Evaluation Of Light Bulbs And The Use Of Foliar Fertilizer During Off-Season Production Of Dragon Fruit

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Abstract

Under natural conditions, dragon cactus produced flowers and bears fruit only during the long-day months from May to October. In other countries, dragon fruit plants produce fruits almost all year round and can possibly be done in the Philippines. Timing of fruit ripening can satisfy the market demand during off-season by providing additional light during the short-day period to induce flowering at the required period. Thus, this study evaluated light bulbs and the application of foliar fertilizer during off-season production of dragon fruit.

The experiment was laid out in Split plot Design where light bulbs as the main plot and foliar fertilization as the sub-plot. The main plot were 100 watt-incandescent bulb (IB), 26 watt-compact fluorescent bulb (CFL) and 6 watt- light emitting diode (LED)while with and without foliar fertilization as the sub-plot. Supplemental lighting was introduced between 10 o'clock in the evening until two o'clock the following morning by suspending the bulbs. These were positioned at the center of the four posts of dragon cactus about five feet above the ground.

Dragon cactus lighted with different bulbs as well asthose applied and unapplied with foliar fertilizer did not show significant results in terms ofnumber of fruits, weight per fruit, yield per post and yield per hectare. In addition, the interaction between the effect of light bulbs and the foliar fertilizer gaveinsignificant result.

In a 1,000 m^2 area, the use 6-W LED bulbs gave the highest cost of materials and installation of PhP60,610.00 followed by 26-W CFL (PhP43,735.00) and the least was from 100-W IB PhP31,485.00. However, in terms of electric consumption and the cost of electricity, the use of 6-WLED bulbs was the lowest followed by those with 26-W CFL while those with 100-W IB rose relatively. In six month-period, plants lighted with 6-WLED bulbs (PhP86,726.00) and 26-W CFL (PhP82,421.00) had higher net income than those in the 100-W IB (PhP26,647.00) plot.

Introduction

Dragon cactus (*Hylocereus* spp.) belongs to the Cactaceae family from the subfamily Cactoidea of the tribe Cactea (Raveh, 1993) and most widely distributed in six continents (Crane and Balerdi, 2009). It is a native of Central America (Thulaja, 1999; Zee et. al., 2004).

In the Philippines, dragon fruit is becoming a favourite of many Filipinos for its known therapeutic properties. This fruit is now considered as "Healthy Food for the Table," because of low in calories but rich in fiber and minerals (www. bezearch.com; Mizrahi and Nerd, 1999, Le Bellec et al. 2006; Mahattanatawee et al., 2006; and Khalili et. al, 2006). It is now gaining popularity and will eventually pose a great demand among local consumers. This is therefore becoming an emerging champion in the local fruit industry. It is excellently grown in Ilocos Norte because of its adaptability to the climatic (Type 1) and soil conditions of the province. It can grow even in marginal upland and sand dune areas which abound in the province (Pascua, et al. 2010; 2012).

Having a potential in IlocosNorte, Hon. Imee R. Marcos is pushing the development of dragon fruit industry in the province specifically tohave a year round supply of dragon fruit in the market. Thiscan boost the dragon fruit industry and finally, attract investors in the production, processing, export and other business opportunities and hopefully become an export earner in the near future. This will create niche in the agri-business ventures. Thus, the development of technology that focused on this aspect should be considered.This can solve the constraint of low supply of dragon fruit in the market during the period of December to April. This will answer the high demand on these months and the continuous supply for the export in the future. Usually, demands of dragon fruit are high during these months especially during New Year. With this technology, this will give morelucrative income to growers.

One of the environmental signals is to control the timing of the production of florigen and antiflorigen. The link between environmental and internal signals has been most clearly established for photoperiod. The role of day length in the regulation of flowering had been recognized in 1913. The impact of photoperiod in numerous species soon became apparent.

Photoperiodism is one of the many factors to induce flowering of plants (Summerfield et. al., 1992; Laurie, 1997; Adams et.al., 2001; Boss et.al., 2004; Baurle and Dean, 2006). It is the induction of flowering in plants by day length or more appropriately night length. The effect of photoperiod can be divided into several response classifications. The distinction between the different classes of responses lay in their reaction to the length of night or darkness period. The short day plants initiate flowering when the dark period reaches a minimum threshold length. Any greater period of darkness will also induce flowering. For long day plants, flower initiation occurs when dark periods (nights) are reduced below the threshold levels. This occurs during the days when they are growing longer and nights shorter. A group in the intermediate class falls between the long and short days and have two possible initiation events per year. Day neutral plants are those that do not respond to the light or dark periods in order to flower but flower due to age or other factors. The threshold for flowering varies from plant to plant, some flower when days are longer than 12 hours and others require shorter than eight hours.

In several countries, flowering can be induced in various plants most especially in greenhouses during shorter days using artificial lighting treatments. Flowering in cannabis is triggered by a hormonal reaction within the plant that is set on by an increase in its dark cycle. A plant needs sufficient prolonged darkness for calyx development(flowering). Some *indica* varieties can take as little as 8 hours of dark to begin flowering, whereas some *sativa* varieties can take up to 13 (wikipedia.org/wiki/Cannabis_cultivation).

Dragon cactus is photoperiodic, meaning it flowers in response to the length of the day and night. Itproduced flowers and bears fruit during the long-day months of May to October thatrequiresshort dark night to produce flowers. Controlling the day length or photoperiod by providing supplemental lighting can influence flower induction.The induction of flowering by manipulating the environment is possible already in other countries. In Taiwan, the flowering of dragon fruit can be prolonged between September and March. The flowering can be induced by breaking the dark period with supplemental lighting between 10:00 p.m. and 2:00 a.m., allowing off-season production from November to April. The fruits produced during the cool season in Taiwan are more desired in the market than fruits from summer crops because the off-season fruits are larger and sweeter. The recommend lighting utilizes 100 watt-incandescent light bulbs at about 4–5 feet spacing suspended about 6 feet above the ground (Zee et al. 2004).

In Vietnam, dragon fruit plants produce fruits almost all year round, especially if irrigation and fertilizer are provided. Timing of fruit ripening to satisfy the market demand at particular period can be done by providing additional light during the short-day period to induce flowering at the required period(http://www.fao.org/docrep/008/ad523e/ad523e05.htm).May (www.ehow.com/how) recommended some tips how to induce flowering on long day-plants.

In the Philippines, the use of incandescent light bulbs might be prohibitive in the off-season dragon fruit production because this requires high electricity cost. The search of alternative bulbs is deemed necessary. Together with the incandescent bulb, other locally available bulbs such as CFL and LEDwere evaluated to compare their profitability as supplemental lighting during off-season dragon fruit production. In addition, the foliar fertilization can possibly increase the yield.Thus, this study was conducted.

Objective

The objective of the study is to evaluate light bulbs and foliar fertilizer in inducing flowering during off-season months

Materials and Methods

The experiment was conducted at the dragon farm of MMSU. In each treatment, fifteen posts of dragon cactus were usedlaid out in three rows and five posts in each row. The inner row was used as sampling area.

The experiment was laid out in a Split Plot Design where light bulbs served as the main plot and foliar fertilization as the sub-plot. The main plotwas100 watt-incandescent bulb (IB), 26 watt-compact fluorescent bulb(CFL) and 6 watt- light emitting diode (LED). The sub-plot waswith or no foliar fertilizationwhere thefoliar fertilizerwas applied using the manufacturer’s recommendation at weekly interval.

Supplemental lighting was introduced between 10 o'clock in the evening until two o'clock the following morning by suspending the bulbs. These were positioned at the center of the four posts of dragon cactus about five feet above the ground.

Data on the light intensity of the different bulbs, weight of fruits, number of fruits, yield per post as well as the cost and return were gathered.

Results

Dragon cactus lighted with IB had higher number of fruits, weight per fruit, yield per post and yield per hectare than those on CFL and LED plots.However, statistical analysis showed that theydid not differ significantly ($P < 0.01$; Fc=2.82, 0.48, 1.97, 1.97) (Table 1). Likewise, dragon cactus sprayed with foliar fertilizer did vary significantly when compared with the unsprayed plants in terms of number of fruits, weight per fruit, yield per post and yield per hectare. In addition, the interaction between the effect of light bulbs and the foliar fertilizer did not give significant result.

Table 1. Agronomic and yield of dragon cactus using different electric bulbs and foliar fertilizer during off-season months

Light Bulb (LB)	No. of fruits	Weight (g)/fruit	Yield (kg)/post	Yield (kg)/ha
IB (100 w)	10.2	320.25	3.25	5,204.80
CFL (26 w)	8.0	333.06	2.69	4,304.00
LED (6 w)	8.0	308.00	2.35	3,753.60
Fc	2.82^{ns}	0.48^{ns}	1.97^{ns}	1.97^{ns}
Foliar Fertilizer (FF)				
Unsprayed	9.07	315.93	2.85	4,560.00
Sprayed	8.27	324.94	2.68	4,281.00
Fc	0.61^{ns}	0.33^{ns}	0.32^{ns}	0.32^{ns}
LB x FF	0.97^{ns}	1.06^{ns}	0.65^{ns}	0.65^{ns}

In a 1,000 m^2 area, the use 6-W LED bulbs gave the highest cost of materials and installation of PhP60,610.00 followed by 26-W CFL (PhP43,735.00) and the least was from 100-W IB PhP31,485.00 (Table 2).However, in terms of electric consumption and the cost of electricity, the use of LED bulbs was the lowest followed by those with CFL and those with ID rose relatively (Table 3). As a result, this gave those plots lighted with LED bulbs and CFL higher net income than those in the IB plot despite of higher yield in the latter.

Discussion

In plants, the timing of floral transition has a direct impact on reproductive success. The floral transition is triggered by both endogenous and environmental factors. One of the most important environmental factors for floral transition is the change in day length or photoperiod. While other environmental factors vary from year to year, day length change follows a predictable pattern. Therefore, a large majority of plants have evolved mechanisms to integrate the response to day length changes into the pathways regulating floral initiation.

Table 2. Cost of materials and installation in a 1,000 m^2 area per treatment

Particular	Unit Price	Treatment		
		26-W CFL	6-W LED Bulb	100-W IB
160 pcs. bulbs		20,250.00	37,125.00	8,000.00
160 pcs. Rubber socket (heavy duty weather proof)	45.00	6,075.00	6,075.00	6,075.00
7 boxes (150m/box) 2 mm^2 THHN copper wire	2,000.00	14,000.00	14,000.00	14,000.00
6 rolls electric tape	35.00	210.00	210.00	210.00
1 pc. Circuit breaker with casing (15A)	700.00	700.00	700.00	700.00
Time setting device	500.00	500.00	500.00	500.00
Labor cost		2,000.00	2,000.00	2,000.00
Total		43,735.00	60,610.00	31,485.00

Table 3. Cost and return analysis in a 1,000 m^2 area per treatment in a six month-period

Parameter	Treatment		
	26-W CFL	6-W LED Bulb	100-W IB
Yield (kg)	860.8	752.72	1,040.96
Price/kg	150.00	150.00	150.00
Gross income	129,120.00	112,608.00	156,144.00
Material & Installation cost*	8,747.00	12,122.00	6,297.00
Electric consumption (kw-hr)	2,995.2	576.00	11,520.00
Cost of electricity	29,952.00	5,760.00	115,200.00
Harvesting cost	8,000.00	8,000.00	8,000.00
Total Cost	46,699.00	25,882.00	129,497.00
Net Income	82,421.00	86,726.00	26,647.00

*Total material and installation cost was divided by 5 which means five years usage life

Photoperiodism means the plant's response to certain signals, including both the duration and the quality of light it receives. In plants, part of the electromagnetic spectrum acts by providing for specific photo-chemical reactions in both control and energy production pathways. Plants capture light energy to make carbohydrates and to control some of the thousands of processes that occur in plant cells and also the wavelength used to make carbohydrates. Likewise, light controls the natural rhythm of the plant or the circardian clock which is inherent in all forms of life, however, not only through its presence but its quality as well.

A plant senses both the quality and the quantity of the light it perceives where it will sense different ratio of colors based on environmental factors. This difference is basically measured by the pigments when coupled with other triggers and processes, control what the plant does and when. It sets the biological clock in the plant so that all the plant's processes continue to run in harmony.

The level of pytochrome may influence an internal biological clock that keeps track of time. The clock establishes a free-running circardian rhythm of about twenty-four hours, this clock is constantly reset to parallel the natural changes in photoperiod as the seasons change. As the phytochrome interacts with the clock to synchronize the rhythm with the environment, a prospect is strengthened by the night break experiments, where the time of the light flash during the night is critical. Breaking the dark period promotes flowering in long-day plants (Cathey and Borthwick, 1964). This was proven in the previous study of Zee et al. (2004) and the result of the experiment.Supplemental lighting introduced between 10 o'clock in the evening until two o'clock the following morning was very effective.

Many plants like dragon cactus which flower only in long days are of interest of researchers and plant enthusiasts. The interest is to manipulate the environment to produce flowers even during short day months. One of the most important environmental factors for floral transition is the change in day length or photoperiod. It is because under the natural conditions, long day plants flower with long days and short nights. Induced flowering by environmental manipulations is a potential of answering the great demand of dragon fruit in the market during shorter days. In Vietnam, dragon fruit plants produce fruits almost all year round. Timing of fruit ripening to satisfy the market demand at particular period can be done by providing additional light during the short-day period to induce flowering at the required period(http://www.fao.org/docrep/008/ad523e/ad523e05.htm).

In the Philippines, off-season production is now a reality. This was exhibited by the result of the study through supplemental lighting introduced between 10 o'clock in the evening until two o'clock the following morning. However, the use of 100 watt-IB as recommended by Zee et al. (2004) and as the current technology of Vietnam (personal observation), is profitable considering the high cost of electricityin the Philippines. In our study, other bulbs such as CFL and LED bulbs were used which were equally effectivebut they had lower electric consumption as shown in the comparison of the three bulbs in Tables 3 and 4.

Table 4. Electrical power equivalents for differing lamps (wikipedia.org/wiki/Compact_fluorescent_lamp)

Minimum light output (lumens)	**Electrical power consumption (Watts)**		
	IB	CFL	LED
450	40	9-13	4-9
800	60	13-15	10-15
1,100	75	18-25	N/A
1,600	100	23-30	N/A
2,600	150	30-52	N/A

Light intensity is higher in CFL than in LED. In addition, IB and as the distance between the bulb and the object become farther, the light intensity lowers (Table 5). This data indicates that closer distance of posts of dragon cactus is recommended especially if using LED bulbs. A distance of 2 to 2.5 m between posts is recommended to fully utilize the available lights produced by the bulbs.

Table 5. Light intensity of light bulbs at different distances

Distance from the bulb to the object	Light Intensity (lumen/ft^2)		
	CFL (26 w)	LED (6 w)	IB (100 w)
1 ft.	105.0	30.0	59.0
2 ft.	24.0	9.0	16.0
3 ft.	11.3	3.2	7.7
4 ft.	3.5	2.0	4.0

A CFL was designed to replace an incandescent lamp; some types fit into light fixtures formerly used for incandescent lamps. Compared to general-service incandescent lamps giving the same amount of visible light, CFLs use one-fifth to one-third the electric power, and last eight to fifteen times longer. CFLs radiate a spectral power distribution that is different from that of incandescent lamps.

On the other hand, LED lamp is an energy efficient-product that delivers the same light output and offer significant saving on electric bill. It is a revolutionary green technology proven to outlast incandescent bulb and even CFLs, produce higher illumination, use of minimal energy and limits carbon emission. It can deliver similar output as the regular incandescent bulb but with a considerably extensive life span that can last from up 15,000 to 25,000 hours. They provide 80% more energy savings and can be used for more than 10 years on an average of three hours per day usage without needing replacement (Philstar, June 1, 2013).

Conclusion and Recommendation

The flowering of dragon cactus can now be induced supplemental lighting, breaking up the dark period by turning lights on for four in the middle of the night known as night-break.This can be done between 10 o'clock in the evening until two o'clock the following morningusing CFL or LED bulbs. However, high cost of electricity is one of the constraints of this technology.Research in reducing the electric consumption should be the focus. Intermittent or cyclic lighting can also be used during a nightinterruption. Cyclic lighting offers the opportunity to provide long-days while reducing electrical costs compared to standard nightinterruption lighting.

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