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Growth and Flowering Responses of *Petunia × hybrida* to different Photoperiods, Light qualities and Temperatures. Does Light Quality affect Photosynthetic Apparatus of Petunia?

By

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Summary

ILIAS I. F. & RAJAPAKSE N. 2012. Growth and flowering responses of *Petunia × hybrida* to different photoperiods, light qualities and temperatures. Does light quality affect photosynthetic apparatus of petunia? – Phyton (Horn, Austria) 52 (1): 163–175.

Factorial combinations of two photoperiods (10 and 14 hd^{-1}), two day temperatures (20 and 26 °C) and two light qualities Red (R) and Far red (FR) were imposed on growth, flowering development and chlorophyll fluorescence of *Petunia × hybrida* VILM. plants grown for 6 weeks in growth chambers. 14 hd^{-1} photoperiod decreased the day to flowering by 8 d while the days to flower (DF) were on average 3.1 longer under R light compared to FR light. Light intensity was on average 5.38 higher under R light compared to FR light. Stem dry weight was on average 0.17 g higher when temperature was 20 °C as compared to 26 °C. Leaf dry weight can effect by temperature and light quality while the interaction between them can affect the number of lateral shoots and the number of unflowering buds. Light quality can affect the number of flowers. The differences in flowering, height and weight observed for petunia suggest that they may be useful sources of variability for petunia breeding programs. Additionally temperature and photoperiod under FR light quality didn't

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affect the chlorophyll fluorescence parameters while under R light the maximum quantum yield (Fv/Fm) decreased significantly.

Zusammenfassung

ILIAS I. F. & RAJAPAKSE N. 2012. Growth and flowering responses of *Petunia* × *hybrida* to different photoperiods, light qualities and temperatures. Does light quality affect photosynthetic apparatus of petunia? [Wachstums- und Blühreaktionen von *Petunia* × *hybrida* auf unterschiedliche Fotoperioden, Lichtqualitäten und Temperaturen. Beeinflusst die Qualität des Lichtes den fotosynthetischen Apparat von *Petunia*?]. – Phyton (Horn, Austria) 52 (1): 163–175.

Für 6 Wochen wurden Petunien-Pflanzen (*Petunia* × *hybrida* VILM.) in Wachstumskammern unterschiedlichen Kombinationen zweier Fotoperioden (10 und 14 hd^{-1}), zweier Tagestemperaturen (20 und 26 °C) und zweier Lichtqualitäten Rot (R) und Dunkelrot (FR) ausgesetzt und die Auswirkungen auf Wachstum, Blütenbildung und Chlorophyllfluoreszenz untersucht. 14 h Fotoperiode verzögerte das Blühen um 8 Tage während es, im Vergleich zu FR, unter R im Schnitt um 3,1 Tage länger dauerte, bis die Pflanzen blühten. Verglichen mit FR war die Lichtintensität unter R-Licht im Schnitt um 5,38 höher. Gegenüber einer Wachstumstemperatur von 26 °C nahm das Trockengewicht der Sprosse bei einer Temperatur von 20 °C um 0,17 g zu. Das Blatttrockengewicht kann durch Temperatur und Lichtqualität beeinflusst werden, während Interaktionen zwischen diesen die Anzahl der Seitentriebe und die Anzahl nicht-blühender Knospen beeinflusst. Die Lichtqualität kann die Anzahl der Blüten verändern. Die Unterschiede beim Blühen, bei der Größe und beim Gewicht, die bei Petunia beobachtet wurden, lassen vermuten, dass das Wissen über den Einfluss dieser Parameter für Petunia-Zuchtprogramme hilfreich sein könnte. Zusätzliche Veränderungen der Temperatur und der Fotoperiode unter FR beeinflussten das Fluoreszenzverhalten des Chlorophylls nicht, während unter R-Licht das Verhältnis variabler Chlorophyllfluoreszenz zu maximaler (Fv/Fm) deutlich sank.

Introduction

Petunia, a quantitative long-day plant, is widely grown in nurseries in Greece and in the United States greenhouse and it is popular among homeowners and landscape architects as a bedding plant. Different non-chemical factors such as temperature, light quality manipulation, nutrition, CO_2, etc are used in wide range for 2-fold, First to reduce costs, health risk to greenhouse workers and consumers and potential environmental pollution associate with chemical growth regulators and Second to control plant growth and flowering of petunia plants.

Light, as a main environmental trigger, plays a central role in regulating plant development. The most effective components of the spectrum of light are Red (R), Far red (FR), and Blue. These lights are involved in the regulation of photosynthesis, pigment biosynthesis, photoperiodism, phototropism, and photomorphogensis (WELLER & al. 2000). Both the quality and quantity of light particularly play a significant role in stem elongation (MORGAN & SMITH 1979). Plants perceive the quality of light and photoperiod through photoreceptors or photosensors known as phytochromes. Phytochrome is a chromic-bili protein that absorbs principally in the spectral regions (600–800 nm) and exists in two forms, Red light and Far red light.

In previous studies individual factors such as temperature, photoperiod, and light quality were investigated. More specific time to flower decreased by high temperatures, high intensities of fluorescent, lights supplemental lighting, long days (KACZPERSKI & al. 1991, ADAMS & al. 2001). Combination of these factors showed that day to flower was a curvilinear function of average temperature, with 25 °C being the optimum temperature at PPF of 13 mol $m^{-2} \cdot d^{-1}$ (KACZPERSKI & al. 1991). They reported also that petunia plants of cv. 'Snow Cloud' grown in growth chambers flowered after 74 days at 15 °C compared to 46 d at 25 °C. ADAMS & al. 2001, reported that the rate of progress to flowering increased linearly with increasing PPF and temperature, up to an optimum, which was dependent on photoperiod. Plant height of petunia seedling increased by increasing both day and night temperature (KRIZEK & al. 1972), while KACZPERSKI & al. 1991, reported that plant height increased linearly and average internodes length increased quadratically as day temperature increased. Lateral shoots of petunia decreased by high temperatures (CARPENTER & CARLSON 1974, KACZPERSKI & al. 1991). Additionally, lateral shoots of petunia and other crops increased when light intensity increased (ERICKSON & al. 1980) while KACZPERSKI & al. 1991, found that under 200 mmol s^{-1} m^{-2}, there is no increase in lateral shoots. Shoot dry weight gain per unit area increased with increasing PPF density and had a convex relationship with air temperature (LIETH & PASIAN 1990, KIM & LIETH 2003). Furthermore, MERRITT & KOHL 1982 reported that petunia crops grown in growth chambers had the same crop productivity (total dry weight per unit area) when grown at either 7.2 or 15.6 °C. MERRITT & KOHL 1982, also reported that petunia grown at a long photoperiod showed increased dry weight production in comparison with a short-photoperiod crop only when the light-gathering capacity of the crop was below the maximum and before a large number of sinks were available, i.e. before branching had occurred.

Chlorophyll fluorescence of green leaves provides basic information about the actual state of the photosynthesis apparatus of plants. It has developed into a standard method in plant physiology for determining the stress status of plants (KRAUSE & WEIS 1991, SCHREIBER & BILGER 1993). The intensity ratio F690/F730 of the two peaks of chlorophyll fluorescence at 690nm (Red) and 730nm (Far red) is well correlated with the (active) chlorophyll content of the leaves and can therefore be used to detect the chlorophyll content of the plants (BUSCHMANN 2007, THOREN & SCHMIDHALTER 2008). The two-wavelength fluorescence measurement has the advantage of enabling non-destructive, remote and distance-independent, and instantaneous determination of chlorophyll content (CHAERLE & al. 2007), and determining photosynthetic activity and thus assimilative yield (BUSCHMANN & LICHTENTHALER 1998). These advantages allow the beneficial use of the F690/F730 ratio for numerous applications in plant physiology (ZIMMERMANN & GUNTHER 1986, BUSCHMANN 2007). Our objective of this work was to combine all these factors and to investigate their response to plant growth, flowering and the state of the photosynthesis apparatus of petunia by temperature, light quality and photoperiod since very few attempts have been made.

Material and Methods

Plant Material and Culture

Experiments were conducted in growth chambers at the Horticulture Department of Clemson University from March 2002 to June 2002. *Petunia* × *hybrida* VILM. 'Celebrity Burgundy' seeds were germinated on a greenhouse mist bench (20 seconds of mist every 30 minutes) set at 22 ± 2 °C. At the four to five leaf stage, uniform seedlings were transplanted individually into 165 mL plastic pots containing a commercial potting mix (Fafard 3-B Mix, Fafard Inc., Anderson, SC). Plants were acclimatized for one week in the growth chambers before being subjected to treatments. All plants were irrigated as needed and fertilized continuously through irrigation water with 1 gL^{-1} of 20mg N-4.4mg P_2O_5-16.7 mg K_2O water-soluble fertilizer (Peters 20-10-20 Peat-Lite Special, Scotts-Sierra Horticultural Products Co., Marysville, Ohio) during the experiments.

Lighting and Temperature Conditions

Three trays with twelve plants in each tray were used for each treatment combination/replicate get one of the following treatments:

1. Two different photoperiods were used in all combinations: weakly and strong inductive photoperiods of 10 and 14 hd^{-1} respectively.
2. Two different temperature regimes were used in all combinations: 20 and 26 °C day/night with relative humidity 80 ± 10 %.
3. Red (R) and Far red (FR) light were used in all combinations. FR light was a mixture of sixteen 160 W (Sylvania Canada) white fluorescent lamps and six 90 W incandescent bulbs (Sylvania Canada) provided a PAR of 450 $\mu mol \cdot m^{-2} \cdot s^{-1}$. R light was sixteen 160 W (Sylvania Canada) white fluorescent lamps provided a PAR of 450 $\mu mol \cdot m^{-2} \cdot s^{-1}$. In all experiments, the lamps were switched on automatically at 8.00 am.

In vivo Chlorophyll Fluorescence Measurements

Experiments were reconducted from February 2008 to June 2008 in growth chambers at the Technological Educational Institute of Thessaloniki, Greece. The conditions were just the same as in growth chambers as mentioned before. Fast chlorophyll fluorescence was measured on the upper surface of the latest fully expanded leaf and used for primary photochemistry detection. The chlorophyll fluorescence induction curve was monitored by a Plant Efficiency Analyzer (PEA, Hansatech Ltd King's Lynn, Norfolk, England) with 600 Wm^{-2} of Red (630) light intensity (excitation intensity), and were left for 20 min., to dark adaptation, at room temperature. Different values were selected in order to determine any structural and functional changes of the photosynthetic apparatus as a result of the different growth regulator applications. The initial fluorescence intensity (Fo) when all reactions centres (RCs) are open, the maximal fluorescence intensity when all reactions are close (Fm), the variable fluorescence (Fv) and the time to reach the maximal fluorescence intensity (tmax), were calculated. The indicators were measured at room temperature on intact leaves of five replicate plants from the treatments (Ouzounidou & Ilias 2005). Ratios Fv/Fm and Fv/Fo, which provide an estimation of the maximal photochemical efficiency of photosystem II and the apparent quantum yield of the photosynthesis rate (Ouzounidou & al. 2006) were used, to evaluate alterations.

Growth Measurements and Experimental Design

The experiment was conducted as a split-plot design with whole plot factors of photoperiod and temperature and light quality as the sub-plot factor. Thirty six plants were used in each treatment combination/replicate. The day length (photoperiod) were set up at 10 and 14 hd^{-1}, temperatures of 20 and 26 °C day/night, light quality of Red and Far red light provided a PAR of 450 $\mu mol \cdot m^{-2} \cdot s^{-1}$. Main stem length (measured at the end of the experiment from growing medium surface to apex), days to flowering (measured as the time from seeding to first flower anthesis), number of flowers (open flower and unopened buds when all plants had at least one open flower), number of lateral shoots, leaf greenness, stem and leaf dry weight were recorded. Leaf chlorophyll content was measured with a Spad-502 meter (Spectrum Technologies Inc., Plainfield, IL) on four leaves below the apex of each plant. For dry weight measurements, stem and leaves were oven-dried for two days at 85 °C. All plants were harvested 6 weeks after treatments. Data were subjected to analysis of variance using procedures of SAS (SAS Institute, Inc., Cary, N. C.) and differences among treatment means were compared using LSD at P=0.05.

Abbreviations: R: Red light; FR: Far red light; chlorophyll contents (SPAD); PAR: photosynthetically active radiation; Fo: initial fluorescence intensity when all reactions centres (RCs) are open; Fm: the maximal fluorescence intensity when all reactions are close; Fv: the variable fluorescence; Tm: the time to reach the maximal fluorescence intensity; Area: area over the fluorescence curve between Fo and Fm; RCs: reaction centres; PPF: photosynthetic photon flux.

Results

Growth and Flowering Responses

Combination of high temperature and FR light increased significantly the main stem length of petunia plants, measured at the end of the experiments (Table 1). Increasing the photoperiods to 14 hd^{-1} leads to ~50% higher plants than under 10 hd^{-1}. Photoperiod and light quality affect significantly the main stem length of plants. Combination of 14 hd^{-1} and FR light leads also to ~50% higher plants than plants grown under R light.

Plants grown under 10 hd^{-1}, R and FR light were compact and much smaller than those grown under 14 hd^{-1} (Table 1). Interaction between temperatures, photoperiod and and light quality affect significantly plant height of petunia plants.

Table 1. The effect of temperature (T), photoperiod (PP), and light quality (R, FR) on final main stem height (H), days to flower (DF), chlorophyll contents (SPAD), stem dry weight (SDW), leaves dry weight (LDW), number of lateral shoots (NB), number of flowers (NF), and number of unflowering buds (NUFB) of petunia plants grown inside growth chambers. The values are mean ± SD of 36 plants.

T (°C)	PP (h)	LQ	H^z(cm)	DF	SPAD	SDW (g)	LDW (g)	NB	NF	NUFB
20	10	R	4.0±0.2b	25.6±0.6d	49.2±1.1bc	0.4±0.0d	1.1±0.1d	5.5±0.2d	2.6±0.4b	2.8±0.3b
20	10	FR	5.8±0.3c	22.1±0.4c	42.6±0.9a	0.4±0.0cd	1.0±0.1cd	4.3±0.2c	3.2±0.3b	2.6±0.2ab
20	14	R	8.2±0.3d	18.3±0.4b	50.4±0.9c	0.3±0.0bc	0.9±0.1cd	4.3±0.2c	2.8±0.3b	2.8±0.2b
20	14	FR	17.2±0.7f	15.6±0.4a	45.9±0.7b	0.5±0.0d	1.1±0.1d	3.1±0.2b	3.4±0.3b	2.4±0.2ab
26	10	R	2.7±0.2a	29.6±0.7e	48.1±1.1bc	0.2±0.0a	0.6±0.0ab	3.7±0.2c	1.5±0.2a	1.9±0.2a
26	10	FR	5.7±0.5c	26.5±1.2d	41.8±1.0a	0.3±0.0bc	0.8±0.1bc	3.9±0.2c	2.9±3.4b	2.1±0.2ab
26	14	R	12.7±0.6e	20.3±0.6c	45.9±1.0b	0.2±0.0a	0.6±0.0a	1.6±0.2a	5.0±0.3c	1.9±0.1ab
26	14	FR	23.3±0.7g	17.3±0.7ab	41.7±1.0a	0.3±0.0bc	0.8±0.1bc	1.8±0.2a	6.2±0.4c	2.1±0.1ab

^{Z} Measured at the end of the experiment.

Means followed by diffrerent letters in the same column for each treatment differ significantly (p=0.05).

Photoperiod and light quality affect the time to flowering while temperature had no significant effect. At a photoperiod of 10 hd^{-1} (weakly inductive photoperiods) time to flower of petunia plants was delayed by 8 days compared to plants receiving 14 hd^{-1}. In addition to photoperiod, light quality affect earliness of flowering. R light increased time to flower in petunia by 3.1 days as compared to FR light (Table 1). Our data showed that combination between low temperatures and high photoperiod (14 hd^{-1}) decreased the time to flowering by 10 days compared to 10 hd^{-1} photoperiod. Leaf color intensity was not significantly affected by temperature and photoperiod (Table 1). However, leaves of R light treated plants were darker green (average of 5.38) than leaves of the FR light treated plants.

Temperature affects significantly the stem and leaf dry weigh of petunia. In plants grown under 20 °C, stem dry weight was on average 1.7 times higher than plants grown under 26 °C. On the contrary, lower temperature increased leaf dry weight as compared to a temperature of 26 °C. However, the amount of the differences between the lower and higher temperatures depends on the kind of light quality. When light quality is FR light, leaf dry weight is on average 0.22 higher for the lower temperature as compared to the higher temperature. When the light quality was R light, leaf dry weight was on average 0.40 higher for the lower temperature. For light quality, the leaf dry weight was higher at the FR light; however, the amount of the differences between the two kinds of light quality was depended on temperature. When the temperature was 20 °C, there was no significant difference in the means of leaf dry weight for FR and R light. When the temperature was 26 °C, leaf dry weight was on average 0.20 higher under FR light as compared to R light (Table 1).

The number of lateral shoots was not significantly affected by high temperature when petunia plants were grown under R and FR light. However, low temperature and light quality interacted to affect significantly the number of lateral shoots (Table 1). The mean number of lateral shoots of plants under R light was 1.2 higher than the mean of lateral shoots under FR light when the temperature was 20 °C. Also, in plants grown under R light, there was a difference in the mean of lateral shoots for the two temperatures. The mean of lateral shoots for 20 °C was 2.2 higher than at 26 °C whereas plants under FR light, there was no significant difference in the lateral shoots means for the two temperatures. Light quality affects significantly the number of flowers. FR light increased significantly the total number of flowers developed by an average of 0.96 compared to plants grown under R light.

Temperature and the interaction between temperature and light quality significantly affect the number of unflowering buds. Plants grown at 20 °C had higher number of unflowering buds than at high temperature. However, the amount of the difference between the lower and higher temperature depended on light quality. When plants were grown under FR and R light, the number of unflowering buds was on average 0.4 and 0.9 respectively higher for the lower temperature as compared to the higher temperature (Table 1). When the temperature was 26 °C, there was not a significant difference in the means of the number of unflowering buds for FR and R light. When the temperature was 20 °C, the number of unflowering buds was on average 0.3 higher under R light as compared to plants under FR light.

Chlorophyll Fluorescence Responses

Maximum quantum yield of primary photochemistry (Fv/Fm) was increased under FR light and 20 °C by 4,4% compared with R light under 10 hd^{-1}, whereas it was reduced under R light by 7% compared with R light under 14 hd^{-1}. No alteration was found at 26 °C compared with plants under 20 °C (Table 2). Additionally, the ratio Fv/Fo (the photochemical efficiency of PSII) that is more sensitive than the maximum quantum yield was increased under FR light and 20 °C by 30% compared with R light under 14 hd^{-1} and 20 °C, declined under 10 hd^{-1} by 28% compared with under FR light (20 °C, 14 hd^{-1}) showing alterations of PSII reaction centers and an inhibition of enzymatic process in the Calvin cycle. Fo was significantly decreased under R light, whereas under FR light it was significantly altered (Table 2). Fm increased under both light qualities. The ratio Tmax/Area was significantly suppressed under R light. R light caused a severe increase on the ratio Area/Fv, whereas FR treatment resulted in no significant increases.

Table 2. The effect of temperature (T), photoperiod (PP) and light quality (R, FR) on chlorophyll a fluorescence parameters of petunia plants grown inside growth chambers. The values are mean ± SD of 16 plants.

T (°C)	PP (h)	LQ	Fo	Fm	Fv	Fv/Fm	Fv/Fo	Tm/area	Area/Fv	1/Fo-1/Fm
20	10	R	379a	3837b	2648a	751a	3.4a	0.4a	23.4b	0.0002a
20	10	FR	768c	3844b	2887a	0.8b	5.3b	0.6b	18.7a	0.002ab
20	14	R	448b	2268a	1840a	0.8ab	4.1a	0.5a	20.6b	0.0004a
20	14	FR	507b	3172b	2665a	0.8b	5.3b	0.7b	18.3a	0.07b
26	10	R	501b	1915a	1414a	0.7a	2.8a	0.4a	21.7b	0.007ab
26	10	FR	483b	2934b	2451a	0.8b	5.1b	0.6b	17.9a	0.07b
26	14	R	424b	2049a	1625a	0.8ab	3.8a	0.5a	23.9b	0.007ab
26	14	FR	606c	3927b	3321b	0.8b	5.4b	0.7b	18.1a	0.07b

Means with the same letter in the same column do not significantly differ at p = 0.05

Discussion

The objective of the present study was to investigate how the influence of photoperiod, light quality and temperature could provide invaluable information for commercial development of petunia plants with high ornamental value grown under controlled conditions. Our experiments showed that petunia height was highly dependent on temperature, light quality and photoperiod. These data are in agreement with KACZPERSKI & al. 1991, who reported that plant height increased as day temperature increased in petunia plants and with KRIZEK & al. 1972, who reported that increasing both day and night temperature increased plant height in petunia seedling. MOE & HEINS 1990, reported that a proper R light treatment suppress stem elongation in some important flower crops such as Easter lilias, poinsettia, pot mums, Campanula and Fuchsia. These results are with agreement with our data showing that FR light leads to higher plants grown under long photoperiod and high temperature. However, plants grown under short days tended to be short and compact independently the light quality.

Short photoperiod and R light delayed flowering of petunia plants. This delay in flowering may be due to the increased bud abortion at the lower photoperiod and R light condition. These data are in with agreement with results of previous research where time to flowering of petunia can be hastened under long photoperiod (PIRINGER & CATHEY 1960, ADAMS & al. 1999) and with THOMAS & VINCE-PRUE 1997, who showed that flowering is often most rapid when photoperiods contain some minimal amount of FR light. Similar results showed by ADAMS & al. 1997, who found the critical photoperiod to flowering in trailing petunia, a close relative of *Petunia* ×

hybrida to be in the region of 15 to 15.5 hd^{-1}. ADAMS & al. 1998, also showed that the rate of progress to first flowering increased linearly with increasing photoperiod up to a critical photoperiod of 14.3 hd^{-1}.

ADAMS & al. 1999, reported that low temperature and low light prolonged the juvenile growth period of petunia plants. An acceleration in time of flower under a higher temperature was not evident from our data. This is because of small average between 20 °C and 26 °C used at this experiment. Similar results were shown by KACZPERSKI & al. 1991, who found that day to flower was a curvilinear function of average temperature, with 25 °C being the optimum temperature at PPF of 13 $mol \cdot m^{-2} \cdot d^{-1}$ and thus plants of cv. 'Snow Cloud' grown in growth chambers flowered after 74 days at 15 °C compared to 46 days at 25 °C. Light quality had affected (influenced) significantly the chlorophyll content of petunia plants whereas previous work reported that chlorophyll content of petunia plants grown under R and FR light were similar to control plants (HALIAPAS & al. 2008).

Our data showed that temperature and light quality interacted to affect significantly leaf dry weight of petunia plants. Temperature affected stem and leaf dry weight. In contrast, LIETH & al. 1991 and MERRITT & KOHL 1982 showed that petunia crops grown in growth chambers had the same crop productivity (total dry weight unit area) when grown at either 7.2 or 15.6 °C. Our experiments showed that the photoperiod did not affected significantly stem and leaf dry weight. However, previous studies by MERRITT & KOHL 1982, reported that petunia grown at a long photoperiod showed increased dry weight production in comparison with a short photoperiod crop only when the light-gathering capacity of the crop was below the maximum and before a large number of sinks were available, i.e. before branching had occurred.

The number of lateral shoots formed by the plants was not affected significantly by high temperature. It is possible that the optimum temperature for growth petunia lateral shoots is relatively low. Previous work showed that higher temperatures decreased lateral shoots in petunia (CARPENTER 1974, CARPENTER & CARLSON 1974, PIRINGER & CATHEY 1960, KACZPERSKI & al. 1991). Similar results found by MERRITT & KOHL 1991, who reported that petunia grown in low night temperatures (27 °C day/ 7 °C night) had more lateral shoots and were only about one-half the height of warmer night temperature plants (27 °C day/18 °C night) whereas MERRITT & KOHL 1989, reported petunia grown in greenhouses, held at day temperatures of 21 and 27 °C, respectively, and 7 °C night temperatures had more basal branches and were one-third the height of those grown at a 27 °C day and 18 °C night.

Our results showed that plants grown under 26 hd^{-1} reduced the number of lateral shoots. These results are similarly observed by ADAMS & al. 1998, who reported that petunia plants under long photoperiod tended to be single stemmed. MOE & HEINS 1990, reported that FR light strongly inhibits lateral branching in some important flower crops such as Easter lilias, poinsettia, pot mums, Campanula and Fuchsia. Our finding supports these results that R light increased significantly the number of lateral shoots of petunia plants especially when R light combined with low temperature. Number of flowers and unflowering buds was higher under FR light while temperature and photoperiod had not. These data are with agreement with the finding of HALIAPAS & al. 2008, who reported that no flower bud formation in petunia plants grown under R light treatments. Increasing the temperature to 26 °C, did not significantly affect the number of lateral shoots for FR and R light.

As an alternative indicator of PSII functionality, we determined the parameter 1/Fo-1/Fm (HAVAUX & al. 1991, WALTERS & HORTON 1993), obtained from measurements of Fo and Fm after dark treatment following illumination. Our data showed that fluorescence parameter declined under R light. Thus, the fluorescence parameter 1/Fo-1/Fm, easily measured even on intact plants in the field, is a good indicator of the content of functional PSII complexes. The net CO_2, assimilation and photochemical activity were evaluated by measurements of leaf gas exchange, chlorophyll a fluorescence and chlorophyll content on four leaves of the main stem treated with R and FR light. Net CO_2, assimilation rate and stomata conductance were not affected by light quality whatever the leaf age (data not shown) agreed with previous research (KENZO & al. 2008). R light induced a small but significant decrease of photochemical quantum yield of PSII centre for the just unfolded leaf only. However, the calculation of electron transport rate from PSII showed that the electron flow was not significantly different between light quality treatments. The main effect of R and FR was a strong decrease in chlorophyll a content of young unfolded treated leaf. This showed an improvement of thylakoid stacking (HERAUT-BRON & al. 1998) in the first stage of the leaf life. However, those effects were not persistent as they were not maintained when the leaf was mature.

Conclusion

1 Temperature affected significantly the date to flowering, leaf chlorophyll contents, stem and leaf dry weight, number of lateral shoots, number of flowers and number of unflowering buds of petunia plants as presented.
2 Photoperiod affected significantly the main stem length, date to flowering, leaf chlorophyll contents, number of lateral shoots and number of flowers.
3 Light quality affected significantly all the examined parameters except of number of unflowering buds.

4 Temperature and photoperiod interacted to affect significantly plant height, leaf chlorophyll contents, number of lateral shoots and flowers.
5 Interaction between temperature and light quality affected significantly stem and leaf dry weight, number of lateral shoots and number of unflowering buds.
6 Interaction between photoperiod and light quality affected significantly plant height, stem and leaf dry weight.
7 Interaction between temperature, photoperiod and light quality affected significantly plant height of petunia plants.
8 Temperature and photoperiod didn't affect the chlorophyll fluorescence parameters under FR light quality while under R light the maximum quantum yield (Fv/Fm) decreased significantly.

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