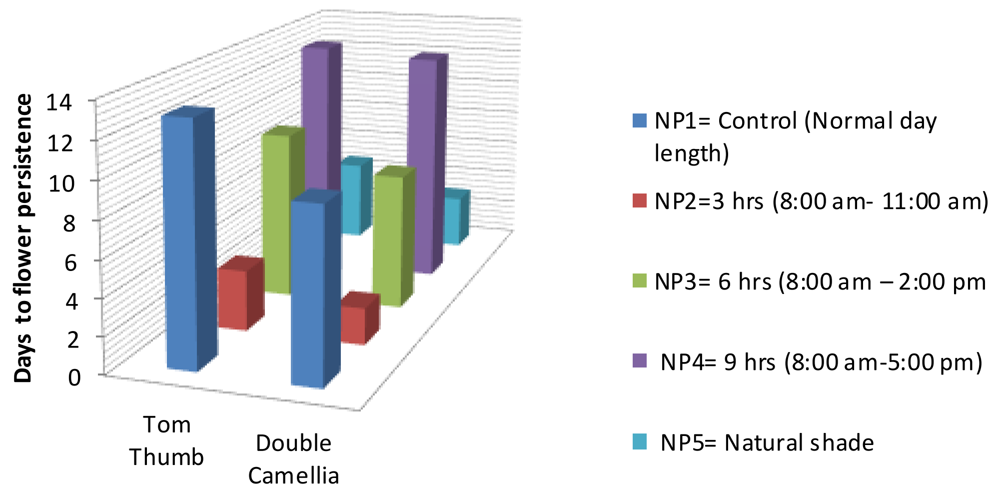
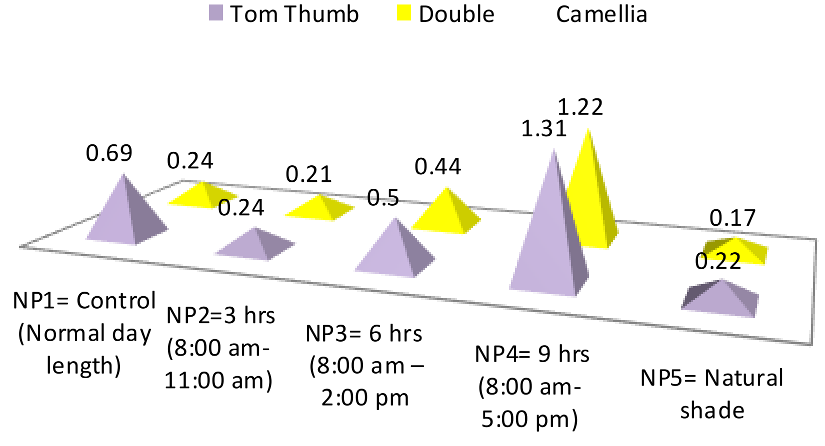


Fig. 7: Days to flower persistence of balsam in response to natural photoperiods

Weight of single flower (g)

The data regarding weight of single flower (g) plant^{-1} as affected by different natural photoperiods have been presented in the Fig. 8. It can be inferred from the data that weight of single flower plant^{-1} varied significantly ($P<0.05$) for varieties under treatments. Both the varieties responded well when plants were grown under natural photoperiod of 09 hours from 8:00 am to 5:00 pm here plants of variety "Tom Thumb" had displayed maximum weight of single flower plant $^{-1}$ (1.31g) followed by "Double camellia" (1.22g). Balsam varieties grown in full day sunlight of 12 hours developed flowers having maximum weight in variety "Tom Thumb" (0.69 g) where as variety "Double camellia" had flower weight of 0.44 g when grown under 6 hrs of photoperiod (8:00 am – 2:00 pm). However, when both varieties were grown under natural shade produced less weight of single flower plant $^{-1}$ (0.22 and 0.17 g, respectively).

Fig. 8: Weight single flower plant^{-1} of balsam in response to natural photoperiods



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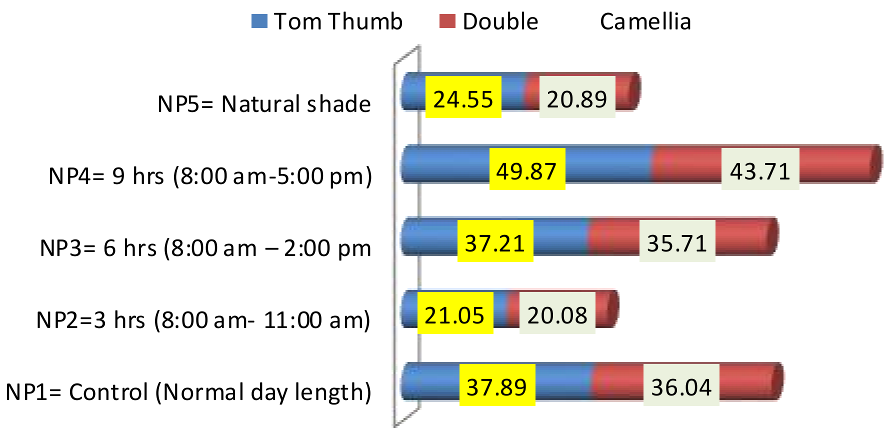
Chlorophyll content (SPAD)

The results (Fig.9) for both varieties of Balsam revealed that Both the varieties responded well when exposed to natural photoperiod from 8:00 am to 5:00 pm where, "Tom Thumb" had developed maximum chlorophyll content (49.87) followed by "Double camellia" (43.71). These varieties when grown under normal day length (12 hrs) developed chlorophyll content of maximum (37.89) in "Tom Thumb" followed by "Double camellia" (36.04). However when both varieties were exposed to low photoperiod from 8:00 am to 11:00 am produced less chlorophyll content (21.05 and 20.08, respectively) followed by plants grown under shade (24.55 and 20.89, respectively).

Fig. 9: Chlorophyll content (SPAD) of balsam in response to natural photoperiods



Correlations (Pearson)

	GP%	G.index	chlorph	flowpet	flowrpp	fstfemer	weight
Gindex	0.7571						
chlorph	0.7349	0.7747					
flowpet	0.7350	0.6996	0.8226				
flowrpp	0.6964	0.6530	0.7365	0.7370			
1stflower	-0.6730	-0.7221	-0.7928	-0.7304	-0.7448		
weight	0.8246	0.8933	0.8851	0.8150	0.7462	-0.7890	
height	0.4658	0.4553	0.7592	0.7247	0.5790	-0.5775	0.5393

Germination percentage (GP%) has been positively correlated with plant height (0.4658), chlorophyll content (0.7349) and days to flower persistence (0.7350), however this parameter had maximum correlation with flower weight (0.8246), however, germination % had negatively been correlated with days to 1st flower appearance (-0.6730). Chlorophyll content had been positively correlated at maximum with weight of flower (0.8851) and days to flower persistence (0.8226) followed by plant height (0.7592). Days to first flower emergence has been negatively correlated with flower weight (-0.7890) and plant height (-0.5775). Weight of single flower has shown positive correlation with germination index (0.8933), chlorophyll content (0.8851). Days to 1st flower emergence has shown negative correlation with all the parameters studied.

IV. DISCUSSION

It is obvious the present results had significant effects on varieties and natural photoperiod and varieties. For obtaining good germination keeping the soil moist is favorable and seeds are sown in early season covering with 1/8" of soil layer and water is given continuously to keep the soil moist till the germination is completed. The germination initiation may range between 10-15 days (Li *et al*., 2011; Hua *et al*., 2012; Christopher, 2013). The present study had significant effects on varieties and natural photoperiod and varieties. Interactive effect showed that maximum seed germination was recorded from Tom Thumb variety under NP4= 9 hrs (8:00am -5:00am) natural photoperiod, whereas the lowest seed germination was observed under plants grown in shade. Both varieties of Balsam produced maximum parameters less than 9 hours of photoperiod. Akbarian *et al*. (2016) observed best seed germination and quality flower seedlings under combinations of 25% blue and 75% red and fluorescent lamps for 10 hours of photoperiod. Kim *et al*. (2009) reported that flowering behavior in plant cycle shows the adaptability of plants to seasonal changes; and increase in duration of photoperiod reduced time to first visible bud. Temperature and day length are related in the sense that as the natural day length becomes longer or shorter, the temperature warms or cools, respectively. Tooke and Battey (2000) found that the completion of flower development in *Impatiens balsamina* requires continuous inductive (short-day) conditions. Plants were grown in long-day (LD) conditions of 8 hr of light provided by tungsten and fluorescent bulbs at 271 to 309 µmol.m^{-2} sec^{-1}, followed by 16 hr of tungsten light at 4.2 to 5.2 µmol.m^{-2} sec^{-1}. Short-day (SD) conditions were 8 hr of tungsten and fluorescent light (as above) followed by 16 hr of darkness. Kim *et al*., (2009) indicated that the chemical, biological and physiological process is influenced by temperature. The cut flowers produced during summer when temperature exceeds 38^{o}C, the biological processes are adversely affected. The leaf number below the 1st flower was affected by the addition of supplemental lighting with one some species of ornamental plants (Erwin and Warner 2002; Blanchard and Runkle, 2011). Under the conditions of extremely high temperatures, the plant proteins are denatured, affecting these processes and subsequently the flower quality has been adversely affected due to florigen present in flower (Wahocho *et al*., 2016). Erwin and Warner (2002) cultivated ornamental plants at 16 ^{0}C or 20 ^{0}C in combination with short day (SD, 8 hours) or long day (LD, 16 hours). Time to flower (first horizontal petals) at 16^{0}C increased from 56 to 64 days as so increased from 1 week to continuous conditions in SD, while LD decreased time to flower from 64 to56 days. Time to flower at 20 ^{0}C varied from 73 to 87 days with additional SD exposure resulting in flower and LD in faster flowering.

V. CONCLUSION

From present study It is concluded that Balsam variety "Tom Thumb" variety grown under NP4= 9 hrs (8:00am - 5:00am) natural photoperiod had significant effect on all the vegetative and flower traits studied. The results also revealed that the decrease in daylight adversely affected the traits investigated and photoperiod treatment comprised of 9 hours (8 am – 5:00) severely increased the flowers plant^{-1} as well as the flower quality. So, Balsam can be successfully grown for commercial purpose under 9 hrs (8:00am -5:00am) of natural photoperiod.

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Picture gallery of experiment

Experimental set up of Balsam varieties under different Natural photoperiod

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Measuring Chlorophyll content of Balsam plant

Researcher taking observations from Balsam plant