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Planting Time Effects of Top-Shoot Cutting on Yield and Grade for Rapid Seed Potato Multiplication

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Abstract

Top-shoot cuttings were evaluated as planting material with different planting time for rapid multiplication of potato. Plants produced from top-shoot cuttings planted on 25th November (T_3) produced higher mean tuber yield (32.95 tha^{-1}) than December planting. Total yield of potato increased 122.8% from early one source crop plants due to taking two times cutting and it was 89.7 % from late one source crop plants. Seed tuber yield increased 167.89% and 95.33% in early and late one source crop plants, respectively. The highest gross net return of Tk. 984,440 was found from whole tuber planted on 10th November with benefit cost ratio of 3.42. From top shoot cuttings, the highest net return of Tk. 739,600 was found in T_3 (25th November planting) with benefit cost ratio of 6.20. The crop grown from early planted top-shoot cuttings also produced higher percentage of A and B grade seed tubers than late planting. The results revealed that top shoot cuttings would be used in potato production for getting maximum economic return.

Keywords

Top Shoot Cutting, Planting Date, Seed Potato Multiplication

Subject Areas: **Plant Science**

1. Introduction

Potato is the important food crops in the world and it stands 3rd among the major food crops in Bangladesh. In

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spite of its starchy tubers, potato is usually utilized as vegetables in Bangladesh. In terms of area and production, potato ranks first among the vegetables in Bangladesh and the production is about 8.95 million tons from 0.462 million hectares [1]. Presently, the total seed potato requirement of the country is about 0.60 million tons to cover 0.46 million hectares of land [2]. Out of the total requirement, Bangladesh Agricultural Development Corporation (BADC) supplied only about 27,000 m. tons (4.11%) in 2014-2015 [2] that was used by the farmers as the replacement stock. So, there is a vast demand of quality seed tuber as planting material in the country [3]. The area and production of potatoes are increasing day by day due to its higher demand and profitability. Moreover, the yield of potato in Bangladesh is 19.37 tons per hectare, which is very low compared to other potato growing countries in the world. Several types of propagating materials like sprout cutting, top shoot cutting or stem parts with at least one bud, true potato seed, whole tuber and cut tuber are used for growing potatoes [4]. The length of growing period of potato is relatively short (around 90 days) during winter (Mid-November to mid-February) in all over Bangladesh [5]. Rashid [6] reported that 25% to 50% of the total cost was involved in seed potato tuber purchase due to high price during sowing time. To minimize the seed cost, farmers of many potato growing areas are using cut tubers with closer spacing for commercial potato production. But seed cost remains more or less same since the farmers use closer spacing for cut tubers instead of using whole tuber at wider spacing. According to Hossain [7], top-shoot cuttings are routinely used in seed potato production for breeder seed multiplication. By using top-shoot cuttings farmers can reduce their production cost. There is a scope to use top-shoot cuttings from the plants grown early in medium to high land for cultivating potato in low land by reducing seed cost.

Appropriate and proper time of sowing is one of the basic requirements for obtaining maximum yield and high profit returns of potato [8]. Many experiments regarding sowing and transplanting time are being conducted in different parts of the world which revealed that the total yield of the crop is markedly influenced by different sowing and transplanting times [9]-[11]. Early planted top-shoot cuttings produced more tubers per plant with a greater mean tuber weight than from the late planting [12]. But top-shoot cuttings are not being used by the farmers for potato production. It can be extended among the farmers providing them with appropriate production technology. Therefore the present study has been undertaken with the following objectives: 1) to assess the yield performance, seed grades, yield potential of top-shoot cuttings; and 2) to determine the economics of potato tuber production by using of top-shoot cuttings.

2. Materials and Methods

2.1. Location, Test Crop and Agro-Climatic Condition

Top-shoot cuttings were evaluated as planting material with different planting time for rapid multiplication of potato at Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU) during winter, 2011-2012. The location is situated at about 24˚23' north latitude, 90˚08' east longitude and an altitude of 8.4 m above sea level and adjacent to capital Dhaka city. Potato variety Diamant (BARI Potato-7) was used as test crop. During the growing period maximum and minimum air temperature, relative humidity (%), precipitation and evaporation data were recorded throughout the crop period (**Table 1**). The air temperature was decreasing in trend from November to January and thereafter increased.

Table 1. Agro-climatic data in average of the month during the growing period, 2011-2012.

Month	Air temperature (˚C)			Humidity (%)	Rainfall (mm)	Evaporation (mm)
	Max.	Min.	Ave.			
November	27.76	23.76	25.76	85.66	0.00	55.06
December	24.80	16.58	20.69	90.70	5.19	208.15
January	22.32	11.53	16.93	89.81	0.00	1.37
February	27.31	13.24	20.28	87.66	0.00	3.6
March	32.58	20.68	26.63	83.94	0.00	4.03

2.2. Design and Treatment

The experiment was laid out in randomized complete block design (RCBD) with three replications. The treatments were: T_1 = Whole tuber planting at 1st November (1st Control), T_2 = Whole tuber planting at 1st November for cutting; T_3 = 1st cutting from T_2 planted on 25th November; T_4 = 2nd cutting from T_2 on 5th December; T_5 = Whole tuber planting on 10th November (2nd control); T_6 = Whole tuber planting on 10th November for cutting; T_7 = 1st cutting from T_6 on 5th December and T_8 = 2nd cutting from T_6 on 15th December.

2.3. Seed Preparation, Planting of Tubers and Stem Cutting

The seed tubers were kept in a well-ventilated room and allowed to sprouting under light at night for obtaining healthy green sprouts prior to planting. In this process, 8 - 10 days were elapsed for sprouting. The sprouted tubers were planted at 1st November (T_1 and T_2) and 10th November (T_5 and T_6). T_1 and T_5 were treated as control for producing normal crop. Treatments T_2 and T_6 were used as source of top shoot cuttings. First top-shoot cuttings with at least two nodes were taken from T_2 at 25 days after planting (DAP) which were used as planting material for T_3. Second cuttings were taken from (T_2) at 10 days after first cutting which were used as planting material for T_4. Cuttings were taken by slant cut with a sharp blade and the cut end immerged into water immediately. Then the shoot cuttings were planted in the main plot after treating them with rooting hormone (Napthalene Acetic Acid-16 ppm). Before planting the shoot cuttings in the experimental plots, the plots were irrigated properly so that the cut portion came to the soil and moisture contact. Similarly the top-shoot cuttings were taken from T_6 which were used as planting materials for T_7 and T_8 at 5th December and 15th December, respectively.

2.4. Fertilizer Application

Full doses of cow dung (10 $t \cdot ha^{-1}$), triple super phosphate (220 $kg \cdot ha^{-1}$), muriate of potatsh (270 $kg \cdot ha^{-1}$), gypsum (120 $kg \cdot ha^{-1}$), boric acid (6 $kg \cdot ha^{-1}$) and half dose of urea (175 $kg \cdot ha^{-1}$) were applied at final land preparation. The rest half of urea (175 $kg \cdot ha^{-1}$) was top dressed at 30 DAP followed by earthing up and light irrigation. Ridge method was used for whole tuber planting (T_1, T_2, T_5 and T_6) treatments.

2.5. Intercultural Operation

Healthy top shoot cuttings were planted in well watered flat bed. After establishment of the shoot cuttings, ridge was made by earthing up of sides. Intercultural operations such as weeding and earthing up were done manually. Earthing up was done two times, first earthing up was done at 30 DAP when the plant attained a height of about 15 - 20 cm from the base, second time was done at 20 days after the first earthing up. Before the first earthing up, urea was applied. Irrigation was applied five times. The first one was applied at two weeks after planting, the second one was just after earthing up (30 DAP), the third one was at 45 DAP, the 4th one on 60 DAP, and the last one was at 75 DAP. During land preparation, Furadan 5G was applied 10 kg/ha as basal to control soil borne insects and Malathion (0.2%) sprayed in two installments at 45 and 60 DAP control foliar insects. Dithane-M 45 (0.2%) and Secure (0.1%) sprayed alternately five times at 30, 40, 50, 60, 70 DAP to prevent the late blight disease [13]. Haulm pulling was done at 80 DAP in all treatments. Hardening and setting up of skins of tubers were allowed for 10 days under the soil and there after the crop was harvested at 90 DAP.

2.6. Data Collection

2.6.1. Yield of Tubers

The gross yield of tubers per plot was recorded by taking weight of the harvested tubers from all plants of a unit plot and was converted into yield in tons per hectare by using following formula:

$$\text{Yield}\ (\text{ton/ha}) = \left[\text{Tuber yield per plot}\ (\text{kg}) \times 10\right] \Big/ \text{Area of plot}\ (\text{sq} \cdot \text{m}) \quad (1)$$

2.6.2. Tuber Grade by Number (%)

All the tubers from the randomly selected five plants were graded into four groups by number (under size ≤ 28 mm, Grade A = 28 - 40 mm, Grade B = 41 - 55 mm and Over size ≥ 55 mm) and expressed in percentage. By using the following formula percentage of each grade was calculated.

$$\text{Tuber grade by number } (\%) = \left[\left(\text{Number of tubers of particular grade}\right)/\left(\text{Total number of tubers}\right)\right]\times 100 \quad (2)$$

2.6.3. Tuber Grade by Weight (%)

All the tubers from the randomly selected five plants were graded into four groups by weight (under size ≤ 28 mm, Grade-A = 28 - 40 mm, Grade-B = 41 - 55 mm and over size ≥ 55 mm) and expressed in percentage. By using the following formula percentage of each grade was calculated.

$$\text{Tuber grade by weight } (\%) = \left[\left(\text{Weight of tubers of particular grade}\right)/\left(\text{Weight of tubers}\right)\right]\times 100 \quad (3)$$

2.7. Data Analysis

Recorded data on tuber yield, grades of tuber by weight and by number were analyzed statistically using the software MSTATC (Developed by the Department of Crop and Soil Sciences, Michigan State University, East Lansing, MI 48824 USA). Significance between treatments were tested by using Duncan Multiple Range Test (DMRT) at $p < 0.05$ level. Benefit cost ratio (BCR) was calculated according to Khan *et al*. [14].

3. Results and Discussion

3.1. Yield

Tuber yield per hectare significantly influenced by planting time (**Table 2**) and ranged from 18.89 to 42.56 t·ha^{-1}. Yield decreased in stem cuttings with delayed planting. The highest tuber yield (42.56 t·ha^{-1}) was obtained from whole tuber planted at 10th November (T_5) which was statistically similar with planted at 1st November (T_1) yielded 41.84 t·ha^{-1}. In case of top-shoot cutting, early planted cuttings (25th November) produced maximum tuber yield of 32.95 t·ha^{-1} followed by 5th December planting (25.65 t·ha^{-1}). The lowest yield (18.89 t·ha^{-1}) was found in late planted (15th December) cuttings. Tuber yield of potato increased 122.8% (41.84 t·ha^{-1} to 93.23 t·ha^{-1}) from early one source crop due to taking two times cuttings, while it was 89.7% (from 42.56 t·ha^{-1} to 80.75 t·ha^{-1}) from late one source crop. Tuber yield reduced in the treatments T_4, T_3 and T_2 compared to its corresponding control (T_1).

The plants used for cuttings produced from whole tuber planted at 1st November (T_2) showed 17.2 % of yield reduction compared to control (T_1) might be due to two times top shoot cuttings that reduced photosynthetic area and resulted in lower yield. Photosynthesis is positively related with the leaf area and foliage coverage [15]. Many authors previously reported similar results on seed tuber multiplication through top shoot cuttings ([4] [12] [16] [17]).

Table 2. Effects of planting time on tuber yield and yield increase or decrease as compare to respective control.

Treatments	Yield (t·ha^{-1})	Cumulative yield (t·ha^{-1})	Yield increase (%) with destructive haulm	Yield decrease as compare to respective control (%)	Yield decrease (−)/increase (+) in 2nd planting as compare to 1st planting (%)
T_1	41.84 a	41.84	-	-	-
T_2	34.63 c	93.23	122.8	17.2	-
T_3	32.95 d	-	-	21.2	-
T_4	25.65 e	-	-	38.7	-
T_5	42.56 a	42.56	-	-	1.7
T_6	37.52 b	80.75	89.7	11.8	8.3
T_7	24.34 e	-	-	42.8	−26.1
T_8	18.89 f	-	-	55.6	−26.4
CV (%)	5.01				
Level of significance	**				

Means bearing same letter in a column do not differ significantly at 1% level of probability.

Again, 21.2% and 38.7% yield reduction was observed in top shoot cuttings treatments T_3 and T_4, respectively. Top-shoot cutting plants needed more time for its establishment and plants got less time to tuber initiation and development resulting lower yield. Similar trend was observed in the treatments T_5, T_6, T_7 and T_8. The yield reduction was higher in the treatments T_7 and T_8 (42.4% and 55.6% respectively) due to late planting of top-shoot cuttings which took more time to establish and simultaneously faced higher temperature which was not suitable for tuber initiation and development [18]. But increased yield was found in T_5 and T_6 (1.7% and 8.3%, respectively) compared to respective T_1 and T_2. It might be due to getting more favorable environment as a result of proper time planting in Bangladesh situation. The crop produced from top-shoot cuttings planted at 5th and 15th December (T_7 and T_8 respectively) showed more yield reduction (26.1% and 26.4% respectively) compared to the cuttings planted on 25th November (T_3) and 5th December (T_4) due to prevailing higher temperature. Early planted tubers favors the better vegetative growth of plants than late planted tubers which ultimately favors the healthier production of top shoots and resulted better establishment of the cuttings [17]. This practice caused production of vigorous plants with better plant height having more number of leaves which ultimately favors in more photosynthesis; a necessary component for obtaining higher yield [19]. Previous studies reported that the yield decreases with delayed planting [9]-[11]. Yield reductions in delayed planting regardless of the precocity and the type of planting materials [20]-[22]. These results are in conformity with the findings of Akhter *et al*. [23].

Seed tuber yield increased 167.89% (30.96 $t{\cdot}ha^{-1}$ to 82.94 $t{\cdot}ha^{-1}$) from early one source crop due to taking two times cuttings, while it was 95.33% (from 37.88 $t{\cdot}ha^{-1}$ to73.99 $t{\cdot}ha^{-1}$ cumulative yield) from late one source crop (**Table 3**). Number of cumulative seed tuber increased from 918519 to 1560741with 69.91% increased from early one source crop due to taking two times cutting, while it was 63.19% (from 923,704 to 1,507,408) from late one source crop.

3.2. Tuber Grade (% by Number and by Weight)

Planting time of top shoot cutting of potato had significant effects on tuber grade by number (**Table 4**). Maximum percentage (53.3%) of A grade (28 - 40 mm) seed by number was recorded from T_4 followed by T_7 (53.10%) and T_2 (52.80%) which were statistically similar. The lowest percentage (45.6%) of A-grade seed was recorded from T_3. Highest percentage (36.50%) of B-grade (41 - 55 mm) seed was obtained from T_6 followed by T_5 (33.60%) and T_7 (33.30%). The lowest percentage (24.0) of B-grade seed was recorded in T_2.

Planting time of top shoot cuttings of potato on tuber grade by weight was significant (**Table 4**). Maximum percentage (70.20%) of A-grade seed (28 - 40 mm) was found in T_8 and minimum percentage (25.50%) of A-grade seed was found in T_3. The highest percentage (65.90%) of B-grade seed (41-55mm) was found in T_6 which was followed by T_4 (63.70), T_7 (61.0%) and T_3 (60.30%). The lowest percentage (21.6) of B-grade seed was found in T_8. The highest percentage (14.20%) of non-seed tuber (<28 mm and >55 mm) was found in T_3 followed by T_5 (11.00%) and the lowest percentage (7.10%) fromT_2.The highest percentage (26.00%) of non-seed (<28 mm + >55 mm) was found from T_1 followed by T_2 (23.20%) and T_3 (22.00%) which were statis-

Table 3. Seed yield potential of potato with non-destructive haulm due to cuttings at different time.

Planting time	Seed yield ($t{\cdot}ha^{-1}$)	Cumulative seed yield ($t{\cdot}ha^{-1}$)	Seed yield increase (%) with destructive haulm	Seed tuber (no/ha)		Number increase (%) with destructive haulm
				Actual tuber	Cumulative tuber	
T_1	30.96	30.96	-	918,519	918,519	-
T_2	31.86	82.94	167.89	834,815	1,560,741	69.91
T_3	28.00	-	-	355,556	-	-
T_4	23.08	-	-	370,370	-	-
T_5	37.88	37.88	-	923,704	923,704	-
T_6	34.89	73.99	95.33	852,593	1,507,408	63.19
T_7	21.91	-	-	337,778	-	-
T_8	17.19	-	-	317,037	-	-

tically similar and the lowest percentage (13.60%) of non-seed was found in T_7 followed by T_4 (14.7%) and T_6 (16.8%). Potato produced from stem cutting revealed that delayed planting reduced total tuber number and potato grade. These results are in conformity with the findings of [24] [25].

3.3. Economic Analysis

Variations in benefit cost ratio (BCR) were observed among the treatments (**Table 5**). In case of top shoot cuttings, high labor involvement required compared to whole tuber planting. In seed production of potato from whole tuber planting, total cost was the highest (Tk. 288,000) in treatments T_1, T_2, T_5 and T_6 and was the lowest (Tk. 119,367) in treatments T_3, T_4, T_7 and T_8. The highest gross return of Tk. 984,440 was found in T_5 and the lowest from T_8 (TK. 443,190).

Considering seed production from top shoot cuttings, total cost was the minimum in the treatments T_3, T_4, T_7 and T_8 and it was Tk. 119,367. The highest gross return of Tk. 739,600 was found in T_3 followed by T_4 (Tk. 597,560). The lowest net return of Tk. 443,190 was found in T_8. The maximum benefit cost ratio (BCR) of 6.20 also recorded from T_3 followed by T_4. The overall BCR was obtained higher in top shoot cuttings than whole

Table 4. Effects of planting time on tuber grade by number and weight.

Treatment	% Grade by number			% Grade by weight		
	Grade A (28 - 40 mm)	Grade B (41 - 55 mm)	%Non-seed (<28 mm + >55 mm)	Grade A (28 - 40 mm)	Grade B (41 - 55 mm)	%Non-seed (<28mm + >55mm)
T_1	48.1	25.9	26.0	38.2	53.0	8.9
T_2	52.8	24.0	23.2	44.3	48.5	7.1
T_3	45.6	32.5	22.0	25.5	60.3	14.2
T_4	53.3	32.0	14.7	26.8	63.7	9.4
T_5	48.7	33.6	17.7	42.5	46.5	11.0
T_6	46.7	36.5	16.8	27.1	65.9	7.0
T_7	53.1	33.3	13.6	29.8	61.0	9.2
T_8	50.9	28.9	20.2	70.2	21.6	8.2
Level of significance	**	**	**	**	**	**
CV (%)	8.08	7.91	8.64	11.75	10.10	9.36

Table 5. Partial budget analysis of potato for different treatment combinations of top shoot cutting and control.

Treatment	Total material cost (Tk.)	Total non-material cost (Tk.)	Total variable cost (Tk.)	Gross return (Tk./ha)		Total gross return (Tk./ha)	Net return (Tk.)	BCR
				Seed	Non-seed			
T_1	218,600	69,400	288,000	774,000	84,160	858,160	570,159	2.98
T_2	218,600	69,400	288,000	796,500	22,160	818,660	530,659	2.84
T_3	45,034	74,333	119,367	700,000	39,600	739,600	620,233	6.20
T_4	45,034	74,333	119,367	577,000	20,560	597,560	478,193	5.01
T_5	218,600	69,400	288,000	947,000	37,440	984,440	696,439	3.42
T_6	218,600	69,400	288,000	872,250	21,040	893,290	605,289	3.10
T_7	45,034	74,333	119,367	547,750	19,440	567,190	447,823	4.75
T_8	45,034	74,333	119,367	429,750	13,440	443,190	323,823	3.71

1 USD = 78.30 Tk.

tubers being no required seed cost. Our study revealed that the BCR for whole tuber planting was the highest at mid-November planting and for the top shoots cutting; BCR was highest at early planting of top shoot cutting. Many authors previously reported similar results on seed tuber multiplication [26]-[28].

4. Conclusion

Early planted top shoot cutting (25th November planting) yielded maximum than late planting (December). The crop grown from early planted top-shoot cuttings produced higher percentage of A- (28 - 40 mm) and B-grade (41 - 55 mm) seed tubers than late planting. For getting maximum benefit top shoot cuttings would be used in potato production rather than the plants produced from whole tubers.

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References

[1] Horetex Newsletter (2011) The Horticulture Export Development Foundation, Dhaka, Bangladesh. Volume 11, Number 3.

[2] Annual Report (2015) Annual Report 2014-15. Monitoring Division, Bangladesh Agriculture Development Corporation (BADC), Krishi Bhaban, 49-51, Dilkhusha C/A, Dhaka.

[3] Sarath, G.I., Kadian, M.S., Hossain, M., Hossain, A.E., Jayasinghe, U. and Mahmud, A.A. (2001) Toward Alleviating Poverty of Rural Potato Farmers by Strengthening the Potato Seed System in Bangladesh: A Rapid Rural Appraisal. Scientist and Farmer. Partners in Research for the 21st Century. Program Report 1999-2000, 259-264.

[4] Hossain, M.J., Nahar, M.S. and Ahmed, A.S.U. (1999) Sprout and Top Shoot Cutting for Rapid Multiplication of Potato in Bangladesh. *The Journal of Agricultural Science*, Cambridge, **132**, 437-443. http://dx.doi.org/10.1017/S0021859699006565

[5] Rashid, M.M., Khan, A.L. and Ali, M.S. (1986) Seed Potato Production. 1st Edition, Potato Research Centre. Bangladesh Agricultural Research Institute, Joydebpur, Gazipur.

[6] Rashid, M.M. (1999) Vegetable Science [in Bengali: Sobji Bigyan]. 2nd Edition, Rashid Publishing House, Dhaka, 138-139.

[7] Hossain, M.J. (1993) Tuber from Leaf-Bud and Apical-Bud Cutting: Methods for Rapid Clonal Propagation of Potato in Bangladesh. *Field Crops Research*, **35**, 147-148. http://dx.doi.org/10.1016/0378-4290(93)90147-f

[8] Kar, G. (2003) Tuber Yield of Potato as Influenced by Planting Dates and Mulches. *Journal of Agrometeorology*, **5**, 60-67.

[9] Braun, E.E. (1997) Planting Dates and Crop of Potatoes in the Northern and Western Kazakhstan, West Kazakhstan. CSTI, Uralsk, 39.

[10] Khan, A.A., Jilani, M.S., Khan, M.Q. and Zubair, M. (2011) Effect of Seasonal Variation on Tuber Bulking Rate of Potato. *Journal of Animal and Plant Sciences*, **21**, 31-37.

[11] Dehdar, B., Asadi, A., Jahani, Y. and Ghasemi, K. (2012) The Effect of Planting and Harvesting Dates on Yield and Vegetative Growth of Two Potato Cultivars in Ardabil Region. *International Journal of Agronomy and Plant Production*, **3**, 675-678.

[12] Hossain, M.J. (1997) Enhanced Seed Multiplication in Potato through Cut Seed and Stem Cutting. *Journal of Indian Potato Association*, **24**, 101-103.

[13] Dey, T.K., Prodhan, Z.H. and Hossain, M.S. (2007) Potato Late Blight and Its Integrated Management (Booklet in Bengali). Breeders Seed Production Centre, Bangladesh Agricultural Research Institute, Debiganj, Panchagarh.

[14] Khan, M.S.A., Hossain, M.A., Mahmud, A.A., Howlader, M.I.A. and Rahman, M.A. (2008) Integrated Weed Management in Potato at Munshigonj. *Bangladesh Journal of Agricultural Research*, **33**, 647-654.

[15] Mahmud, A.A. (2012) Improvement of Drought Tolerant Potato Variety. Ph.D. Dissertation, Department of Horticulture, Banngabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur.

[16] Hossain, M.J. (1993) Tuber from Leaf-Bud and Apical Bud Cutting: Methods for Rapid Clonal Propagation of Potato in Bangladesh. *Field Crops Research*, **35**, 147-148. http://dx.doi.org/10.1016/0378-4290(93)90147-F

[17] Yasmin, M.F. (2008) Effect of Planting Time and Plant Density of Top Shoot Cuttings in Potato Production. Master's Thesis, Department of Horticulture, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Salna.

[18] Burton, W.G. (1996) Yield and Content Dry Matter: 1—The Underlying Physiological Processes. In: Burton, W.G., Ed., *The Potato*, Longman Scientific & Technical, Essex, 84-155.

[19] Farooque, K. (2005) Use of True Potato Seed for Better Yields. Ph.D. Dissertation, Department of Agronomy, University of Arid Agriculture, Rawalpindi.

[20] Hassanpanah, D., Hosienzadeh, A.A. and Allahyari, N. (2009) Evaluation of Planting Date Effects on Yield and Yield Components of Savalan and Agria Cultivars in Ardabil Region. *Journal of Food, Agriculture and Environment*, **7**, 525-528.

[21] Taheri, S. and Shamabadi, Z.A. (2013) Effect of Planting Date and Plant Density on Potato Yield, Approach Energy Efficiency. *International Journal of Agriculture and Crop Sciences*, **5**, 747-754.

[22] Kawakami, J., Iwama, K. and Jitsuyama, Y. (2005) Effects of Planting Date on the Growth and Yield of Two Potato Cultivars Grown from Microtubers and Conventional Seed Tubers. *Plant Production Science*, **8**, 74-78. http://dx.doi.org/10.1626/pps.8.74

[23] Akhter, S., Islam, M.M., Azad, M.A.K., Hakim, M.A., Alam, M.S. and Rahman, M.W. (2013) Effects of Planting Time and Variety on the Yield and Processing Quality of Potato. *Food, Agriculture and Environment*, **11**, 461-465.

[24] Basappa, S., Krishnappa, K.S., Reddy, N.S. and Gowda, M.C. (2000) Effects of Planting Dates and Genotypes on Growth and Yield of Potato Raised from TPS Transplants. *Mysore Journal of Agricultural Sciences*, **34**, 55-60.

[25] RahmanJamro, M.M., Tunio, S.D. and Chachar, Q.D. (2015) Effect of Planting Dates on Growth and Yield of True Potato Seed (TPS) in Nursery Raising Approach. *Journal of Basic & Applied Sciences*, **11**, 318-322. http://dx.doi.org/10.6000/1927-5129.2015.11.47

[26] Haque, M.E., Hossain, M.S., Islam, M.K., Waliullah, M.H. and Dey, T.K. (2013) Effect of Planting Time and Fungicidal Spray in Controlling Late Blight of Potato Variety Raja. *Journal of Agroforestry and Environment*, **7**, 123-126.

[27] Haque, M.A., MonayemMiah, M.A., Hossain, S. and Rahman, M.M. (2012) Profitability of BARI Released Potato (*Solanum tuberosum* L.) Varieties in Some Selected Locations of Bangladesh. *Bangladesh Journal of Agricultural Research*, **37**, 149-158.

[28] Moniruzzaman, Hoq, M.S., Islam, M.K., Jasmin, J. and Khanam, M.M. (2015) Agro-Economic Performance of Seed Potato Production under Contract Farming in Bangladesh. *Eco-Friendly Agriculture Journal*, **8**, 30-36.