Effect of Transplanting Date and Harvesting Period on Bulb Production of Winter Onion (*Allium cepa* L.)

ABSTRACT

Climate change has brought about unpredictable temperature fluctuations and altered rainfall patterns, which directly impact onion cultivation. Adjustment in planting and harvesting schedules in the context of changing climate and environmental factors is not only academically significant but also holds practical implications for agriculture, resource management, climate adaptation, economic development, and food security in Bangladesh. The present study was carried out to observe the influence of the transplanting and harvesting time on maximizing onion production. The experiment followed a RCB design with three replications, involving the cultivation of BARI Piaz-1 as the test crop with varying transplanting dates on November 1st, November 15th, and December 1st, and harvesting periods at 120, 130, and 140 days after planting (DAP). The study's results indicated that the choice of transplanting date and harvesting period had significantly influenced onion yield and yield attributes. Improved performances, including increase in plant height, number of leaves per plant, neck diameter, bulb diameter, bulb length, bulb weight, and overall yield were observed when onions were transplanted on November 15th and harvested after 130 days from planting. The highest yields, specifically 10.32 t/ha in 2018 and 11.33 /ha in 2019, were achieved under this conditions. Conversely, the lowest yields 6.28 t/ha in 2018 and 6.70 /ha in 2019 were obtained when onions were transplanted on December 1st and harvested after 120 days from planting. Additionaly, early planting (November 1st) exhibited a higher incidence of bolting, while late planting (December 1st) showed a higher disease incidence. Therefore, optimizing transplanting dates to align with November 15th and a 130-day harvesting period proved to be the most effective strategy for maximizing onion yield and other attributes, while late planting and early harvesting adversely affected these key attributes.

Keywords: Onion; BARI Piaz-1; transplanting time; harvesting period.

1. INTRODUCTION

The onion (*Allium cepa* L.) belongs to the family *alliaceous*, a group that includes bulb crops. It is a multi-use vegetable that is consumed fresh as salad as well as in the form of a number of processed products [1]. Worldwide production of onions is approximately 104.55 million metric tons annualy cultivated across 5.47 million hectares of land; and more than 90% of which is consumed within the countries where it is grown [2]. In Bangladesh, onion is a major spice crop and ranks first in terms of uses. During 2020-21 season, onion production was arround 2.2 million metric tonnes from 0.194 million hectares of land [3].

Onion is preferred for its flavor and pungency, attributed to the presence of the volatile oil “allyl propyl disulphide”. Onion bulbs are rich in carbohydrates, protein, vitamin C, phosphorus, and calcium and also possess valuable medicinal properties [4]. It can be consumed as raw, in salads, fried, boiled, or roasted, and is also used to enhance the flavor in soups, canned food products, and other savory dishes. The mature bulb contains starch and substantial quantities of sugar, protein, and vitamins A, B, and C. According to the National Onion Association, the nutritional composition of onions is approximately as follows: moisture (89%) sugar (4%) protein (1%), fiber (2%), and fat (1%) [5]. Onions are also rich in sulfur-containing compounds that are responsible for their pungent aroma, along with fibers, potassium, vitamin B, vitamin C and very low levels of fat [6].

Onions are a biennial crop that is propagated either by seeds, bulbs or sets (small bulbs) [7]. The onion bulb is a short, modified underground stem surrounded by usually fleshy, modified leaves that store nutrient for the growth and serve as a reproductive structure. Bulbs and sets production is affected by many environmental factors such as temperature, photoperiod, and interactions between them [8]. During the initial stages of development, onions show a relatively slow growth rate followed by a rapid increase in leaf area and plant height [9]. As the onion matures, food reserves accumulate in the leaf bases, causing the bulb to swells. Leaves are produced from the moistened apex [10]. All aspects of the onion plant growth are affected by temperature [11]. Additionally, rainfall during harvesting time adversely affects the quality of onion bulb.

Numerous researcher from worldwide studied and reported that there are significant effect of planting time and harvesting period on onion yield and quality [12,13].
As climate changing rapidly due to civilization and anthropogenic activities, temperature fluctuations can harmfully affect the rate of growth, development and processes of yield formation [14,15,16].

So, selection of appropriate planting date to align with the desired maturity time is crucial for successful onion production due to its extensive consequences in the context of changing climate and environmental factors. This is essential for ensuring agricultural sustainability, as the country heavily depends on onion cultivation for food security and economic stability.

Considering these factors, this study was undertaken to determine the optimal planting time and harvesting period for onion bulb production in Bangladesh. The study would contribute to climate resilience in onion production, helping farmers adapt to climate-related risks, considering Bangladesh's vulnerability to climate change. Furthermore, this research holds substantial academic and practical value, with the potential to enhance food security, resource efficiency, and economic development in Bangladesh.

2. MATERIALS AND METHODS

2.1 Experimental Site

The present study was conducted at the research field of regional spices research centre, BARI, Magura, during the rabi (winter) seasons of 2017-2018 and 2018-2019 to find out the suitable time for transplanting and harvesting to maximize the onion bulb production. The experimental site belongs to the Agro-Ecological Zone (AEZ) No. 11 (High Ganges River Floodplain), and the geographic coordinates are latitude: 23º29’18.468546” N and longitude: 89º24’8.06306” E. Soil samples were randomly collected at 0-30 cm depth for physical and chemical analysis before the commencement of the experiment. The soil sample was air dried ground and sieved. Then the soil sample was ready for analysis [17]. All soil samples were analyzed in the Regional Laboratory of the Soil Resource Development Institute (SRDI), Khulna. Soil properties were analyzed by using different methods proposed from the earlier studies and were presented in Table 1. The general soil type was Calcareous dark grey floodplain and the series was Ghior, soil was clay loam in texture and pH was 7.54.

2.2 Seedling Nursery Preparation and Subsequent Managements

Seeds of BARI Piaz-1 were sown on 3 m x 1 m nursery beds in September and October respectively in both year. In the experimental plot, 45-day-old seedlings were uprooted for transplanting. Before transplanting, the roots of the seedlings were soaked in Carbendazim @ 2g/L solution for 5 minutes and about 5 cm of seedling tops were trimmed out.

2.3 Experimental Design and Treatments

The two-factor experiment was conducted in a Randomized Complete Block Design (RCBD) with three replications. The onion seedlings were transplanted on three different times, viz., 1st November (T1), 15 November (T2) and 1st December (T3) and were harvested at 120, 130 and 140 days after transplanting (DAT) respectively. The unit plot size was 3 m x 2 m. The seedlings were transplanted maintaining the spacing of 15 cm x 10 cm.

Table 1. Chemical properties of initial soil (before sowing) of the experimental site at a depth of 0-30 cm during the rabi season of 2017-2018 and 2018-2019

Soil properties		Methods of analyses
Soil pH	7.8	Glass electrode method
OM (%)	1.55	Wet oxidation method
K (meq/100g soil)	0.34	Bray and Kurtz method
Total N (%)	0.09	Atomic absorption spectrophotometry
P (µg/g soil)	52.71	Atomic absorption spectrophotometry
S (µg/g soil)	11.47	Turbidity method
Z ($\mu g.g^{1}$ soil)	0.98	0.1N HCl (hydrochloric acid) extraction method
B ($\mu g.g^{-1}$soil)	0.42	Hot water text method
Soil texture	Clay loam	Hydrometer method

Table 2. Monthly average weather data of the experimental period of the experimental site from September to May of 2017-18 and 2018–19

Month	Temperature (° C)						Rainfall (mm)	
	Maximum		Minimum		Mean			
	2017-18	2018-19	201718	2018-19	2017-18	2018-19	2017-18	2018-19
September	33.70	33.50	26.50	26.40	30.10	29.90	5.10	4.30
October	31.60	31.20	24.10	21.50	27.90	26.30	6.60	1.60
November	26.70	29.90	18.70	17.70	22.70	23.80	0.20	0.10
December	26.00	25.50	14.00	12.40	20.00	18.90	0.80	0.30
January	24.40	26.40	9.40	12.00	16.90	19.20	0.00	0.00
February	30.30	27.80	15.70	17.40	23.00	22.60	0.10	2.00
March	34.70	31.30	20.80	21.50	27.70	26.40	0.80	0.40
April	32.90	33.40	22.80	24.20	27.90	28.80	3.90	2.90
May	31.60	34.30	23.60	26.00	27.60	30.20	8.10	2.40

2.4 Crop Growing Conditions/ Intercultural Operations

The fertilizers were applied in the form of urea, triple super phosphate, muriate of potash and gypsum at a rate of N_{120} P_{54} K_{75} S_{20} kg/ha respectively according to Fertilizer Recommendation Guide 2016 (FRG). Three-hand weedings at 30, 45 and 60 DAP, and three irrigations at 20, 50 and 80 DAP were provided. The fungicide Rovral (Iprodione) @ 3 g/L liter of water was sprayed at 30 days intervals commencing from one month after transplanting of seedlings.

2.5 Data Collection and Analysis

Observations on different weather parameters, such as maximum temperature, minimum temperature, and rainfall which were recorded during two crop seasons are presented in Table 2. Data on plant height (cm), number of leaves per plant (nos.), neck diameter (cm), bulb length (cm), bolting percentage (%), bulb diameter (cm) and individual bulb weight (g) were recorded from randomly selected ten plants from each experimental unit and averaged; while bulb fresh yield (t/ha) were taken on whole plot basis. To determine the significance of variation caused by experimental treatments, the recorded data on various parameters were statistically analyzed using Statitix10 software. To determine the cost-efficiency of the treatments, the Benefit Cost Ratio (BCR) was calculated based on the local market price of onion bulbs and input costs. The BCR was measured by the following formula:

$$\text{Benefit Cost Ratio (BCR)} = \frac{\text{Gross return}}{\text{Total cost of production}}$$

3. RESULTS AND DISCUSSION

3.1. Results

3.1.1 Effect of transplanting time

Different characteristics of onion showed significant variations due to different transplanting times (Table 3). Maximum plant height (46.69 cm in 2018 and 48.69 cm in 2019), number of leaves per plant (7.49 in 2018 and 7.19 in 2019), neck diameter (1.29 cm in 2018 and 1.67 cm in 2019), bulb diameter (4.42 cm in 2018 and 4.37 cm in 2019), bulb length (4.56 cm in 2018 and 4.83 cm in 2019), individual bulb weight (33.92 g in 2018 and 35.21 g in 2019), and yield (10.06 t/ha in 2018 and 11.67 t/ha in 2019) were found from 15 November transplanting. Minimum plant height (40.12 cm in 2018 and 42.12 cm in 2019), number of leaves per plant (6.74 in 2018 and 6.44 in 2019), neck diameter (0.98 cm in 2018 and 1.58 cm in 2019), bulb diameter (3.30 cm in 2018 and 3.67 cm in 2019), bulb length (4.06 cm in 2018, and 4.17 cm in 2019), individual bulb weight (26.72 g in 2018, and 28.21 g in 2019) and yield (6.75 t/ha in 2018 and 6.95 t/ha in 2019) were recorded from 1st December transplanting.

3.1.2 Effect of harvesting period

Significant variations on different parameters of onion were observed due to different harvesting periods (Table 4). Maximum plant height (44.84 cm in 2018 and 46.33 t/ha in 2019), number of leaves per plant (7.21 in 2018 and 7.91 in 2019), neck diameter (1.19 cm in 2018 and 1.07 cm in 2019), bulb diameter (4.06 cm in 2018 and 4.33 cm in 2019), bulb length (4.42 cm in 2018 and 4.57 cm in 2019), individual bulb weight (31.19 g in 2018 and 33.19 g in 2019) and yield (8.71t/ha in 2018 and 9.16 t/ha in 2019) were found when the crop was harvested at 130 DAT. Minimum plant height (42.45cm in 2018 and 41.67cm in 2019), number of leaves per plant (6.91in 2018 and 6.50 in 2019), neck diameter (1.06 cm in 2018 and 1.1 cm in 2019), bulb diameter (3.66 cm in 2018 and 3.89 cm in 2019), bulb length (4.19 cm in 2018 and 4.06 cm in 2019), individual bulb weight (28.76 g in 2018 and 27.62 g in 2019) and yield (7.93 t/ha in 2018 and 7.31 t/ha in 2019) were found when the crop was harvested at 120.

3.1.3 Combined effect of planting time and harvesting period on yield attributes

The yield and yield contributing characters varied significantly due to the interaction effect of planting time and harvesting period (Table 5). Maximum plant height (47.77 cm in 2018 and 49.56 t/ha in 2019), bulb diameter (4.63 cm in 2018 and 4.66 cm in 2019), bulb length (4.67 cm in 2018 and 4.82 cm in 2019), individual bulb weight (36.38 g in 2018 and 34.58 cm in 2019) and yield (10.32 t/ha in 2018 and 11.33 t/ha in 2019) were obtained when BARI Piaz-1 was transplanted in 15 November and harvested at 130 DAT. Minimum plant height (38.59 cm in 2018 and 40.56 cm in 2019), bulb diameter (3.19 cm in 2018 and 3.87 cm in 2019), bulb length (2.65 cm in 2018 and 2.65 cm in 2019), individual

Table 3. Yield and yield components of BARI Piaz-1 as influenced by transplanting date

Treatments	Plant height (cm)		No. of leaves /plant		Neck Diameter (cm)		Bulb diameter (cm)		Bulb length (cm)		Single bulb weight (g)		Yield (t/ha)	
	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19
T_1	44.05b	43.05b	7.00b	6.53b	1.08b	1.61b	3.78b	3.52b	4.33b	4.33b	29.17b	29.73b	8.27b	7.33b
T_2	46.69a	48.69a	7.49a	7.19a	1.29a	1.67a	4.42a	4.37a	4.56a	4.83a	33.92a	35.21a	10.06a	11.67a
T_3	40.12c	42.12c	6.74c	6.44c	0.98c	1.58c	3.30c	3.67cb	4.04c	4.17c	26.72c	28.21c	6.75c	6.95c
L.S.	**	**	**	**	**	**	**	**	**	**	**	**	**	**

*Note: T_1= 1st November, T_2=15 November, T_3=1st December, mean followed by the same letters did not differ significantly, L.S.= Level of significance and ** = 1% level of significance*

Table 4. Effect of different treatments on yield and yield contributing parameters of onion during the rabi season of 2017-18 and 2018-2019

Treatments	Plant height (cm)		Leaves/plant (nos.)		Neck Diameter (cm)		Bulb diameter (cm)		Bulb length (cm)		Single bulb weight (g)		Yield (t/ha)	
Year	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19
H_1	42.45a	41.67a	6.91c	6.50c	1.06c	1.10c	3.66c	3.89c	4.19c	4.06c	28.76c	27.62c	8.27b	7.31b
H_2	44.84a	46.33b	7.21a	7.91a	1.19a	1.28a	4.04a	4.33a	4.42a	4.57a	31.19a	33.19a	10.06a	9.16a
H_3	43.57ab	43.71ab	7.11ab	6.83ab	1.12b	1.15b	3.81b	3.90b	4.32b	4.14b	29.86b	29.63b	6.75c	8.31c
L.S.	**	**	*	**	**	**	**	**	**	**	**	**	**	**

*Note: H_1= 120 DAT, H_2= 130 DAT, H_3= 140 DAT, mean followed by the same letters did not differ significantly, L.S.= Level of significance, * = 5% level of significance.and ** = 1% level of significance*

Table 5. Interaction effect of planting time and harvesting period on yield attributes of BARI Piaz-1 during 2017-18 and 2018-2019

Treatments	Plant height (cm)		Leaves/plant (nos.)		Neck diameter (cm)		Bulb diameter (cm)		Bulb length (cm)		Single bulb weight(g)		Yield (t/ha)	
Year	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19
T_1H_1	43.25e	43.5d	6.80d	7.00d	1.03def	1.03e	3.56e	3.72e	42.38de	41.25d	28.23de	30.58d	7.65c	7.67c
T_1H_2	44.41d	44.33e	7.26cd	7.10c	1.14cd	1.18cd	4.03c	3.91c	44.40c	43.58c	30.64c	32.68c	8.65b	9.67c
T_1H_3	44.49d	46.5d	6.93bc	7.60cd	1.08de	0.93e	3.76d	3.85b	43.13d	43.25d	28.64d	29.58d	8.50b	7.17b
T_2H_1	45.50c	47.25c	7.23bc	7.20bc	1.21bc	1.14c	4.24b	4.14c	44.55c	46.56c	31.53c	30.45c	9.86a	10.33a
T_2H_2	47.77a	49.56a	7.57ab	8.5ab	1.39a	1.48a	4.63a	4.75a	4.67a	4.82a	36.38a	34.58a	10.32a	11.33a
T_2H_3	46.78b	45.25b	7.67a	7.00a	1.28ab	1.26ab	44.09b	4.56b	4.56b	4.56b	33.85b	32.49b	9.99a	10.00a
T_3H_1	38.59h	40.56h	6.70d	6.50d	0.94f	0.96f	31.92f	3.31d	3.87g	3.75e	26.50e	24.48e	6.28e	6.70e
T_3H_2	42.32f	42.25f	6.80d	7.10d	1.03def	1.01ef	3.47e	3.25e	4.17ef	4.16g	26.54e	28.58e	7.15d	7.92d
T_3H_3	39.44g	37.25g	6.73d	6.50d	0.99ef	0.93f	3.26f	3.46f	4.10f	4.02f	27.10de	26.68e	6.83d	6.83d
CV	0.93	1.04	2.83	2.61	6.58	6.60	2.70	2.90	1.28	1.12	3.66	3.50	3.23	3.50
L.S.	**	**	*	**	**	**	**	**	**	**	**	**	**	**

*Note: T_1= 1st November, T_2=15 November, T_3=1st December, H_1= 120 DAT, H_2= 130 DAT, H_3= 140 DAT, mean followed by the same letters did not differ significantly, L. S.= Level of significance, * = 5% level of significance and ** = 1% level of significance*

Table 6. Interaction effect of planting time and harvesting period on bolting percentage and disease incidence of BARI Piaz-1 during 2017-18 and 2018-2019

Treatments	Bolting (%)		Incidence of purple blotch disease (%)	
	2017-18	2018-19	2017-18	2018-19
T_1H_1	29.00 a	32.00 a	12.00 g	13.66 e
T_1H_2	25.33 b	29.00 b	14.33 fg	15.33 e
T_1H_3	27.60 a	30.33 ab	16.33 ef	18.00 d
T_2H_1	17.33 cd	20.00 cd	17.66 de	19.66 cd
T_2H_2	15.66 d	17.66 d	19.66 cd	21.66 bc
T_2H_3	18.33 c	21.00 c	21.66 bc	23.66 b
T_3H_1	5.66 e	7.00 e	22.33 b	23.66 b
T_3H_2	5.66 e	6.66 e	24.00 ab	26.33 a
T_3H_3	3.00 f	3.66 f	25.00 a	27.66 a
CV	7.01	9.16	7.56	6.84
L.S.	**	**	**	**

*Note: T_1= 1st November, T_2=15 November, T_3=1st December, H_1= 120 DAT, H_2= 130 DAT, H_3= 140 DAT, mean followed by the same letters did not differ significantly, CV = Co-efficient of variation, L.S.= Level of significance and ** = 1% level of significance*

Table 7. Cost-benefit analysis as influenced by transplanting time and harvesting period during 2017-18 and 2018-19

Treatments	Yield (Kg/ha)		Unit price at harvest (tk./kg)	Gross return (tk./ha)		Total cultivation cost (tk./ha)		Net return (tk./ha)		BCR	
Year	**2017-18**	**2018-19**		**2017-18**	**2018-19**	**2017-18**	**2018-19**	**2017-18**	**2018-19**	**2017-18**	**2018-19**
T_1H_1	7.65	7.17	50	382500	358500	130000	150000	232500	208500	2.55	2.39
T_1H_2	8.65	10.33	45	389250	464850	130000	150000	239250	314850	2.60	3.10
T_1H_3	8.5	11.33	45	382500	509850	130000	150000	232500	359850	2.55	3.40
T_2H_1	9.86	10.00	45	443700	450000	130000	150000	293700	300000	2.96	3.00
T_2H_2	10.32	6.83	45	464400	307350	130000	150000	314400	157350	3.10	3.50
T_2H_3	9.99	7.92	40	399600	316800	130000	150000	249600	166800	2.66	2.11
T_3H_1	6.28	6.83	35	219800	239050	130000	150000	69800	89050	1.47	1.59
T_3H_2	7.15	7.17	30	214500	215100	130000	150000	64500	65100	1.43	1.43
T_3H_3	6.83	10.33	30	204900	309900	130000	150000	54900	159900	1.37	2.07

Note: Urea-Tk. 16/kg, TSP-Tk. 15/kg, MoP-Tk.15/kg, Gypsum- Tk. 10/kg, Zinc sulphate –Tk.100/kg, Boric acid-Tk. 100/kg, Labour- Tk. 400/man/day, Irrigation-3000/ha/irrigation, Leas value- Tk. 25000/ha for 5 months, Seed-1500/kg, Sale price-Tk. (50-30) /kg bulb. T: Transplanting time, H: Harvesting period, DAP: Days after planting, T_1*: 1 November,* T_2*: 15 November,* T_3*:1 December,* H_1*: 120 DAP,* H_2*: 130 DAP,* H_3*: 140 DAP* bulb weight (26.52 g in 2018 and 24.48 g in 2019) and yield (6.28 t/ha in 2018 and 6.70 t/ha in 2019) were obtained when BARI Piaz-1 was transplanted in 1st December and harvested at 120 DAT.

3.1.4 Bulb quality as influenced by transplanting and harvesting time

The bolting percentage and disease incidence were found to be statistically significant due to different planting times and harvesting periods (Table 6). The higher bolting percentage (29.00 % in 2018 and 32.00 % in 2019) was recorded from transplanted on 1st November and harvested at 120 DAT. On the other hand, the lowest bolting percentage (3.00% in 2018 and 3.66% in 2019) was recorded when transplanted on 15 December and harvested at 140 DAT. Maximum disease incidence (25.00% in 2018 and 27.66% in 2019) was observed on transplanting 15 December and harvesting at 140 DAT. The minimum disease incidence (12.00% in 2018 and 13.66% in 2019) was observed on transplanting 1st November and harvesting at 120 DAP.

3.1.5 Cost-benefit analysis due to different planting time and harvesting periods

The cost-benefit analysis of BARI Piaz-1 due to different planting times and harvesting periods is shown in Table 7. The highest Benefit Cost Ration (3.10 in 2018 and 3.50 in 2019) was calculated when transplanted on 15 November and harvested at 130 DAT. The lowest BCR (1.37 in 2018 and 2.07 in 2019) was calculated when transplanted on 1st December and harvested at 140 DAT.

3.2 Discussion

Transplanting onion seedlings on 15 November and harvesting at 130 DAT had a significant effect on all studied parameters, such as plant height, number of leaves/plant, neck diameter, individual bulb weight and bulb yield (Table 4). Onion seedling transplanting dates reflect the effects of edaphic factors as well as all environmental conditions. During the early stage of bulbing, the mean temperature was 16-18ºC and in the maturity stage, it was 26-28ºC. Onions require cool temperatures (6 to 20ºC) at the early growth and development stage but during bulb initiation and development, warmer temperatures (25º to 27°C) are required [18,19]. Mean temperatures during bulbing is 13 -17.5°C and high temperature between 25ºC-27ºC enhance bulb formation and maturity [19]. The optimum day temperature is 18ºC-24ºC and the night temperature is 10-12ºC for onion bulb production [20]. Onion bulbing is promoted by long days and high temperatures. Night temperature and far-red light are necessary for the induction of bulbing in phytotron-grown plants [21]. Other factors also determine bulb onion yields, such as cultivar, sowing date, and plant density [22].

In both years, the highest bolting percentage was observed in the first November transplanting of onion seeding. Early transplanting could be one of the reasons for the higher bolting percentage. It was also reported that early planting resulted in higher accumulated temperatures, which led to a high bolting percentage [23]. Sowing date is an important production factor that needs to be taken into consideration in preventing bolting [24]. Similar findings were also reported by [25,26,27].

The highest disease incidence was observed in late transplantation (1st December) and the lowest disease incidence was observed in early transplantation (1st November) in both years. Purple blotch of onion, caused by the fungus Alternaria porri, is the most observed disease in onion experiment fields. It was also reported that sowing the crop on 1st November resulted in significantly lower disease intensity (42.49 and 35.17% in the first and second years, respectively) [28]. The optimum temperature for the development of infection on onion under controlled conditions is 10–25º C [29,30, 31].

Therefore, optimum transplanting dates have a vital role in maximizing growth, bulb yield and onion quality and disease incidence.

4. CONCLUSION

The present study was conducted with the aim to identify the optimal transplanting and harvesting times for maximizing onion bulb production. The research involved three different transplanting and harvesting time. The findings revealed that transplanting onion seedlings on November 15th and harvesting after 130 days significantly improved all of these parameters, resulting in higher yields and quality. Conversely, early planting (November 1st) led to a higher incidence of bolting, while late planting (December 1st) increased disease prevalence. The cost-benefit analysis demonstrated that the November 15th transplanting and 130-day harvesting strategy yielded the highest benefit-cost ratio. These results highlight the importance of selecting the right transplanting and harvesting times to optimize onion production, maximize crop yields, and mitigate disease incidence in the context of the specific agroecological conditions of Bangladesh under changing clime.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Manohar CM, Xua J, Murayyan A, Neethirajan S, Shi J. Antioxidant activity of polyphenols from ontario grown onion varieties using pressurized low polarity water technology. J Funct Foods. 2017; 31:52–62.
   DOI: 10.1016/j.jff.2017.01.037
2. FAO. World food and agriculture – Statistical Yearbook 2021. Rome; 2021.
3. BBS. Yearbook of agricultural statistics-2021. Bangladesh bureau of statistics. Statistics and informatics division (SID). Ministry of planning. Government of the People's Republic of Bangladesh. Dhaka. 2022;33:138.
4. Ramesh G, Ajithkumar K, Amaresh YS, Savitha AS. Influence of integrated nutrient management on growth parameters, Yield and severity of disease in onion (*Allium cepa* L.) International Journal of Current Microbiology and Applied Sciences. 2017;6(8):1020-1028.
5. Adeyeye AS, Ishaku MA, Gadu HO, Olalekan KK, Lamid WA*.* Comparative effect of organic and inorganic fertilizer treatments on the growth and yield of onion (*Allium cepa*). Research & Reviews: Journal of Botanical Sciences. 2017;2(2):8-11.
6. Ayyachamy M, Khelawan K, Pillay D, Permaul K, Singh S. Production of inulinase by *Xanthomonas campestris* pv phaseoli using onion (*Allium cepa*) and garlic (*Allium sativum*) peels in solid state cultivation. Letters in Applied Microbiology. 2007;45(4):439-444.
7. Charkroborty M. Cytological investigation and molecular characterization of selected mutant line of Onion against purple blotch using SSR marker. A thesis, Bangladash Agricultural University. Roll no. 13Ag GPB JJ-13M; 2014.
8. Mettananda KA. Effect of extended photoperiod on dry set production of big Onion (*Allium cepa* L.) Ann. Sri. Lanka Dep. Agric. 2003;5(1):181-192.
9. Fontes PCR. Cultura da cebola. Vicosa: UFV. 1998;40p.
10. Abubakar SS, Murtala GB, Sani I, Jaliya MM. Garlic production under irrigation. Extention bulletin No. 205. Agricultural Engineering Series no. 2010;(6)
11. Coolong TW, Randle WM. Temperature influences flavor intensity and quality in Granex 33 onion. American Journal Society of Horticultural Science. 2003;128 (2):176-181.
12. Mollah MRA, Ali MA, Ahmad M, Hassan MK, Alam MJ. Effect of plant-ing dates on the yield and quality of true seeds on onion. Int J Appl Sci Biotechnol. 2015;3(1):67–72.
13. El-Helaly MA, Karam SS. Influence of planting date on the production and quality of onion seeds. J Hortic Sci Ornam Plants. 2012;4(3):275–9.
14. Ahmed S, Rashid MAR, Zafar SA, Azhar MT, Waqas M, Uzair M, Rana IA, Azeem F, Chung G, Ali Z, Atif RM. Genome-wide investigation and expression analysis of APETALA-2 transcription factor subfamily reveals its evolution, expansion and regulatory role in abiotic stress responses in Indica Rice (*Oryza sativa* L. ssp. indica). Genomics. 2020;113(1):1029–43.
15. Waqas MA, Wang X, Zafar SA, Noor MA, Hussain HA, Nawaz MA, Farooq M. Thermal stresses in maize: Effects and management strategies Plants. 2021;10:293.
16. Zafar SA, Arif MH, Uzair M, Rashid U, Naeem MK, Rehman OU, Rehman N, Zaid IU, Farooq MS, Zahra N, Saleem B, Xu J, Li Z, Ali J, Ali GM, Yang SH, Khan MR. Agronomic and physiological indices for reproductive stage heat stress tolerance in green super rice. Agronomy 2022;12(8): 1907.
17. Hossain MF, Islam MN, Halim MA, Kamaruzzaman M, Islam MJ. Changes of physical properties, land use patterns and crop diversification of AEZ (Agroecological Zone)-11 Soils of Rajshahi, Bangladesh. Journal of the Environment. 2012 Dec;9(1):77-85.
18. Ansari NA. Effect of density, cultivars and sowing date on Onion sets production.

Asian journal of Plants Science. 2007; 6:1147-1150.
19. Brewster JL. Onion and garlic ln: Wien, H.C (Ed.) The physiology of vegetable crops. CAB International, Wallingford, UK. 1997;581-619.
20. Nikus O, Mulugeta F. Onion seed production techniques. A manual for extension agents and seed producers. FAO. crop diversification and marketing development project. Asella, Ethiopia; 2010.
21. Lancaster JE, Triggs CM, De Ruiter JM, Gandar PW. Bulbing in onions: Photoperiod and temperature requirements and prediction of bulb size and maturity. Annals of Botany. 1996;78(4):423-430.
22. Brewster JL. Onions and other vegetable alliums (No. 15). CABI; 2008.
23. Dong Y, Cheng Z, Meng H, Liu H, Wu C, Khan AR. The effect of cultivar, sowing date and transplant location in field on bolting of Welsh onion (*Allium fistulosum* L.). BMC plant biology. 2013;13:154. Available:https://doi.org/10.1186/ 1471-2229-13-154
24. Albert S. Bulb onion growing, Day length and temperature allies: Botany, cultivation and utilization. London: World Crops Books, Leonard Hill; 2013.
25. Singh L, Singh SP, Mishra PK. Evaluation of onion varieties at Karnal. Newsletter-Associated Agricultural Development Foundation. 1993;11(3):3-4.
26. Cramer CS. Performance of fall-sown onion cultivars using four seeding dates. J. Am. Soc. Hortic. Sci. 2003;128(4):472-478.
27. Bijarniya NK, Jat ML, Patel BA, Bana ML. Effect of age of seedling and dates of transplanting on growth, yield and quality of onion (*Allium cepa* L.) in rabi under north gujarat condition. J. Rural Agric. Res. 2015;5(2):38-42.
28. Efath S, Razdan VK, Kumar A, Bandey S. Effect of variation in the sowing dates on foliar blight of onion. International Journal of Farm Sciences. 2016;6(2):102-107.
29. Suheri H, Price TV. Infection of onion leaves by *Alternaria porri* and *Stemphylium vesicarium* and disease development in controlled environments. Plant Pathology. 2000;49(3):375–382.
30. Jakhar SS, Duhan JC, Suhag LS. Studies on the epidemiology and survival of *Stemphylium vesicarium* (Wallr.) Simmons in debris and seeds of onion. Seed Research. 1996a;24-2:135-140.
31. Jakhar SS, Duhan JC, Suhag LS. Studies on conidial germination and factors affecting disease development of Stemphylium blight of onion. Indian Phytopathology. 1996b;49(4):362-365.
