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Photoperiodic Regulation of Bulbing in Onions (*Allium Cepa* L. Var. Yellow Granex)

Jennifer P. Celades[1], Zenaida C. Gonzaga[2]

[1]College of Agricultural Sciences, Bohol Island State University, Bilar Campus, Bohol, Philippines

[2]Department of Horticulture, Visayas State University, Visca, Baybay City, Leyte, Philippines

ABSTRACT: Photoperiod plays a vital role in the growth, bulb formation, and yield of onion (*Allium cepa* L.). This study evaluated the effects of varying photoperiods on the growth and bulb development of onion cv. Yellow Granex. The experiment was conducted from February to May 2024 at the ACIAR–ICM project site, Department of Horticulture, Visayas State University, Visca, Baybay City, Leyte, Philippines. The treatments consisted of natural daylength (control) and photoperiod extensions of 8, 10, 12, 14, and 16 hours arranged in a Randomized Complete Block Design (RCBD) with three replications. Growth and yield parameters such as days to bulb formation, plant height, number of leaves, neck diameter, bulb weight, bulb length, and bulb diameter were evaluated. Results revealed significant effects of photoperiod on the horticultural characteristics and yield components of onion. The earliest bulb formation was observed under the 14-hour photoperiod, followed by the 16-hour treatment, while delayed bulbing occurred under the 8- and 10-hour photoperiods. Plants exposed to shorter photoperiods produced taller plants and more leaves, indicating prolonged vegetative growth. In contrast, longer photoperiods promoted earlier bulb initiation but reduced vegetative growth. The control and 12-hour photoperiod treatments produced significantly heavier and larger bulbs compared with shorter photoperiod treatments. The findings demonstrated that photoperiod strongly influenced bulb initiation, vegetative growth, and bulb development in onion. A 12-hour photoperiod was found to be favorable for bulb yield and quality under protected cultivation conditions.

KEYWORDS: *Allium cepa*, bulb initiation, daylength, photoperiod, yellow granex

INTRODUCTION

Onion (Allium cepa L.) is one of the most important bulb vegetable crops worldwide and belongs to the family Alliaceae. It is among the most widely cultivated vegetable crops globally and ranks next to tomato in terms of production due to its high economic and culinary value. Onions are generally classified into long-day, intermediate-day, and short-day cultivars according to their photoperiodic requirements for bulb formation. During early development, onion plants primarily produce vegetative leaves before initiating bulb formation depending on cultivar type and daylength conditions. Because of its increasing demand in both domestic and international markets, onion production requires proper crop management practices to improve yield, bulb quality, and overall productivity (Sharma et al., 2016).

Bulb formation and subsequent growth in onion are greatly influenced by environmental factors, particularly temperature and photoperiod (Brewster et al., 1977). Previous studies have demonstrated that longer photoperiods and higher temperatures promote bulb initiation and development in onion (Lancaster et al., 1996; Brewster, 2008; Atif et al., 2020). Prior to bulb initiation, onion plants undergo a vegetative or juvenile stage during which they remain insensitive to photoperiodic signals. Once plants reach a critical developmental stage, exposure to sufficient daylength stimulates bulbing (Ibrahim, 2010). Bulb formation occurs when the photoperiod requirement of a specific cultivar is met together with favorable temperature conditions, generally above 16°C. Conversely, if the required daylength is not achieved, plants continue vegetative growth without proper bulb development (Ibrahim, 2010). Bulbing response is also enhanced under cooler night temperatures and in larger plants with sufficient leaf development.

Onion growth, bulb formation, and maturity are largely determined by the interaction between genotype and environmental conditions (Brewster, 1990). In many onion-producing regions worldwide, bulb formation occurs under increasing photoperiod conditions, with minimum requirements generally ranging from 12 to 16 hours of light depending on cultivar type (Brewster, 1990; Ibrahim, 2010). Moreover, variations in light quality, intensity, and duration directly affect bulb initiation and enlargement. Studies have reported that lower red-to-far-red light ratios enhance bulb induction, whereas exposure to red light alone may suppress bulb enlargement (Atif et al., 2020). These findings emphasize the importance of photoperiod management in improving onion growth and bulb productivity under protected cultivation systems.

With proper cultural management practices such as adequate fertilization, weed and disease control, and optimized photoperiod manipulation, onion bulb yield and quality can be significantly improved. However, information regarding the response of onion cv. Yellow Granex to varying photoperiods under protected cultivation remains limited. Thus, the present study was conducted to determine the effects of varying photoperiods (daylength extension) on the growth and bulb yield of onion grown under protected cultivation.

MATERIALS AND METHODS

Experimental Site

The experiment was conducted from February to May 2024 at the ACIAR–ICM project site of the Department of Horticulture, Visayas State University, Visca, Baybay City, Leyte.

Seedling Preparation and Transplanting

Seeds of onion 'Yellow Granex' were sown in a germination box. Two weeks after germination, the seedlings were individually transferred into seedling trays filled with a 1:1:1 mixture of carbonized rice hull, vermicast, and garden soil medium. After eight weeks, uniform seedlings were selected and transplanted into 7 × 8 cm plastic pots containing the same type of compost. Prior to the application of treatments, the plants were maintained under the same conditions for another week to allow recovery from transplanting stress. Thus, all plants were nine weeks old at the start of the experiment.

Experimental Design and Treatments

The experiment was laid out in a Randomized Complete Block Design (RCBD) with six treatments replicated three times, with ten (10) sample plants per replication. The photoperiod treatments consisted of natural day length (control) and photoperiod durations of 8, 10, 12, 14, and 16 hours.

The photoperiodic treatments were imposed using "covers" described by Filby, which enabled the plants to receive daylight when required while enclosing them in a light-tight improvised chamber at other times. Within the chamber, 100-watt incandescent bulbs provided illumination controlled by a time switch. Except for the natural daylength treatment (control), photoperiodic extensions facilitated by incandescent bulbs were equally distributed before and after the main light period. Individual photoperiod treatments were achieved by manually covering the plants with the light-tight improvised chamber at specific time intervals.

The treatments were designated as follows:

T0- Control
T1 – 8 hours photoperiod (6:00am-2:00pm)
T2 – 10 hours photoperiod (6:00am – 4:00pm)
T3 – 12 hours photoperiod (6:00am – 6:00pm)
T4 – 14 hours photoperiod (6:00am-8:00pm)
T5 – 16 hours photoperiod (6:00am – 10:00pm)

The experiment ended when 70% of the leaves in the treatments that had formed bulbs collapsed due to maturity. The bulbs were harvested sixteen (16) weeks after transplanting. After harvest, the onion bulbs were cured (sun-dried) for four days prior to the measurement of the following parameters.

Data gathered:

Plant Height

Plant height was measured from ground level to the tip of the longest leaf and expressed in centimeters (cm) at weekly intervals.

Number of Leaves

The number of leaves per sample plant per treatment was counted at the end of the experiment.

Leaf Length and Diameter

Leaf length and diameter of sample plants per treatment were measured at the end of the experiment and expressed in centimeters (cm).

Neck Diameter

Neck diameter below the joint of the leaf lamina was measured using a Vernier caliper and expressed in millimeters (mm).

Bulb weight

Bulbs from the sample plants were weighed using an electronic balance after cutting the leaves approximately 2–2.5 cm above the bulb neck. The average bulb weight per plot was computed and expressed in grams (g).

Bulb Size (Polar and Equatorial Diameter)

The polar and equatorial diameters of harvested bulb onions from each plot were measured using a Vernier caliper and expressed in millimeters (mm).

Statistical Analysis

The data were statistically analyzed using the Statistical Tool for Agricultural Research (STAR) version 2.0.1 (2014), Biometrics and Breeding Informatics, PBGB Division, International Rice Research Institute, Los Baños, Laguna. Comparison of treatment means was performed using the Least Significant Difference (LSD) Test at the 5% level of significance.

RESULTS AND DISCUSSION

Horticultural characteristics

Table 1 presents the horticultural characteristics of bulb onions as influenced by varying photoperiod treatments. Significant differences were observed in the number of days to bulb formation, plant height, number of leaves, and neck diameter, indicating that photoperiod strongly affected both vegetative growth and bulb initiation of onion under protected cultivation.

The earliest bulb formation was observed in T4 (14-hour photoperiod) at 36.67 days after transplanting (DAT), closely followed by T5 (16-hour photoperiod) with 39.00 DAT. In contrast, delayed bulb formation was recorded in T1 (8-hour photoperiod) and T2 (10-hour photoperiod), which required 57.74 and 52.09 DAT, respectively. The earlier bulbing observed under longer photoperiods may be attributed to enhanced phytochrome-mediated responses and increased photosynthetic activity that accelerated the transition from vegetative to reproductive growth. Onion is a quantitative long-day plant in which bulb initiation is stimulated once the critical photoperiod requirement of the cultivar is reached (Brewster, 2008). Similarly, Lancaster et al. (1996) reported that increasing daylength and favorable temperatures accelerate bulb initiation and maturity in onions. Recent findings by Atif et al. (2020) further emphasized that photoperiod and light quality regulate bulb enlargement through hormonal and photoreceptor-mediated mechanisms, particularly involving red and far-red light interactions. Delayed bulbing under shorter photoperiods may therefore be associated with insufficient light exposure and prolonged vegetative growth, preventing the activation of bulbing signals.

Plant height was significantly influenced by photoperiod treatments. T1 produced the tallest plants (46.89 cm), comparable with T3 and the control treatment, whereas the shortest plants were observed in T5 (25.52 cm), followed by T4 (35.19 cm). The taller plants under shorter photoperiods suggest that reduced daylength prolonged vegetative development, allowing continuous leaf elongation before bulb initiation occurred. Conversely, longer photoperiods accelerated bulb formation, thereby diverting assimilates and nutrients toward bulb development rather than vegetative growth. Similar observations were reported by Brewster (2008), who explained that onions exposed to shorter daylengths tend to maintain vegetative growth, while longer daylengths promote rapid transition to bulb formation.

A similar trend was observed in the number of leaves. T1 recorded the highest number of leaves (4.67), followed by T2 and T3, whereas T5 produced the fewest leaves (1.67). This result indicates that shorter photoperiods favored continuous leaf production due to delayed bulb initiation. According to Ibrahim (2010), onions grown under insufficient daylength continue producing leaves without initiating bulbs because the critical photoperiod requirement has not yet been satisfied. Moreover, prolonged vegetative growth under shorter photoperiods may have contributed to greater leaf expansion and canopy development.

Neck diameter also differed significantly among treatments, with T3 (12-hour photoperiod) producing the widest neck diameter (1.03 cm), comparable with T1 and T2, while narrower neck diameters were observed in the control, T4, and T5 treatments. Wider neck diameter under intermediate photoperiods may indicate active vegetative growth and carbohydrate translocation before full bulb maturity. In contrast, narrower neck diameters under longer photoperiods may be associated with accelerated bulb maturation and tissue compaction. Brewster (2008) noted that neck thickness is influenced by the balance between vegetative growth and bulb development, wherein rapid bulb enlargement is often associated with reduced neck thickness. Overall, the results demonstrate that photoperiod significantly regulates the vegetative and reproductive responses of bulb onion, particularly in terms of bulb initiation, leaf production, and bulb development.

Table 1. Horticultural characteristics of Bulb Onions in response to varying photoperiod.

TREATMENTS	Number of Days to Bulb Formation	Plant Height (cm)	Number of leaves	Neck diameter (cm)
Control	44.67b	42.32ab	3.00bc	0.63b
T1 – 8 hours	57.74a	46.89a	4.67a	0.73ab
T2 – 10 hours	52.09a	40.74ab	4.00ab	0.73ab
T3 – 12 hours	42.33bc	45.94a	4.00ab	1.03a
T4 – 14 hours	36.67c	35.19b	2.67cd	0.60b
T5 – 16 hours	39.00bc	25.52c	1.67d	0.47b
cv (%)	4.80	7.17	12.25	18.63

Means within the same column followed by a common letter and or without letter designation are not significantly different from each other at 5 % level of significance.

Bulb yield components

Table 2 presents the bulb weight, bulb length, and bulb diameter of onions as affected by varying photoperiod treatments. Significant differences were observed among treatments, indicating that photoperiod strongly influenced bulb development and yield performance of onion under protected cultivation.

The control treatment produced the heaviest bulbs (20.93 g), which was statistically comparable to T3 (12-hour photoperiod) with 16.87 g. In contrast, T1 (8-hour photoperiod) produced the lightest bulbs (1.17 g), comparable to T2 (10-hour photoperiod) with 2.37 g. Similarly, bulb length and bulb diameter followed the same trend, wherein the control and T3 produced larger bulbs, while T1 and T2 generated significantly smaller bulbs. These findings suggest that shorter photoperiods were insufficient to induce proper bulb enlargement, resulting in prolonged vegetative growth and poor assimilate partitioning toward bulb development. Onion is highly sensitive to photoperiod, and inadequate daylength delays bulb initiation and limits bulb expansion due to reduced photosynthate accumulation in the storage tissues (Brewster, 2008).

The superior bulb performance observed under the control and 12-hour photoperiod treatments may be associated with a more favorable balance between vegetative growth and bulb initiation. Under these conditions, plants were able to accumulate sufficient carbohydrates through photosynthesis before the onset of rapid bulb enlargement. According to Lancaster et al. (1996), bulb size and maturity are strongly influenced by the interaction between temperature and photoperiod, with optimal daylength promoting efficient translocation of assimilates into the developing bulb. Furthermore, Atif et al. (2020) explained that bulb enlargement in Allium crops is regulated by photoreceptors and hormonal signaling pathways that respond to changes in light duration and light quality. Longer photoperiods enhance bulb induction by activating genes associated with bulb formation and carbohydrate metabolism.

However, although T4 (14-hour photoperiod) and T5 (16-hour photoperiod) promoted earlier bulb initiation, bulb weight and diameter were reduced compared with the control and T3 treatments. This result suggests that excessively long photoperiods may have accelerated bulb formation at the expense of bulb enlargement. Rapid transition from vegetative to reproductive growth may have shortened the duration of leaf development, thereby reduced the photosynthetic area and limited carbohydrate accumulation required for larger bulb formation. Similar observations were reported by Brewster (2008), who noted that excessive daylength may induce premature bulb maturity and smaller bulb size in certain onion cultivars. The response may also vary depending on cultivar adaptability and environmental conditions (Costa, 1995).

The poor bulb development observed in T1 and T2 may further be attributed to insufficient photoperiod exposure and unfavorable light quality for bulb induction. Studies have demonstrated that lower red-to-far-red light ratios enhance bulb induction, whereas red light exposure alone may suppress bulb enlargement in onions (Atif et al., 2020). Inadequate photoperiod conditions may therefore have limited phytochrome activity and delayed the physiological processes involved in bulb initiation and enlargement. Moreover, plants exposed to shorter photoperiods likely continued allocating assimilates toward leaf production rather than storage organ development, resulting in smaller and lighter bulbs.

Overall, the results indicate that photoperiod plays a critical role in regulating bulb yield and bulb size in onion. The 12-hour photoperiod appeared to provide the most favorable condition for bulb enlargement and yield production under protected cultivation, as evidenced by its comparable performance with the control treatment. These findings highlight the importance of optimizing photoperiod management to improve bulb yield and quality in onion production systems.

Table 2. Bulb weight, bulb length and bulb diameter of Onions in response to varying photoperiod.

TREATMENTS	Bulb weight (g)	Bulb length (cm)	Bulb diameter (cm)
Control	20.93a	3.20a	3.20a
T1 – 8 hours	1.17c	1.76b	1.00d
T2 – 10 hours	2.37c	1.94b	1.09d
T3 – 12 hours	16.87a	3.20a	2.52b
T4 – 14 hours	8.23b	3.18a	2.25b
T5 – 16 hours	4.80bc	3.18a	1.79c
cv (%)	16.35	8.23	7.67

Means within the same column followed by a common letter and or without letter designation are not significantly different from each other at 5 % level of significance.



Figure 1. Growth and bulb development responses of onion (*Allium cepa* L. var. Yellow Granex) under varying photoperiods

CONCLUSION

The study demonstrated significant differences in the growth and yield components of bulb onions under varying photoperiods. Early bulb formation was observed in T4 and T5, while T1 and T2 exhibited delayed bulb formation, likely due to reduced light during the early growth stages and the accumulation of an inhibitor. These results are consistent with previous findings that longer days and higher temperatures accelerate bulbing. Plant height and the number of leaves were also influenced by photoperiod, with T1 showing the tallest plants and most leaves, whereas T5 exhibited the shortest plants and fewest leaves, suggesting that shorter photoperiods prolong vegetative growth. Neck diameter was highest in T3, similar to T1 and T2, and lowest in Control, T4, and T5. Additionally, bulb weight, length, and diameter varied significantly, with the control treatment producing the heaviest and largest bulbs, indicating the critical role of light quality and duration in bulb development.

RECOMMENDATION

Based on the study's results, for early bulb formation, it is recommended to extend the photoperiod more than the critical day length for long-day plants.

Further studies should be conducted considering the light quality measurements, particularly on the red-to-far-red (Pr/Pfr) light ratio and the duration of exposure to extended photoperiods during key growth stages. This can help refine lighting strategies to promote optimal bulbing and improve overall crop performance.

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