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Growth and flowering of shrub (*Turnera trioniflora*) under different shade levels

[Pertumbuhan dan pembungaan pokok renek (*Turnera trioniflora*) di bawah tahap lindungan yang berbeza]

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Key words: *Turnera trioniflora*, growth, flowering, shades

Abstract

A study was conducted to evaluate the growth and flowering responses of *Turnera trioniflora* to different shade levels viz. 0 (open), 20, 50, 80 and 90%. All shade treatments delayed time to first flowering, in which plants at 80% shade required twice longer time to flower as compared to plants under fully exposed to sunlight. Number of nodes and shoot length at first flowering also increased as shade level increased. Shade also strongly influenced flower production per day. The main factor that contributed to low flower production was the reduction of flowering branches. Low number of flower buds and frequency of return bloom on each branch also contributed to reduction of flowers under heavy shades. Generally, the growth of *T. trioniflora* was only affected by heavy shades (80% and 90%). Plants responded to shade by changing the morphology such as increasing leaf size and reducing leaf thickness to adapt to low light conditions. It is recommended that *T. trioniflora* should be planted in the open or light shade condition for optimum flowering.

Introduction

Flowering shrubs are among the important components in landscape garden. The ability to flower in various colours will add a contrast to the main trees, hence enhancing the beauty of landscape garden. Shrubs are often being planted underneath big trees and occupied the lower strata of most landscape gardens. They may also be planted in boxes, which are normally near the buildings. Such situation will cause the shrub to be shaded by big trees or buildings for the entire or part of the day. It was reported that different shrub species tolerate differently to shade levels. In *Bougainvillea* spp. (Hackett and Sach 1967) and *Geranium* spp. (Armitage and Wetzstein 1984), flowering is reduced or delayed as irradiance is reduced. In some shrubs such as the *Rhododendron* spp., it requires certain degree of shade for optimum flowering (Larson 1980). Flower quality of some species such as *Begonia* spp. (Kessler and Armitage 1992) and some lilies (Armitage 1991) is improved by shading.

Among shrub species that is popular in Malaysian landscape is *Turnera trioniflora*. The species is native to this country and normally found in the ex-mining areas (Hanim and Zaini 2000). The species is easy to propagate and establish, fast growing and flowering, compact growth and produces abundance of flowers and gives a fast impact in landscaping. *Turnera trioniflora* flowers throughout the year. It is the characteristic of all *Turnera* spp. to bloom in the morning and closed several hours later (Gilman

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2007). New flowers will be produced on the following day. In landscaping, it is normally used as bedding plants or planted along the roadsides and dividers. However, it is often observed that the performance in terms of growth and flowering of the plants varies from one site to the others. Shading could be one of the important factors that influence the performance. To date not much information regarding the tolerance of this species to different shades is available. This study was conducted to evaluate growth and flowering of *T. trioniflora* grown under different shade levels.

Materials and methods

Cuttings of *T. trioniflora* were planted in the plug trays with cell size of 3 cm x 3 cm, containing peat medium for rooting. A month later, the rooted cuttings were planted into 20 cm diameter pots containing mixture of coir-dust, peat and fine sand in equal proportion and incorporated with 15 g of slow-release fertilizer containing 15% N, 15% P_2O_5 and 15% K_2O. Three plants were planted in each pot. All plants were cut back at the main stem at 15 cm from the base 10 days later. Plants were placed under different five shading treatments two weeks after planting. Only three lateral shoots on the main stem were allowed to develop.

The five shade treatments were 0 (open), 20, 50, 80 and 90%. Shading material used was black polyacclerene net mounted on wooden frames with measurements of 1.2 x 5.0 x 1.5 (width, length and height). The experiment was laid in a Randomized Complete Block Design (RCBD) with three replicates, and each replicate consists of six pots (18 plants). Analysis of variance was performed using SAS and treatment differences were compared using Duncan Multiple Range Test (DMRT).

Flowering

Data on first flowering were recorded on the individual plant as soon as the first flower opened. The number of days, number of nodes and length of lateral shoots at the first flowering were recorded. Number of flowers per plant was recorded at weekly intervals. Since flowers open and drop on the same day, the number of flowers recorded is regarded as the number of flowers per day.

At 10th week, 10 shoots were selected at random from each plot for daily recording of flower to determine the frequency of return bloom and the number of buds present on each shoot. The number of flowering branches was also recorded.

Growth analysis

At the end of the study (14 weeks after treatment), a destructive growth sampling was performed. Six randomly selected plants from each plot were cut at the growing medium level and separated into main components of leaves and stems. The number of leaves was counted and leaf area was measured using leaf area meter (LI-COR 2000, USA). Leaves and stems were oven-dried separately at 80 °C for 48 h. The specific leaf area (SLA) was determined from measurements of leaf area and leaf dry weight.

Data analysis

Statistical analysis was performed using SAS and treatment means were compared using Duncan multiple range test (DMRT).

Results

Effect of shade on first flowering

Flowering occurred in all shade treatments except for 90% shade level, but the number of days, number of nodes and length of shoot at the first flowering varied among shade treatments (*Table 1*). Plants in the open flowered at 27 days after treatment began, and as shade level increased the number of days to flowering was significantly longer (p <0.001). Plants at 80% shade required twice longer period to flower as compared to those under exposed conditions. There was no significant difference between open and 20% shade on the number of nodes to first flowering,

but as shade levels increased there was a significant increase (p <0.01) in number of nodes. Similarly, there was no obvious effect on the shoot length at first flowering between exposed and shaded plants at 50% level. However, shoot length of 80% shaded plants was significantly longer than exposed plants

Effect of shade on flower production

The number of flowers per plant per day at various weeks during the experimental period is shown in *Figure 1*. Plants in the open, under 20% and 50% shades began to flower at the 4th week, but those under 80% shade, flowering started at 6th weeks after treatment. However, plants under 90% shades did not flower at all. Generally flowers per plant increased with time and the highest number of flowers was recorded at the 13th week following treatment.

The effect of shade was more obvious at early stages than at later stages of plant development. At the beginning of flowering (i.e. 4th week), light shade (20%) caused reduction of more than 50% of flower production, where as at later stages (13th and 14th week) flower number was correspondingly reduced with increasing level of shade.

Table 1. Effect of different shade levels on *Turnera trioniflora* at first flowering

Shade levels (%)	Days at first flowering	Nodes at first flowering	Length at first flowering (cm)
0 (Open)	27.15d	6.42c	16.64b
20	31.94c	6.68c	14.35c
50	35.69b	7.62b	17.75b
80	52.93a	10.58a	29.61a
90	–	–	–
Significant level	p <0.001	p <0.01	p <0.01

Mean values in each column with the same letter are not significantly different (p <0.05)

Effect of shade on flowering pattern

The effect of shades on flowering pattern of *T. trioniflora* is summarized in *Table 2*. The number of flowering branches (FB) recorded at 10th week was significantly reduced (p <0.001) as the shade level increased. Plants in the open produced 9.17 FB and correspondingly reduced as shade level increased. Again there was no FB found at 90% shade.

The number of flower buds per shoot and the frequency of return bloom were also affected by shades, but the magnitudes

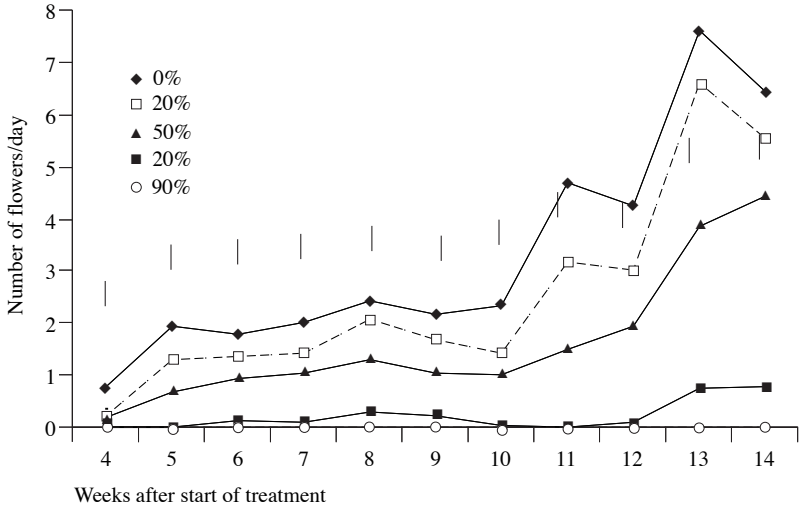

Figure 1. Daily flower production of ***Turnera trioniflora*** *under different shade levels. Vertical bars represent LSD (p <0.05)*

Table 2. Flowering characteristics of *Turnera trioniflora* under different shade levels

Shade levels (%)	No. flowering shoots/plant at 10th week[Y]	No. flower buds per shoot at 10th week[Z]	Frequency of return bloom between 10th and 14th week (days)[Z]
0 (open)	9.17a	8.56a	1.73a
20	6.22b	9.10a	1.53a
50	3.86c	7.93b	1.81a
80	0.39d	6.04c	2.85b
90	0.00d	–	–
Significant level	p <0.001	p <0.01	p <0.05

Mean values in each column with the same letter are not significantly different (p <0.05)
[Y]18 plants/replicate x 3 replicates
[Z]10 shoots/replicate x 3 replicates

Table 3. Growth and leaf characteristics of *Turnera trioniflora* measured at 14th week after treatment

Shade levels (%)	Total leaf no.	Total leaf area	Mean leaf area (cm^2)	Leaf dry wt. (g)	Stem dry wt. (g)	Total dry wt. (g)	Specific leaf area (cm^2)
0 (open)	244.7a	325b	1.33d	2.37ab	7.55a	9.93a	136.9d
20	224.8a	505b	2.25cd	2.65ab	6.64a	9.29a	191.0cd
50	218.9a	797a	3.64c	3.31a	6.91a	10.22a	241.3c
80	86.9b	774a	8.91b	1.99b	3.52b	5.51b	388.7b
90	30.6b	417b	13.60a	0.74c	0.81c	1.55c	568.0a
Significant level	p <0.01	p <0.01	p <0.001	p <0.001	p <0.001	p <0.001	p <0.001

Mean values in each column with the same letter are not significantly different (p <0.05)

were less as compared to effect on flowering branches. Significant reduction on flower buds per shoot and frequency of return bloom were only found under 50% and 80% shades, respectively.

Effect of shade on growth

Results of destructive analysis at 14th week are summarized in *Table 3*. Total leaf number, total leaf area and mean leaf area responded differently towards increased shade levels. Shade levels of 20% and 50% did not affect significantly the number of green leaves present on the plant. Significant reduction (p <0.01) on leaf number was only observed under 80% and 90% shade levels. Generally, shades increased the total leaf area, but significant increased (p <0.01) was only found at 50% and 80%. Similarly, the mean leaf area also increased by increasing the shade level, in which plants under 90% shade had 10 times larger leaves than under open.

Shades also influenced plant dry weight. The 50% shade (moderate) seems to have higher leaf dry weight, but the differences between moderate and fully exposed plants were not significant. There was a significant reduction (p <0.001) on stem dry weight under 80% and 90% shades as compared to those exposed and other shade treatments. Similar response was also observed for total dry weight.

The effect of shade levels on specific leaf area (SLA) was also significant (p <0.001). The SLA at 90% shade was five times higher than under exposed condition.

Discussion

Shade levels strongly influenced the initial flowering of *T. trioniflora*. As shade levels increased, the time to first flowering was delayed from 27 days under exposed condition to 53 days under 80% shade. A similar response has been found in *Begonia* x *semperflorens-cultorum* (Kessler

and Armitage 1992) and other bedding plants (Erwin et al. 2003). The number of nodes at first flowering was also increased by shade but significant increase was only found at higher shade levels (above 50%). According to Dieleman and Heuvelink (1990), the delay in the first flowering may be due to slower rate of leaf production and flower initiation. The results of this study are in agreement to their findings. For flower initiation to take place there must be a minimum amount of assimilates available in the apex (Sach and Hackett 1969), and it was obvious in this study that shade is a strong factor that reduces assimilates production, which finally causes delay in flowering (Flore and Layne 1999).

Apart from the delay to first flowering, higher shade levels also reduced the number of flower produced. The greater difference was observed at the earlier stage of flowering as compared to later stages. The differences in time of flowering and the influence of self shading at later stages may contribute to this phenomenon. The reduction of flower number may associate with several factors. Among these factors is the reduction in the number of flowering shoots (*Table 2*). Similar results have been reported by Karlsson et al. (1989) and Schoellorn et al. (1996) for chrysanthemum, in which branching was strongly reduced under low light condition. The number of flower buds present on a shoot also affected by shade and contributed to low flower production. It was also observed that, no flower abortion occur under all shade treatments, unlike what has been found in Easter lily that low light caused high abortion rate (Wang 1996). Another factor that contributed to low flower production was low frequency of return bloom but this happened only to plants grown at high shade level (80%).

However, the growth of *T. trioniflora* was less affected by shade. The total leaf number, stem and total dry matter were only significantly reduced when shade level was 80% or higher. Although the plants at 20% and 50% shades received less amount of light, but they adapting toward reduced light conditions by increasing the leaf area per plant. This would increase the photosynthetic efficiency of the plant. The leaf number under 0, 20 and 50% shade levels was similar but the leaf size increased as shade leaves increased. Some plants like strawberry, when light level was reduced, the fraction of light interception and efficiency of light utilization were increased (Wright and Sandrang 1995). Looking at the responses of plant leaves to different light levels, it was obvious that the plants had a great mechanism to adapt to low light condition to sustain growth but not for flowering. The increase in SLA (thinner leaves) to about five folds under high shade levels (90%), clearly demonstrated that the species belongs to shade intolerant category (Smith 1981; Corre 1983).

Conclusion

The results of this study suggest that *T. trioniflora* plants are best to be planted under open conditions for maximum flowering. The results also showed that the plant could stand moderate shades but the flowering intensity was reduced. However, under partially shaded areas, efficient pruning practices could be adopted to increase flowering potential. Under very heavy shade (>80%), plants were not able to flower at all. The main factors that contribute to the reduction of flower number under the shade were due to low production of flowering shoots and low frequency of return bloom.

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Abstrak

Satu kajian telah dijalankan untuk menilai tindak balas pertumbuhan dan pembungaan *Turnera trioniflora* di bawah aras lindungan yang berbeza iaitu 0 (tiada lindungan), 20, 50, 80 dan 90% lindungan. Kesemua aras lindungan didapati telah melambatkan pengeluaran bunga pertama, dengan pokok pada lindungan 80% mengambil masa dua kali ganda lebih lambat untuk berbunga berbanding dengan pokok yang tiada lindungan. Bilangan ruas dan panjang pucuk semasa pembungaan pertama juga bertambah dengan bertambahnya aras lindungan. Lindungan yang tinggi juga menyebabkan pengurangan bilangan bunga yang kembang dalam sehari. Faktor utama yang menyebabkan berkurangnya pengeluaran bunga ialah berkurangnya bilangan cabang bunga. Di samping itu, bilangan putik bunga dan kekerapan berbunga semula yang rendah pada sesuatu cabang juga menyumbang kepada pengeluaran bunga yang rendah pada aras lindungan yang tinggi. Pada amnya, pertumbuhan *T. trioniflora* hanya terjejas oleh aras lindungan yang tinggi (80% dan 90%). Tumbuhan ini berupaya mengubah suai morfologi seperti pertambahan lebar daun dan pengurangan ketebalan daun untuk tumbuh dalam keadaan cahaya yang kurang. Oleh itu, pokok *T. trioniflora* disyorkan ditanam di kawasan terbuka atau lindungan yang sederhana bagi pengeluaran bunga yang optimum.

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