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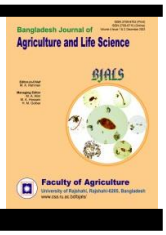

Effect of Planting Date and Variety on Yield and Yield Attributes of Potato in the Rangpur Region of Bangladesh

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ABSTRACT

A field experiment was carried out at the Agronomy Farm, Agricultural Training Institute, Tajhat, Rangpur, Bangladesh during the period from November 2019 to March 2020 to study the effect of sowing date on the performance of potato varieties. Four potato varieties viz. BARI potato 25, BARI potato 28, BARI potato 29 and BARI potato 57 were sown at 10-day intervals starting from 20 November to 10 December 2019 to identify the suitable variety and optimum sowing date for getting maximum yield. Among the varieties BARI potato 57 was ranked first in terms of tuber yield (33.45 t ha^{-1}) and the lowest tuber yield (22.82 t ha^{-1}) was obtained from BARI potato 29. The highest tuber yield (32.64 t ha^{-1}) was obtained from the date of sowing 20 November followed by 30 November (27.72 t ha^{-1}) and the date of sowing 10 December produced the lowest tuber yield (18.90 t ha^{-1}). BARI potato 57 yielded the highest tuber yield (42.05 t ha^{-1}) when sown on 20 November followed by 30 November with BARI potato 57 (35.19 t ha^{-1}) and BARI potato 25 sown in 10 December produced the lowest tuber yield (16.80 t ha^{-1}). Thus, it could be concluded that varietal and environmental variations as well as their combination had considerable influence on tuber yield and the potato's attributes. Therefore, considering all results the first date of sowing 20 November BARI potato 57 could be recommended to the potato growers of Rangpur region.

Introduction

Potato (*Solanum tuberosum* L.) is the staple food of almost half of the world's population (Thiele et al., 2010). It ranks fourth most important food crop in the world after maize, wheat and rice in terms of human consumption (FAO, 2008). It is one of the most diverse and nutritious crops on the planet and can be grown almost all the continents (Khurana and Rana, 2008).

Bangladesh is the seven-largest producer of potato in the world (Saxena and Mathur, 2013). In Bangladesh around 9.89 million tons of potato were produced by the farmers of Bangladesh and the average national yield was 21.09 t ha^{-1} in the fiscal year of 2020-2021 (BBS.2021). The national average yield is low as compared to other potato growing countries of the world such as Netherlands (44.7 t ha^{-1}), USA (44.6 t ha^{-1}), France (43.2 t ha^{-1}) in 2007 (Anonymous,2008). The main reasons for the low yield include the use of lower-yielding varieties, poor quality seed tubers and inefficient management practices. Potato is a weather sensitive crop. Its growth and yield is influenced by climate and several other factors like use of improved varieties, good quality seeds. Planting time, nutrition and irrigation, incidence of pest and diseases and weeds. Among these factors, planting time plays a very important role in potato production as manipulation of light and temperature can be done to acertain extent by altering planting time. For best yields, potato crop needs long day conditions and short day conditions during tuberization (Chadha, 2009). The average

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yield of potato in Bangladesh could be increased through the introduction of high yielding varieties or cultivation of varieties that are high yielders with better quality and are resistant to insects and diseases and climatic stresses. The information about the proper period of time for planting the potatoes in Rangpur region of Bangladesh is not available.

Planting dates influence stolon development and tuber formation in potato. Therefore, it is necessarily important to find out a suitable planting date for better plant growth and higher tuber yield of potato. However, a good number of studies has already been done on planting dates of potato at home and abroad (White et al., 1983; Ahmed et al., 2017; Jamro et al., 2015) but very limited studies have been done on planting dates in the Rangpur region of Bangladesh. In view of these facts the present investigation was designed to find out a suitable variety and the optimum date of planting to maximize productivity of the crop in Rangpur region.

Materials and methods

The experiment was conducted at Agronomy Farm of Agricultural Training Institute (ATI), Department of Agricultural Extension, Tajhat, Rangpur during the robi season from November to December 2019. The experiment was laid out in a split-plot design with three replications. There were 36 plots altogether, 12 plots in each replication. The size of the unit plot was 4m x 3m. The treatments were a combination of three planting dates (D) and four varieties (V). The three dates of planting followed in the experiment were 20 November, 30 November and 10 December. The varieties were BARI potato 25, BARI potato 28, BARI potato 29 and BARI potato 57. The treatment date of sowing (D) was assigned to the main plots and variety (V) to the sub plots. The seed tubers of these varieties were collected from Breeder Seed Production Centre ,BARI ,Debigonj, Panchagor. Well sprouted foundation seed tubers were planted standard cultural practices were followed for raising a successful crop. A fertilizer dose of urea @260 kg ha^{-1}, TSP @ 98 Kg ha^{-1}, MOP @148 Kg ha^{-1}, Gypsum @ 74 Kg ha^{-1}, Zinc sulphate 7.4 Kg ha^{-1}, Boric acid @ 3.7 kg ha^{-1} and $MgSO_4$ @ 50 Kg ha^{-1} were applied. Decomposed cow dung was applied @ 5 t ha^{-1}. 50% of urea, whole of other fertilizers were applied before furrows making and remaining 50% of urea was top dressed at the time of earthing up after 30 days of planting.

Planting was done at 60 cm (between) x 20 cm (within) spacing. The crop was dehaulmed at 85 DAP. The yield and yield attributers were recorded on 10 randomly selected plants from each plots. Harvesting was done after 10 days of haulm-cutting to allow tuber curing in the field. Data recorded on main stem, plant height, tuber $plant^{-1}$, tuber weight $plant^{-1}$, individual tuber weight and tuber yield.

Data were checked for all ANOVA assumptions. Analysis of variance (ANOVA) was done using Statistics 10.0 Software. Mean separations were done using LSD All-Pairwise Comparisons Test at 5% probability level.

Results

Number of main stem hill^{-1}

The effect of dates of sowing with respect to number of main stem $hill^{-1}$ was recorded significantly (Table-1). First planting on 20 November (D_1) were found higher stem (3.97) might be due to optimum environmental condition for growth. Least numbers of main stem per plant (3.64) were observed on 10 December planting (D_3).

The highest number of stems was recorded for BARI Potato (4.52) on average per plant and this value was statistically significant with stem numbers obtained from other varieties, while the lowest (2.91) was obtained from BARI potato 28 (Table-2).

Interaction between date of sowing and variety was significantly affected the number of main stem (Table-3). Numerically the maximum number (4.73) was recorded from D_1V_1 which was statistically similar with D_1V_4 (4.68) while the lowest number of number of main stem $hill^{-1}$ (2.80) was observed in D_3V_2 which was similar to D_2V_2 (2.81).

Plant height

The plant height was influenced significantly by the effect of date of sowing of potato tuber. The treatment D_1 produced the tallest plant (70.16 cm) and the lowest height (62.49 cm) was observed in the treatment D_3.(Table-1). Data from Table-2 showed that plant height was observed the significant variation among varieties of the potato with the result of tallest plant (71.33 cm) on the variety V_1 (BARI potato 25) followed by V_4 (70.88 cm) and V_3 (64.19 cm).

Number of tuber hill^{-1}

Among different date of planting, D_1 produced the highest number of tuber per hill (6.38) and the lowest number of tubers (4.96) was recorded in the treatment D_3.(Table-1). Number of tubers $hill^{-1}$ was significantly affected by variety (Table-2). The maximum number (7.16) of tuber was recorded from variety V_4 (BARI potato 57) while the minimum number (4.75) of tubers recorded from variety V_2 (BARI potato 28). The apparent variation could be due to the difference in genetic potential among potato varieties.

Tuber weight hill^{-1} (g)

Significant result was found on tuber weight $hill^{-1}$ influenced by date of sowing of potato (Figure-1). Tubers sowing on 20 November (D_1) recorded the

highest weight of tubers hill^{-1} (396.16 g) and then gradually decreased. The lowest 232.99 g weight per hill was found in treatment D_3 (10 December).

Results of tuber weight hill^{-1} (Table-2) was significantly highest (414.42 g) in V_4 (BARI potato 57) and lowest (275.40 g) in V_3 (BARI potato 29) weight.These differences in days to flowering among the different potato varieties are most probably associated with the genetic makeup of the varieties.

Individual tuber weight (g)

The main effects of date of sowing of potato tuber had significant difference on individual tuber weight of potato (Table-1).Individual weight of potato tubers planted on 20 November (D_1) was significantly higher over other two dates of sowing and decreased with the delay of sowing (Figure-1). The lowest weight, 47.40 g was found in last date of sowing 10 December (D_3).

Results indicated that the interaction of variety and date of sowing was significantly influencing the individual tuber weight of potato. The maximum individual tuber weight (69.80 g) recorded from 20 November date of sowing (D_1) with variety BARI potato 25 ($V_{1)}$) while the minimum individual tuber weight (43.65 g) was recorded from 10 December date of sowing with variety BARI potato 25 (Table-3).

Table. 1. Effect of sowing date on yield and yield contributing characters of potato

Treatment (Sowing date)	Main stem plant^{-1} (no.)	Plant height (cm)	Tuber plant^{-1} (no.)	Tuber weight plant^{-1} (g)	Individual tuber weight (g)	Tuber yield (t ha^{-1})
D_1(20 Nov.)	3.97 a	70.16 a	6.38 a	396.14 a	64.07 a	32.64 a
D_2 (30 Nov.)	3.73 b	65.09 b	5.71 b	337.04 b	60.24 b	27.72 b
D_3 (10 Dec.)	3.64 c	62.49 c	4.96 c	232.99 c	47.40 c	18.90 c
$LSD_{(0.05)}$	0.05	0.43	0.10	7.19	2.75	0.40
Grand Mean	3.78	65.91	5.68	322.06	57.24	26.42
%CV	1.76	0.66	2.31	1.23	5.81	0.80

In a column, figures with the same letters do not differ significantly whereas figures with dissimilar letters differ significantly as per LSD All-pairwise comparisons test. LSD = Least Significant Difference, CV= Co-efficient of Variation, D_1= 20 Nov. D_2 = 30 Nov., D_3 = 10 Dec.

Table. 2. Effect of variety on yield and yield contributing characters of potato

Treatment (Variety)	Main stem plant^{-1} (no.)	Plant height (cm)	Tuber plant^{-1} (no.)	Tuber Weight plant^{-1}(g)	Individual tuber weight (g)	Tuber yield (t ha^{-1})
V_1(BARI-25)	4.46 b	71.33 a	5.58 b	318.99 b	59.23 a	26.29 b
V_2(BARI-28)	2.91 d	57.26 d	4.75 d	279.43 c	59.04 a	23.11 c
V_3(BARI-29)	3.22 c	64.19 c	5.25 c	275.40 d	51.99 b	22.82 d
V_4 (BARI 57)	4.52 a	70.88 b	7.16 a	414.42 a	58.67 a	33.45 a
$LSD_{(0.05)}$	0.07	0.43	0.14	7.19	3.29	0.21
Grand Mean	3.78	65.91	5.68	322.06	57.24	26.42
%CV	1.76	0.66	2.31	1.23	5.81	0.80

Means within a column followed by the same letter (s) are not significantly different whereas figures with dissimilar letters differ significantly as per LSD All-pairwise comparisons Tests. LSD = Least Significant Difference. CV = Co-efficient of Variation. V_1 = BARI potato 25, V_2 = BARI potato28, V_3 = BARI potato 29, V_4 BARI potato 57)

Tuber yield (t ha^{-1})

The Tuber yield was significantly affected by date of transplanting of potato tuber (Table-1). Tuber yield was negatively correlated with the time of planting and delayed plantings caused significant loss of yield. The highest tuber yield (32.64 t ha^{-1}) was obtained from the early date of sowing 20 November (D_1). Tuber yield 27.72 t ha^{-1} and 18.90 t ha^{-1} was found from 30 November (D_2) and 10 December (D_3) respectively. The average tuber yield of potato was significantly affected by potato variety (Figure-2). The highest 33.45 t ha^{-1} of potato tuber was found from the variety V_4 (BARI potato 57) and the 2nd highest (26.29 t ha^{-1}) was recorded in V_1 whereas the lowest (22.82 t ha^{-1}) of potato tuber was recorded from V_3 (BARI potato 29).There was a significant interaction between sowing dates and varieties with respect to tuber yield. The highest tuber yield (42.05 t ha^{-1}) was obtained from the variety BARI potato 57 transplanted on 20 November (Table-3). The 2nd highest tuber of 35.19 t ha^{-1} was obtained from 30 November (D_2) transplanting with same variety V_4 (BARI potato 57).The lowest tuber yield of 16.80 t ha^{-1} was found on last sowing date 10 December with variety BARI potato 25 (Table-3).

Table. 3: Interaction effect of date of sowing on yield and yield contributing characters of potato

Treatment Interaction	Main stem plant^{-1} (no.)	Plant height (cm)	Tuber plant^{-1}(no.)	Tuber weight plant^{-1} (g)	Individual tuber weight (g)	Tuber yield (t ha^{-1})
D_1V_1	4.73 a	76.64 a	6.43 c	410.89 c	69.793 a	33.16 c
D_1V_2	3.13 e	62.11 g	4.90 fg	331.61 e	67.75 ab	27.48 f
D_1V_3	3.34 d	69.13 d	6.09 d	333.62 e	54.28 d	27.86 e
D_1V_4	4.67 a	72.74 b	8.09 a	508.45 a	64.46 abc	42.05 a
D_2V_1	4.46 b	70.31 c	5.77 e	347.34 d	64.26 abc	28.90 d
D_2V_2	2.81 f	55.74 i	4.78 gh	299.81 f	63.38 bc	24.65 g
D_2V_3	3.20 e	63.54 f	5.11 f	268.12 c	52.41 d	22.14 i
D_2V_4	4.46 b	70.78 c	7.16 b	432.91 b	60.90 c	35.19 b
D_3V_1	4.19 c	67.02 f	4.53 i	198.73 j	43.65 f	16.80 d
D_3V_2	2.80 f	53.92 j	4.57 hi	206.87 i	5.99 ef	17.21 k
D_3V_3	3.11 e	59.88 h	4.54 i	224.47 h	9.30 def	18.45 j
D_3V_4	4.44 b	59.13 d	6.21 cd	301.9 f	50.64 de	23.12 h
LSD at 0.05	0.11	6.03	0.24	6.03	5.70	0.36
Grand Mean	3.78	65.91	5.68	322.06	57.24	26.42
% CV	1.76	0.66	2.31	1.23	5.81	0.80

Means within a column followed by the same letter (s) are not significantly different at 0.05 level of significance. LSD = Least Significant Difference. CV = Co-efficient of Variation

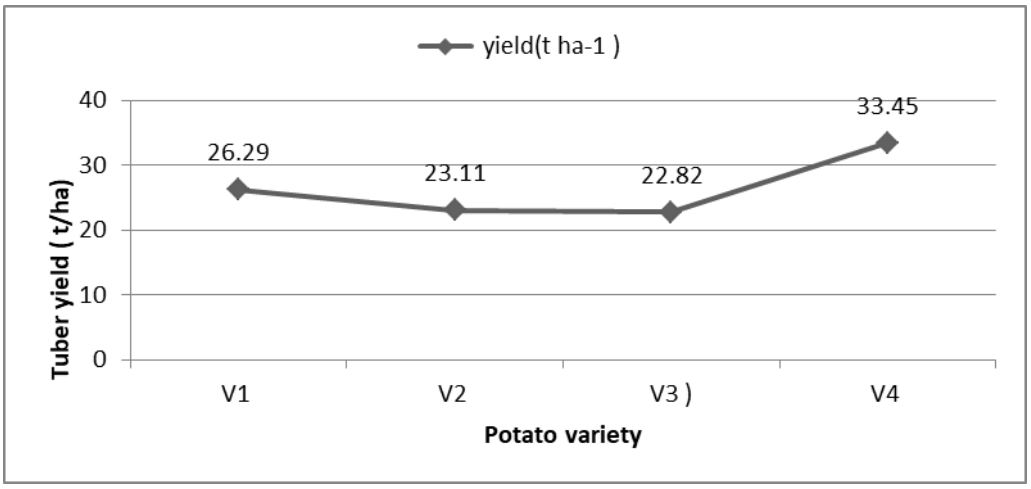

Fig.1. Tuber yield affected by different variety of potato

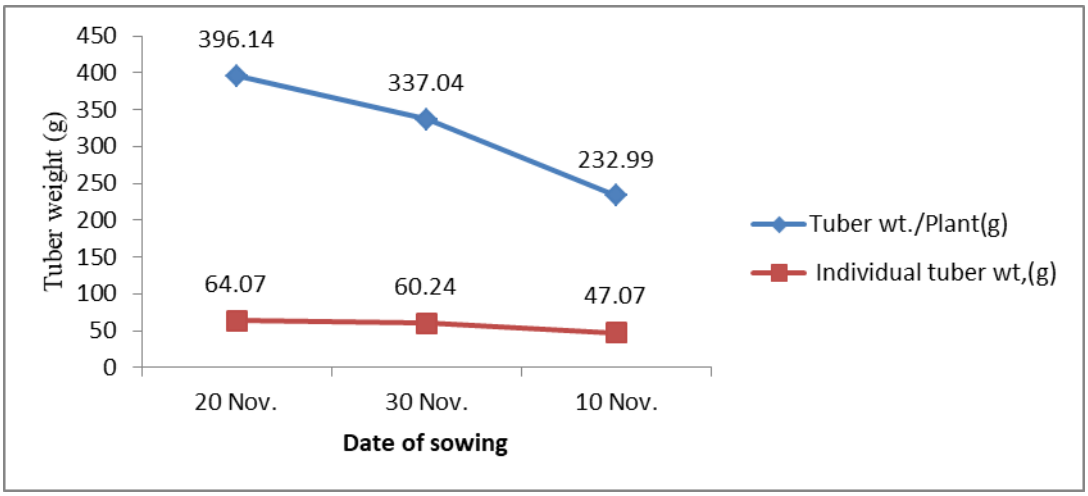

Fig.2. Tuber weight plant^{-1} (g) and individual tuber weight (g) affected by different date of sowing of potato

Discussion

Dash et al (2018) observed number of main stem per plant was significantly maximum (4.2) in15 November planting and minimum (3.5) on 5 December. The variation in stem number per plant among different potato varieties could be due to their inherent variation (Tekalign, 2005). This result is in conformity with Vander Zaag et al. (1990) who reported stem number per hill variability among potato cultivars tested.

Production of higher stem number hill^{-1} by BARI potato 57 was probably due to the greater number of sprouts observed which might have resulted from its genetic potential for sprouting capacity.

The better growth in planting date of D_2 might be due to prevalence of favorable temperature (15.6 to 27.9°C) required for better vegetative growth. Similar findings were also reported by Modisane (2007) who reported that plants grew taller at high temperature (27/17^{0}C) as compared with low temperature (22/14 ^{0}C). Similar findings have also been reported by Ezekiel and Bhargava (1992) and Singh and Khurana, (1997). Thongam et al., (2017) recorded the maximum height 52.9 and 70.2 cm at 45 and 75 days after planting in 10 October planting time.

The variety V_2 showed the lowest plant height (57.27 cm). Plant genetics and the quality of plant materials might be the cause for differences in plant height between the varieties (Touria, 2017). Many authors conceived that the potato germplasm had difference response of plant height in different part of the world (Asefa et al., 2016; Basavaraj et al., 2005).Plant height was observed to be significantly highest (76.64 cm) in treatment combination D_1V_1 (Table 3). On the other hand, the lowest plant height (53.92 cm) was observed in the treatment combination of D_3 (10 December) with variety V_2 (BARI potato 28).

This was conformity with the finding of Demagante and Zaag (1988) and Walworth and Carling (2002) who reported that the total intercepted solar radiation was positively correlated with the final tuber yield and total dry matter production and that environmental conditions such as temperature influenced the number of tubers per plant. These results are also in conformity with the earlier findings of Khan et al. (2011) and Sharma and Verma (1987).

The potential tuber number that can be successfully produced by a plant varies with the genotype (Mihovilovich*et al.*, 2009). Number of tuber hill^{-1} was also influenced by the interaction effect of sowing date and variety of potato. The treatment combination D_1V_4 produced the maximum number of tubers hill^{-1} (8.09), The 2nd highest (7.16) was obtained from the treatment combination of D_2V_4 (Table-3). On the other hand, minimum number of tuber plant^{-1} (4.52) was found in the treatment combination of D_3V_1 which was statistically identical to D_1V_1 (4.54).

This higher tuber weight at D_1 may be attributed to efficiency of translocation of plant food from the source to sink. The growth duration was shortened due to delay in planting date, hence, dry matter accumulation, tuber fresh weight and final yield were all decreased because of insufficient cumulative temperature over the shorter growing periods (Wang et al., 2014).

The tuber yield is affected by environmental factors such as soil temperature, moisture, light intensity, fertilizer delivery, and disease and pest control (Struik& Wiersema, 1999). Differences in yield among varieties might be genetically determined, the quality of potato seed, or the variety's adaptive

responses to the experimental site's climatic conditions were also might be the factors for this result. Higher yield in the local cultivar; Bajhang local is consistent with (Khatri, 2004 and Shrestha *et al.,* 2020)'s findings. It is revealed that effect of variety on tuber weight hill^{-1} was significantly different from another. The highest tuber weight hill^{-1} (508.45 g) was observed at BARI potato 57 (V_4) at November 20 (Table-3) sowing time and the lowest tuber weight hill^{-1} (198.73 g) was obtained from the variety BARI potato 25 on 10 December sowing time.

The higher tuber weight in planting dates of 20th November and 20th October (D3) could be attributed to overall strong vegetative structures of plants raised during this period which might have supplied the required quantum of photosynthates towards the development of tubers over a long period of time that might have resulted in gaining higher weight of individual tuber. Further, the lower temperature (12 ^{0}C) and short days might have resulted in better growth of the tubers. Similar results were obtained by Sharma and Verma (1987).

The analysis of variance for the individual tuber weight gave varieties to be significantly Highest weight 59.23 g from V_1 which was statistically similar to V_4 (58.67 g) and V_2 (59.04 g) , lowest 51.99 g from V_3 (Table-2). The variation may be attributed to the inherent genetic variation on tuber bulking among potato varieties. Such a response that tuber size distribution is affected by the genotype is confirmed by the results of Sharma et al., (2013).

Yield loss increased with delay in planting because plants were subjected to lower temperature range in early period and also very short photo period as reported by Sarma and Sarma (1998); The beneficial effect of early planting might be associated with the prevalence of low temperature during the tuber development stage. Temperature is the most dominating factor in yield contribution of potato, the required temperatures during vegetative as well as reproductive growth phase might have contributed towards getting better vegetative growth and higher yield in this early planting date. Similar findings were also reported by Perumal (1981), who recorded higher yield due to persistence of foliage and high rate of uninterrupted tuber bulking under regional conditions.

The tuber yield is affected by environmental factors such as soil temperature, moisture, light intensity, fertilizer delivery, and disease and pest control (Struik& Wiersema, 1999). Differences in yield among varieties might be genetically determined, the quality of potato seed, or the variety's adaptive responses to the experimental site's climatic conditions were also might be the factors for this result. Higher yield in the local cultivar; Bajhang local is consistent with Khatri, 2004 and Shrestha *et al.,* 2002)'s findings.

Conclusion

It can be concluded that, the planting time and variety of potato significantly influenced the different growth and yield parameters. The present investigation revealed that the variety BARI potato 57 showed higher yield than other variety transplanted on all three dates of planting. Therefore, according to the current study, BARI potato 57 can be transplanted on 20 November to 30 November for optimum growth and high yield of potato at Rangpur Region of Bangladesh.

Author's Contribution

Conceptualization, NMAB, MAA and MBH; Methodology, NMAB, MAA and MBH, Investigation, NMAB, MAA, MBH and MMH; Data collection and analysis, NMAB, MAA, MBH and MMH; Draft preparation, NMAB, MAA MBH and MMH. Review and editing MAA and MBH; All authors have read and agreed to the published version of the manuscript.

Conflict of Interest

The authors declare no conflicts of interests.

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