



Revisiting of planting dates for maximizing seed size potato (*Solaum tuberosum*) tuber yield as per changing climatic scenario

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ABSTRACT

Potato (*Solaum tuberosum* L.) varieties, viz. Kufri Chandramukhi, Kufri Sindhuri and Kufri Chipsona 1 were evaluated for seed production in west-central Indian conditions. Days to the emergence and 50 % emergence were delayed in 10 and 17 October plantings (10.6, 10.5 days and 16.9, 16.6 days, respectively) and in the variety Kufri Sindhuri (10.6 days and 16.5 days). 7 November planting recorded higher growth attributes like emergence, number of stems, compound leaves except plant height. Delayed planting resulted in the reduction of plant height. Among the varieties, Kufri Sindhuri and Kufri Chipsona-1 recorded significantly higher growth parameters, viz. stem number, compound leaves and plant height. Higher seed size and total tuber number and per ha yield were recorded in 17 October onward plantings over other 10 October planting and highest was in 7 November planting (355 and 634 thousand/ha and 19.33 and 24.63 t/ha seed size and total tuber number and weight, respectively). Severe mosaic, mild mosaic and off types in each date of planting and varieties were below maximum permissible limit as per Indian minimum seed certification standards. Aphid population (weekly) was below the critical limit in all date of plantings and varieties. Gwalior region of west-central India is most suitable for seed production under prevailing climatic situation for getting higher seed yield.

Key words: Aphid population, Health standards, Planting window, Seed production, Variety

India has an area of approximately 2.0 million ha under potato (*Solaum tuberosum* L.) cultivation (Anonymous 2017) which requires about 4.73 million tonnes of quality seed to achieve 100% seed replacement rate (SRR). Currently, about 2.96 million tonnes (8.5%) of the total potato production are being used as seed. In potato cultivation, the seed is most expensive input accounting for 40–50% of the production cost, which needs to be changed after few multiplications due to the high rate of degeneration (Singh and Pandey 2013). The quality of seed potatoes is an important determinant of the successful potato cultivation (Struik and Wiersema 1999, Pandey 2013). Being a nodal agency ICAR-Central Potato Research Institute is producing only about 2600 tonnes of breeder seed per annum, which is not enough to achieve the target of 100% SRR. There is a huge gap between supply and demand of potato seed. Private Sector has entered into potato seed sector in a big way (Singh and Pandey 2013). In India, 94% of the total seed is produced in sub-tropical plains and remaining 6% in hilly areas (Sharma *et al.* 2013). Potato requires cool night temperature to induce tuberization

(Singh and Lal 2009) and optimum soil temperature of 16–19 °C for tuber initiation in the early season. Tuber development requires a temperature of 20°C (Khan *et al.* 2011) and potato crop growth is not possible below 2°C and above 30°C, however, for net photosynthesis minimum (0–7°C), optimum (16–25°C) and maximum temperature (40°C) are required (Singh and Lal 2009).

The crop productivity is affected by the climate thus, optimum planting date is considered as an important aspect of crop production (Kalbarczyk 2000 and Gomma 2014). Appropriate and proper time of sowing is basic requirement for obtaining maximum yield and high-profit returns of potato (Kar 2003). Performance of potato crop highly depends upon planting time for each region in the country, where each stage of growth should coincide with appropriate environmental conditions. Hence, it is necessary to determine planting time for different climatic conditions according to characteristics of cultivars (Ahmed *et al.* 2017). For potato, planting dates should be calculated on the basis of duration of growing season, and in regions with limited growing season, planting dates should be selected in a way that tuber formation and growth should not coincide with high temperature conditions (Mortazavi-bak and Ramin-pour 2009). Date of planting in potato is highly location specific and varies with the prevailing weather conditions, type of soil and cropping systems (Pandey 2013).

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Virus infection is the major limiting factor for producing high-quality seed potato, and aphids normally affect seed potato production in two ways: direct damage caused by the feeding on the plants and indirect damage through virus transmission (Carli and Baltaev 2008). Green peach aphid is the most viruliferous aphid species and is considered as a vector of Potato Leaf Curl Virus (PLRV) that is transmitted in a persistent manner (Milosevic *et al.* 2012). Degeneration of seed potatoes in the country showed that the aphid, particularly *Myzus persicae* (Sulzer), is responsible for the spread of virus diseases in the fields (Lakra 2010).

For determining the planting dates, there should be a congenial environment for each stage of plant growth, viz. emergence and seedling establishment, tuber initiation and development (Dehdar *et al.* 2003). Months from October to January are considered best for production of potato seed in Gwalior region in west-central India. Generally, planting of potato for seed production starts in the third week of October (Annual Report CPRS 2016-2017). The present studies were undertaken to evaluate the planting window for quality seed potato production for the region.

MATERIALS AND METHODS

Three popular varieties Kufri Chandramukhi (early) and Kufri Sindhuri (late) and Kufri Chipsona 1 (medium) were evaluated for seed production for six consecutive years with five planting dates, i.e. 10 October, 17 October, 24 October, 31 October and 7 November at ICAR-Central Potato Research Station, Gwalior, Madhya Pradesh, India. Sprouted seed sized tubers weighing 40–50 g were planted in plot size 4.2 × 4.0 m with a spacing of 60 cm (row to row) and 20 cm (plant to plant). The field experiment was laid down under split-plot design. Nitrogen, phosphorus and potassium were applied @150 kg/ha, 80 kg/ha and 100 kg/ha, respectively. The sources of PK were single super phosphate and murate of potash, whereas half of the nitrogen was supplied by ammonium sulfate at the time of planting and a half was supplied by urea at the time of earthing up. Recommended seed production practices were followed during the crop growth season as mentioned in the seed plot

technique. Thimet 10 G @ 10 kg/ha for controlling insects was applied at the time of earthing up and mancozeb @ 2 kg/ha sprayed as a preventive measure for late blight, leaf spot and other foliar diseases of potato. After emergence at 15–20 days interval, an alternate spray of imidacloprid @ 0.002%, triazophos @1.6 l/ha and thiamethoxam @130 g/ha was done to protect seed crop from insects. For controlling the weeds metribuzin mixed in 1000 l of water was applied @ 0.75 kg a.i. /ha.

The growth and yield parameters were recorded from time to time. Haulms were killed as per the schedule in each date of planting. Visually, virus infections were recorded three times, first before hoeing (before 21-25 days), Second during 50–55 days and third before haulm killing. Weekly data on aphid infestation was recorded after 20 days of planting for each planting date on 15 randomly selected plants from upper, middle and lower leaves. Average max/min temperature, relative humidity and rainfall were recorded for six years.

RESULTS AND DISCUSSION

Plant emergence

Days to emergence were significantly delayed in all planting dates over 31 October planting (8.6 days) and in Kufri Sindhuri (10.6 days) over other two varieties. Among the interaction between the date of planting and variety, Kufri Sindhuri planted on 10 and 17 October showed the highest delay (11.6 and 11.7 days) in emergence (Table 1). In the Gwalior conditions, 5 October and 20 October plantings took 13 days and 8 days of emergence when the temperature ranges from 35–36°C respectively (Sadawarti *et al.* 2014). A similar trend was recorded for maximum temperature (34.9°–35.1°C) during 10 and 17 October planting in the present study. Similarly, 50% emergence was significantly delayed in all the dates of planting when compared to 31 October planting (14.1 days) and among the varieties also delayed when compared to Kufri Chipsona-1 (14.6 days). In interaction, Kufri Sindhuri planted at 10 and 17 October showed high delayed emergence of 17.7 days

Table 1 Emergence count of seed potato under different planting dates and varieties

Date of planting/ Varieties	Days to emergence				Days to 50% emergence				Final emergence (%)			
	KCM	K. Sindhuri	K. Chip-1	Mean	KCM	K. Sindhuri	K. Chip-1	Mean	KCM	K. Sindhuri	K. Chip-1	Mean
10 th Oct	10.4	11.6	10.0	10.6	17.2	17.7	15.9	16.9	89.76	88.81	87.74	date
17 th Oct	10.1	11.7	9.6	10.5	16.4	17.5	15.7	16.6	88.93	89.21	90.16	89.43
24 th Oct	9.5	9.9	9.8	9.7	15.7	15.9	14.8	15.5	90.76	91.87	91.31	91.31
31 st Oct	8.4	9.7	7.9	8.6	14.1	15.6	12.7	14.1	90.28	91.86	91.23	91.12
7 th Nov	9.3	10.0	9.2	9.5	14.4	15.9	13.9	14.8	92.77	93.06	93.10	92.98
Mean	9.5	10.6	9.3		15.6	16.5	14.6		90.50	90.96	90.71	
LSD (P=0.05)	Date of planting			0.47				0.60				1.981
	Variety			0.33				0.51				NS
	Interaction (DOP × Variety)			0.73				1.13				1.942

and 17.5 days, respectively (Table 1). More than 88% final emergence was recorded in all the dates of plantings, i.e. 24 (91.31%), 31 October (91.12%) and 7 November (92.98%) in comparison to early planting, i.e. 10 October planting (88.77%). Similarly, Dash *et al.* (2018) reported the highest emergence percentage in 15 November planting (87.7 %) over any other planting date under All India Coordinated Research Project on Potato, Orissa University of Agriculture and Technology, Bhubaneswar. Among the interaction Kufri Chipsona 1 planted on 7 November showed significantly high final emergence (93.10%) over other combinations (Table 1). Similar findings were reported by Sadawarti *et al.* (2014) under Gwalior region of central India and under Bhubaneswar condition (Dash *et al.* 2018).

Growth attributing parameters

Stem/plant was significantly higher in 24 October (4.2) and 7 November planting (4.5) over other planting dates. Among the varieties, Kufri Sindhuri (4.3) and Kufri Chipsona-1 (4.2) recorded significantly higher stem number over Kufri Chandramukhi (3.6). Among the interaction, 7 November planting of Kufri Sindhuri and Kufri Chipsona-1 recorded significantly higher stem number (4.8). The results obtained under the present study are in line with Khan *et al.* (2011) in which he reported highest numbers of stems/plant (4.16) in the last sowing of 15 October 2004. Number of stems/hill was affected by the sowing time. Rab *et al.* (2013) reported the maximum number of stems/hill (2.72) in 8 October and minimum stems/hill in 15 September planting under Peshawar conditions of Pakistan. Similarly, Dash *et al.* (2018) reported higher number of shoots/plant in 15 November planting under Bhubaneswar conditions.

Maximum number of compound leaves/plant (55.1) were found in 10 October and 24 October planting and found at par with 17 October (51.3) and 7 November (53.3) planting. Among varieties, Kufri Sindhuri (59.6) recorded the maximum number of compound leaves/plant and the minimum was recorded in Kufri Chandramukhi (44.0). Among the interaction between the date of planting and variety, maximum compound leaves/plant were recorded in

24 October planting in Kufri Sindhuri (63.8) and found at par with 10 October planting of the same variety (Table 2). Dash *et al.* (2018) and Rab *et al.* (2013) also reported the effect of planting date and varieties on compound leaves/plant and leaves per hill respectively. For seed potato production Sadawarti *et al.* (2014) reported higher number of stems, compound leaves and plant height/plant in Kufri Sindhuri in 05 and 20 October planting under Gwalior conditions.

With the delay in planting time, the plant height was decreased and maximum plant height was recorded in 10 October planting (56.2 cm). However, among the varieties, Kufri Sindhuri (54.7 cm) recorded the maximum height. Interaction among the date of planting and variety, Kufri Sindhuri planted on 10 October found the maximum height (62.3 cm), which was at par with 17 October planting (59.5 cm) of the same variety (Table 2). Rab *et al.* (2013) reported the maximum height of plant in the 22 September planting and similarly, Sandhu *et al.* (2014) also reported the maximum plant height during the 1 November planting. These differences in plant height can be attributed to the differences in the prevailing weather conditions. The highest plant height recorded in 10 October can be attributed to the most favourable environment for plant growth during the cropping season. The least plant height recorded in 7 November can be due to the lower temperature experienced by the plants after emergence compared to other planting dates. Thus, lower temperature might have reduced allocation of assimilates for growth than the remaining three planting dates. The present study confirms this and climatic data indicates that minimum temperature falls below 10°C after 7 November planting. Decreasing trend in plant height with the delay in planting under Bhubaneswar conditions was also reported by Dash *et al.* (2018).

Yield attributes

Grade wise seed tuber and total tubers/ha

For quantification of total tuber for further seed multiplication according to the Indian minimum seed certification standards, seed tubers were graded in three

Table 2 Growth parameters as influenced by different planting dates and varieties

Date of planting/ Varieties	No. of stems/plant				No. of compound leaves/plant				Plant height (cm)			
	KCM	K. Sindhuri	K. Chip-1	Mean	KCM	K. Sindhuri	K. Chip-1	Mean	KCM	K. Sindhuri	K. Chip-1	Mean
10 th Oct	3.3	3.9	4.4	3.9	48.4	61.8	54.9	55.1	52.6	62.3	53.8	56.2
17 th Oct	3.3	3.6	3.8	3.6	41.8	58.2	53.9	51.3	47.5	59.5	51.2	52.7
24 th Oct	3.7	4.4	4.5	4.2	45.7	63.8	55.9	55.1	43.9	54.2	49.8	49.3
31 st Oct	3.9	4.6	3.6	4.0	39.8	55.4	49.3	48.1	40.8	51.7	46.3	46.3
7 th Nov	3.8	4.8	4.8	4.5	44.1	58.7	57.2	53.3	42.3	46.0	49.0	45.8
Mean	3.6	4.3	4.2		44.0	59.6	54.2		45.4	54.7	50.0	
LSD (P=0.05)	Date of planting			0.42				5.30				2.25
	Variety			0.24				2.20				1.58
	Interaction (DOP × Variety)			0.54				4.92				3.52

Table 4 Grade-wise and total seed tuber yield (t/ha) as influenced by different planting dates and varieties

Date of planting/ Varieties	<25 g				25-125 g				>125 g				Total			
	KCM	K. Sindhuri	K. Chip-1	Mean	KCM	K. Sindhuri	K. Chip-1	Mean	KCM	K. Sindhuri	K. Chip-1	Mean	KCM	K. Sindhuri	K. Chip-1	Mean
10 th Oct	2.07	2.79	2.43	2.43	11.60	13.47	12.84	12.64	3.50	2.13	2.02	2.55	17.22	18.26	17.34	17.61
17 th Oct	2.42	2.92	3.07	2.80	14.50	15.68	14.69	14.96	2.50	2.54	2.10	2.38	16.57	21.65	20.24	19.48
24 th Oct	1.98	3.61	2.74	2.78	13.38	18.22	17.06	16.22	2.50	1.59	1.93	2.01	17.72	23.30	21.69	20.90
31 st Oct	2.71	3.62	2.53	2.95	14.79	18.99	18.48	17.42	2.39	2.21	1.88	2.16	19.91	24.92	23.04	22.63
7 th Nov	3.02	3.75	3.03	3.27	16.52	20.81	20.65	19.33	1.91	1.53	2.10	1.84	23.11	25.27	25.52	24.63
Mean	2.44	3.34	2.76		14.16	17.43	16.74		2.56	2.00	2.01		18.91	22.68	21.57	
LSD (P=0.05)	Date of planting			0.359				1.685				0.335				0.734
	Variety			0.269				0.946				0.257				0.739
	Interaction (DOP × Variety)			0.602				2.114				0.575				1.651

Pradesh. Under normal crop, highest tuber number and yield was reported by Dash *et al.* (2018) under Bhubneshwer conditions. Seed production in a temperature range of 25–28°C was found to reduce yield when compared with the cooler grown seed at 16–22°C (Bodlaender 1972). In the present investigations, 7 November planting conceived the optimal temperature, humidity and intermittent rainfall during the seed crop growth, which results in the higher total seed number and yield (Fig. 1, 2, 6).

Health standards

Severe mosaic, mild mosaic and off type

Production of high quality and disease-free breeder seed is important for its further multiplication and higher production. Hence, it is necessary to remove the diseased plants particularly mosaic affected and off types. There was no sign of mosaic in the first roguing in all the planting dates and varieties. During the second roguing, 10 October planting (0.05%) recorded the lower severe mosaic, which was at par with 17 October, 31 October and 7 November plantings (Table 5). Among varieties, Kufri Sindhuri and Kufri Chipsona 1 (0.06%) recorded non-significantly lower severe mosaic. The severe mosaic in each date of planting and varieties were far below maximum permissible limit under Indian minimum seed certification standards, viz. 0.50% for foundation-1, 0.75% for foundation-2 and 1% for certified seed (IMSCS 2013). No significant results were found for mild mosaic among date of planting and varieties for all three rogues. Mild mosaic incidence and off types were non significant in all the dates of planting and varieties for all the three rouging. This was below the maximum permissible limits under Indian minimum seed certification standards viz 1% for foundation-1, 2% for foundation-2 and 3% for certified seed for mild mosaic and 0.05% for foundation-1, 0.05% for foundation-2 and 1% for certified seed for off type (IMSCS 2013).

Aphid population

During the potato seed production, the aphid population should be below the critical limit. In the present investigation, aphid population monitoring was done on 15 compound leaves per plot. In the course of study, the aphid population was found below the critical limit (3/15 compound leaves) in all the planting dates and varieties. The aphid population was higher during 4–9 weeks, but it was far below the critical limit. The minimum aphid population during the crop seasons was due to the intermittent rainfall leading to low temperature and high relative humidity during the crop growth (Fig. 1, 2). Temperature is the most important environmental factor that affects aphid behavior, development and reproduction (Karim *et al.* 2011).

Relative humidity plays the critical role in aphid population development. With the decrease of relative humidity, there was an increase in aphid population and it was highest when the relative humidity was around 65%. In the present study, the relative humidity was also high in

Table 5 Health parameters (per cent) as influenced by planting dates and varieties

Date of planting/ variety	Health standard								
	Severe mosaic			Mild mosaic			Off type		
	1 st	2 nd	3 rd	1 st	2 nd	3 rd	1 st	2 nd	3 rd
<i>Date of planting</i>									
10 th Oct	0.00	0.05	0.07	0.01	0.11	0.08	0.05	0.00	0.00
17 th Oct	0.00	0.08	0.13	0.01	0.08	0.05	0.04	0.00	0.00
24 th Oct	0.00	0.12	0.07	0.03	0.05	0.08	0.07	0.00	0.00
31 st Oct	0.00	0.09	0.08	0.01	0.07	0.08	0.03	0.00	0.00
7 th Nov	0.00	0.08	0.12	0.03	0.11	0.08	0.08	0.00	0.00
CD (P=0.05)	NS	0.051	NS	NS	NS	NS	NS	NS	NS
<i>Variety</i>									
KCM	0.00	0.14	0.17	0.02	0.14	0.13	0.06	0.00	0.00
K. Sindhuri	0.00	0.06	0.06	0.01	0.05	0.04	0.06	0.00	0.00
K. Chipsona-1	0.00	0.06	0.06	0.03	0.06	0.06	0.04	0.00	0.00
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
CD (DOP x VAR)	NS	NS	NS	NS	NS	NS	NS	NS	NS

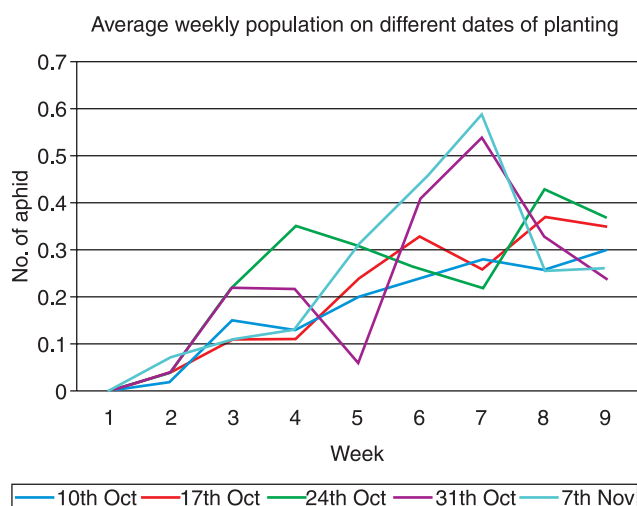


Fig 1 Average weekly aphid population according to DOP for six year (2012-12 to 2017-18) during crop growth.

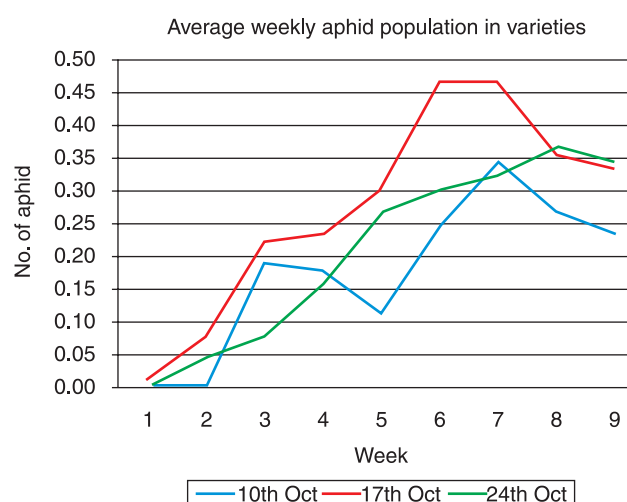


Fig 2 Average weekly aphid population according to variety for six year (2012-13 to 2017-18) during crop growth.

the range of 80–90% in the same data recording period (Fig 2). The regression analysis proved that there was a negative correlation of aphid population with relative humidity in all the consecutive three cropping seasons (Karim *et al.* 2011). Seed production was done with standard seed plot techniques with the use of insecticide at a regular interval, which also led to a very low population of aphid during seed production. Konar (1998) also reported the effect of relative humidity and temperature on the critical level of *Mysus persicae* under Kalyani conditions of West Bengal. In the present study, the critical limit was not crossed up to halum killing of the plant till the end of January. This indicates the favourable conditions for breeder seed potato production.

Conclusion

From the present study, it can be concluded that aphid

population which mainly causes the spread of viral diseases was below the critical limit under Gwalior region of west-central India, which makes this region more suitable for potato breeder seed production. Health standards (Severe mosaic, mild mosaic and off-type) in different date of plantings and in varieties were below the recommended limits as per IMSCS, 2013. Kufri Sindhuri and Kufri Chipsona-1 recorded significantly higher growth attributes, seed tuber number and yield for <25 g, 25–125 g grades and total tuber yield per ha. Hence, it may be recommended that the first week of November is the most suitable planting time for getting a higher seed size tuber yield under Gwalior conditions of west-central India.

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