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Performance of Winter Potato with varied dates of planting under Mid Hills of Meghalaya

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ABSTRACT

The performance of Potato (*Solanum tuberosum* L.) was assessed under mid hills of Meghalaya during winter season of 2016-17. A field trial was laid out with four different dates of planting, *viz.* D_1- 1st November, D_2- 11th November, D_3- 21st November and D_4- 1st December and replicated thrice. Irrigation was provided with micro irrigation system at respective scheduled dates. Tubers planted on D_2 date of sowing showed higher results for number of leaves per plant, leaf area index (LAI), dry matter accumulation (g), number of tubers per plant, weight of tubers per plant (g), tuber yield (t ha¯1) and benefit cost ratio over D_1, D_3 and D_4. The highest recorded tuber yield was 15.30 t ha^{-1} for D_2 over other three planting dates. Similarly the maximum field water use efficiency (WUE) was recorded for D_2 (56.09 kg $ha^{-1}mm^{-1}$) and the value of WUE for D_1, D_3 and D_4 are 50.37 kg $ha^{-1}mm^{-1}$, 49.71 kg $ha^{-1}mm^{-1}$ and 44.23 kg ha¯1mm¯1, respectively.

1. Introduction

Potato (*Solanum tuberosum L.*) is considered to be an indigenous crop of South America (Singh *et al.,* 2008). It fulfils all the criteria for a healthy food and offers a great potential for decreasing global food crisis. In India, potato is not primarily a rural staple food, rather a cash crop that provides significant income for small and marginal farmers. In North Eastern Hill (NEH) region of India especially under the hilly tracts, the potato is grown under rainfed conditions (Sah *et al*., 2011). It is grown in an area of 18,173 ha producing 1,81,089 metric tonnes from the hilly states of NE India (Saxena and Mathur, 2013). The NEH region covers almost 10% of the country's total potato area. As the agriculture production system in this region is mostly rainfed, mono-cropped and subsistence level, potato productivity (8.16 t ha^{-1}) of this region is very low (Roy Burman *et al*., 2007). Potato is a temperate crop and grows well during *rabi* season, but under sub-tropical areas also it can be cultivated successfully.

Well drained sandy loam soils are well suited for higher yield. It prefers a pH ranging from 5.5 to 6.5 (Prasad, 2015). Potato yield is highest when average daytime temperatures are about 21°C. Cool night temperatures are critical for the accumulation of carbohydrates and dry matter in the tubers (Belanger *et al.,* 2000). Various researchers have reported the importance of effect of planting dates on the crop yield of potatoes (Arab *et al*., 2011; Muthuraj and Ravichandran, 2014; Srivastava *et al*., 2016). In Meghalaya due to favourable temperature conditions, potato is planted under a wide range of dates in the fields. It is planted from September onwards upto first week of January. Hence, if a certain specific window of date of planting can be ascertained to the farmers of this region then it would help to cultivate potato exactly when the climatic conditions are favourable for its growth and ultimately to get a high crop yield. Various field trials conducted in NEH region have showed that Kufri Megha has established itself as a promising variety for the NER and Meghalaya. It gave a high yield as compared to other varieties with high Benefit: Cost (B: C) ratio (Gupta *et al.,* 2009; Baishya *et al*., 2013; Srivastava *et al,.* 2016). Under this scenario an experiment on the effects of different dates of planting of potato was conducted with the variety Kufri Megha.

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2. Materials and Methods

A field experiment was conducted during winter season (2016-17) at the experimental farm of the College of Postgraduate Studies, Barapani (CAU, Imphal), to evaluate the yielding capacity of potato (variety: Kufri Megha) under different dates of sowing. The experiment was laid out in split plot design with three irrigation scheduling *viz*., IW/CPE-0.75 (I_1), IW/CPE-1.00 (I_2) and IW/CPE-1.25 (I_3) along with four different dates of planting, *viz.*, 1st November- D_1, 11th November- D_2, 21st November- D_3 and 1st December- D_4; and replicated thrice. The experimental site is situated at 91˚18' E longitude and 25˚40' N latitude and at an altitude of 950 m above the mean sea level (MSL). Disease free tubers of Kufri Megha were planted on top of the ridges (50 cm × 20 cm). Recommended doses of N, P and K @100:80:60 kg ha^{-1} (Full doses P and K was applied at time of sowing along with 50% of N and rest 50% of N at tuber initiation stage through top dressing). Farmyard manure @ 5 t ha^{-1} and it was applied 15 days before sowing of potato. Lime application was done to neutralize the acidity of soil in the field @ 500 kg ha^{-}1 in furrows.

The details of the crop calendar are presented in Table 1. Standard agronomic practices were followed during crop growth and crop was harvested at maturity. Also a standard plant protection method was followed. During the experiment the crop growth parameters, *viz.* number of leaves, leaf area index (LAI) and dry matter accumulation per plant (g) were taken at 30 days interval. The yield of the plant (t ha^{-1}) along with the number of tubers per plant and weight of tubers per plant (g) were recorded. The irrigation water was applied based on the soil water depletion scheduling on weekly basis using a 0.5 hp electric pump set by volumetric basis and accordingly the total quantum of water applied was worked out. The water use efficiency (WUE) of the crop was determined using standard empirical formulae. Meteorological data were recorded at meteorological station (ICAR for NEH region, Umiam) situated nearby the experimental site. Daily evaporation was recorded in the observatory along with other weekly data as average temperature, relative humidity, sunshine and total rainfall during the potato growing period from November 1st to April 1st. Figure 1 represents the meteorological data occurring during the cropping period.

Table 1. Crop calendar

Sl. No.	Cultural Operation	Date of Operation
1.	Field preparation	19th Oct. 2016
2.	Application of FYM	20th Oct. 2016
3.	Field layout	31st Oct. 2016
4.	Sowing/ Planting of tubers and fertilizer application	1st Nov.2016 11th Nov. 2016 21st Nov. 2016 1st Jan. 2017
5.	Gap filling 1st Nov. planting 11th Nov. planting 21st Nov. planting 1st Dec. planting	 1st Dec. 2016 11th Dec. 2016 21st Dec. 2016 31st Dec. 2016
7.	Weeding	9th Dec. 2016 (as and when required)
8.	Earthing up 1st Nov. planting 11th Nov. planting 21st Nov. planting 1st Dec. planting	 10th Dec. 2016 20th Dec. 2016 30th Dec. 2016 9th Jan. 2017
9.	Remaining fertilizer application 1st Nov. planting 11th Nov. planting 21st Nov. planting 1st Dec. planting	 15th Dec. 2016 25th Dec. 2016 4th Jan. 2017 14th Jan. 2017
10.	Harvesting 1st Nov. planting 11th Nov. planting 21st Nov. planting 1st Dec. planting	 18th Feb. 2017 28thFeb. 2017 10th Mar. 2017 20th Mar. 2017

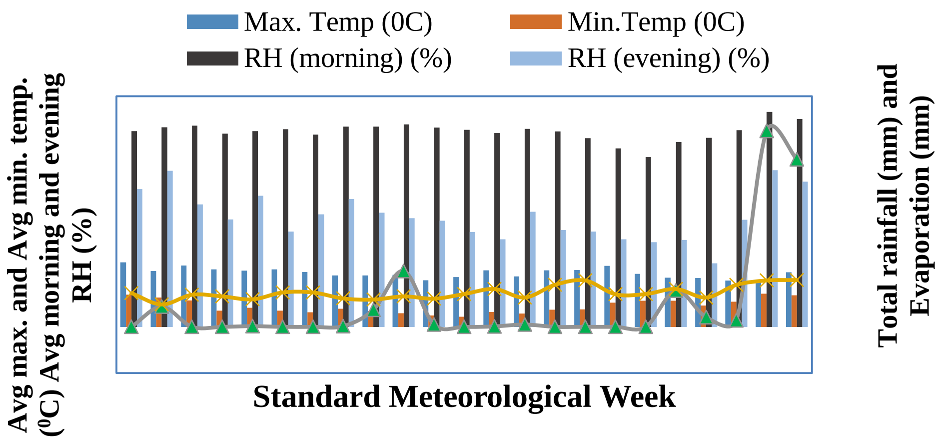

Figure 1. Weekly weather data prevailed during crop season

Plant height (cm):

The height of the plant in cm was determined from the sample tagged plants by measuring the height from the ground level to the tip of the longest stem or main stem at 30 days interval and their mean was computed as plant height using a standard scale of 60 cm length.

Leaf area index (LAI):

Leaf area index is defined as the leaf area per unit of ground area. The leaf area index was estimated by dividing leaf area per plant to the ground area covered by per plant. It is calculated through following equation (Watson, 1952).

$$\text{LAI} = \frac{\text{Total leaf area (cm}^2)}{\text{Ground area (cm}^2)}$$

Dry matter accumulation per plant (g):

Five plants from each plot (not the tagged one) were selected and picked randomly. After washing properly, *i.e.* after removal of foreign particles, excess moisture was removed with the help of blotting paper. The plant after separating as root, stem, leaves, stolon and tubers were weighed for taking fresh weight. After that, it was kept in the oven for about 48 hr at 60 ^{0}C till a constant weight was obtained. The dried weight of destructive samples were recorded and dry matter accumulation was calculated.

$$\text{Dry matter accumulation} = \text{fresh weight} - \text{dry weight}$$

Tuber yield (t ha^{-1}):

Data on tuber yields were prepared at the time of harvest by weighing the tubers from each plot and after that converting it into t ha^{-1}.

Weight of tubers per plant (g):

It was recorded at the time of harvest by taking the weight of tubers of each plot and then dividing with total numbers of plants within the plot.

Number of tubers per plant:

At the time of harvesting, the total numbers of tubers were counted per plot and the value was divided with total numbers of plant per plot. This gave us the approximate number of tubers per plant.

Field water use efficiency (WUE):

Water use efficiency under different dates of planting was calculated at the time of harvest by dividing the yield with total amount of water used.

$$\textbf{WUE (Field)} = \frac{\text{Y (kg/ha)}}{\text{WR (mm)}}$$

Benefit cost ratio (BCR):

Utility of adopting different practices was compared by using the following economic parameters:

Gross return = Tuber yield x local market price of potato tubers

Local market price of the potato tubers were assumed ` 12 kg^{-1}

Net return = Gross return – Cost of cultivation

$$\textbf{Benefit cost ratio} = \frac{\text{Gross returns (}Rs.ha^{-1})}{\text{Cost of cultivation (Rs.}ha^{-1})}$$

Table 2. Plant Growth Attributes

Parameters	Number of compound leaves			Leaf area index (LAI)			Dry matter accumulation (g)		
Date of planting (D)									
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
1st November (D_1)	4.56	9.64	12.16	0.18	1.26	2.16	3.88	7.61	39.61
11th November (D_2)	4.83	10.44	12.74	0.12	1.45	2.49	3.93	8.57	47.07
21st November (D_3)	4.37	9.18	11.50	0.11	1.12	2.02	3.85	6.16	30.91
1st October (D_4)	4.26	8.89	11.28	0.11	1.02	1.95	3.28	5.54	22.53
S.E.(m) ±	0.12	0.37	0.53	0.01	0.10	0.16	0.19	0.21	1.20
C.D.(*p*=0.05)	NS	1.12	NS	NS	0.30	NS	NS	0.63	3.55

Table 3. Yield attributes

Treatments	Yield parameters		
Date of planting (D)	**Number of tubers plant^{-1}**	**Weight of tubers (g)**	**Tuber yield (t ha^{-1})**
1st November (D_1)	6.93	175.76	14.19
11th November (D_2)	7.29	195.48	15.30
21st November (D_3)	6.51	168.07	13.45
1st October (D_4)	5.98	152.61	12.21
S.E.(m) ±	0.31	6.85	0.57
C.D.(*p*=0.05)	0.93	20.35	1.69

3. Results and Discussion

The plant growth attributes, *viz.* number of leaves, leaf area index and dry matter accumulation is presented in Table. 2. The yield attributes, *viz.* number of tubers plant-1, weight of tubers (g), tuber yield (t ha^{-}1) and WUE is presented in Table.3. The BCR is represented in Table 5.

Total number of leaves per plant:

The results showed that the total number of compound leaves per plant went on increasing significantly during the active growth period of 60 DAS (Table 2). After that there was a gradual decrease in the number of leaves as the plant reached its 90 DAS period of growth. This may be because of falling off of the leaves after the plant had attained its physiological maturity. The highest recorded number of compound leaves was 12.52. Tubers planted on 1st November (D_1) and 11th November (D_2) both registered higher number of leaves over both D_1 and D_2. As tubers planted on 11th November had better growth over those planted on other dates, it allowed the crop to have more numbers of leaves thus increasing its biomass by expanding plant canopy.

Leaf Area Index (LAI):

Performance of the plants, planted under different planting dates recorded significantly different from each other at all levels of growth period. LAI increased very noticeably upto 60 DAS. However, between 60 to 90 DAS the difference in increase was very nominal. The LAI regularly increased as the growth of plant progressed and the maximum LAI observed was 2.49 with D_2 planting date. Lower amount of leaves intercepted less light which later resulted in reduction in dry matter accumulation in tubers. LAI of plants planted on 11th November (D_2) was significantly higher over other three dates of planting and LAI decreased with delay in sowing. This increase in LAI might be due to the favourable climatic condition available during crop growth period during D_2 date of planting.

Dry matter accumulation per plant:

Among the different planting dates, highest dry matter accumulation per plant was recorded significant in D2 (47.07 g) over D1 (39.61 g), D3 (30.91 g) and D4 (22.53 g). In the present study, higher LAI registered under D2 was largely responsible for increased dry matter production. It was because higher the leaf area development higher was the potential site of photosynthesis.

Plant dry bio-mass was higher by planting the potato earlier which gave higher total tuber yield as compared to planting at later dates (Khan *et al.,* 2011; Rab *et al.,* 2013). Depending on the amount of photo-assimilates fixed through photosynthesis, there occurs increase in the dry mass of plants (Lawlor, 1990). The increase in dry matter during 60 and 90 DAS can be attributed to the fact that at earlier stages, most of the dry matter was concentrated in leaf and stem and from tuber initiation to tuber development it accumulated in stolon. At maturity stage and onwards stem and leaf dry weight decreased and this decrease could be due to the translocation of assimilates from leaf and stem to tuber (Begun *et al.,* 2015).

Number of tubers per plant:

An assessment of data indicates that the highest number of tubers per plant (7.29) was obtained under D_2 date of planting which was significantly higher over D_3 (6.51) and D_4 (5.98) but was statistically at par with D_1 (6.93). This was in 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 final tuber yield and total dry matter production and that environmental conditions such as soil type and temperature influenced the number of tubers per plant.

Tuber weight per plant:

Tubers planted on 11th November (D_2) recorded significantly higher tuber weight per plant (195.48) over those planted on D_1 (175.76), D_3 (168.07) and D_4 (152.61). This higher tuber weight at D_2 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).

Tuber yield:

Among different planting date treatments, D_2 (15.30 t ha^{-1}) and D_1 (14.19 t ha^{-1}) recorded significant highest tuber yield over D_3 (13.45 t ha^{-1}) and D_4 (12.21 t ha^{-1}). This may be due to high LAI and leaf area duration at early crop stage. It has been reported that establishment of a high LAI and leaf area duration early in the growth will increase the photosynthetic capacity and the amount of photosynthates produced and, consequently, greater tuber yield production (Kormondy, 1996). Similar results were also confirmed by Patel *et al*. (2010). 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); Balali *et al.* (2008); Khan *et al.* (2011); Sandhu *et al.* (2012). Tuber yield was negatively correlated with the time of planting and delayed plantings caused significant loss of yield. The beneficial effect of early planting might be associated with the prevalence of low temperature during the tuber development stage. The results corroborate the findings of Birhman and Verma (1980), and Sharma and Verma (1987), Shiri-*e*-Janagard *et al.* (2009).

Table 4. Water use efficiency

Treatments	
Date of planting (D)	**Water use efficiency (kg/ha/mm)**
1st November (D_1)	50.37
11th November (D_2)	56.09
21st November (D_3)	49.71
1st October (D_4)	44.23
S.E.(m) ±	2.10
C.D.(p=0.05)	6.23

WUE:

D_2 registered significantly higher WUE (56.09 kg ha^{-1} mm^{-1}) over D_3 (49.71 kg ha^{-1} mm^{-1}) and D_4 (44.23 kg ha^{-1} mm^{-1}) but was at par with D_1 (50.37 kg ha^{-1} mm^{-1}). It was recorded that, as the dates of planting of tubers were delayed so was there a reduction in the WUE. Such reduction in WUE under late sown conditions has also been reported in many crops (Singh and Mahey, 1998; Panda *et al*., 2004; Awasthi *et al*., 2007; Patel *et al*., 2010). Optimum planting date can facilitate drought escape by matching the crop growth cycle to amount and pattern of rainfall to minimize the chance of exposure to water deficit at drought susceptible stages which will increase yield and WUE of the early-sown crops (Gregory and Eastham, 1996).

Benefit Cost Ratio (BCR):

Significant result was found on gross return, net return and BCR in different dates of planting treatments (Table 4). The maximum gross return, net return and BCR recorded were Rs. 1, 83,659, Rs. 92,632 and 2.02, respectively in D_2. It was significantly higher over D_3 and D_4 but was statistically at par with D_1. It was thus recorded that tubers that were planted on 11th November gave higher economic benefits than that sown on other four dates.

Table 5. Benefit cost ratio

Treatments	Economic analysis		
Date of planting (D)	**Gross Return (Rs. ha^{-1})**	**Net Return (Rs. ha^{-1})**	**BCR**
1st November (D_1)	1,70,327	79,300	1.87
11th November (D_2)	1,83,659	92,632	2.02
21st November (D_3)	1,61,344	70,318	1.77
1st October (D_4)	1,46,508	55,482	1.61
S.E.(m) ±	6,803	6,803	0.07
C.D.(p=0.05)	20,210	20,210	0.22

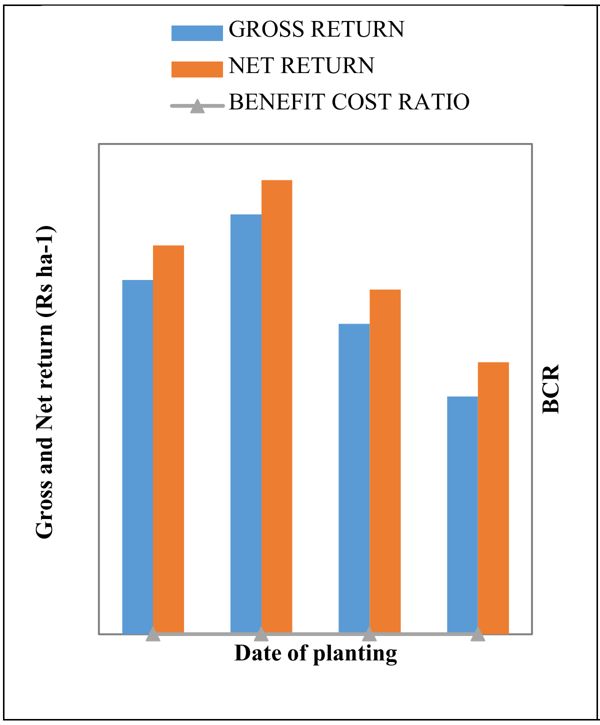

Figure 2. Effect of different date of planting on gross return, net return and BCR

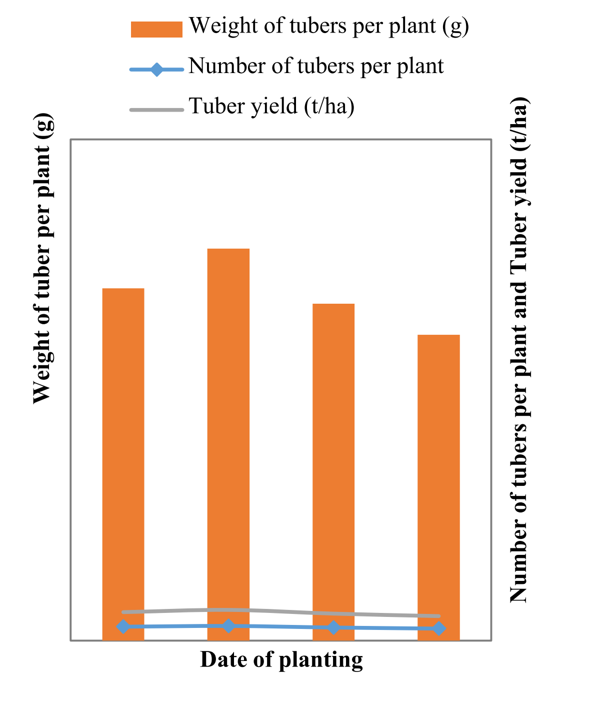

Figure 3. Effect of different date of planting on yield attributes

Conclusions

This study reflects that when winter potato is planted during 11th November in the NEH region using sprinkler irrigation technique, it can prove to be economically profitable to the farmers of this region. So, for yield optimization, planting at appropriate time is very critical as then we can get healthy plants with good yield. In all the recordings of both the growth as well as yield parameters, tubers planted at D_2 recorded maximum over $D_{1,}$ D_3 and D_4. Plants planted at D_2 had higher number of compound leaves (12.74), high LAI (2.49) and dry matter accumulation (47.07 g) which ultimately increases the number of tubers per plant (7.29) with high tuber weight per plant (195.48 g) and tuber yield (15.30 t ha^{-1}) as compared to other planting dates. Tubers planted on D_2 also gave higher gross return (`1, 83,659), net return (`92,632) and BCR (2.02). So, it can be concluded that if a calendar for timely planting of tubers can be prepared and according to that if suggestions can be given to the farmers for potato crop cultivation, it will help the growers to get a good winter potato yield with high profit.

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