

## **EFFECTS OF EXTENDED PHOTOPERIOD ON “DRY SET” PRODUCTION OF BIG ONION (*Allium cepa* L.)**

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### **ABSTRACT**

Dry-set is a reliable planting material that can be used for onion bulb and seed production. However, the production of onion "dry sets" under local condition is difficult due to the short photoperiod, which is not favorable for early initiation of onion bulbs. However, according to research information, it should be possible to overcome this problem by using tungsten lights to extend the photoperiod although little information is available on this aspect for local condition. Experiments were conducted at the Field Crop Research and Development Institute at Mahalluppallama to test the possibility of inducing set production of onion under extended photoperiod conditions. Results revealed that extension of photo-period by four hours from 6pm to 10 pm using 60W tungsten lamps fixed 2m apart at 1m height from the seedling canopy level could induce set production of onion under local condition. It was also demonstrated that the exposure to the longer photoperiod could be started as early as two weeks from seedling emergence and could be effectively induced set even by providing it every other day under local field conditions. Photoperiod extension could be discontinued after the initiation of bulbing without affecting the quality of harvested sets.

**KEYWORDS:** Onion set production, Photoperiod extension, Tropical onion.

### **INTRODUCTION**

"Sets" (also referred to as "dry sets") are small dry onion bulbs used as an alternative planting material in onion cultivation. Use of sets as planting material would be advantageous in tropical regions in obtaining good quality bulbs, more uniform bulbing, high percentage of bulbing, high percentage of thin neck bulbs, early maturity, flexibility in planting time, easy nursery management, and easy planting in the field over the alternative methods of direct sowing and seedling transplanting. Larger sets could also be used as mother bulbs in onion seed production during *yala* season.

Onion is a long day plant and therefore, it prefers long day condition for bulb formation. Photoperiod requirement for bulbing varies from cultivar to cultivar. As shown by Heath and Holdsworth (1948), photoperiod requirement for bulbing of plants propagated from sets is less compared to that of seedlings. However, production of sets is difficult for most of the onion cultivars grown under tropical field conditions due to the short day condition. Therefore, it is

important to identify methods to overcome this problem in order to gain the maximum advantage of using sets.

It has been shown that the rate of bulb development increases with the increase of photoperiod (Magruder and Allard, 1937; Austin, 1972; Mondale *et al.*, 1986; Mettananda and Fordham, 1997). The spectral quality of incident light can modify the photoperiodic response of onion plant. Most long day plants require a mixture of red and far-red light to obtain maximum photoperiodic response (Evans, 1971). Austin (1972) found that red and far-red light mixture with lower red : far-red ratio such as in tungsten lights favour photoperiodic induction of onion bulbing. Therefore, it will be possible to induce set production of tropical onion by providing a photoperiodic extension using tungsten lamps. However, in order to reduce the cost of production, it is important to identify the minimum level of artificial lighting necessary to induce set production in tropical onions. Thus, experiments were conducted in order to (i) Identify the possibility of inducing set production by intermittent exposure to long day conditions, (ii) Identify the effective distance from the light source in inducing set production, (iii) Test the effect of return to a normal 12h photoperiod after inducing set production under long day conditions, (iv) Test the effect of seedling age on exposure to long day condition in set production and (v) Identify the most economical way of using artificial lights in obtaining the advantages of long day condition in inducing set production of tropical onion cultivars.

## MATERIALS AND METHODS

The 1<sup>st</sup> two experiments were conducted at the Field Crop Research and Development Institute at Mahalluppallama, Sri Lanka as described below.

### Experiment 1

Effects of interrupted exposure to long day condition on set production of onion were studied using three cultivars of tropical onion. The photoperiod treatments were; (i). A 12-hour (12h) continuous, (ii). A 16-hour (16h) continuous, (iii). One day for 12h alternating with one day for 16h, (iv). Two days for 12h alternating with one day for 16h, and (v). One day for 12h alternating with two days for 16h.

### Experiment 2

Effects of different photoperiod treatments on dryset production of tropical onion were studied using three onion cultivars under four photoperiod treatments; (i). Exposed to 16h photoperiod from 14 days after emergence, (ii).

Exposed to 16h photoperiod from 14 days after emergence and transferred to 12h photoperiod after scale leaf formation, (iii). Exposed to 16h photoperiod from 28 days after emergence, (iv). Exposed to 16h photoperiod from 28 days after emergence and transferred to 12h photoperiod after scale leaf formation.

For both experiments, three onion cultivars namely; (1) Agrifound light red (AFLR), (2) Agrifound dark red (AFDR) (3) Galil were used. Treatments were arranged in a split plot design with photoperiod treatment as the main plot, with three replicates. A row of 60W tungsten light bulbs set at 1m apart and placed at a height of 1m from the trays was used from 6pm to 10pm to provide 16h photoperiod. Seeds of the three cultivars were sown on 15cm x 22cm size black plastic seed trays filled with 1:1 mixture of cattle manure and soil at the rate of 2g of seeds per tray on 11.7.95 for exp.1 and on 12.7.95 for exp. 2. Extra seedlings were thinned out at 2 weeks after sowing and 16h photoperiod was provided from four weeks from sowing. Thick black polythene screens were used at night to protect 12h treatments from having residual effects of 16h treatments. Seedlings were maintained under the management practices for onion recommended by the Department of Agriculture (DOA, 1990).

### **Observations and records**

Destructive harvests were made at weekly intervals to monitor bulb scale formation and identify re-growth of bladed leaves. Leaf area was measured using a Delta T leaf area meter. Leaf blades were flattened after placing on the light box of the leaf area metre before taking the measurement.

### **Experiment 3**

Effects of distance from light source in inducing set production in tropical onions were investigated under tropical field conditions with four cultivars of onions namely; Agrifound dark red, Agrifound light red, Galil, and Red creole. Observations were made at twelve distances, namely 1. 0m (below the light source), 2 1m away from the light source. 3. – 12. From 2m – 12m away from the light source respectively. A 0.5m high thick black polythene screen was placed in between distance 11 and 12 to cut off the effect of extended photoperiod to distance 12 making it is equal to control where photoperiod is around 12h (Plate 1).



**Plate 1. Field layout of experiment number 3 at the FCRDI, Mahailuppallama.**

Seeds were sown on 12.7.95 in five rows of 50cm long on nursery beds of 2.5m x 0.6m x 0.015m prepared on each distance line and seedlings were maintained under the management practices for onion recommended by the Department of Agriculture (DOA, 1990). At 14 days after emergence a 4 hour extension of tungsten light photoperiod was provided at the end of the day by using a row of 60W tungsten light bulbs set at 1m apart and 1m height from the centre of the 1st row of beds. Intensity of these lights on the seedling canopy was measured as  $8.5 \text{ W m}^{-2} \text{ s}^{-1}$  (total radiation), using a tube solarimeter attached to a microvolt integrator. Light intensity decreased in proportion to the square of the distance from the source. Therefore, at different distances from the light source the intensities could be calculated as follows.

- i. 0m distance - Actual distance from the light source is 1 metre because the row of bulbs is at a 1m height from the seedling canopy. Therefore, the actual light intensity =  $8.5 / (1 \times 1) = 8.5 \text{ W m}^{-2} \text{ s}^{-1}$ .
- ii. 1m distance - Actual distance from light source is  $\sqrt{2}$  (Pythagorus), therefore, the light intensity =  $8.5 / (\sqrt{2} \times \sqrt{2}) = 4.25 \text{ W m}^{-2} \text{ s}^{-1}$ .
- iii.. It is 1.7, 0.85, 0.5,  $\text{W m}^{-2} \text{ s}^{-1}$  at the distances 2, 3 and 4 metres from the light source respectively.

The black polythene screen separating the treatment 11 and 12 was removed during the day light period to avoid possible shading. Split plot design with four replications was used considering the factor distances as main plot and cultivars as sub plot factor. It was not possible to randomise the main plot factor within blocks due to the nature of the factor. However, a uniform site was

selected for all four blocks in order to minimise the possible effects of gradient in soil and micro-climatic conditions.

### Observations and records

Data were recorded at weekly intervals on leaf emergence, leaf area and days to scale initiation, in three randomly selected plants within each treatment.

## RESULTS AND DISCUSSION

### Experiment 1

All three cultivars used in this study behaved similarly under the different photoperiod treatments except that the response time to different photoperiod treatments was about 2 weeks longer in case of the cultivar Agrifound Dark Red. By considering the similarity of the behaviour of different cultivars only the data for the cultivar Agrifound dark red are presented.

### Days to scale initiation and cessation of leaf emergence

Onset of scale leaf formation inside the base of the onion plant is considered as the initiation of bulb formation (Brewster, 1990). Earliest scale initiation was observed under continuous exposure to 16h photoperiod. In interrupting the 16h photoperiod with a return to 12h, alternating two days at 16h with one day at 12h, and one day at 16h with one day at 12h were both effective at inducing scale initiation although to a lesser extent than the continuous long day treatment. Scale initiation under 2 days at 12h alternating with one day at 16h was similar to that of continuous 12h treatment. (table 1)

**Table 1. Effect of different photoperiods on time to scale initiation (SI) in tropical onion cultivar Agrifound dark red.**

<i>Treatment</i>	<i>Days to scale initiation after starting photoperiod treatment</i>
16h continuous	42
Two days at 16h alternating with one day at 12h	75
One day at 16h alternating with one day at 12h	102
One day at 16h alternating with two days at 12h	>120
12h continuous	>120
<b>Standard error of the difference (SED)</b>	<b>8.4</b>

### Leaf area

Leaf area development followed a similar pattern to that of scale initiation in response to the different photoperiod treatments. Reduction in leaf area in respective photoperiod treatments is due to the cessation of leaf emergence and leaf senescence in those treatments with the onset of bulbing. Exposure to 16h photoperiod alternating with two days at 12h showed a similar response to that of exposure to a continuous 12h photoperiod (figure 1).

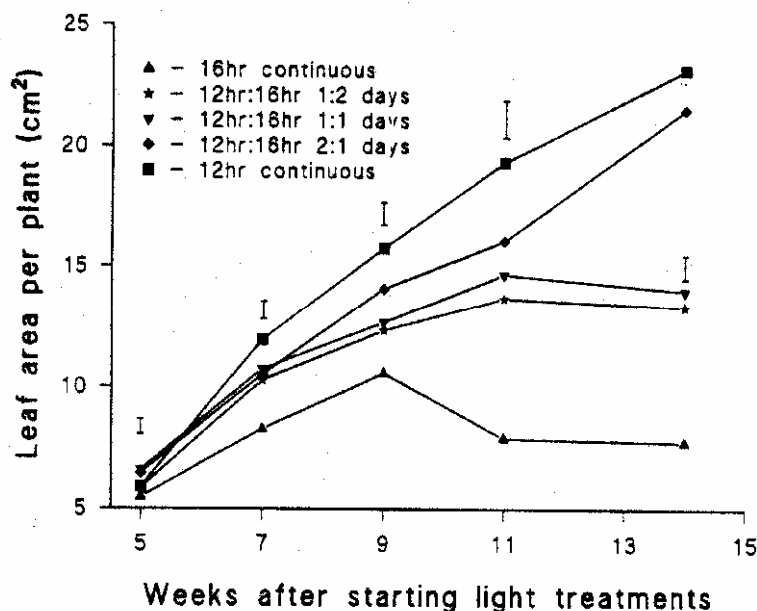


Figure 1. Effect of expose to different photoperiod treatments on the leaf area development of onion cultivar: Agrifound dark red (Vertical bars: Standard error of the difference).

Results revealed that an exposure to a 16h photoperiod induce early set production in tropical onion compared to that under a natural 12h photoperiod. Intermittent exposure to 16h photoperiod was also effective in inducing bulbing but the longer the exposure to 16h photoperiod in a cycle, quicker it was. This suggests a cumulative nature of bulbing stimulus when the photoperiod is maintained at least under the minimum required for any particular cultivar. However, there was no significant improvement in attaining bulbing when the plants were exposed to a 16h photoperiod for a shorter period than that of 12h photoperiod.

In summary, the results of this experiment support the cumulative theory of bulbing stimulus suggested by Brewster (1990). However, when the frequency of exposure to longer photoperiods is low (eg. returning to two days

for 12h after only being one day at 16h) there is no comparative advantage over 12h continuous photoperiod in accumulating bulbing stimulus.

## Experiment 2

The response time to bulb induction under different photoperiod treatments was about two weeks earlier in the case of cultivar Galil and about two weeks late in case of cultivar Agrifound dark red when compared to the cultivar Agrifound light red in this study. However, the general behaviour of all three cultivars with respect to the different photoperiod treatments was similar. Data are therefore presented for the cultivar Agrifound light red only.

### Leaf number

The time to cessation of leaf emergence varied between different photoperiod treatments. Early exposure to the 16h photoperiod induced seedlings to stop leaf emergence early when compared to late exposure. This could be due to an early switch over to scale leaf production when seedlings were exposed to long day condition at an early stage of growth. Transferring plants back to the 12h natural photoperiod after the cessation of leaf emergence under the 16h photoperiod did not allow them to resume bladed leaf production in both instances. This indicated the ability of tropical cultivars to maintain their bulbing status under the natural 12h photoperiod once induced under a longer photoperiod (figure 2).

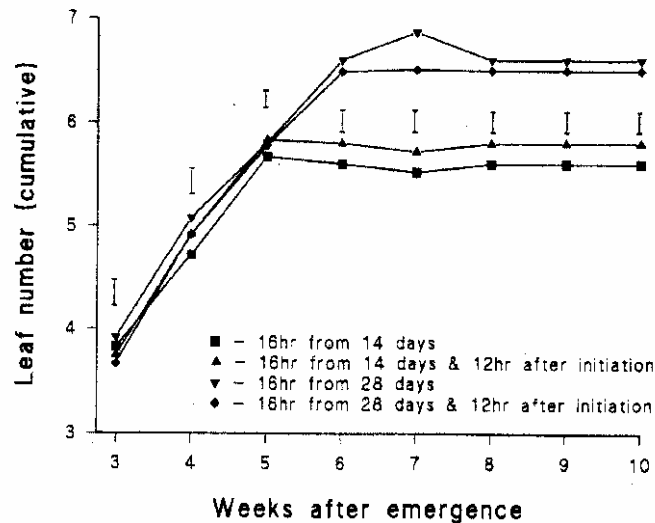


Figure 2. Effect of different photoperiod treatments on leaf emergence of onion cultivar: Agrifound light red (vertical bars: Standard error of the difference)

### Leaf area

The leaf area followed a pattern similar to that of leaf emergence although, it continued to expand at a reduced rate, beyond the cessation of leaf emergence. This could be due to the continued growth of existing leaves (figure 3).

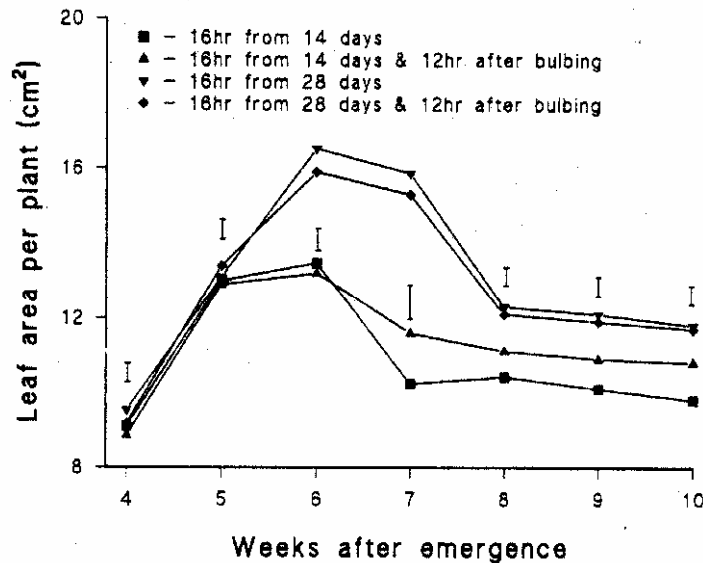


Figure 3. Effect of different photoperiod treatments on leaf area development of tropical onion cultivar: Agrifound light red (Vertical bars: Standard error of the difference)

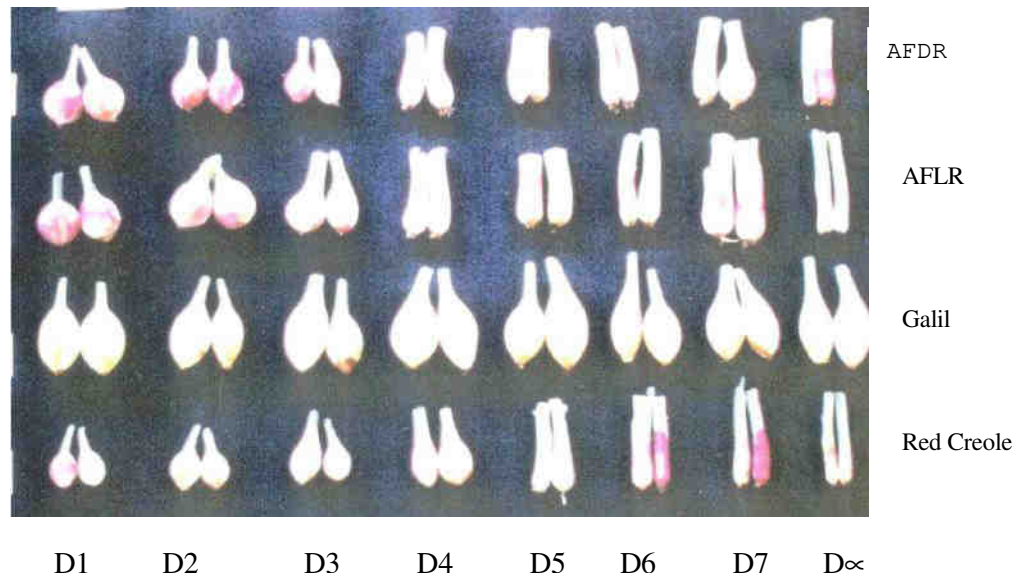
This experiment shows, once set production is induced under a longer photoperiod, plants could remain in a bulbing state even after transferring them back to a 12h natural photoperiod. The earlier the exposure to longer photoperiods the quicker the initiation of set production occurred. Once the set formation induced under long photoperiods the seedlings must have been able to maintain it under the 12h photoperiod, which is the minimum, required for bulbing.

In summary, the results of experiment 2 demonstrated the ability of tropical onion to remain in bulbing state even under a 12h natural photoperiod once it induced under a longer photoperiod. They could be induced to bulb by exposing to 16h photoperiod as early as 2 weeks from emergence. The ability of

tropical onion to stay in bulbing after induction is important in reducing the cost of set production under extended photoperiod by using tungsten light.

### Experiment 3

Data on the effects of distance from light source on different aspects of growth and bulbing parameters were collected weekly and are presented below (figure 4, table 2). As there were no effects on bulbing of any of the tested cultivars beyond 4 metres from the light source, data between 5 -11m distances are omitted in the presentation to improve clarity.



**Plate 2:** Level of bulb initiation at different distances from the light source of four cultivars of onion by 5 weeks after starting the 16h light treatment (D – distance from the light source, 1- under the light, 2 – 7 one to seven metre away from the base of the light,  $\infty$  - distance with no effect of extended photoperiod).

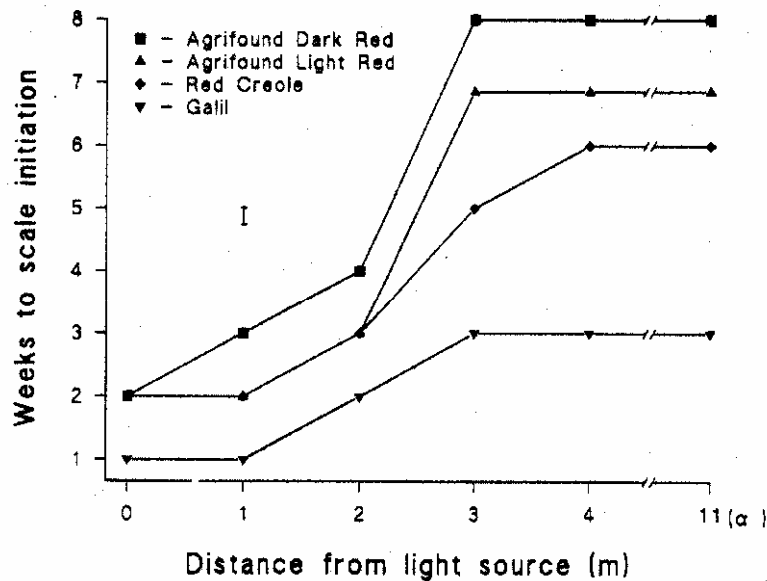
### Weeks to scale initiation/bulbing

Weeks to scale initiation/bulbing varied with both cultivar and distance from the light source. Cultivar Galil was the earliest to initiate scales. It occurred at all distances, including the control, by 3 weeks after the light treatment. This indicates that the natural 12h photoperiod is even sufficient to cause bulb induction in this cultivar. This shows its high sensitivity to the photoperiodic stimulus compared to other cultivars tested. In cultivars Agrifound light red (AFLR) and Agrifound dark red (AFDR) scale initiation was induced by the long day effect of lights up to a distance of 2m by 3 and 4 weeks respectively. At all other distances including the control, scale initiation occurred by 7 and 8 weeks in Agrifound light red and dark red respectively. In

the cultivar Red Creole, scale initiation was induced up to 3m by 5 weeks after light treatment due to long day effect. In all the other distances including the control, the scale initiation occurred by 6 weeks due to natural day light induction (plate 2, figure 4 and table 2).

**Table 2. Effect of distance from the light source on time to scale initiation in long day induction of set production in four cultivars of tropical onion.**

Distance (D) from the light source (m)	Weeks to scale initiation for the cultivar (C) from the start of the light treatment			
	AFDR	AFLR	Galil	Red Creole
0	2.5	2.5	2.0	2.3
1	3.3	2.3	2.3	2.5
2	4.0	3.3	3.0	3.5
3	8.0	7.0	3.0	5.0
4	8.0	7.0	3.0	6.0
5	8.0	7.0	3.0	6.0
Control	8.0	7.0	3.0	6.0
Standard error of the difference (D x C)			0.42	



**Figure 4. Effect of distance from light source on time to set initiation on four cultivars of tropical onion (Vertical bar: Standard error of the difference)**

The effective distance for inducing set production with tungsten light photoperiodic extension varied between cultivars. All four cultivars indicated an early set initiation up to a distance of 2 metres from the light source. However, the difference between the time to bulbing under 12hr and 16hr photoperiod is less in Galil indicating its less sensitivity to long photoperiod. But the cultivar Agri found dark red and Red creole showed an increased sensitivity to long photoperiod for bulbing. Comparisons between the cost of either raising seedlings under natural photoperiod or by using daylength extension to produce dry sets indicated that costs of the latter were only about 5% higher (table 3). When considering the advantages of using sets under tropical conditions the additional cost could be considered negligible. In addition, possibility to use sets as mother bulbs for seed production during *yala* season is a major advantage.

**Table 3. Comparison of cost of production of seedlings and drysets of onion for planting one-hectare area in Sri Lanka.**

<i>Item</i>	<i>Seedlings</i>	<i>Drysets</i>
Seed cost	7.2kg x 1500Rs = 10800Rs.	7.2kg x 1500Rs = 10800Rs.
Labour	45 labour days x 250Rs. = 11250Rs.	= 60 labour days x 250Rs = 15000Rs
White polythene to cover the nursery beds.	35kg x 100Rs. = 3500Rs	Not required
Other material cost	= 2000Rs	= 2500Rs.
Cost of lighting for photoperiod extension	None	Rs. 792*
<b>Total cost</b>	<b>Rs 27550/=</b>	<b>Rs. 29092/=</b>

\* Area covered with one 60W bulb = 2m radius (12.5 m<sup>2</sup>) or 4 standard size (3mx 1m) nursery beds. It is required about 120 standard size beds to produce “dry sets” to plant one-hectare area in the field which needs about 30, 60W tungsten lamps. Therefore, it needs about 1800W (*ie* 30 x 60W) at any time. Lighting is required for 4h per day using lamps only in alternate days over a period of 21 days (*ie*. total KWH required = 4h x 11days x 1.8KW = 79.2KWH) The cost of a one KWH Sri Lanka at present is 10Rs (2003). Therefore, the total cost of lighting will be 79.2 x 10 = 7926Rs.

In summary, use of tungsten light in long day induction of set production is a useful technique for marginal photoperiod areas in tropical regions. The effective distance of photoperiodic induction from a given light source depends on the photoperiodic sensitivity of the cultivar.

## CONCLUSIONS

Photoperiod extension using tungsten lamps could be used for set production from big onion in the dry zone of Sri Lanka. One 60W tungsten bulb could be used to induce sets in an area of about two-metre radius in the nursery. It is sufficient to provide a 16h photoperiod every other day to promote set production under tropical field conditions. It is not necessary to provide photoperiodic extension after starting the set formation. Exposure to extended photoperiod could be started as early as 14 days after emergence, which will promote early set production when compared to later exposure. Therefore, this could be used as a practical method for producing sets in tropical countries where production under natural conditions is difficult due to the marginality of the available photoperiods.

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