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Effect of planting periods on production potential of potato (*Solanum tuberosum*) varieties under aeroponics

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ABSTRACT

An experiment was conducted during 2017–18 in the aeroponic unit of ICAR-Central Potato Research Institute in Shimla, Himachal Pradesh, to evaluate 3 potato (*Solanum tuberosum* L.) cultivar's, viz. Kufri Mohan, Kufri Lauvkar and Kufri Himalini growth and production behaviour under 2 different planting periods spaced 10 days apart during the autumnal season. The yield per plant and the total number of mini-tubers were shown to be strongly impacted by the planting season as well as the cultivar, according to the findings. The average number of tubers harvested was 32.7/plant in early (10th September) planting as against 21.2 mini-tubers/plant in late (20th September). Similarly, yield per plant was significantly higher (67.67 g/plant) with early planting than with late planting (35.99 g/plant). The production behaviour of the potato varieties under consideration varied significantly. The maximum yield/plant and mini-tuber numbers were recorded in Kufri Lauvkar (34.17 and 73.12 g/plant, respectively), which were significantly higher than the remaining 2 cultivars, which were statistically at par for both the number of yield/plant and mini-tubers. A delay in the planting of 10 days under aeroponics results in a significant reduction not only in the vigour of plants but subsequently in the number as well as weight of mini-tubers harvested. Thus, for attaining higher rates of multiplication under aeroponics during the autumn season, planting should not be delayed beyond 10th September in a hilly temperate wet zone.

Keywords: Autumn, Aeroponics, Mini-tubers, Potato, Planting period, Root length, Stolon

On account of vegetative propagation, seed constitutes a major and important input in potato (*Solanum tuberosum* L.) cultivation. The requirement of seed potatoes (tubers) is voluminous (2.5–3.5 tonne/ha) and accounts for 40–50% of the total cost of production (Sharma and Singh 2010, Singh *et al.* 2019). One of the most significant factors restricting potato output in underdeveloped nations is a lack of high-quality seeds (Naik and Karihaloo 2007). India's poor production of potatoes in comparison to wealthy nations is mostly caused by the lack of sufficient supplies of high-quality seeds (Rana *et al.* 2013). To cope with enormous demands for quality seed in India, new technological interventions like micro-propagation, apically rooted cuttings (ARC) and aeroponics etc., are incessantly in progress to replace the conventional clonal seed multiplication system (Buckseth *et al.* 2022a). Among these, the aeroponics technique, on account of numerous advantages such as higher rates of multiplication, improved health standards and size regulation with sequential harvesting of mini-tubers etc., is finding favour among potato seed growers of the country. Aeroponics also has additional benefits that contribute to its increased acceptance, including solution recirculation, little water consumption and effective nutrient and *p*H monitoring (Farran *et al.* 2006). It has previously been noted that aeroponics produces much more mini-tubers in temperate climates (Ritter *et al.* 2001). But in India, the aeroponics technique, still in its infancy, needs many refinements to further improve the efficacy of the system.

Different planting periods are known to affect the performance of plants in an aeroponics system in addition to many other parameters (Mateus-Rodriguez *et al.* 2014, Yan *et al.* 2000). Numerous studies (Farran *et al.* 2006, Otazu 2010) have also discovered variations in the performance of potato cultivars grown in aeroponic systems. Therefore, choosing the right planting date is essential to increase the quantity and size of potato mini-tubers in aeroponics.

Keeping in view, the fact that no such information is available under Indian conditions, the present study was carried out with the objective to know the optimum time of planting in aeroponics for obtaining higher number and yields of mini-tubers in different potato cultivars during autumn season in temperate hill conditions.

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MATERIALS AND METHODS

In order to accomplish the aforementioned goals, an experiment was conducted in the aeroponic unit at the ICAR-Central Potato Research Institute, Shimla, Himachal Pradesh during 2017 and 2018. Three different potato varieties, viz. Kufri Mohan, Kufri Himalini and Kufri Lauvkar were evaluated during 2 distinct planting periods spaced 10 days apart during the fall season in a randomized block design. Three-weeks-old *in vitro* plantlets of all 3 cultivars were planted on 2 dates of planting (DOP), viz. 10th and 20th September each year at standard planting geometry of 15 cm × 10 cm. The crop was raised using an aeroponic system, following the standard set of procedures. Each treatment had 3 replications with 10 plants per replication. Up to 4 weeks of weekly data on plant establishment and the number of main stolons per plant at 30, 45 and 60 days following planting were gathered (DAP). Plant height along with root length (cm) was measured 3 times during the crop season after 15, 30 and 45 DAP, as well as final plant height and root length were observed towards the end of crop season after 90 days of planting. Mini-tuber harvesting began at 40 DAP, with a total of 14 harvestings carried out at an intervals of 7 days. By adding together all 14 harvests throughout the course of the whole crop season, information on the overall number of tubers as well as yield/plant was gathered.

Statistical analysis: The average of 2 years' worth of data was statistically analyzed using the Gomez and Gomez (1984) described method of analysis of variance (ANOVA) since the year × year fluctuations were not statistically significant. The F-test was used to determine the mean values and separate them at a 5% level of significance.

RESULTS AND DISCUSSION

Per cent plant establishment: Plant establishment in aeroponics was shown to be 100% in all treatments and was not impacted by planting timing or genotypes (data not given). This high plant survival rate under aeroponics could be because plants in aeroponics system are totally suspended in the air, giving the plant stem and root systems access to 100% of the available oxygen. In addition, plants have 100% access to carbon dioxide concentrations for photosynthesis (Ritter *et al.* 2001, Sun *et al.* 2004). The results obtained under aeroponics concur with those obtained by Tshoka *et al.* (2012) who reported non-significant differences in plant survival rates among genotypes under aeroponics system. Most importantly, plants of appropriate ages and sizes should undergo an acclimation period before planting in the aeroponic boxes (Tunio *et al.* 2020).

Days to root, stolon, tuber initiation and number of stolons/plant: Significant variations in days to root initiation were seen amongst the cultivars. The data on days required for root, stolon and tuber initiation in 3 potato cultivars at two dates of planting under aeroponics is presented in Table 1. A perusal of the data reveals that early planted crops resulted in early root initiation in aeroponics. The number of days taken for root initiation was significantly less (4.5 days) in the 10th September planted crops compared to 6.0 days in the 20th September planting. Root initiation was early in Kufri Lauvkar and late in Kufri Mohan. However, Kufri Himalini was at par with Kufri Mohan for days required to root initiation. Days required for stolon initiation were also impacted considerably by a period of planting and by genotype. However, in comparison to root initiation, an opposite trend was noticed for days required for stolon initiation in response to a period of planting (Table 1). Contrary to root initiation, stolon initiation was early in the late planted crop (20th September) than early planted crop (10th September). Similar to how roots are initiated, stolons are initiated among the cultivars in a similar manner. Significantly early stolonisation was experienced in Kufri Lauvkar (13.8 DAP), followed by Kufri Himalini (22.8 DAP) and late (23.5 DAP) in Kufri Mohan (Table 1). Days to tuber initiation were directly correlated to the days required for stolon initiation. Tuber initiation was impacted significantly by the period of planting and genotype. Tuber initiation was about 1 week early (29.3 DAP) in early (10th September) planted crop than late planted (20th September) (23.7 DAP). Significant variation in days to tuber initiation was also noticed among cultivars. Like stolon initiation, tuber initiation was early in Kufri Lauvkar (23.2 DAP) and late in Kufri Mohan (30.6 DAP), whereas Kufri Himalini was in between the 2 cultivars with 25.7 days for tuber initiation (Table 1). These findings are consistent with those of other investigators (Yan *et al.* 2000, Mateus Rodriguez *et al.* 2014), who also noted that the performance of potato plants cultivated in an aeroponic system is impacted by the

Table 1 Effect of period of planting on days taken for root, stolon and tuber initiation in 3 potato cultivars under aeroponics

Cultivar	Days to root initiation			Days to stolon initiation			Days to tuber initiation		
	DOP 10/9	DOP 20/9	Mean	DOP 10/9	DOP 20/9	Mean	DOP 10/9	DOP 20/9	Mean
K Lauvkar	4.0	5.3	4.7	16.3	15.3	13.8	25.6	20.7	23.2
K Himalini	4.3	6.7	5.5	27.3	18.3	22.8	30.0	21.3	25.7
K Mohan	5.3	6.0	5.7	26.7	20.3	23.5	32.3	29.0	30.6
Mean	4.5	6.0		22.1	18.0		29.3	23.7	
CD 0.05									
Cultivar (A)		0.70			1.00			1.95	
DOP (B)		0.60			0.82			1.59	
A × B		N/A			1.41			2.75	

planting season. Stolon formation is an important attribute known to directly affect the number of tubers produced. Data on a number of primary stolons per plant indicates that an early planting by 10 days (10th September) was more beneficial in improving the number of stolons (1.89/plant) than late planting (20th September) (1.48/plant). A gradual increase in the number of stolons was observed with increasing crop duration from 30–60 days. Number of stolons per plant were minimum (1.43/plant) after 30 days of planting and maximum (1.97/plant) at 60 DAP. Number of primary stolons per plant were significantly different among the potato cultivars evaluated. Maximum number of stolons were found in Kufri Mohan (2.29/plant) and minimum in Kufri Himalini (1.32 stolons/plant). Variations in number of stolons/plant with different planting period can be attributed to the corresponding plant vigour in respect of plant height and root length (Table 2). On the similar lines, the cultivars with more plant height and root length resulted in more number of stolon/plant.

Plant height and root length: Data on the plant height and root length of 3 potato cultivars planted at two periodical intervals under aeroponics is presented in Table 2. It is apparent from the data that plant height and root length were affected significantly with a period of planting as well as with cultivars at all the stages of plant growth. An early planting by 10 days (10th September) resulted in a significantly higher plant height (28.08 cm) than the 20th September planting (15.85 cm). Plant height followed an increasing trend at all the intervals of crop growth till 90 days after planting. Height was minimum (11.85 cm) after 15 days of planting which steadily increased to 26.72 cm at 90 days of crop duration (Table 2). Among the different crop durations, plant height increment was found to be significant between the initial crop duration of 15–30 days. Thereafter, the increase in plant height was found to be statistically at par between subsequent crop durations. Among the cultivars, plant height varied significantly and observed to be a maximum (24.10 cm) in Kufri Lauvkar and a minimum (19.97 cm) in Kufri Mohan (Table 2). Significant differences in plant height because of the cultivar is in agreement with Otazu (2010) and Masengesho *et al.* (2012), who have also reported that the vegetative development of potatoes inside an aeroponic system is genotype dependent. The difference in plant height with planting period tells the already well-established role of day length along with temperature on potato's plant height. There can be various reasons for such variations in plant growth amongst the cultivars. Farran *et al.* (2006) reported that the poor plant growth in some genotypes under aeroponics was due to their poor capacity for using low light intensity, whereas, Sharma *et al.* (2013) also stated variations in cultivar's dry-matter partitioning in a warmer climate. The average root length was significantly more (23.15 cm) with early (10th September) planting than with late (20th September) planting (12.89 cm). A continuous and steady increase in root length was noticed at all the intervals of crop duration from beginning to end. Root length was significantly low (8.81 cm) at 15 days' crop

Table 2 Effect of planting period on plant height and root length of potato cultivars at different crop durations under aeroponics

Days after planting	Plant height (cm)									Root length (cm)								
	K Lauvkar			K Himalini			K Mohan			K Lauvkar			K Himalini			K Mohan		
	DOP 10/9	DOP 20/9	Mean	DOP 10/9	DOP 20/9	Mean	DOP 10/9	DOP 20/9	Mean	DOP 10/9	DOP 20/9	Mean	DOP 10/9	DOP 20/9	Mean	DOP 10/9	DOP 20/9	Mean
15 DAP	12.26	11.33	11.80	13.20	8.83	11.02	13.30	12.20	12.75	18.4	6.86	12.63	7.30	4.30	5.80	11.10	4.86	7.98
30 DAP	38.63	15.86	27.25	30.73	13.83	22.28	25.40	14.83	20.11	26.3	10.63	18.47	16.97	10.43	13.70	23.97	7.76	15.87
45 DAP	38.96	18.73	28.85	32.73	20.30	26.51	28.16	17.63	22.90	29.1	12.63	20.85	22.73	15.20	19.97	25.93	9.60	17.77
90 DAP	39.30	17.73	28.51	34.50	20.53	27.51	29.86	18.40	24.13	34.5	21.53	28.03	31.30	27.63	29.47	30.20	23.30	26.75
Mean	32.29	15.92	24.10	27.79	15.87	21.83	24.18	15.77	19.97	27.1	12.92	19.99	19.57	14.39	16.98	22.80	11.38	17.09
CD (0.05)																		
Cultivar (A)						2.56									2.24			
DOP (B)						2.09									1.83			
A × B						3.62									3.17			
Interval/ DAP ©						2.96									2.59			
B × C						N/A									N/A			
A × C						4.19									3.66			
A × B × C						N/A									N/A			

Table 3 Effect of period of planting on number and yield of potato mini-tubers/plant in 3 potato cultivars under aeroponics

Cultivar	Mini-tubers/plant			Yield/plant (g)		
	DOP 10/9	DOP 20/9	Mean	DOP 10/9	DOP 20/9	Mean
K Lauvkar	46.00	22.33	34.17	101.77	44.47	73.12
K Himalini	25.67	21.67	23.67	42.78	27.64	35.21
K Mohan	26.33	19.67	23.00	58.46	35.87	47.17
Mean	32.67	21.22		67.67	35.99	
CD (0.05)						
Cultivar (A)		9.24			20.97	
DOP (B)		7.55			17.12	
A × B		N/A			N/A	

duration, which goes to a maximum (28.08 cm) after 90 days of planting (Table 2). Among the cultivars evaluated, root length was significantly higher in Kufri Lauvkar (about 20.0 cm) than in the other 2 cultivars, which had almost similar (statistically at par) root lengths. The substantial variation in root length across the cultivars may be due to genotypic variations. Earlier workers (Farran *et al.* 2006, Masengesho *et al.* 2012, Buckseth *et al.* 2022b) have also stated that different potato cultivars result in varying plant growth under aeroponics. Significant variations in root length in the current study are also attributed to the differential genotypic makeup of the cultivars and consequently their varying response in plant growth under aeroponics.

Number of minitubers and yield/plant: The data pertaining to yield attributes, viz. total number and yield of mini-tubers per plant as attained throughout 14 sequential harvests, is presented in (Table 3). A perusal of the data reveals that the total number of mini-tubers and yield per plant was significantly affected by the period of planting as well as the genotype. Early planting (10th September) showed a significant rise in the number of mini-tubers and yield per plant over a delay in planting by 10 days (20th September). A total number of tubers harvested was 32.67/plant on the 10th September planting as against 21.22 mini-tubers/plant on the 20th September planting (Table 3). Similarly, yield per plant was significantly higher (67.67 g/plant) in early planting than in late planting (35.99 g/plant). The production behaviour of the many potato varieties under consideration varied significantly. The highest number of mini-tubers and yield/plant were found in Kufri Lauvkar (34.17 and 73.12 g/plant, respectively), which was significantly higher than the remaining 2 cultivars, which were statistically at par for both numbers of mini-tubers and yield/plant. Although the number of mini-tubers/plant were similar in Kufri Mohan and Kufri Himalini, yield/plant was somewhat higher (47.17 g/plant) in Kufri Mohan as compared to Kufri Himalini (35.21 g), which indicates that the average size of mini-tuber harvested was better in Kufri Mohan than Kufri Himalini. Our findings are consistent with those of Borcic *et al.* (2022), who found that greater vegetative growth produced more mini-tubers because enhanced photosynthetic activity was the cause of the rise in tuber number. But the variations in potato cultivar production potentiality may be linked to the corresponding growth vigour as well as the varied genetic background that results in different production potentiality of the cultivars tested.

Numerous other researchers, including Farran *et al.* (2006), Movahedi *et al.* (2012) and Mateus Rodriguez *et al.* (2014) have also reported that response in an aeroponics system for yield variables was mainly affected by genotype and environmental, and it is therefore advised to evaluate each genotype. According to Otazu (2010), aeroponic cultivation prolongs the potato plants vegetation period by 1 to 2 months thereby increasing the number of harvests which ultimately increase the yield. Mateus Rodriguez *et al.* (2014) reported a significant increase in the duration of a vegetative cycle for 10 investigated potato genotypes grown in aeroponics compared to the length expected under field conditions, with the genotypes Venturana and Serranita taking up to 291.3 days to senescence. Tierno *et al.* (2014) reported that plants in the aeroponic system showed increased growth and their vegetative cycle was prolonged 12–36% compared to the plants cultivated in greenhouse beds. The growth observed in plants cultivated without soil can be influenced by so many factors such as the variety, the availability of nutrients, stretching of the cycle and culture density. These results are in agreement with many earlier workers (Mbiyu *et al.* 2012, Ngawang 2018) during their aeroponic studies on potatoes. More production of photosynthates also favours the plant to produce more tubers per plant and subsequently more total tuber yield (Buckseth *et al.* 2020). The healthy crop yield was high due to the translocation of more photosynthates to tubers (Buckseth *et al.* 2020). The above result was in contrast with the finding of Tshoka *et al.* (2012) that the low yields corresponded to an increase in aboveground growth due to the competition for sucrose unloading between the storage organs (mini-tubers) and the aboveground growth (leaves and stems).

The results of our study signify that planting period is very crucial for potato mini-tubers production during autumn season in high hills. A delay in planting of 10 days results in significant reduction not only in vigour of plants under aeroponics but subsequently on the number and weight of

mini-tubers harvested during the crop cycle. Genotypic differences for plant growth as well as for potato mini-tuber production are a feature even under aeroponics. Successful production of potato mini-tubers under aeroponics during the autumn (off) season will definitely help in augmenting the ever short availability of healthy planting material of potato.

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